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water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: OPTIONS ANALYSIS

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT

RECORD OF IMPLEMENTATION DECISIONS: NTABELANGA DAM AND ASSOCIATED INFRASTRUCTURE

OCTOBER 2014

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT

APPROVAL

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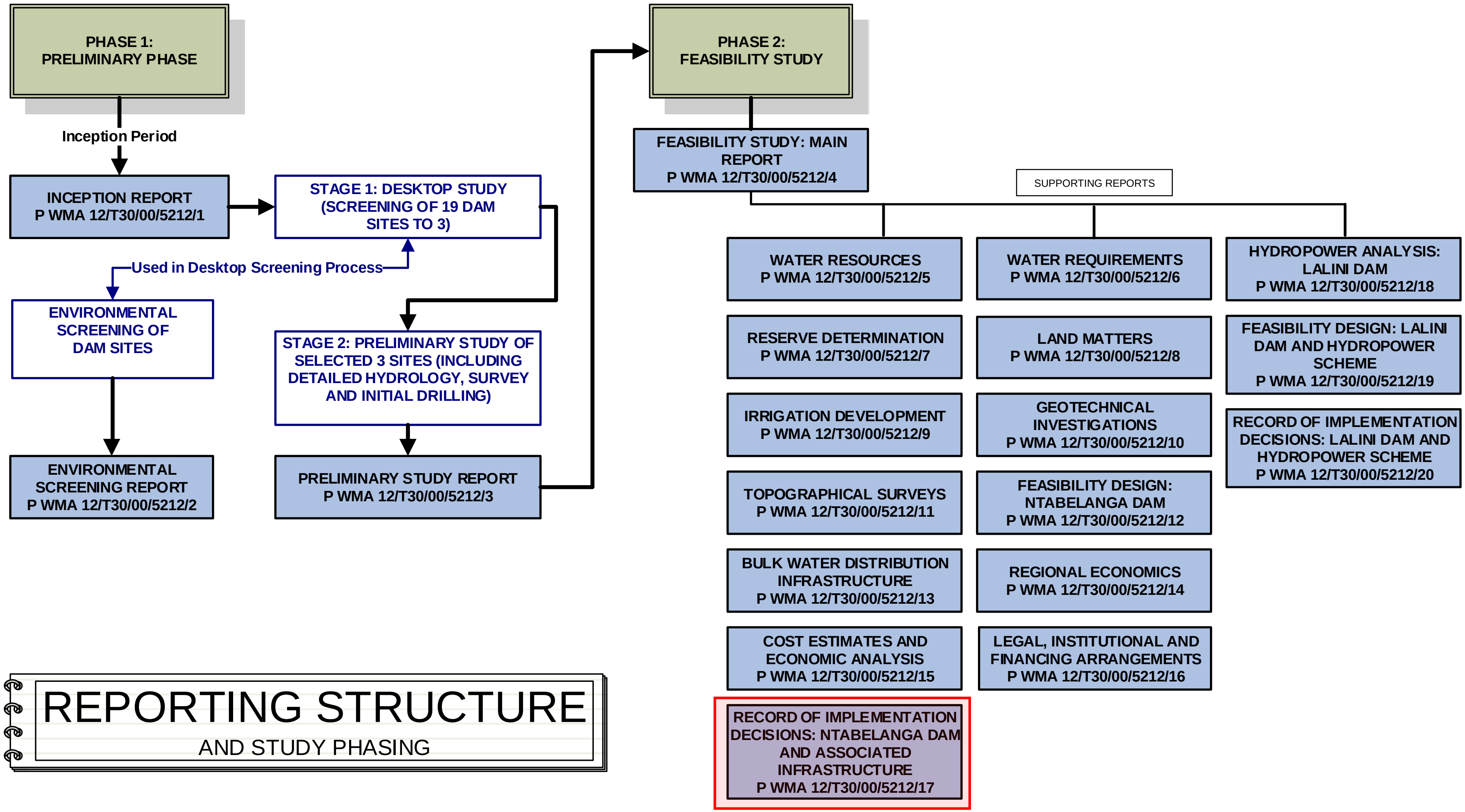
LIST OF REPORTS

REPORT TITLE	DWS REPORT NUMBER
Inception Report	P WMA 12/T30/00/5212/1
Environmental Screening	P WMA 12/T30/00/5212/2
Preliminary Study	P WMA 12/T30/00/5212/3
Feasibility Study: Main Report	P WMA 12/T30/00/5212/4
Volume 1: Report	
Volume 2: Book of Drawings	
FEASIBILITY STUDY: SUPPORTING REPORTS:	
Water Resources	P WMA 12/T30/00/5212/5
Water Requirements	P WMA 12/T30/00/5212/6
Reserve Determination	P WMA 12/T30/00/5212/7
Volume 1: River	
Volume 2: Estuary: Report	
Volume 3 :Estuary: Appendices	
Land Matters	P WMA 12/T30/00/5212/8
Irrigation Development	P WMA 12/T30/00/5212/9
Geotechnical Investigations	P WMA 12/T30/00/5212/10
Volume 1: Ntabelanga, Somabadi and Thabeng Dam Sites: Report	
Volume 2: Ntabelanga, Somabadi and Thabeng Dam Sites: Appendices	
Volume 3: Lalini Dam and Hydropower Scheme: Report	
Volume 4: Lalini Dam and Hydropower Scheme: Appendices	
Topographical Surveys	P WMA 12/T30/00/5212/11
Feasibility Design: Ntabelanga Dam	P WMA 12/T30/00/5212/12
Bulk Water Distribution Infrastructure	P WMA 12/T30/00/5212/13
Regional Economics	P WMA 12/T30/00/5212/14
Cost Estimates and Economic Analysis	P WMA 12/T30/00/5212/15
Legal, Institutional and Financing Arrangements	P WMA 12/T30/00/5212/16
Record of Implementation Decisions: Ntabelanga Dam and Associated Infrastructure	**P WMA 12/T30/00/5212/17**
Hydropower Analysis: Lalini Dam	P WMA 12/T30/00/5212/18
Feasibility Design: Lalini Dam and Hydropower Scheme	P WMA 12/T30/00/5212/19
Record of Implementation Decisions: Lalini Dam and Hydropower Scheme	P WMA 12/T30/00/5212/20

REPORTING STRUCTURE

AND STUDY PHASING



REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa (2014). ***Record of Implementation Decisions: Ntabelanga Dam and Associated Infrastructure***

DWS Report No: P WMA 12/T30/00/5212/17

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Note on Departmental Name Change:

In 2014, the Department of Water Affairs changed its name to the Department of Water and Sanitation, which happened during the course of this study. In some cases this was after some of the study reports had been finalized. The reader should therefore kindly note that references to the Department of Water Affairs and the Department of Water and Sanitation herein should be considered to be one and the same.

Note on Spelling of Laleni:

The settlement named Laleni on maps issued by the Surveyor General is locally known as Lalini and both names therefore refer to the same settlement.

TABLE OF CONTENTS

APPENDICES

FIGURES

TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

ASGISA-EC	Accelerated and Shared Growth Initiative for South Africa – Eastern Cape
CAPEX	Capital Expenditure
CFRD	Concrete-faced rockfill dam
CMA	Catchment Management Agency
CTC	Cost to Company
CV	Coefficient of Variability
DAFF	Department of Agriculture, Forestry and Fisheries
DBSA	Development Bank of Southern Africa
DEA	Department of Environment Affairs (National)
Dia.	Diameter
DM	District Municipality
DME	Department of Minerals and Energy
DoE	Department of Energy
DRDAR	Department of Rural Development and Agrarian Reform
DRDLR	Department of Rural Development and Land Reform
DWA	Department of Water and Sanitation
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EC	Eastern Cape
ECRD	Earth core rockfill dam
EF	Earthfill (dam)
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMP	Environmental Management Plan
EPWP	Expanded Public Works Programme
ESIA	Environmental and Social Impact Assessment
EWR	Environmental Water Requirements
FSL	Full Supply Level
GERCC	Grout enriched RCC
GMA	Gross margin analysis
GN	Government Notices
GW	Gigawatt
GWh/a	Gigawatt hour per annum
IAPs	Invasive Alien Plants
IB	Irrigation Board
IFC	International Finance Corporation
IPP	Independent Power Producer
IRR	Internal Rate of Return
IMRP	Integrated Water Resource Planning (Directorate)
IVRCC	Internally vibrated RCC
ISO	International Standards Organisation

kW	Kilowatt
LM	Local Municipality
ℓ/s	Litres per second
ℓ/c/d	Litres per capita per day
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MEC	Member of the Executive Council
MIG	Municipal Infrastructure Grant
MW	Megawatt
NEMA	National Environmental Management Act
NERSA	National Energy Regulator of South Africa
NHRA	National Heritage Resources Act
NOCL	Non-overspill crest level
NWA	National Water Act
NWPR	National Water Policy Review
NWRMS	National Water Resources Management Strategy
O&M	Operations and Maintenance
OPEX	Operational Expenditure
PES	Present Ecological Status
PICC	Presidential Infrastructure Co-ordinating Committee
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PSC	Project Steering Committee
PSP	Professional Services Provider
RBIG	Regional Bulk Infrastructure Grant
RCC	Roller-compacted concrete
RDF	Recommended Design Flood
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RID	Record of Implementation Decisions
RWI	Regional Water Institution
RWU	Regional Water Utilities
SAWS	South African Weather Service
SEF	Safety Evaluation Flood
SEZ	Special Economic Zone
SIP	Strategic Integrated Project
SMC	Study Management Committee
SPV	Special Purpose Vehicle
TCTA	Trans Caledon Tunnel Authority
TOR	Terms of Reference
UOS	Use of System
URV	Unit Reference Value
V_{50}	Sedimentation over 50 years

WEF	Water Energy Food
WRC	Water Research Commission
WRYM	Water Resources Yield Model
WSA	Water Services Authority
WSP	Water Services Provider
WTE	Water Trade Entity
WTW	Water treatment works
WUA	Water User Association
WWTW	Wastewater treatment works

LIST OF UNITS

Description	Standard unit
Elevation	m a.s.l.
Height	m
Distance	m, km
Dimension	mm, m
Area	m^2, ha or km^2
Volume (storage)	m^3
Yield, Mean Annual Runoff	m^3/a
Rotational speed	rpm
Head of Water	m
Pressure	Pa
Diameter	mm or m
Temperature	^oC

Description	Standard unit
Velocity, speed	m/s, km/hr
Discharge	m^3/s
Mass	kg, tonne
Force, weight	N
Gradient (V:H)	%
Slope (H:V) or (V:H)	1:5 (H:V) <u>or</u> 5:1 (V:H)
Volt	V
Power	W
Energy used	kWh
Acceleration	m/s^2
Density	kg/m^3
Frequency	Hz

1. BACKGROUND AND INTRODUCTION

The Mzimvubu River catchment in the Eastern Cape Province of South Africa is situated in one of the poorest and least developed regions of the country. Development of the area to accelerate the social and economic upliftment of the people was therefore identified as one of the priority initiatives of the Eastern Cape Provincial Government.

Harnessing the water resources of the Mzimvubu River, the only major river in the country which is still largely unutilised, is considered by the Eastern Cape Provincial Government as offering one of the best opportunities in the Province to achieve such development. In 2007, a special-purpose vehicle (SPV) called ASGISA-Eastem Cape (Pty) Ltd (ASGISA-EC) was formed in terms of the Companies Act to initiate planning and to facilitate and drive the Mzimvubu River Water Resources Development.

The five pillars on which the Eastern Cape Provincial Government and ASGISA-EC proposed to model the Mzimvubu River Water Resources Development are:

- Forestry;
- Irrigation;
- Hydropower;
- Water transfer; and
- Tourism.

The Department of Water and Sanitation (DWS) commissioned the Feasibility Study for the Mzimvubu Water Project with the overarching aim of developing water resources schemes (dams) that can be multi-purpose reservoirs in order to provide benefits to the surrounding communities and to provide a stimulus for the regional economy, in terms of irrigation, forestry, domestic water supply and the potential for hydropower generation amongst others.

The objective of the study was to screen and rank previously identified dam development options, and to select the best single option to be implemented first, using appropriate decision-making criteria. The scope of the study required that the selected single multi-purpose scheme be investigated to a feasibility level of detail, ready to be handed over for detailed design and implementation.

The resulting recommended scheme comprises the following:

A new dam at Ntabelanga on the Tsitsa River (a major tributary of the Mzimvubu River), with storage capacity sufficient to reliably supply the rawand potable water requirements to a planning horizon of the year 2050, for:

- some 726 616 people and other water consumers in the region,
- irrigation of some 2 868 ha of high potential agricultural land, including a bulk raw water distribution system to supply irrigation water to some 2 868 ha of high potential land,
- a new water treatment works at the Ntabelanga dam to supply the potable water requirements,
- primary and secondary bulk water distribution systems to deliver treated water in bulk to the whole supply area. From these bulk systems, tertiary distribution systems to the consumers will be implemented by the District Municipalities,and
- a hydropower plant at Ntabelanga Dam to generate up to 5 MW of power.

1.1 Additional Detailed Investigations for Lalini Dam and Hydropower Scheme

Further detailed investigations were undertaken for a second dam on the Tsitsa at Lalini (just above the Tsitsa Falls) which would be operated conjunctively with the Ntabelanga Dam to generate significant hydropower for supply into the national grid.

The Feasibility Design of the Lalini Dam and hydropower scheme is described in Report No. P WMA 12/T30/00/5212/19.

A separate Record of Implementation Decisions will be issued for this project component, as Report No. P WMA 12/T30/00/5212/20.

1.2 Project Locality

The Mzimvubu River Catchment is situated in the Eastern Cape (EC) Province of South Africa which consists of six District Municipalities (DM) namely Alfred Nzo, OR Tambo, Joe Gqabi, Cacadu, Chris Hani and Amathole, and two Metropolitan Municipalities (Buffalo City and Nelson Mandela Bay).

The Mzimvubu River Catchment is situated predominantly within three of these DM's, namely the Joe Gqabi DM in the north west, the OR Tambo DM in the south west and the Alfred Nzo DM in the east and north east.

A locality map of the whole catchment area and its position in relation to the DM's in the area is provided in Figure 1-1 overleaf.

As shown in Figure 1-2 the Ntabelanga Dam is located approximately 55 km north of Mthatha and 20 km east of Maclear in the Eastern Cape Province.

The dam is situated on the Tsitsa River (a tributary of the Mzimvubu River) which in turn is fed by the Mooi and Pot Rivers. A major tributary of the Tsitsa River, the Inxu River, flows into the Tsitsa River approximately 3 km downstream of the proposed dam location.

The dam catchment area of some 1970 km^2 consists of five quaternary catchments T35A, T35B, T35C, T35D and T35E, as depicted in Figure 1-3. This also shows deails and locations of relevant streamflow gauging stations.

The dam catchment area is partially developed, with approximately 10% of the catchment area under afforestation, 5% under subsistence agriculture and approximately 80% of the catchment under grasslands (National Land Cover (database) (NLC), 2000).

The average Mean Annual Precipitation (MAP) of the contributing catchment area was calculated to be 907 mm, based on the Design Rainfall Utility (Smithers and Schulze, 2000).

The Present Day Mean Annual Runoff (MAR_{PD}) of the river at the Ntabelanga Dam is 415 million m^3/a.

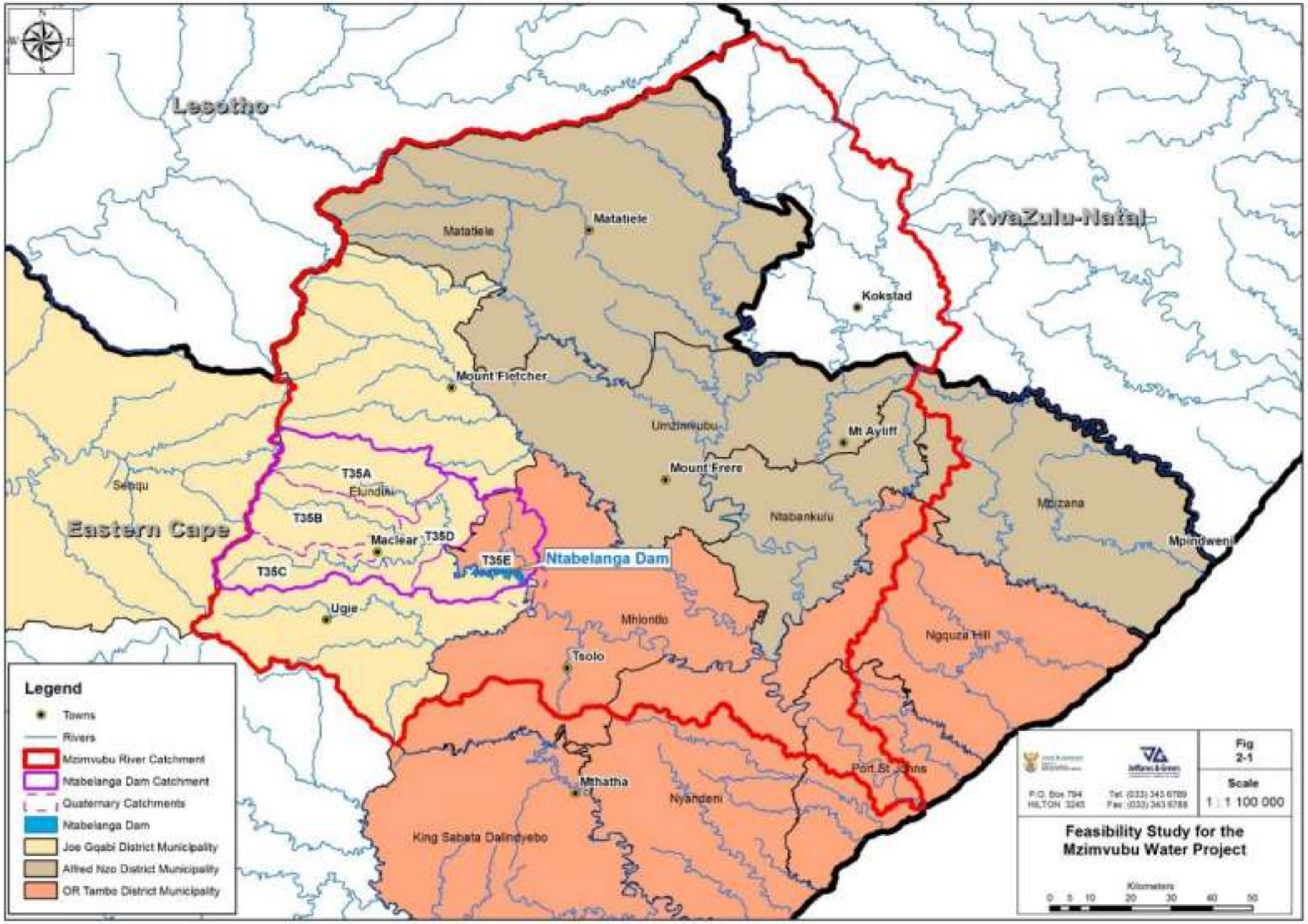


Figure 1-1: Locality of the Mzimvubu River and Ntabelanga Dam Catchments

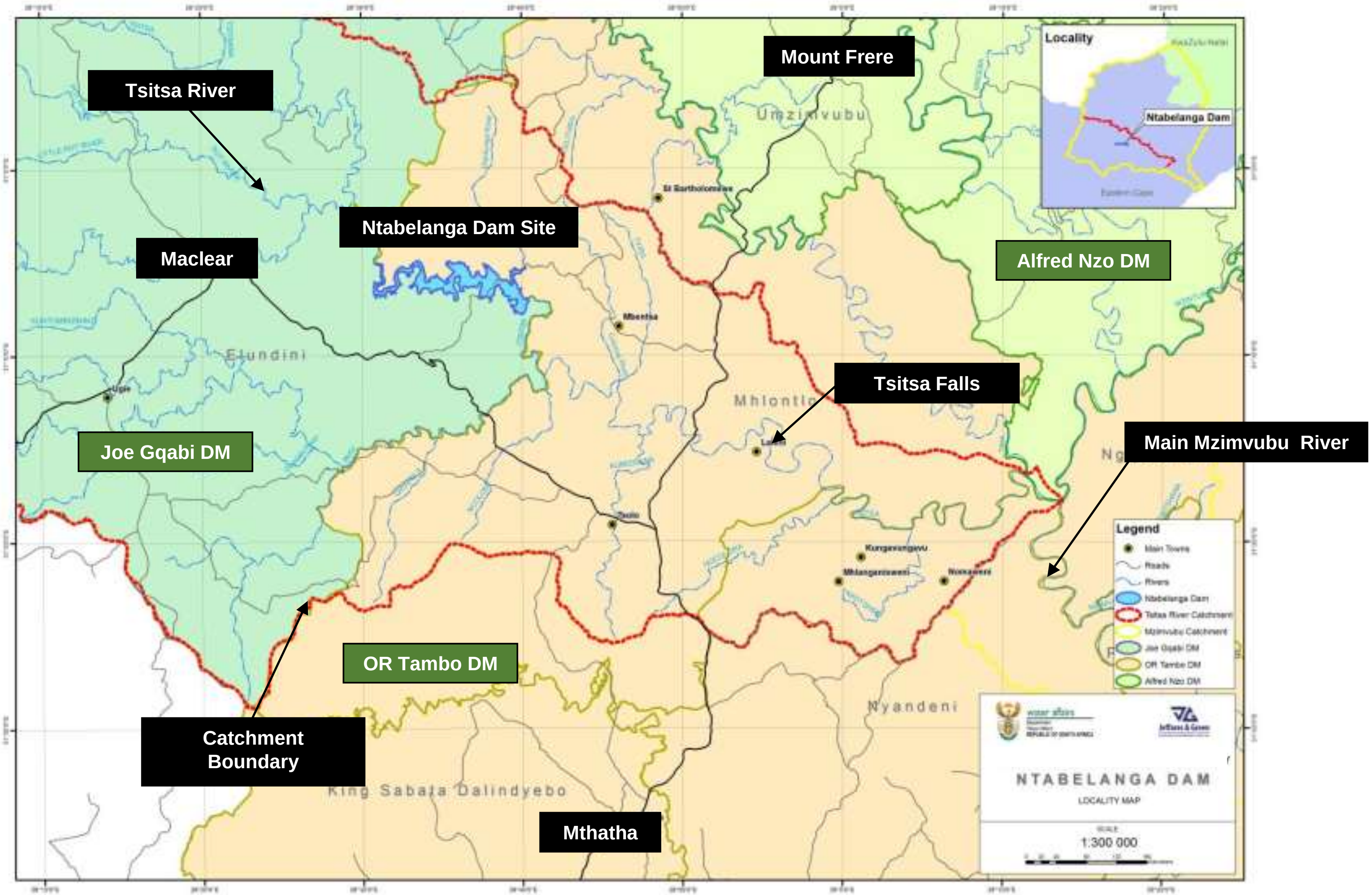


Figure 1-2: Location of Ntabelanga Dam

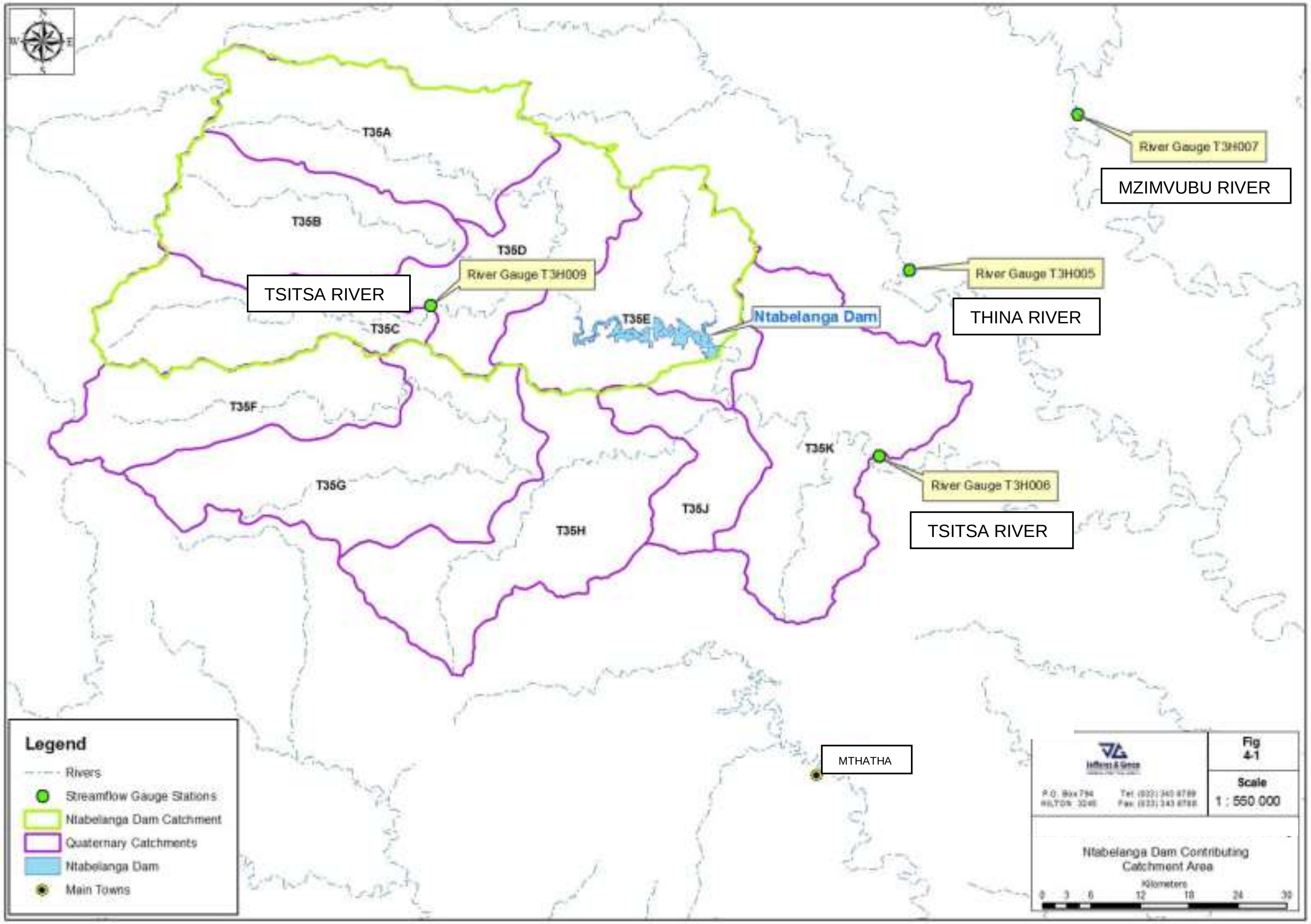


Figure 1-3: Ntabelanga Dam Contributing Catchment Areas

1.3 Scope of the Record of Implementation Decisions

A Memorandum of Agreement between the Chief Directorates Integrated Water Resource Planning (CD: IWRP) and Infrastructure Development (CD: ID) dated March 2005, clarifies "the division and/or sharing of roles, responsibilities and accountability of the Chief Directorates through the various project phases from planning to the commissioning of a project".

The Memorandum furthermore states that once the detail planning of the Project has been concluded and the scheme configuration and other related requirements for implementation have been approved by the Minister, the project shall be formally handed over by the CD: IWRP to the CD: ID for implementation. This formal handover of the project is concluded through an official document called the Record of Implementation Decisions (RID), and is signed off by responsible officials from both the CD: IWRP and the CD: ID.

The RID describes the scope of the project, the specific configuration of the scheme to be implemented, the required implementation timelines, the finalisation of required institutional arrangements and the required environmental mitigation measures as described in the Environmental Impact Report (EIR) as well as any further requirements that may be prescribed by the National Department of Environmental Affairs (DEA) in the Environmental Authorisation (EA).

Any work carried out outside of the scope of the RID is considered unauthorised work unless official approval for such work has been obtained from the CD: IWRP prior to such work being carried out. The powers of the CD: IWRP to authorise the extent of development is vested in the approval by the Minister. Anything beyond what was originally approved by the Minister then becomes unauthorised developments.

This document serves as the RID for the implementation of the Mzimvubu Water Project: Ntabelanga Dam and Associated Infrastructure and therefore concludes the formal handover of the project from CD: IWRP to CD: ID. The purpose of the RID is to enable the Department of Water and Sanitation (DWS) to implement the decisions taken on the basis of the recommendations of the Feasibility Study. In this regard the other Feasibility Study reports serve to support this document. The Feasibility Study reports are as listed above.

The RID should be read in conjunction with the original Feasibility Study reports as well as the Environmental Impact Report (EIR), the EA as issued by DEA, and the reserve determination study report, amongst others.

The Ministerial Approval is included as Appendix A.

The RID does not only deal with the construction of the physical infrastructure but also touches on other aspects that are required for the successful implementation of the project.

2. OVERVIEW OF THE PROJECT

2.1 Mzimvubu Feasibility Study

The Mzimvubu Feasibility Study commenced in January 2012 and was completed in October 2014 in three stages as follows:

- Inception;
- Phase 1 – Preliminary Study; and
- Phase 2 – Feasibility Study.

The purpose of the study was not to repeat or restate the research and analyses undertaken on the several key previous studies, but to make use of that information previously collected, to update and add to this information. The purpose was also to undertake more focussed and detailed investigations and feasibility level analyses for the dam site options identified as being the most promising and cost beneficial.

2.1.1 Inception Stage

The aim of the Inception stage was to finalise the Terms of Reference (TOR) as well as to include, inter alia, the following:

- A detailed review of all the data and information sources available for the assignment;
- A revised study methodology and scope of work;
- A detailed review of the proposed project schedule, work plan and work breakdown structure indicating major milestones;
- Provision of an updated organogram and human resources schedule, and
- Provision of an updated project budget and monthly cash flow projections.

The Inception Phase culminated in the production of an Inception Report (DWS Report Number P WMA 12/T30/00/5212/1) which also constituted the final TOR for the study.

2.2 Screening of Alternative Development Options

2.2.1 Preliminary Study Phase

The Preliminary Report describes the activities undertaken during the preliminary study phase, summarizes the findings and conclusions, and provides recommendations for the way forward and scope of work to be undertaken during the Feasibility Study phase.

The Preliminary Study Phase was divided into two stages:

i. Desktop Study, and
ii. Preliminary Study.

The aim of the desktop study was, through a process of desktop review, analyses of existing reports and data, and screening, to determine the three best development options from the pre-identified 19 development options (from the previous investigation).

The aim of the preliminary study was to gather more information with regard to the three selected development options as well as to involve the Eastern Cape Provincial Government and key stakeholders in the process of selecting the single best development option to be taken forward into Phase 2 of the study.

The main activities undertaken during the second stage of Phase 1 were as follows:

- Stakeholder involvement;
- Environmental screening;
- Water requirements (including domestic water supply, irrigation and hydropower);
- Hydrological investigations;
- Geotechnical investigations;
- Topographical survey investigations; and
- Selection process.

The three development options that were investigated were multi-purpose dams and associated infrastructure at the following dam sites:

- Ntabelanga on the Tsitsa River (a tributary of the Mzimvubu River)
- Thabeng on the Kinira River (a tributary of the Mzimvubu River)
- Somabadi on the Kinira River (a tributary of the Mzimvubu River)

The multi-purpose usage of all three dam options included regional bulk potable water supplies, irrigated agriculture, and hydropower.

An extensive investigation of the water requirements, cost-benefits, social upliftment and impacts was undertaken as well as a multi-criteria decision-making process and the resulting choice of preferred option was that at Ntabelanga Dam site.

The findings and recommendations from the screening of Alternative Development Options are described in the Preliminary Study Report No. P WMA 12/T30/00/5212/3.

Preliminary Environmental Screening was also carried out at this stage, and a Terms of Reference for the full Environmental Impact Assessment Study was prepared. This is described in the Environmental Screening Report No. P WMA 12/T30/00/5212/2.

The Preliminary Study recommended Ntabelanga as the preferred dam site and scheme development to be taken forward to Feasibility Study level.

3. DETAILED PLANNING STAGE

3.1 Planning Processes

The key activities undertaken during the feasibility study were as follows:

- Detailed hydrology (over and above that undertaken during the Preliminary Study);
- Reserve determination;
- Water requirements investigation (including agricultural and domestic water supply investigations);
- Topographical survey (over and above that undertaken during the Preliminary Study);
- Geotechnical investigation (more detailed investigations than during the Preliminary Study);
- Dam feasibility design;
- Irrigation Development;
- Bulk Potable and Irrigation Water Distribution feasibility design;
- Hydropower analysis;
- Land matters;
- Public participation;
- Regional economics;
- Cost Estimates and Economic Analysis, and
- Legal, institutional and financial arrangements.

An Environmental Impact Assessment was undertaken in a separate study that was undertaken in parallel to the technical feasibility study.

The above activities are described in more detail in the Main Report No. P WMA 12/T30/00/5212/4 and are summarised herein.

The multi-purpose usages and requirements for the Ntabelanga Dam are described in the Water Requirements Report No. P WMA 12/T30/00/5212/6, and the Irrigation Development Report No. P WMA 12/T30/00/5212/9.

The conjunctive hydropower scheme for the Ntabelanga and Lalini Dams is described in the Hydropower Analysis: Lalini Dam Report No. P WMA 12/T30/00/5212/18, the Feasibility Design: Lalini Dam and Hydropower Scheme Report No. P WMA 12/T30/00/5212/19, and the Record of Implementation Decisions: Lalini Dam and Hydropower Scheme Report No. P WMA 12/T30/00/5212/20.

3.2 Reserve Determination

An Intermediate Reserve Determination for the Tsitsa/Mzimvubu River system was completed in 2013 as a component of this project. This study focused on the riverine and estuarine ecological water requirements (EWR), including a socio-economic assessment of the catchment-wide flow scenarios. EWRs were determined for two sites, namely the selected riverine EWR site below the proposed Ntabelanga Dam site on the Tsitsa River and the estuarine EWR site on the Mzimvubu River.

The water resources of the Tsitsa River at the EWR site is currently in a C category (moderately modified state), mainly due to water quality impacts (a result of increased sedimentation in the system), and localised disturbances (e.g. alien invasive plants and concomitant bank erosion). The system has a moderate Ecological Importance and Sensitivity. The overall confidence in these results is medium.

The Reserve Determination Report No. P WMA 12/T30/00/5212/7 determines the Environmental Water Requirements (EWR) to be released downstream of the dam.

The recommended total releases are those required to maintain an intermediate ecological Class C of 87.249 million m^3 per annum, which equates to an average of some 7.27 million m^3 per month, or 2.8 m^3/s.

The EWR is actually required to be released according to a seasonal pattern and this also depends on whether the river is in a status of flood or drought. EWR release rules are proposed in the Reserve Determination Report, and release criteria are based upon preceding inflows.

3.3 Water Requirements

3.3.1 Water Quality and Treatment Requirements

No water quality sampling or testing was undertaken as part of the feasibility study.

It is recommended that an ongoing programme of sampling and testing be implemented immediately to provide sufficient information to inform the detailed design of the water treatment works.

