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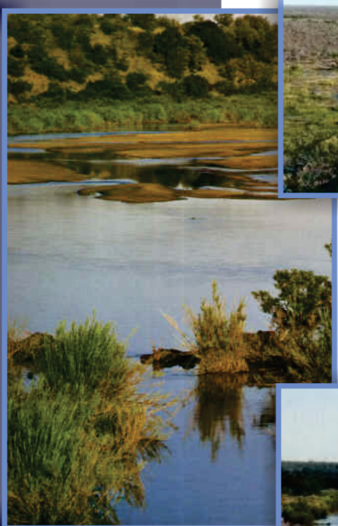
Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

WATER SUPPLY SCHEMES, SOCIAL AND ENVIRONMENTAL ASPECTS REPORT



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DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

WATER SUPPLY SCHEMES, SOCIAL AND ENVIRONMENTAL ASPECTS REPORT

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Acting Director: National Water Resource Planning

(Project Manager)

LIST OF REPORTS

The following reports form part of this study:

Report Title	Report number
Inception Report	P WMA 02/B810/00/1412/1
Literature Review Report	P WMA 02/B810/00/1412/2
Water Requirements and Return Flow Report	P WMA 02/B810/00/1412/3
Rainfall Analysis Report	P WMA 02/B810/00/1412/4
Hydrology Report (includes IAP)	P WMA 02/B810/00/1412/5
Water Conservation and Water Demand Management Report	P WMA 02/B810/00/1412/6
Water Re-Use report	P WMA 02/B810/00/1412/7
Water Quality Assessment Report	P WMA 02/B810/00/1412/8
Groundwater Utilization Scenarios	P WMA 02/B810/00/1412/9
Yield Analysis Report (includes EWR)	P WMA 02/B810/00/1412/12
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Water Supply Schemes, Social and Environmental Aspects Report	**P WMA 02/B810/00/1412/14**
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Executive Summary of Final Reconciliation Strategy	P WMA 02/B810/00/1412/16
Demographic and Economic Development Potential Report	P WMA 02/B810/00/1412/17

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

Water Supply Schemes, Social and Environmental Aspects Report

EXECUTIVE SUMMARY

The Department of Water Affairs (DWA) has identified the need for a Reconciliation Study for the Luvuvhu and Letaba Water Management Area (WMA). The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams. The recently completed Nandoni Dam located in the Luvuvhu basin will be managed in combination with Albasini, Vondo and Damani Dams as one system. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (waste water) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

To achieve the above objectives, the following main aspects will be covered in the study:

- *Update the current and future urban and agricultural water requirements and return flows;*
- *Assess the water resources and existing infrastructure;*
- *Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;*
- *To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;*
- *To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the Reconciliation Strategy;*

- *Formulate reconciliation interventions, both structural and administrative/regulatory;*
- *Document the reconciliation process including decision processes that are required by the strategy; and*
- *Conduct stakeholder consultation in the development of the strategy.*

The study area comprises of the water resources of the catchments of the Luvuvhu, Mutale, Letaba and Shingwedzi Rivers linked to adjacent systems. This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area. For the purpose of evaluation of the options the study area was sub-divided into the following sub-areas:

- *Luvuvhu River Main Catchment*
- *Mutale River Catchment*
- *Shingwedzi River Catchment*
- *Groot Letaba River Catchment*
- *Middle and Klein Letaba River Catchments*

The focus of this report is to address the bulk water supply infrastructure aspects of the Reconciliation Strategy Study by:

- *Providing brief descriptions of the different bulk infrastructure components for the existing and the proposed development of water resources and bulk water supply schemes.*
- *Reviewing previous designs of the bulk infrastructure components for the proposed development of water resources and bulk water supply schemes and making necessary adjustments.*
- *Reviewing and updating cost estimates for the proposed development of water resources and bulk water supply schemes.*
- *Engineering economic analyses of the proposed development of water resources and bulk water supply schemes and assessing life cycle costs (expressed as Unit Reference Values).*
- *Evaluating and quantifying the environmental and social impacts for the proposed development of water resources and bulk water supply schemes.*

Several potential options were identified from the Literature Review Report (Report No. P WMA 02/B810/00/1412/2) and subsequent Screening Workshop. These options were reviewed, with comments and motivations for either discarding it as a non-viable augmentation option, or for pursuing it in further detail.

The identified intervention options that were adopted for further assessment are listed in the following table.

Selected Intervention Options

Catchment Area	*Intervention Option*	*Description of Intervention Option*
Luvuvhu Main Catchment Area	*Option Lu8*	*Paswane Dam on Mutshindudi River*
	Option Lu9	*Xikundu Dam on Luvuvhu River*
Mutale River Catchment Area	*Option Mu3*	*A new dam on the Mutale River* • *Tswera Dam* • *Rambuda Dam (d/s site)* • *Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)*
Middle and Klein Letaba River Catchment Area	*Option MKL3*	*Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline*
	Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Crystalfontein Dam with pumping scheme and gravity pipeline* • *Majosi Dam with flood diversion canal*

Engineering economic analyses were performed for the selected intervention options. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014. Unit reference values (URV) were determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction).

The following table contains a summary of the total discounted costs and use, including URV's for the selected intervention options.

Summary of Unit Reference Values

Intervention Option	*Description of Intervention Option*	*Discount Rate (%)*	*Total Discounted Costs*	*Total Discounted Use (million m³)*	*URV Rand/m³*
Option Lu8	*Paswane Dam on Mutshindudi River*	*6%*	*288,272,394*	*416.98 (Historic)* *533.34 (Stochastic)*	*0.691* *0.540*
		8%	*256,764,969*	*281.30 (Historic)* *359.80 (Stochastic)*	*0.913* *0.714*
		10%	*229,847,986*	*197.85 (Historic)* *253.06 (Stochastic)*	*1.162* *0.908*

Intervention Option	*Description of Intervention Option*	*Discount Rate (%)*	*Total Discounted Costs*	*Total Discounted Use (million m³)*	*URV Rand/m³*
Option Lu9	*Xikundu Dam on Luvuvhu River*	*6%*	*348,575,386*	*494.56 (Historic) 606.07 (Stochastic)*	*0.705 0.575*
		8%	*310,176,242*	*333.63 (Historic) 408.86 (Stochastic)*	*0.930 0.759*
		10%	*277,422,899*	*234.65 (Historic) 287.57 (Stochastic)*	*1.182 0.965*
Option Mu3	*A new dam on the Mutale River* • *Tswera Dam*	*6%*	*375,958,504*	*588.37 (Historic)*	*0.639*
		8%	*343,689,378*	*412.04 (Historic)*	*0.834*
		10%	*315,130,463*	*300.63 (Historic)*	*1.048*
Option Mu3	*A new dam on the Mutale River* • *Rambuda Dam (d/s site)*	*6%*	*202,099,024*	*137.29 (Historic)*	*1.472*
		8%	*182,973,900*	*96.14 (Historic)*	*1.903*
		10%	*166,367,598*	*70.15 (Historic)*	*2.372*
Option Mu3	*A new dam on the Mutale River* • *Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)*	*6%*	*246,359,682*	*555.68 (Historic)*	*0.443*
		8%	*225,463,089*	*389.15 (Historic)*	*0.579*
		10%	*206,924,372*	*283.93 (Historic)*	*0.729*
Option MKL3	*Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline*	*6%*	*311,833,458*	*327.77 (Historic)*	*0.951*
		8%	*270,581,320*	*233.87 (Historic)*	*1.157*
		10%	*239,280,332*	*173.80 (Historic)*	*1.377*

Intervention Option	*Description of Intervention Option*	*Discount Rate (%)*	*Total Discounted Costs*	*Total Discounted Use (million m³)*	*URV Rand/m³*
Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Crystalfontein Dam with pumping scheme and gravity pipeline*	*6%*	*376,820,764* *376,471,300*	*58.18 (Historic & No EWR)* *52.36 (Historic & EWR Included)*	*6.476* *7.189*
		8%	*335,152,878* *334,917,127*	*39.25 (Historic & No EWR)* *35.33 (Historic & EWR Included)*	*8.539* *9.481*
Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Crystalfontein Dam with pumping scheme and gravity pipeline*	*10%*	*299,823,847* *299,658,035*	*27.61 (Historic & No EWR)* *24.85 (Historic & EWR Included)*	*10.861* *12.061*
Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Majosi Dam with flood diversion canal*	*6%*	*302,945,344*	*53.33 (Historic & No EWR)* *44.61 (Historic & EWR Included)*	*5.680* *6.791*
		8%	*269,152,280*	*35.98 (Historic & No EWR)* *30.09 (Historic & EWR Included)*	*7.481* *8.944*
		10%	*240,376,780*	*25.31 (Historic & No EWR)* *21.16 (Historic & EWR Included)*	*9.499* *11.357*

Socio and economic impact assessments, as well as environmental impact assessments were conducted for the selected intervention options. The following table contains a summary of the classifications assigned to the respective options.

Socio-Economic and Environmental Impacts Summary

Intervention Option	*Description of Intervention Option*	*Socio-Economic Classification*	*Environmental Classification*
Option Lu8	*Paswane Dam on Mutshindudi River*	***Apparently Acceptable***	***Apparently Acceptable***
Option Lu9	*Xikundu Dam on Luvuvhu River*	***Apparently Acceptable***	***Apparently Acceptable***
Option Mu3	*A new dam on the Mutale River* • *Tswera Dam*	***Flawed***	***Caution***
Option Mu3	*A new dam on the Mutale River* • *Rambuda Dam (d/s site)*	***Acceptable***	***Caution***
Option Mu3	*A new dam on the Mutale River* • *Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)*	***Flawed***	***Apparently Acceptable***
Option MKL3	*Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline*	***Acceptable***	***Apparently Acceptable***
Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Crystalfontein Dam with pumping scheme and gravity pipeline*	***Apparently Acceptable***	***Apparently Acceptable***
Option MKL5	*Construction of a new dam on the Klein Letaba River* • *Majosi Dam with flood diversion canal*	***Apparently Acceptable***	***Apparently Acceptable***

Taking cognisance of the URV's, social-economic and environmental classifications the following recommendations are proposed for the selected intervention options.

Luvuvhu Main Catchment Area

Intervention Option	*Description of Intervention Option*	*Discount Rate (%)*	*URV Rand/m³*	*Classification*	
				Socio-Economic	*Environmental*
Option Lu8	*Paswane Dam on Mutshindudi River*	*6%*	*0.691* *0.540*	*Apparently Acceptable*	*Apparently Acceptable*
		8%	*0.913* *0.714*		
		10%	*1.162* *0.908*		
Option Lu9	*Xikundu Dam on Luvuvhu River*	*6%*	*0.705* *0.575*	*Apparently Acceptable*	*Apparently Acceptable*
		8%	*0.930* *0.759*		

Intervention Option	*Description of Intervention Option*	*Discount Rate (%)*	*URV Rand/m³*	*Classification*	
				Socio-Economic	*Environmental*
		10%	*1.182* *0.965*		

Both intervention options for the Luvuvhu Main Catchment Area received classifications of Apparently Acceptable for Social-Economic and Environmental Impacts. From an engineering economic point of view, Option Lu8 – Paswane Dam on the Mutshindudi River, is the recommended way forward, i.e. lowest Unit Reference Value (URV).

Mutale River Catchment Area

Intervention Option	Description of Intervention Option	Discount Rate (%)	URV Rand/m³	Classification	
				Socio-Economic	Environmental
Option Mu3	A new dam on the Mutale River • Tswera Dam	6%	0.639	Flawed	Caution
		8%	0.834		
		10%	1.048		
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	6%	1.472	Acceptable	Caution
		8%	1.903		
		10%	2.372		
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	6%	0.443	Flawed	Apparently Acceptable
		8%	0.579		
		10%	0.729		

From the table above it is evident that the intervention option with the lowest Unit Reference Value (URV) is the Proposed Thengwe Dam on the Lower Mutale. Given the potential socio-economic impacts this water intervention option is 'flagged' as being ***flawed***. Even though the intervention will provide water to households on a broader regional scale with low associated macro-economic costs, the socio-economic and socio-cultural costs will be very high and may prove difficult to mitigate.

The intervention option for the Mutale River Catchment Area that will be feasible in terms of its classifications for Social-Economic and Environmental Impacts is the option with the highest URV, the Rambuda Dam (d/s site).

It is recommended that further investigations are conducted before a decision can be made on which option to implement.

Middle and Klein Letaba River Catchment Area

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m³)	URV Rand/m³	Classification	
					Socio-Economic	Environmental
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	6%	327.77	0.951	Acceptable	Apparently Acceptable
		8%	233.87	1.157		
		10%	173.80	1.377		

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m³)	URV Rand/m³	Classification	
					Socio-Economic	Environmental
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	6%	58.18 52.36	6.476 7.189	Apparently Acceptable	Apparently Acceptable
		8%	39.25 35.33	8.539 9.481		
		10%	27.61 24.85	10.861 12.061		
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	6%	53.33 44.61	5.680 6.791	Apparently Acceptable	Apparently Acceptable
		8%	35.98 30.09	7.481 8.944		
		10%	25.31 21.16	9.499 11.357		

The most cost effective scheme is the replacement of the transfer canal by a pipeline. However, the quantity of water that may be saved should be verified in field surveys of actual canal sections.

Both proposed dam intervention options for the Middle and Klein Letaba River Catchment Area received classifications of Apparently Acceptable for Social-Economic and Environmental Impacts. From an engineering economic point of view the Majosi Dam with a flood diversion canal, is the recommended way forward, i.e. lowest Unit Reference Value (URV). The risk of the canal being breached when diverting water will be high if it is not regularly maintained and restored. When it is dry, the canal is likely to be damaged by livestock and humans crossing it by foot to avoid the longer walking distances to use the overpasses. A further aspect that requires careful consideration is that of safety, since the canal will be dry for long periods and may start to flow without warning and drownings may occur.

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

Water Supply Schemes, Social and Environmental Aspects Report

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Acronyms

ACRU	Agrohydrological Modelling System
BID	Background Information Documents
CBO	Community Based Organisation
DA	Drainage Area
DM	District Municipality
DPLG	Department of Provincial and Local Government
DWA	Department of Water Affairs
EFR	Environmental Flow Requirement
EMA	Ecological Management Area
FSL	Full Supply Level
GIS	Geographical Information System
GRIP	Groundwater Resource Information Project
IAPs	Interested and Affected Parties
IFR	Instream Flow Requirements
IWRM	Integrated Water Resource Management
LLRS	Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System
MAR	Mean Annual Runoff
MASL	Metres Above Sea Level
NGDB	National Groundwater Database
NGO	Non-Governmental Organisation
NOC	Non-Overspill Crest
RWQO	River Water Quality Objectives
SAGDT	South African Groundwater Tool
SSC	Study Steering Committee
STW	Sewer Treatment Works
TDS	Total Dissolved Solids
URV	Unit Reference Value
WC	Water Conservation
WDM	Water Demand Management
WMA	Water Management Area
WRC	Water Research Commission
WRP	WRP Consulting Engineers (Pty) Ltd
WRSS	Water Reconciliation Strategy Study
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSA	Water Service Authority
WSAs	Water Service Authorities
WSP	Water Service Providers
WTW	Water Treatment Works

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

Water Supply Schemes, Social and Environmental Aspects Report

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for a Reconciliation Study for the Luvuvhu and Letaba Water Management Area (WMA). The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams (refer to Figure 1.1). The recently completed Nandoni Dam located in the Luvuvhu basin will be managed in combination with Albasini, Vondo and Damani Dams as one system. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main urban areas in these catchments are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment and Thohoyandou and Makhado (Louis Trichardt) in the Luvuvhu River catchment. An emergency water supply scheme to transfer water from Nandoni Dam is currently under construction to alleviate the deficits of the stressed Middle Letaba sub-system in the Letaba River basin. Other future developments planned to be supplied from Nandoni Dam will already utilize the full yield available from the Nandoni sub-system by 2021, without supporting Giyani. Supporting Giyani from Nandoni will bring this date forward to approximately 2018.

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele Rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg. The area, particularly the Groot Letaba sub-area, is a highly productive agricultural area with mixed farming, including cattle ranching, game farming, dry land crop production and irrigated cropping. Agriculture, with the irrigation sector in particular, is the main base of the economy of the region. Large scale utilization of the groundwater resource occurs mostly downstream of the Albasini Dam in the Luvuvhu catchment, where it is used by irrigators as well as in the vicinity of Thohoyandou where it is used to supply rural communities. The limited mineral resources in the Luvuvhu basin are dominated by deposits of cooking coal in the north-east near Masisi. In addition to irrigation water supply from the dams in the study area, towns, villages and rural settlements are also supplied with potable water.

DWA and other institutions involved in the management of the water resource and supply systems of the Luvuvhu and Letaba catchments, have in the past carried out various studies on intervention measures to improve the water supply situation. In order to harness this information a Literature Review Report (Report No. P WMA 02/B810/00/1412/2) was compiled that summarised the available information in one document and also presented a synthesis of the information by highlighting the pertinent aspects of Integrated Water Resource Management that will be assessed and incorporated in the Reconciliation Strategy.

1.2 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (waste water) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

1.3 STUDY AREA AND RESOURCE STATUS OVERVIEW

The study area comprises of the water resources of the catchments of the Luvuvhu, Mutale, Letaba and Shingwedzi Rivers linked to adjacent systems as indicated by the inter-basin transfers on Figure 1.1. This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.

For the purpose of evaluation of the options the study area was sub-divided into the following sub-areas:

- Luvuvhu River Main Catchment
- Mutale River Catchment
- Shingwedzi River Catchment
- Groot Letaba River Catchment
- Middle and Klein Letaba River Catchments

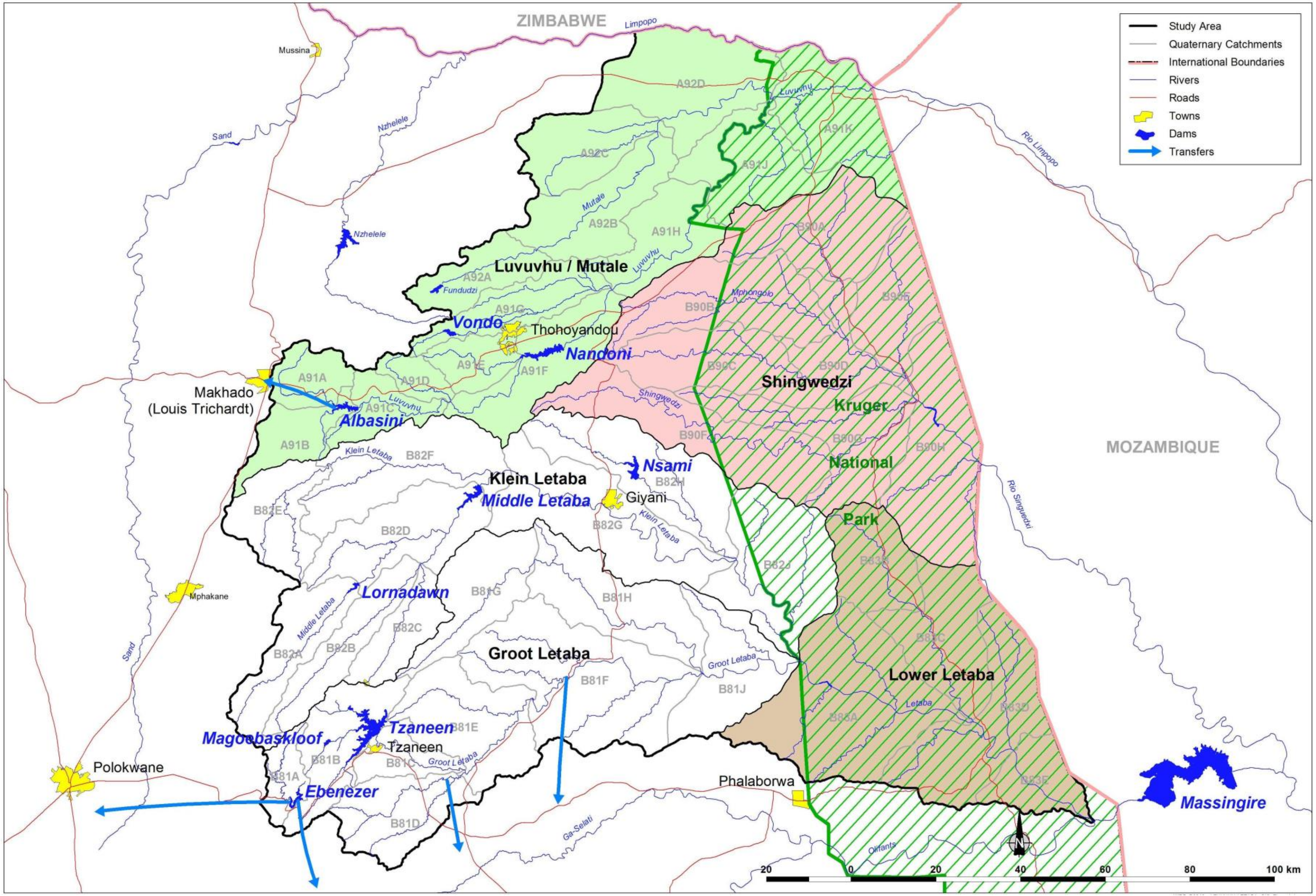

Figure 1.1: Study Area

The Luvuvhu and Letaba WMA is located in the north-eastern corner of South Africa, where it borders on Zimbabwe in the north and on Mozambique along the eastern side. It falls entirely within the Northern Province, and adjoins the Olifants and Limpopo WMA's to the south and west respectively. The Luvuhu and Letaba WMA forms part of the Limpopo River Basin, an international river shared by South Africa, Botswana, Zimbabwe and Mozambique.

Approximately 35% of the land area of the WMA along the eastern boundary falls within the Kruger National Park. The rivers flowing through the park are of particular importance to the maintenance of ecosystems.

The confluence of the Luvuvhu and Limpopo Rivers forms the common point where South Africa borders on both Zimbabwe and Mozambique. The Shingwedzi River first flows into the Rio des Elephantes (Olifants River) in Mozambique, which then joins the Limpopo River.

The two main branches of the Letaba River, the Klein and Groot Letaba, have their confluence on the western boundary of the Kruger National Park. The Letaba River flows into the Olifants River just upstream of the border with Mozambique (refer to Figure 1.1).

The topography is marked by the northern extremity of the Drakensberg range and the eastern Soutpansberg, which both extend to the western parts of the water management area, and the characteristic wide expanse of the Lowveld to the east of the escarpment. Climate over the water management area is generally sub-tropical, although mostly semi-arid to arid. Rainfall usually occurs in summer and is strongly influenced by the topography.

Along the western escarpment rainfall can be well over 1 000 mm per year, while in the Lowveld region in the eastern parts of the water management area rainfall decreases to less than 300 mm per year and the potential evaporation is well in excess of the rainfall. Grassland and sparse bushveld shrubbery and trees cover most of the terrain, marked by isolated giant Boabab trees.

The geology is varied and complex and consists mainly of sedimentary rocks in the north, and metamorphic and igneous rocks in the south. High quality coal deposits are found near Tsikondeni and in the northern part of the Kruger National Park. The eastern limb of the mineral rich Bushveld Igneous Complex touches on the southern parts of the WMA. With the exception of sandy aquifers in the Limpopo River valley, the formation is of relatively low water bearing capacity. A wide spectrum of soils occurs in the WMA, with sandy soils being most common.

1.4 PURPOSE OF THIS REPORT

The focus of this report is to address the bulk water supply infrastructure aspects of the Reconciliation Strategy Study by:

- Providing brief descriptions of the different bulk infrastructure components for the existing and the proposed development of water resources and bulk water supply schemes.
- Reviewing previous designs of the bulk infrastructure components for the proposed development of water resources and bulk water supply schemes and making necessary adjustments.

- Reviewing and updating cost estimates for the proposed development of water resources and bulk water supply schemes.
- Engineering economic analyses of the proposed development of water resources and bulk water supply schemes and assessing life cycle costs (expressed as Unit Reference Values).
- Evaluating and quantifying the environmental and social impacts for the proposed development of water resources and bulk water supply schemes.

1.5 METHODOLOGY

The methodology that was followed for the infrastructure component of the Reconciliation Strategy is described in the following paragraphs.

1.5.1 Literature Review and Consultations with Role Players

The literature review exercise was the first step in gathering information and obtaining an understanding of the existing and the planned bulk water supply infrastructure in the study area. A number of role players were also consulted to ensure that the information obtained was correctly interpreted and to identify problem areas and to determine the phasing and planned implementation time frames for proposed upgrading and augmentation projects. The role players who were engaged include the Department of Water Affairs, as well as a number of consulting engineering firms who are, or have been involved with the planning and development of water resources and bulk water services in the affected areas including Murango Consulting Engineers, EVN, and Bigen Africa.

1.5.2 Details of Existing and Proposed Schemes

Details of design capacities and sizes of components of bulk infrastructure of water resources, bulk water services, and irrigation were obtained from existing design reports and in cases where design reports were not available, by undertaking desktop assessments.

1.6 SUMMARY OF IDENTIFIED INTERVENTION OPTIONS

Several potential options were identified from the Literature Review Report (Report No. P WMA 02/B810/00/1412/2) and subsequent Screening Workshop and are summarized in Table 1.1. Figure 1.2 shows a spatial presentation of the proposed water resource development and bulk water supply schemes in the study area. Section 2 contains a summarised overview and description of each intervention option, with comments and motivations for either discarding it as a non-viable augmentation option, or for pursuing it in further detail.