Based upon the nature and land use of the catchment upstream of the dam, the water treatment processes required to reduce the contaminant levels to comply with SANS 241:2006 would typically include processes to deal with the following:

- Possibly iron,
- Possibly manganese,
- Possible nitrates and phosphates,
- Turbidity,
- Suspended solids,
- Microbiological characteristics, and
- Disinfection.

It is expected that, after debris screening and grit removal, conventional settlement processes will be sufficient to deal with such sediment load and turbidity. Selection of the best coagulant will be undertaken after appropriate laboratory testing of water samples.

The depth of water in the dam will create thermal stratification in the body of water impounded. The outlet works are designed such that water can be drawn off from the dam at different levels based upon the monitored limnology conditions, in order to obtain the best quality water given the seasonal and depth variations that occur in normal dam operation.

It is recommended that reservoir stratification modelling be undertaken during the operation stage so that, in conjunction with reserve determination specialists, a set of operating rules can be established taking cognisance of the EWR requirements, and optimum drawoff elevations can be established.

It is recommended that an ongoing water quality sampling and testing programme be implemented immediately so that an assessment of contaminants can be made, as well as potential nutrient sources identification to determine whether filamentous algae might become a problem.

The catchment area is known to have some of the highest sediment loadings in Southern Africa given the soil types, steep topography, eroded nature of the terrain, and the overgrazed, thinly layered soils, contributing a high percentage thereof.

The rivers in the catchment have been the subject of some recent studies by WRC and Rhodes University, and do exhibit very high sediment loads and turbidity levels. The dam itself will act as a significant sediment trap and settlement basin resulting in a very significant reduction in the suspended solids and turbidity of water entering the water treatment works.

This emphasises the importance of undertaking a concerted catchment restoration and management programme in the catchment above the dam, both before construction and continuing into the future. DEA started a 10 year catchment rehabilitation programme in April 2014.

3.3.2 Domestic Water Requirements

The investigations of domestic water requirements to be supplied by the Ntabelanga Dam included a process of consultation with stakeholders throughout the feasibility study, and, in particular, taking cognisance of the regional water planning undertaken by the three DMs responsible for water services in this area – OR Tambo, Alfred Nzo, and Joe Gqabi. These three DMs appointed Amatola Water to be their implementation agent in this regard, and the planning of the water requirements and bulk infrastructure was undertaken in conjunction with them. The supply area was split into four zones for infrastructure planning purposes, primarily based upon the topographical nature of the terrain. Details of the supply zones can be found in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13. The project supply area and zone boundaries are as shown in Figures 3-1 and 3-2.

The four supply zone boundaries are determined by the settlements that can be supplied predominantly by gravity from each of the four main command reservoirs and secondary reservoirs. This includes the villages located within and adjacent to the dam basin that would be inundated by the dam reservoir. It is important that these communities, that would be the most affected by the scheme, should be given special consideration as regards the provision of potable water supply and sanitation facilities.

The population to be serviced by the water supply schemes emanating from the construction of the Ntabelanga Dam is depicted in Table 3-1.

Table 3-1: Populations to be Supplied by the Ntabelanga Dam

	Population				
	2013	**2020**	**2030**	**2040**	**2050**
Zone 1	39 404	42 247	46 667	51 549	56 942
Zone 2	288 234	309 026	341 357	377 071	416 521
Zone 3	147 195	157 813	174 324	192 562	212 708
Zone 4	27 988	30 007	33 147	36 615	40 445
Total	**502 822**	**539 094**	**595 495**	**657 797**	**726 616**

The Ntabelanga dam and its bulk water distribution infrastructure will be able to supply the following:

- All existing communities shown on the figures above, comprising a total of 502 822 people in 102 723 households as at 2013; and
- Population growth projections to year 2050, bringing the total population supplied to 726 616 in 148 443 households

The water demand projections used for water requirements assessment include supplying some communities with existing water supplies (including groundwater, river abstractions and springs) and the demand projections are therefore maximum figures.

Cognisance must be taken when developing the water treatment works and distribution systems that some existing schemes will continue to operate independently and others would be integrated into the new system.

This should be taken into account as the distribution systems are “rolled out”, and in many cases these existing schemes will be in need of refurbishment or replacement.

Consequently, consideration is made for staging the development of certain key components such as the water treatment works and pumping stations, as well as the strategic bulk storage reservoirs. This does not apply to the dam itself, as there is no benefit in phasing in its capacity.

The design criteria used for the development of the scheme are:

- Domestic water requirement - rural - 60 litres/capita/day (ℓ/c/d)
- Domestic water requirement – urban - 125 ℓ/c/d
- Allowance for transmission losses - 10%
- Allowance for water treatment works losses - 5%
- Summer peak factor for bulk - 1.2 x Annual Average Daily Demand
- Bulk water transfer pipelines peak factor - 1.2 (20 hours pumping per day)
- Population growth rate - 1% per annum

The summer peak factor and bulk water requirement peak factors are standards per the DWS’s “Technical Guidelines for the Development of Water and Sanitation Infrastructure” and the “Guidelines for Development of Human Settlements Planning and Design” prepared by the Department of Housing.

The populations and households to be supplied are distributed between the District Municipalities, as shown in Table 3-2.

Table 3-2: Population and Households Supplied

POPULATION					
	2013	**2020**	**2030**	**2040**	**2050**
Alfred Nzo DM	165 735	177 691	196 281	216 816	239 500
Joe Gqabi DM	33 513	35 931	39 690	43 842	48 429
OR Tambo DM	303 574	325 472	359 524	397 138	438 687
Totals	**502 822**	**539 094**	**595 495**	**657 797**	**726 616**
HOUSEHOLDS					
	2013	**2020**	**2030**	**2040**	**2050**
Alfred Nzo DM	33 859	36 301	40 099	44 294	48 928
Joe Gqabi DM	6 847	7 340	8 108	8 957	9 894
OR Tambo DM	62 018	66 492	73 448	81 133	89 621
Totals	**102 723**	**110 133**	**121 656**	**134 383**	**148 443**

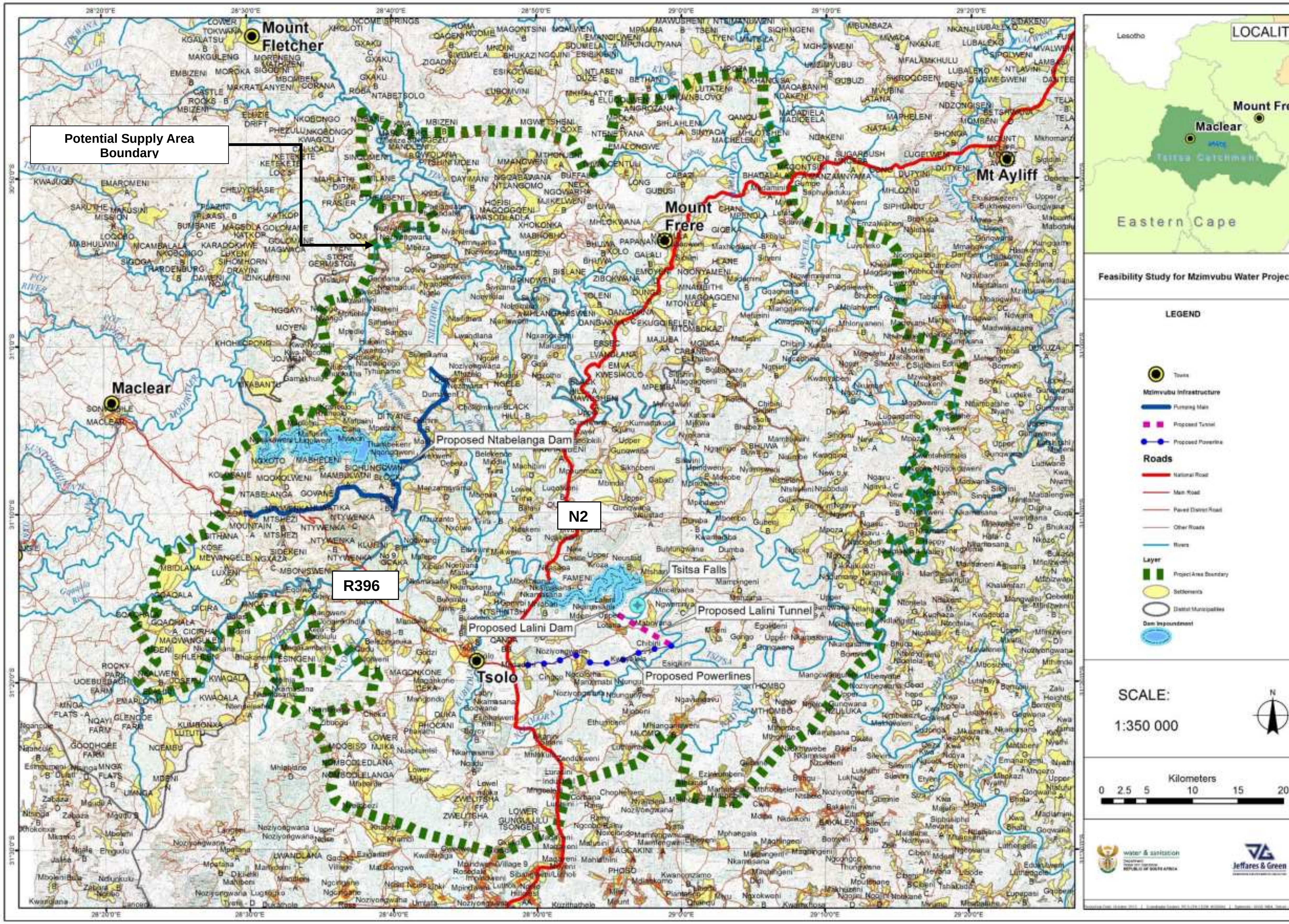


Figure 3-1: Potential Ntabelanga Water Supply Area Boundary

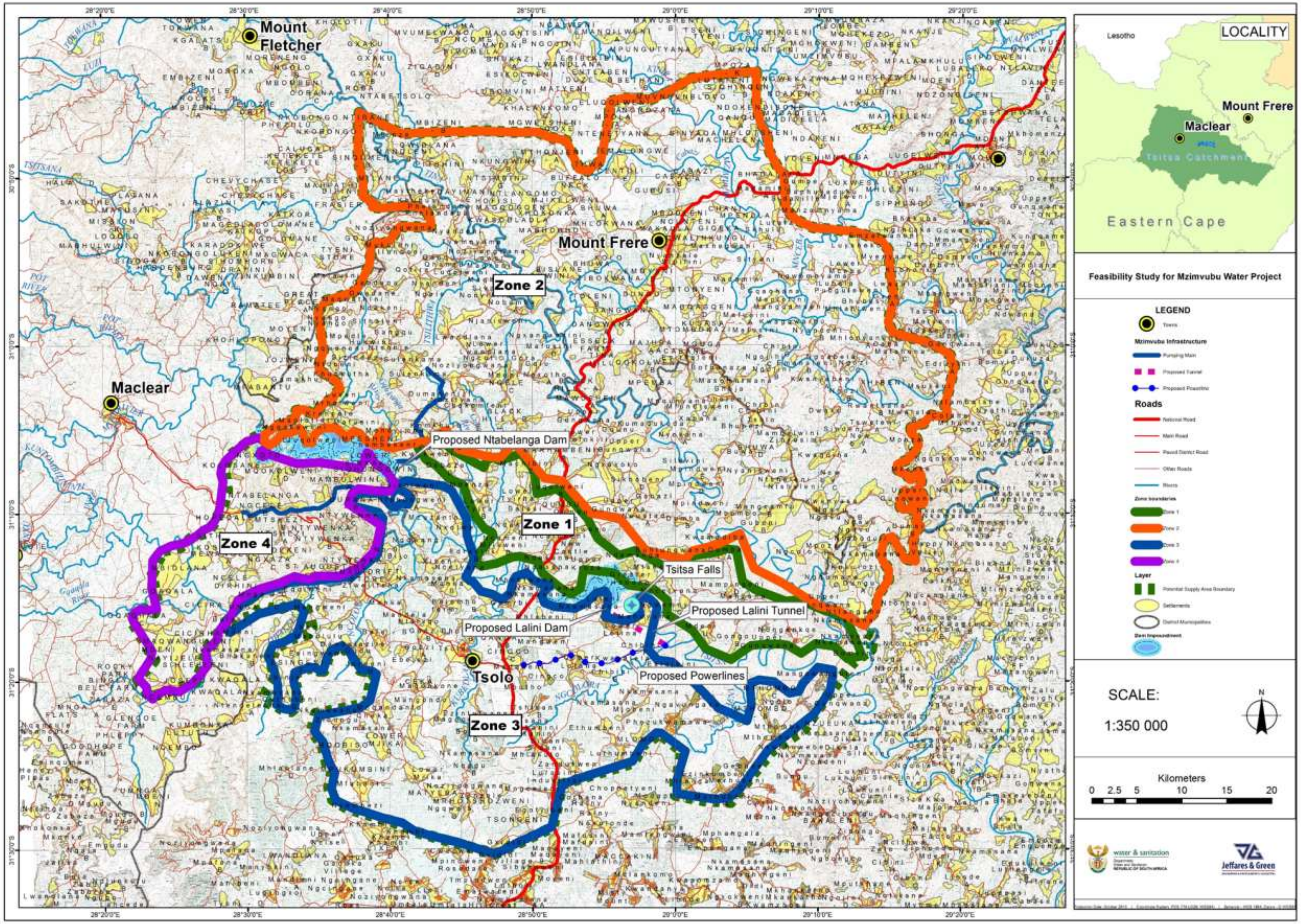


Figure 3-2: Supply Zones for Infrastructure Planning

Based on the water requirements calculated from the above population growth projections and the design criteria, the projected growth in total water volumes to be supplied, and the proportion to be supplied to the three DMs by the Ntabelanga Dam water supply scheme, is as shown in Tables 3-3 and 3-4.

Table 3-3: Domestic Water Requirement Projections

Projection Year :>	2013	2020	2030	2040	2050
Average daily requirements (m^3/d)	58 541	62 764	69 330	76 583	84 596
Peak daily requirement (m^3/d)	70 248	75 316	83 196	91 900	101 515
Average annual requirements (million m^3/a)	**21.6**	**22.9**	**25.3**	**28.0**	**30.9**

Table 3-4: Potable Water Requirements by District Municipality

Projected Average Demands (m^3/d)				
	2020	**2030**	**2040**	**2050**
Alfred Nzo DM	20 687	22 852	25 243	27 884
Joe Gqabi DM	4 183	4 621	5 104	5 638
OR Tambo DM	37 893	41 857	46 236	51 074
Total	**62 764**	**69 330**	**76 583**	**84 596**

Figure 3-3 summarises the growth projection of domestic water requirements, including allowances for conveyance losses.

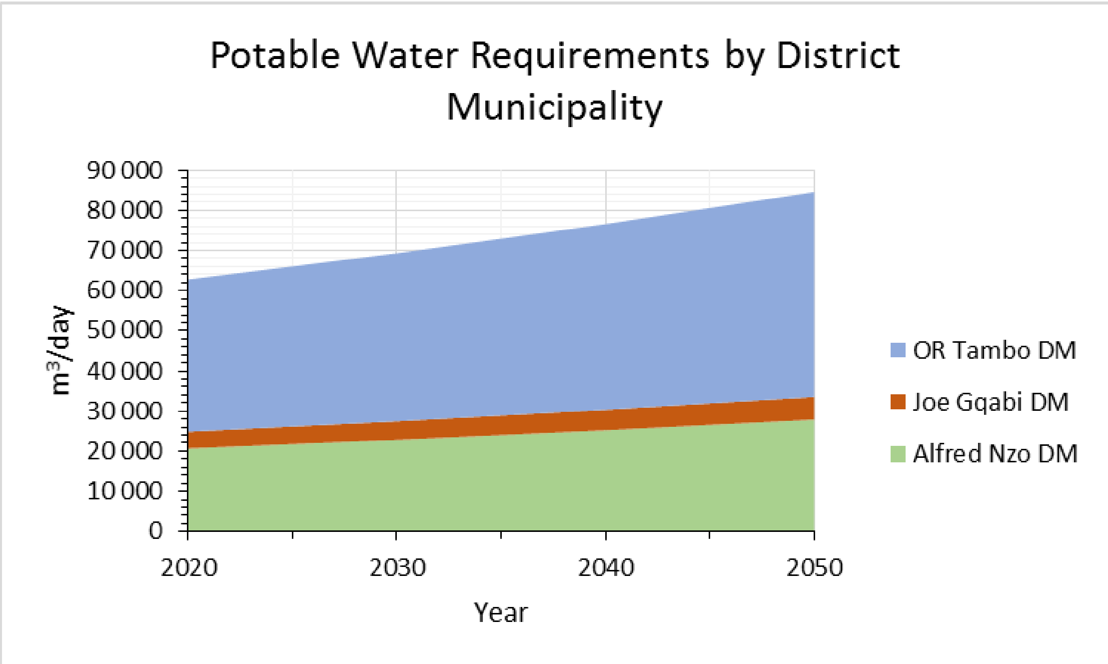


Figure 3-3: Potable Water Requirements by District Municipality

Figure 3-4 summarises the growth projection of raw water requirement on the Ntabelanga Dam to meet domestic water requirements, including allowances for conveyance and treatment losses, which totals **32.4 million m^3/a** by the year 2050. This assumes that comprehensive and diligent water demand management and unaccounted for water reduction measures are implemented and maintained.

This also assumes a fully developed treated water delivery distribution network by the time that the Ntabelanga dam is commissioned. If, as is likely, the actual water consumption uptake is slower than projected, and/or the implementation of the tertiary water distribution system is undertaken in stages and over a longer period, then certain works (eg WTW, installed pumping plant, and bulk water storage facilities) could possibly be developed in phases to defer capital expenditure accordingly.

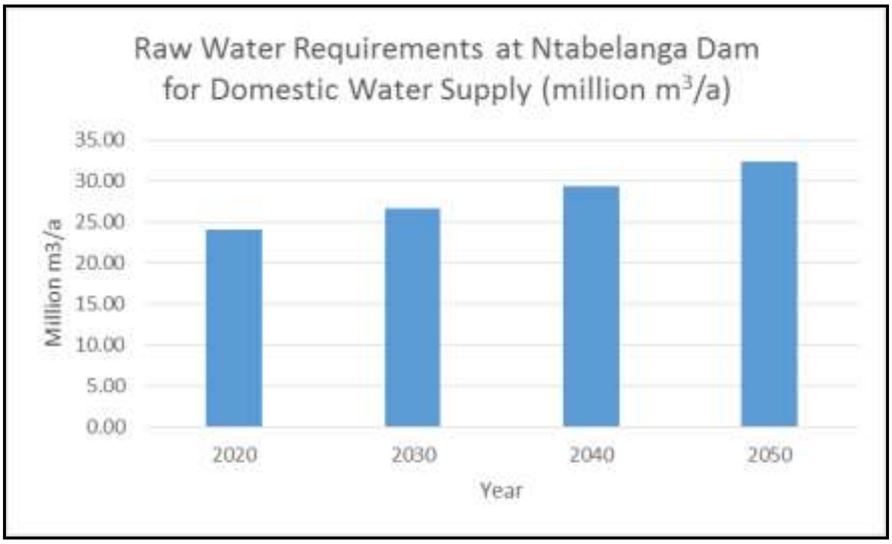


Figure 3-4: Raw Water Requirements: Domestic Supply

3.3.3 *Irrigation Water Requirements*

The process to identify high potential irrigable land that could be supplied with raw water from the Ntabelanga Dam is described in the Irrigation Development Report No. P WMA 12/T30/00/5212/9.

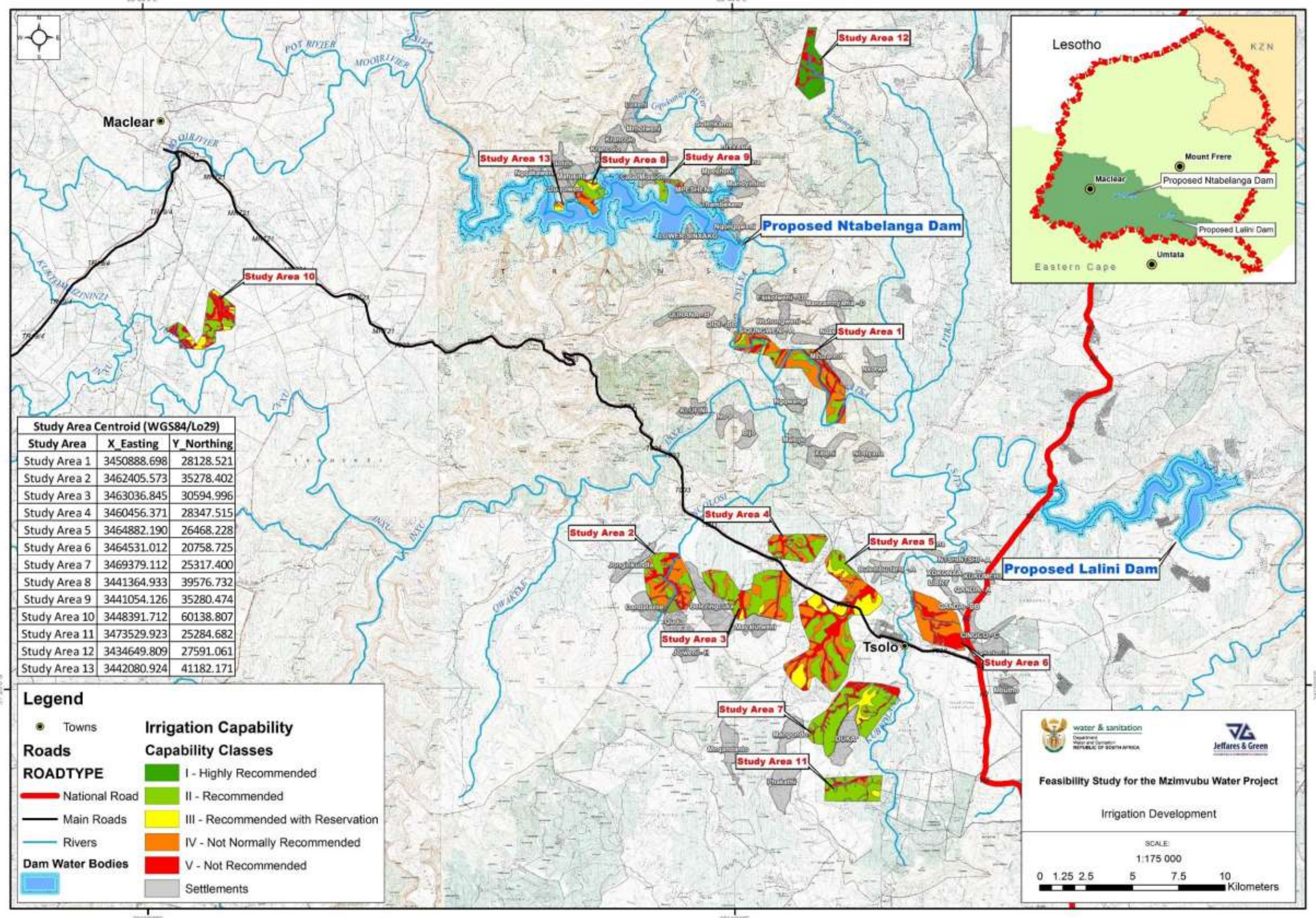
From this it was established that some 2 868 ha of land in this study area had potential to be viably developed for irrigated agriculture, of which some 2 450 ha are located in the Tsolo region. The location of this higher potential irrigable land is shown in Figure 3-5.

The ultimate determination of annual water use for the irrigation of this land first requires the selection of suitable crops for the prevailing climate, and finally the determination of a monthly irrigation regime, taking into account the rainfall and evapotranspiration of the area.

a) Climate

There is no reliable, long term recorded climate data available for the study area, hence the climate data presented below is modelled data (Table 3-5).

Eighty-nine percent (89%) of the study area is located in the Tsolo vicinity, and hence climate data is presented for this location. Tsolo receives 780 mm mean annual precipitation (MAP) and has a mean annual temperature (MAT) of 16 °C. The mean annual evaporation (A pan) is high at 1 659 mm. Frost occurs in winter. Snow cannot be ruled out on high-lying ground.



Study Area Centroid (WGS84/Lo29)		
Study Area	X_Easting	Y_Northing
Study Area 1	3450888.698	28128.521
Study Area 2	3462405.573	35278.402
Study Area 3	3463036.845	30594.996
Study Area 4	3460456.371	28347.515
Study Area 5	3464882.190	26468.228
Study Area 6	3464531.012	20758.725
Study Area 7	3469379.112	25317.400
Study Area 8	3441364.933	39576.732
Study Area 9	3441054.126	35280.474
Study Area 10	3448391.712	60138.807
Study Area 11	3473529.923	25284.682
Study Area 12	3434649.809	27591.061
Study Area 13	3442080.924	41182.171

Figure 3-5: Higher Potential Irrigable Soils - Ntabelanga Dam

The climate dictates that crops tolerant of cool conditions and frost be established. The somewhat low MAT suggests that crop growth will be retarded (due to low heat units) to some extent and that subsequent crop yields will be somewhat restricted. Irrigation will supplement soil moisture deficits during the dry winter months and will provide a significant yield increase compared to current rainfed agricultural practice.

b) Suitable Crops and Expected Yields

Based on the climate data presented (particularly mean annual temperature and frost occurrence), soil types and soil properties, and assuming a medium level of irrigation management input, a variety of possible crops recommended for irrigation in the Tsolo area are presented in Table 3-6.

Determining the irrigation water use of a typical farming unit in the Tsolo area depends on a number of factors, including what crop is planted to what area, historical rainfall, planting and harvesting dates, whether crops are perennial or seasonal, whether double cropping occurs for seasonal crops, and management factors.

These factors make it impractical to assess the multitude of crop types, areas and planting combinations. However, a theoretical maximum water use per hectare can be determined by studying the water demand of a reference crop. This is a crop with a crop factor of 1 all year round, and assumes that irrigation is supplied where evapotranspiration (ETo) is greater than rainfall. Irrigation requirement is calculated as the difference between evapotranspiration and historical rainfall for a crop with a crop factor of 1 in all months.

Table 3-5: Modelled Climatic Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean
Mean monthly rainfall (mm)	129	108	108	46	18	5	8	14	36	69	105	101	**780**
Mean daily maximum temperature (°C)	26	26	25	22	21	18	18	20	21	22	23	25	**22**
Mean daily minimum temperature (°C)	14	14	13	10	7	4	4	5	8	10	11	13	**9**
Mean daily temperature (°C)	20	20	19	16	14	11	11	13	15	16	17	10	**16**
Mean Evapotranspiration (mm)	184	149	149	111	102	89	98	126	138	158	164	191	**1 659**
Humidity (%)	69	69	68	65	62	62	60	60	63	67	68	68	**65**

Table 3-6: Suitable Crops and Estimated Yields for Irrigation Classes I, II and III

Crop	Uses	Suitability	Expected Yield
Cabbage	Food	Moderate	50 tons/ha
Carrot	Food	High	30 tons/ha
Green Bean	Food	High	8 tons/ha
Italian Ryegrass	Nutritious grazing	High	10 tons/ha
Lettuce	Food	Moderate	20 tons/ha
Lucerne	Fodder crop	Moderate	18 tons/ha
Lupin	Forage	High	3 tons/ha
Maize	Grain	Moderate	8 tons/ha
Oats	Winter grazing or green feed	High	7 tons/ha
Onion	Food	High	25 tons/ha
Potato	Food	High	30 tons/ha
Soya bean	Food, oil seed, animal feed	Moderate	3 tons/ha
Spinach	Food	High	20 tons/ha
Tomato	Food	Moderate	35 tons/ha

Irrigation water demand for a reference crop has been modelled in the SAPWAT model, and the results are presented in Table 3-7.

Table 3-7: Irrigation Water Demand for a Reference Crop

Water use (mm @ 80% assurance of supply)												Water use	Water use
Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**(m^3/ha/a)**	**(mm/a)**
96	84	74	75	82	80	91	116	118	110	97	118	**11 410**	**1 141**

While this is a theoretical crop, it is useful in that it provides an upper limit of irrigation demand, irrespective of the crop mix, or areas under crops that will be grown. Any crop mix should demand less than this in practice.

In discussion with the Department of Agriculture Forestry and Fisheries and local stakeholders including the Eastern Cape Department of Rural Development and Agrarian Reform, it was agreed that in order to increase the viability of developing irrigated agriculture in this region, it would be necessary to reform current land use practices from subsistence to commercially operated farming units. Given the shape and size of the high potential land identified above, it was proposed that such farm units be of a 60 ha average size.

Applying this principle, a realistic crop mix was developed to determine water requirements, as shown in Table 3-8.

Table 3-8: Water Use for a Realistic Crop Mix on a Typical 60 ha Farm

Cropped area (ha)	Crop 1	Crop 2	Water use (mm @ 80% assurance of supply)												Water use
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(m³/a)
1	Green beans											43	42	81	**1 660**
		Carrot		81	69	54	60								**2 640**
1	Lettuce										87	68	92	87	**3 340**
		Lettuce	92	64	75	65									**2 960**
2	Potatoes		109	0								37	56	164	**7 320**
		Cabbage			81	41	60	82	36						**6 000**
10	Lucerne		92	74	45	18	18	41	21	36	73	96	91	114	**71 900**
5	Oats						41	21	40	81	111	127	29		**22 500**
1	Spinach		112	96								84	67	128	**4 870**
		Onion			136	68	80	62	60	40	91				**5 370**
4	Soybean		148	113	69								181	76	**23 480**
5	Ryegrass							182	41	80	164	187	49		**35 150**
1	Tomatoes		118	101	64							73	48	100	**5 040**
30	Maize		166	89	44							125	29	145	**179 400**
Total = 60														**Total**	**371 630**

This would provide for a mixed enterprise, economically viable irrigated farm with a manageable mix of row crops, vegetable cash crops, and pasture/forage crops suitable for livestock farming. The above total estimate consumption per year is equivalent to an average of 619 mm/year of irrigation. The above two methods thus give a range of irrigation from 619 to 1 141 mm/year.

As the occurrence frequency of such “maximum” and “realistic” irrigation requirements cannot be predicted with any degree of certainty, a figure of an average of this range was used to determine the likely average annual irrigation water demand upon the Ntabelanga Dam, which, including allowance for losses amounted to some 880 mm/year of irrigation applied over the total areas to be irrigated.

For the purposes of determining the average raw water requirements on the Ntabelanga Dam for irrigation purposes, the average application rate of 880 mm/a was applied to the above irrigable areas, which after allowing 10% for losses, gave an annual irrigation raw water requirement of **27.8 million m³/annum**.

3.4 Ntabelanga Water Requirements Summary

Taking the two consumptive water requirement components described above, Table 3-9 summarizes the total water requirements from the Ntabelanga Dam before other considerations are included.

Table 3-9: Summary of Raw Water Demand

Treated Bulk Water Supply Requirements				
Bulk Supply Service Reservoir	**Population Served**	**Average**	**Conveyance**	**Total Required**
	Year 2050	**litres/capita/day**	**Losses**	**m^3/day**
Sidwadweni Nduku Reservoir	90 545	60	10%	5 976
Reservoir B	186 794	125	10%	25 684
Reservoir C (Mount Frere)	33 589	125	10%	4 619
Reservoir D	55 549	99	10%	7 638
Reservoir E (Joe Gqabi DM)	40 445	125	10%	5 561
Cullunca Command Reservoir	94 553	125	10%	13 001
Mvumelwano Scheme	84 935	125	10%	11 679
Nduku Reservoir in Nyandeni LM	140 207	60	10%	10 438
Totals:	***726 616***			***84 596***
		add treatment losses	*5%*	*4 230*
Total Raw Water Required at Source for Potable Use			**m^3/day**	**88 825**
Total Raw Water Required at Source for Potable Use			**million m^3/a**	**32.4**
Irrigation Water Supply Requirements				
Estimated high potential irrigable land availability			ha	2 868
Average application rate per hectare			mm/a	880
Allowance for losses			%	10
Total Raw Water Required at Source for Irrigation			**million m^3/a**	**27.8**
Grand Total Raw Water Requirement at Ntabelanga Dam			**million m^3/a**	**60.2**

This raw water demand of 60.2 million m^3/a was applied to the WRYM dam yield model, together with the Environmental Water Requirements developed to meet the Class C classification recommended by the Reserve Determination team and as given in Report No. P WMA 12/T30/00/5212/7. These models were run both with and without hydropower production. For the hydropower modelling scenario, this demand has been rounded to 60 million m^3/yr.

3.5 Bulk Water Distribution Scheme for Domestic Water Supply

The whole scheme is to be supplied by a proposed new WTW located immediately downstream of the Ntabelanga dam wall, and supplied with raw water from the dam by gravity. For details of this raw water supply arrangement, please see Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12.

The Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13 describes the distribution scheme development in more detail. The geometry of the systems and hydraulic models are contained on data files to be submitted to DWS as a deliverable of this study.

The distribution system is divided into three components, namely the Primary, Secondary and Tertiary systems.

The primary bulk water distribution system is illustrated diagrammatically in Figure 3-6, and its layout is shown in Figures 3-7 and 3-8. The capacity of the main components is shown on Figure 3-6, and it can be seen that the configuration has been designed to minimise the pumping of water to the higher elevations as much as possible.

From the WTW, treated water is pumped from pump station 1 (PS1) via a rising main going north to primary command reservoir 1 which then gravity feeds the bulk water distribution system designated as Zone 1 in Figure 3-2.

A pump station (PS2) lifts water from primary command reservoir 1 to primary command reservoir 2 which is located at a higher elevation. From this reservoir, water is gravity fed to the bulk water supply system in the higher elevations of the Tsitsa valley watershed, as well as supplying some of the neighbouring DM settlements over the watershed and reaching almost to the southern outskirts of the town of Mount Frere. This is designated as supply Zone 2.

Similarly on the southern side of the river, potable water is pumped from pump station PS3 at the WTW to primary command reservoir 3 from where gravity fed bulk mains transfer water to the settlements in Zone 3.

Pump station (PS4) at primary command reservoir 3 lifts water in a westerly direction to the higher lying primary command reservoir 4, which can also deliver water by gravity in the direction of Maclear, and to settlements in the Tsitsa River valley adjacent to the flooded area of impoundment once the dam is constructed. This area is shown as Zone 4 in Figure 3-2.

The secondary bulk water distribution system consists of the main bulk pipelines fed by gravity from the above primary command reservoirs 1, 2, 3 and 4. The secondary systems transfer water in bulk to secondary command reservoirs, which form the second level of strategic storage.

The layouts of the secondary bulk potable water distribution pipelines and reservoir locations are shown in Figure 3-9.

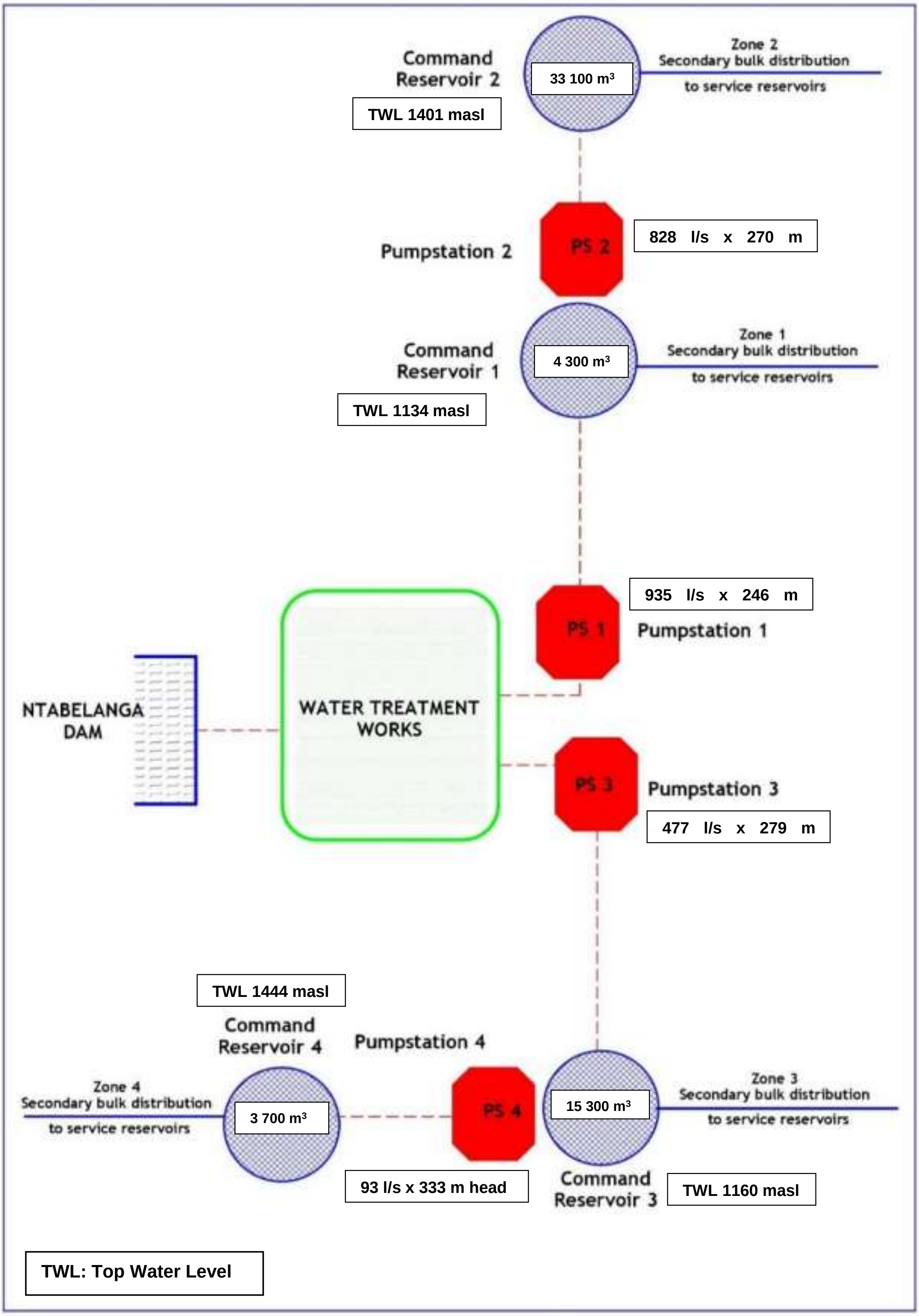


Figure 3-6: Diagram of Primary Bulk Water Distribution System

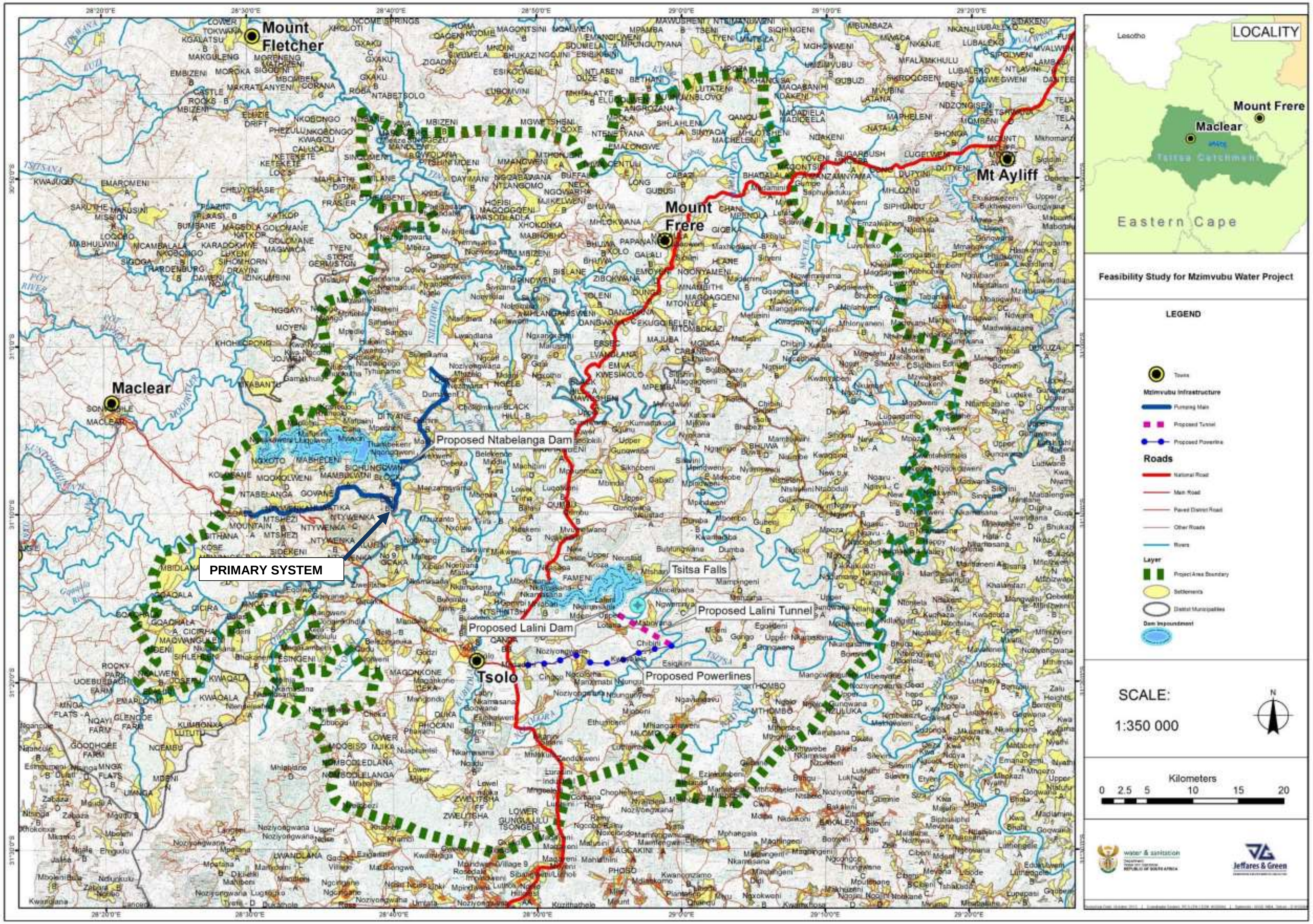


Figure 3-7: Layout of Scheme and Supply Area

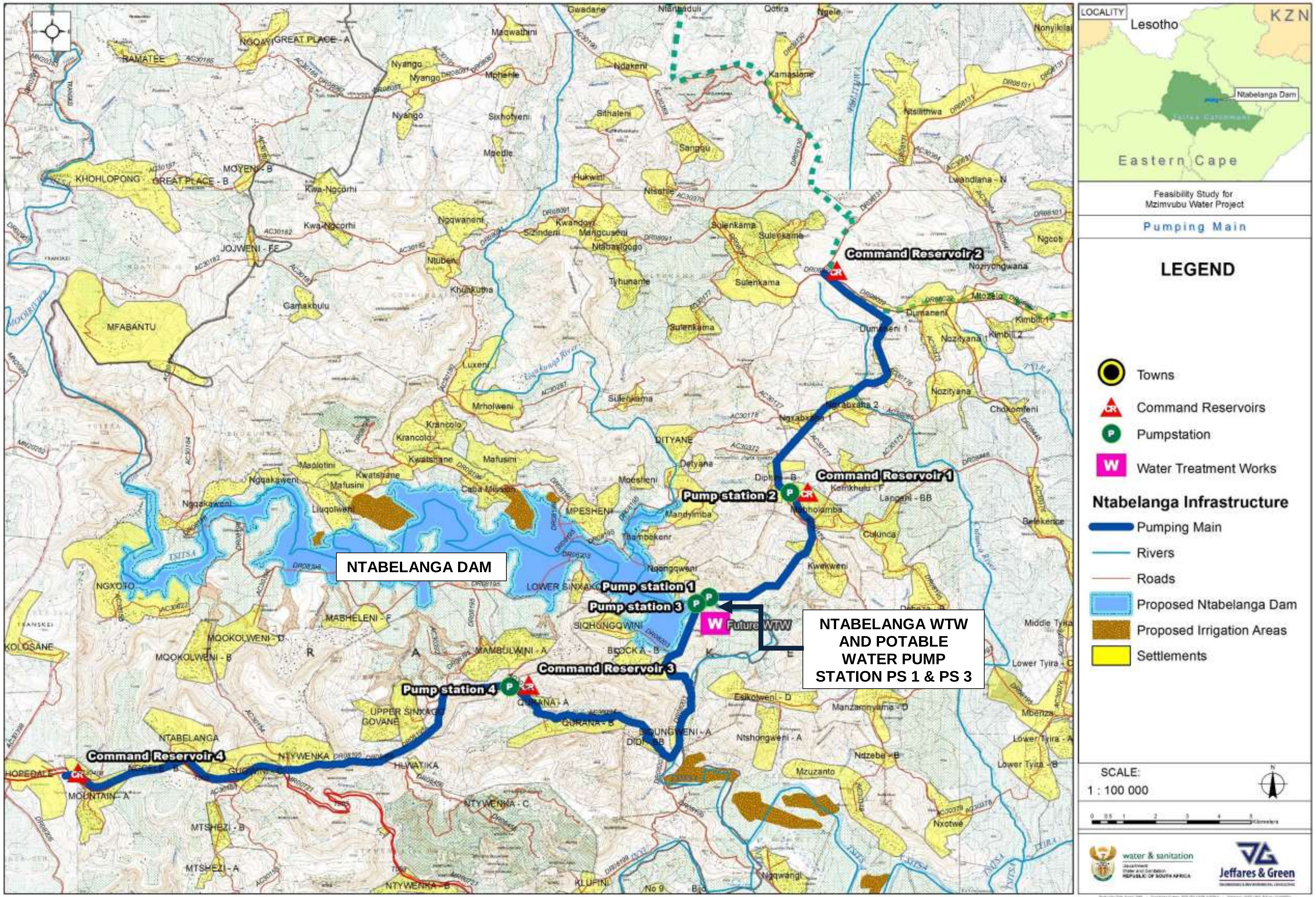


Figure 3-8: Primary Bulk Potable Water Pipelines, Pumping Stations and Command Reservoirs

In keeping with the planning being undertaken by the DMs, these secondary system command storage sites generally coincide with sites of existing reservoirs that are located at strategic high points, but that can, for the most part, be supplied with potable water by gravity from the primary system, with only a small proportion of the water supplied needing to be boosted to overcome high spots en route. This is achieved by three small booster pumping stations which only operate under peak demand periods when head loss in the system is highest. At low or medium demand periods, the system operates under gravity flow.

A simplified diagram of the primary and secondary pipelines layout is given in Figure 3-10.

Figure 3-11 shows the potential alignments of the tertiary pipelines that would be implemented by the DMs to deliver potable water from the proposed primary and secondary bulk potable water distribution systems. All of these tertiary pipelines would operate under gravity and no additional pumping would be required.

The hydraulic capacity, sizing, alignments, and costing of these lines has been undertaken at a feasibility level, and it will be the responsibility of the DMs to undertake the optimisation, detailed design, and implementation of the tertiary lines and storage facilities in each settlement. This process is ongoing and the planning of the overall scheme has taken into account the DM planning and implementation of these systems that is currently underway.

It should be noted that the scope of the Mzimvubu Water Project is the primary and secondary pipelines only. Analysis of the tertiary lines was undertaken purely to ensure that correct allowance has been made for delivery into these systems.

The implementation of the primary and secondary bulk potable water distribution pipelines and associated pumping stations and storage reservoirs would be undertaken under a separate contract, and contract limits between this contract and that of the water treatment work (which includes the clear water pumping station) must be clearly indicated in the contract documents and drawings. These works could be further broken into several smaller packages to promote a fair distribution of work to established and emerging contractors.

The DM's are responsible for the delivery of water from the secondary reservoirs to the households. They will need to co-ordinate such implementation with the programme for the construction of the primary and secondary pipeline system, and applications for funding from appropriate sources (e.g. RBIG, MIG) should be commenced in a timely manner.

The timing of the implementation of the primary, secondary and tertiary lines would need to be co-ordinated to try to ensure that the systems are ready to deliver water to consumers once the Ntabelanga Dam and WTW have been completed and commissioned.

The detailed design and implementation of the irrigation bulk water distribution system should only commence once the process of consultation, land-use and agrarian reform has taken place, and consensus reached with the stakeholders. This process would result in the final definition of size, numbers, and locations of the new farming units to be supplied with water, and thus the final capacity and alignments of the irrigation bulk water distribution system.

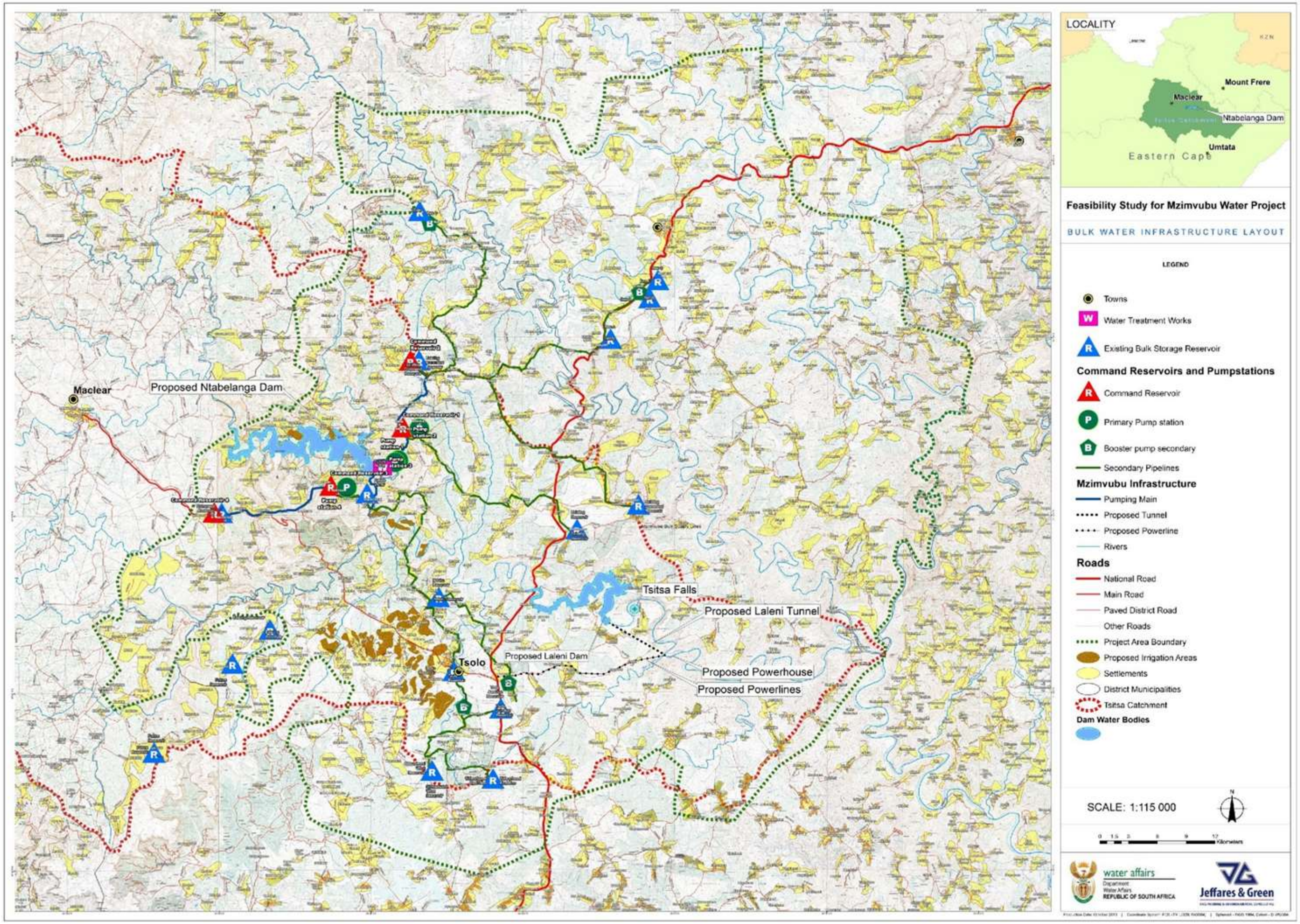


Figure 3-9: Secondary Bulk Potable Water Distribution Pipelines and Command Reservoirs

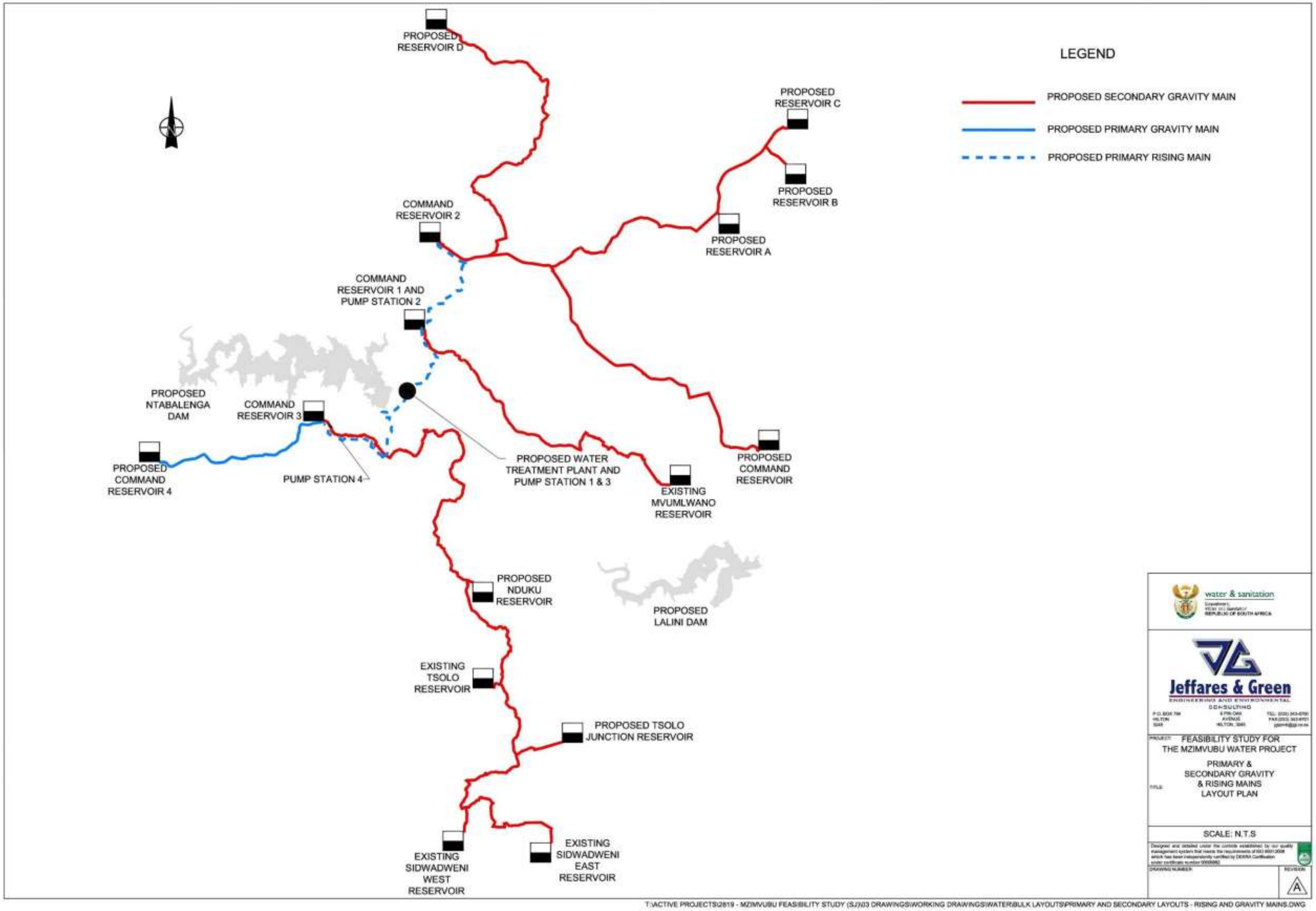


Figure 3-10: Layout Diagram of Primary and Secondary Pipelines

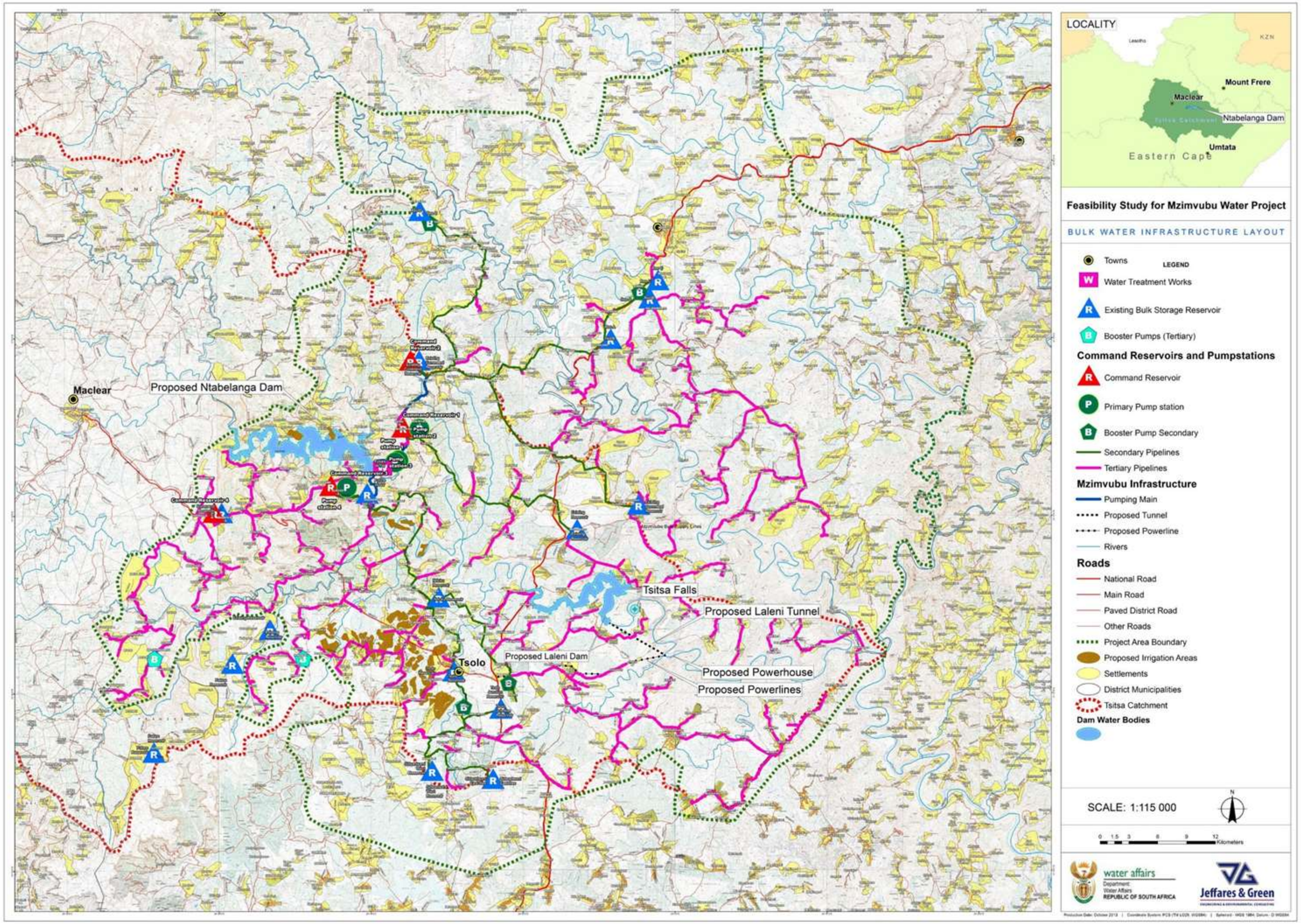


Figure 3-11: Layout of Potential Tertiary Pipelines

3.6 Hydrological Studies

Full details of the hydrological analyses undertaken can be found in the Water Resources Report No. P WMA 12/T30/00/5212/5.

The water resources assessment in Phase 1 undertook to investigate three preferred dam sites and, ultimately, to provide input into the selection of the final site for detailed analyses. The three preferred dam sites were the proposed Ntabelanga, Somabadi and Thabeng dams on the Tsitsa and Kinira Rivers, respectively.

The results highlighted that the Ntabelanga Dam was the preferred dam site from a water resources perspective, not only for the provision of raw water to meet potable water demands and irrigation requirements, but also to potentially generate hydropower within the Tsitsa River system.

This was confirmed in an economic analysis of the three options described in Report No. P WMA 12/T30/00/5212/3.

A more detailed water resources assessment (Phase 2) was undertaken on the Ntabelanga Dam, with a higher level assessment also being undertaken of the hydropower generation potential of the Tsitsa River at Lalini above the Tsitsa Falls.

The same methodology adopted for Phase 1 was followed in Phase 2, with two changes:

1. Some of the input information was updated, namely:
    a. Rainfall;
    b. Land use;
    c. Sedimentation; and
    d. EWR.
2. Hydropower scenarios were included through the addition of a dam at Lalini above the Tsitsa Falls.

The results from the rainfall analysis were used in the rainfall-runoff and yield modelling exercises (as presented in Table 3-10), which had a positive impact by increasing the available stream flow across the catchment due to an overall increase in rainfall depth.

Table 3-10: Mean Annual Precipitation of the Tsitsa Quaternary Catchments

Quaternary Catchment	Phase 2 MAP (mm)	WR2005 MAP (mm)
T35A	927.9	912.0
T35B	867.5	915.0
T35C	974.2	1 008.0
T35D	816.6	818.0
T35E	941.1	918.0
T35F	907.5	860.0
T35G	705.7	759.0
T35H	935.7	845.0
T35J	985.6	924.0
T35K	828.7	783.0
T35L	657.6	764.0

The land use inputs from Phase 1, i.e. commercial forestry, irrigation and invasive alien plants (IAPs) were updated due to the recent availability of a biodiversity study undertaken in the Ntabelanga Dam catchment, up to and including Quaternary Catchment T35E. Commercial forestry increased from 334.0 to 380.3 km^2 and IAPs increased from 37.5 to 41.0 km^2 from Phase 1 to Phase 2.

The sedimentation allowance was updated in Phase 2, from using the Rooseboom (1992) method to using the updated version of the same method, developed by the WRC (2010). This method was also used to determine the incremental sedimentation allowance for the proposed Lalini Dam, below Ntabelanga Dam. The new values selected for the Ntabelanga and Lalini Dams were the V50 values of 35.7 and 32.1 million m^3, respectively.

The EWR for the Ntabelanga Dam in Phase 2 was determined through an Intermediate Reserve Determination (see Report no. P WMA 12/T30/00/5212/7), which determined the river reach associated with the Ntabelanga Dam to be an ecological Class C, allocating 87.25 million m^3 (20.4% MAR) as an annual average.

The updated inputs were used in the rainfall-runoff modelling based on the same configuration as in the Phase 1 study. Through a process of calibrating the poor quality stream flow data and using the new rainfall and land use inputs, better calibrations were achieved using WRSM2000. These simulated natural stream flow results were accepted and used in the stochastic and yield analyses.

The simulated natural mean annual stream flow was modelled to be 428.5 million m^3/a at the Ntabelanga Dam site, with the present day mean annual runoff (MAR_{PD}) at the same site being slightly lower at 415.0 million m^3/a. This proportionally low reduction in MAR highlighted the relatively small development level within the catchment. Thus, indicating the potential for water resource development.

The yield modelling of the Ntabelanga Dam for raw water abstraction (60.2 million m^3/a for potable water and irrigation requirements) used the same system configuration as in Phase 1, with the updated input information.

In spite of an increase in sedimentation volume, EWR allowance and stream flow reducing land use, the yield of the system increased from Phase 1. This increase was as a result of the higher simulated natural stream flow values. Similarly to Phase 1, a range of dam capacities were assessed from 0.10 MAR_{PD} to 1.80 MAR_{PD}.

The results of the Phase 2 yield modelling are given in Figure 3-12 and Table 3-11.

The Ntabelanga Dam can supply a high demand scenario of approximately 60 million m^3/a at a 98% assurance of supply from a relatively small impoundment of 67.0 million m^3 (≈ 0.15 MAR).

Any increase in impoundment volume above 67.0 million m^3 has a large impact on increasing the yield due to the large proportional increase in live storage once the dead storage allocation has been overcome. The high demand scenario from the Ntabelanga Dam accounts for the provision of the following water uses:

- Class C EWR from Ntabelanga Dam;
- Raw water supply for end user potable water; and
- Irrigation potential (cf. Report no. P WMA 12/T30/00/5212/9).

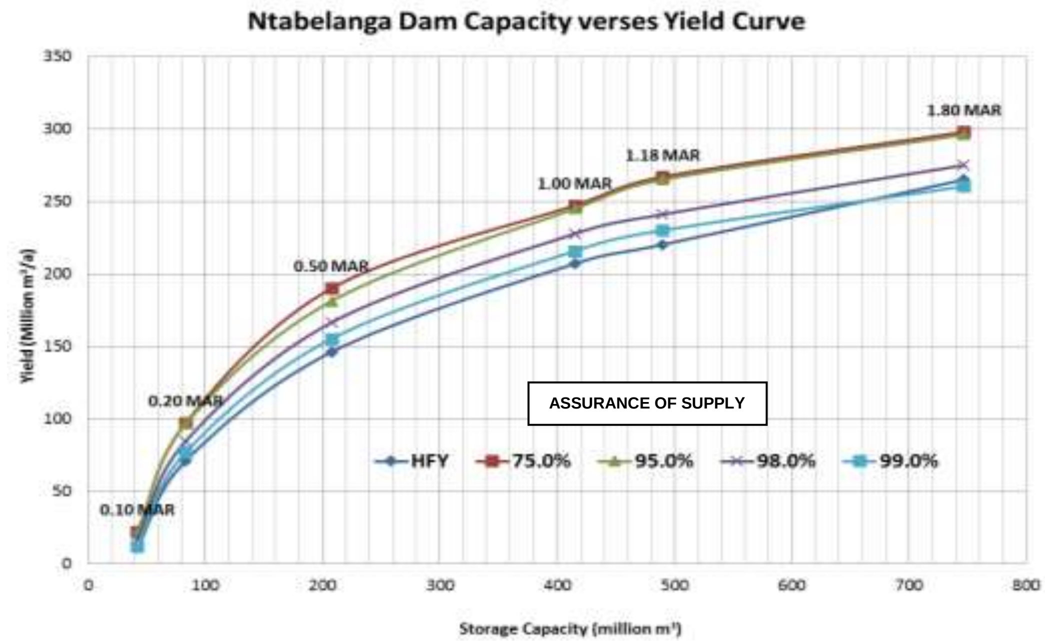


Figure 3-12: Capacity verses Yield Curve for the Ntabelanga Dam

Table 3-11: Capacity verses Yield Results for the Ntabelanga Dam

	Ntabelanga Reservoir Characteristics					EWR			HFY	Yield (million m³/a) at return interval and % annual assurance			
Dam Capacity	FSL	MOL	Total Cap	Live Cap	Area*	Class	Requirement			1:4	1:20	1:50	1:100
Scenario	m.a.s.l	m.a.s.l	million m³	million m³	km²		million m³/a	%MAR	million m³/a	75.0%	95.0%	98.0%	99.0%
0.10 MAR	919.5	918.2	41.500	5.800	4.354	C	87.249	20.4%	10.80	22.00	21.10	16.70	12.00
0.20 MAR	925.9	918.2	83.000	47.300	8.625	C	87.249	20.4%	71.00	97.20	96.40	84.50	76.80
0.50 MAR	935.4	918.2	207.500	171.800	17.841	C	87.249	20.4%	146.15	190.10	181.30	166.50	155.30
1.00 MAR	944.2	918.2	415.000	379.300	24.213	C	87.249	20.4%	207.10	247.30	245.00	227.70	215.80
1.18 MAR	947.3	918.2	489.700	454.000	32.844	C	87.249	20.4%	220.20	267.00	265.00	241.00	230.00
1.80 MAR	957.9	918.2	747.000	711.300	46.367	C	87.249	20.4%	265.00	298.00	296.10	275.00	260.40

FSL: Full Supply Level MOL: Minimum Operating Level * Surface area of inundation at FSL

3.7 Flood Hydrology and Spillway Capacity

As part of the Mzimvubu Water Project, the Ntabelanga Dam site was selected as the preferred site at which to construct a dam. As part of the dam feasibility design process, the dam spillway needs to be sized in accordance to the guidelines published by the South African National Council on Large Dams (SANCOLD) in SANCOLD, 1991.

This section provides the SANCOLD design requirements for the Ntabelanga Dam as well as methodologies undertaken to determine peak discharge values used to determine the Recommended Design Flood (RDF) and Safety Evaluation Flood (SEF) for the design of the Ntabelanga Dam spillway.

The potential flood damage that could be inflicted on a hydraulic structure may be related to one or more of the following parameters:

- High Flood Level – the maximum water level reached during a flood event;
- Peak Discharge – the maximum flow rate during a flood event;
- Maximum Flow Velocity – the maximum calculated flow velocity associated with a given flow rate;
- Flood Volume – the volume of water that is released from a catchment during a flood event; and
- Flood Duration – the period of time when the discharge associated with a flood event exceeds a specified limit.

Peak discharge is the most useful parameter in design calculation requirements for structures to resist potential damage imposed by flood events. The peak discharge of a catchment is directly related to the characteristics of the storm event and characteristics of the contributing catchment area. The requirements for the design of the proposed Ntabelanga Dam spillway, as per the SANCOLD guidelines, are presented in the following section.

3.7.1 Design Flood Guidelines

Guidelines on dam safety in relation to floods were published by the SANCOLD (1991) to facilitate the requirements for the determination of flood values for the purposes of dam design. This was undertaken to ensure that the risk of failure through inadequacy of the spillway system could be kept to acceptable levels hence, these guidelines were used in this investigation. The guidelines outline the requirements for the Recommended Design Flood (RDF) and the Safety Evaluation Flood (SEF).