Table 1.1: Identified Intervention Options

Catchment Area	Intervention Option	Description of Intervention Option
Luvuvhu Main Catchment Area	Option Lu1	Reconsideration of supply to Makhado (Louis Trichardt) from Albasini Dam
	Option Lu2	Reconsideration of supply to Makhado (Louis Trichardt) primarily from Nandoni Dam
	Option Lu3	Reconsideration of supply to Makhado (Louis Trichardt) from Nandoni Dam and Albasini Dam
	Option Lu4	Groundwater utilisation in the Nandoni Supply Area
	Option Lu5	Raising of Vondo Dam
	Option Lu6	Proposed Mid-Dzindi Dam
	Option Lu7	Proposed Latonyanda Dam
	Option Lu8	Proposed Paswane Dam
	Option Lu9	Proposed Xikundu Dam
Mutale River Catchment Area	Option Mu1	Water conservation and demand management
	Option Mu2	Groundwater development
	Option Mu3	A new dam on the Mutale River • Tswera Dam • Rambuda Dam (d/s site) • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)
	Option Mu4	Abstraction from Limpopo River
Shingwedzi River Catchment Area	Option Sw1	Groundwater development
	Option Sw2	Transfer from Nandoni Dam
Groot Letaba River Catchment Area	Option GL1	Raising of Tzaneen Dam
	Option GL2	Construction of Nwamitwa Dam
	Option GL3	Bulk water supply infrastructure
	Option GL4	Construction of Letsitele River Valley Dam
	Option GL5	Construction of Mulele Dam
	Option GL6	Groundwater development
Middle and Klein Letaba River Catchment Area	Option MKL1	Water conservation and demand management
	Option MKL2	Groundwater development
	Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline
	Option MKL4	Transfer scheme from Nandoni Dam
	Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline • Majosi Dam with flood diversion canal

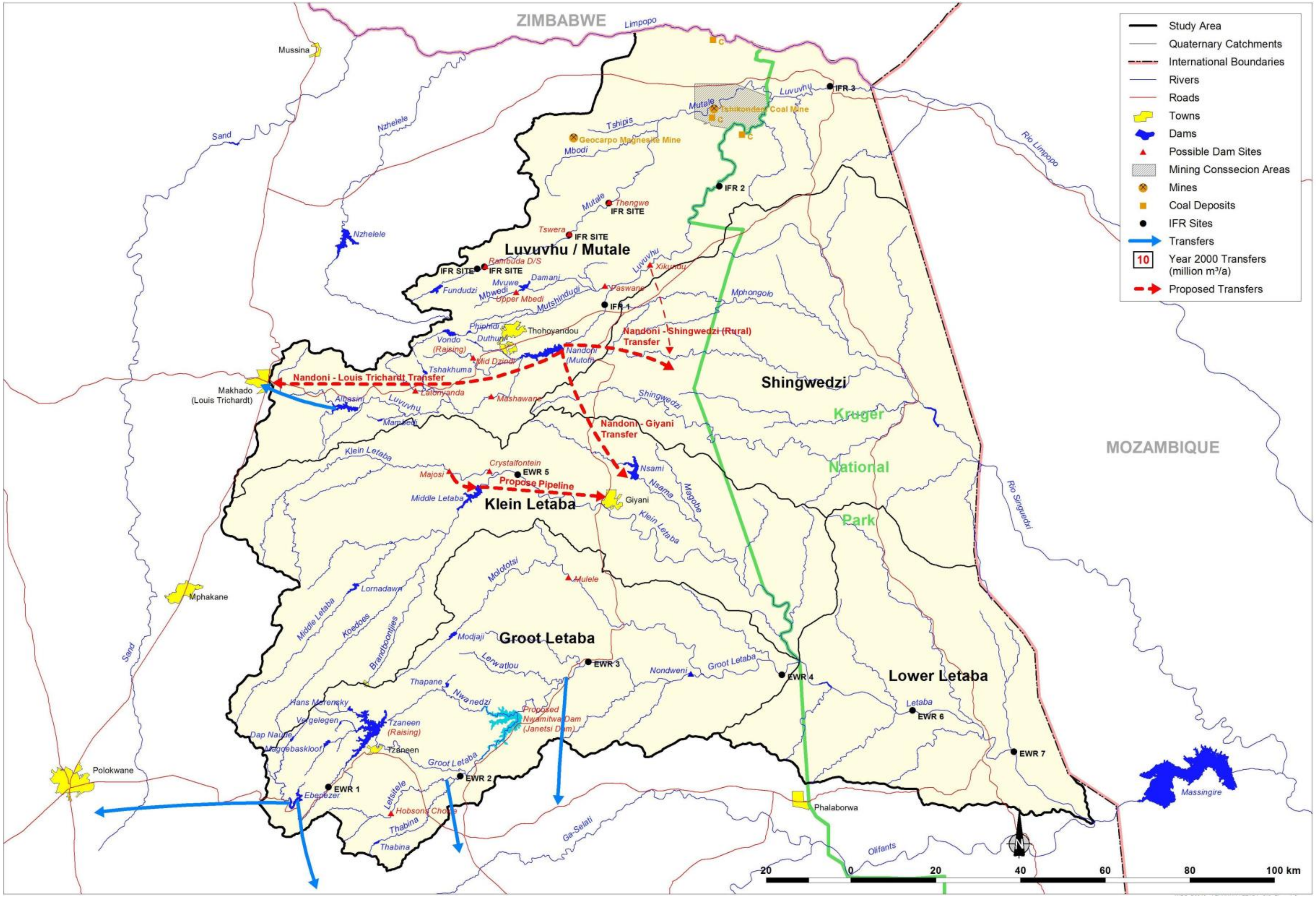

Figure 1.2: Identified Intervention Options

2 IDENTIFIED INTERVENTION OPTIONS

2.1 LUVUVHU MAIN CATCHMENT AREA

The Luvuvhu River Catchment is located in the north-eastern corner of South Africa. It rises near to Makhado (Louis Trichardt) and flows in a north-easterly direction to its junction with the Limpopo River near to Pafuri. The catchment area is approximately 3 568 km². The catchment shape is very elongated, the longest channel is approximately 250 km long and the catchment width varies between 8 km and 35 km. The Luvuvhu River is the main river in the catchment and is a tributary of the Limpopo River, which is an international water course, shared by South Africa, Botswana, Zimbabwe and Mozambique. The Luvuvhu River transverses the northern section of the Kruger National Park, where the Luvuvhu (Lanner) Gorge and the Pafuri flood plain are prominent features.

The major existing dams in the Luvuvhu River Basin are the Vondo, Albasini, Tshakuma, Nandoni and Mambedi Dams. The Mambedi Dam on the Mambedi Stream is privately owned by the Sapekoe Tea Company and the catchment of the dam is mostly on the Sapekoe property. There are approximately 80 smaller agricultural dams in the basin, most of them in the Upper Basin area.

There are three major water supply schemes, a number of government irrigation schemes and a large number of privately owned irrigation development in the basin.

The major water supply schemes are the following:

- The Albasini Government Water Scheme. The scheme comprises of the Albisini Dam, four weirs on the Luvuvhu River and the Latonyanda and Barotta Streams, a system of irrigation canals and a water treatment works downstream of the dam with a pipeline to the town of Makhado (Louis Trichardt). The scheme provides domestic and industrial water to Makhado (Louis Trichardt), water for irrigation and water for the Sapekoe Estate.

- The Vondo Regional Water Supply Scheme. The scheme is supplied from the Vondo Dam. Water is supplied from the dam under gravity to the Phiphidi water treatment works (current capacity 40 Ml/d). Treated water is then pumped to a number of reservoirs from where it is distributed to the scheme under gravity flow. The scheme supplies water to Thohoyandou and the areas surrounding Thohoyandou. Irrigation water is also supplied to the Tshivase Tea Estate.

- The Malamulele Regional Water Supply Scheme. The scheme comprises of a weir on the Luvuvhu River, a water treatment works, a supply system to reservoirs in the town of Malamulele and distribution pipework downstream of the reservoirs. Treated water is distributed to areas both within and outside of the Luvuvhu Basin. The scheme relies on run-of-river flow.

- Smaller irrigation schemes. There are a number of existing and proposed irrigation schemes in the Luvuvhu Basin.

Water use by afforestation, irrigation and for domestic use to supply the large population in the Luvuvhu River catchment with water, as well as the construction of large dams in the catchment has an adverse effect on the flow in the Luvuvhu River, particularly in the Kruger National Park. Intensive studies were performed under the supervision of DWA in close liaison with other affected authorities and organisations and it was found that in combination with the existing infrastructure, a project consisting of the Nandoni Dam and Xikundu Weir on the Luvuvhu River will provide the most comprehensive solution to the widest range of water shortages in the Luvuvhu River Catchment.

2.1.1 Option Lu1 – Reconsideration of Supply to Louis Trichardt from Albasini Dam

The main thrust of this option is to increase the supply to Makhado (Louis Trichardt) from Albasini dam. This can be achieved by re-allocating the available water from Albasini Dam through:

- Reduction in canal losses on the irrigation supply system;
- Buying out some of the irrigation allocations;
- Construction of infrastructure to supply a larger portion of the irrigation area from the Latonyanda River;
- Using groundwater to supply part of the downstream irrigation requirement;
- Improve Albasini Dam yield by reducing upstream irrigation from surface water, groundwater abstractions within the dam catchment and upstream afforestation.

Options Lu1 (Section 2.1.1), Lu2 (Section 2.1.2) and Lu3 (Section 2.1.3) are interlinked and some of the components forms part of more than one of the given options. Results from the system yield analyses indicated that Option Lu3 is in general the better option to use. Option Lu3 however do include many of the components forming part of Options Lu1 and Lu2. The reader is referred to the conclusion and motivation given regarding the recommended components forming part of the selected option as explained in more detail in Section 2.1.3.

2.1.2 Option Lu2 – Reconsideration of Supply to Makhado (Louis Trichardt) Primarily from Nandoni Dam

Under this option the supply to Makhado (Louis Trichardt) from Albasini Dam will be reduced and the bulk of the water requirements for Makhado (Louis Trichardt) will be supplied from Nandoni Dam. This will also improve the supply to irrigation from Albasini Dam.

Transfer of water from Nandoni to Makhado (Louis Trichardt) will be via the Luvuvhu River Government Water Scheme. The Luvuvhu River Government Water Scheme also supplies water to other regional water schemes, including Vondo RWS, Vondo Rural RWS, Malamulele East RWS, Malamulele West RWS, Tshakuma RWS, Makhado RWS, Sithumule/Kutama RWS, Levubu CBD, Valdezia RWS, Elim/Vleifontein RWS and can be extended further south to cover the Matoks/Botlokwa RWS.

Water will be pumped from Nandoni WTW to Mavambe Reservoir (NR5) through an existing 7 km long by 700 mm ND pipeline. From the Mavambe Reservoir, water will be pumped through a 30 km long by 900 mm ND pipeline to Vondo South RWS NN20D Reservoir (NR7) at Vuwani.

The Vuwani pump station which is currently under construction will pump water from NR7 Reservoir to Valdezia Reservoir (NL9) through a 29 km long pipeline which is still under construction and is scheduled to be completed mid 2015. The pipeline will comprise a 13 km long by 850 mm ND section and a 16 km long by 800 mm ND section.

The Vhembe District Municipality is responsible to construct the connecting bulk transfer pipeline from Valdezia to Makhado (the Mowkop Reservoir). The downstream infrastructure from Makhado into Sinthumule/Kutama RWS and the Makhado Air Force Base has already been constructed and is ready to distribute this source as an augmentation to the over-stressed groundwater system.

Results from the system yield analyses indicated that Option Lu3 (Section 2.1.3) is in general the better option to utilise. Option Lu3 however do include many of the components forming part of Options Lu1 (Section 2.1.1) and Lu2 (Section 2.1.2). The reader is refered to the conclusion and motivation given regarding the recommended components forming part of the selected option as explained in more detail in Section 2.1.3.

2.1.3 Option Lu3 – Reconsideration of Supply to Louis Trichardt from Nandoni Dam and Albasini Dam

This option is a combination of Options Lu1 and Lu2 and entails that the supply to Makhado (Louis Trichardt) from Albasini Dam will be maintained at the existing supply of 2.4 million m³/a and additional requirements to be provided from Nandoni Dam.

As well as to increase the supply to Makhado (Louis Trichardt) from Albasini Dam by re-allocating the available water from Albasini Dam through:

- Reduction in canal losses on the irrigation supply system;
- Buying out some of the irrigation allocations;
- Construction of infrastructure to supply a larger portion of the irrigation area from the Latonyanda River;
- Using groundwater to supply part of the downstream irrigation requirement;
- Improve Albasini Dam yield by reducing upstream irrigation from surface water, groundwater abstractions within the dam catchment and upstream afforestation.

Both the proposed Latonyanda and Lower Latonyanda Dams have a gross full supply capacity of 96.40 million m³. The historic firm yield determined for Latonyanda Dam is 7.8 million m³/a, and 8.1 million m³/a for the Lower Latonyanda Dam. The Latonyanda Dam resulted in a decrease in the yield at Nandoni Dam by 4 million m³/a. The net increase in the system yield is thus only 3.8 million m³/a, which is very low for an additional storage of 96.40 million m³ (see Paswane Dam yield (Section 2.1.8) of 43 million m³/a for a 90 million m³ storage). The construction of infrastructure on the Latonyanda River was thus excluded from the final recommended Option Lu3 as it will result in an excessive unit cost.

The impact of current irrigation development abstractions upstream of Albasini Dam from both surface and groundwater combined is in the order of 8 million m³/a. Some of this irrigation may be unlawful and should be removed once the current validation and verification process have been completed.

Due to the severe shortages experienced from Albasini Dam, the irrigators started to move towards the use of groundwater resources. The best estimate of the available current groundwater resources within the irrigation area was given as 2.4 million m³/a. This is however insufficient to support all the irrigation allocated to Albasini Dam. A detailed groundwater investigation in combination with the removal of unlawful irrigation developments upstream of Albasini Dam should be carried out as soon as the verification component of the current Validation Verification Study has been completed.

2.1.4 Option Lu4 – Groundwater Utilisation in the Nandoni Supply Area

This option encompasses the assessment of groundwater availability and utilisation to determine areas of over exploitation of groundwater use. The areas of over exploitation will require augmentation. The infrastructure requirements will only be known once the detail assessments have been completed for identified areas and are thus not costed at this stage or considered for further assessment.

2.1.5 Option Lu5 – Raising of Vondo Dam

Under this option the raising of Vondo Dam is considered to increase its storage capacity and thereby reducing the supply from Nandoni Dam.

Vondo Dam is an earthfill embankment type dam and is located approximately 14 km west of Thohoyandou on the Mutshindudi River. The dam was first completed in 1982 with a height of 30 m and a storage capacity of 5.3 million m³. The dam wall was raised in 1994 increasing the storage capacity of the dam to 30.5 million m³. According to the "Water Resources Planning of the Luvuvhu River Basin – Study of Development Potential and Management of the Water Resources: Basin Study Report: Volume 11", when the dam was first constructed, provision was made for a final raising of the dam wall to provide a capacity of 30.5 million m³. **[1]** It was therefore accepted that there is no scope for the further raising of Vondo Dam and this option was not considered for further assessment.

2.1.6 Option Lu6 – Proposed Mid-Dzindi Dam

The main purpose of the proposed dam will be for rural domestic water supply and irrigation in the surrounding areas and to reduce pumping costs due to its location.

The Mid-Dzindi Dam site is located on the Dzindi River approximately 8 km south-west of Thohoyandou CBD, and just upstream of the main road from Thohoyandou to Makhado (Louis

Trichardt) (R524). The Dzindi River is a tributary of the Luvuvhu River. The catchment area for the dam site is approximately 57 km².

The proposed dam wall is a 23 m high and 450 m long earthfill embankment with a concrete lined spillway. The proposed FSL is at 587 masl. The dam will have a gross storage capacity of 3.8 million m³ (approximately 15% of the natural MAR). The construction of a new water treatment works will also be required.

Similar to the proposed Latonyanda Dam, it was found that the net yield benefit of the proposed Mid-Dzindi Dam is too small to justify further assessment of this option.

2.1.7 Option Lu7 – Proposed Latonyanda Dam

The main purpose of the dam is to augment the water supply to Makhado (Louis Trichardt) and surrounding areas by swopping of water allocations between irrigators and Makhado (Louis Trichardt). A large portion of the allocation for irrigation from the Albasini Dam will be given to Makhado (Louis Trichardt), and this will be replaced by an allocation from the proposed Latonyanda Dam. This arrangement was meant to avoid having to lay a major pipeline from the proposed Latonyanda Dam to the water treatment works at Albasini Dam.

The proposed Latonyanda Dam site is located approximately 40 km east of Makhado (Louis Trichardt) and 35 km west of Thohoyandou. The proposed dam wall is a 43.5 m high and 500 m long earthfill embankment with a trough spillway and the FSL will be at 690 masl. The dam will have a gross storage capacity of 15.2 million m³. Infrastructure required with this option:

- Pump station and pipelines to transfer water from the dam into the existing Albasini irrigation scheme canals;
- Upgraded bulk pipelines from Albasini Dam to Louis Trichardt and environs;
- New pipelines from Albasini Dam to Elim, Waterval, Valdezia and environs.

The viability of developing the Latonyanda Dam on the Latonyanda River was investigated at feasibility level in 1997. **[8]** A borehole drilling program during geotechnical investigations revealed very poor foundations, with weathering to depths of up to 30 m on the right flank and up to 50 m on the left flank. Excavation to slightly weathered to un-weathered rock, suitable as foundations for a central concrete spillway, will involve the removal of between 1 m and 5 m of alluvium, and up to 16 m of weathered rock. Therefore depending on the width of the spillway, it is anticipated that excavation for concrete will vary between 7 m and 15 m on the lower left flank, and from 4 m to 23 m on the lower right flank. The proposed Latonyanda Dam will inundate approximately 8 km of the main Makhado (Louis Trichardt) to Thohoyandou road (R524), which will have to be re-aligned.

Based on the very high estimated cost for the construction of the dam, the 1997 feasibility study concluded that the Latonyanda Dam will not be an economically viable source of water for Makhado (Louis Trichardt). **[8]**

A study of the 1 in 50 000 topographical maps showed no discernible alternative dam positions on the Latonyanda River, downstream of its confluence with the Barotta River and upstream of its confluence with the Luvuvhu River.

Both the proposed Latonyanda and Lower Latonyanda Dams have a gross full supply capacity of 96.40 million m^3. The historic firm yield determined for Latonyanda Dam is 7.8 million m^3/a and 8.1 million m^3/a for the Lower Latonyanda Dam. The Latonyanda Dam resulted in a decrease in the yield at Nandoni Dam by 4 million m^3/a. The net increase in the system yield is thus only 3.8 million m^3/a, which is very low for an additional storage of 96.4 million m^3 (see Paswane Dam yield (Section 2.1.8) of 43 million m^3/a for a 90 million m^3 storage). An economic analysis on the possible Latonyanda Dam option was thus not required and this option was excluded from further assessments.

2.1.8 Option Lu8 – Proposed Paswane Dam

The purpose of the proposed dam is for rural domestic water supply along the lower Mutshindudi and Luvuvhu Rivers, regulation of river flow to irrigation schemes along the lower Luvuvhu River and environmental flow to the Kruger National Park (40 km downstream of the dam).

The Paswane Dam site is located on the Mutshindudi River approximately 21 km north-east of Thohoyandou. A preliminary design for the dam was previously carried out at a reconnaissance level of detail in 1990. **[4]**

A composite earthfill embankment/rollcrete with a central stepped spillway was considered to be the most suitable type of dam for the site in the reconnaissance study. On account of the topography of the dam site and the effects of flooding of a village and parts of a secondary road from Mukula to Paswane a FSL of 495 masl was considered to be the practical upper limit for the site. For a FSL of 495 masl the dam will have a gross storage capacity of 90 million m^3 (approximately 99% of the natural MAR). The maximum height of the dam wall will be 40 m and the total length of the dam wall will be 1 560 m. The catchment area for the dam site is approximately 402 km^2.

Paswane Dam (90 million m^3 storage) provided a historic firm yield of 43 million m^3/a, with a 1 in 50 year stochastic yield of 55 million m^3/a. This option can significantly increase the yield of the Luvuvhu System and was recommended for further assessment.

2.1.9 Option Lu9 – Proposed Xikundu Dam

The purpose of the proposed dam is for rural domestic water supply, irrigation schemes along the lower Luvuvhu River and environmental flow to the Kruger National Park (20 km downstream of the dam).

The Xikundu Dam site is located on the Luvuvhu River approximately 40 km north-east of Thohoyandou. Preliminary design for the dam was previously carried out at a reconnaissance level of detail in 1990. **[5]** A weir was constructed at the dam site.

An earthfill embankment with a concrete lined spillway on the left flank was considered to be the most suitable type of dam for the site in the reconnaissance study. The FSL of RL 460 m above mean sea level is governed by the need to prevent flooding of the main road from Thohoyandou to

Punda Maria. For a FSL of RL 460 m the dam will have a gross storage capacity of 139 million m^3 (approximately 53% of the natural MAR). The maximum height of the dam wall will be 35 m and the total length of the dam wall will be 930 m. The catchment area for the dam site is approximately 2 233 km^2.

The proposed Xikundu Dam (139 million m^3 storage) has a historic firm yield of 51 million m^3/a and a 1 in 50 year stochastic yield of 62.5 million m^3/a. This dam will significantly increase the Luvuvhu System yield and was thus recommended for further assessment.

2.2 MUTALE RIVER CATCHMENT AREA

The Mutale River catchment is located in the northern region of the Limpopo Province and consists of tertiary catchment area A92. The Mutale River catchment is drained by the Mutale River and its major tributaries, the Tshirovha, Mudaswali, Sambandou, Tshala, Mbodi and Tshipise Rivers.

The only significant existing dam in the catchment is the Mukumbani Dam in the upper reaches of the Tshirovha River. The Mukumbani Dam is used to irrigate tea plantations at the Mukumbani Tea Estates in the adjacent Luvuvhu River catchment. The dam has a catchment area of about 8 km^2, a natural MAR of about 6 x 10^6 m^3 and a gross storage capacity of 3.9 x 10^6 m^3. There is only one WTW (capacity of 2.2 Ml/day) in the study area situated near Tshandama to supply treated water for the Mutale Regional Water Project.

There are two existing regional bulk water supply schemes (Vondo and Mutale) that supply treated water to communities in the central part of the Mutale River catchment. The other communities not served, obtain water for domestic water use from nearby boreholes, springs and streams. Three borehole schemes supply domestic water to communities.

Two pipelines exist where bulk water is transferred for irrigation use to the Mukumbani Tea Estate and the Damani Coffee Project, outside and inside the Mutale River catchment respectively. Various distribution pipelines exist as part of the internal irrigation pipework of the other irrigation schemes. The Tshiombo and Rambuda irrigation schemes are supplied with irrigation water by means of concrete lined canals.

2.2.1 Option Mu1 – Water Conservation and Demand Management

The main thrust of this option is to reduce existing water shortages through improvements in the efficiency of water use through water conservation and demand management. The introduction of more ecologically sound agricultural practices including realistic stock levels should be considered.

Water conservation and demand management is a given component in all the systems and will always be one of the intervention options included in the water balances. A possible reduction of 20% in the current urban/rural domestic water use, was estimated for the Mutale catchment. Details of the budget requirements for the next five years to achieve the WC/WDM targets are given in the “Water Conservation and Water Demand Management Strategy and Business Plan Report” which is part of the suite of reports prepared for the Luvuvhu Letaba Reconciliation Strategy Study. **[24]**

2.2.2 Option Mu2 – Groundwater Development

As part of the Reconciliation Strategy Study, high level catchment wide groundwater assessments were carried out (desktop balances). **[24]** These assessments indicated that in some areas additional groundwater abstractions are possible, and this was included in the water balances as possible intervention options.

From this study the remaining potable exploitation potential groundwater within the water services schemes in the Mutale catchment was determined and allowed for an increase in groundwater use of 2.7 million m^3/a, which is approximately 60% of the potable exploitation potential determined. Although these results will provide reasonable indications of the groundwater availability, more detailed groundwater investigations are required to ensure that final planned groundwater developments will be feasible and sustaining.

2.2.3 Option Mu3 – A New Dam on Mutale River

There has been very little development of the water resources of the Mutale River catchment, the water use relying mostly on run-of–river supplies, which are partly regulated by Lake Fundudzi at the upstream end of the catchment. Lake Funduzi has been formed by a landslide, which created a pervious embankment that stores high flows and then gradually releases the stored water by seepage through the embankment. The lake has a catchment area of 61 km^2, a natural MAR of 19.7×10^6 m^3 and a maximum utilised storage capacity of about 22×10^6 m^3.

As part of the 1999 Mutale River Water Resources Investigation conducted by the Department of Water Affairs and Forestry’s Directorate of Water Resources Planning, four dam sites that are most likely to be considered for development to supply the future water requirements from the Mutale River catchment, were selected for further investigation. **[12]** Selection of the sites for further investigation was made on the basis of the MAR at the dam site and the likely yield of the dam, relative cost of providing storage and least negative environmental impact, from a list of possible dam sites on the Mutale River and its tributaries that had been identified in previous studies. The four selected dam sites are shown on Figure 2.1. Investigations on the selected dam sites were carried out at a reconnaissance level of detail. Details of the investigations are provided in Volume 10 – Annexure 17 of the Mutale River Water Resources Investigation. **[12]** Summarised details for proposed dams on each of the selected sites are presented in the following paragraphs.

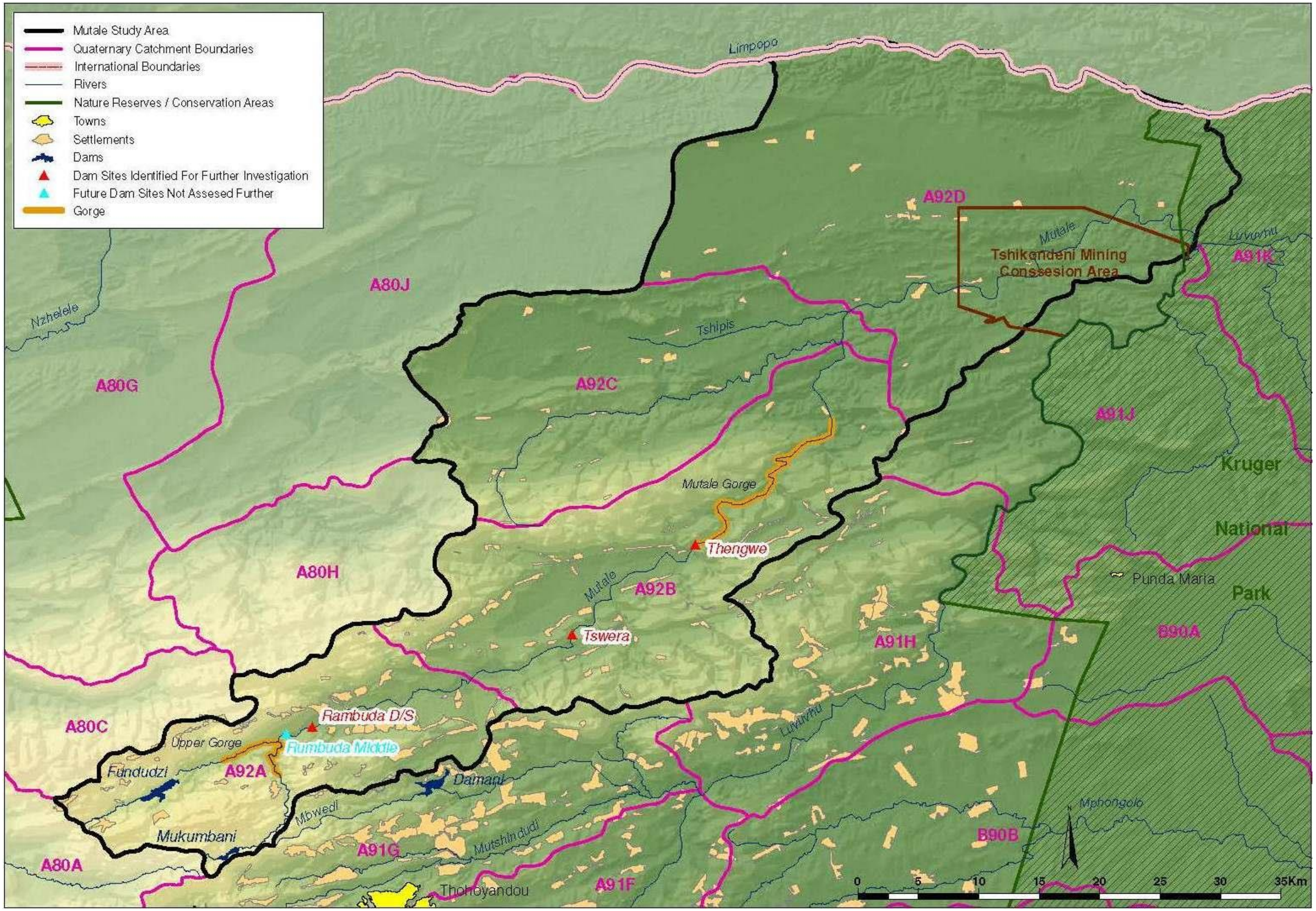

Figure 2.1: Locality Map for Mutale River Dam Sites

2.2.3.1 Rambuda Middle Dam Site

The Rambuda Middle Dam site is situated on the Mutale River immediately downstream of its confluence with the Tshirovha River, near the communities of Tshagwa, Dzimauli (Rambuda) and Tshidzivhe. The catchment area for the dam site is approximately 160 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 740.9 masl, and this will result in a gross storage capacity of 85.3 x 10^6 m^3 (approximately 155% of the natural MAR). The maximum height of the dam wall with a NOC at RL 745 will be 75 m and the total length of the dam wall will be 890 m.