The spillway should be designed such that it can safely discharge the peak flow rate associated with the RDF, without any damage to the dam wall or spillway. The SEF is used to ensure that the spillway is designed to sufficiently discharge the SEF associated peak flow rate without catastrophic failure of the dam wall or spillway (some damage is tolerated), whilst making no allowance for freeboard, thus maintaining the dam’s integrity until such a time as it can be repaired.

The SANCOLD Guidelines used to determine the RDF and SEF requirements for the design of the Ntabelanga Dam spillway are presented in Tables 3-12 to 3-16. These guidelines were applied for a large dam wall (greater than 30 m high), an assumed potential loss of life greater than 10 people and a great potential economic loss.

Table 3-12: Dam Size Classification

Size Class	Maximum Wall Height (m)
Small	More than 5 and less than 12
Medium	Equal to or more than 12 but less than 30
Large	Equal to or more than 30

Table 3-13: Hazard Classification

Hazard Rating	Potential Loss of Life	Potential Economic Loss
Low	None	Minimal
Significant	Not more than 10 lives	Significant
High	More than 10 lives	Great

Table 3-14: Dam Safety Categorisation

Dam Size Class	Dam Safety Class		
	Low	Significant	High
Small	1	2	2
Medium	2	2	3
Large	3	3	3

Table 3-15: Recommended Design Flood Values

Dam Size Class	Recommended Design Flood		
	Low	Significant	High
Small	$0.5Q_{50} – Q_{50}$	Q_{100}	Q_{100}
Medium	Q_{100}	Q_{100}	Q_{200}
Large	Q_{200}	Q_{200}	Q_{200}

Table 3-16: Safety Evaluation Flood Values

Dam Size Class	Safety Evaluation Flood		
	Low	Significant	High
Small	$RMF_{-\Delta}$	$RMF_{-\Delta}$	RMF
Medium	$RMF_{-\Delta}$	RMF	$RMF_{+\Delta}$
Large	RMF	$RMF_{+\Delta}$	$RMF_{+\Delta}$

In each of the Tables 3-12 to 3-16, the assumptions relating to the Ntabelanga Dam are highlighted in yellow. A summary of this information is provided in Table 3-17.

From this it is evident that the Ntabelanga Dam will be classed as a Category III Dam, therefore the RDF and SEF used to size the dam spillway will be equal to the 1:200 year design flood event and the Regional Maximum Flood (RMF; Kovacs, 1988) plus a category, respectively.

Table 3-17: Flood Categories Applicable to Ntabelanga Dam

Size Classification	Large	Downstream wall height ≥ 30m
Hazard Classification	High	Great potential economic loss
Dam Safety Categorisation	**3**	
Recommended Design Flood Values	$\mathbf{Q_{200}}$	
Safety Evaluation Flood Values	$\mathbf{RMF_{+\Delta}}$	

3.7.2 Design Flood Hydrology Methods

SANCOLD (1991) specifies that for new Category III dams site specific hydrological calculations need to be used to estimate the design floods.

The methods used to determine the design flood hydrology for the Ntabelanga Dam were as follows:

- Statistical Methods
  - Probability Distribution Fitting to Observed Streamflow Data
- Deterministic Methods
  - Synthetic Unit Hydrograph (SUH)
  - Rational Method
- Empirical Methods
  - Catchment Parameter Method (CAPA)
  - HRU 1/71
  - Midgely and Pitman Method (MIPI)
  - Standard Design Flood (SDF)
  - Regional Maximum Flood (TR 137)

Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12 – Appendix A provides a detailed description of the analyses undertaken for these various methods.

3.7.3 Flood Hydrology and Spillway Capacity Results

Based on the 1:200 year return period peak discharge results obtained from Statistical, Empirical and Deterministic flood calculation methods, it is recommended that a RDF peak discharge value of 2 500 m^3/s is adopted for the proposed Ntabelanga Dam spillway design. This RDF value is less than the 1:200 year return period peak discharge value estimated using the scaled RMF and SDF method, however, it is greater than the estimated 1:200 year return period peak discharge values obtained using deterministic methods (Rational and Unit Hydrograph Methods).

The results obtained from the Statistical Method, based on gauged streamflow data, were not considered in determining the final RDF peak, due to the high level of missing data associated with the streamflow gauges. It was concluded that the missing and capped Annual Maximum Series (AMS) data from the gauges resulted in low estimated peak discharge values.

The SEF, based on a Kovacs K-Factor of 5.2 and a catchment area of 1 971 km^2, was determined to be 5 532 m^3/s. It is therefore recommended that this value also be used in the design of the Ntabelanga Dam spillway.

These results have been reviewed and accepted by the DWS Directorate Hydrological Services, and have been used in the development of the feasibility design of the dam.

3.8 Hydropower Potential

Consideration was given as to whether there would be cost benefits in increasing the capacity of the Ntabelanga Dam (from the minimum 0.15 MAR_{PD} option) to provide additional flow regulation and head so that hydropower could be viably generated.

In reviewing studies undertaken by ESKOM in 2004, the study team identified a high potential hydropower generation site at Lalini, on the Tsitsa River downstream of the Ntabelanga dam site.

The primary focus for this aspect of the study was a potential conjunctive use hydropower scheme that includes the Lalini Dam located some 3.5 km upstream of Tsitsa Falls, a tunnel, and a hydropower generation plant located in the gorge below the Tsitsa Falls. The Lalini Dam would be used as a head race solely for hydropower generation and, if shown to be viable, the conjunctive operation of both dams could improve the economics of the scheme as a whole.

The balancing storage of the Lalini dam is supplemented by water releases from the Ntabelanga dam, as well as the contributing catchment areas between Ntabelanga and Lalini dams. This arrangement is shown on Figures 3-13.

The benefits of the conjunctive scheme would be realised if the energy produced can be utilised to reduce the net power costs of the water supply and irrigation schemes, as well as potentially producing surplus income to cross-subsidise other operating and maintenance costs, as well as future capital works development in the region. This is discussed in detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

The process and results of the detailed hydropower potential assessment and the feasibility design of the Lalini Dam and its hydropower scheme are described in Report Nos. P WMA 12/T30/00/5212/18 and 19. A separate RID has been issued for the Lalini Dam and Hydropower Scheme as Report No. P WMA 12/T30/00/5212/20.

As described in these reports, a hydropower simulation model was developed and run which, in addition to the main Lalini hydropower plant, included mini-hydropower plants located at each of the two dams themselves which utilized EWR releases as well as flows that would have otherwise passed over the spillway of each dam.

Operating rules were set to ensure that minimum and maximum allowable EWR releases were maintained throughout. See the Reserve Determination: Volume 1: River Report No. P WMA 12/T30/00/5212/7 and Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12. The flow duration curve applicable to the EWR release rules is given on Figure 3-14.

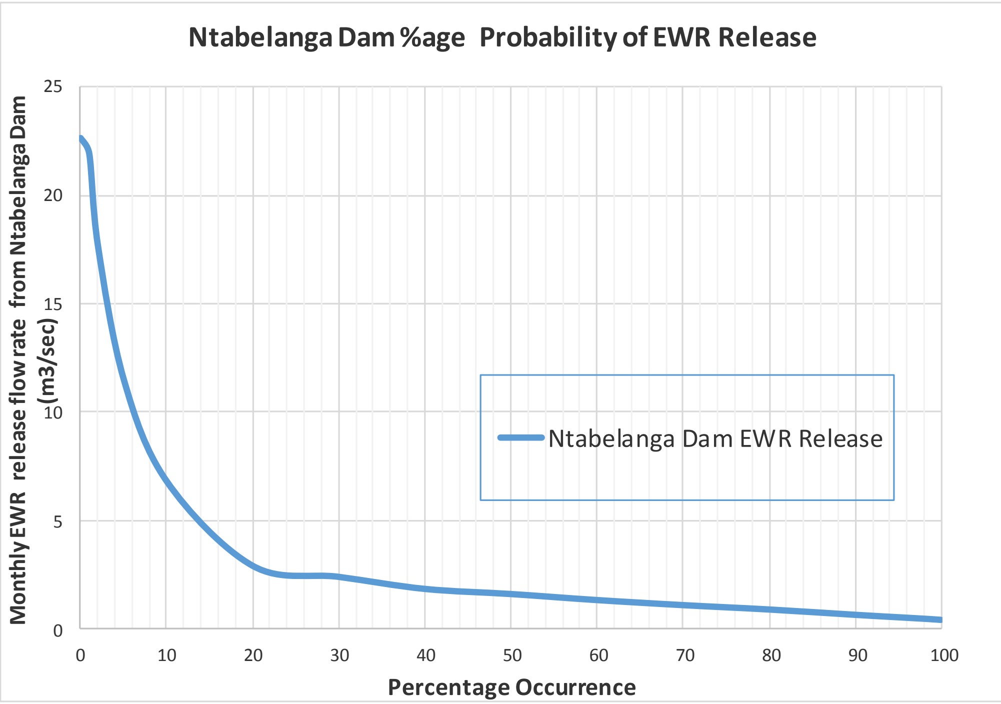


Figure 3-13: Probability of Required EWR Release Rates

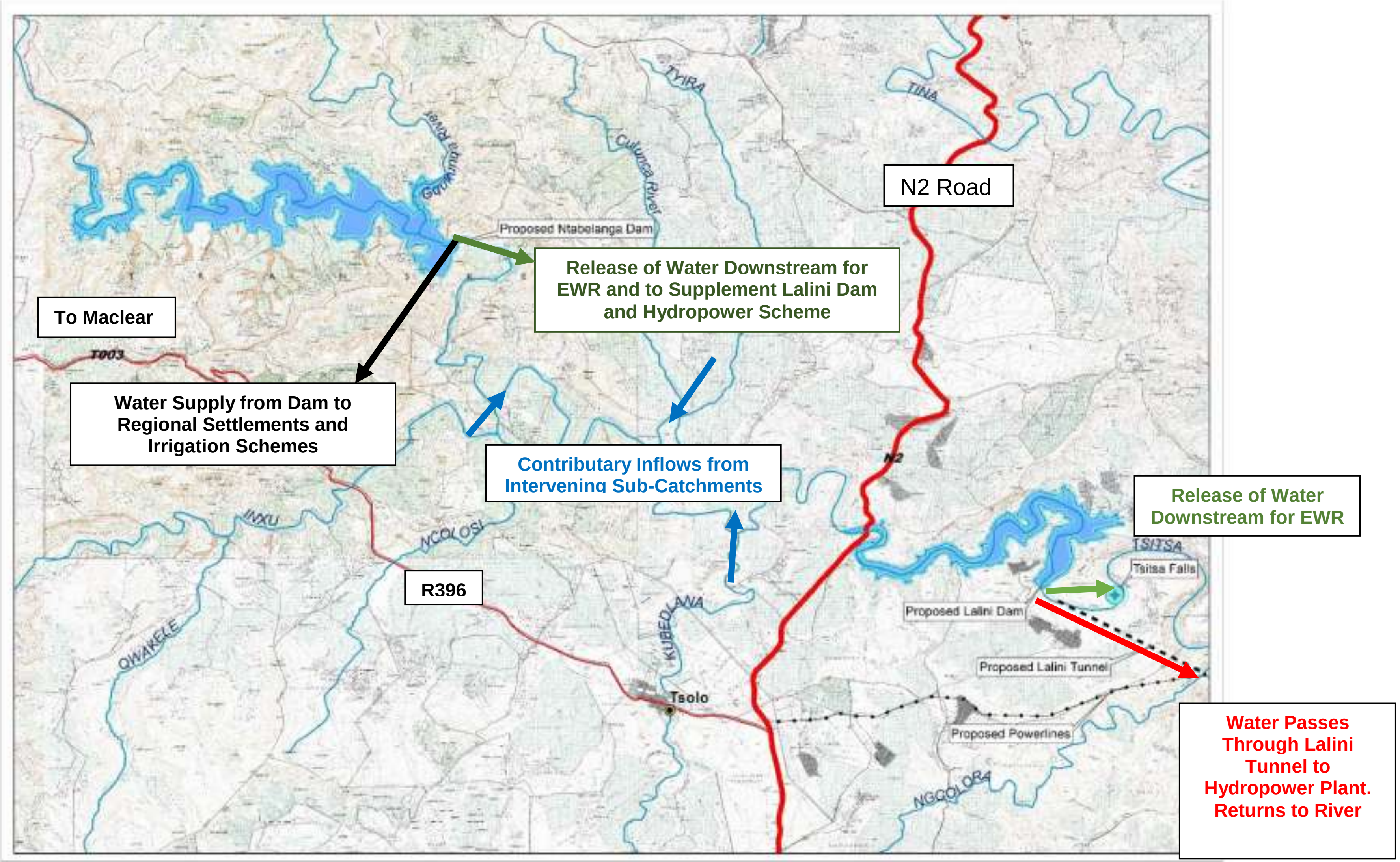


Figure 3-14: Conjunctive Hydropower Scheme

The results of this modelling given in Table 3-18 indicated that a hydropower plant of some 5 MW should be installed at Ntabelanga Dam and that this would be operated in accordance with the agreed EWR release rules.

From the modelling results, average power outputs varied monthly, and in accordance with the pattern shown in Figure 3-15.

Table 3-18: Model Results: Ntabelanga Dam HEP

Month	Monthly Target (MW)	Average HP Output (MW)	Average Energy Supplied (KWh)
Oct	1.00	0.74	547 860
Nov	3.00	1.71	1 229 237
Dec	3.00	1.55	1 152 316
Jan	4.00	2.00	1 491 215
Feb	5.00	3.77	2 557 827
Mar	5.00	3.14	2 338 611
Apr	5.00	2.07	1 493 446
May	4.00	0.99	734 676
Jun	2.00	0.91	652 112
Jul	1.00	0.62	460 567
Aug	1.00	0.59	436 999
Sep	1.00	0.69	500 319
Total Energy Per Year (kWh)			**13 595 184**
Average Power (MW)		**1.57**	

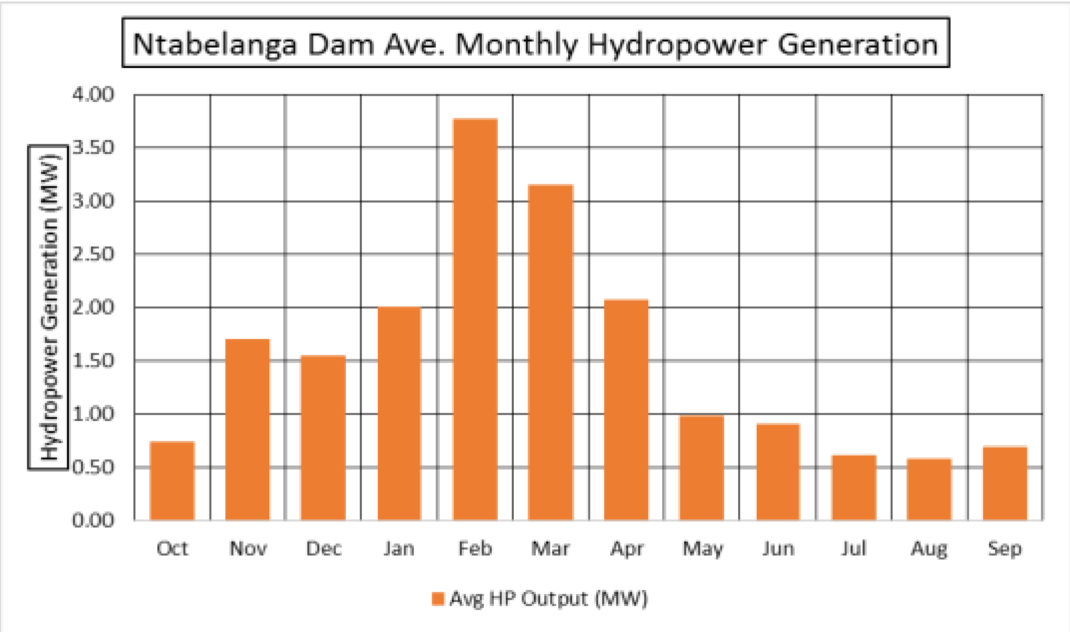


Figure 3-15: Ntabelanga Dam HEP Average Monthly Hydropower Generation

As can be seen, whilst the plant can produce up to 5 MW at peak (i.e. when sufficient flows are available), on average the wet season monthly output would be some 3.75 MW, and the dry season average monthly output would be some 1.4 MW (with some drier months operating at only 0.75 MW). Thus the hydroelectric plant (HEP) needs to be configured to be able to operate within this full range of outputs.

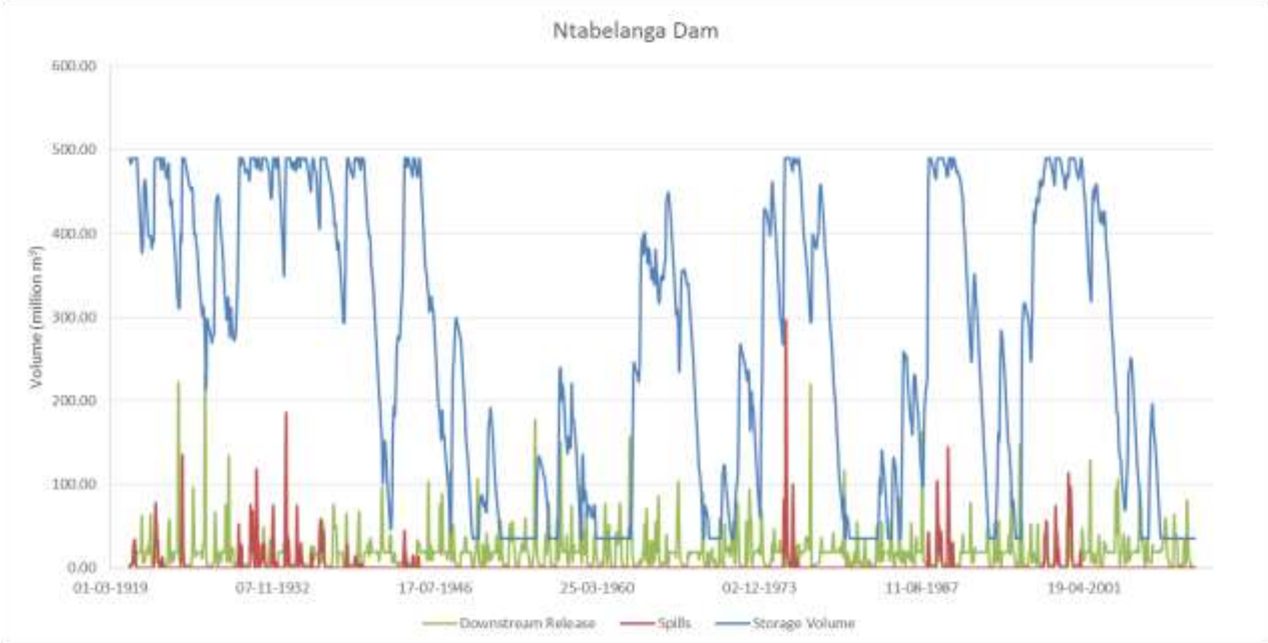


Figure 3-16: Storage Trajectory for Conjunctive Use Simulation at Ntabelanga Dam

The same analyses also produced a historical simulation of water levels in the Ntabelanga Dam which is shown in Figure 3-16. This shows that the full capacity range of the dam will be utilized on a regular basis throughout, with only moderate incidence of spillage, which justifies the sizing of the dam for this conjunctive purpose. It should be noted that the operating rules of the dam have been set to ensure that EWR is always released as well as meeting the potable and irrigation water requirements with the required assurance of supply, as determined under this feasibility study.

The Ntabelanga Dam outlet works pipework configuration allows for large and small release discharges directly into the stilling basin. The off-take pipework to the Ntabelanga mini-hydropower plant and WTW is sized for the maximum hydropower output, WTW, and raw water requirements of 16 m³/s, 1.3 m³/s and 1.1 m³/s respectively. In this case, a 2.5 m diameter pipe was deemed to be sufficient.

This arrangement is as shown in Figure 3-17.

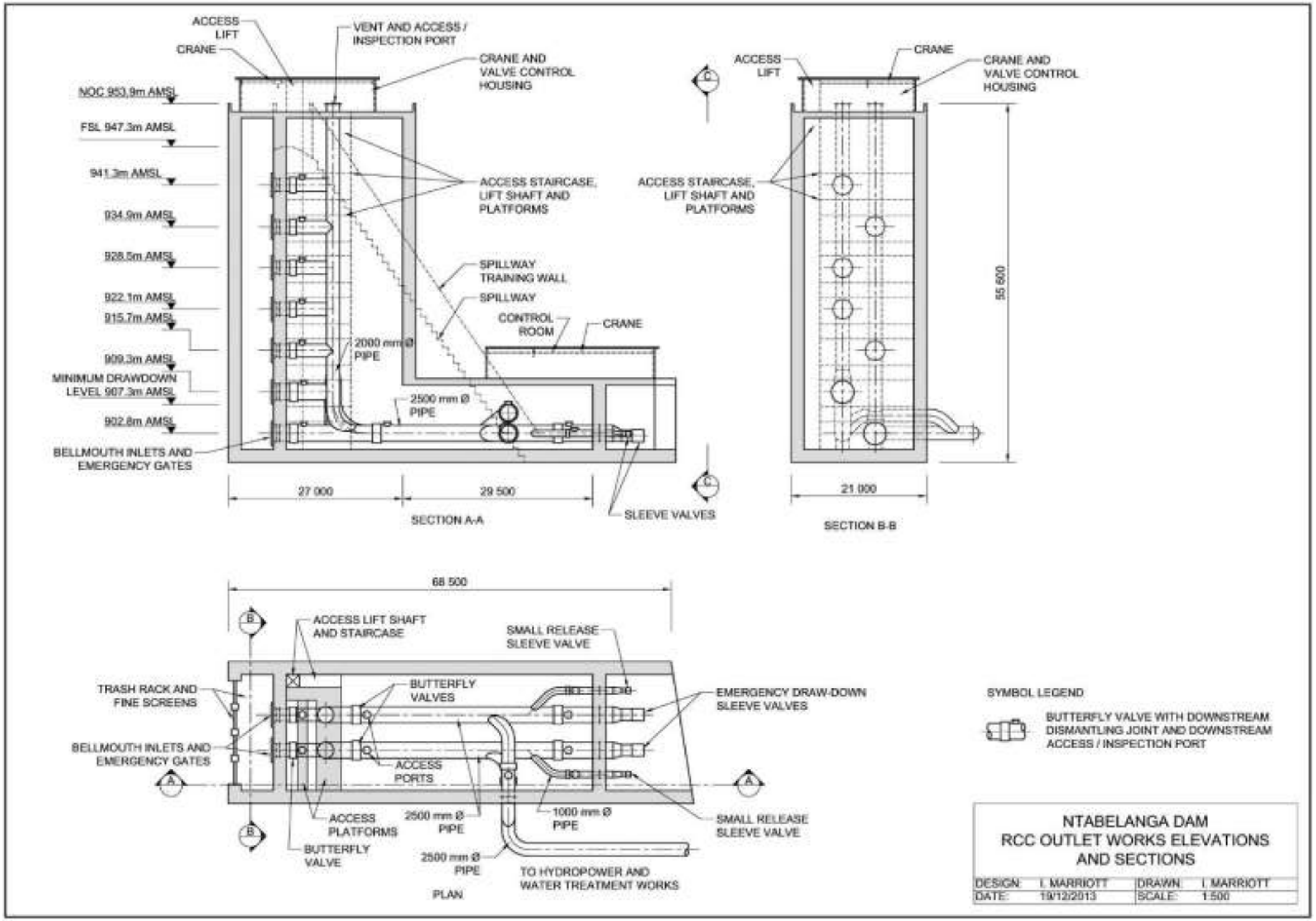


Figure 3-17: Outlet Works Elevations and Sections

3.9 Economic Assessment of Ntabelanga Dam and Bulk Infrastructure

The region is characterised by very low income, resource-poor subsistence farming, and significant unemployment. The potential dam offers a unique opportunity to make water available to address some of these issues by supporting water allocation and land use reform, and creating job opportunities.

The objective of this investigation was to identify ways in which the sustainable yield made available by the dam can be used to meet these objectives and to ensure that the available natural resources of the area are used to the greatest benefit of society.

The suite of options that should be included when water allocation is considered includes:

- Allocation of water to the municipalities. Most of this water would be used to directly support equity needs, as the majority of water users fall into the indigent category.
- Allocation of water for irrigation, thus improving the livelihoods of resource poor farmers and encouraging black commercial farmers and investors. This is an incentive to make land available for land reform and to create jobs.
- Allocation of water for the generation of power, the sale of which can be used as a revenue stream to reduce the operating costs of the overall scheme, and could possibly also generate surplus funds to redeem the capital investment.

The proposed development options will require significant engagement by the DWS and close co-operation with other spheres of government to ensure the success of any initiative. This will also require a major shift in current thinking about the water-energy-agriculture nexus, and a fully integrated approach is proposed.

The EIA Study was still underway at the time of undertaking feasibility economic assessment. This includes the investigation of both environmental and socio-economic impacts. This will also raise issues that might have additional cost implications, including compensation and mitigation costs. In the meantime, some provision has been made for this in the cost estimates, but this will need to be reviewed once the EIA has been completed and the environmental authorisation has been issued..

There are a number of complexities, as some individuals and activities will benefit from the project, while others will be either temporarily disrupted or permanently affected in a negative way. A socio-economic impact assessment was undertaken in both the feasibility and EIA studies to analyse and weigh these effects against one another.

Social benefits of the project are important for the poverty alleviation strategies of the study area. Jobs, new sources of income and opportunities for economic advancement are all to be created.

With adequate support in terms of training and funding, the project could result in significant improvements in the overall standard of living of the large scattered rural population residing in the supply area.

Refer to Regional Economics Report No. P WMA 12/T30/00/5212/14, as well as the Economic Impact Assessment report to be produced under the EIA.

3.10 Dam Economics

A detailed dam type analysis was undertaken to determine the optimum dam type and spillway arrangements. This is described in detail in Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12.

The following dam types were investigated:

- Roller compacted concrete (RCC) gravity dam;
- Concrete faced rockfill dam (CFRD);
- Earth core rockfill dam (ECRD);
- Earthfill embankment dam with earth core (EF); and
- Composite central concrete gravity spillway/embankment flank options (CCS).

Further options regarding the spillway alternatives of left or right bank side channels, cut through, or central spillway were also investigated.

The outcome of the economic analysis for dam type selection was that the RCC and ECRD (with right hand side channel spillway) options were ranked very closely, with all other options more than 10% higher in cost.

It was therefore concluded that there is little to choose between these two options as far as costs were concerned, and other factors were therefore considered to inform the decision-making process, namely:

- Ability to build in stages if a smaller dam is built first and then raised;
- Speed of implementation to first water delivery;
- Simplified infrastructure layout and access;
- Low maintenance inputs;
- Less risk when dealing with floods during construction, and
- Environmental impacts.

Taking the above decision-making factors into consideration, and as recommended in Report No. P WMA 12/T30/00/5212/12, it is concluded that the preferred dam type is the RCC solution.

This would provide for a simplified operational layout, and better aesthetics and less environmental impact than an ECRD dam with a side channel spillway, and would offer the better opportunity for implementation in a shorter time period.

The fact that the DWS Infrastructure Branch is considering the implementation of the project in-house to reduce the implementation time, and that they have more experience with RCC technology than rock-fill, would further justify the preference of RCC as the dam type to be implemented.

Therefore the dam and ancillary works that is further described in Section 4 is based on the RCC solution.

3.10.1 Costing of Ntabelanga Dam and Potable Water Supply System

The Ntabelanga dam type, the dam alignment, general feasibility design approach, and associated works layout were reviewed by the Review Panel expert, which included a site visit.

Based upon the agreed final configurations, the dam cost estimates were updated, other costs estimates prepared, and URV analyses rerun on the final scheme, which included the following components:

- Ntabelanga Dam and Outlet Works to WTW
- Ntabelanga Water Treatment Works
- Associated works, which included:
    - Upgrading surfaced main access roads
    - Upgrading gravel main access roads
    - Upgrade and realignment of villages access roads
    - Temporary haul roads
    - Downstream bridge across river
    - Staff housing complex
    - Visitors centre
    - Temporary water abstraction, treatment and supply
    - Wastewater treatment plant
    - Power lines and Transformers (22 kVA)
    - Gauging weirs
- Primary Treated Water Pump Stations and Bulk Water Distribution System
- Secondary Treated Water Pump Stations and Bulk Water Distribution System
- Expropriation Costs
- Environmental Mitigation
- Resettlement
- Servitudes

The tertiary treated water booster pumping stations and bulk water distribution systems were excluded from the analysis as these would not be a part of the works to be implemented by the DWS.

Also not included in this analysis was the hydropower plant or the raw water transfer system for irrigation, both of which were dealt with as separate components.

These costs were again based upon mid-July 2014 price levels, and included engineering design and supervision, EMP preparation costs, contingencies, and VAT.

Power costs were calculated at an average tariff of Rand 0.48/kWh (year 2014 ESKOM Ruraflex average tariffs and assuming 20 hours per day pumping to avoid peak hourly tariff charges).

Management, operation and maintenance costs are also estimated by applying the following factors recommended in the DWS's "Technical Guidelines for the Development of Water and Sanitation Infrastructure":

Pump station:	0.50 % per annum (p.a.) of total pipeline costs
	0.25 % p.a. of pump station civil costs
	4.00% p.a. of pump station mechanical and electrical costs
Pipeline:	0.50 % p.a. of total costs
Civil Works:	0.25 % p.a. of total costs

The URV analyses were undertaken for both full capital cost redemption scenario, and a second scenario whereby only operation and maintenance, power costs and recurrent plant replacement costs are considered.

Analyses were also undertaken to test the sensitivity of subsidisation of power cost at both 50% subsidised and 100%.

Discounted cash flow analyses were based upon discounting rates of between 6% and 10% in accordance with Treasury guidelines, but a further analysis was undertaken using a "social discount rate" of 2%, which has been suggested as a means to evaluate projects which are poverty alleviation based, and which are not normally able to effect full cost recovery.

Table 3-19 summarizes the results of the URV analysis.

Table 3-19: URV for Ntabelanga Potable Water Scheme Alone – Excluding Tertiary Pipelines

SCENARIO	COMPONENTS GRANT FUNDED	URV OF WATER SUPPLIED (R/m^3)		
		6%	8%	10%
1	Full Capital Redemption	9.45	10.20	10.92
2	Fully grant funded	2.47	2.27	2.08
3	Fully grant funded + 50% Energy Subsidized	2.05	1.88	1.73
4	Fully grant funded + 100% Energy Subsidized	1.62	1.49	1.38

As can be seen the results clearly show that the URV of water supplied is very high if full capital cost redemption is taken into consideration.

The situation is more reasonable and financially sustainable if only operation and maintenance, power costs and recurrent plant replacement costs are considered.

This indicates that grant subsidization of a significant proportion of the capital cost of the works will be required, which is typically the case on projects with a widely scattered, rural nature, with a high proportion of indigent consumers. This also assumes that the majority of consumers would use 60 l/c/d, but the reality may be that consumption is much less than this, at least initially.

3.11 Economic Viability of Irrigation Farming

3.11.1 Land Matters

Current land use is by resource-poor subsistence farmers, who have been allocated State-owned land by the Traditional Authorities. From the discussions held with stakeholders, and in particular the DAFF and the Eastern Cape Department of Rural Development and Agrarian Reform, the approach would be to develop commercially run irrigation farming units. This will provide the incentive for each farm to be economically viable and sustainable, which has been a key problem with existing irrigation schemes in the past. It will require the introduction of new technology to the area with the necessary training and support, and will require an overhaul of the current system of communal farming currently in place in the area.

Extensive public consultation with the community, Traditional Leaders and government officials will be required. It is important that a land register of current land use is set up so that land claims and disputes can be properly addressed and managed. An asset register of the project footprint areas was prepared as part of the EIA.

Determination of farming unit size has been determined on the premise that each farming unit should own their own tractor and farming implements, and the appropriate farm size to economically justify this approach. This has been determined as 60 ha per farming unit on average. The 2 868 ha of irrigable land around the Ntabelanga Dam and Tsolo can be reasonably grouped into 45 farming units of average size circa 60 ha per unit.

The current system of land tenure is communal dry-land farming on State-owned land. It is suggested that commercial leases of at least 20 years be entered into with prospective farmers, with leases being conditional upon proper and effective use of the land.

Technical training and support structures do exist in the area. The Department of Rural Development and Agrarian Reform is well positioned to provide training and extension services in the area. Tsolo Agricultural College and Jongiliswe Agricultural College for Traditional Leaders are local resources that could be used to train, mentor and support developing farmers. Business training will need to be a focus area for the farmers, as the farms need to be economically sustainable.

3.11.2 Agricultural Economics

A 60 ha farming unit will potentially have an annual turnover of between R3 million and R5 million.

A Gross Margin Analysis (GMA) has been carried out for the crops that are suited to the area. The GMA per crop is presented in the Irrigation Development Report No. P WMA 12/T30/005212/9. A typical crop planting scenario on a 60 ha farming unit with a mix of vegetables, row crops and forage/fodder crops indicates that a Gross Margin of around R580 000 is realistic per 60 ha farming unit. It is stressed that this is a gross margin on directly allocatable costs, and not a measure of profit.

A possible employee structure per 60ha mixed enterprise irrigation farming unit has been considered, comprising 75 permanent employees per unit and 20-30 seasonal employees per unit. Based on 45 farming units, this would result in 3 375 permanent direct jobs, and up to 1 350 seasonal direct jobs.

3.11.3 Supply of Raw Water to Edge of Field

Several options were considered for transfer of raw water from Ntabelanga Dam to the proposed farming units. The preferred option was pumping directly from the Ntabelanga Dam to an intermediate open storage reservoir at an elevated location, from where a gravity system conveys water to local header tanks adjacent to the proposed farming units. Two small booster pumping stations are required to supply water to the farming units located at the highest elevations. This arrangement is shown on Figure 3-18.

For the economic analysis of the preferred option, various capital redemption scenarios have been modelled from no grant funding (100 % capital cost taken into account in Net Present Value) to full grant funding of the various system components.

For grant funded options, the full cost of operation, maintenance, staffing and power cost is again included, with the exception of scenarios where the impact of partial or full subsidization of power costs are investigated.

Table 3-20 summarises the results of this analysis.

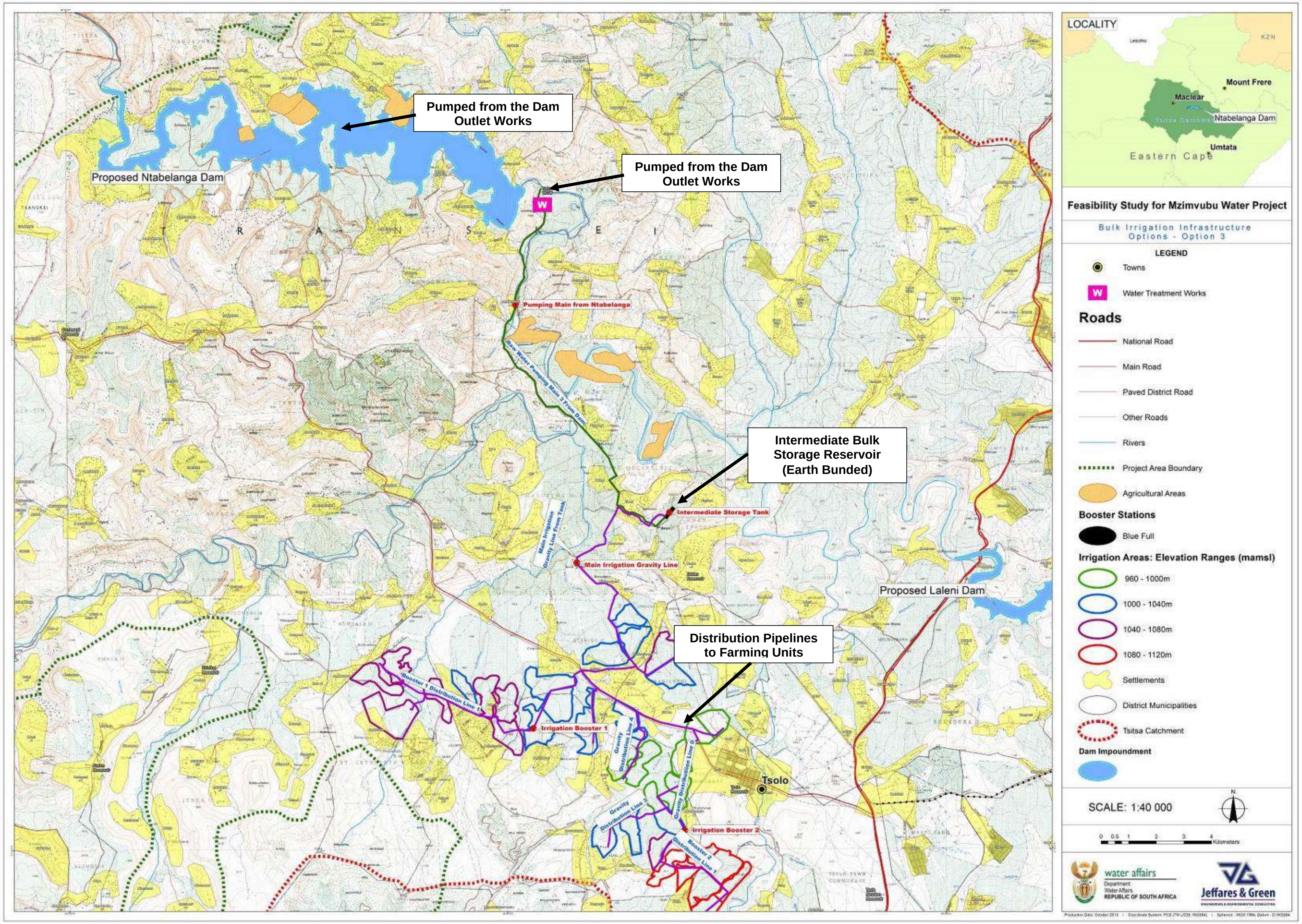


Figure 3-18: Overall Layout Plan of Preferred Option

Table 3-20: Summary of Results of Irrigation Water System URV Analysis

URV: IRRIGATION SCHEME COMPONENTS ONLY				
Scenario	Components Grant Funded	URV OF WATER SUPPLIED (R/m^3)		
		6%	8%	10%
1	Full Capital Redemption	3.94	4.26	4.56
2	Fully Grant Funded	0.53	0.48	0.44
3	Grant Funded and 50% Energy Subsidized	0.44	0.40	0.37
4	Grant Funded and 100% Energy Subsidized	0.35	0.32	0.29

The results serve as an illustration of the obvious benefits of grant funding and the impacts of partial or full subsidization of the energy costs.

Whilst the Unit Reference Value (URV) of water supplied does not relate directly to the tariff requirements for a viable scheme, experience has shown that for irrigated agriculture, where low unit cost of water is required for viability, this value should be well below R0.50/m^3 on grant funded schemes where operation, maintenance and staffing costs need to be recovered for sustainability.

The above table and figure show the significant impact on the URV of raw water delivered in bulk to the edge of field of the proposed farming units, when capital costs and power costs are subsidized.

This is reflected when taking a straightforward non-discounting approach to the operation and maintenance cost of this component, as is shown in Table 3-21.

Table 3-21: Financing and O&M Cost Analysis of Irrigation System

OPTION 3 - IRRIGATION PIPELINE DIRECT FROM DAM				O&M per year		
ITEM	DESCRIPTION	AMOUNT				
1	Pipelines	R	405 636 748	0.50%	R	2 028 184
2	Abstraction works	R	8 000 000	0.25%	R	20 000
3	Pumpstations	R	23 280 152	4%	R	931 206
4	Reservoirs	R	50 000 000	0.25%	R	125 000
5	Electrical supply	R	10 000 000	4%	R	400 000
6	Contingencies	R	49 691 690	1%	R	496 917
7	Engineering fees	R	32 796 515			
	Allowance for M&E depreciation and replacement funding				R	956 515
	Total 1	**R**	**579 405 105**		**R**	**4 957 822**
	VAT	R	81 116 715		R	694 095
	Total	**R**	**660 521 820**		**R**	**5 651 917**
				Tot. Water		
O&M Cost for supply of raw water to edge of field excluding power				21 240 366		R 0.27
Power Cost per year		**R**	**18 559 958**	21 240 366		R 0.87
Cost for supply of raw water to edge of field including power				**R/m^3**		**R 1.14**

Operation, maintenance and power cost analyses showed that the preferred option had the lowest unit cost of water at R1.14/m^3. This does not allow for capital redemption.

This is high when analysing the current economics of irrigation which typically considers bulk water supply tariffs of R0.25/m^3 to R0.40/m^3 to be viable, and given that about 70% of this unit cost of water supplied is for power consumption.

This emphasises the need to reduce the net running costs of the scheme by beneficial development of the conjunctive hydropower scheme, and effectively links the two water uses together.

Discounted cashflow analysis shows that the URV of water supplied to edge of field at 8% discount rate is R4.26/m^3 if full capital redemption is included, and this drops to R0.48/m^3 if only operation and maintenance, power costs and recurrent plant replacement costs are considered. Subsidizing power costs brings this URV down even further.

This again indicates that grant funding subsidization of capital works will be required in order to ensure that the proposed agricultural developments are financially viable.

This is in line with approaches proposed in the DWS Revised Water Pricing Strategy for Raw Water whereby it is recognized that resource poor farmers could benefit from subsidies in the form of caps on raw water charges. This is also discussed further in the institutional and financing task and is described in Report No. P WMA 12/T30/00/5212/16.

3.11.4 Conclusion on Irrigation Development

An area of 2 868 ha of potential irrigable land has been identified around the Ntabelanga Dam and Tsolo. This land can be reasonably grouped into 45 farming units, each of approximately 60 ha. Depending on what crop mix is planted to what area, the water demand from the dam will be between 17.8 million m^3/a and 32.7 million m^3/a, with an average of 27.8 million m^3/a.

Introduction of a commercial irrigation farming model is recommended. However this will constitute a major change from the current system of land use. Extensive community consultation will be required. Failure to garner broad community support for the proposal will constitute the biggest risk to failure of the scheme, both in the short and long term.

In order to give investors the confidence of a long enough tenure to obtain a return on their investment, a commercial lease system of 20 year leases is proposed, performance linked to proper land use and productive use of the land. An annual gross margin of around R580 000 per farming unit is realistic for a typical mix of vegetables, row crops and fodder crops.

Up to 3 375 permanent direct jobs, and up to 1 350 seasonal direct jobs could be created on the farming units.

Key issues that will need to be resolved are:

- Land reform and a change of mind set as regards agrarian practices and land tenure;
- This will require extensive consultation with Traditional Leaders and the affected people in the areas to be developed;
- Investment in training, facilitation, and support services;
- The economics of the identified development option are based upon:
    - Grant funding of the main bulk water supply infrastructure to ensure that the water supplied is affordable, and
    - Reduction of power costs through the beneficial usage of the hydropower generated by the Lalini hydropower component of the project.

3.12 Economic Viability of Hydropower Options

As a part of Phase 2 of the feasibility study, economic analysis was undertaken for an Ntabelanga Dam hydroelectric plant (HEP) used conjunctively with the Lalini hydropower scheme. This analysis was run for the largest capacity Ntabelanga Dam operated in conjunction with the smallest capacity Lalini Dam, as well as the smallest capacity Ntabelanga Dam in conjunction with the largest capacity Lalini Dam.

A further scenario was investigated where the Lalini scheme was not built, but the Ntabelanga Dam hydropower plant was developed alone including the incremental cost of building the maximum capacity Ntabelanga Dam.

The objective of this was to determine whether to proceed with more detailed investigations for the Lalini Dam and Hydropower Scheme.

This is discussed in more detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15 and the Lalini Hydropower Analysis Report No. P WMA 12/T30/00/5212/18 but, in summary, the results of both conjunctive and single plant hydropower analysis are given in Table 3-22.

Table 3-22: Comparison of Levelized (URV) Cost of Power Produced by the Hydropower Options

					LEVELIZED COST OF POWER (R/kWh) FOR DISCOUNT RATES					
	DAM CAPACITY (MAR x)		INSTALLED HYDROPOWER		WITH FULL CAPEX INCLUDED			O&M AND REFURB COSTS ONLY		
OPTION	NTABELANGA	LALINI	NTABELANGA	LALINI	6%	8%	10%	6%	8%	10%
NTABELANGA DAM ONLY	1.18	NO DAM	5 MW	NIL	R3.24	R3.60	R3.97	R0.76	R0.67	R0.60
NTABELANGA DAM PLUS LALINI DAM	1.18	0.15	5 MW	30 MW	R0.82	R0.94	R1.06	R0.11	R0.10	R0.09
NTABELANGA DAM PLUS LALINI DAM	0.15	0.78	NIL	30 MW	R0.97	R1.11	R1.24	R0.13	R0.11	R0.10

This shows that developing the Ntabelanga hydropower option only is not viable, having a levelized cost of power ranging from R3.24/kWh to R3.97/kWh, including capital redemption. A benchmark for levelized costs for a viable hydropower scheme is currently in the range of R1.00/kWh to R1.50/kWh. Therefore, only if this option were to be grant funded would it be considered to be viable.

The conjunctive use options, however, show levelized costs well within the range currently considered to be viable, even allowing for full capital cost (“capex”) redemption.

The large Ntabelanga/small Lalini option had the lowest levelized cost of power ranging from R0.82/kWh to R1.06/kWh, including capital redemption, which could drop as low as R0.09/kWh if grant funding can be provided and only operation and maintenance and plant refurbishment costs are considered.

Given this result, a more detailed water resources, dam optimisation and hydropower analysis was undertaken on the Lalini Dam site based upon the large capacity Ntabelanga Dam (1.18 MAR) and for a range of Lalini Dam capacity options.

The Reserve Determination and operating rules were also revisited for the Lalini Dam site as the hydropower releases have a significant impact upon the riparian hydrology downstream of the proposed dam site and hydropower tunnel exit point.

The findings are given in the Feasibility Design: Lalini Dam and Hydropower Scheme Report No. P WMA 12/T30/00/5212/19, and a separate RID was also prepared for the Lalini Dam component as Report No. P WMA 12/T30/00/5212/20.

3.13 Conclusions from the Ntabelanga Dam Aspects of the Feasibility Study

The infrastructure to be developed is described in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13, and the Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12.

The reports listed above describe the development of solutions for these multi-purposes, and the resulting project infrastructure, which comprises the following:

- a new dam on the Tsitsa River at Ntabelanga, with capacity to reliably supply the raw and potable water requirements for the area as well as operating in conjunction with the proposed Lalini Dam and Hydropower Scheme,
- a water treatment works at the Ntabelanga dam to supply the potable water requirements,
- primary and secondary bulk water distribution systems that deliver potable water to the whole supply area. Tertiary distribution systems to the consumers will be implemented by the District Municipalities,
- a bulk raw water distribution system to supply irrigation water to some 2 868 ha of high potential land, and
- a mini hydropower plant at Ntabelanga Dam to generate up to 5 MW of power.

Based on the Feasibility Study findings, conclusions are drawn in terms of the items listed below. The future actions that need to be taken following the Feasibility Study are indicated below, against each conclusion:

i. Dam detailed design and related issues;
ii. Water quality sampling and testing;
iii. Associated water resources management;
iv. Updating of Costs;
v. Other technical and economic considerations;
vi. Use of water;
vii. Environmental issues and mitigation measures;
viii. Operating rules;
ix. Implementation of the Reserve; and
x. Scheme financing and implementation.

These conclusions are summarized in the following sections.

3.13.1 Ntabelanga Dam Design and Related Issues

Following the feasibility design process, the findings concluded in Table 3-23 are relevant to the detailed design and construction stage of this project.

Table 3-23: Conclusions on Ntabelanga Dam Design and Related Issues

Findings	Remarks
a) A Gravity RCC type of dam is the recommended optimum solution.	To be further refined and optimised in the detailed design stage.
b) The dam has a centrally located ogee spillway with stepped chute.	To be optimised in the design phase. Physical modelling of spillway, chute, and plunge pool is recommended
c) A multi-level outlet structure must be built to ensure good quality water for treatment and that the water quality and temperature requirements of the downstream aquatic system can be satisfied.	The EWR requires a multi-level outlet structure. Operating rules to be established.
d) The required normal operation outlet capacity of the dam needs to be based upon flow ranges for the EWR, hydropower plant peak output, peak raw water pumping to irrigation, and peak daily WTW capacities.	River outlet capacity to be optimised in the design phase, considering these requirements and releases required for irrigation. The requirements will need to be in line with both the reserve and the conjunctive operational regime.

e) The emergency drawdown outlet capacity will allow rapid drawdown of the dam to one-third of its maximum water depth within 90 days.	Layout to be finalised in the design phase. Modelling of outlet hydrodynamics is recommended to optimise system performance under high flows, and ensure no surge or vibration problems occur.
f) Results from the geotechnical investigations indicate that foundations are on competent rock, and that adequate materials are available close to the dam wall for the proposed maximum sized dam. The source/availability of suitably graded sand for concrete upstream in the river channel still needs to be confirmed.	Additional geotechnical work is required for the design phase to improve information available and to check for any foundation anomalies. The source/availability of suitable sand needs to be confirmed.

3.13.2 *Water Quality*

Water quality recommendations regarding thermal stratification and the need for a multi-level outlet structure are summarized in Table 3-24.

Table 3-24: Conclusions on Water Quality Issues

Findings	Remarks
a) A multi-level intake for the outlet structure is required in terms of the Reserve requirements.	Seven outlet levels have been included in the Feasibility Design Report in accordance with the recommendation of the Reserve Determination Report.
b) Water quality sampling should be undertaken and water quality and thermal stratification models built to inform the final design and operating rules and results must be included in the final Environmental Management Plan.	The approved Reserve must be complied with.
c) The upstream catchment is severely degraded with poor land use management practices. Erosion is amongst the highest in the country.	A 10 year extensive catchment restoration and on-going management programme was started in April 2014 spearheaded by the Department of Environmental Affairs.

3.13.3 *Associated Water Resources*

Recommendations regarding the management of associated water resources are summarized in Table 3-25.

Table 3-25: Conclusions on Associated Water Resources Issues

Findings	Remarks
a) Water demand management must be implemented for both potable water supplies and on irrigation schemes.	This action to be continued by EC Regional Office in conjunction with the Directorate: Water Use Efficiency or CMA when established. The CMA must enforce the development of this Plan and then help the WUAs each year to evaluate and review it in order to achieve water conservation and demand management. Drip irrigation would be the most efficient.

b) There are some existing water sources and schemes within the area to be supplied by the project. These comprise small stream intakes, springs and groundwater. DMs report many problems with maintenance and reliability.	As the distribution system is developed, each existing scheme should be investigated on its own merits and either integrated into the main system, or allowed to continue operation. DMs should make these decisions in conjunction with any appointed Implementing Agent.

3.13.4 *Costs and Economics*

Recommendations regarding the costing and economics of the proposed works are summarized in Table 3-26.

Table 3-26: Conclusions on Costing and Economics Issues

Findings	Remarks
a) The maximum capacity dam and appurtenant infrastructure, which would allow for the hydropower option to be developed, is estimated at R1 366 million (including VAT).	Costing to be updated after detail design.
b) The Ntabelanga Dam has 60 million m^3/a allocated for potable and irrigation water supply. At an 8% discount rate, water supplied from the dam has a URV of R10.20/m^3 if full capital redemption is considered, or R2.27/m^3 if only operation and maintenance, power costs and recurrent plant replacement costs are considered.	Cost to be updated.
c) The above cost includes impacts on roads and other infrastructure as well as some costs allowed for environmental and social mitigation measures.	Impact on roads and other infrastructure, and associated costs need to be finalised during design.

3.13.5 *Other Technical Considerations*

A summary of other technical and economic considerations is given in Table 3-27.

Table 3-27: Conclusions on Other Technical Issues

Findings	Remarks
a) Technically feasible re-alignments can be achieved for existing roads affected by the inundation caused by construction of the dam.	Details of road realignment to be optimised in the design phase.
b) Land inundated includes residential development, agricultural developments and associated infrastructure.	This aspect was considered in more detail in the EIA. The dam boundary (purchase) line and servitudes for infrastructure need to be determined as part of the detail design stage.

3.13.6 *Use of the water*

Recommendations regarding the use of the water are summarized in Table 3-28.

Table 3-28: Recommendations Regarding Use of Water

Findings	Remarks
a) Indications are that there is adequate requirement for water and significant support for the dam from the water service providers in the region.	The three DMs in the region have appointed Amatola Water to undertake the planning of the water supply to a future population of some 726,000 people, based upon the Ntabelanga Dam as the source of water.

Findings	Remarks
b) The availability of land with suitable soil for irrigated agriculture is not a limiting factor to the expansion of irrigation in the study area.	Some 2 868 ha of high potential land suitable for irrigated agriculture has been identified. Extensive land use and land tenure reform will be required before financial viability of water usage for commercial irrigated agriculture can be assured.
c) The scheme would provide the possibility to make significant water allocations to resource poor farmers. The DWS should ensure that raw water is made available from the construction of the dam to stimulate development and poverty alleviation in the area.	This is one of the prime objectives of the development of this project and further investigations mentioned above must be implemented by DWS and other role players.
d) Water supplied to resource poor farmers will need to be subsidized through capital grants and/or tariff caps.	Revised DWS Raw Water Pricing Policy recognises this.
e) Any potential identified opportunities for future irrigation would need to be evaluated in terms of the conditions and costs relating to that specific opportunity. Final cost estimates of specific development options must be obtained, based on the cost of the dam, and the available yield for allocation to new irrigation development.	Investigation into future irrigation development will be the function of the Provincial Department of Agriculture and Agrarian Reform. Water allocation to future irrigation users will be dealt with by the DWS Directorate: Water Allocation.

3.13.7 *Operating Rules*

Comments on the establishment of operating rules for the dam are given in Table 3-29.

Table 3-29: Comments on Dam Operating Rules

Findings	Remarks
a) Operating rules need to be established for the dam. The operating rules need to take the existing users in the different river reaches, the inflow from tributaries downstream, the water quality issues such as the seasonal variability etc., into consideration. New areas of possible irrigation development will *inter-alia* also need to be considered.	It is recommended that a release pattern be determined, based on the operating rules of the dam as well as the ecological requirement and hydropower requirements downstream of the dam.

3.13.8 *Implementation of the Reserve*

Comments on the implementation of the Reserve are given in Table 3-30.

Table 3-30: Comments on Implementation of the Reserve

Findings	Remarks
a) Develop and implement a detailed riverine monitoring programme.	Reserve implementation and monitoring to be performed by RDM Office and the DWS Regional Office.
b) On an on-going basis, monitor the effectiveness of the proposed ecological releases, and implement refinement of the releases if needed.	Reserve implementation and monitoring to be performed by RDM Office and the DWS Regional Office

c) Institute a monitoring programme for the systematic monitoring of the pertinent data for assessing or modelling water quality in the reservoir. This programme should include: ● Hourly or daily meteorological data (air temperature, dew point temperature, wind speed, wind direction, and percentage sunshine); ● Inflow rates; ● Inflow and in-lake water quality; and ● Release rates.	Reserve implementation and monitoring to be performed by RDM Office and the DWS Regional Office.
d) Monitor nutrient loads flowing into the Dam. It is also recommended that monitoring of the inflow water chemistry be implemented and that the inflowing nutrient loads are examined on an annual basis.	To be addressed and implemented in detailed design and operation phases.

3.13.9 Scheme Financing and Implementation

Comments on scheme financing and implementation issues are given in Table 3-31.

Table 3-31: Comments on Scheme Financing and Implementation

Findings	Remarks
a) Significant grant funding will be required to reduce the unit cost of water to a level that can sustain all operation, maintenance, power, and recurrent plant replacement costs. The potential capping of raw water tariffs for the new farmers should be considered, in order to make the water more affordable to resource-poor farmers.	To be considered in the funding model.
b) Government need to fund the capital cost of this Strategic Integrated Project. This would however not be in accordance with the DWS's pricing policy but could be motivated in terms of the aim of the project, namely poverty alleviation and social upliftment of the very large number of indigent beneficiaries.	To be considered in the funding model.
c) The roles and responsibilities of various Government departments, WUAs, municipalities, and other government entities in terms of the implementation of the project must be clarified and such organisations need to commit to allocated responsibilities.	Refer to the Legal, Institutional and Financing Arrangements Report (No. P WMA 12/T30/00/5212/16).

4. FEASIBILITY DESIGN OF THE NTABELANGA DAM

The feasibility design is based upon the recommended RCC gravity dam type with a capacity sufficient to supply water for domestic water supply, irrigation, and to generate hydropower, both at Ntabelanga dam itself, and in conjunction with the downstream Lalini Dam hydropower scheme. Full details of the feasibility design of the dam are given in the Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12. This includes stability analysis, a summary of the geotechnical investigations and materials availability.

A book of drawings accompanies the Main Report No. P WMA 12/T30/00/5212/4.

4.1 Dam Wall and Spillway

As described in the above report, an RCC gravity dam is recommended, with an ogee spillway with stepped downstream face, with a slope of 1 vertically to 0.70 horizontally (1V:0.7H), or step dimensions of 1 200 mm high by 840 mm wide.

During the undertaking of the feasibility design of this dam, the design process and relevant associated reports were reviewed by specialists on the Review Panel. The main review expert also visited the site with the study team, and fine tuning of dam centreline alignments and other details were agreed. This involved adjusting the axis of the dam wall to be squarer to the contours on both flanks, and this effectively moved the centre point of the dam very slightly upstream. This also has the advantage of reducing the maximum dam wall height by 1.7 m and the crest length by some 33 m.

Figures 4-1, 4-2 and 4-3 overleaf show the proposed layout plan, typical wall and spillway cross-sections, and longitudinal cross-sections for the recommended dam type and spillway.

The proposed Ntabelanga Dam has the following parameters:

Full Supply Level (FSL)	947.3 m.a.s.l.
Non-Overspill Crest Level – right flank (NOCL)	953.9 m.a.s.l.
Minimum bed level in river at dam:	886.7 m.a.s.l.
Crest width	6 m
Minimum operating level* (MOL)	918.00 m.a.s.l.
**Dictated by estimate 50 year sedimentation volume of 37 million m^3*	
Emergency drawdown min. outlet level	907.00 m.a.s.l.
Maximum dam wall height to NOC	66.1 m
Wall crest length (incl spillway)	407 m
Spillway crest length	150 m
Gross stored volume at FSL	490 million m^3
Mean Annual Runoff at dam	415 million m^3
Dead storage below MOL	37 million m^3
Surface area of lake behind dam	31.5 km^2
Backwater reach upstream of dam	15.5 km

The dam wall height, impoundment volume, and downstream potential risk factors for the Ntabelanga Dam put this structure into a Category 3 dam in accordance with SANCOLD Guidelines. As discussed above and as reviewed and accepted by the DWS, the flood criteria for design of this dam are as follows:

1 in 200 year return period Design Flood (RDF)	2 500 m^3/s
Safety Evaluation Flood (SEF):	5 530 m^3/s

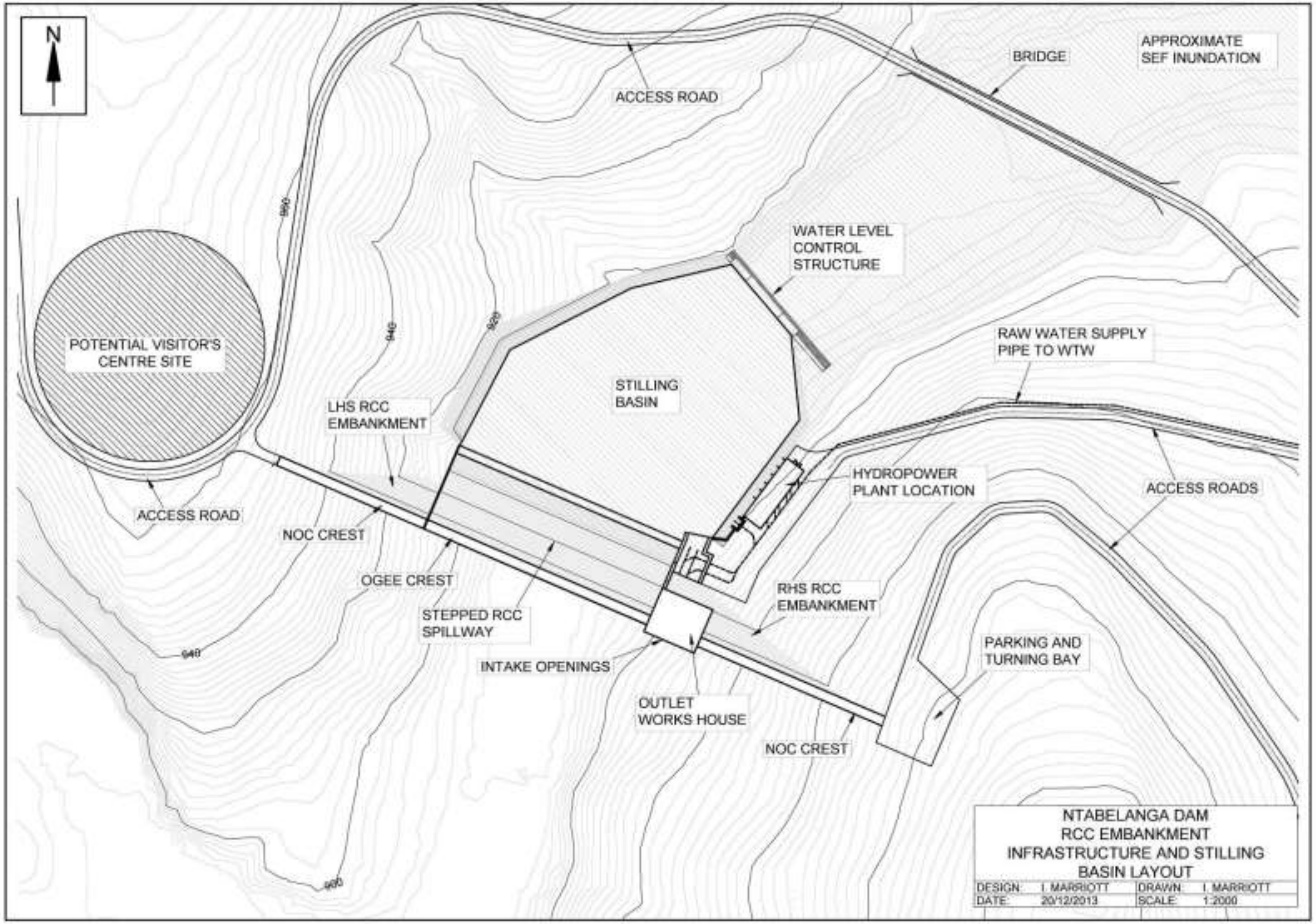


Figure 4-1: RCC Dam and Stilling Basin Layout

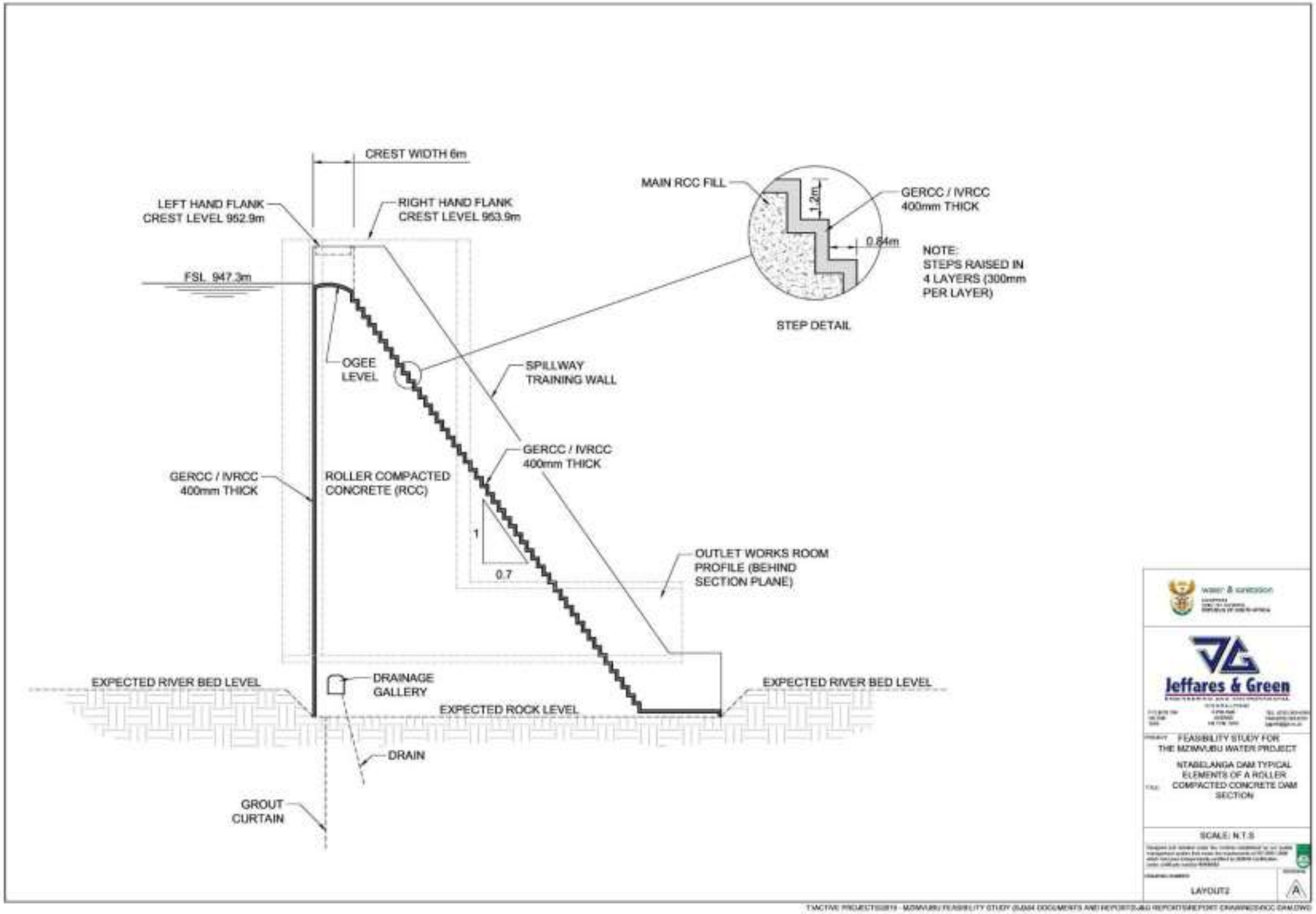


Figure 4-2: RCC Dam Wall and Spillway Typical Cross Section

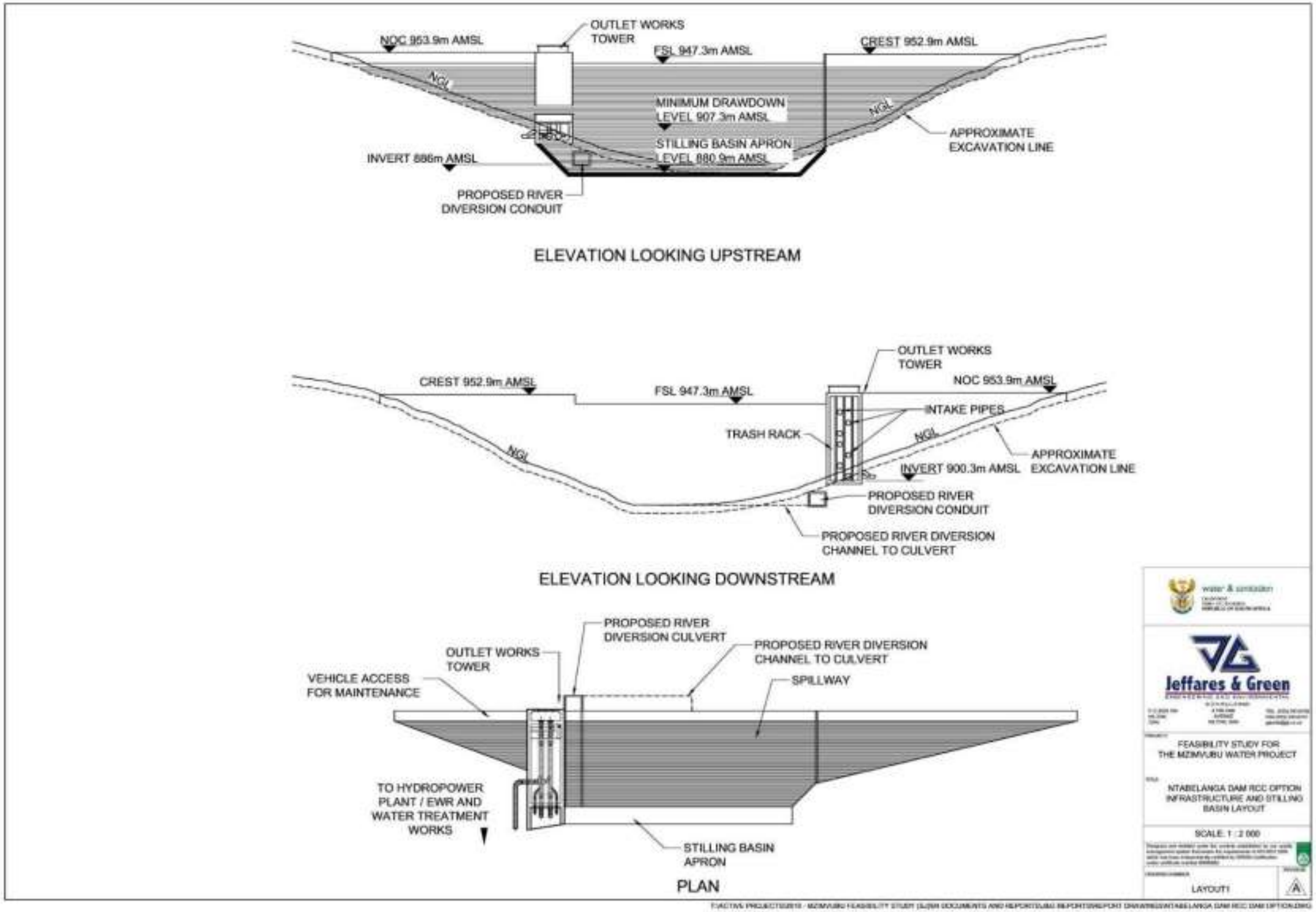


Figure 4-3: RCC Dam Embankment Plan and Longitudinal Elevations

As described in Geotechnical Investigations Report No. P WMA 12/T30/00/5212/10, the investigations have indicated that the founding conditions of both dam wall and stilling basin are in competent dolerite rock, which will have a low erodibility. It was thus agreed with the review expert that the spillway width could be reduced to 150 m and the stilling basin accordingly reduced in width, length and depth, thus saving costs. It was also not considered necessary to install a flip bucket at the lower end of the stepped spillway chute.