Foundation excavations are expected to be approximately 2 m deep on the left flank and in the river section. The bedrock will require only minimal scour protection downstream of the central spillway. A thick talus and alluvial deposit occurs on the lower right flank. The upper part of the lower right flank can possibly be material from a shallow slide. The thickness of this layer is not known, but 2 m – 5 m and thicker closer to the foot of the slope can be assumed.

The previous Mutale River Water Resources Assessment Study indicated that on the basis of the socio-economic, cultural and/or ecological considerations, the Rambuda Middle Dam site option is unlikely to be acceptable for development. **[12]** The cost of water secured by a dam at the Rambuda middle site was also considered to be far too high. For this reason the Rambuda Middle Dam site option was not considered for further assessment.

2.2.3.2 Rambuda Downstream Dam Site

The Rambuda Downstream Dam site is situated on the Mutale River, some 4 km downstream of the Rambuda Middle site. The nearest community is Dzimauli (Rambuda) to the north. The catchment area for the dam site is about 168 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 675 masl, and this will result in a gross storage capacity of 13.52 x 10^6 m^3 (approximately 23% of the natural MAR). The maximum height of the dam wall with a NOC at RL 680 will be 37 m and the total length of the dam wall will be 315 m. Foundation excavation depths are expected to be approximately 2 m on the right flank, 5 – 8 m in the river section, and up to 15 m excavations will probably be needed in the slope debris on the left flank.

The most viable dam sites as identified by the Mutale River Water Resources Assessment Study are the Rambuda Downstream Dam site and the Tswera Dam site. Both these dam sites were therefore considered for further assessment.

2.2.3.3 Tswera Dam Site

The Tswera Dam site is situated on the Mutale River some 5 km upstream of its confluence with the Sambandou River. Relative to the Rambuda sites, the area is more densely inhabited with large areas of the flood plain upstream of the dam site under irrigated and dry land cultivation. There are a number of communities close to the dam site, but those most likely to be affected by flooding include Tswera, Shadani and Tshivhangani and a number of smaller communities. The catchment area for the dam site is approximately 405 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 594.5 masl, and this will result in a gross storage capacity of 130.98 x 10^6 m^3 (approximately 120% of the natural MAR). The maximum height of the dam wall with a NOC at RL 600 will be 37 m and the total length of the dam wall will be 250 m.

Shallow foundation excavations, of less than 3 m on average are expected at this site. Minimal protection against scouring will be required downstream in the river section.

The Tswera Dam site was from previous studies identified as one of the most viable dam sites, and thus considered for further assessment.

2.2.3.4 Thengwe Dam Site

The Thengwe Dam site is situated on the Mutale River, some 9.5 km downstream of its confluence with the Sambandou River. Relative to the Rambuda sites, the area is more densely inhabited with large areas of the flood plain upstream of the dam site under dry land cultivation. There are a number of communities close to the dam site, but those most likely to be flooded include Tshidzwi, Mukondeni and Tshanzhe and a number of smaller communities. The catchment area for the dam site is approximately 695 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 554 masl, and this will result in a gross storage capacity of 115.9 x 10^6 m^3 (approximately 82% of the natural MAR). The maximum height of the dam wall with a Non-overspill crest level (NOCL) at RL 560 will be 27 m and the total length of the dam wall will be 180 m.

Both flanks are covered with a thin layer of talus, including fairly large quartzite blocks of up to 2 m in size. Excavations to slightly weathered, jointed bedrock, of approximately 2 m below surface are expected on both flanks depending on the talus thickness.

The river section is approximately 70 m wide with alluvial sands of 1 m thickness on the river banks and rock outcrop or boulders in the river channel. The quartzite outcrops are un-weathered and shallow excavations of up to 2 m are anticipated to reach the jointed bedrock.

Although this option was not recommended as one of the most viable dam sites from the previous Mutale River Water Resources Assessment Study, mainly due to its location, the SSC members requested that this option be included in further assessments.

2.2.4 Option Mu4 – Abstraction from the Limpopo River

This option entails the abstraction of water from the Limpopo River to supply the water requirements of future mines if development of coalfields in the northern part of the sub-catchment takes place. Mines in this area are already utilising ground water resources within their area. The assessment of groundwater availability and utilisation to determine areas of over exploitation of groundwater use should be considered. The areas of over exploitation will require augmentation. The infrastructure requirements will only be known once the assessment has been completed.

The SSC meeting stated that the Limpopo River is not a good resource and that the possible dam on the Lower Mutale should rather be considered (see Section 2.2.3). Option Mu4 was therefore not considered for further assessment.

2.3 SHINGWEDZI RIVER CATCHMENT AREA

The Shingwedzi River catchment consists of tertiary catchment area A90 and comprises the catchments of tributaries of the Shingwedzi River. The Shingwedzi River basin covers approximately 6000 km^2 and its major tributaries are the Shisha, Mphongolo and Phugwane Rivers.

The Shingwedzi River catchment is situated almost entirely in the Kruger National Park. For all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment. There are no major dams in the Shingwedzi basin due to the limited water resources and the unavailability of suitable dam sites. Some small dams have, however, been constructed in the Kruger National Park for game watering. Of these, the most notable are the Kanniedood Dam on the Shingwedzi River and the Engelhard Dam on the Letaba River.

More than half of the water available is abstracted from groundwater. Only one scheme operates in the catchment, being the Malamulele East Regional Water Scheme (RWS), which has its source at the Malamulele Weir in the Luvuvhu River. Water is treated at the Malamulele WTW.

2.3.1 Option Sw1 – Groundwater Development

This option encompasses the assessment of groundwater availability and utilisation to determine areas of over exploitation of groundwater use. The areas of over exploitation will require augmentation. The development of the under-utilised groundwater resource to augment the water resources in the area should be investigated, as well as the quality of the identified groundwater resources. Infrastructural requirements will only be known once the groundwater assessment has been completed.

As part of the Reconciliation Strategy Study, high level catchment wide groundwater assessments were carried out (desktop balances). Based on these results the remaining potential potable exploitation groundwater within the water services schemes South Malamulele East and North Malamulele East in the Shingwedzi catchment, was determined as 4.66 million m³/a. These results provide a reasonable indication of the groundwater availability. Future development of groundwater resources in this area was recommended and included in the water balances. More detailed groundwater investigations are required to ensure that the final planned groundwater developments will be feasible and sustaining. Cost estimations for these possible groundwater developments were therefore not prepared as part of this study. Groundwater is only a small component of the total water supply to this area.

2.3.2 Option Sw2 – Transfer from Nandoni Dam

The Shingwedzi River catchment is situated almost entirely in the Kruger National Park with human settlements confined to a small section in the western part of the catchment. The Malamulele East Regional Water Scheme (RWS) supplies water to most of the communities in the area. Raw water feeding the Malamulele RWS is abstracted and purified at three weirs on the Luvuvhu River, viz. Malamulele Weir, Xikundu Weir and Mhinga Weir.

The proposal in previous studies to establish a transfer link for water from Nandoni Dam WTW to Malamulele Regional Storage Reservoirs to augment the Malamulele RWS, was done a few years ago. The water is pumped from the Mavambe Reservoir to the Malamulele Storage Reservoirs. The sizing of this infrastructure however was based on the Malamulele East RWS South (NN7S) area.

Additional bulk distribution pipelines were also proposed from the regional reservoirs to service reservoirs supplying further communities in Shingwedzi River catchment area. Economic analysis is not required for this option, as it forms part of the existing Nandoni Supply Scheme, with the required upgrades already starting to take place in some areas.

2.4 GROOT LETABA CATCHMENT AREA

The Letaba River catchment is drained by the Groot Letaba River and it's major tributaries are the Klein Letaba, Middle Letaba, Letsitele and Molototsi Rivers. The Groot Letaba River catchment utilizes water from the Groot Letaba River and its tributaries to supply water to various towns including Polokwane, Tzaneen, Haenertsburg, Duiwelskloof and to a number of rural villages. Water use in the Groot Letaba catchment is dominated by irrigation.

The surface water resources within this catchment are extensively developed with a large number of small to major dams constructed to meet domestic (urban and rural), irrigation and industrial water needs.

There are eight main dams in this catchment and the water is treated at nine different treatment plants. All the water supply schemes in the Groot Letaba River catchment, except the Modjadji Scheme, form part of the inter-linked Letaba Regional Water Supply Scheme. The infrastructure between the schemes is not necessarily linked, but upstream infrastructure and water use, have an impact on the water availability at further downstream scheme components.

The Modjadji Scheme utilizes water from the Molototsi River. It is located adjacent to the Groot

Letaba River system in the B81 tertiary catchment area, but operates on it's own, without any significant effect on the Groot Letaba River system. This scheme consists of three sub-schemes, which draws water from the Modjadji Dam in the Molototsi River. Treated water from the Modjadji Water Treatment Works is then distributed to villages through a series of pipelines, either pumped or under gravity and stored in reservoirs.

The water schemes located in the Groot Letaba River catchment using large dams as a source include the Dap Naude Dam, Ebenezer Dam, Hans Merensky Dam, Tzaneen Dam, Magoebaskloof Dam, Vergelegen Dam, Thapane Dam and Thabina Dam Water Supply Schemes, Letaba Regional Scheme, Nondweni Weir and the Modjadji Scheme.

Water schemes with its source in the Groot Letaba River catchment, but supplying water users located outside its boundaries are Dap Naude Dam Scheme, Pietersburg Government RWS, Ebenezer Dam Water Scheme, Thabina Dam Scheme and Ritavi II Water Scheme. Two schemes in the Middle/Klein Letaba River catchment also supply water to villages located in the Groot Letaba River catchment.

Figure 2.2 is a Locality Map of Potential Dam Sites in the Groot Letaba Catchment Area.

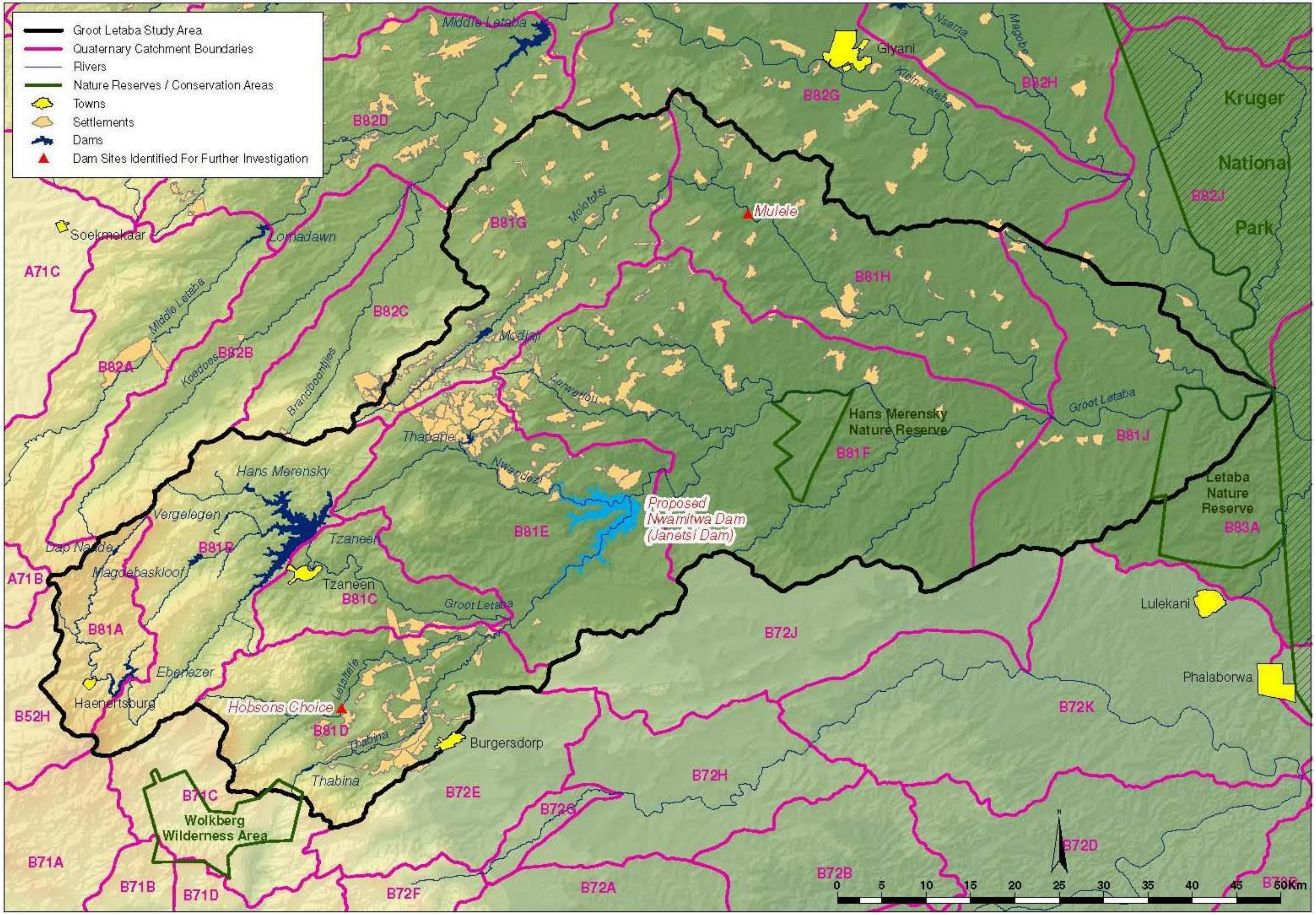

Figure 2.2: Locality Map of Potential Dam Sites in the Groot Letaba Catchment Area

2.4.1 Option GL1 – Raising of Tzaneen Dam

The Tzaneen Dam is located on the Groot Letaba River immediately to the north of Tzaneen Town. The purpose of the dam is for irrigation and domestic water supply. The dam was first completed in 1977 and it comprises a central mass concrete gravity spillway section flanked by earthfill embankments. The spillway is a 91.44 m long uncontrolled ogee type structure with a crest level of 723.90 masl. The NOC is 1 063.5 m long with a crest level of 730.60 masl. Both upstream and downstream faces of the earth embankments are protected by interlocking concrete blocks. The gross storage capacity of the dam is 157.3 million m^3 and its catchment area is 652 km^2.

Preliminary design stage investigations for the proposed dam raising were completed in May 2010. [20] Three methods were investigated for the raising of Tzaneen Dam:

- Hydroplus fusegates
- Labyrinth spillway
- Side channel spillway

The comparison was made for a 3 m raising of the FSL to 726.9 masl. The amount by which the FSL and NOC can be raised is limited by the soffit levels of the Sybrand and Marietjie van Niekerk Bridges on the R36/R71 road and the fact that additional land may have to be acquired for the dam basin and surrounding buffer strip. A 3 m raising of the FSL will increase the gross storage capacity of the dam to 193 million m^3 and the firm yield of the dam will increase from 60 to 64 million m^3 per annum.

The side channel option, whilst technically feasible, was discarded as on option based on cost. Both the labyrinth spillway and the hydroplus fusegate options are considered to be technically feasible. However, given the fact that the labyrinth spillway option is the most cost effective solution coupled with the fact that this option has very low future maintenance costs, it is recommended that this method of raising be adopted. Should it be discovered during the detailed design phase, that the potential impact of the extreme flood events or the integrity of the Sybrand and Marietjie van Niekerk Bridges is considered unacceptable, then the hydroplus fusegate option will become the preferred option for the raising of Tzaneen Dam.

The economic evaluation of this option was carried out as part of the GleWaP study. **[21]** This option was recommended and already approved by Parliament. The raising of Tzaneen Dam is in the final design stage and URV's were therefore not required as part of this study.

2.4.2 Option GL2 – Construction of Nwamitwa Dam

The Nwamitwa Dam site is located on the Groot Letaba River, just downstream of its confluence with the Nwanedzi River and approximately 40 km east of Tzaneen Town. The proposed dam will enable additional water to be allocated to the primary water users, allow the ecological reserve to be implemented and improve the assurance of supply to the agricultural sector. The catchment area for the dam site including the area upstream of Tzaneen Dam is 1 944 km^2.

Preliminary design stage investigations for the proposed dam were completed in May 2010. **[19]**

The proposed dam wall will be 34 m high with a total crest length (including the spillway) of 3 500 m. The dam wall will comprise a concrete structure in the river section accommodating a spillway and outlet works, with earth embankments on both flanks. The NOC will be at RL 486.0 masl. The dam will have a gross storage capacity of 187 x 10^6 m^3 (1.16 x MAR) and a historical firm yield of 14 x 10^6 m^3/a.

A number of provincial roads will be affected by the proposed dam. Possible routes for the realignment of the roads were investigated and preliminary costs determined.

The Nwamitwa Dam was a recommendation from the GleWaP study and the construction of this dam has already been approved by Parliament. **[20]** The Nwamitwa Dam option is currently in the final design stage and URV's were therefore not required as part of this study.

2.4.3 Option GL3 – Bulk Water Supply Infrastructure

One of the primary purposes of the proposed Nwamitwa Dam is to enable additional water to be allocated to the primary water users. The bulk water supply infrastructure requirements for the areas around the proposed Nwamitwa Dam were investigated in the Groot Letaba River Water Development Project bridging study which was completed in 2010. **[19 & 20]** In order to determine the logical supply area for the proposed Nwamitwa Dam the water requirements in the areas immediately surrounding the proposed dam were analysed and then compared to the anticipated yield from the proposed Nwamitwa Dam. The water resource analysis indicated that 13 x 10^6 m^3/a can safely be supplied from Nwamitwa Dam at a 98% level of assurance for domestic use. The following existing water supply systems are located in close proximity to and can therefore be potentially supplied from the proposed Nwamitwa Dam:

- Letaba Ritavi System
- Thapane System
- Modjadji System
- Worcester/Mothobeki System
- Lower Molototsi System

Figure 2.3 shows a map of the logical supply area for the proposed Nwamitwa Dam.

Currently water is abstracted from a weir on the Groot Letaba River, just downstream of the Nwamitwa Dam site. The raw water is treated at the Nkambako Water Treatment Works (WTW). The Nkambako WTW has a capacity of 12 Mℓ/d (including the recently constructed 6 Mℓ/d extension). In view of the uncertainty associated with the current and future water requirements it is proposed that any future upgrading be undertaken in increments of 12 Mℓ/d. The high level service water requirement scenario indicates that the capacity of the WTW (based on peak week water requirements) should be 45 Mℓ/d in 2027.

Existing pipelines from the Nkambako WTW were designed to cater for the Letaba System only. Linking of the three systems will require the installation of additional bulk water pipeline capacity and the upgrading of clear water pumps. It is proposed that two new bulk pipelines be constructed, one from Nkambako WTW to the existing Babanana Command Reservoir (Command Reservoir B) and the other from Nkambako WTW to the existing Serolorolo Command Reservoir (Command Reservoir A). A pipeline with a booster pump station is proposed to link the Babanana Command Reservoir and the proposed Mohlakong Regional Reservoir in Thapane. The existing 300 mm diameter pumping main from the Nkambako WTW will be dedicated to supply the regional reservoir at Runnymede.

The Worcester/Molototsi System (including parts of the Giyani supply area) has to be linked by new pipelines from Serolorolo Command Reservoir to the proposed Command Reservoirs C and D. These reservoirs will then feed into Worcester/Molototsi System through the Worcester/Mothobeki and the Giyani Supply Systems.

The existing clear water pumps at Nkambako WTW cannot supply the combined system and it is therefore proposed that new pumping capacity be provided to serve the Babanana Command Reservoir and another for the Serolorolo Command Reservoir, and that the existing pumps be used to serve the Runnymede Regional Reservoir. There is also a need for a rising main with pump station to supply the proposed Command Reservoir C north-west of the village of Hlohlokwe from the Command Reservoir at Serolorolo. Command Reservoir D, situated to the north-east of Gamokgwathi, can be fed by the bulk water gravity main from the existing Command Reservoir at Serolorolo.

Currently all the supply systems include a number of village reservoirs as well as a few main regional reservoirs. The purpose of the regional reservoirs (or command reservoirs) is to provide balancing storage as well as emergency storage in the case of a disruption of supply. It is proposed to provide bulk command reservoirs in the Worcester/Molototsi System (including a service to parts of the Giyani System), Thapane and Letaba/Ritavi Systems by constructing two new command reservoirs. Two existing regional supply reservoirs, namely the 5 Mℓ Reservoir at Serolorolo (Command Reservoir A) and the 7 Mℓ Reservoir at Babanana (Command Reservoir B) should be utilised as command reservoirs. The proposed two new command reservoirs are at an elevation high enough to feed the supply area under gravity. For this reason the command reservoirs are capable of supplying villages outside their respective supply areas which adds redundancy, and also reliability, to the system.

An analysis was undertaken to determine the available storage in hours, based on the standard and high water requirement for 2007 and 2027. It is proposed that the two new Command Reservoirs C and D be sized at 5 Mℓ. This will ensure compliance with the requirement to provide approximately 48 hours of storage in the reticulation system in the case of a pumped supply with one source and approximately 36 hours of storage in the reticulation system in the case of a pumped supply with two sources. This capacity is also comparable to the existing 5 Mℓ Reservoir at Serolorolo and the existing 7 Mℓ Reservoir at Babanana.

This option forms part of the Nwamitwa Dam option as recommended by the GleWaP study. **[20]** URV’s were therefore not determined for the distribution system as part of the Luvuvhu Letaba Reconciliation Strategy Study.

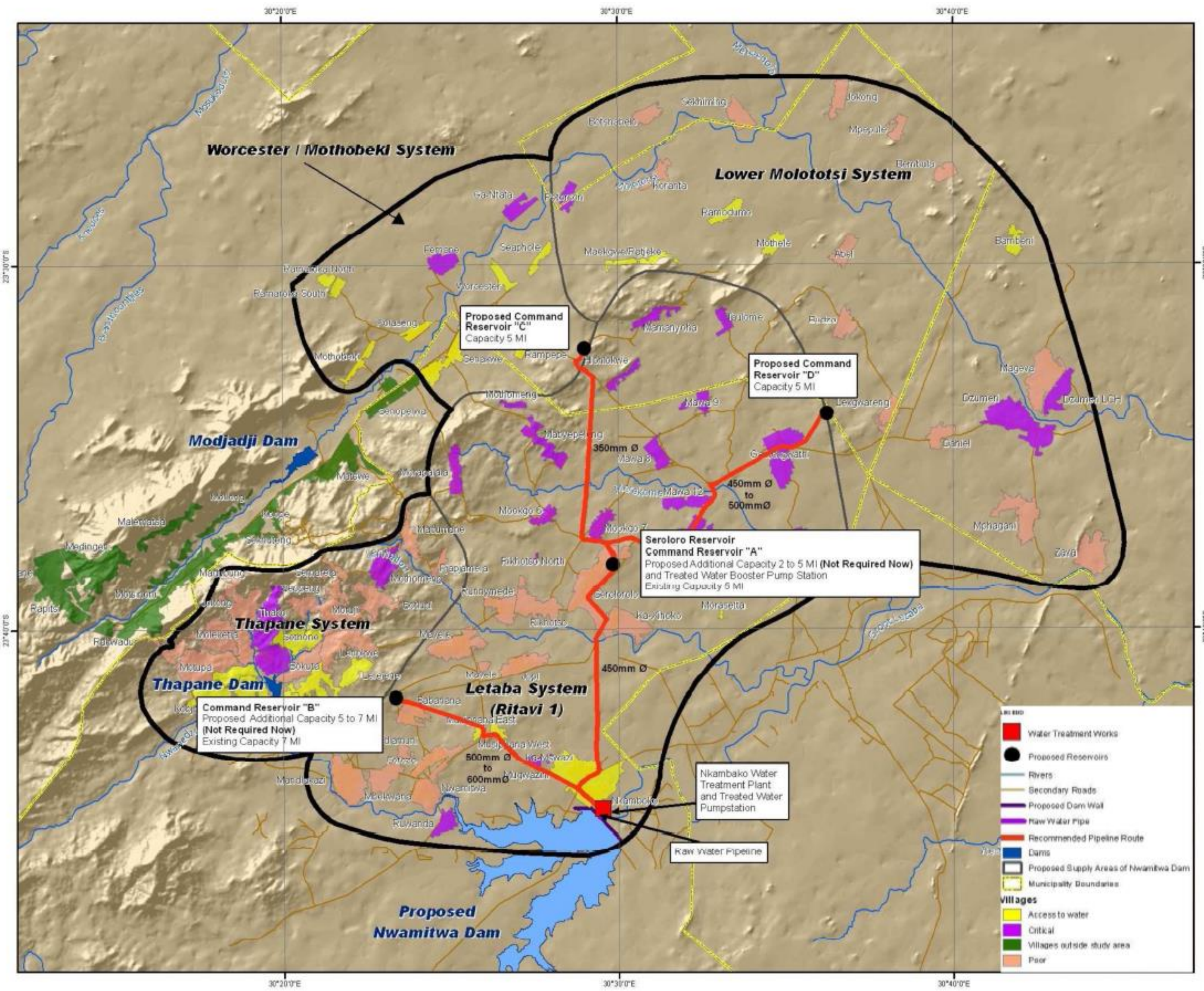

Figure 2.3: Logical Supply Area for the Proposed Nwamitwa Dam

2.4.4 Option GL4 – Construction of the Letsitele River Valley Dam

The Letsitele River Valley Dam site is located on the Letsitele River approximately 16 km south of Tzaneen Town. The proposed dam will be used for irrigation and domestic water supply. The catchment area for the dam site is 124 km^2.