Given that the dam wall is to be entirely of RCC construction, and is built on competent rock foundations, the wall structure can therefore tolerate some overtopping under both design flood and SEF conditions. It was therefore suggested that it would not be necessary to increase the non-overspill crest level of the dam, and this would result in approximately a one (1) m overtop level under the extremely rare SEF event, and some wave over-splash during a design flood event.

The hydraulic analysis was undertaken using the normal ogee spillway crest formula and a spillway crest width of 150 m. The 2 500 m^3/s design discharge results in a flow depth of 3.9 m over the spillway. This limits the unit discharge rate to an acceptable 16.7 m^3/s/m.

The NOC level of the dam wall left flank is set at 4.6 m above spillway crest level, and has a further upstand wall increasing the overflow level to 5.6 m above spillway crest level. On the right flank, the NOC level is controlled by the main outlet works structure and is 6.6 m above NOC as no overflow of the right flank should be permitted. The resulting 1.7 m freeboard under design flood conditions is adequate to deal with wind run-up, weaves, surges and seiches.

The depth of flow over the 150 m spillway during the SEF event, which has a flow rate of 5 530 m^3/s, is 6.6 m, and there would therefore be a 1 m overtopping of the left flank only during this event. This should be reviewed during the detailed design stage once the spillway physical modelling has been undertaken. In addition, attention should be made to the effects on the abutment rock face of this left flank overtop under SEF conditions, and decisions made as to whether it is necessary to add special scour protection measures or additional training walls at this location.

The SEF event flood produces a unit discharge rate over the spillway crest of 36.8 m^3/s/m, which is at the upper end of that recommended for stepped spillways to reduce nap separation and cavitation action.

The spillway, chute and stilling basin arrangement must be investigated in more detail and optimised during the detailed design stage, which could include both Computational Fluid Dynamics (CFD) and physical modelling.

CFD is optional, given that it requires very intense computational power and can be time-consuming, but physical modelling is considered essential. Research is currently being undertaken at the University of Stellenbosch regarding the impacts on discharge efficiency of high flows over ogee-crested stepped spillways, and it is evident that much attention must be paid to ensuring that the nap adheres to the ogee crest and does not separate. Physical modelling will therefore inform the design and, if necessary, a longer spillway crest length might result.

4.2 Outlet Works

As has been described above, the dam wall and spillway will be constructed using RCC, and it is proposed that the intake and outlet works be housed in a reinforced concrete structure incorporated in the dam wall as is shown on the layout drawings in Figures 4-1 to 4-4.

The intake and outlet works will have a multi-purpose which is described in the following sub-sections. The dam outlet arrangements will be subject to review during the detailed design stage and may therefore change from this feasibility level design approach.

4.2.1 *EWR Releases*

The Reserve Determination Report No. P WMA 12/T30/00/5212/7 determines the Environmental Water Release (EWR) requirements to be released downstream of the dam. This is based upon running WRYM hydrological simulations and takes into account the expected spills during the same period of simulation.

The recommended total releases which are required to maintain an intermediate ecological Class C river, amounts to 87.249 million m^3 per annum (which is an average of 2.8 m^3/s).

EWR release rules are proposed in the Reserve Determination Report, and release criteria are based upon preceding inflows.

The monthly model simulation results are shown in Appendix E in Dam Feasibility Design Report No. P WMA 12/T30/00/5212/12, and a statistical analysis has been undertaken to determine the probability of various release volumes that would likely be required. Figure 4-5 shows this in chart form.

As can be seen, the EWR release requirement varies from almost zero to 23 m^3/s. The 2.8 m^3/s average figure is required only 25% of the time, with lower figures required 75% of the time, and flow rates above 16 m^3/s are required less than 2.5 % of the time.

Given that water released for EWR can also be passed through a hydropower generation turbine before release, it was decided to consider both EWR and hydropower releases together to determine outlet conduit capacity.

4.2.2 *Hydropower Generation*

The investigation and analysis of hydropower generation at Ntabelanga Dam is summarised in Section 3.8 of this report and in detail in the Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12.

It is proposed that the Ntabelanga and Lalini Dams be operated conjunctively to generate hydropower. During the more detailed investigations of the Lalini Dam and hydropower scheme (see Report Nos. P WMA 12/T30/00/5212/18 and P WMA 12/T30/00/5212/19) a hydropower simulation model was developed and run which, in addition to the main Lalini hydropower plant, included mini-hydropower plants located at each of the two dams themselves which utilized EWR releases as well as flows that would have otherwise passed over the spillway of each dam.

Operating rules were set to ensure that minimum and maximum allowable EWR releases were maintained throughout.

The outlet works pipework configuration allows for large and small release discharges directly into the stilling basin. The off-take pipework to the Ntabelanga mini-hydropower plant and WTW is sized for the maximum hydropower output, WTW, and raw water requirements of 16 m^3/s, 1.3 m^3/s and 1.1 m^3/s respectively. In this case, a 2.5 m diameter pipe was deemed to be sufficient.

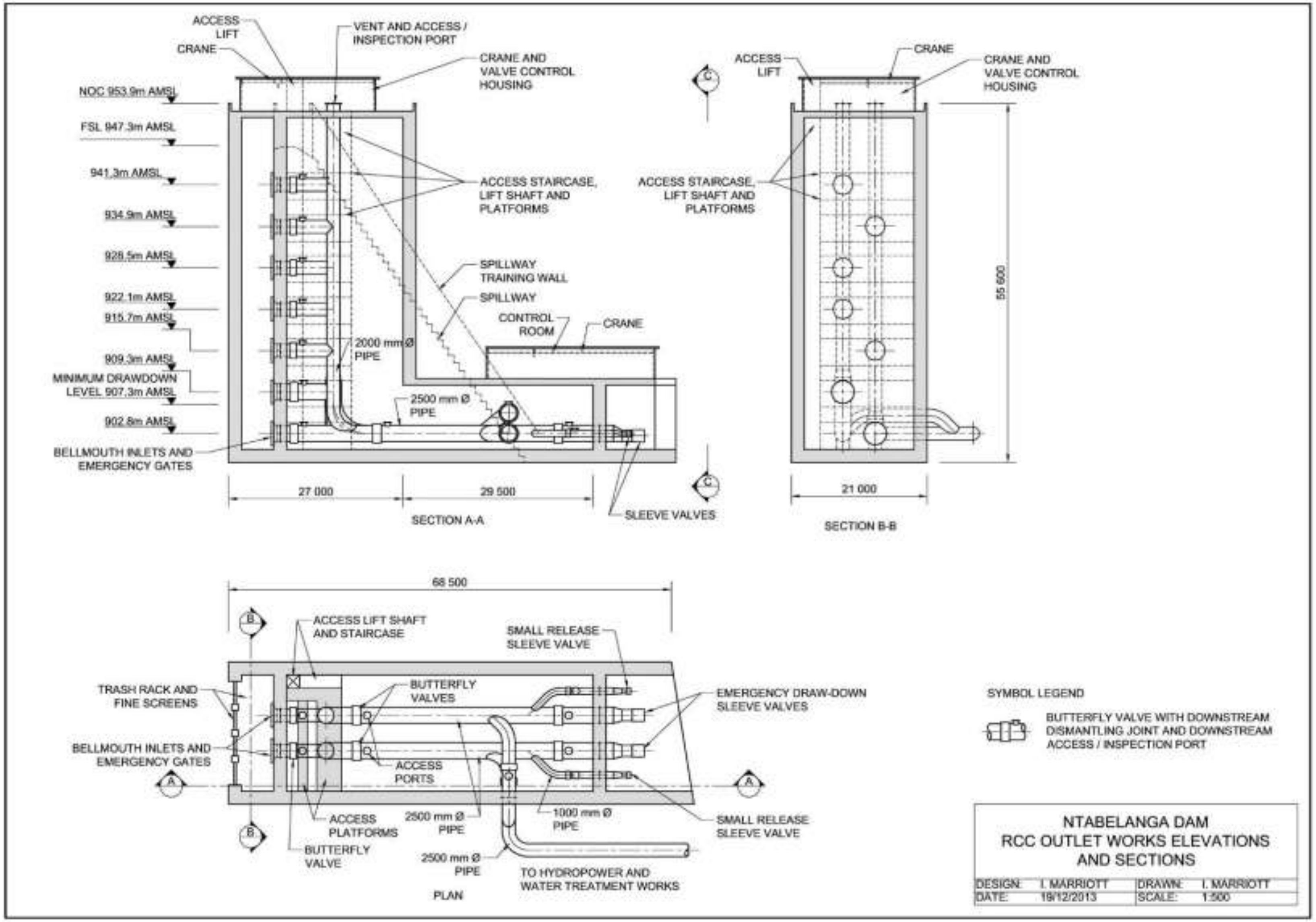


Figure 4-4: Outlet Works Elevations and Sections

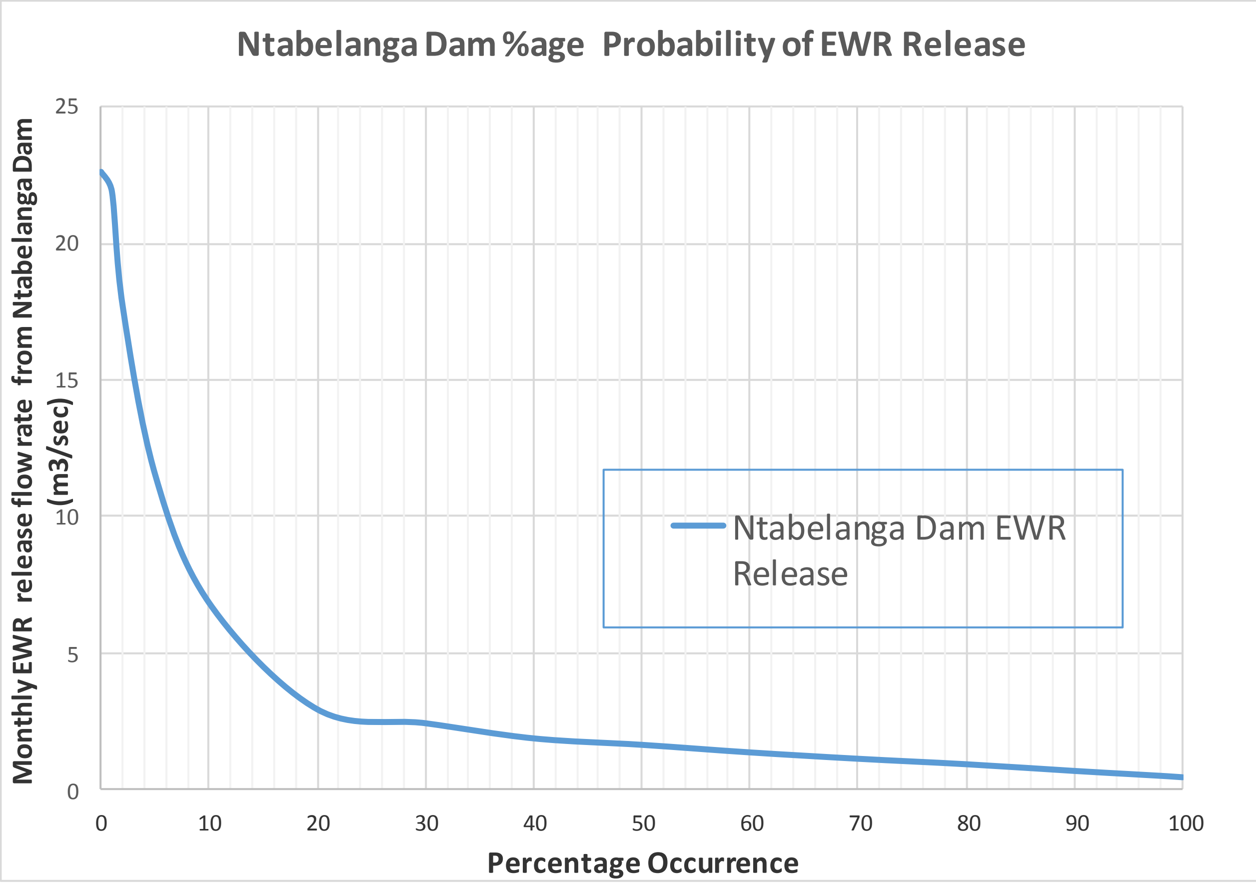


Figure 4-5: Probability of Required EWR Release Rates

One key issue discussed with the DWS Reserve Directed Measures (RDM) office was the release of water from Ntabelanga Dam to supplement flow into the Lalini Dam and hydropower scheme in very low flow winter months. The RDM office has accepted that a release of up to 7 m^3/s could be released in these low flow periods, which figure has been included as one of the hydropower modeling parameters.

Based on the results of this analysis and given the above agreement, it was recommended that a hydropower plant of installed capacity of 5 MW should be installed at Ntabelanga Dam and that this would be operated in accordance with the agreed EWR release rules.

4.2.3 Pipeline to Water Treatment Works

A further function of the intake and outlet works is to deliver water to the water treatment works. As described in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13, the summer peak raw water demand for Domestic Requirements was 101 515 m^3/day + 10% WTW losses = 111 667 m^3/day, which is 1.3 m^3/s.

The water treatment works inlet is located approximately 1.2 km from the dam outlet works with an inlet level of 900.00 m.a.s.l. Given the recommended bottom operating level of the dam of 918.00 m.a.s.l., a minimum gravity head of 18 m is available to transfer water from the dam to the WTW.

Limiting the flow velocity in this transfer pipeline to less than 2 m/s would require a 1 000 mm diameter pipeline, which would have less than 10 m total head loss under this flow condition. However, this pipeline will also transfer water to the raw water pump station for the irrigation scheme, and therefore this transfer pipeline is sized at 1 600 mm diameter.

The minimum recommended velocity for self-cleansing of raw water pipelines is 0.6 m/s. At this velocity, a 1 600 mm diameter pipeline would convey some 104 000 m^3/day (1.2 m^3/s). Therefore, if the first stage development of the WTW and the irrigation scheme combined were to have less than this capacity, consideration should be given to installing two smaller raw water pipelines, and using one initially to maintain self-cleansing velocities above this minimum.

As can be seen on Figure 4-4, the proposal is to run twin 2.5 m diameter steel conduits through the outlet works. These will be supplied from six x 2 m diameter bellmouth drawoffs located on the front face of the outlet works, and positioned at various depths to allow water to be drawn at the best level for water quality purposes. In this respect, turbidity and suspended solids will be of importance for the treatment process, and temperature is also important for the EWR aspects.

In the unusual case of single outlet operation, each single 2 m diameter bellmouth drawoff and 2 m diameter conduit can convey flows up to the design peak flow of 16 m^3/s for hydropower or EWR purposes + 2.4 m^3/s for the peak water treatment works and irrigation scheme output, at a velocity of 5.8 m/s, which is acceptable. In the very rare absolute peak flow periods, this velocity would still not exceed 8 m/s.

Under maximum hydropower production, peak water treatment works operation, and raw water pumping flow conditions, the head loss to the hydropower plant would be approximately 5 m.

The configuration shown in Figure 4-4 allows either or both conduits to be used at any time, to supply both water treatment works and hydropower plant/EWR outlet simultaneously.

4.2.4 Pipeline to Irrigated Areas

As described in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13, the lowest unit cost solution is to abstract raw water at the Ntabelanga Dam and to pump a distance of 16.4 km to an intermediate storage reservoir before distributing onwards to the farming units located in the Tsolo area.

The 1.1 m^3/s peak flow rate required for irrigation has been allowed for in the Ntabelanga Dam outlet works design. This arrangement has the advantage of centralising all operations at the Ntabelanga Dam site rather than having to operate and maintain a separate river intake works, settling channels or basins, and pumping station downstream of the dam.

The raw water pumping station required for the irrigation scheme has been located at the water treatment works site to simplify raw water inlet pipework arrangements. This will also allow the treated water pumping and raw water pumping operations to be managed by the same operations staff. It will also simplify and centralise power transformers and supply lines.

Figure 4-6 shows a proposed arrangement for the irrigation raw water pump station, which pumping configuration is as described in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13.

Potential new farms that have been identified and which are located adjacent to the dam water line and to the river downstream of the Ntabelanga Dam would be irrigated from portable abstraction plants and quick-fit coupling pipeline and spray systems that are commonly available.

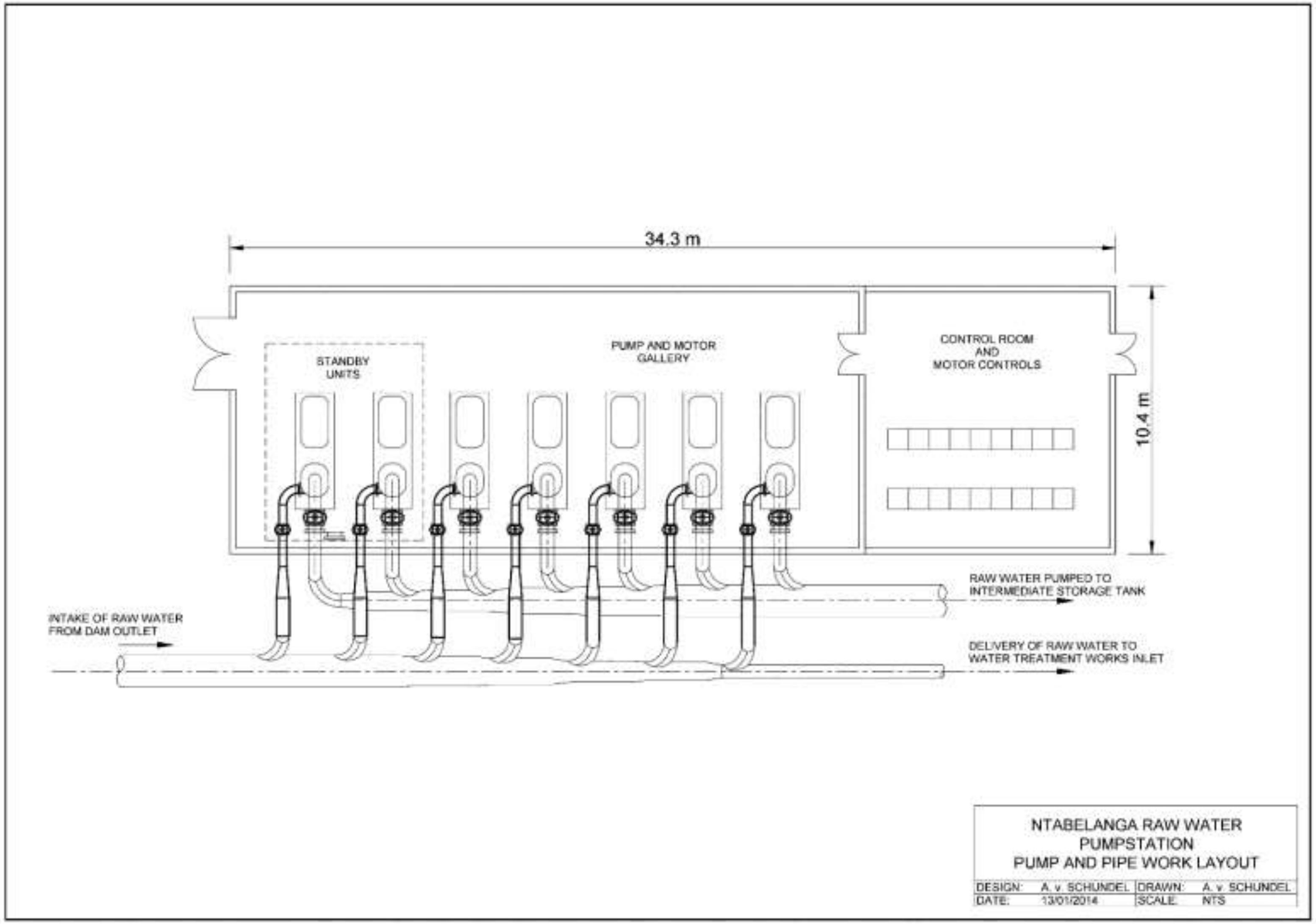


Figure 4-6: Layout of Raw Water Pump Station to Supply Irrigation Scheme

4.2.5 *Emergency Drawdown Facilities*

It is a normal requirement to be able to rapidly drawdown the dam water level in the case of an emergency. This requires that the dam water level be reduced from FSL to one third of its full water depth in 90 days.

For the Ntabelanga Dam, this means that some 485 million m^3 of water would need to be released in 90 days. This is an average flow of 62 m^3/s, with a peak flow of approximately 72 m^3/s. This was taken into consideration for the outlet works feasibility design.

Some dams have completely separate emergency drawdown systems, and given that these are very rarely used, can be a cause of problems if they silt up or are not maintained properly.

Under an emergency rapid drawdown situation, it is proposed that all seven outlet bellmouths would be opened as well as the downstream discharge valves on both of the outlet conduits.

Under such conditions the required peak drawdown rate of 72 m^3/s and average of 62 m^3/s will be achieved, and the maximum velocity in each conduit would be 8.0 m/s, which is acceptable for limited periods and infrequent occurrences.

In addition to the upstream emergency gates and butterfly valves on each of the six offtakes upstream, there would be sleeve valves at the outlet of each of the rapid drawdown and small release conduits. Given the velocities involved, these sleeve valves are more suitable for flow control and tight closure.

It should be noted that total head loss in the system will increase under this rare emergency drawdown period. This will not affect the water treatment works and raw water pumping station output but the hydropower plant output will be down on its normal performance for equivalent dam water levels.

It is again recommended that such a system be modelled and optimised using physical modelling or possibly computational fluid dynamics modelling (CFD) during the detailed design stage, to ensure that surge and vibration effects are minimised or avoided altogether.

4.2.6 *Summary of Outlet Works Parameters*

Table 4-1 summarised the outlet works and pipeline parameters required to meet the above functionality requirements.

Table 4-1: Summary of Outlet Works Parameters

		Flow Scenario					
		Peak Demand		EWR		RDD	
Description	**Pipe dia.**	**Flow**	**Velocity**	**Flow**	**Velocity**	**Flow**	**Velocity**
Intake stack	2.0 m	18.4 m^3/s	5.9 m/s	25.0 m^3/s	8.0 m/s	72.0 m^3/s	11.5 m/s
EWR and RDD pipe	2.5 m	N/A	N/A	25.0 m^3/s	5.1 m/s	72.0 m^3/s	7.3 m/s
Outlet pipe	2.5 m	18.4 m^3/s	3.7 m/s	N/A	N/A	N/A	N/A
Water Treatment Works	1.6 m	2.4 m^3/s	1.2 m/s	N/A	N/A	N/A	N/A
Irrigation	1.0 m	1.1 m^3/s	1.4 m/s	N/A	N/A	N/A	N/A

***EWR**: Environmental Water Requirements* ***RDD**: Rapid Draw Down*

4.2.7 Outlet Pipeline Implementation

The proposed pipeline material is welded steel pipe with external protection and epoxy lining, laid in a trench. Cathodic protection will probably be required due to the presence of power lines and stray currents near to the pipeline routes.

The alignments have been selected to follow contours and avoid high points, and to stay outside of the SEF flood line downstream of the dam.

This flood line has been calculated by modelling the downstream river sections using HEC-RAS software.

EWR flows can still be released in a controlled manner from the bypass and sleeve valves in the hydropower station, when the hydropower station is off-line.

The outlet pipelines should be implemented under the dam construction contract with contract limits between the outlet pipework and the inlet to the water treatment works (WTW) clearly indicated in the contract documents and drawings for both dam and WTW packages.

4.3 River Diversion

A 1 in 5 year flood event (some 500 m^3/s) was used to design temporary diversion works for the RCC dam, since a RCC dam can accommodate minor overtopping during construction. Hence, it requires a lesser safety margin in terms of floods.

The first stage river diversion would require protecting the right flank by means of a cofferdam with diversion of the river flow to the left flank. The cofferdam is required to enable and protect the excavation for the outlet works, right flank non-overspill concrete section and a portion of the spillway to accommodate construction of the second stage diversion conduit and low notch.

For this RCC dam, it is proposed that a second stage river diversion conduit (opening) for low flows (up to 150 m^3/s) and an open channel (low notch) be constructed in the spillway section. An opening measuring approximately 4 m x 3 m needs to be constructed on the right flank of the river channel below the right hand section of the spillway, and adjacent to the outlet works structure. This would have a maximum flow capacity of 160 m^3/s and would limit flood water level rise upstream to just over 10 m. This will comprise an opening in the concrete spillway section at the appropriate level, which can be closed by steel gates/stoplogs and filled with concrete when the dam starts impounding. An open channel (low notch), at a higher elevation than the conduit, is formed in the spillway section to accommodate the remainder of the flood within the second stage cofferdam.

Together with the above measures, the timing of the second stage diversion is essential so that it coincides with the dry season (low river flow). The excavation within this cofferdam needs to be completed as quickly as possible and the first concrete placed. This will protect the foundations and limit damage if the design flood for the diversion is exceeded. The risk of these proposed measures is regarded as acceptable for the construction of a RCC dam when compared to the alternative of providing much larger diversion works.

The eventual river diversion works will depend upon the design proposed by the design team and the construction contractor's proposed approach and methodology, which needs to be approved by the Approved Professional Person.

The primary issue is to ensure that such works are properly designed and do not form potential seepage paths in the longer term. The design of these works must include a method to seal and plug these works securely once it is time to start impounding water in the dam. This has been done successfully at similar DWS dams, such as Nandoni and De Hoop.

For the 500 m^3/s design flood, the maximum rise in water level should be limited to some 8 m, which is considered acceptable and can be contained by the second stage diversion cofferdam of about 10 m high.

In the context of the feasibility level analysis, the cost of the proposed upstream and downstream cofferdams and flood diversion conduit has been included in the cost estimate and economic analysis undertaken under this Feasibility Study.

4.4 Dam Foundations

The foundation levels for this RCC dam type are based upon borehole core log descriptions and seismic velocity profiles. *Van den Berg and Parrock (2009)* recommend the following foundation criteria for dams exceeding 60 m in height:

Table 4-2: Recommended Foundation Design Criteria for RCC Dams

Foundation Design Criteria						
E_{mod}	RMR	Weathering	UCS	RQD	Joint Spacing	Joint Condition
> 4.5 GPa	> 40	Medium to Slightly Weathered	> 20 MPa	> 30%	> 300 mm	Rough, Unaltered

E_{mod}: **Elastic Modulus**
RMR: **Rock Mass Rating**
UCS: **Uniaxial Compressive Strength**
RQD: **Rock Quality Designation**

The longitudinal section in Figure 4-7 shows the recommended foundation excavation profile, which is based upon the results of the rotary core drilling and seismic refraction survey undertaken during this Feasibility Study.

This foundation profile targets the founding on medium hard to hard rock, complying with the parameters recommended in Table 4-2 as well as the 2 000 m/s seismic velocity profile.

This places the foundation in an intermediate to generally hard excavation category and it is likely that some blasting will be necessary to achieve excavation to good quality foundation rock.

However, blasting must be minimised so as to avoid excessive blast fracturing, which compromises the integrity of the foundation rock. *Van Schalkwyk et al (2009)* recommend stopping bulk blasting about one (1) m above the expected founding level and proceeding below this with controlled blasting or powerful excavating equipment.

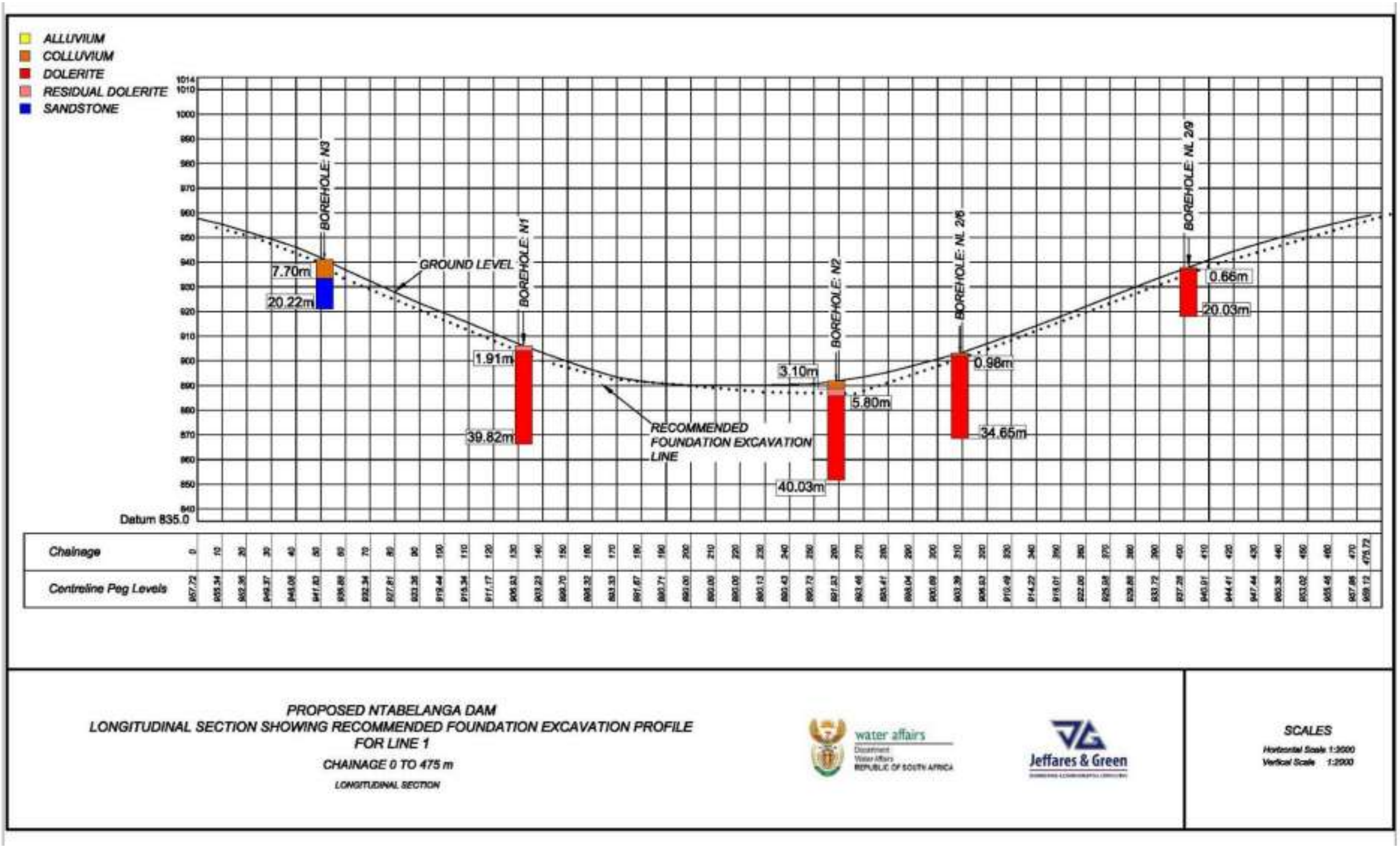


Figure 4-7: Recommended Foundation Profile for Competent Rock Levels

The longitudinal profile indicates the following excavation depths:

- about 9 m on the upper left flank,
- about 7.5 m on the mid to lower left flank,
- about 4 m through the river section,
- about 6.4 m on the lower right flank, and
- less than 1 m on the mid to upper right flank.

It is recommended that the profile is amended during the detailed design stage as more drilling information becomes available during the detailed design geotechnical investigations. This further investigation should be planned to check for faults, fractures and lineaments below the dam footprint, although it is not expected that such problems will be identified. Furthermore, all foundation excavations must be continuously monitored, verified, and the final excavation mapped by an experienced geotechnical professional during construction.

A budget has been allowed in the cost estimates for drilling, grouting and test drilling programme, covering the upstream heel areas of the dam foundation footprint, the outlet works, the spillway, and the temporary river diversion works conduit. Lugeon testing during the core drilling undertaken to date showed very low or no uptakes, and therefore only limited grouting is expected to be required.

4.5 Dam Stability Analysis

The following information and assumptions were used in undertaking the stability analysis:

- Ntabelanga Dam will have a maximum height of 67 m from the river bed level and a total crest length of 400 m.
- Flood will be discharged by means of un-controlled Ogee stepped spillway.
- Concrete density of 2 400 kg/m^3,
- Concrete grade C15/53 would be used mainly for the RCC;
- Solid dolerite founding condition with minimum cohesion of 0.3 MPa and minimum angle of friction of 35°;
- Horizontal component of peak ground acceleration: 0.15 g; and
- Vertical component of peak ground acceleration: 0.08 g.

The loading conditions to be investigated were discussed and agreed with the Department of Water and Sanitation and are shown in Table 4-3.

Table 4-3: Loading Conditions

Type	Case	FSL	RDF	SEF	Silt (S)	Tail water TW)	Drained (D)	Undrained (UD)	Seismic (SM)
Normal	1	√			√		√		
	2		√		√	√	√		
Abnormal	3		√		√	√		√	
	4			√	√	√	√		
	5	√			√	√	√		√
Extreme	6		√		√	√	√		√
	7			√	√	√		√	

Tables 4-4 and 4-5 present the results obtained from the various load cases in Table 4-3. The analysis results are compared with the allowable factors of safety and maximum stresses according to various international guidelines. Analysis was run for downstream wall slopes of both 1V:0.70H and 1V:0.75H.