The Groot Letaba Water Resource Development Feasibility Study which was completed in December 1998 concluded that the proposed Letsitele River Valley Dam was not economically viable and should not be developed. **[9 & 10]** This conclusion was based on information that was available when the study was undertaken and should not preclude the Letsitele River Valley Dam site from being considered as an option for the development of additional water resources to meet future water requirements in the area.

The proposed dam wall will be 33.5 m high with a total crest length (including the spillway) of 1 050 m, comprising a gravity concrete structure in the river section accommodating a spillway and outlet works, with earth embankments on both flanks. The spillway will be 70 m long with a crest level of 647.8 masl and the NOC at RL 651.5 masl. The dam will have a gross storage capacity of 14.2 x 10^3 m^3 (0.5 x MAR).

An engineering geological investigation indicated that the dam site is underlain by biotite granite of early Vaalian age which is intruded by diabase dykes of late Vaalian age. The site is covered by sandy colluvium to a maximum depth of 2 m on the upper flanks. The lower flanks are covered by alluvial deposits to a maximum depth of 6 m. Alluvial boulders and gravel were encountered at a maximum depth of 9.3 m. The underlying bedrock consists of weathered and un-weathered granite and diabase.

The left flank is highly to completely weathered to a depth of 4.8 m to 15.6 m. An irregular weathering profile characteristic of granite is evident. The right flank is not as deeply weathered as the left flank; completely too highly weathered rock is intercepted to a maximum depth of 9.0 m from the ground surface. The surface of un-weathered rock ranges from a depth of 6.5 m to 15.2 m from the ground surface. The moderate to un-weathered rock with medium to wide joint spacing has high to very high rock strength, and a sound rock quality.

Excavation depths for concrete structures are expected to be between 9.9 m and 16.5 m on the left flank and 4.5 m to 11.7 m on the right flank. In the river section sound rock suitable for founding was encountered between 5.1 m and 6.5 m. Suitable founding conditions for the downstream spillway apron occur at 11.7 m to 16.5 m in slightly weathered granite with medium joint spacing.

Water pressure tests conducted in the moderately to un-weathered rock indicate a low permeability (<3 Lugeons) of the founding rock mass.

Although no major access roads are affected, some 7.3 km of local roads will have to be constructed or upgraded, including two new river crossings.

Results from the yield analysis showed that the net yield benefit for this option is very small. This dam will also result in a reduction in the yield at Nwamitwa Dam. This option was therefore not considered for further assessment.

2.4.5 Option GL5 –Mulele Dam Site

The Mulele Dam site is situated on the Molototsi River and was one of the five water resource development options that were recommended to be carried through for further investigation by the Letaba Water Resources Pre-Feasibility Study. **[7]** However, this option was not considered for further investigation, in the subsequent Groot Letaba Water Resource Development Feasibility Study as the location of the site in relation to the demand nodes was less favourable than the other options. **[10 & 11]** The high sediment load in the river and the inundation of extensive areas under dry land cultivation that will be caused by the proposed dam were also cited as drawbacks against this option in the Letaba Water Resources Pre-Feasibility study. **[7]** The possibility of constructing a dam or weir at the Mulele Dam site to be used for artificial recharge of groundwater can still be evaluated and this option was assessed further as part of the groundwater task forming part of the Luvuvhu Letaba Reconciliation Strategy Study.

The groundwater analysis indicated that the scheme can provide between 0.05-0.055 million m^3/a without the construction of a weir, and 0.05-0.065 million m^3/a with a 1.3 m weir in place, depending on the level of assurance of supply selected. The benefit through artificial recharge is thus too small to be considered as a viable option and no further assessments were carried out.

2.4.6 Option GL6 – Groundwater Development

This option requires that the existing and identified future viable groundwater sources be incorporated into proposed regional bulk water schemes from the proposed Nwamitwa Dam.

As part of the Reconciliation Strategy Study, high level catchment wide groundwater assessments were carried out (desktop balances). From these assessments stressed catchments were identified (water use from groundwater is greater than 80% of the potable exploitation potential) and for the Groot Letaba catchment these areas include the lower Groot Letaba in the vicinity of the proposed Nwamitwa Dam (B81C-H).

The results from the high level groundwater assessments showed that future development of groundwater water resources in this area is limited due to the stressed areas and it was estimated to be in the order of 2.5 million m^3/a. More detailed groundwater investigations are required to ensure that final planned groundwater developments will be feasible and sustaining. Cost estimations for these possible groundwater developments were therefore not prepared as part of this study. Groundwater is only a small component of the total water supply to this area.

2.5 MIDDLE AND KLEIN LETABA RIVER CATCHMENT AREA

The Middle and Klein Letaba River catchment consists of tertiary catchment area B82 and includes the catchments of the Middle Letaba River, Klein Letaba River and tributaries thereof such as the Koedoes River, Brandboontjies River and Nsami River.

The water is mainly sourced from the Middle Letaba and Nsami Dams and is treated at three different treatment plants. The water schemes operating in this catchment are the Sekgopo and Tshitale/Sekgosese borehole schemes, the Middle Letaba “M”, “N”, “MW” and “A, B, C, D, E, F” water schemes. The Middle Letaba "M", "N" and "A, B, C, D, E" schemes also supply potable water to other catchments, being Groot Letaba River and Luvuvhu/Vondo River catchments. The Middle Letaba/Nsami canal transfers water from the Middle Letaba Dam to the Nsami Dam.

The bulk water supply scheme can be subdivided into three main sections, as described below:

- 9 Villages supplied from a treatment works at Middle Letaba Dam.
- Villages supplied from a treatment works (Malamule West Water Works) located adjacent to the canal between Middle Letaba Dam and Nsami Dam.
- Villages and Giyani Town supplied from the treatment works at Nsami Dam.

The schemes that transfer water across tertiary catchment boundaries include:

- Giyani Regional Scheme: Nsami Dam transfers water to villages in the Groot Letaba River and Shingwedzi River catchments.
- Middle Letaba Regional Scheme: Middle Letaba Dam transfers water to villages in the Luvuvhu River and Groot Letaba River catchments.
- Malamulele West Regional Scheme transfers water to villages in the Luvuvhu River catchment.

2.5.1 Option MKL1 – WC/WDM

This option entails the implementation of water conservation and demand management (WC/WDM) measures to reduce water losses from the distribution infrastructure and achieve more efficient use of the resource in areas around Giyani where the current per capita water use is very high (above 300 ℓ/c/d). This need to be done in combination with the transfer from Nandoni otherwise the system will still be in deficit.

Water conservation and demand management is a given component in all the systems and is one of the intervention options that is always included in the water balances. A possible reduction of 9% (2.8 million m³/a) in the current urban/rural domestic water use was estimated for this system. Details of the budget requirements for the next five years to achieve the WC/WDM targets are given in the Water Conservation and Water Demand Management Strategy and Business Plan Report. **[24]** This report forms part of the suite of reports prepared for the Luvuvhu Letaba Reconciliation Strategy Study.

2.5.2 Option MKL2 – Groundwater Development

This option addresses the development of the under-utilised groundwater resource to augment the water resources in the area and reduce dependency on the overstressed surface water resource. An investigation of the quality of the identified groundwater resources is also required.

As part of the Reconciliation Strategy Study, high level catchment wide groundwater assessments were carried out (desktop balances). From these assessments it was clear that groundwater is in most of the related supply areas still under-utilised. It was estimated that in future an additional 12.9 million m³/a of the available potable exploitation potential, can still be utilised.

Future groundwater developments is one of the major intervention options within this scheme and it is very important to first commission a groundwater development feasibility study, to determine the viability of these groundwater resources in future. Cost estimations for these possible groundwater developments were therefore not prepared as part of this study.

2.5.3 Option MKL3 – Replacement of Middle Letaba Dam to Nsami Dam Transfer Canal with a Pipeline

This option entails the replacement of the existing transfer canal between the Middle Letaba and Nsami Dams with a pipeline. The scheme will comprise a pump station and rising main (800 mm ND x 6.7 km) from the dam to a local high point and a gravity pipeline (1000 mm ND x 33.3 km) from the high point to the Nsami Dam.

The 60 km long transfer canal from Middle Letaba Dam to Nsami Dam was constructed as part of a regional water supply scheme developed by the former Gazankulu Homeland Authority, in the late nineteen seventies to early nineteen eighties to supply both domestic and irrigation water requirements to the communities in Giyani and surrounding areas. Figure 2.4 shows a locality map of the transfer canal. Since its inception the domestic water supply area has extended to include villages beyond the Klein Letaba River catchment area, including villages far to the south of Giyani on the banks of the Groot Letaba River, and to the north-west in the Luvuvhu River Catchment area.

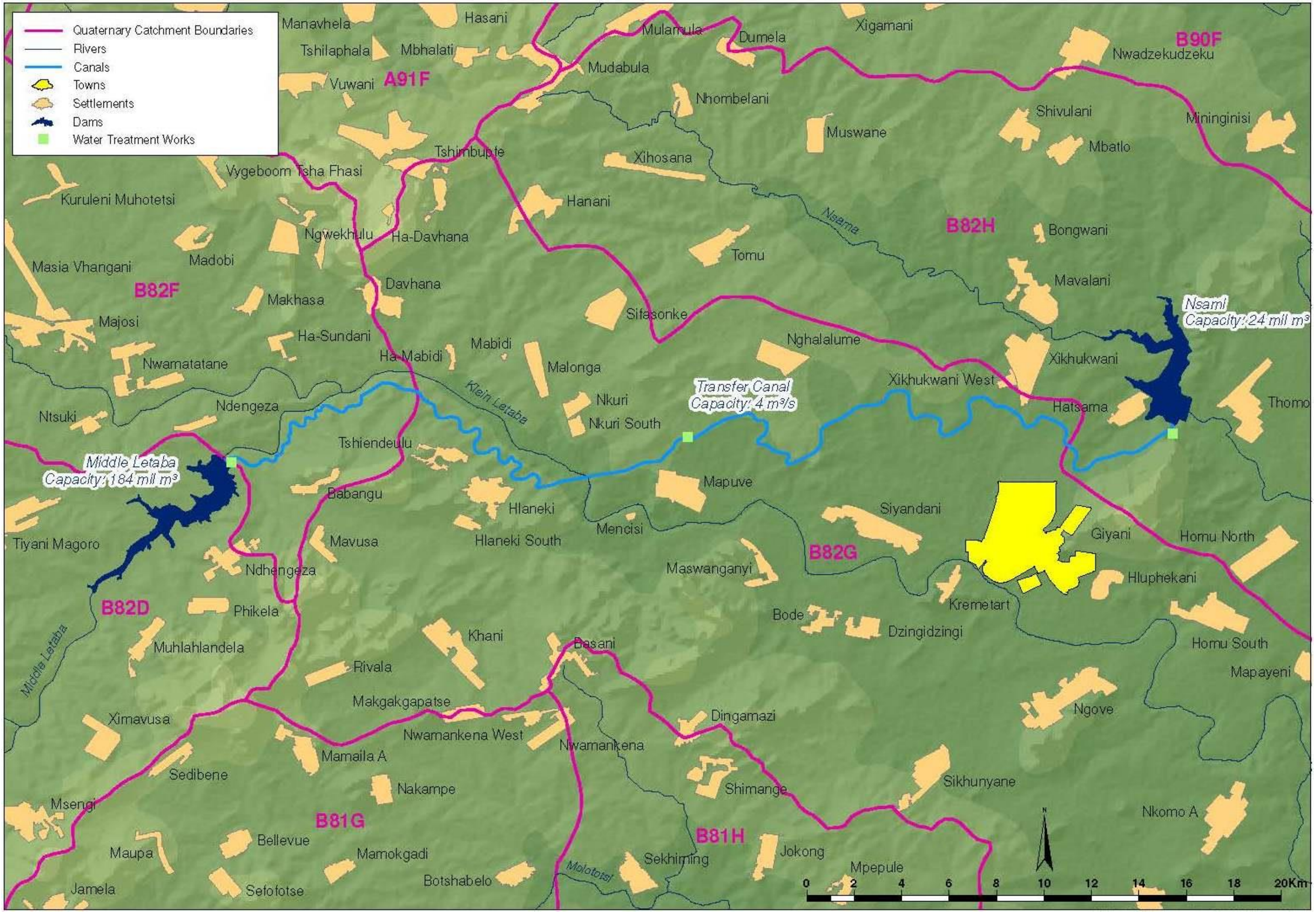

Figure 2.4: Locality Map of the Middle Letaba Dam to Nsami Dam Transfer Canal

The construction of a new pipeline to replace the transfer canal from Middle Letaba Dam to Nsami Dam in order to reduce transmission losses, thereby increasing the availability of water in the Middle and Klein Letaba catchment area, was considered at a reconnaissance level of detail in 2003. **[18]**

A provisional estimate of canal losses through seepage and evaporation was made based on a theoretical design loss of 1 ℓ/s per 1000 m^2 of wetted canal area. A potential saving in canal losses of 4 x 10^6 m^3/a was assumed in the 2003 reconnaissance study. **[18]** Replacement of the transfer canal by a pipeline was determined to be most cost effective of all the options that were considered. However, the quantity of water that can be saved should be verified by actual field measurements.

A preliminary route selection was done taking into consideration the location of existing irrigation abstraction points along the transfer canal. Although the proposed 40 km pipeline falls a total of 32 m from Middle Letaba Dam to Nsami Dam WTW, it was decided to first pump the water through a 6.7 km rising main up to a local high point in order to obtain more head so that a smaller diameter gravity main can be used and to have sufficient pressure in the gravity main to minimise pumping costs in the irrigation system.

The design flow rate was taken as 900 ℓ/s, based on the summer peak demand of the existing water treatment works at Nsami Dam (with no provision for extensions to the works) as well as a peak irrigation demand to supply the requirements of I 000 ha. The proposed diameters of the rising and the gravity mains are 800 mm and 1 000 mm respectively.

The capacity (0.9 m^3/s) of the recommended pipeline is much lower than the existing canal capacity of 4 m^3/s. This is due to the recent yield estimations for Middle Letaba Dam which is significantly less than the initial estimations. The lower yield is confirmed by the poor and low water supply assurance from this dam over the years, resulting in a large reduction in the irrigated area in comparison with the originally envisaged irrigation development. Due to this limited and low assurance of water supply received from Middle Letaba Dam over the years, the reducing trend of the irrigation area still continues. It is possible that the required capacity of this pipeline can in future be reduced even further, resulting in a lower cost and increased viability of this option. This option was thus recommended for further assessment.

2.5.4 Option MKL4 – Transfer Scheme from Nandoni Dam

The recurring water shortages experienced in the Luvuvhu River catchment necessitated the construction of the Nandoni Dam to make reliable water supply available for domestic use. Water from Nandoni Dam is released directly into the Luvhuvhu River to support irrigation and domestic abstractions mainly from weirs in the river, downstream of Nandoni Dam. Potable water is distributed from the water purification plant at Nandoni Dam to various towns and villages including Thohoyandou.

The water treatment works was constructed adjacent to the dam wall. The dam and treatment works have the following characteristics:

Nandoni Dam: Resource Capacity

- Storage Capacity: 163 million m³
- Original Primary use allocation: 48 million m³/a
- Ecological reserve: 35 million m³/a
- Irrigation: 10.4 million m³/a

Nandoni Dam WTW: Infrastructure Capacity

- Existing WTW Capacity (Peak): 60 Mℓ/d
- Existing WTW Capacity (Average): 40 Mℓ/d
- Pump and pipeline capacity: 1 068 ℓ/s (76.9 Mℓ/d @ 20 hrs pumping)

The new Nandoni Dam and Xikundu Weir together with the existing Albasini, Vondo, Phiphidi and Tshakhuma Dams and the associated bulk purified water supply infrastructure are known as the Luvuvhu River Government Water Scheme. Nandoni Dam started to store water during 2002/03 and was able to augment the flow in the river from the winter of 2003. This scheme is managed as an integrated system to supply water for domestic, industrial, irrigation and for the ecological component of the reserve. Damani, Mambedi and Frank Ravelle Dams are also part of the Luvuvhu River System, but are used to supply local water requirements and are therefore managed independently. Mambedi Dam was severely damaged during a flood event and is no longer in use. The Xikundu/Malamulele System consists of three weirs and respective water works, these are the Mhinga Abstraction Point and Treatment Works, Malamulele Weir and Treatment Works and Xikundu Weir and Treatment Works. The System covers the Nzanwe, Duvhuledza, Tshaulu and Mhinga Service Areas under the Xikundu Sub-System, and Mhinga Pipeline, Ntlaveni Pipeline and Fumani Pipeline Service Areas under the Malamulele Sub-System. The Damani Water Supply Area is rural and abuts the Vondo Rural and Thohoyandou/Vuwani Service Areas of the Nandoni System. The Nandoni System includes Thohoyandou, Tshakuma RWS, Vondo RWS, Malamulele RWS and West, Vuwani and Makhado Sub-Systems, which serve the following areas:

- Malamulele East and West;
- Levubu CBD;
- Thohoyandou and Vuwani;
- Vondo Rural;
- Tshakhuma RWS;
- Valdezia RWS;
- Makhado (Louis Trichardt), including the Air Force Base;

- Sinthumule Kutama RWS;
- Tshitale RWS; and
- Northern Regions of the Middle Letaba RWS – Elim and Waterval.

The infrastructure from the Nandoni WTW to the Vondo Service Area consists of large diameter pipelines that deliver water at the following points:

- Reservoirs R9A and B (at the Punda Maria tar road): 104 ℓ/s (7.5 Mℓ/d at 20 hrs/d)
- Reservoir R5 (north of Univen): 241 ℓ/s (17.4 Mℓ/d at 20 hrs/d)
- Reservoir R7 at Vuwani to serve the NN20D area

The Vuwani pump station which is currently under construction will pump water from Reservoir R7 to Valdezia Reservoir (NL9) through a 29 km long pipeline which is still under construction and is scheduled to be completed in mid 2015. The pipeline will comprise a 13 km long by 850 mm ND section and a 16 km long by 800 mm ND section.

The bulk water supply infrastructure between Nandoni Dam and Makhado (Louis Trichardt) includes the following:

- A duplicate 1200 mm ND pipeline between Nandoni WTW and Mavambe Reservoir.
- A duplicate 900 mm ND pipeline between Mavambe Reservoir and R7 Reservoir at Vuwani.
- A duplicate pipeline between R7 and Valdezia (NL9) Reservoirs, comprising a 5 km long by 1100 mm ND section, a 5 km long by 550 mm ND section and a 16 km long by 500 mm ND section.
- A pump station at Valdezia Reservoir (NL9), to pump water to the Albasini WTW pump sump.
- A 5 km long by 900 mm ND pipeline between Valdezia (NL9) reservoir and the Albasini WTW pump sump.
- A 23 km long by 800 mm ND pipeline between Albasini WTW pump station and Makhado (Louis Trichardt).

An emergency water supply scheme to transfer water from Nandoni Dam is currently under construction to alleviate the deficits of the stressed Middle Letaba Sub-System in the Letaba River basin. This scheme will be able to transfer 5 million m^3/a to the treatment works at Nsami Dam. Other future developments planned to be supplied from Nandoni Dam will already utilize the full yield available from the Nandoni Sub-System by 2034, without supporting Giyani. Supporting Giyani from Nandoni Dam will bring this date forward to approximately 2031.

As the pipeline is already under construction, it is not necessary to do further economic assessments for this option. This option was therefore considered as a given and will not be affected by comparing its URV with those of other options. Figure 2.5 is a schematic layout of the Nandoni Transfer Scheme.

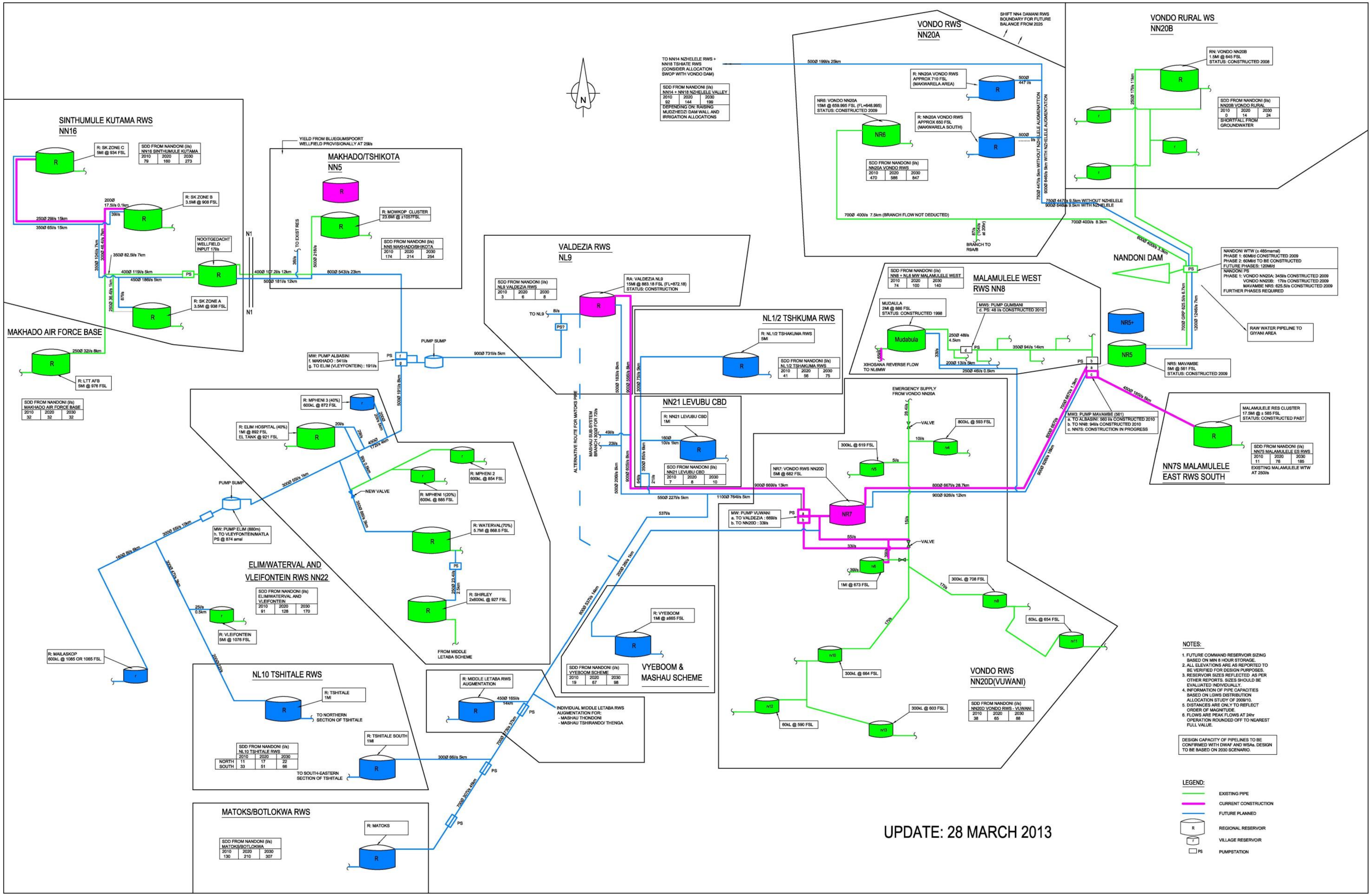

Figure 2.5: Schematic Layout of Nandoni Transfer Scheme

2.5.5 Option MKL5 – Construction of New Dam on Klein Letaba River

The upper Klein Letaba River was identified in the Letaba River Basin Study as a potential option for the development of surface water resource. **[6]** No potential dam sites were considered to be suitable in the Lower Klein Letaba River catchment due to the high evaporation and low run-off from the catchment (excluding contributions from upstream catchments) and the negative impact that the construction of a dam on this part of the river will have on the ecology of the Letaba River in the Kruger National Park.

Initially, a screening study was undertaken to assess and compare a total of five dam development options. Based on geotechnical, hydrological and cost considerations two sites, at Majosi and Crystalfontein were selected for further and more detailed assessment, in the Reconnaissance Study to Augment the Water Resources of the Klein and Middle Letaba River catchment. **[16]** The two dam sites are shown on Figure 2.6.

The following schemes to transfer water from the proposed dams to the water treatment works at the Middle Letaba Dam were identified:

- Crystalfontein Dam with pumping scheme and gravity pipeline to the Middle Letaba WTW.

The scheme comprises a rising main from the dam to a break-pressure tank on the catchment divide and a gravity pipeline from the divide to the water treatment works. Designs were carried out for four different capacities and costed. **[18]**

- Majosi Dam with flood diversion canal to Middle Letaba Dam.

The scheme comprises a small dam or weir at the Majosi site with a canal to divert water from the Klein Letaba River to the Middle Letaba Dam. **[18]**

Summarised details for the proposed dams are presented in the following paragraphs.

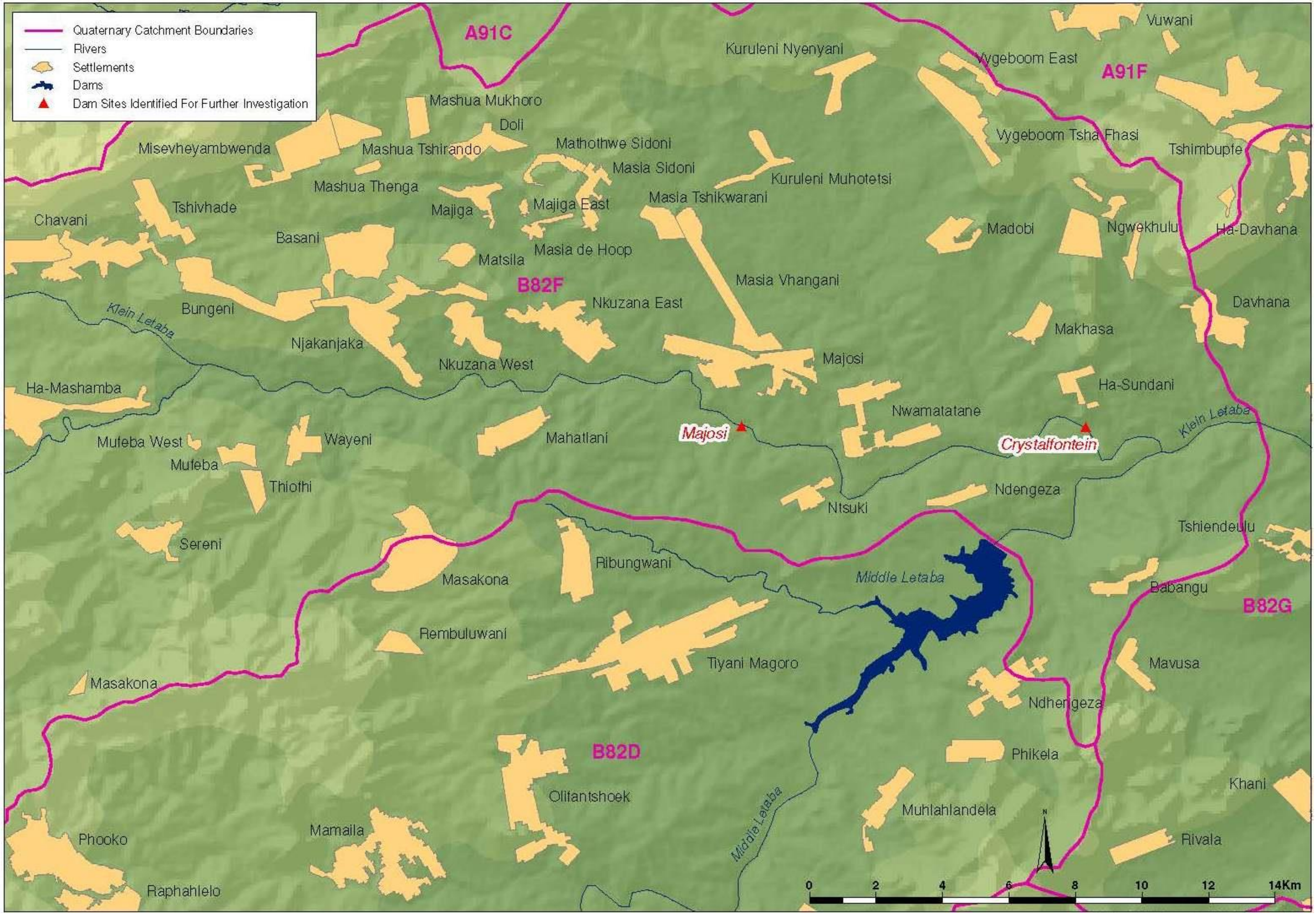

Figure 2.6: Klein Letaba River Dam Sites Locality Map

2.5.5.1 Crystalfontein Dam Site

The Crystalfontein Dam site is situated on the Klein Letaba River approximately 2.5 km upstream of its confluence with the Middle Letaba River and about 4 km north-east of the Middle Letaba Dam. The dam site is near the community of Sundani. The catchment area for the dam site is approximately 1 119 km^2.

The scheme comprises a pump station (Q = 328 l/s, pumping period = 24 hrs/d) and rising main (500 mm ND x 1.3 km) from the dam to a break-pressure tank on the catchment divide and a gravity pipeline (500 mm ND x 3.0 km) from the divide to the water treatment works.

A composite dam type, comprising a RCC structure in the river section accommodating a 170 m long spillway and outlet works, a RCC non-overspill section on the left flank and an earthfill embankment on the right flank was considered for this site in the reconnaissance study. **[18]** However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam that was considered is at RL 521 masl, and this will result in a gross storage capacity of 96 x 10^6 m^3 (approximately 303% of the natural MAR). The maximum height of the dam wall with a NOC at RL 526 will be 28 m and the total length of the dam wall will be approximately 1 300 m.

According to findings of the preliminary geological investigations foundation excavations are expected to be approximately 4 m to 5 m deep on the left flank, 3 m to 4 m in the alluvium riverbed and up to 4 m on the right flank.

A section of the eastern Cahora Bassa power line in the dam basin will require realignment. The reservoir of the proposed dam will inundate part of the tarred provincial road to Elim. A new 10 km road and a new bridge across the Klein Letaba River will have to be constructed. A number of major services along the existing road, including a 350 mm diameter steel rising main and Telkom optic fibre cables, will also have to be re-routed.

Based on geotechnical, hydrological and cost considerations from the Reconnaissance Study to Augment the Water Resources of the Klein and Middle Letaba River Catchment, Crystalfontein Dam was selected as one of the best options for further and more detailed assessment. **[18]** It was agreed in the Screening Workshop by the SSC members that this option be considered for further assessment as part of the Luvuvhu Letaba Reconciliation Strategy Study.

2.5.5.2 Majosi Dam Site

The Majosi Dam site is situated on the Klein Letaba River approximately 12 km west of its confluence with the Middle Letaba River and about 8 km north-west of the Middle Letaba Dam. The dam site is near the community of Ka-Majosi. The catchment area for the dam site is about 942 km^2.

A weir or small dam is to be built at Majosi to divert water flowing in the Klein Letaba River into the basin of the Middle Letaba Dam. It was assumed that the dam water level will not remain for long periods above FSL and that the water from the canal will discharge above FSL. The canal will have to cross the catchment watershed and a deep open cut will be required.

The canal will be 12.5 km long and being unlined, a flat slope of 1 in 8 800 was selected to minimize flow velocities (for scour) and simultaneously maintain an acceptable velocity to minimize sediment depositions. The flow velocity at 5 m^3/s will be 0.4 m/s. To be able to utilize the yield in a dam at Majosi, the invert level of the canal at the head of the works should be below the FSL. The canal was provisionally sized to have a bottom width of 1 m, side slope of 1V:3H and be at least 2.2 m deep. The design also included culverts. The Majosi Dam FSL was provisionally selected at 538.5 m and the canal capacity at 5 m^3/s.

A composite dam type, comprising a RCC structure in the river section and earthfill embankments on both flanks was considered for this site in the reconnaissance study. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL that was considered is at RL 538.5 masl, and this will result in a gross storage capacity of 29 x 10^6 m^3 (approximately 115% of the natural MAR). The maximum height of the dam wall with a NOC at RL 543 will be 22 m.

From the preliminary geological investigations estimated foundation excavation depths are 3.5 m cut-off beneath the fluvial deposits on the lower left bank, a cut-off depth of 2.5 m on the right bank and upper left bank, and 1 m beneath the shell footprint. The river section will require excavation down to 2 m to expose good rock over the whole area.

The canal has to cross the existing tarred provincial road to Elim and also pass through the village of Ntsuki. Allowance was made for ten bridges crossing the canal, for human and stock access, as well as the relocation of the village of Ntsuki.

If this option is pursued, the canal breaching risk should be evaluated and suitable measures taken to minimise it.

Similar to the Crystalfontein Dam option, Majosi Dam was also selected for further assessment as part of the Luvuvhu Letaba Reconciliation Strategy Study.

3 SELECTED INTERVENTION OPTIONS

3.1 INTRODUCTION

The identified intervention options that were adopted for further assessment after the preliminary screening workshop, calculation of water demands and yield analyses are listed in Table 3.1.

Table 3.1: Selected Intervention Options

Catchment Area	Intervention Option	Description of Intervention Option
Luvuvhu Main Catchment Area	Option Lu8	Paswane Dam on Mutshindudi River
	Option Lu9	Xikundu Dam on Luvuvhu River
Mutale River Catchment Area	Option Mu3	A new dam on the Mutale River • Tswera Dam • Rambuda Dam (d/s site) • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)
Middle and Klein Letaba River Catchment Area	Option MKL3	Replacement of Middle Letaba Dam – Nsami Dam transfer canal with a pipeline
	Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline • Majosi Dam with flood diversion canal

3.2 SOCIAL AND ECONOMIC IMPACTS

The ***methodology*** utilised to conduct the socio-economic impact assessment of the selected intervention options consisted of the following six steps:

- **Step 1:** Identify the spatial dimensions of each of the selected intervention options and gather all relevant Geographic Information System (GIS) data required to conduct the impact assessment.
- **Step 2:** Identify the socio-economic impacts of each selected intervention option as acknowledged by previous studies done.
- **Step 3:** Design an assessment structure which is informed by the socio-economic impacts of previous studies.

- **Step 4:** Identify the socio-economic impacts.
- **Step 5:** Integrate the applicable findings acknowledged by previous studies with the findings of this assessment.
- **Step 6:** Flag each of the selected intervention options as being:
    - *Acceptable*: No significantly negative socio-economic impacts.
    - *Apparently Acceptable*: Some significantly negative socio-economic impacts. Mitigation of impacts highly likely.
    - *Flawed*: Dominating negative socio-economic impacts. Mitigation of impacts is likely.
    - *Fatally Flawed*: Dominating negative socio-economic impacts. Mitigation of impacts is highly unlikely.

The following ***assessment structure*** was used to evaluate the potential socio-economic impacts of the selected intervention options:

- **Purpose and Recipients of the Completed Water Option**
    - The intended recipients of advantages related to the water option.
- **Macro-Economic Aspects**
    - Major Land-Use Activities that will be affected by the implementation of the water option.
- **Socio-Economic Aspects**
    - Effects of Loss in Land-Use Activities on the Livelihoods of Local Communities (Employment, Income, Dependency).
    - Relocations (Costs, Stress and Social Upheaval).
- **Socio-Cultural Aspects**
    - Historically Significant Aspects or Features.
    - Land Ownership Issues: Amongst others tribal or community owned land.
- **Infrastructural Aspects**
    - Loss of Infrastructure with a focus on the loss of social connections due to the implementation of the water option.
- **Other Aspects**
    - Integrate impacts from previous assessments that are still applicable or should be confirmed by more detailed studies into the previously mentioned.

The socio-economic assessment is based on the following ***assumptions***:

- The maximum Full Supply Level (FSL) of each proposed dam was used as guidance for the assessment.
- This is only a screening study; therefore it is assumed that, where applicable, more detailed studies will be done in the future.
- In order to get an indication of how many households will potentially have to be relocated, Eskom Spot Building Counts (SBC) for 2012 was utilised as proxy for number of households. Only SBC's relating to residential use were utilised.
- It is assumed that some social impacts identified by previous and in some cases more detailed socio-economic assessments are still applicable today. These impacts are therefore incorporated into the assessment based on a discretionary basis regarding the nature of the impact.
- The water intervention options were 'flagged' based on the practitioner's intuition with regards to the nature and extent of the socio-economic impacts.

3.3 ENVIRONMENTAL IMPACT

The ***methodology*** utilised to conduct the environmental impact assessment of the selected intervention options consisted of the following six steps:

- **Step 1:** Identify the spatial dimensions of each of the selected intervention options and gather all relevant Geographic Information System (GIS) data required to conduct the impact assessment.
- **Step 2:** Identify the environmental impacts of each selected intervention option as acknowledged by previous studies done.
- **Step 3:** Identify the current state of the environment for each of the intervention option sites by:
  - Using the gathered GIS data for Limpopo to determine likely **ecological advantages and disadvantages**. Aspects that were considered included:
    - Natural state of the receiving environment;
    - Distance of the site to NFEPA wetlands or surface water resources;
    - Distance of the site to conservation areas;
    - Occurrence of rare or endangered fauna on site;
    - Occurrence of rare or endangered flora on site;

- Determining the **Present Ecological State (PES)** of each site if it is inside a watercourse.

  The Present Ecological State assessment determines the level of disturbance to or modification of riparian habitats and wetlands relative to their natural state or reference condition. Both are rated on a scale of A to F, with A being a natural or un-impacted system and F being a completely modified and disturbed system. The PES score is based on observed physical disturbance and hydrological changes. Please refer to Table 3.2 below for PES categories.

Table 3.2: PES Categories

PES Category	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.
C	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.
D	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota have occurred.
E	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.
F	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.

- Determining the **Critical Biodiversity Area (CBA)** that each site is located in.

  Critical Biodiversity Areas (CBA's) within the bioregion are the portfolio of sites that are required to meet the region's biodiversity targets, and need to be maintained in the appropriate condition for their category. A map of CBA's for Limpopo was produced as part of this plan and sites were assigned to CBA categories based on their biodiversity characteristics, spatial configuration and requirement for meeting targets for both biodiversity pattern and ecological processes.

  Based on the Limpopo Conservation Plan, 40% of the province is designated as CBAs. These CBA's have been split into CBA 1 and CBA 2 on the basis of selection frequency and the underlying characteristics of the biodiversity features which are being protected (i.e. location fixed features such as sites for Critically Endangered (CR) species and flexible ones such as Least Cost Corridors). The majority of the CBA's in the province are CBA 1 (22 %), which can be considered "irreplaceable" in that there is little choice in terms of areas available to meet targets. If CBA 1 areas are not maintained in a natural state then targets cannot be achieved. CBA 2 areas are considered "optimal" as there is significant design involved in their identification, make up 18 % of the province. CBA 2's represent areas where there are spatial options for achieving targets and the selected sites are the ones that best achieve targets within the landscape design objectives of the plan.

An additional 23% of the province is designated as Ecological Support Area (ESA). This category has also been split on the basis of land-cover into ESA 1 (16%) and ESA 2 (7%), with ESA 1 being in a largely natural state, while ESA 2 areas are no longer intact but potentially retain significant importance from a process perspective (e.g. maintaining landscape connectivity).

- Determining the **River Health (RH)** of each site if inside watercourse.

The RH therefore focuses on selected ecological indicator groups that are representative of the larger ecosystem and are feasible to measure. Through scientifically derived measurement indices, the complex data that are collected for each indicator group can be summarised and expressed in an easy-to-understand format. The following indices were used to assess the health of rivers:

- **South African Scoring System (SASS) for aquatic invertebrates** – A variety of invertebrate organisms (e.g. insects, mussels, snails, crabs, worms) require specific aquatic habitat types and water quality conditions for at least part of their life cycles. Changes in the composition and structure of aquatic invertebrate communities are signs of changes in overall river conditions. As most invertebrates are relatively short-lived and remain in one area during their aquatic life phase, they are particularly good indicators of localised conditions in a river over the short term. The SASS is a relatively simple index which is based on the families of aquatic invertebrates present at a site. This information is translated into a reflection of the quality of the water in the river.

- **Fish Assemblage Integrity Index (FAII) –** Fish, being relatively long-lived and mobile, are good indicators of longer term influences on a river reach and the general habitat conditions within the reach. The number of species of fish that occur in a specific reach, their sensitivity to various forms of disturbances, as well as factors such as different size classes and the health of fish, can be used as indicators of river health. The FAII integrates such characteristics of a fish assemblage. The output of the FAII is an expression of the degree to which a fish assemblage deviates from what would have been expected in the absence of human impacts.

- **Riparian Vegetation Index (RVI)** – Healthy riparian zones provide habitat for aquatic and terrestrial species, contribute towards maintaining the form of the river channel and serve as filters for sediment, nutrients and light. The structure and function of riparian vegetation are altered with vegetation removal, cultivation, construction, inundation, erosion, sedimentation and alien vegetation invasion within or close to the riparian zone. The RVI is used to determine the degree of modification in riparian conditions.

The results that are obtained by applying the above biological and habitat indices during a river survey provide the context for determining the health state of the river. In order to standardise the output of the different indices as well as to allow comparison of the health of different river systems, a river health categorization is used. Each index is calibrated so that its results can be expressed as a river health category. Please refer to **Table 3.3** below for River Health Categories.

Table 3.3: River Health Categories

RIVER HEALTH CATEGORY	ECOLOGICAL PERSPECTIVE	MANAGEMENT PERSPECTIVE
Natural	No or negligible modification of in-stream and riparian habitats and biota.	Relatively untouched by human No discharges or impoundments.
Good	Biodiversity largely intact.	Some human-related disturbance but ecosystems essentially in good state.
Fair	A few sensitive species may be lost in parts and lower abundances of some populations may occur.	Zones of competing uses. Some natural systems may occur but developmental pressures are prominent in other parts.
Poor	Only more tolerant species remain; alien species have invaded the ecosystem; population dynamics have been disrupted (e.g. where biota can no longer breed); species present are often diseased.	Often characterised by high human densities or extensive resource exploitation. Management intervention is needed to improve river health – e.g. to restore flow patterns, river habitats or water quality.

- **Step 4**: Identify the environmental impacts.
- **Step 5**: Integrate the applicable findings acknowledged by previous studies with the findings of this assessment.
- **Step 6**: Flag each of the selected intervention options as being:

FLAG	DESCRIPTION
Acceptable	No significantly environmental impacts.
Apparently Acceptable	Some significantly negative environmental impacts. Mitigation of impacts highly likely.
Caution	More detailed site specific studies required to flag the option.
Flawed	Dominating negative environmental impacts. Mitigation of impacts is likely.
Fatally Flawed	Dominating negative environmental impacts. Mitigation of impacts is highly unlikely.

LIMITATIONS

- Only a desktop level assessment was conducted. No site survey was undertaken.
- This is only a screening study; therefore it is assumed that, where applicable, more detailed studies will be done in the future.

- It is assumed that some environmental impacts identified by previous and in some cases more detailed environmental assessments are still applicable today. These impacts are therefore incorporated into the assessment based on a discretionary basis regarding the nature of the impact.
- The water intervention options were 'flagged' based on the practitioner's intuition with regards to the nature and extent of the environmental impacts.

3.4 ENGINEERING ECONOMIC ANALYSES

An engineering economic analysis was conducted for each of the selected intervention options summarised in Table 3.1 to enable the identification of the most economical viable option for each catchment area.

In order to compare for example an option with a significant capital expenditure (CAPEX) and low operation and maintenance expenditures (OPEX) with another option with a low CAPEX and significant OPEX, all costs must be converted/escalated to a common base date (Net Present Value). These costs serve as input into the calculation of the unit reference values (URV), i.e. the costs will be discounted at three values for the discount rate and the net present costs and URV's will be calculated. The option with the lowest URV will be the preferred option from an engineering economic point of view.

3.5 ASSUMPTIONS

The costing and engineering economic analyses study were based on the following assumptions:

- The engineering design is considered at a reconnaissance level of detail.
- Costs of previously investigated studies were escalated. The cost base date is January 2014.
- Stochastic and historic firm yields were used and not water demands.
- Costs incurred by making use of the existing infrastructure to distribute the water have not been determined as part of this study and should be addressed in future studies.
- The existing power supply at each pump station is sufficient for the proposed new installations and no upgrading is required.
- No provision was made for cathodic protection costs.
- The economic life of all components was taken as 45 years.
- For planning purposes a 30 year design horizon was used.

3.6 COSTING

3.6.1 Costing Parameters

For the purposes of this study the following parameters were utilised in the engineering economic analyses:

Table 3.4: Costing Parameters

Description	Note / Assumption
Energy Tariff	Eskom Miniflex (Local Authority Rates)
Discount rate (real)	6, 8 and 10%
Analysis Period	45 years

3.6.2 Construction Values

3.6.2.1 Bills of Quantities

The Bills of Quantities of previously investigated studies were used. The costs of the options were escalated to a common base date, i.e. January 2014.

3.6.2.2 Cost Breakdown for Pump Stations

Engineering (discipline breakdown of costs):

Mechanical Cost: 50%

Electrical Cost: 20%

Civil Cost: 30%

Mechanical (further breakdown of costs)

Pumps and motors: 60% of Total Mechanical Cost

Valves: 25 % of Total Mechanical Cost

Pipework: 15% of Total Mechanical Cost

3.6.2.3 Planning, Design and Supervision Fees

The following percentages were used in the cost models to compare the options on the same basis:

SUB-TOTAL A - CONSTRUCTION VALUE

Planning, Design and Supervision Fees (12% of Sub-Total A)

Social and Environmental (1% of Sub-Total A)

3.6.3 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as laid out hereunder:

- 0,5% of the pipeline cost;
- 0,25% of the dam cost;
- 4% of the electrical and mechanical installation of a pump station;
- 0,25% of the capital cost of civil structures, including the civil portion of the pump stations.
- Pumps and motors (major overhaul every 15 years)
- 15% of initial capital cost of pump and motor

3.6.4 Escalation of Unit Rates

The base date for costing of the Luvuvhu and Letaba Water Supply System Reconciliation Strategy Study is January 2014.

For the purpose of this study the scheme/option costs utilised in the various planning reports were escalated to the base year, January 2014. The base date for these previous studies varies from 1987 to 2000.

The formula used in the Civil Engineering Industry for Contract Price Adjustment (CPA) has four coefficients which represents the proportionate values of Labour, Material, Plant and Fuel. The proportions will vary depending upon the nature of the work, whether it is plant or labour intensive for instance. For the purpose of this study the proportions were assumed as follows:

•	Labour	:	32,5 %
•	Materials	:	25,0 %
•	Plant	:	32,5 %
•	Fuel	:	10,0 %
	Total	:	100,0 %

Indices obtained from Statistics South Africa were used to calculate factors to adjust/escalate rates to the base date.

Statistics South Africa Indices:

Labour		
	June 1987	30
CPI base year 2008	September 1998	65.7
CPI base year 2008	July 2000	68.1
CPI base year 2008	April 2008	99.4
CPI base year 2008	January 2010	108.3
CPI base year 2008	February 2011	113.8
CPI base year 2008	December 2011	119.2
CPI base year 2012	December 2011	95.1
CPI base year 2012	January 2014	106.9
Materials		
	June 1987	30
CPI base year 2000	September 1998	89.36
CPI base year 2000	July 2000	100.63
CPI base year 2000	April 2008	191
CPI base year 2000	January 2010	212.5
CPI base year 2000	February 2011	215.9
CPI base year 2000	December 2011	223.6
CPI base year 2012	December 2011	98.4
CPI base year 2012	January 2014	105.9
Plant		
	June 1987	30
CPI base year 2000	September 1998	86.25
CPI base year 2000	July 2000	99.23
CPI base year 2000	April 2008	161.4
CPI base year 2000	January 2010	188.1
CPI base year 2000	February 2011	186.6
CPI base year 2000	December 2011	188.4
CPI base year 2012	December 2011	98.7
CPI base year 2012	January 2014	110.7
Fuel		
	June 1987	30
CPI base year 2000	September 1998	47.6
CPI base year 2000	July 2000	77.7
CPI base year 2000	April 2008	372.6
CPI base year 2000	January 2010	273.3

Fuel		
CPI base year 2000	February 2011	322.9
CPI base year 2000	December 2011	409.4
CPI base year 2012	December 2011	96.6
CPI base year 2012	January 2014	117.6

Calculations:

June 1987	32.5%(30.00)+25.0%(30.00)+32.5%(30.00)+10.0%(30.00)	=	30.00
September 1998	32.5%(65.70)+25.0%(89.36)+32.5%(86.25)+10.0%(47.60)	=	86.69
July 2000	32.5%(68.10)+25.0%(100.63)+32.5%(99.23)+10.0%(77.70)	=	97.90
April 2008	32.5%(99.40)+25.0%(191.00)+32.5%(161.40)+10.0%(372.60)	=	185.21
January 2010	32.5%(108.30)+25.0%(212.50)+32.5%(188.10)+10.0%(273.30)	=	193.62
February 2011	32.5%(113.80)+25.0%(215.90)+32.5%(186.60)+10.0%(322.90)	=	183.90
December 2011	32.5%(119.20)+25.0%(223.60)+32.5%(188.40)+10.0%(409.40)	=	215.34
December 2011	32.5%(95.10)+25.0%(98.40)+32.5%(98.70)+10.0%(96.60)	=	97.25
January 2014	32.5%(106.90)+25.0%(105.90)+32.5%(110.70)+10.0%(117.60)	=	108.96

Multiplication Factor 1

June 1987 to December 2011	215.34 ÷ 30.00	=	7.18
September 1998 to December 2011	215.34 ÷ 86.69	=	2.48
July 2000 to December 2011	215.34 ÷ 97.90	=	2.20
April 2008 to December 2011	215.34 ÷ 185.21	=	1.16
January 2010 to December 2011	215.34 ÷ 193.62	=	1.11
February 2011 to December 2011	215.34 ÷ 183.90	=	1.17

Multiplication Factor 2

December 2011 to January 2014	108.96 ÷ 97.25	=	1.12

Combined Multiplication Factor

June 1987 to January 2014	7.18 x 1.12	=	8.04
September 1998 to January 2014	2.48 x 1.12	=	2.78

July 2000 to January 2014	2.20 x 1.12	=	2.46
April 2008 to January 2014	1.16 x 1.12	=	1.30
January 2010 to January 2014	1.11 x 1.12	=	1.25
February 2011 to January 2014	1.17 x 1.12	=	1.31
December 2011 to January 2014		=	1.12

4 LUVUVHU MAIN CATCHMENT AREA

4.1 OPTION LU8 – PASWANE DAM

4.1.1 Engineering

The purpose of the proposed dam is for rural domestic water supply along the lower Mutshindudi and Luvuvhu Rivers, regulation of river flow to irrigation schemes along the lower Luvuvhu River and environmental flow to the Kruger National Park (40 km downstream of the dam).

The Paswane Dam site is located on the Mutshindudi River approximately 21 km north-east of Thohoyandou. Preliminary design for the dam was previously carried out at a reconnaissance level of detail in 1990. **[4]**

A composite earthfill embankment/rollcrete with a central stepped spillway was considered to be the most suitable type of dam for the site in the reconnaissance study. On account of the topography of the dam site and the effects of flooding of a village and parts of a secondary road from Mukula to Paswane a FSL of 495 masl was considered to be the practical upper limit for the site. For a FSL of 495 masl the dam will have a gross storage capacity of 90 million m^3 (approximately 99% of the natural MAR). The maximum height of the dam wall will be 40 m and the total length of the dam wall will be 1 560 m. The catchment area for the dam site is approximately 402 km^2.

4.1.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 495 m. Calculations based on the maximum FSL suggests a total dam coverage of roughly 1 058 ha. The proposed site is currently utilised for cultivation, rural settlements and bushveld - as set out in the table below.

Table 4.1: Paswane Dam on the Luvuvhu River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	514 ha
Cultivated – Commercial farming	32 ha
Cultivated – Woodland	3 ha
Rural Settlements	17 ha
Bushveld or Open Space	492 ha
Total	**1 058 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly an estimated 549 ha of cultivated land will be inundated. 514 ha of this land is used by subsistence and small scale farmers for dryland cultivation irrigated farming while 32 ha is used for large scale commercial farming and 3 ha for woodland cultivation. Based on these findings it is believed that there will be some macro-economic impacts as a result of loss in land use – a loss in regional GDP and employment opportunities mainly due to the inundation of commercial farms and even small scale farming. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Nonetheless, the majority of land that will be lost is subsistence and small scale farming land. Loss in land use will therefore have significant negative impacts on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. Furthermore, almost 500 ha of bushveld will also be inundated. This has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is predisposed. The chances are slim for residents to be given alternative farmland due the scarcity and topography of the land as well as the extent of tribal communities in the area – tribes and traditional communities are culturally associated with a specific portion of land and any attempt to move them is likely to result in major upheavals. Mitigation measures addressing food security and livelihoods should be explored.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. A total of 3 rural settlements are located on the proposed dam site and will be partially inundated. Subsequently, an estimated 107 households and 17 ha of existing settlements will have to be relocated. The affected settlements include: Maluvuhe (2 of 661 households), Tshidzini (23 of 562 households) and Tshikambe (38 of 426 households) and 44 scattered households. There are strong social, cultural and economic ties within any community, especially rural and tribal communities. Therefore communities or parts of communities cannot just be relocated – the community as a whole should be considered. In all of the cases above only small portions of the communities need to be relocated. In cases where only a few households are relocated, households should be relocated to somewhere in the existing community (infill-relocations) if possible. Densification strategies should also be considered where and if applicable, especially to accommodate the scattered households. Relocations are always accompanied with high levels of social stress and upheavals and should therefore be considered carefully. The best relocation scenario should be chosen in order to minimise social, economic and cultural losses as well as community upheaval.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding the construction site. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Paswane Dam the area surrounding the dam is very densely populated. Roughly 27 small settlements and 12 000 households are located within a 5 km radius of the construction. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Mphaphuli and Tshivhase respectively. Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will result in the inundation of a large tarred road linking Tshivhiliwi and Maluvuhe as well as several smaller connector roads and some smaller pedestrian routes. As a result communities and settlements in the north and south of the proposed dam will therefore be segregated. The degree of social and economic interaction as a result of this access road should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Lastly, the dam will stimulate rural domestic water supply and irrigation potential for potentially fertile agricultural land in the surrounding areas which will indirectly improve the socio-economic conditions and livelihoods of some households in the broader region. Economic growth and employment will also be stimulated and can once again be translated into improved living conditions for local residents.