Table 4-4: Analysis Results and Comparison (1V:0.70H Slope)

Type	Case	Tensile Stress (MPa)		Compressive Stress (MPa)		Sliding (residual) Factor of safety (FOS)		Downstream overturning Factor of safety (FOS)	
		R	A	R	A	R	A	R	A
Normal	1	+0.19	0.0	-1.2	-3.0	1.5	1.5	1.5	1.5
	2	+0.4	0.0	-1.4	-3.0	1.3	1.4	1.3	1.4
Abnormal	3	+0.61	0.2	-1.4	-4.5	1.1	1.1	1.1	1.2
	4	+0.56	0.2	-1.5	-4.5	1.1	1.1	1.2	1.2
	5	-0.27	0.2	-0.88	-4.5	2.2	1.1	1.7	1.2
Extreme	6	-0.07	0.35	-1.04	-4.5	1.9	1.0	1.5	1.1
	7	+0.77	0.35	-1.5	-4.5	1.0	1.0	1.0	1.1

*<u>Legend</u> - **A** = Allowable - = Compression **R** = Result + = Tension*

Table 4-5: Analysis Results and Comparison (1V:0.75H Slope)

Type	Case	Tensile Stress (MPa)		Compressive Stress (MPa)		Sliding (residual) Factor of safety (FOS)		Downstream overturning Factor of safety (FOS)	
		R	A	R	A	R	A	R	A
Normal	1	+0.03	0.0	-1.1	-3.0	1.62	1.5	1.54	1.5
	2	+0.22	0.0	-1.9	-3.0	1.4	1.4	1.4	1.4
Abnormal	3	+0.43	0.2	-1.9	-4.5	1.1	1.1	1.2	1.2
	4	+0.36	0.2	-2.0	-4.5	1.2	1.1	1.3	1.2
	5	-0.4	0.2	-1.2	-4.5	2.4	1.1	1.83	1.2
Extreme	6	-0.22	0.35	-1.4	-4.5	2.1	1.0	1.65	1.1
	7	+0.57	0.35	-2.0	-4.5	1.0	1.0	1.1	1.1

*<u>Legend</u> - **A** = Allowable - = Compression **R** = Result + = Tension*

These feasibility level results show that factors of safety for sliding and overturning are very close to those allowable for the 1V:0.70H downstream slope option, and are conservative for the 1V:0.75H downstream slope option. In both options, some of the tensile stress results are higher than allowable.

The eventual geometry of the dam wall would be determined following an extensive detailed design process including finite element and numerical elastic analyses, and this is normally a balance between minimising cost and meeting all of the allowable safety criteria.

This would include consideration of various cross section profiles, mix designs, and tensile crack control/induction methodologies. This will also include considering whether a sloped (rather than vertical) upstream face, or horizontally arched upstream face option is a beneficial and economic solution.

Typically RCC dams are built with downstream slopes of between 1V:0.70H and 1V:0.80H, but this can be steeper on the upper part of the embankment if a non-symmetrical slope approach (base slope shallower than higher up the wall) is adopted.

For the feasibility design and costing of the Ntabelanga Dam, a simple symmetrical profile as given in Figure 4-3 has been adopted, with a slope of 1V:0.70H.

At the detailed design stage, a detailed structural analysis should be performed on the finally selected dam, spillway and outlet works configuration using this and other available engineering methods and best practice, to optimise the dam structure.

4.6 Estimated RCC Dam Construction Materials

4.6.1 Rock Aggregate

Current feasibility design estimates indicate a volume of some 500 000 m³ of crushed rock aggregates will be required for a low paste RCC dam construction. Extensive reserves of competent, hard solid dolerite rock occur on the right flank. This was estimated to be more than twice the required rock volume for construction.

Boreholes drilled during geological investigations on the right flank upstream of the dam axis indicate hard rock dolerite occurring from depths of around 1 m and in some places, dolerite occurs as sporadic outcrop and sub-outcrop.

Core samples retrieved from the boreholes were submitted for petrographic analyses and unconfined compressive strength (UCS) testing. The petrographic analyses results indicate a relatively low degree of alteration and insignificant amounts of deleterious alteration products, such as smectite clay minerals. UCS test results on cores from the upper right flank indicate competent, high strength dolerite. The rock is suitable for use as crushed rock aggregate in RCC dam construction, and for reinforced concrete.

Surface mapping identified that the reserves of potentially good quality dolerite in the right flank to the east and south east of the dam are vast and are potentially far in excess of the required quantities for RCC dam construction.

It is expected that all of the required dolerite could be quarried from this right flank upstream of the dam wall, and below the dam full supply level. Thus there should be no permanent environmental impacts, or significant quarry closure requirements.

4.6.2 Sand

Sand along a section of the Tsitsa River upstream of the dam was sampled, as indicated by the yellow hatching on Figure B.3 in Appendix B in the Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12. The Tsitsa River in the project area generally flows in a relatively incised channel with sand deposits confined to the river channel. Over-bank deposits on inside meanders are of a restricted and localised nature.
Therefore sand deposits in the Tsitsa River are relatively narrow and will require selective exploitation during the dry season. Screening will be required to remove gravel (mudrock fragments), pebbles and boulders. Furthermore, the sand requires blending using crusher sand to achieve the grading required for the concrete mix. Test results available do not indicate the presence of deleterious chemical constituents.

Estimated reserves within the area investigated are approximately 130 000 m³. Considering that this sand will need to be blended with crushed stone to provide required grading for RCC construction, the volume of the available sand for construction can be stated in excess of the above value. Furthermore, visually the actual feasibly exploitable reserves in the Tsitsa River, available within the impoundment basin, and within economic haulage distance of the dam, will be far in excess of two times the required volume of some 200 000 m³ of sand for the proposed RCC dam.

An alternative source of sand that can be investigated during the detailed design stage is from the crushing of dolerite as a part of the quarry development and crushing operation.

4.6.3 Other Concrete Constituents

As a part of the detailed costing of the RCC concrete mix, an analysis was undertaken of the sources of fly-ash, cement, and concrete additives from the South African major suppliers of these materials. These companies included Lafarge, Ash Resources, etc.

All of these materials are readily available albeit with significant transport costs. The costs of these materials as provided by the manufacturers have been taken into account when building up the cost estimates for the project.

This is reported further in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

4.6.4 Recommendations for Further Detailed Geotechnical Investigations

Based upon the results of the feasibility level investigations, founding conditions are suitable for an RCC dam. Additional, detailed investigations considered necessary to bring the level of detail up to that required to undertake the detailed design and tender documentation for the proposed construction of the dam and appurtenant works are described in the Geotechnical Investigations Report.

> It is recommended that the detailed rotary core drilling investigation concentrates on infill drilling of the foundation footprint on both dam flanks, spillway components, appurtenant structures and to prove sufficient reserves of rock aggregate for construction.

It is recommended that an inclined borehole be drilled through the dolerite / sandstone contact on the mid left flank and that another inclined borehole is drilled beneath the river section from the left river bank. Provision must also be made for additional drilling on both the upstream and downstream dam foundation footprints.

Following design confirmation of the locations of the appurtenant works such as spillway, intake tower, outlet works, pipelines, hydropower plant, water treatment plant, roads, downstream river bridge and other related infrastructure, drilling and trial pitting will be required to augment the feasibility level investigations in proving suitable founding conditions and to prove adequate reserves of rock aggregate and sand.

4.6.5 Stilling Basin Excavation

As is shown on Figure 4-1, water passing over the spillway will be channelled into a stilling basin cut into the existing rock downstream of the dam, to a depth of 5 m below the existing river bed level.
This starts at the base of the spillway where flow into the stilling basin is transitioned over a 20 m reinforced concrete apron to protect the rock at the toe of the spillway from scouring.

The stilling basin width gradually reduces from 150 m to 50 m over a distance of about 200 m, where a bunding and outlet weir controls the stilling basin water.

The twin emergency drawdown river outlets discharge into the same stilling basin from a chamber on the right hand side of the spillway chute side wall. The hydropower plant and the EWR release valve also discharge flow back into the stilling basin.

> It is again recommended that physical (and possibly CFD) modelling is undertaken to optimise the spillway performance, and the stilling basin shape and depth.

4.7 Water Treatment Works

The location of this water treatment works (WTW) relative to the dam is shown on Figure 4-8, and a conceptual layout and hydraulic flow regime of the water treatment works itself is shown on Figures 4-9 and 4-10.

The treatment processes envisaged are conventional and will include:

- Flocculation
- Coagulation
- Settlement in Clarifiers
- Filtration in Rapid Gravity Filters
- Disinfection using Chlorine gas

It is recommended that regular water quality sampling and testing be implemented as soon as possible to inform the detailed design and optimisation of the water treatment works processes. Given that there are many proprietary treatment process available, it is common practice that large water treatment works are procured through a design and build contracting approach, and in order to ensure that the best solution is selected, such historical water quality information would be essential.

The WTW will be required to deliver an average daily output of some 85 000 m^3/day of treated water, with a peak daily output of 102 000 m^3/day. Consideration could be made to develop these works in modular stages, depending upon the expected programme of implementation of the bulk water distribution system, and the expected uptake of demand therefrom.

The clear water pumping station, containing pump sets PS 1 and PS 3, is also located such that the pumps will always operate under drowned suction conditions, when transferring treated water from the WTW clear water contact tank, to the Primary Command Reservoirs.

The 898.00 m.a.s.l. elevation at the WTW inlet works is such that raw water from the Ntabelanga Dam outlet works can be transferred under gravity flow, even at the bottom operating level of the dam.

The works is also positioned with space allowed for sludge dewatering lagoons, and all works are located above the river flood line, even under SEF conditions.

More details are provided in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13.

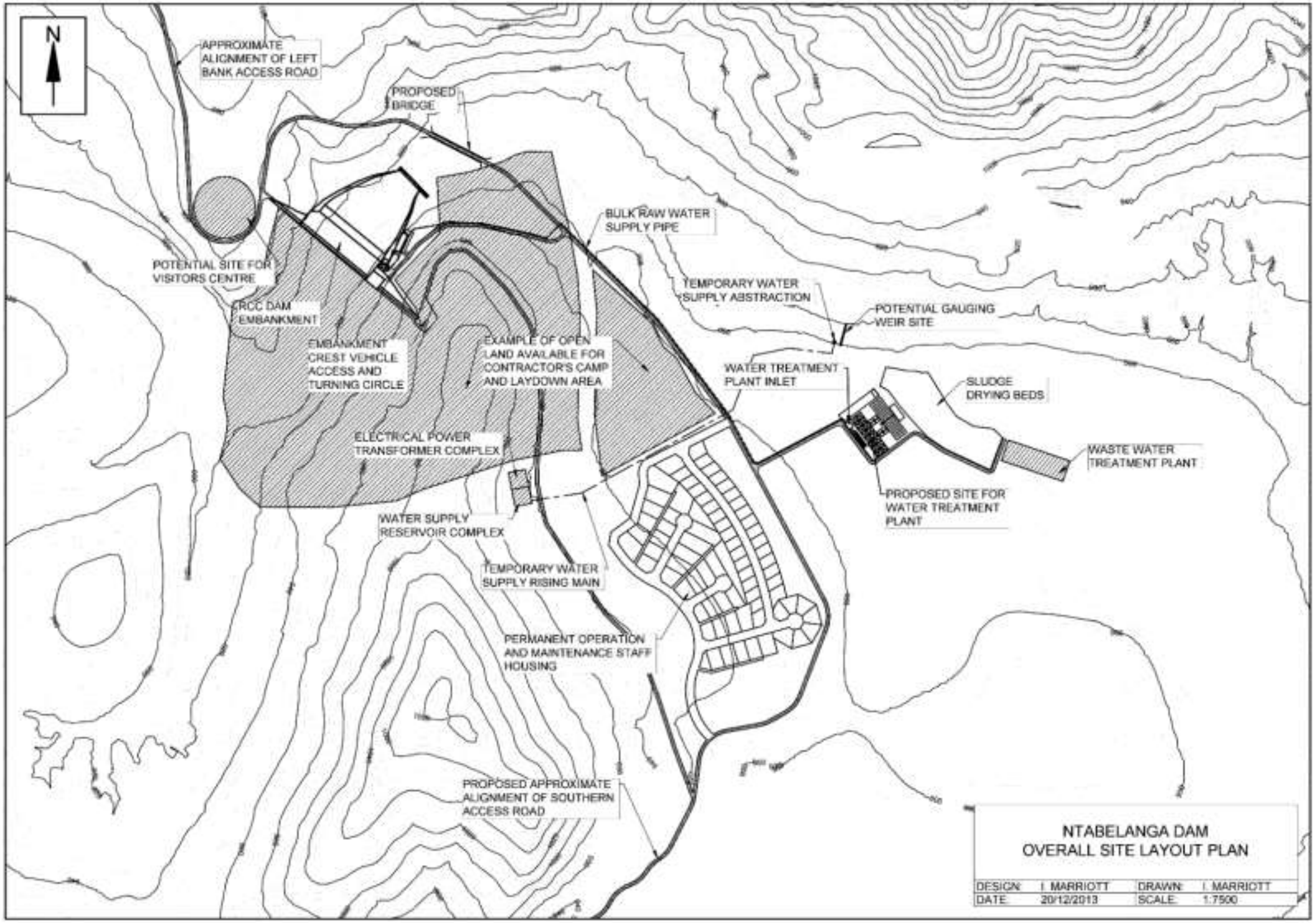


Figure 4-8: Overall Layout of the Ntabelanga Dam and Associated Infrastructure

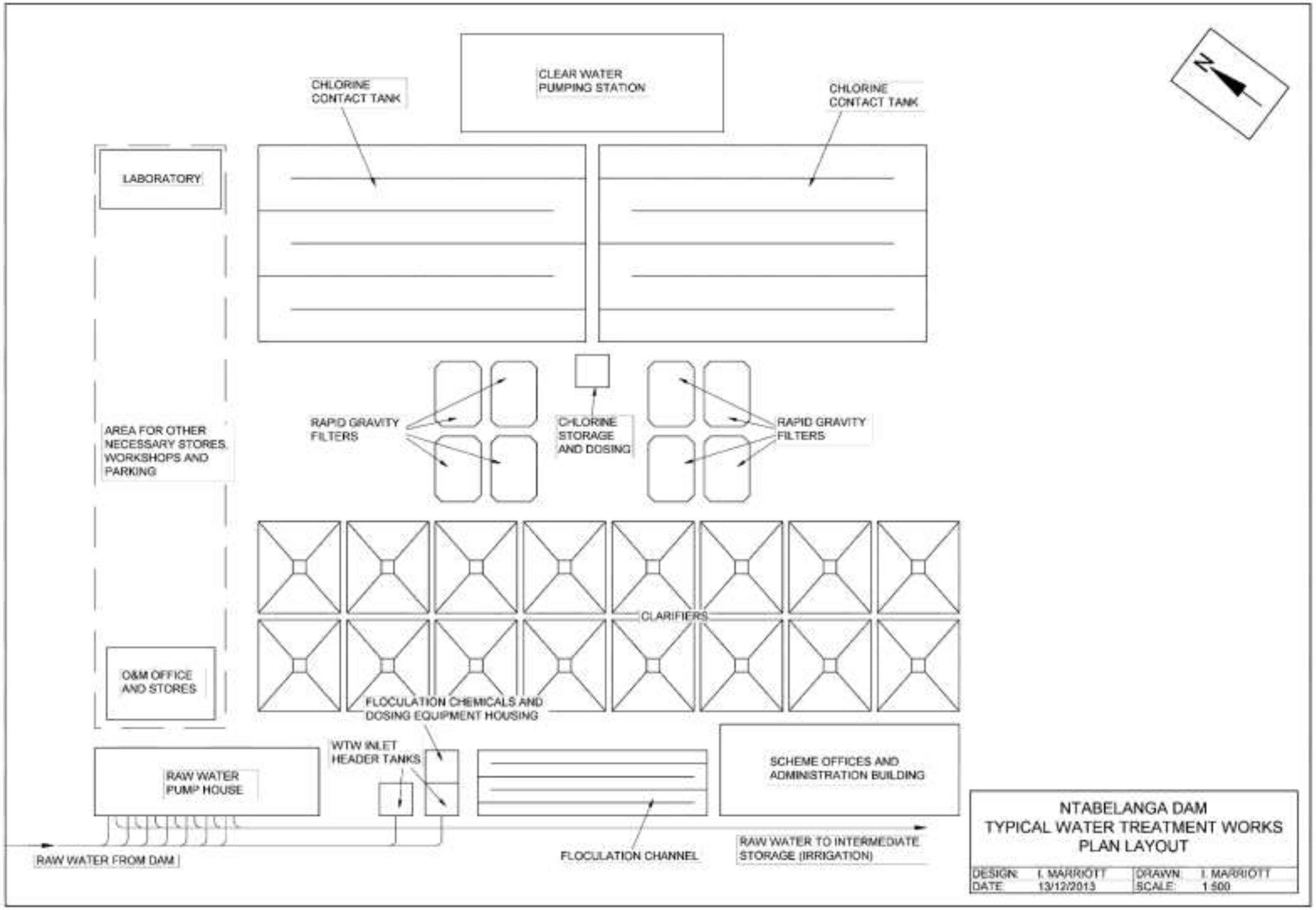


Figure 4-9: Typical Arrangement of the Water Treatment Works

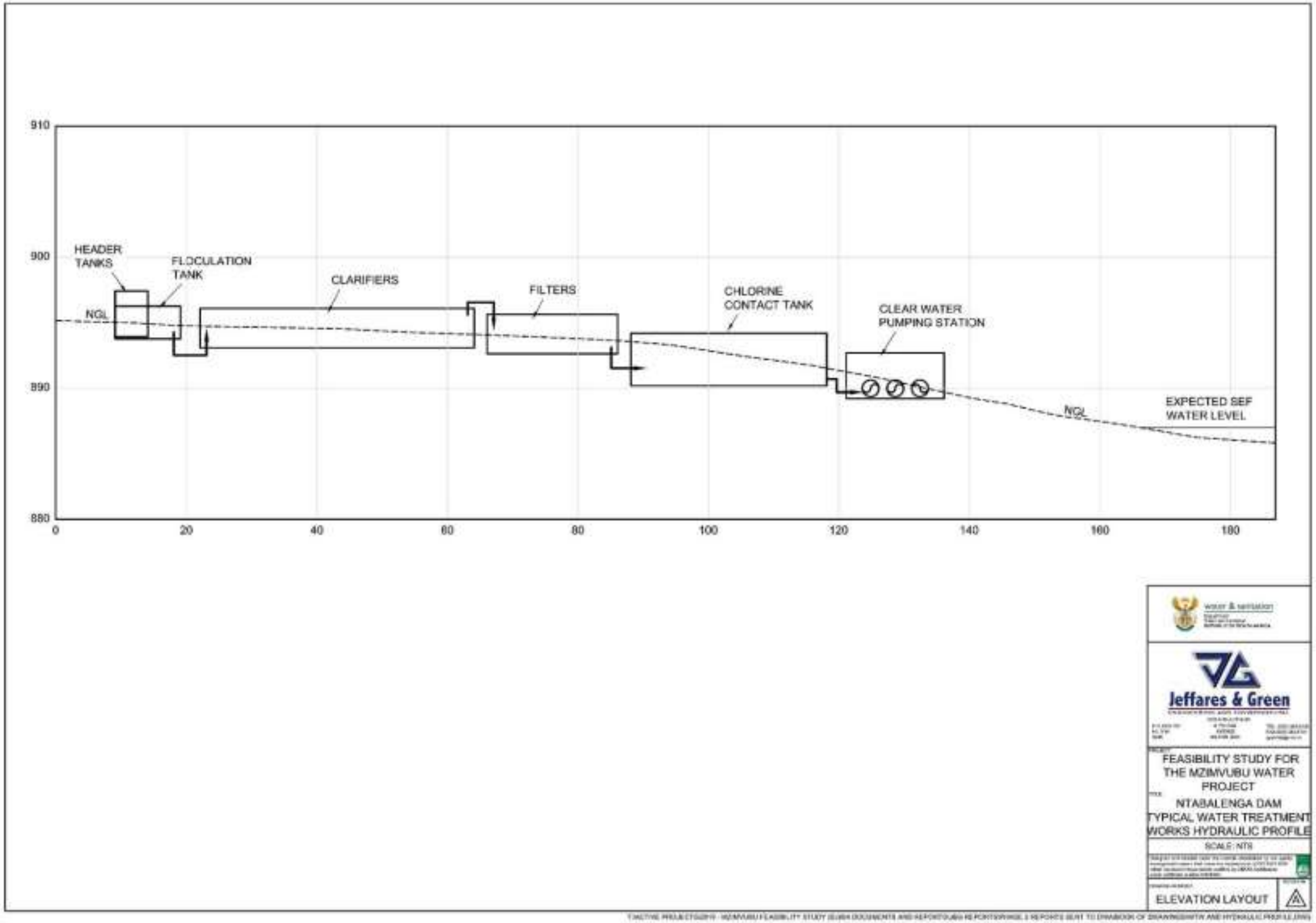


Figure 4-10: Hydraulic Flow Diagram through Ntabelanga WTW

4.8 Ntabelanga Hydropower Plant

The hydropower plant configuration has been based upon an operating range of between 0.75 MW and 5 MW.

Hydropower plant suppliers proposed the operation of 6 turbines in parallel - 3 pairs with one synchronous and one asynchronous generator. The synchronous generator of each unit is started in the beginning (blackstart capability, able to run in island mode), the asynchronous unit follows later depending on the available flow.

For easy maintenance and stable operation all turbines are of the same size. The speed of asynchronous units will be 750 rpm, the synchronous units speed has to be defined depending on the efficiency expectations (600 rpm or also 750 rpm).

The typical pump-turbine units suggested are detailed in Report No. P WMA 12/T30/00/5212/12.

The total number of installed turbine units can produce the following performance:

Table 4-6: Hydropower Plant Output Performance

Scenario	Head (m)	Flow (m^3/s)	Duty Generating Units	Installed Output Power (kW)
Minimum	22	6.0	T1/T2/T3/T4	956
Average	40	9.0	T1/T2/T3/T4	2 606
Maximum	45	16.0	T1/T2/T3/T4/T5/T6	5 212

Note: T1: Turbine 1, T2: Turbine 2, etc.

Figure 4-11 shows a proposed layout of the hydropower turbine house together with the inlet and outlet pipework arrangements.

The building structure would be of similar design to that of the larger pump stations proposed in this study.

This arrangement allows for the whole hydropower plant to be by-passed when not in use, whilst still allowing for release of water for EWR purposes via a sleeve valve outlet.

If one pair of turbines needs to be taken out of service for maintenance or repair, then the other sets can be run at higher flow rates to maintain power output during that period.

The options for utilisation of the hydropower produced at the Ntabelanga Dam are described in detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

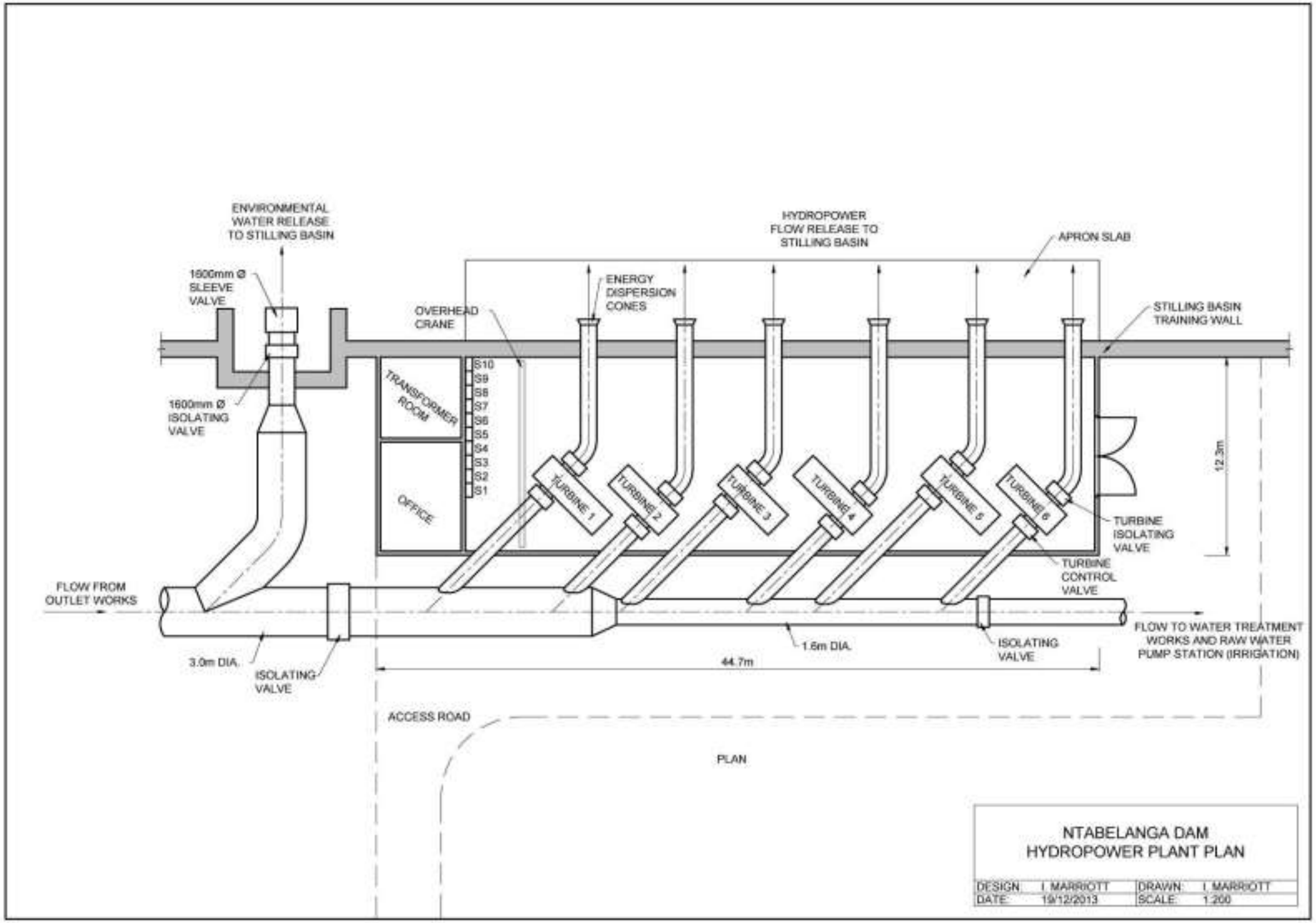


Figure 4-11: Proposed Layout of Ntabelanga Dam Hydropower Plant and EWR Release Point

4.9 Associated Infrastructure

4.9.1 Roads

The local gravel roads on the north and south banks of the basin (shown in purple on Figure 4-12) are existing low quality access roads to the local settlements, and are normally affected by inclement weather. Some sections of the existing tracks will be inundated by the reservoir water level and will need to be realigned. The existing bridge across the river linking the two sides will also be inundated and a new bridge will be constructed just downstream of the dam wall, to restore this main crossing route.

All of these tracks and drainage structures (shown in purple on Figure 4-12) would be upgraded to all-weather gravel roads so that the affected settlements will have improved transport links which are unaffected by the raised water level. These particular upgrades will total some 32 km of road, which will have a servitude width of some 10 m.

As all of these improvements will be aligned along existing tracks, or on currently unoccupied areas, this should have only limited or no resettlement or compensation implications. The two existing gravel access roads shown in yellow and green are currently low quality roads albeit wider than the above existing gravel roads. It is proposed that both these roads are upgraded to secondary surfaced standards, in order to provide all-weather access to heavy vehicles during construction, as well as leaving behind upgraded transport routes to the larger centres of Maclear, Tsolo, and Mthatha. These two route upgrades will also contribute to improvement of the economy in the area by improving speed and ease of access for business and private travel as well as opening up tourism in the area. Better road quality also reduces wear, tear and maintenance to vehicles using the road.

These upgrades (shown in yellow and green) will be to a higher standard than the other roads above, and will be two lane carriageways (one each way) with a servitude width of between 20 m and 30 m (depending on terrain). The Maclear route would be some 18.9 km long and the Tsolo link some 12.9 km long.

Once again, these improvements will be primarily aligned along existing routes, and this should have only limited or no resettlement or compensation implications. Where this road alignment and the alignment of local access roads on the north shore of the dam will become inundated by rising water level, realignments will be required. Figure 4-13 shows new roads that will have to be constructed at the dam wall itself, and its appurtenant outlet works, hydropower plant, water treatment works and offices, staff housing, and pumping station site. A new dam site access road will be required which will connect with the above upgraded road from the Tsolo direction, and will run through the new operational works as shown. This road will have service roads branching off it to the temporary water works, the staff housing, the hydropower plant, the water and wastewater treatment plants, the pumping stations, accesses to the dam wall and outlet works, and then across the new river bridge to link with the upgraded existing roads on the north bank of the scheme.

The length of this new access road (to the dam) will be approximately 5 km, and will have a servitude width of approximately 20 m. The existing land use features some subsistence agriculture which fields are fenced, but no habitable structures.

The dam site as a whole would need to be expropriated in its entirety, as well as the associated water treatment works, accommodation, access roads, and construction works areas shown on Figure 4-13. This will include a site for a proposed visitor's centre, which will require resettlement involving two or three existing dwellings that can be seen on the figure.

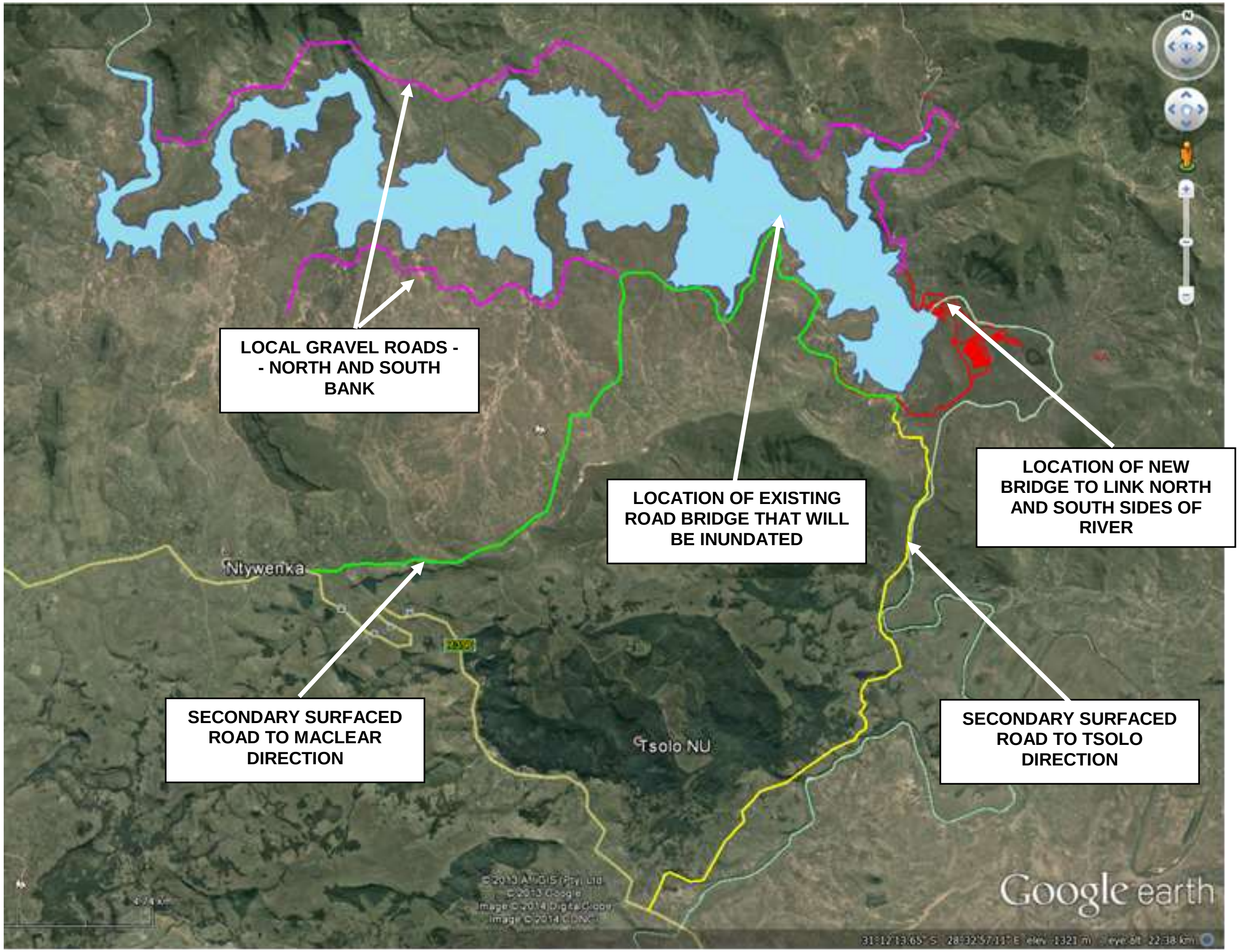


Figure 4-12: Roadways to be Permanently Upgraded Before and During Construction

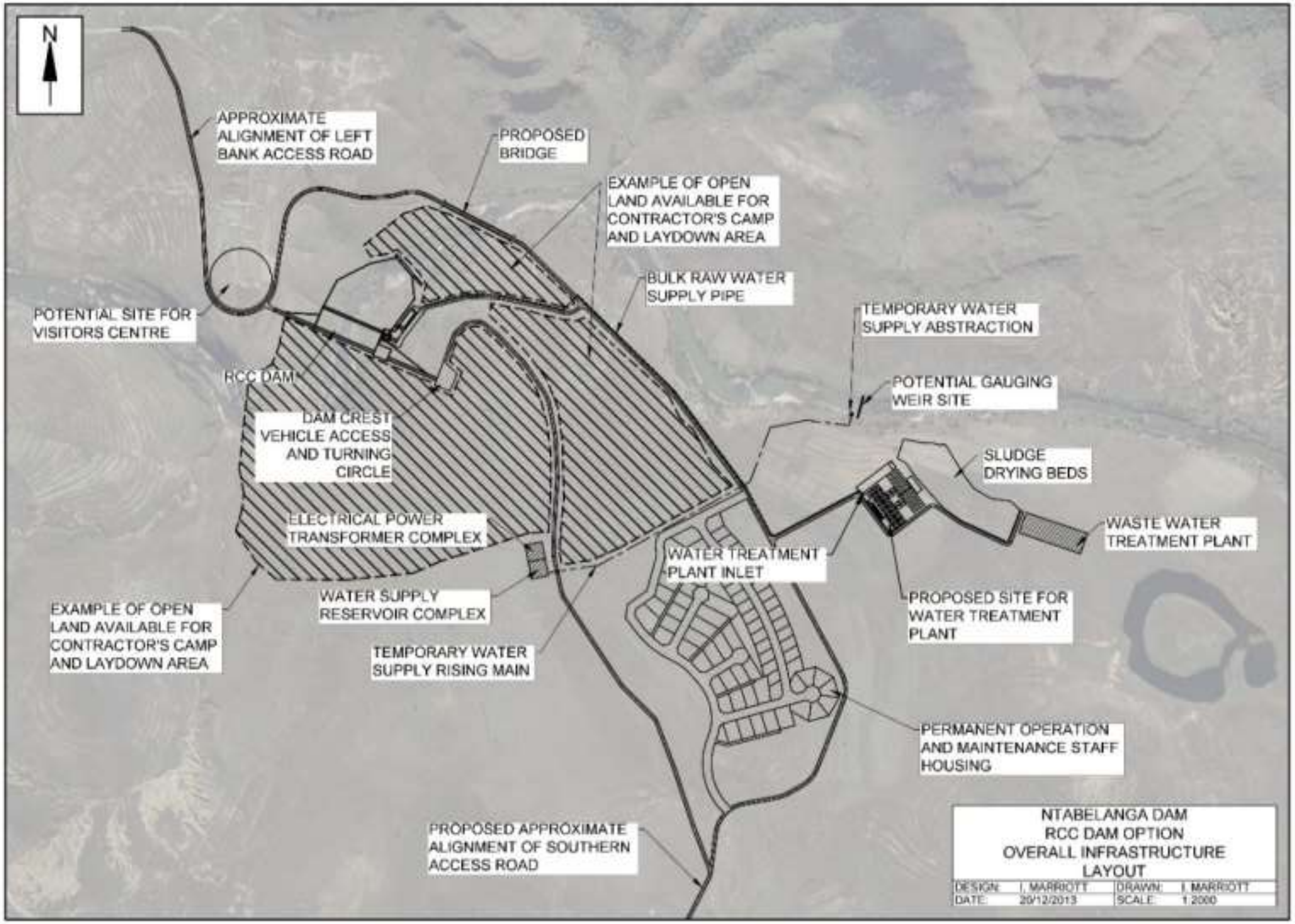


Figure 4-13: General Layout of the Proposed Dam and Associated Works

4.9.2 Camps and Permanent Staff Accommodation

Several construction contracts are likely to be awarded to undertake the various components of this project. Depending upon the timing of the various contracts and the approach and methodology of the contractors, the construction of the works will provide construction work opportunities for between 400 and 1 500 people for varying periods[1]. Most of these jobs will be filled with labour commuting or being transported from local communities including the small villages close to the works as well as from the urban areas such as Maclear, Tsolo and Mthatha, and it is not therefore expected that a significant amount of permanent camp accommodation would be required. The contractors will normally make this decision at tender stage in their approach and methodology, and costs for these requirements are included within the P&G items. There will, however, need to be some permanent staff accommodation built for the operational staff and their families, who will need to live close to the works.