This water intervention option is therefore ‘flagged’ as being Apparently Acceptable. Even though the intervention will have a negative impact on the livelihoods and survivalist strategies of some members of the community, the agricultural potential that can result from the dam may have major positive impacts in the community and broader region. Macro-economic costs, socio-economic and socio-cultural costs are also relatively insignificant or non-existing.

Table 4.2: Socio-Economic Impacts Summary – Paswane Dam on the Luvuvhu River

Impact	Impact Description	Data Source
Loss of Agricultural Land	549 ha agricultural land will be inundated (32 ha commercial + irrigated; 514 ha subsistence + 3 ha cultivated; woodland).	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA - CSIR
Irrigation Potential and regional GDP growth	Irrigation for agricultural purposes increases farming potential in the region which may translate into GDP growth and growth in employment opportunities.	Inferred from given information.
Loss in Economic Opportunities, Income and Livelihoods	Due to loss of agricultural land.	Inferred from land use and vegetation data.
New Economic Opportunities	Economic Opportunities – due to new irrigation and commercial farming potential. Economic Opportunities – construction and operation phases.	Not Applicable.
Household Relocations	107 households will have to be relocated. 3 settlements and 17 ha of these settlements will be partially inundated.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Construction and Safety Issues	Area around dam is densely populated – many households will be disturbed during construction phase.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)

Impact	Impact Description	Data Source
Land Ownership	Tribal Land/Traditionally Owned.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Loss in Social and Economic Connections and Linkages	A large tarred road linking Tshivhiliwi and Maluvuhe as well as several smaller connector roads will be inundated.	GIS Data depicting road networks - 2013 Aerial Photography Topographical Maps (1: 50 000)
Apparently Acceptable		

4.1.3 Environmental Impact

Site Information	
Co-ordinates	S22.85084 E30.68967
River	Mutshindudi
Current Ecological Information	
Present Ecological State Class	Moderately Modified
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 2
Wetland National Ecological Freshwater Priority Class	NFEPA wetlands up and downstream of the dam site.
South African Scoring System (SASS) for aquatic invertebrates	Good
Fish Assemblage Integrity Index (FAII)	Fair
Riparian Vegetation Index (RVI)	Fair
River Health Category	Good
Potential Environmental Impacts	
Except for the generic environmental impact that accompany most dams the following specific environmental impacts are of importance : • Construction of the Dam will create barriers to migratory species in the river. The area downstream surrounding the confluence of the Mutshindudi and the Luvuvhu Rivers is regarded as a diversity hotspot for fish and invertebrates. Healthy populations of red data fish species, Southern Barred Minnow and the provincially scarce Line-Spotted Barb occur in the Mukhase River. When conditions permit, these species move into the Mbwedi, Mutshindudi and Luvuvhu Rivers. • Sedimentation will decrease downstream from the site. Agriculture (small scale subsistence and commercial crop production) is the main economic activity in the Mutshindudi River catchment.	

Traditional cattle farming, irrigated estates and schemes, rain-fed orchards and irrigated informal gardens are expanding. The land tenure system has resulted in the overstocking of cattle and goats with resultant high levels of erosion. The riparian vegetation is over-utilised, mainly for firewood, fence construction, furniture, medicinal purposes and food. In many areas, the riparian vegetation has been completely replaced by crops and, as a result, siltation of the river is increasing. The resultant health of the riparian zone along the Mutshindudi River is fair but is deteriorating. Sediment inflows into the Mutshindudi are likely to increase, causing loss of in-stream habitats and eventual loss of fish and invertebrate species from the river.

- The area of the dam basin (measured below a crest level of 500 m MSL) is 1 316 ha, of which about 200 ha consist of dryland cultivation. Flooding of approximately 400 homes will occur for which compensation will be required.
- Flooding of the dam basin will lead to the loss of 1 316 ha of natural vegetation and potential habitat.

Environmental Classification

Pending further detailed studies on the impact on the populations of red data fish species, Southern Barred Minnow and Line-Spotted Barb this option is seen as **Apparently Acceptable.**

Legal Requirements

A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following:

- National Environmental Management Act (Act No. 107 of 1998)
- National Water Act (Act No. 36 of 1998)
- National Heritage Resources Act (Act No. 25 of 1999)
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
- National Forests Act (Act No. 84 of 1998)

4.1.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 4.3 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 4.3: Breakdown of Capital Cost for Option Lu8 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 495 m	R 328,506,564.02
	Sub-Total (including P&G and Contingencies)	**R 328,506,564.02**
	Professional Fees (12% of Sub-Total)	R 39,420,787.68
	Social & Environmental (1% of Sub-Total)	R 3,285,065.64
	Cost of Infrastructure Replacement	R 18,416,569.52

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
	Cost of Land Acquisition and Relocation	R 5,790,362.47
	Total	**R 395,419,349.32**

4.1.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R 821,266.41	-	-

4.1.6 Yields

The following table comprises a summary of the yields used.

Table 4.4: Summary of Yields for Option Lu8

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Paswane Dam on Mutshindudi River	55	43	No EWR

4.1.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix A and summarised in Table 4.5. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 4.5: Summary of Present Values for Option Lu8

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	280,308,425	7,963,968	288,272,394
8%	251,392,415	5,372,555	256,764,969
10%	226,069,279	3,778,706	229,847,986

4.1.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in

Appendix A and summarised in Table 4.6.

Table 4.6: Summary of Unit Reference Values for Option Lu8

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m³)	URV Rand/m³
6%	288,272,394	416.98 533.34	0.691 0.540
8%	256,764,969	281.30 359.80	0.913 0.714
10%	229,847,986	197.85 253.06	1.162 0.908

4.2 OPTION LU9 – XIKUNDU DAM

4.2.1 Engineering

The purpose of the proposed dam is for rural domestic water supply, irrigation schemes along the lower Luvuvhu River and environmental flow to the Kruger National Park (20 km downstream of the dam).

The Xikundu Dam site is located on the Luvuvhu River approximately 40 km north-east of Thohoyandou. Preliminary design for the dam was previously carried out at a reconnaissance level of detail in 1990. **[5]** A weir was constructed at the dam site.

An earthfill embankment with a concrete lined spillway on the left flank was considered to be the most suitable type of dam for the site in the reconnaissance study. The FSL of RL 460 m above mean sea level is governed by the need to prevent flooding of the main road from Thohoyandou to Punda Maria. For a FSL of RL 460 m the dam will have a gross storage capacity of 139 million m³ (approximately 53% of the natural MAR). The maximum height of the dam wall will be 35 m and the total length of the dam wall will be 930 m. The catchment area for the dam site is approximately 2 233 km².

4.2.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 460 m. Calculations based on the maximum FSL suggest a total dam coverage of roughly 919 ha. The proposed site is currently utilised for cultivation, rural settlements and bushveld - as set out in the table 4.7.

Table 4.7: Xikundu Dam on the Luvuvhu River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	474 ha
Cultivated – Commercial farming	16 ha
Cultivated – Woodland	3 ha
Rural Settlements	14 ha
Bushveld or Open Space	412 ha
Total	**919 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly an estimated 493 ha of cultivated land will be inundated of which the majority (474 ha) is used by subsistence and small scale farmers for dryland cultivation 16 ha of land is used for commercial farming practices and 3 ha for woodland cultivation. Based on these findings it is believed that there will be little macro-economic impact as a result of loss in land use – the loss in regional GDP and formal employment opportunities should be little given the small proportion of land used for formal activities (commercial farming). The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Despite small macro-economic impacts, the loss in land use will definitely have an immense impact on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. Furthermore, roughly 400 ha of bushveld will be inundated. This has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is predisposed. The chances are slim for residents to be given alternative farmland due the scarcity and topography of the land as well as the extent of tribal communities in the area – tribes and traditional communities are culturally associated with a specific portion of land and any attempt to move them is likely to result in major upheavals. Mitigation measures addressing food security and livelihoods should be explored

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. A total of 2 rural settlements are located on the proposed dam site and will be partially inundated. Subsequently, an estimated 45 households and 14 ha of existing settlements will have to be relocated. The affected settlements include: Gonani (39 of 103), Buluni (2 of 105) and 4 scattered households. There are strong social, cultural and economic ties within any community, especially rural and tribal communities. Therefore communities or parts of communities cannot just be relocated – the community as a whole should be considered. A relatively large part of Gonani, for example, will have to be relocated. In this case an attempt should be made to keep the community together – locating these households to another side of the community. In cases where only a few households are relocated such as Buluni, households should be relocated to somewhere in the existing community (infill-relocations) if possible. Densification strategies should also be considered where and if applicable. Relocations are always accompanied with high levels of social stress and upheavals and should therefore be considered carefully. The best relocation scenario should be chosen in order to minimise social, economic and cultural losses as well as community upheaval.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding construction sites. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Xikundu Dam the immediate area surrounding the dam is sparsely populated however the broader area is extremely dense. Roughly 35 small settlements and 21 000 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Mphaphuli, Shikundu, Tshikonelo and Malamulele respectively. Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will result in the inundation of a large tarred road linking Tshikonelo and Dzivhadolo as well as some smaller pedestrian routes. The degree of social and economic interaction as a result of this access road should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Lastly, the dam will stimulate rural domestic water supply and irrigation potential for potentially fertile agricultural land in the surrounding areas which will indirectly improve the socio-economic conditions and livelihoods of some households in the broader region. Economic growth and employment will also be stimulated and can once again be translated into improved living conditions for local residents.

This water intervention option is therefore ‘flagged’ as being *Apparently Acceptable*. Even though the intervention will have a negative impact on the livelihoods and survivalist strategies of some members of the community, the agricultural potential that can result from the dam may have major positive impacts in the community and broader region. Macro-economic costs, socio-economic and socio-cultural costs are also relatively insignificant or non-existing.

Table 4.8: Socio-Economic Impacts Summary – Xikundu Dam on the Luvuvhu River

Impact	Impact Description	Data Source
Loss of Agricultural Land	493 ha agricultural land will be inundated (16 ha commercial + irrigated; 474 ha subsistence + 3 ha cultivated; woodland).	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR
Irrigation Potential and regional GDP growth	Irrigation for agricultural purposes increases farming potential in the region which may translate into GDP growth and growth in employment opportunities.	Inferred from given information.
Loss of Bushland/Open Space	412 ha bushland used for grazing will be lost.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR
Loss in Economic Opportunities, Income and Livelihoods	Loss of employment, income and livelihoods due to loss of agricultural land.	Inferred from land use and vegetation information.
New Economic Opportunities	Economic Opportunities – due to new irrigation and commercial farming potential. Economic Opportunities – construction phase and operations phase.	Not Applicable.

Impact	Impact Description	Data Source
Household Relocations	44 households will have to be relocated. 3 settlements and 14 ha of these settlements will be partially inundated.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Construction and Safety Issues	Immediate area surrounding dam not dense. Broader area very densely populated – many households will be disturbed during construction phase.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Land Ownership	Tribal Land/Traditionally Owned.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Loss in Social and Economic Connections and Linkages	A large road between Tshikonelo and Dzivhadolo and some other smaller roads will be inundated.	GIS Data depicting road networks - 2013 Aerial Photography Topographical Maps (1: 50 000)
Apparently Acceptable		

4.2.3 Environmental Impact

Site Information	
Co-ordinates	S22.80749 E30.79811
River	Luvuvhu
Current Ecological Information	
Present Ecological State Class	Unmodified, Natural/Largely Natural
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 1
South African Scoring System (SASS) for aquatic invertebrates	Natural
Fish Assemblage Integrity Index (FAII)	Fair

Riparian Vegetation Index (RVI)	Poor
River Health Category	Fair
Potential Environmental Impacts	
Except for the generic environmental impact that accompany most dams the following specific environmental impacts are of importance : • Occurrence of populations of red data fish species, Southern Barred Minnow and the provincially scarce Line-Spotted Barb occur in the Luvuvhu River. • There is a high density of rural communities in this area. Activities that have negative impacts on the river include overgrazing, trampling, vegetation cutting, washing, sand mining and hand irrigated lands within the riparian zone. • Los of natural vegetation and habitats as a result of flooding.	
Environmental Classification	
Pending further detailed site specific studies on the impact on the populations of red data fish species, Southern Barred Minnow and Line-Spotted Barb this option is seen as **Apparently Acceptable.**	
Legal Requirements	
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)	

4.2.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 4.9 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 4.9: Breakdown of Capital Cost for Option Lu9 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 460 m	R 420,195,345.26
	Sub-Total (including P&G and Contingencies)	**R 420,195,345.26**
	Professional Fees (12% of Sub-Total)	R 50,423,441.43
	Social & Environmental (1% of Sub-Total)	R 4,201,953.45

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
	Cost of Infrastructure Replacement	R 241,265.10
	Cost of Land Acquisition and Relocation	R 3,088,193.32
	Total	**R 478,150,198.57**

4.2.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R1,050,488.36	-	-

4.2.6 Yields

The following table comprises a summary of the yields used.

Table 4.10: Summary of Yields for Option Lu9

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Xikundu Dam on Luvuvhu River	62.5	51	No EWR

4.2.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix B and summarised in Table 4.11. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 4.11: Summary of Present Values for Option Lu9

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	338,388,611	10,186,775	348,575,386
8%	303,304,165	6,872,077	310,176,242
10%	272,589,526	4,833,373	277,422,899

4.2.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix B and summarised in Table 4.12.

Table 4.12: Summary of Unit Reference Values for Option Lu9

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m³)	URV Rand/m³
6%	348,575,386	494.56 606.07	0.705 0.575
8%	310,176,242	333.63 408.86	0.930 0.759
10%	277,422,899	234.65 287.57	1.182 0.965

5 MUTALE RIVER CATCHMENT AREA

5.1 OPTION MU3 – TSWERA DAM

5.1.1 Engineering

The Tswera Dam site is situated on the Mutale River some 5 km upstream of its confluence with the Sambandou River. Relative to the Rambuda sites, the area is more densely inhabited with large areas of the flood plain upstream of the dam site under irrigated and dry land cultivation. There are a number of communities close to the dam site, but those most likely to be affected by flooding include Tswera, Shadani and Tshivhangani and a number of smaller communities. The catchment area for the dam site is approximately 405 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 594.5 masl, and this will result in a gross storage capacity of 130.98 x 10^6 m^3 (approximately 120% of the natural MAR). The maximum height of the dam wall with a NOC at RL 600 will be 37 m and the total length of the dam wall will be 250 m.

Shallow foundation excavations, of less than 3 m on average are expected at this site. Minimal protection against scouring will be required downstream in the river section.

5.1.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 594.5 m (rounded to 595 m). Calculations based on the maximum FSL suggests a total dam coverage of roughly 1 330 ha. The proposed site is currently utilised for cultivation, rural settlements and bushveld - as set out in the table below.

Table 5.1: Tswera Dam on the Mutale River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	879 ha
Cultivated – Commercial farming	74 ha
Rural Settlements	81 ha
Bushveld or Open Space	296 ha
Total	**1 330 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly and estimated 953 ha of cultivated land will be inundated. 879 ha of this land is used by subsistence and small scale farmers for dryland cultivation and irrigated farming while 74 ha is used for large scale commercial farming. Amongst the commercial farms are the Mutale Agricultural Estates which is the only formal agricultural project generating significant employment opportunities and regional GDP that is located on the Mutale River. Based on these findings it is believed that there will be some macro-economic impacts as a result of loss in land use – the loss in regional GDP and employment opportunities due to the inundation of commercial farms. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Nonetheless, the loss in land use will have significant negative impacts on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. Furthermore, almost 300 ha of bushveld will be inundated. This has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is predisposed. The chances are slim for residents to be given alternative farmland due the scarcity and topography of the land as well as the extent of tribal communities in the area – tribes and traditional communities are culturally associated with a specific portion of land and any attempt to move them is likely to result in major upheavals. Mitigation measures addressing food security and livelihoods should be explored.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. A total of 4 rural settlements are located on the proposed dam site and will be partially inundated. Subsequently, an estimated 210 households and 81 ha of existing settlements will have to be relocated. The affected settlements include: Tshiawelo (10 of 286 households), Lunononi (20 of 60 households), Lungoni (70 of 76 households), Tswera (80 of 360 households) and 30 scattered households. There are strong social, cultural and economic ties within any community, especially rural and tribal communities. Therefore communities or parts of communities cannot just be relocated – the community as a whole should be considered. The majority of Lungoni (almost whole settlement), for example, will have to be relocated with only a few households remaining. In this case an attempt should be made to keep the community together. In cases where only a few households are relocated, households should be relocated to somewhere in the existing community (infill-relocations) if possible. Densification strategies should also be considered where and if applicable. Relocations are always accompanied with high levels of social stress and upheavals and should therefore be considered carefully. The best relocation scenario should be chosen in order to minimise social, economic and cultural losses as well as community upheaval.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding the construction site. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Tswera Dam the area surrounding the dam is very densely populated. Roughly 39 small settlements and 14 000 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Tshivhase, Thengwe and Mphaphuli respectively. The area will most probably have at least one graveyard. The relocation of these graves will be difficult and will involve extensive negotiations. Part of the area within the proposed dam basin is also used to harvest scarce medicinal plants as well as to host initiation schools – an integral part of day-to-day living in the communities. The medicinal plants are apparently only found in this specific valley. Furthermore, the proposed dam has provoked great resistance from traditional leaders and communities in the past. Past experience also proved that the relocation of tribal communities can be extremely difficult. The 'sacred caves' is located in the proposed dam basin and is a potentially significant cultural heritage site. If this is the case, it will be very difficult and even impossible to continue with the proposed dam at the maximum FSL. Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will result in the inundation of a tarred access road between Khakhu and Thengwe Passes and some smaller pedestrian routes. The degree of social and economic interaction as a result of this access road should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Lastly, the dam will have a positive socio-economic impact on households living in the broader Tshiombo-Thengwe valley, the Malonga Flats, the Mudaswali valley and Sambonou valley by ensuring that the future water needs of these households are met.

This water intervention option is therefore 'flagged' as being ***flawed***. Even though the intervention will provide water on a broader regional scale, macro-economic costs, socio-economic and socio-cultural costs will be very high, but can be possible to mitigate without fatal short and long term impacts on the communities, economy and employment.

Table 5.2: Socio-Economic Impacts Summary – Tswera Dam on the Mutale River

Impact	Impact Description	Data Source
Loss of Agricultural and Bushland/Grazing	953 ha agricultural land (74 ha commercial farming + irrigation; 740 ha subsistence + dryland; 139 ha subsistence + irrigated) and 337 ha bushland/grazing will be inundated.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR
Loss of Bushland/Open Space	296 ha bushland used for grazing will be lost.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR
Loss in Employment Opportunities and regional GDP	Loss of employment due to loss of agricultural land.	Inferred from land use and vegetation data.
Loss in Income and Livelihoods	Loss of income and livelihoods due to loss of agricultural land.	Inferred from land use and vegetation data.
New Employment Opportunities	Economic Opportunities – construction and operation phases.	Not Applicable.
Household Relocations	210 households will have to be relocated. 4 settlements and 81 ha of these settlements will be partially inundated.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)

Impact	Impact Description	Data Source
Construction and Safety Issues	Area around dam is densely populated – many households will be disturbed during construction phase.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Land Ownership	Tribal Land/Traditionally Owned.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Heritage Sites	'Sacred caves' - still needs verification.	Mutale River Water Resource Investigation: Situation Assessment, Management and Development Potential
Loss in Social and Economic Connections and Linkages	A tarred road between Khakhu and Thengwe Passes will be inundated. Apart from this, no influence on connectivity and social/economic interaction.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Other Impacts	Medicinal plants and initiation schools.	Mutale River Water Resource Investigation: Situation Assessment, Management and Development Potential.
Flawed		

5.1.3 Environmental Impact

Site Information	
Co-ordinates	S22.74638 E30.61210
River	Mutale
Current Ecological Information	
Present Ecological State Class	Unmodified, Natural/Largely Natural
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 1

Wetland National Ecological Freshwater Priority Class	NFEPA wetlands downstream of the dam site.
South African Scoring System (SASS) for aquatic invertebrates	Good
Fish Assemblage Integrity Index (FAII)	Good
Riparian Vegetation Index (RVI)	Poor
River Health Category	Good

Potential Environmental Impacts

Except for the generic environmental impact that accompany most dams the following specific environmental impacts are of importance :

- The Tswera site lies near the middle of 40 km reach of the river, extending from the Rambuda Downstream site to Thengwe site, with slopes of the river channel being gentle. Channel slope and intensive land-use are reflected in riparian vegetation, consisting mainly of reeds and aquatic vegetation which is apparent within the river. This part of the river has rich avifauna. At the FSL the dam basin will extend upstream to within 8 km of the Rambuda Downstream site.
- Inundation of wetlands on Nyahalwe, Lumvulini and Mudaswali tributaries.
- Barrier to migratory fish species.
- The Tswera Dam will have an impact on the river channel and river biology between the dam and the gorge below the Thengwe site.
- The degree to which the operation of the Tswera dam may alter the river channel and the river biology between the dam and the gorge below the Thengwe site.
- There will be an impact on water quality and the predicted anaerobic condition of the hypolimnion.
- Changes in river temperatures and particulate matter below the dam can have biological impacts.

Environmental Classification

Pending more detailed investigations, the Tswera Dam site is given a **Caution** environmental classification owing to the stretch of wetlands which will be inundated by the dam.

Legal Requirements

A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following:

- National Environmental Management Act (Act No. 107 of 1998)
- National Water Act (Act No. 36 of 1998)
- National Heritage Resources Act (Act No. 25 of 1999)
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
- National Forests Act (Act No. 84 of 1998)

5.1.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 5.3 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 5.3: Breakdown of Capital Cost for Option Mu3 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 594.5 m	R 180,780,324.58
	Sub-Total (including P&G and Contingencies)	**R 180,780,324.58**
	Professional Fees (12% of Sub-Total)	R 21,693,638.95
	Social & Environmental (1% of Sub-Total)	R 1,807,803.25
	Cost of Infrastructure Replacement	R 0.00
	Cost of Land Acquisition and Relocation	R 282,974,839.86
	Total	**R 487,256,606.63**

5.1.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R 451,950.81	-	-

5.1.6 Yields

The following table comprises a summary of the yields used.

Table 5.4: Summary of Yields for Option Mu3

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
A new dam on the Mutale River • Tswera Dam	-	54	No EWR

5.1.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix C and summarised in Table 5.5. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 5.5: Summary of Present Values for Option Mu3

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	371,034,160	4,924,344	375,958,504
8%	340,240,836	3,448,541	343,689,378
10%	312,614,319	2,516,145	315,130,463

5.1.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix C and summarised in Table 5.6.

Table 5.6: Summary of Unit Reference Values for Option Mu3

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m^3)	URV Rand/m^3
6%	375,958,504	588.37	0.639
8%	343,689,378	412.04	0.834
10%	315,130,463	300.63	1.048

5.2 OPTION MU3 – RAMBUDA DAM (DOWNSTREAM SITE)

5.2.1 Engineering

The Rambuda Downstream Dam site is situated on the Mutale River, some 4 km downstream of the Rambuda Middle site. The nearest community is Dzimauli (Rambuda) to the north. The catchment area for the dam site is about 168 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 675 masl, and this will result in a gross storage capacity of 13.52 x 10^6 m^3 (approximately 23% of the natural MAR). The maximum height of the dam wall with a NOC at RL 680 will be 37 m and the total length of the dam wall will be 315 m.

Foundation excavation depths are expected to be approximately 2 m on the right flank, 5 – 8 m in the river section, and up to 15 m excavations will probably be needed in the slope debris on the left flank.

5.2.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 675 m. Calculations based on the maximum FSL suggests a total dam coverage of roughly 146 ha. The proposed site is currently utilised as bushveld - as set out in the table below.

Table 5.7: Rambuda Dam (Downstream Site) on the Mutale River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Bushveld or Open Space	146 ha
Total	**146 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly no signs of subsistence farming or small scale farming practices were found. Also no signs of large scale commercial farming practices or major irrigation systems were found. Based on these findings it is believed that there will be no significant macro-economic impact as a result of loss in land use – the loss in regional GDP and formal employment opportunities should be low given that there is no significant land use activities in the affected area. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Furthermore, even though there are no direct farming practices, almost a 150 ha of bushveld will be inundated. This has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is compromised.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. No settlements or scattered households are located within the proposed site and subsequently no households will have to be relocated.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding the construction site. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Rambuda Dam (Downstream site) the immediate area surrounding the proposed dam site is relatively sparsely populated yet roughly 14 small settlements and 3 900 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Rambuda and Tshivhase respectively. Also, Lake Funduzi, 7 km south-west of the proposed dam site is a historically significant site and big tourist attraction representing a central role in local history and beliefs. As far as can be determined, the Lake is not located in a broader protected or historically significant area. The proposed Rambuda Dam will not have a direct influence on Lake Funduzi and is also not located in other protected or historically significant areas. If the Lake is influenced in any way by the dam, local communities will resist the construction of the dam. Therefore, the whole process of building a dam close to such a significant feature should be carefully discussed and negotiated with local communities. Special mitigation plans and measures should be put in place to protect Lake Funduzi and the immediate area surrounding the Lake. Also, past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport (pedestrian routes) routes GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will not result in the loss of any access routes. It seems as if there are no pedestrian routes in the proposed dam site.

This water intervention option is therefore 'flagged' as being *Acceptable*. There are no significantly negative macro-economic, socio-economic, socio-cultural or infrastructural impacts. It should be noted that if Lake Funduzi is to be influenced in any negative way, this intervention option should be 'flagged' as being *Fatally Flawed*.

Table 5.8: Socio-Economic Impacts Summary – Rambuda Dam (Downstream Site) on the Mutale River

Impact	Impact Description	Data Source
New Economic Opportunities	Economic Opportunities – construction phase and operations phase.	Not Applicable.
Loss of Bushland and Grazing Land	Roughly 146 ha of bushland and grazing land will be lost. The dam site consists of mostly undisturbed bushland. Small areas of the proposed dam site are used for grazing purposes.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA - CSIR
Land Ownership	Tribal under custodianship of the Chiefs of Rambuda and Tshivhase respectively.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Protected Areas	Lake Funduzi 7 km south-west of the proposed dam site is a historically significant site representing a central role in local history and beliefs. The lake will not be influenced however caution should be taken during the construction phase. Lake must not be disturbed in any way, not during construction or operation.	Aerial Photography Google Earth
Acceptable		

5.2.3 Environmental Impact

Site Information	
Co-ordinates	S22.81408 E30.39581
River	Mutale
Current Ecological Information	
Present Ecological State Class	Unmodified, Natural/Largely Natural
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 1
South African Scoring System (SASS) for aquatic invertebrates	Good
Fish Assemblage Integrity Index (FAII)	Good

Riparian Vegetation Index (RVI)	Fair
River Health Category	Good
Potential Environmental Impacts	
Except for the generic environmental impact that accompany most dams the following specific environmental impacts are of importance : • Inundation of Mingerhout trees. This is a specially protected tree species in South Africa under the National Forests Act (Act No. 84 of 1998). • The dam will impact on the Mutale Southern Barred Minnow (a rare and endangered fish species which is found only in flowing water) population. The dam will inundate part of the restricted range of the distribution of the species, but it may survive in the Tshirovha and Mutale Rivers upstream of the dam basin. • Barrier to migratory fish species. • The Rambuda Dam will have an impact on the river channel and river biology between the dam and the gorge below the Thengwe site. • The impact on water quality and the predicted anaerobic condition of the hypolimnion. • Changes in river temperatures and particulate matter below the dam can have biological impacts.	
Environmental Classification	
Pending more detailed investigations, the Rambuda Dam site is given a **Caution** classification as a result of the population of rare and endangered Southern Barred Minnow that may vanish as a result of the dam.	
Legal Requirements	
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)	

5.2.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 5.9 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 5.9: Breakdown of Capital Cost for Option Mu3 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 675 m	R 226,585,761.80
	Sub-Total (including P&G and Contingencies)	**R 226,585,761.80**
	Professional Fees (12% of Sub-Total)	R 27,190,291.42
	Social & Environmental (1% of Sub-Total)	R 2,265,857.62
	Cost of Infrastructure Replacement	R 0.00
	Cost of Land Acquisition and Relocation	R 5,615,064.55
	Total	**R 261,656,975.38**

5.2.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R 566,464.40	-	-

5.2.6 Yields

The following table comprises a summary of the yields used.

Table 5.10: Summary of Yields for Option Mu3

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
A new dam on the Mutale River • Rambuda Dam (Downstream Site)	-	12.6	No EWR

5.2.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix D and summarised in Table 5.11. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 5.11: Summary of Present Values for Option Mu3

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	195,926,969	6,172,056	202,099,024
8%	178,651,581	4,322,320	182,973,900
10%	163,213,922	3,153,676	166,367,598

5.2.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix D and summarised in Table 5.12.

Table 5.12: Summary of Unit Reference Values for Option Mu3

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m^3)	URV Rand/m^3
6%	202,099,024	137.29	1.472
8%	182,973,900	96.14	1.903
10%	166,367,598	70.15	2.372

5.3 OPTION MU3 – THENGWE DAM

5.3.1 Engineering

The Thengwe Dam site is situated on the Mutale River, some 9.5 km downstream of its confluence with the Sambandou River. Relative to the Rambuda sites, the area is more densely inhabited with large areas of the flood plain upstream of the dam site under dry land cultivation. There are a number of communities close to the dam site, but those most likely to be flooded include Tshidzwi, Mukondeni and Tshanzhe and a number of smaller communities. The catchment area for the dam site is approximately 695 km^2.

Based on preliminary indications a mass gravity rollcrete dam with a central spillway was the dam type that was adopted for the purpose of initial comparison of this site with other selected dam sites. However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam investigated was taken to be at RL 554 masl, and this will result in a gross storage capacity of 115.9 x 10^6 m^3 (approximately 82% of the natural MAR). The maximum height of the dam wall with a NOC at RL 560 will be 27 m and the total length of the dam wall will be 180 m.

Both flanks are covered with a thin layer of talus, including fairly large quartzite blocks of up to 2 m in size. Excavations to slightly weathered, jointed bedrock, of approximately 2 m below surface are expected on both flanks depending on the talus thickness.

The river section is approximately 70 m wide with alluvial sands of 1 m thickness on the river banks and rock outcrop or boulders in the river channel. The quartzite outcrops are un-weathered and shallow excavations of up to 2 m are anticipated to reach the jointed bedrock.

5.3.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 554 m. Calculations on the maximum FSL suggests a total dam coverage of roughly 1 766 ha. The proposed site is currently utilised for cultivation, rural settlements and bushveld - as set out in the table below.

Table 5.13: Thengwe Dam on the Mutale River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	760 ha
Rural Settlements	70 ha
Bushveld	936 ha
Total	**1 766 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly an estimated 760 ha of cultivated land will be inundated which is mainly used by subsistence and small scale farmers for dryland cultivation. No signs of large scale commercial farming practices or major irrigation systems were found. Based on these findings it is believed that there will be no significant macro-economic impact as a result of loss in land use – the loss in regional GDP and formal employment opportunities should be low given the less formal nature of land use activities in the affected area. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Despite insignificant macro-economic impacts, the loss in land use will definitely have an immense impact on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. Furthermore, almost 1000 ha of bushveld will be inundated. This has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is compromised. The chances are slim for residents to be given alternative farmland due the scarcity and topography of the land as well as the extent of tribal communities in the area – tribes and traditional communities are culturally associated with a specific portion of land and any attempt to move them is likely to result in major upheavals. Mitigation measures addressing food security and livelihoods should be explored.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. A total of 4 rural settlements are located on the proposed dam site and will be partially inundated. Subsequently, an estimated 250 households and 70 ha of existing settlements will have to be relocated. The affected settlements include: Tshanzhe (100 of 200 households), Tshiozwi (75 of

95 households), Lurangwe (30 of 154 households), Mukondeni (5 of 73 households) and 40 scattered households. There are strong social, cultural and economic ties within any community, especially rural and tribal communities. Therefore communities or parts of communities cannot just be relocated – the community as a whole should be considered. The majority of Tshanzhe and Tshiozwi, for example, will have to be relocated with only a few households remaining. In this case an attempt should be made to keep the community together. In cases where only a few households are relocated, households should be relocated to somewhere in the existing community (infill-relocations) if possible. Densification strategies should also be considered where and if applicable. Relocations are always accompanied with high levels of social stress and upheavals and should therefore be considered carefully. The best relocation scenario should be chosen in order to minimise social, economic and cultural losses as well as community upheaval.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding construction sites. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Thengwe Dam the area surrounding the proposed dam site is densely populated. Roughly 28 small settlements and 4 500 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chief of Tshikundamalema and Chief Nethengwe NS. The Chief of Tshikundamalema's 'kraal /Musanda' will be inundated together with the royal graveyard (4 graves). Apart from the royal graveyard, it is likely that there are many more graves located on the site. The relocation of these graves will be difficult and will involve extensive negotiations. Part of the area within the proposed dam basin is also used to harvest scarce medicinal plants as well as to host initiation schools – an integral part of day-to-day living in the communities. The medicinal plants are apparently only found in this specific valley. Furthermore, the proposed dam has provoked great resistance from traditional leaders and communities in the past. Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will not result in the loss of major formalised access routes. However, smaller transport and pedestrian routes between communities and agricultural areas will be inundated. Communities and settlements in the north and south of the proposed dam will therefore be segregated. The degree of social and economic interaction between the different communities and between the communities and agricultural areas should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Lastly, the dam will have a positive socio-economic impact on households living in the broader Tshiombo-Thengwe valley, the Malonga Flats, the Mudaswali valley and Sambonou valley by ensuring that the future water needs of these households are met.

Given the potential socio-economic impacts this water intervention option is 'flagged' as being ***flawed***. Even though the intervention will provide water to households on a broader regional scale with low associated macro-economic costs, the socio-economic and socio-cultural costs will be very high and may prove difficult to mitigate.

Table 5.14: Socio-Economic Impacts Summary - Thengwe Dam on the Mutale River

Impact	Impact Description	Data Source
Loss of Agricultural Land	760 ha cultivated land will be inundated.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA - CSIR
Loss of Bushveld/Open Space	936 ha bushland used for grazing will be lost.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA - CSIR
Household Relocations	250 households; 4 settlements and 70 ha of these settlements will be partially inundated.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Land Ownership	Tribal Land.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database

Impact	Impact Description	Data Source
Loss in Income and Livelihoods	Food security and livelihood issues due to loss of agricultural land.	Inferred from land use and vegetation data.
New Employment Opportunities	Economic Opportunities – construction and operation phases.	Not Applicable.
Loss in Social and Economic Connections and Linkages	Communities to the north and south of the proposed dam will be segregated.	GIS Data depicting road networks - 2013 Aerial Photography Topographical Maps (1: 50 000)
Construction and Safety Issues	Area around dam is densely populated – many households will be disturbed during construction phase.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Other Impacts	Royal graveyard, Kraal, medicinal plants and initiation schools.	Mutale River Water Resource Investigation: Situation Assessment, Management and Development Potential of Water Resources (1999)
Flawed		

5.3.3 Environmental Impact

Site Information	
Co-ordinates	S22.67434 E30.70296
River	Mutale
Current Ecological Information	
Present Ecological State Class	Unmodified, Natural/Largely Natural
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 1
South African Scoring System (SASS) for aquatic invertebrates	Good
Fish Assemblage Integrity Index (FAII)	Good
Riparian Vegetation Index (RVI)	Good

River Health Category	Good
Potential Environmental Impacts	
Except for the generic environmental impact that accompany most dams the following specific environmental impacts is of importance : • The Thengwe site lies at the downstream end of a 40 km reach of the river, extending from approximately Rambuda downstream site to Thengwe site, in which the slope of of the river channel is gentle. Channel slope and intensive land-use are reflected in the riparian vegetation, consisting mainly of reeds, and the aquatic vegetation which is apparently within the river. This part of the river has rich avifauna. At FSL the dam basin will extend 15 km upstream of the dam. Leaving some 25 km of the reach not impacted. Thengwe Dam will only impact the lower part of the reach of the river. • The Thengwe site is the upper limit of distribution of true lowveld fish species in the Mutale River. The dam will therefore not interfere with longitudinal migrations of the interesting group of fish. • Prevention of fish passage of non-Lowveld fish species. • Inundation of fairly large wetland north of Mangaya. • The fact that the dam site is immediately above a gorge, in which the river channel has an increased gradient, means that, should anaerobic water be released, re-aeration of water in the river downstream will be rapid. • The water quality due to the depth of the predicted anaerobic conditions of the hypolimnion represents a threat; which can however be overcome through the careful design and operation of the Dam. • There will be changes in the temperature of the river downstream and in the particulate matter below the dam. This can result in biological changes.	
Environmental Classification	
Pending further detailed site specific studies and from the present knowledge of the river ecosystem it is concluded that a dam at Thengwe will be **Apparently Acceptable**, given that mitigation measures is put in place to mitigate the impacts on the river below the dam. A managed flow regime will also require careful planning considering that there is a long gorge below the dam.	
Legal Requirements	
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)	

5.3.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 5.15 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 5.15: Breakdown of Capital Cost for Option Mu3 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 554 m	R 100,356,739.46
	Sub-Total (including P&G and Contingencies)	**R 100,356,739.46**
	Professional Fees (12% of Sub-Total)	R 12,042,808.74
	Social & Environmental (1% of Sub-Total)	R 1,003,567.39
	Cost of Infrastructure Replacement	R 0.00
	Cost of Land Acquisition and Relocation	R 205,926,388.94
	Total	**R 319,329,504.53**

5.3.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R 250,891.85	-	-

5.3.6 Yields

The following table comprises a summary of the yields used.

Table 5.16: Summary of Yields for Option Mu3

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	-	51	No EWR

5.3.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix E and summarised in Table 5.17. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 5.17: Summary of Present Values for Option Mu3

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	243,626,027	2,733,655	246,359,682
8%	223,548,697	1,914,392	225,463,089
10%	205,527,583	1,396,790	206,924,372

5.3.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix E and summarised in Table 5.18.

Table 5.18: Summary of Unit Reference Values for Option Mu3

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m^3)	URV Rand/m^3
6%	246,359,682	555.68	0.443
8%	225,463,089	389.15	0.579
10%	206,924,372	283.93	0.729

6 MIDDLE AND KLEIN LETABA RIVER CATCHMENT AREA

6.1 OPTION MKL3 – REPLACEMENT OF MIDDLE LETABA DAM TO NSAMI DAM TRANSFER CANAL WITH A PIPELINE

6.1.1 Engineering

This option entails the replacement of the existing transfer canal between the Middle Letaba and Nsami Dams with a pipeline. The scheme will comprise a pump station and rising main (800 mm ND x 6.7 km) from the dam to a local high point and a gravity pipeline (1000 mm ND x 33.3 km) from the high point to the Nsami Dam.

The 60 km long transfer canal from Middle Letaba Dam to Nsami Dam was constructed as part of a regional water supply scheme developed by the former Gazankulu Homeland Authority, in the late nineteen seventies to early nineteen eighties to supply both domestic and irrigation water requirements to the communities in Giyani and surrounding areas. Since its inception the domestic water supply area has extended to include villages beyond the Klein Letaba River catchment area, including villages far to the south of Giyani on the banks of the Groot Letaba River, and to the north-west in the Luvuvhu River Catchment area.

The construction of a new pipeline to replace the transfer canal from Middle Letaba Dam to Nsami Dam in order to reduce transmission losses, thereby increasing the availability of water in the Middle and Klein Letaba catchment area, was considered at a reconnaissance level of detail in 2003. **[18]**

A provisional estimate of canal losses through seepage and evaporation was made based on a theoretical design loss of 1 ℓ/s per 1000 m^2 of wetted canal area. A potential saving in canal losses of 4 x 10^6 m^3/a was assumed in the 2003 reconnaissance study. **[18]** Replacement of the transfer canal by a pipeline was determined to be most cost effective of all the options that were considered. However, the quantity of water that can be saved should be verified by actual field measurements.

A preliminary route selection was done taking into consideration the location of existing irrigation abstraction points along the transfer canal. Although the proposed 40 km pipeline falls a total of 32 m from Middle Letaba Dam to Nsami Dam WTW, it was decided to first pump the water through a 6.7 km rising main up to a local high point in order to obtain more head so that a smaller diameter gravity main can be used and to have sufficient pressure in the gravity main to minimise pumping costs in the irrigation system.

The design flow rate was taken as 900 ℓ/s, based on the summer peak demand of the existing water treatment works at Nsami Dam (with no provision for extensions to the works) as well as a peak irrigation demand to supply the requirements of 1 000 ha. The proposed diameters of the rising main and the gravity main are 800 mm and 1 000 mm respectively.

The capacity (0.9 m^3/s) of the recommended pipeline is much lower than the existing canal capacity of 4 m^3/s. This is due to the recent yield estimations for Middle Letaba Dam which is significantly less than the initial estimations. The lower yield is confirmed by the poor and low water supply assurance from this dam over the years, resulting in a large reduction in the irrigated area in comparison with the originally envisaged irrigation development. Due to this limited and low assurance of water supply received from Middle Letaba Dam over the years, the reducing trend of the irrigation area still continues. It is possible that the required capacity of this pipeline can in future be reduced even further, resulting in a lower cost and increased viability of this option.

6.1.2 Social and Economic Impacts

The construction of a new pipeline to replace the transfer canal from Middle Letaba to Nsami Dam is aimed at reducing transmission losses, thereby increasing the availability of water in the catchment area.

According to preliminary designs, the proposed pipeline will have no macro-economic, socio-economic, socio-cultural or infrastructural impacts given that the pipeline will be routed along the existing canal. Employment opportunities may however be created during the construction phase as well as long term operation.

This water intervention option is therefore ‘flagged’ as being *Acceptable*.

Table 6.1: Socio-Economic Impacts Summary – Middle Letaba and Nsami Dam Pipeline

Impact	Impact Description	Data Source
Employment Opportunities	Economic Opportunities – construction and operation phases.	Not Applicable.
Acceptable		

6.1.3 Environmental Impact

Potential Environmental Impacts
In reviewing the route for the pipeline the following environmental impacts are of importance: • Vegetation clearance for pipeline construction. • The canal is currently resulting in loss of water as result of evaporations, spillages and damage to the canal due to animals. Replacing the canal with pipeline will decrease the loss of water. • Current route of the pipeline does not cross any protected areas. Detailed walk down of the route will however be required to identify any protected vegetation species that will need to be relocated. • The pipeline crosses a number of drainage lines and mitigation measures will be required during construction to minimise the impact of construction on these crossings.
Environmental Classification
Most of the impact resulting from the pipeline will be expected to be of low significance and the pipeline route is classified as **<u>Apparently Acceptable</u>**.

Legal Requirements
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)

6.1.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 6.2 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 6.2: Breakdown of Capital Cost for Option MKL3 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Pump Station Q = 900 l/s (28 x 10^6 m³/a) Pumping Period = 24 hours/day	R 36,514,635.33
2	Rising Main L = 6.7 km Dia = 800 mm	R 37,655,987.89
3	Break Pressure Tank (Utilize Existing Infrastructure, i.e. Scott's Camp Balancing Tank)	R 0.00
4	Gravity Main L = 33.3 km Dia = 1000 mm	R 194,354,183.18
	Sub-Total (including P&G and Contingencies)	**R 268,524,806.39**
	Professional Fees (12% of Sub-Total)	R 32,222,976.77
	Social & Environmental (1% of Sub-Total)	R 2,685,248.06
	Cost of Infrastructure Replacement	R 0.00
	Cost of Land Acquisition and Relocation	R 0.00
	Total	**R 303,433,031.22**

6.1.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical	Major Overhaul every 15 years
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**	**15% of initial capital cost of pump and motor (60% Mechanical Capital Cost)**
R 27,385.98	R 730,292.71	R 292,117.08	R 1,643,158.59
R 188,279.94			
R 971,770.92			

6.1.6 Yields

The following table comprises a summary of the yields used.

Table 6.3: Summary of Yields for Option MKL3

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Replacement of Middle Letaba Dam – Nsami Dam transfer canal with a pipeline	-	28.38	No EWR

6.1.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix F and summarised in Table 6.4. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 6.4: Summary of Present Values for Option MKL3

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	234,423,034	77,410,424	311,833,458
8%	215,347,585	55,233,735	270,581,320
10%	198,234,078	41,046,254	239,280,332

6.1.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix F and summarised in Table 6.5.

Table 6.5: Summary of Unit Reference Values for Option MKL3

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m³)	URV Rand/m³
6%	311,833,458	327.77	0.951
8%	270,581,320	233.87	1.157
10%	239,280,332	173.80	1.377

6.2 OPTION MKL5 – CRYSTALFONTEIN DAM WITH PUMPING SCHEME AND GRAVITY PIPELINE TO MIDDLE LETABA WTW

6.2.1 Engineering

The Crystalfontein Dam site is situated on the Klein Letaba River approximately 2.5 km upstream of its confluence with the Middle Letaba River and about 4 km north-east of the Middle Letaba Dam. The dam site is near the community of Sundani. The catchment area for the dam site is approximately 1 119 km^2.

The scheme comprises a pump station (Q = 328 l/s, pumping period = 24 hrs/d) and rising main (500 mm ND x 1.3 km) from the dam to a break-pressure tank on the catchment divide and a gravity pipeline (500 mm ND x 3.0 km) from the divide to the water treatment works.

A composite dam type, comprising a RCC structure in the river section accommodating a 170 m long spillway and outlet works, a RCC non-overspill section on the left flank and an earthfill embankment on the right flank was considered for this site in the reconnaissance study. **[18]** However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL of the largest dam that was considered is at RL 521 masl, and this will result in a gross storage capacity of 96 x 10^6 m^3 (approximately 303% of the natural MAR). The maximum height of the dam wall with a NOC at RL 526 will be 28 m and the total length of the dam wall will be approximately 1 300 m.

According to findings of the preliminary geological investigations foundation excavations are expected to be approximately 4 m to 5 m deep on the left flank, 3 m to 4 m in the alluvium riverbed and up to 4 m on the right flank.

A section of the eastern Cahora Bassa power line in the dam basin will require realignment. The reservoir of the proposed dam will inundate part of the tarred provincial road to Elim. A new 10 km road and a new bridge across the Klein Letaba River will have to be constructed. A number of major services along the existing road, including a 350 mm diameter steel rising main and Telkom optic fibre cables, will also have to be re-routed.

6.2.2 Social and Economic Impacts

The impact assessment is based on a maximum FSL of 521 m (rounded to 520 m). Calculations based on the maximum FSL suggests a total dam coverage of roughly 1 022 ha. The proposed site is currently utilised for cultivation and bushveld - as set out in the table below.

Table 6.6: Crystalfontein Dam on the Klein Letaba River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	362 ha
Cultivated – Woodland	41 ha
Bushveld or Open Space	619 ha
Total	**1 022 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly no signs of large scale commercial farming practices or major irrigation systems were found. Based on these findings it is believed that there will be no significant macro-economic impacts as a result of loss in land use – the loss in regional GDP and formal employment opportunities should be low given that there is no significant land use activities in the affected area. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Furthermore, even though there are no commercial farming practices, almost a 362 ha of subsistence and/or small scale farming practices and 619 ha of bushland will be inundated. The loss in land use will have significant negative impacts on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. The inundation of bushveld has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is predisposed.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. No settlements or scattered households are located within the proposed site and subsequently no households will have to be relocated. The closest settlements are between 100 m and 600 m away from the proposed site. These settlements include: Ndengeza LCH, Nwamatatane and Ntsuki.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding the construction site. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Crystalfontein Dam the immediate area surrounding the proposed dam site is relatively sparsely populated yet roughly 10 small settlements and 11 800 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Khomanani and Davhana respectively Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations. There are no other significant socio-cultural impacts.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical maps (1: 50 000) were utilised. The investigation showed that the construction of the proposed dam will result in the inundation of the R578 including several smaller roads as well as pedestrian routes. Communities and settlements will be segregated. The degree of social and economic interaction between the different communities and between the communities and agricultural areas should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Apart from the Dam, the scheme also consists of a rising main from the dam to a break-pressure tank on the catchment divide and a gravity pipeline from the divide to the water treatment works. According to the preliminary designs the pipeline will be routed through undeveloped areas and will therefore have little to no negative impacts.

This water intervention option is therefore ‘flagged’ as being *Apparently Acceptable*. Even though the intervention does not have major negative macro-economic or socio-cultural impacts with no relocations that have to take place, the influence of the dam on livelihoods and survivalist strategies will be significant.

Table 6.7: Socio-Economic Impacts Summary – Crystalfontein Dam on the Klein Letaba River

Impact	Impact Description	Data Source
Loss of Agricultural Land	403 ha agricultural land will be inundated (362 ha subsistence + 41 ha cultivated; woodland).	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR

Impact	Impact Description	Data Source
New Economic Opportunities	Economic Opportunities – construction phase and operations phase.	Inferred from land use and vegetation data.
Loss in employment opportunities, income and livelihoods	Loss of employment, income and livelihoods due to loss of agricultural land.	Inferred from land use and vegetation data.
Construction and Safety Issues	Area around dam is densely populated – many households will be disturbed during construction phase.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Land Ownership	Tribal Land/Traditionally Owned.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Loss in social and economic connections	The R578 and several smaller roads will be partially or fully inundated. Settlements are also segregated by means of the dam site.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Apparently Acceptable		

6.2.3 Environmental Impact

Site Information	
Co-ordinates	S23.25002 E30.43575
River	Klein Letaba
Current Ecological Information	
Present Ecological State Class	Moderately Modified
Limpopo Critical Biodiversity Area Class	Critical Biodiversity Area 2
South African Scoring System (SASS) for aquatic invertebrates	Fair

Fish Assemblage Integrity Index (FAII)	Poor
Riparian Vegetation Index (RVI)	Fair
River Health Category	Fair

Potential Environmental Impacts

Except for the generic environmental impact that accompany most dams the following specific environmental impacts is of importance :

- The dam will probably exhibit weak stratification in summer and light wind will probably mix the water column. It is estimated that the average temperature will be about 24°C with a summer maximum of about 30°C and in winter minimum of about 17°C.
- Weak water quality differences between surface and bottom water as result of weak summer stratification.
- The dam will have an impact on sediment loads and turbidity downstream. The interception and storage of the flow of sediment are universal impacts of dams. This can have the following impact downstream :
    - Water with reduced sediment loads and increased erosive capacity is discharged, so that material immediately downstream is transported away without being replaced. This will result in changes to channel morphology.
    - The interruption of sediment deposition processes can lead to reduced nutrient inputs to downstream habitats and an alteration in the light regime of the river.
    - The dam releases can contain higher quantities of organic particulates which may ultimately influence the biotic communities and biological integrity of the river.
- Increase in salinity as result of evaporation.
- Increase in water clarity.
- Impact on back erosion and establishment of marginal vegetation.

Environmental Classification

Pending further detailed site specific studies and from the present knowledge of the river ecosystem it is concluded that a dam at Crystalfontein will be **Apparently Acceptable**, given that mitigation measures is put in place to mitigate the impacts on the river below the dam.

Legal Requirements

A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following:

- National Environmental Management Act (Act No. 107 of 1998)
- National Water Act (Act No. 36 of 1998)
- National Heritage Resources Act (Act No. 25 of 1999)
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
- National Forests Act (Act No. 84 of 1998)

6.2.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 6.8 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 6.8: Breakdown of Capital Cost for Option MKL5 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 521 m	R 343,940,947.02
2	Pump Station Q = 328 l/s Pumping Period = 24 hours/day	R 3,609,850.68
3	Rising Main L = 1.3 km Dia = 500 mm	R 3,236,299.91
4	Gravity Main L = 3.0 km Dia = 500 mm	R 7,468,384.41
	Sub-Total (including P&G and Contingencies)	**R 358,255,482.02**
	Professional Fees (12% of Sub-Total)	R 42,990,657.84
	Social & Environmental (1% of Sub-Total)	R 3,582,554.82
	Cost of Infrastructure Replacement	R 82,683,211.06
	Cost of Land Acquisition and Relocation	R 23,778,178.34
	Total	**R 511,290,084.09**

6.2.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical	Major Overhaul every 15 years
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**	**15% of initial capital cost of pump and motor (60% Mechanical Capital Cost)**
R 859,852.37			
R 2,707.39	R 72,197.01	R 28,878.81	R 162,443.28
R 16,181.50			
R 37,341.92			

6.2.6 Yields

The following table comprises a summary of the yields used.

Table 6.9: Summary of Yields/Water Demands for Option MKL5

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Construction of a new dam on the Klein Letaba River • Crystalfontein Dam	-	6 5.4	No EWR EWR included

6.2.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix G and summarised in Table 6.10. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 6.10: Summary of Present Values for Option MKL5

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	363,147,214	13,673,549 13,324,086	376,820,764 376,471,300
8%	325,935,114	9,217,764 8,982,013	335,152,878 334,917,127
10%	293,344,672	6,479,175 6,313,363	299,823,847 299,658,035

6.2.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix G and summarised in Table 6.11.

Table 6.11: Summary of Unit Reference Values for Option MKL5

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m³)	URV Rand/m³
6%	376,820,764 376,471,300	58.18 52.36	6.476 7.189
8%	335,152,878 334,917,127	39.25 35.33	8.539 9.481
10%	299,823,847 299,658,035	27.61 24.85	10.861 12.061

6.3 OPTION MKL5 – MAJOSI DAM WITH FLOOD DIVERSION CANAL TO MIDDLE LETABA DAM

6.3.1 Engineering

The Majosi Dam site is situated on the Klein Letaba River approximately 12 km west of its confluence with the Middle Letaba River and about 8 km north-west of the Middle Letaba Dam. The dam site is near the community of Ka-Majosi. The catchment area for the dam site is about 942 km^2.

A weir or small dam is to be built at Majosi to divert water flowing in the Klein Letaba River into the basin of the Middle Letaba Dam. It was assumed that the dam water level will not remain for long periods above FSL and that the water from the canal will discharge above FSL. The canal will have to cross the catchment watershed and a deep open cut will be required.

The canal is 12.5 km long and being unlined, a flat slope of 1 in 8 800 was selected to minimize flow velocities (for scour) and simultaneously maintain an acceptable velocity to minimize sediment depositions. The flow velocity at 5 m^3/s will be 0.4 m/s. To be able to utilize the yield in a dam at Majosi, the invert level of the canal at the head of the works should be below the FSL. The canal was provisionally sized to have a bottom width of 1 m, side slope of 1V:3H and be at least 2.2 m deep. The design also included culverts. The Majosi Dam FSL was provisionally selected at 538.5 m and the canal capacity at 5 m^3/s.

A composite dam type, comprising a RCC structure in the river section and earthfill embankments on both flanks was considered for this site in the reconnaissance study. **[18]** However, this should be reviewed should further investigations be carried out as other dam types can result in lower costs. The FSL that was considered is at RL 538.5 masl, and this will result in a gross storage capacity of 29 x 10^6 m^3 (approximately 115% of the natural MAR). The maximum height of the dam wall with a NOC at RL 543 will be 22 m. From the preliminary geological investigations estimated foundation excavation depths are 3.5 m cut-off beneath the fluvial deposits on the lower left bank, a cut-off depth of 2.5 m on the right bank and upper left bank, and 1 m beneath the shell footprint. The river section will require excavation down to 2 m to expose good rock over the whole area.

The canal has to cross the existing tarred provincial road to Elim and also pass through the village of Ntsuki. Allowance was made for ten bridges crossing the canal, for human and stock access, as well as the relocation of the village of Ntsuki.

If this option is pursued, the canal breaching risk should be evaluated and suitable measures taken to minimise it.

6.3.2 Social and Economic Impacts

The impact assessment is based on a provisionally selected FSL of 538.5 m (rounded to 540 m). Calculations based on the selected FSL suggest a total dam coverage of roughly 461 ha. The proposed site is currently utilised as open bushveld with some cultivation - as set out in the table below.

Table 6.12: Majosi Dam with Flood Diversion Canal on the Klein Letaba River – Current Land Use of Proposed Site

Land Use	Extent (Area)
Cultivated Land – Subsistence and small scale farming	100 ha
Bushveld	361 ha
Total	**461 ha**

Topographical maps (1:50 000) and aerial photography together with GIS data depicting land use and vegetation types were utilised to identify the loss in land use together with the subsequent socio-economic impacts. Accordingly no signs of large scale commercial farming practices or major irrigation systems were found. Based on these findings it is believed that there will be no significant macro-economic impacts as a result of loss in land use – the loss in regional GDP and formal employment opportunities should be low given that there is no significant land use activities in the affected area. The construction of the dam will certainly create temporary employment opportunities in the region but whether members of the local community will be used as construction workers or not, depends on the local skills base, community interests and construction terms and conditions. Furthermore, even though there are no commercial farming practices, almost a 100 ha of subsistence and/or small scale farming practices and 361 ha of bushland will be inundated. The loss in land use will have significant negative impacts on local residents depending (directly or indirectly) on subsistence and small scale farming practices. The large amount of cultivated land to be lost will have a major impact on local food security; the ability of residents to survive and create a decent livelihood will be severely curtailed. The inundation of bushveld has major implications for households owning livestock. In rural and tribal areas most households own livestock that is dependent on bushveld for grazing. By taking away the little land available, the core existence of these households is compromised.

In order to determine which settlements will be inundated and the number of households to be relocated, GIS data depicting settlements in the area and Eskom Spot Building Counts for 2012 were used in addition to the topographical maps (1:50 000) and aerial photography. No settlements fall within the proposed dam basin and no households will have to be relocated.

The construction of dams takes extended periods of time and tends to have a disrupting effect on communities and local residents surrounding the construction site. Such impacts include: movement of construction vehicles in and around settlements, noise pollution, air pollution as well as increased safety hazards due to the higher volume of people in the area (crime, road safety). The same data used to determine the relocations are used to determine the number of households that will potentially be affected by the construction of the dam. In the case of the Majosi Dam the area surrounding the dam is very densely populated. Roughly 14 small settlements and 14 000 households are located within a 5 km radius of the construction site. The households will most definitely be influenced, directly, indirectly and to different degrees, by the construction of the dam. Where possible mitigation measures should be implemented to reduce the potential impact on communities; this may include routing construction vehicles away from rural settlements, informing communities about the safety hazards involved and attempt to limit noise pollution to acceptable times during the day.

Based on GIS data depicting tribal land in South Africa it was determined that the proposed dam site is located on tribal land and under custodianship of the Chiefs of Khomanani, Tiyani and Bungeni respectively. Past experience proved that the relocation of tribal communities can be extremely difficult and involve lengthy negotiations. There are no other significant socio-cultural impacts.

The loss of or re-routing of infrastructure, especially access roads and other transport routes (pedestrian routes) can have major social and economic impacts on affected communities – this includes increased transport cost and travel time, the segregation of communities, the breaking up of community ties, social and economic interaction. Pedestrian movement plays an integral role in the day to day lives of rural communities. Without pedestrian routes and connections, most rural dwellers will not be able to move around. In order to identify access roads and other transport routes, GIS data depicting road networks, aerial photography and topographical Maps (1: 50 000) were utilised. No significant access roads will be inundated. However, smaller transport routs will be inundated and communities and settlements will be segregated. The degree of social and economic interaction between the different communities and between the communities and agricultural areas should be explored in order to determine the magnitude of social and economic costs. Mitigation measures should ensure that accessibility to social and economic facilities is not undermined in any way.

Apart from the Weir, the scheme also consists of a diversion canal diverting water from the Majosi Weir (Klein Letaba River) to the Middle Letaba Dam. The provisional routing of the canal suggests a total length of 12.5 km with a proposed slope of 1 in 8 800. Given the provisional routing, the canal will pass through at the Ntsuki settlement. The canal will also intersect several roads and transport routes. Initial designs do however make provision for ten bridges crossing the canal, for human and stock access. The exact economic and social cost resulting in the segregation of the settlement and the restriction of movement due to the canal should be considered carefully. The above mentioned impacts can however be mitigated through careful planning and design and should therefore have little to no long term impacts. Apart from crossing the settlement, the canal will pass through open bushveld utilised for grazing as well as through cultivated areas utilised by subsistence farmers. However, the canal will not be more than 10m wide resulting in an insignificant loss of land. Therefore the challenges associated with the canal will be linked to access and the restriction of movement rather than a loss of land. Also, routing an open canal through a settlement will risk the safety of children and domestic animals. Furthermore, the canal will also be located on tribal land. Most of the challenges mentioned above can be mitigated if the canal is routed around the existing settlement. Lastly, the construction of the canal will certainly create employment opportunities in the region.

This water intervention option is therefore ‘flagged’ as being Apparently Acceptable. Even though the intervention will have a negative impact on the livelihoods and survivalist strategies of some members of the community, the agricultural potential that can result from the dam may have major positive impacts in the community and broader region. Macro-economic costs, socio-economic and socio-cultural costs are also relatively insignificant or non-existing.

Table 6.13: Socio-Economic Impacts Summary – Majosi Dam with Flood Diversion Canal on the Klein Letaba River

Impact	Impact Description	Data Source
Loss of Agricultural Land	100 ha of agricultural land will be inundated and 361 ha open bushveld.	Topographical Maps (1:50 000) Aerial Photography GIS data depicting Land Use in SA - CSIR GIS data depicting Vegetation in SA – CSIR
New Economic Opportunities	Economic Opportunities – construction and operation phases.	Not Applicable.
Loss in employment opportunities, income and livelihoods	Livelihoods influence due to loss in cultivated land utilised for subsistence farming.	Inferred from land use and vegetation information.
Construction and Safety Issues	Area around dam is densely populated – many households will be disturbed during construction phase. The open canal will cause major safety risks for children and animals, especially when running through a settlement.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Restricting Movement	The canal will restrict movement and segregate settlements. This is however partially mitigated by making provision for bridges.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Land Ownership	Tribal Land/Traditionally custodianship.	GIS Data depicting tribal land in SA – Limpopo Traditional Authority Database
Loss in Social and Economic connections	Several small roads will be partially or fully inundated. Settlements are also segregated by means of the dam site.	Eskom Spot Building Counts 2012 GIS Data depicting all settlements in the area - DWAF Aerial Photography Topographical Maps (1: 50 000)
Apparently Acceptable		

6.3.3 Environmental Impact

The scheme comprises a small dam or weir at the Majosi site with a canal to divert water from the Klein Letaba River to the Middle Letaba Dam.

The environmental impacts of the construction of a dam at the Majosi site are assessed below.

<table>
<tr><th colspan="2">Site Information</th></tr>
<tr><td>Co-ordinates</td><td>S23.24394 E30.33928</td></tr>
<tr><td>River</td><td>Klein Letaba</td></tr>
<tr><th colspan="2">Current Ecological Information</th></tr>
<tr><td>Present Ecological State Class</td><td>Moderately Modified</td></tr>
<tr><td>Limpopo Critical Biodiversity Area Class</td><td>Critical Biodiversity Area 2</td></tr>
<tr><td>South African Scoring System (SASS) for aquatic invertebrates</td><td>Fair</td></tr>
<tr><td>Fish Assemblage Integrity Index (FAII)</td><td>Poor</td></tr>
<tr><td>Riparian Vegetation Index (RVI)</td><td>Fair</td></tr>
<tr><td>River Health Category</td><td>Fair</td></tr>
<tr><th colspan="2">Potential Environmental Impacts</th></tr>
<tr><td colspan="2">Except for the generic environmental impact that accompany most dams the following specific environmental impacts are of importance :
• The loss of natural vegetation as a result of flooding and the further loss of natural habitat from the relocation of residence and infrastructure to a new site.
• The dam will have an impact on sediment loads and turbidity downstream. The interception and storage of the flow of sediment are universal impacts of dams. This can have the following impact downstream:
o Water with reduced sediment loads and increased erosive capacity is discharged, so that material immediately downstream is transported away without being replaced. This will result in changes to channel morphology.
o The interruption of sediment deposition processes can lead to reduced nutrient inputs to downstream habitats and an alteration in the light regime of the river.
o The dam releases can contain higher quantities of organic particulates which may ultimately influence the biotic communities and biological integrity of the river.</td></tr>
<tr><th colspan="2">Environmental Classification</th></tr>
<tr><td colspan="2">Pending further site specific studies and from the present knowledge of the river ecosystem it is concluded that a dam at Majosi will be <u>Apparently Acceptable</u>, given that mitigation measures is put in place to mitigate the impacts on the river below the dam.</td></tr>
</table>

Legal Requirements
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)

The impacts of a canal diverting water at this site from the Klein Letaba River to the Middel Letaba Dam are assessed below:

Potential Environmental Impacts
Except for the generic impact of canal developments the following specific impacts may occur: • The vegetation in the area is classified as Granite Lowveld. The conservation status of this type of vegetation is vulnerable. More than 20% of this type of vegetation is already transformed by cultivation and settlement development. Vegetation clearance will be required for canal construction. • The canal can result in loss of water as result of evaporations, spillages and damage to the channel due to animals. • Current proposed route option will not cross any protected areas. Detailed walk down of the final route will however be required to identify any protected vegetation species that will need to be relocated.
Environmental Classification
Most of the impact resulting from the canal will be expected to be of low significance and the canal is classified as **Apparently Acceptable**.
Legal Requirements
A summary of all legislation pertaining to the proposed development and the permitting thereof, are contained below. This legislation includes, but is not limited to the following: – National Environmental Management Act (Act No. 107 of 1998) – National Water Act (Act No. 36 of 1998) – National Heritage Resources Act (Act No. 25 of 1999) – National Environmental Management: Biodiversity Act (Act No. 10 of 2004) – National Forests Act (Act No. 84 of 1998)

6.3.4 Total Capital Costs

The Bills of Quantities of previously investigated studies were used. Table 6.14 indicates the total capital costs at January 2014 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 6.14: Breakdown of Capital Cost for Option MKL5 (VAT Excluded)

Item No.	Description	Amount (excl. VAT) Base Date Jan 2014
1	Dam FSL = 538.5 m	R 261,268,131.73
2	Canal	R 50,361,400.30
	Sub-Total (including P&G and Contingencies)	**R 311,629,532.03**
	Professional Fees (12% of Sub-Total)	R 37,395,543.84
	Social & Environmental (1% of Sub-Total)	R 3,116,295.32
	Cost of Infrastructure Replacement	R 43,881,547.31
	Cost of Land Acquisition and Relocation	R 22,048,856.28
	Total	**R 418,071,774.78**

6.3.5 Operation and Maintenance Costs

Annual operation and maintenance (O&M) costs are based on percentages of capital cost as shown below:

Civil	Mechanical	Electrical
0.5% of Pipeline Cost 0.25% of Civil Pump Station Cost 0.25% of Dam Cost	**4% of Mechanical Pump Station Cost**	**4% of Electrical Pump Station Cost**
R 653,170.33	-	-
R 251,807.00	-	-

6.3.6 Yields

The following table comprises a summary of the yields used.

Table 6.15: Summary of Yields for Option MKL5

Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Construction of a new dam on the Klein Letaba River • Majosi Dam	-	5.5 4.6	No EWR EWR included

6.3.7 Discounted Present Values

The present value (PV) calculations are detailed in Appendix H and summarised in Table 6.16. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 6.16: Summary of Present Values for Option MKL5

Discount Rate (%)	Capital	O&M	Total Discounted Costs
6%	294,169,616	8,775,728	302,945,344
8%	263,232,106	5,920,174	269,152,280
10%	236,212,914	4,163,866	240,376,780

6.3.8 Unit Reference Values

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV calculations are detailed in Appendix H and summarised in Table 6.17.

Table 6.17: Summary of Unit Reference Values for Option MKL5

Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m^3)	URV Rand/m^3
6%	302,945,344	53.33 44.61	5.680 6.791
8%	269,152,280	35.98 30.09	7.481 8.944
10%	240,376,780	25.31 21.16	9.499 11.357

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 SELECTED INTERVENTION OPTIONS

The identified intervention options that were adopted for further assessment after the preliminary screening workshop, calculation of water demands and yield analyses are listed in Table 7.1.

Table 7.1: Selected Intervention Options

Catchment Area	Intervention Option	Description of Intervention Option
Luvuvhu Main Catchment Area	Option Lu8	Paswane Dam on Mutshindudi River
	Option Lu9	Xikundu Dam on Luvuvhu River
Mutale River Catchment Area	Option Mu3	A new dam on the Mutale River • Tswera Dam • Rambuda Dam (d/s site) • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)
Middle and Klein Letaba River Catchment Area	Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline
	Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline • Majosi Dam with flood diversion canal

7.2 YIELDS/WATER DEMANDS

The following table comprises a summary of the yields used.

Table 7.2: Summary of Yields/Water Demands

Intervention Option	Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Option Lu8	Paswane Dam on Mutshindudi River	55	43	No EWR
Option Lu9	Xikundu Dam on Luvuvhu River	62.5	51	No EWR
Option Mu3	A new dam on the Mutale River • Tswera Dam	-	54	No EWR

Intervention Option	Description of Intervention Option	Stochastic Yield (million m³/a)	Historic Firm Yield (million m³/a)	Note
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	-	12.6	No EWR
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	-	51	No EWR
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	-	28.38	No EWR
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	-	6 5.4	No EWR EWR included
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	-	5.5 4.6	No EWR EWR included

7.3 DISCOUNTED PRESENT VALUES

The present value (PV) calculations are summarised in Table 7.3. The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2014.

Table 7.3: Summary of Present Values

Intervention Option	Description of Intervention Option	Discount Rate (%)	Capital	O&M	Total Discounted Costs
Option Lu8	Paswane Dam on Mutshindudi River	6%	280,308,425	7,963,968	288,272,394
		8%	251,392,415	5,372,555	256,764,969
		10%	226,069,279	3,778,706	229,847,986
Option Lu9	Xikundu Dam on Luvuvhu River	6%	338,388,611	10,186,775	348,575,386
		8%	303,304,165	6,872,077	310,176,242
		10%	272,589,526	4,833,373	277,422,899

Intervention Option	Description of Intervention Option	Discount Rate (%)	Capital	O&M	Total Discounted Costs
Option Mu3	A new dam on the Mutale River • Tswera Dam	6%	371,034,160	4,924,344	375,958,504
		8%	340,240,836	3,448,541	343,689,378
		10%	312,614,319	2,516,145	315,130,463
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	6%	195,926,969	6,172,056	202,099,024
		8%	178,651,581	4,322,320	182,973,900
		10%	163,213,922	3,153,676	166,367,598
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	6%	243,626,027	2,733,655	246,359,682
		8%	223,548,697	1,914,392	225,463,089
		10%	205,527,583	1,396,790	206,924,372
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	6%	234,423,034	77,410,424	311,833,458
		8%	215,347,585	55,233,735	270,581,320
		10%	198,234,078	41,046,254	239,280,332
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	6%	363,147,214	13,673,549 13,324,086	376,820,764 376,471,300
		8%	325,935,114	9,217,764 8,982,013	335,152,878 334,917,127
		10%	293,344,672	6,479,175 6,313,363	299,823,847 299,658,035
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	6%	294,169,616	8,775,728	302,945,344
		8%	263,232,106	5,920,174	269,152,280
		10%	236,212,914	4,163,866	240,376,780

7.4 UNIT REFERENCE VALUES

The unit reference values (URV) have been determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV's are summarised in Table 7.4.

Table 7.4: Summary of Unit Reference Values

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Costs	Total Discounted Use (million m³)	URV Rand/m³
Option Lu8	Paswane Dam on Mutshindudi River	6%	288,272,394	416.98 533.34	0.691 0.540
		8%	256,764,969	281.30 359.80	0.913 0.714
		10%	229,847,986	197.85 253.06	1.162 0.908
Option Lu9	Xikundu Dam on Luvuvhu River	6%	348,575,386	494.56 606.07	0.705 0.575
		8%	310,176,242	333.63 408.86	0.930 0.759
		10%	277,422,899	234.65 287.57	1.182 0.965
Option Mu3	A new dam on the Mutale River • Tswera Dam	6%	375,958,504	588.37	0.639
		8%	343,689,378	412.04	0.834
		10%	315,130,463	300.63	1.048
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	6%	202,099,024	137.29	1.472
		8%	182,973,900	96.14	1.903
		10%	166,367,598	70.15	2.372
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	6%	246,359,682	555.68	0.443
		8%	225,463,089	389.15	0.579
		10%	206,924,372	283.93	0.729
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	6%	311,833,458	327.77	0.951
		8%	270,581,320	233.87	1.157
		10%	239,280,332	173.80	1.377
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	6%	376,820,764 376,471,300	58.18 52.36	6.476 7.189
		8%	335,152,878 334,917,127	39.25 35.33	8.539 9.481
		10%	299,823,847 299,658,035	27.61 24.85	10.861 12.061
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	6%	302,945,344	53.33 44.61	5.680 6.791
		8%	269,152,280	35.98 30.09	7.481 8.944
		10%	240,376,780	25.31 21.16	9.499 11.357

7.5 SOCIAL AND ECONOMIC IMPACTS

The social and economic impacts of the selected intervention options are summarised in Table 7.5.

Table 7.5: Socio-Economic Impacts Summary

Intervention Option	Description of Intervention Option	Classification
Option Lu8	Paswane Dam on Mutshindudi River	**Apparently Acceptable**
Option Lu9	Xikundu Dam on Luvuvhu River	**Apparently Acceptable**
Option Mu3	A new dam on the Mutale River • Tswera Dam	**Flawed**
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	**Acceptable**
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	**Flawed**
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	**Acceptable**
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	**Apparently Acceptable**
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	**Apparently Acceptable**

7.6 ENVIRONMENTAL IMPACT

The environmental classification of the selected intervention options are summarised in Table 7.6.

Table 7.6: Environmental Impacts Summary

Intervention Option	Description of Intervention Option	Classification
Option Lu8	Paswane Dam on Mutshindudi River	**Apparently Acceptable**
Option Lu9	Xikundu Dam on Luvuvhu River	**Apparently Acceptable**
Option Mu3	A new dam on the Mutale River • Tswera Dam	**Caution**
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	**Caution**

Intervention Option	Description of Intervention Option	Classification
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	**Apparently Acceptable**
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	**Apparently Acceptable**
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	**Apparently Acceptable**
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	**Apparently Acceptable**

7.7 RECOMMENDATIONS

7.7.1 Luvuvhu Main Catchment Area

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m³)	URV Rand/m³	Classification	
					Socio-Economic	Environmental
Option Lu8	Paswane Dam on Mutshindudi River	6%	416.98 533.34	0.691 0.540	Apparently Acceptable	Apparently Acceptable
		8%	281.30 359.80	0.913 0.714		
		10%	197.85 253.06	1.162 0.908		
Option Lu9	Xikundu Dam on Luvuvhu River	6%	494.56 606.07	0.705 0.575	Apparently Acceptable	Apparently Acceptable
		8%	333.63 408.86	0.930 0.759		
		10%	234.65 287.57	1.182 0.965		

Both intervention options for the Luvuvhu Main Catchment Area received classifications of Apparently Acceptable for Social-Economic and Environmental Impacts. From an engineering economic point of view, Option Lu8 – Paswane Dam on the Mutshindudi River, is the recommended way forward, i.e. lowest Unit Reference Value (URV).

7.7.2 Mutale River Catchment Area

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m³)	URV Rand/m³	Classification	
					Socio-Economic	Environmental
Option Mu3	A new dam on the Mutale River • Tswera Dam	6%	588.37	0.639	Flawed	Caution
		8%	412.04	0.834		
		10%	300.63	1.048		
Option Mu3	A new dam on the Mutale River • Rambuda Dam (d/s site)	6%	137.29	1.472	Acceptable	Caution
		8%	96.14	1.903		
		10%	70.15	2.372		
Option Mu3	A new dam on the Mutale River • Thengwe Dam on Lower Mutale (specifically to satisfy mining demands)	6%	555.68	0.443	Flawed	Apparently Acceptable
		8%	389.15	0.579		
		10%	283.93	0.729		

From the table above it is evident that the intervention option with the lowest Unit Reference Value (URV) is the Proposed Thengwe Dam on the Lower Mutale. Given the potential socio-economic impacts this water intervention option is 'flagged' as being ***flawed***. Even though the intervention will provide water to households on a broader regional scale with low associated macro-economic costs, the socio-economic and socio-cultural costs will be very high and may prove difficult to mitigate.

The intervention option for the Mutale River Catchment Area that will be feasible in terms of its classifications for Social-Economic and Environmental Impacts is the option with the highest URV, the Rambuda Dam (d/s site).

It is recommended that further investigations are conducted before a decision can be made on which option to implement.

7.7.3 Middle and Klein Letaba River Catchment Area

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m³)	URV Rand/m³	Classification	
					Socio-Economic	Environmental
Option MKL3	Replacement of Middle Letaba Dam to Nsami Dam transfer canal with a pipeline	6%	327.77	0.951	Acceptable	Apparently Acceptable
		8%	233.87	1.157		
		10%	173.80	1.377		

Intervention Option	Description of Intervention Option	Discount Rate (%)	Total Discounted Use (x 10^6 m^3)	URV Rand/m^3	Classification	
					Socio-Economic	Environmen-tal
Option MKL5	Construction of a new dam on the Klein Letaba River • Crystalfontein Dam with pumping scheme and gravity pipeline	6%	58.18 52.36	6.476 7.189	Apparently Acceptable	Apparently Acceptable
		8%	39.25 35.33	8.539 9.481		
		10%	27.61 24.85	10.861 12.061		
Option MKL5	Construction of a new dam on the Klein Letaba River • Majosi Dam with flood diversion canal	6%	53.33 44.61	5.680 6.791	Apparently Acceptable	Apparently Acceptable
		8%	35.98 30.09	7.481 8.944		
		10%	25.31 21.16	9.499 11.357		

The most cost effective scheme is the replacement of the transfer canal by a pipeline. However, the quantity of water that may be saved should be verified in field surveys of actual canal sections.

Both proposed dam intervention options for the Middle and Klein Letaba River Catchment Area received classifications of Apparently Acceptable for Social-Economic and Environmental Impacts. From an engineering economic point of view the Majosi Dam with a flood diversion canal, is the recommended way forward, i.e. lowest Unit Reference Value (URV). The risk of the canal being breached when diverting water will be high if it is not regularly maintained and restored. When it is dry, the canal is likely to be damaged by livestock and humans crossing it by foot to avoid the longer walking distances to use the overpasses. A further aspect that requires careful consideration is that of safety, since the canal will be dry for long periods and may start to flow without warning and drownings may occur.

8 REFERENCES

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Appendices

Appendix A:

Option Lu8: Proposed Paswane Dam

Appendix B:

Option Lu9: Proposed Xikundu Dam

Appendix C:

Option Mu3: Proposed Tswera Dam

Appendix D:

Option Mu3: Proposed Rambuda Dam (d/s)

Appendix E:

Option Mu3: Proposed Thengwe Dam

Appendix F:

Option MKL3: Proposed Replacement of Canal with a Pipeline

Appendix G:

Option MKL5: Proposed Crystalfontein Dam

Appendix H:

Option MKL5: Proposed Majosi Dam with Flood Diversion Canal