Provision has therefore been made for a housing estate containing up to 75 stands on which one-, two- and three-bedroomed staff houses can be built, as is indicated on Figure 4-13 above. These will also have fitted kitchens, bathrooms, lounge and dining rooms, and will have mains electricity, water, and waterborne sanitation.

Allowance has been made in the project budget for immediate construction of 20 x one bedroom, 10 x two bedroom, and 2 x three bedroom houses in the first phase of the project. These requirements need to be reviewed during the design stage.

Electricity will be via ESKOM connection, water supply from the Ntabelanga WTW, and a wastewater treatment facility will also be built. The housing complex will also have street lighting, tarred or concrete block paved roads and surface water drainage.

4.9.3 Power Supplies

The power requirements for the complete scheme are described in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13. The total required is estimated as 12 572 kVA (circa 13 MW), with the majority of this centralized at the Ntabelanga Dam and WTW sites.

Table 4-5 summarises the duties and power requirements of the various energy consuming infrastructure components in the system.

ESKOM has 132 kV high voltage lines running parallel to the main road from Mount Frere to Mthatha and running through the project supply area from the above alignment to Maclear, passing between the Ntabelanga Dam and Tsolo. This is shown in green in Figure 4-14.

ESKOM are also implementing a programme of expansion of both high and medium voltage power supplies in the area, and information received from them indicates that this will eventually result in complete coverage of power services to all of the settlements in the area.

The Ntabelanga hydropower plant can only produce circa 1.6 MW on average with a maximum of 5 MW, and there will therefore be a need to arrange for an ESKOM power supply to meet all of the project's needs in the Ntabelanga area, given that there will be times when the output of the hydropower plant will be very low or off-line during maintenance periods.

[1] *Figures based upon the average employment created during the Lesotho Metolong Dam Project construction period.*

Table 4-7: Power Requirements for Scheme

2050 Power Requirements									
Treated Water	**Flow (l/s)**	**Head (m)**	**Duty Water Power (kW)**	**Pump Efficiency (%)**	**Maximum Electricity Demand (kW)**	**Maximum Electricity Demand (kVA)**	**Max hours per day**	**Usage - kWh per year**	**Power cost/year (Rand)**
Pump station PS1	935.27	246	2 257	75%	3 010	3 168	20	23 128 671	19 497 470
Pump station PS2	827.70	270	2 193	75%	2 924	3 077	20	22 465 459	18 938 382
Pump station PS3	476.66	279	1 305	75%	1 740	1 831	20	13 368 771	11 269 874
Pump station PS4	92.69	333	303	75%	404	425	20	3 102 814	2 615 672
Booster pump station Z3 PS1	170	94	157	75%	209	220	20	1 606 406	1 354 200
Booster pump station Z4 PS1	12.8	66	8	75%	11	12	20	84 924	71 591
Booster pump station Z4 PS2	3.53	195	7	75%	9	9	20	69 197	58 333
Water treatment plant processes	Estimated				500	526	varies	572 998	483 038
Waste water treatment works	Estimated				100	105	20	768 421	647 779
Housing	Estimated				250	263	12	1 152 632	971 668
Other, incl lighting etc	Estimated				250	263	12	1 152 632	971 668
TOTALS EXCL RAW WATER			**6 230**		**9 406**	**9 901**		**67 472 926**	**56 879 676**
Raw Water for Irrigation									
Main pumping station	1060	183	1 903	75%	2 538	2 671	20	19 500 041	16 438 535
Booster station P1	206	100	202	75%	269	284	20	2 070 836	1 745 715
Booster Station P2	223	165	361	75%	481	507	20	3 698 856	3 118 135
TOTALS INCL RAW WATER			**8 133**		**11 944**	**12 572**		**86 972 967**	**73 318 211**

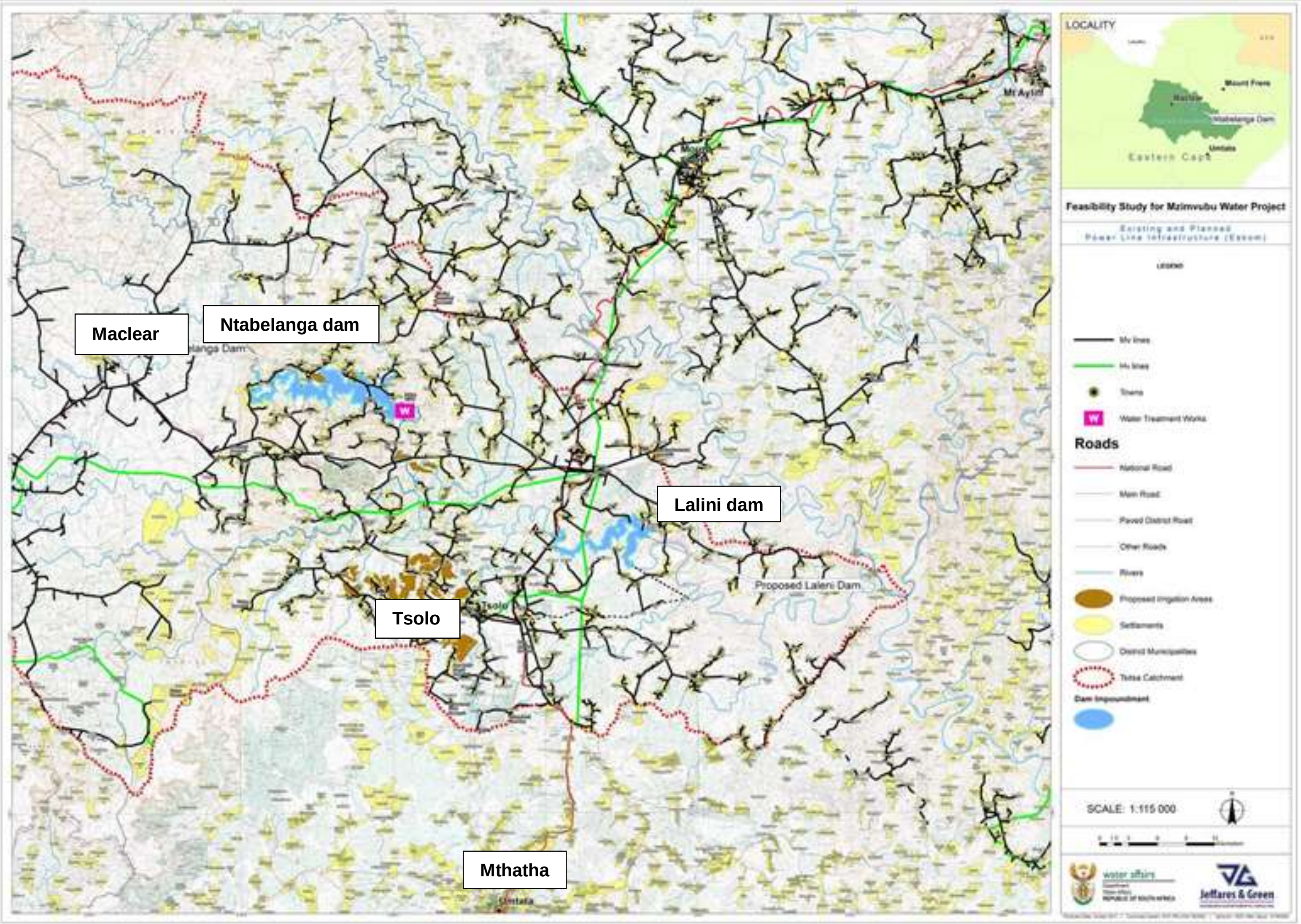


Figure 4-14: ESKOM Existing and Planned Power Distribution Network

Significant power will also be required in advance of the start of construction to supply contractor's camps, temporary water supply, site offices, accommodation, wastewater treatment, site lighting, dewatering, cranes and hoists, crushing and batching plants, etc. It is expected that such needs would also be in the order of 10 000 kVA (say 10 MW). The power supply connection from ESKOM to the Ntabelanga Dam site must therefore be implemented as an advance infrastructure component.

The conjunctive use hydropower scheme (i.e. Ntabelanga Dam in conjunction with the Lalini Dam and hydropower scheme), is expected to produce up to 37 500 kVA on a continuous basis, and this means that the conjunctive scheme will not only be "self-sufficient" in its energy usage for potable and irrigation water supply needs, but will also supply surplus energy into the local grid at the rate of up to 22 000 kVA (say 22 MW) continuously.

ESKOM have confirmed that they will be able to supply power to the project via a new 22 kV line which will need to be constructed ahead of the construction. This same connector would also be used to evacuate any surplus power generated by the Ntabelanga dam hydropower plant into the local grid system.

ESKOM stated that such a connection could take up to two years to complete from the date of application, and it is recommended that this application process be implemented as soon as possible by the DWS.

4.9.4 Temporary Water Supply

A temporary water supply will be required to supply potable water to the site during the construction period, and until the main WTW is commissioned. This will typically have a capacity of approximately 150 m^3/day, and would be a modular package plant.

The plant would be located such that water can be pumped from a river intake to the plant, and the treated water lifted into an elevated storage tank (24 hrs storage) serving the site by a gravity reticulation system. This elevated tank (location shown on Figure 4-13) will later be used as the permanent treated water storage supplying the operations centre and housing, and its location has therefore been determined to meet this longer-term requirement. This water supply should also be installed as a part of the priority works.

4.9.5 Flow Gauging Stations

Gauging stations should be constructed as priority works in order to establish the ongoing monitoring of the river flows prior to and after construction of the dam. The hydrology section of the Department of Water and Sanitation has undertaken a reconnaissance of the scheme and the following sections summarize their recommendations.

a) Gauging Station Upstream of Ntabelanga

Due to problematic access conditions to the Tsitsa River upstream of Ntabelanga, it is recommended that no gauging structure should be constructed to measure inflows into the dam. Inflows should rather be determined indirectly by means of a dam balance calculation. With a dam balance process the actual inflow into a dam can be calculated, using the rainfall and evaporation data collected at the dam in combination with the changes in reservoir level and releases or spills from Ntabelanga Dam.

b) Gauging Structure Downstream of Ntabelanga Dam

It is recommended that a dedicated gauging weir should be constructed approximately 1.5 km downstream of the dam (see Figure 4-15).

This structure should be capable of measuring the total range of controlled releases from the dam into the river and also the first 300 mm to 500 mm of flow flowing over the spillway accurately.

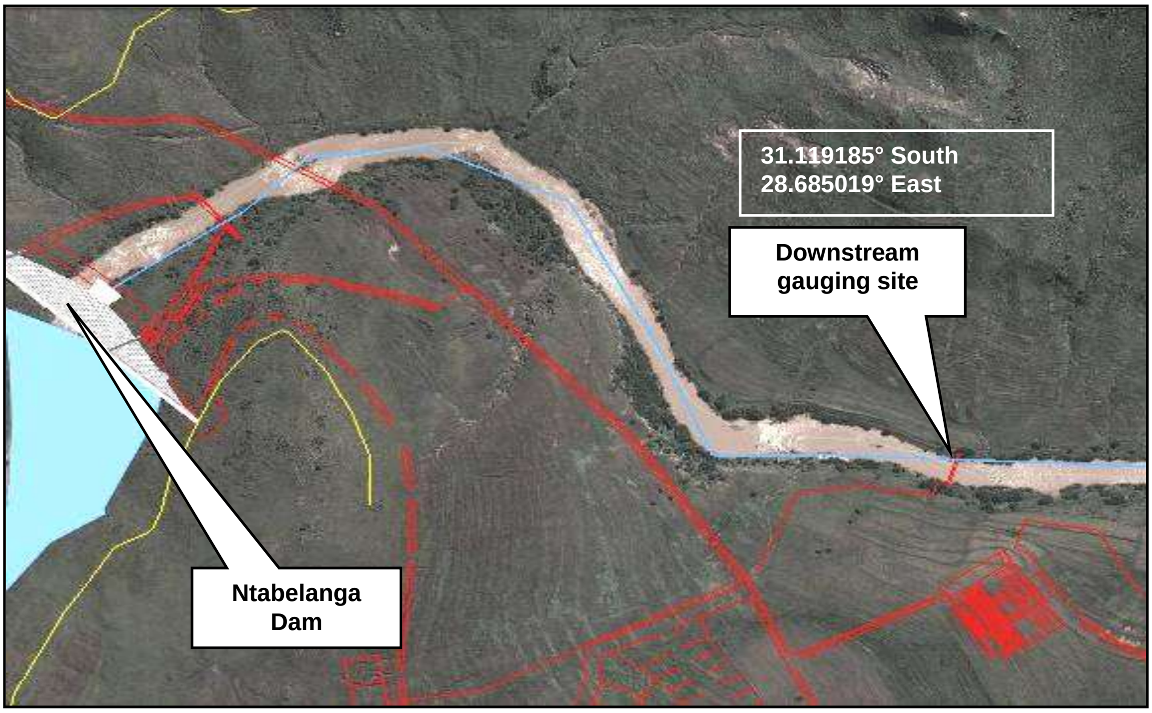


Figure 4-15: Recommended New Gauging Weir Site Downstream of Ntabelanga

The structure should also measure the flows flowing through the hydropower turbines at Ntabelanga. The first gauging station immediately below the Ntabelanga Dam would be an ideal weir structure from which to abstract raw water for the temporary water supply, and it is proposed that the abstraction system be located at this gauging station.

c) Gauging Structure in Tsitsa River Downstream of Inxu Confluence

A gauging weir to measure the flow contribution of the Inxu river is recommended at a site approximately 12.7km downstream of the confluence.

Two site options approximately 200 m apart have been identified (see Figure 4-16), and should be evaluated for construction during the detailed design stage.

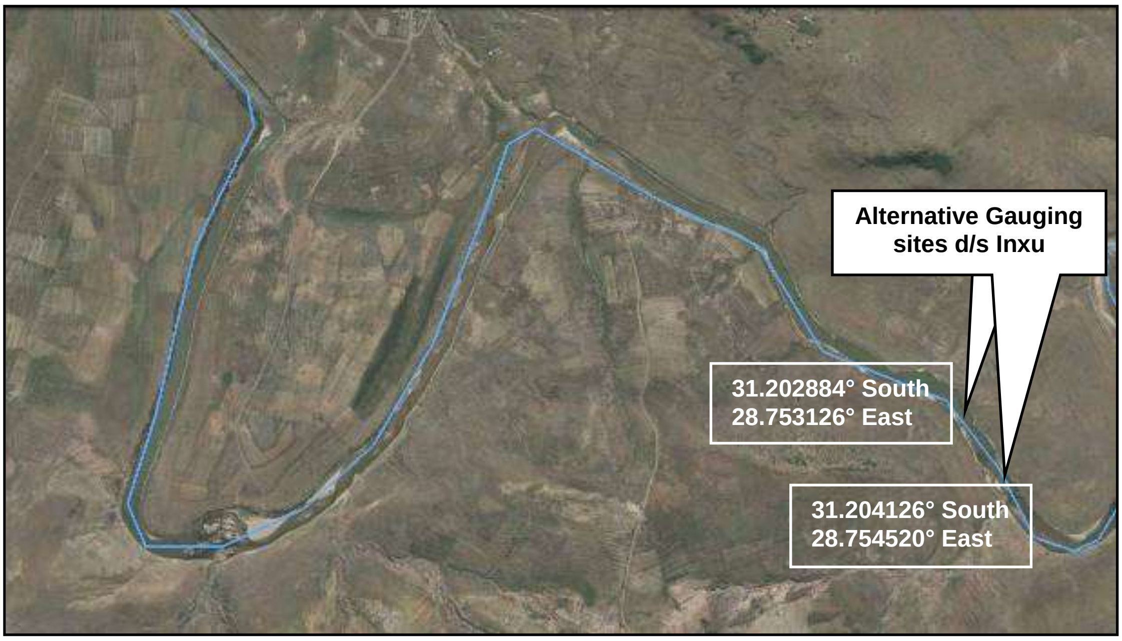


Figure 4-16: Alternative Sites for New Gauging Weir Downstream of Inxu Confluence

d) Tsitsa Upstream of Lalini

If the preferred Lalini Dam scenario is to be implemented the existing DWS gauging structure T3H006 in the Tsitsa, just downstream of the N2 road bridge, will be inundated by the dam when full.

In that case a new structure needs to be constructed to replace T3H006 immediately upstream of the influence sphere of the Lalini Dam, upstream of the N2 road (See Figure 4-17).

e) Tsitsa Downstream of Lalini

Two potential gauging sites downstream of Lalini have been identified approximately 1.3 km and 1.6 km downstream of the wall (See Figure 4-17).

Site 2 is preferred as conditions appear more favourable, however the sites were recommended for assessment in the environmental process, as they are only 300 m apart.

If foundation conditions at site 2 are poorer than expected, it might be necessary to utilise site 1, but constructing a higher than normal gauging structure to overcome the complex flow conditions expected at this site.

f) Tsitsa downstream of the Lalini Dam hydropower turbines

A gauging structure capable of measuring the maximum flow through the turbines accurately located before any water is discharged back into the Tsitsa River is recommended.

The structure should be located and designed in such a manner that flows coming down the Tsitsa will not impact on the gauging accuracy of the turbine measurements (See Figure 4-17).

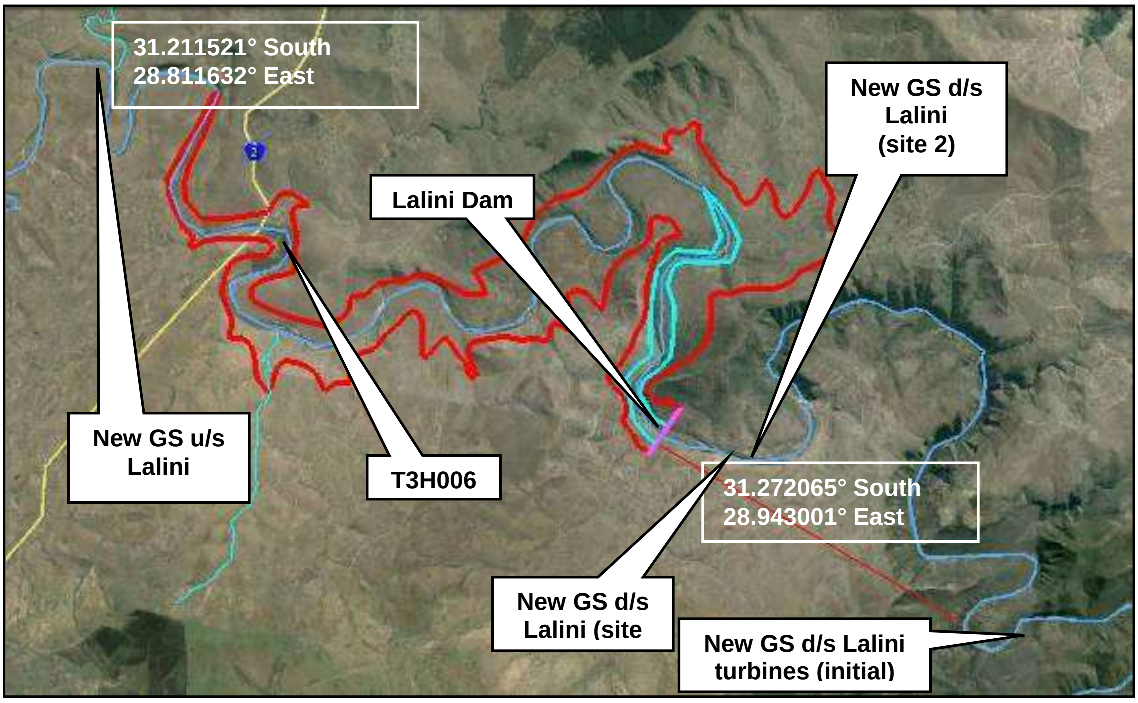


Figure 4-17: Recommended New Gauging Weir Sites Upstream and Downstream of Lalini Dam

4.9.6 Wastewater Treatment Plant

A wastewater treatment plant will be required to treat effluents produced by the Ntabelanga dam operations centre and housing. This will be appropriately sized for this purpose and it is probable that this requirement could be met by using a screening and pre-treatment process followed by a reed bed system.

It is not recommended that such a wastewater treatment plant be designed or used to treat the effluent from the construction activities, as this would be oversized and would have to deal with industrial pollutants as well as domestic effluents.

The contractors themselves must be made responsible for the safe and environmentally sensitive disposal of all of their effluents and waste products, leaving only domestic effluents for the permanent wastewater treatment plant to deal with.

4.9.7 Telecommunications

Whilst the Vodacom network in the region has good coverage, telecommunications in the particular area of the Ntabelanga Dam works are limited, and improved communication systems will be required before the construction activities commence. This should include increasing the reliability and coverage of the cellular network system, as well as providing land lines, and data lines with sufficient transmission speeds for modern communications equipment.

This is normally dealt with by requesting quotations from the nationally-based telecommunications service providers, and this is also considered to be an important advance infrastructure requirement.

4.9.8 Visitor's Centre

The Ntabelanga Dam and its body of water will provide opportunities for tourism and recreation, which in turn can lead to job creation. Many large dams take up such opportunities and offer visitor facilities to encourage tourism and thus promote economic development.

A visitor's centre can form the focus of such an initiative and provide visitors with a view of the works, and information on the project, including the cultural and tourism activities in the area. A location for this centre is suggested above on Figure 4-13.

It is recommended that such a building be of interesting architecture in keeping with the local culture and terrain.

4.9.9 Priority Infrastructure

The following are considered to be works components that should be constructed in advance of the main works, or at least as the first priority if these components are part of the main contract:

- Main access roads, including roads at Ntabelanga Dam site shown on the layout;
- Bridge across the river downstream of the dam;
- Power supplies;
- Temporary water supply and gauging station;
- Other gauging stations; and
- Telecommunications.

Also optional:
- Staff accommodation – if to be used by DWS and/or the supervising Engineer and staff during construction – do not allow contractor to use; and
- Wastewater treatment plant – if staff accommodation is built.

Most of the above works require an environmental authorization (EA), and have been included in the EIA process, except for the power supply lines to the construction sites, as these routes had not been determined. It is important to check the EA for details of the infrastructure authorised and obtain approval for any deviations prior to implementation.

The Feasibility Study also identified the needs and benefits of a concerted catchment rehabilitation and management programme. This has been handed over to the Eastern Cape Provincial Department of Environmental Affairs, who commenced a 10 year programme during April 2014.

4.9.10 Compensation and Mitigation Works

The EIA PSP might identify other mitigations, offsets, and compensation works that will require engineering inputs and construction activities.

Some of these mitigation items might be a condition of the environmental authorisation and could include, *inter alia*:

- Relocation of homesteads affected by the scheme;
- Additional feeder roads, footbridges, etc.;
- Improvements to local water supplies not included in the proposed scheme;
- A sanitation programme; and
- Improvements to clinics, schools and police stations in the areas affected by the dam.

Budgets have been allowed in the cost estimates for these other potential works, the implementation of which should be carried forward and investigated during the detailed design stage. Funding for some of the mitigation items (roads, schools, clinics, etc.) could be provided by the relevant Government departments.

4.10 Land Matters and Servitudes

4.10.1 Acquisition of Land

All of the affected land for Ntabelanga Dam wall, dam basin and associated infrastructure is State-owned and administered by traditional leaders in the region. Acquisition of this land therefore involves the relocation and compensation (replacement and/or financial) of the current occupants for their infrastructure (dwelling, cultivated lands, etc.) and other losses.

An Asset Register of all the areas affected by the project footprint has been prepared as part of the EIA study. This register is based on aerial surveys and Google images and was verified by field observations.

A Relocation Policy Framework (RPF) has been drafted during the EIA study to guide the relocation and compensation of affected communities. The RPF forms the basis of the Relocation Action Plan to be agreed with traditional leaders, ward councillors and affected communities during the design phase. The Asset Register also forms an integral part of the land acquisition process.

Recommendations in the RPF include:

- Thorough identification of abandoned homesteads and recording of field ownership is required.
- The locations of ancestral graves at abandoned homesteads affected by the project must be ascertained.
- Certain structures will require replacement so that the relevant family's socio-economic activities can continue.
- All graves within the full supply levels of the dam should be relocated, with the permission of the next-of-kin and a permit from ECPHRA.

- No associated infrastructure may be located within 100 m of graves outside the full supply levels, and if unavoidable, these graves should also be relocated.
- A destruction permit is required from ECPHRA; if possible a single permit should be obtained for all affected structures.
- Avoid involuntary resettlement wherever possible.
- Undertake consultations with displaced people about acceptable alternatives and strategies and include them in the planning, implementing and monitoring processes.
- Choose the relocation site to ensure that the minimum disruption to displaced families and host communities occurs.
- Sensitise host communities to the pending arrival of the displaced communities;
- Establish a forum or resettlement committee through which resettlement and integration can be controlled by those affected.
- A formal accessible grievance procedure should be implemented and communicated to both the displaced and host communities.
- Ensure that the receiving environment is prepared and has adequate infrastructure, facilities and social services to support both the displaced and host communities, prior to moving the displaced communities.

The use of State land around the dam basin by others, access to the water body by non-State entities (boat clubs, etc.) and related matters shall be in accordance with DWS policies and should be based on formal agreements between DWS, Provincial Government and those entities. It is also within the jurisdiction of Provincial Government to sign agreements on State land.

The zoning of the dam basin for various uses (boating, recreation, development, nature reserve areas, etc.) is the responsibility of DWS Directorate: Integrated Environmental Engineering who needs to prepare a Resource Management Plan for the dam.

4.10.2 Temporary Servitude for Construction

A temporary servitude (access to the land) for construction of the dam may be required prior to finalisation and implementation of the Relocation Action Plan. This aspect needs to be investigated further during detail design phase.

4.10.3 Permanent Servitude for Right of Way

A permanent servitude for right of way will be required for the new roads to be constructed to give access to the dam and other associated works that are not yet accessed by formal roads. A registered permanent servitude is required for infrastructure, such as roads, pipelines and power lines, even if constructed on State-owned land. This aspect needs to form part of the detail design phase.

4.11 Fencing of Project Site

4.11.1 Dam Basin

The dam basin shall be fenced off along the purchase line where required in accordance with DWS standards. The size and type of gates, the number and positions required and the type of locks or padlocks to be used shall be decided upon by the DWS.

4.11.2 Security Fencing

Security fencing shall be provided around the dam wall crest, outlet works, the dam site, the ESKOM switch yard, and other sensitive areas as may be necessary. Security fencing shall be in accordance with DWS standards. ESKOM will determine the fencing standards for their switch yard.

4.11.3 Fencing Around Non-State Owned Infrastructure

It is anticipated that other non-State entities such as tourist facilities, fishing or boating clubs may construct structures on State land. The use of State land, access to the water body and related issues shall be in accordance with DWS policies and agreements.

Any fencing provided around such structures shall comply with DWS fencing standards and agreements with these entities shall incorporate the obligation of the entities to maintain such fences on a regular basis.

4.12 Requirements for Project Implementation

4.12.1 Approval of Project

The Minister will need to approve the construction of the Ntabelanga Dam as a Government Water Works in accordance with Section 109 of the National Water Act, 1998 (Act No. 36 of 1998). This approval is contained in Appendix A. The implementation of the project shall adhere to the general criteria prescribed in Chapter 11 of the Act.

4.12.2 Environmental Authorisation

The project also requires environmental authorisation (EA) in terms of the National Environmental Management Act (NEMA) by the National Department of Environmental Affairs. This authorisation states conditions of compliance for the implementation of the project. The EA must therefore be read in conjunction with this RID for implementation of this project.

Three separate authorisations were submitted to DEA for the components of the project which could be implemented by separate entities, namely, DEA REF No:

- 14/12/16/3/3/2/677 - Dam construction application;
- 14/12/16/3/3/2/678 - Electricity generation application; and
- 14/12/16/3/3/1/1169 - Roads application.

Refer to the DWS Environmental Impact Assessment for the Mzimvubu Water Project Report Nos. P WMA 12/T30/00/5314/1 to 17, and copies of the environmental authorizations included herein as Appendix B.

4.12.3 Other Requirements

Other approvals required for project implementation, which were included in the EIA process, are listed below. Refer to Department of Water and Sanitation, South Africa (2015). Environmental Impact Assessment for the Mzimvubu Water Project: Environmental Impact Assessment Report, DWS Report No: P WMA 12/T30/00/5314/3, for more information.

a) Water Use Licence

The construction of the dams and associated infrastructure involves a number of water uses listed in terms of section 21 of the National Water Act, 1998 (No. 36 of 1998) (NWA). An Integrated Water Use Licence Application (IWULA) has been prepared for submission to DWS.

b) Borrow areas and quarries

Construction materials such as sand, gravel and rock material will be required for the construction of the dam and roads. Existing licensed quarries and borrow pits in the area may not be adequate or suitable to provide all the required construction materials and a new rock quarry and borrow pits for sand and earthfill material will be necessary.

In terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA), as amended, and the Mineral and Petroleum Resources Development Regulations in GNR 527 of 23 April 2004, DWS has been exempted by virtue of GNR 762 of 25 June 2004 from the application procedures and the approval of rights and permits in terms of sections 16, 20, 22, and 27 of the MPRDA. However, in accordance with section 106(2) of the MPRDA, the DWS is required to compile an Environmental Management Plan (EMPL) for approval in terms of the provisions of section 39 (4) of the Act.

The impacts of the new borrow areas and quarries were investigated in the EIA, and EMPLs have been compiled for approval by the Department of Mineral Resources (DMR).

c) Heritage Permits

The proposed project involves a number of activities listed in terms of section 38 of the National Heritage Resources Act, 25 of 1999 (NHRA), which require authorisation from the relevant heritage authorities.

A Heritage Impact Assessment (HIA) has been conducted as part of the EIA process. The HIA has been submitted to the Eastern Cape Provincial Heritage Resources Authority and the South African Heritage Resources Agency (SAHRA) for decision-making regarding heritage resources.

The following approvals are also required for project implementation, but were not included in the EIA process:

d) Waste Management Licence

No Waste Management Licence (WML) Applications was included in this EIA process and if applications are required, they will have to be applied for separately.

e) Licences for the removal of protected trees

Tree species that are protected in terms of the National Forests Act (Act No. 84 of 1998) have been identified within the project footprint. A licence must be obtained from the Department of Agriculture, Forestry and Fisheries (DAFF) to disturb, to damage or to destroy/remove such trees.

4.13 Approval of Design

The Ntabelanga Dam is a Category 3 dam which requires an Approved Professional Person and professional team to be approved by the Minister via the delegated authority of the Dam Safety Office in consultation with the Engineering Council of South Africa (Section 117 of the National Water Act, 1998).

A licence to construct the dam is required in terms of Dam Safety legislation (Chapter 12 of the National Water Act, 1998) before construction can commence and a licence to impound before water may be stored in the dam.

4.14 Electricity supply

Application should be made to ESKOM so that sufficient permanent power is provided to the site for construction and operation purposes. The details of the required electricity supply need to be finalised during the design phase taking into account the likely pumping requirements for the resource poor farmers to be settled on the scheme.

It is proposed that power produced by the conjunctive scheme could be evacuated into the ESKOM grid generating revenue via a wheeling arrangement as defined under ESKOM wheeling guidelines, or through the trading of “green energy”. Further discussion of this is made in the Legal, Institutional and Financing Arrangements Report No. P WMA 12/T30/00/5212/16.

This will need to be urgently discussed and the terms and conditions agreed with ESKOM and green energy trading agencies with immediate effect, as this could affect the overall economic and financial viability of the scheme as a whole.

4.15 Construction Timing

Any construction work undertaken in the river channel and spillway shall as far as possible take place during the dry season (winter) in order to avoid possible flooding and associated damage of the works during the wet season.

Any construction on the works should take the arrangement for the continuous supply of water into consideration and the works should be designed and constructed to ensure minimal interference with the flow of water in the river that currently supplies existing water supply schemes.

4.16 Construction Housing

The contractor will be responsible for accommodation for his employees during construction. Accommodation on site is normally not permitted in terms of the environmental authorisation. This aspect needs to Be confirmed in the conditions of the EA and this information included in the tender specifications for all construction tenders.

4.17 Agreement between IWRP and Infrastructure Development

The conditions specified in the Memorandum of Agreement between the Chief Directorates Integrated Water Resource Planning (IWRP) and Infrastructure Development dated March 2005 shall be adhered to. The RID shall also be applicable to any other implementing agent (such as TCTA or Amatola Water) that may be appointed to implement certain (or all) components of this project.

5. COMPLIANCE WITH APPLICABLE LEGISLATION, REGULATIONS AND POLICY

The Legal, Institutional, and Financing Arrangements report takes into account the legislative compliance of the Ntabelanga Dam, the regional bulk infrastructure for drinking water supply systems, and the raw water bulk infrastructure for irrigation purposes. Whilst there are several options for these arrangements put forward in this report, significant further work will need to be undertaken during the implementation phase that will determine which institutional and financing model will be applied.

This section of the RID therefore gives an outline of the compliance issues as related to the construction of the Ntabelanga Dam and associated infrastructure. The aspects to be complied with during implementation will depend on the final institutional and funding model adopted.

5.1 National Water Act

The National Water Act, 1998 (Act No. 36 of 1998) (NWA) is the primary piece of legislation governing the use, and protection of the country's water resources. The planning, construction, and operation of the Mzimvubu Water Project must be undertaken within the legal framework of this Act and its accompanying regulations.

Chapter 11 of the NWA details the requirements for the Department of Water and Sanitation when establishing and operating a government water works. These requirements cover consultation and environmental impact assessment; financing; and water allocation/charges.

In addition, dam safety is dealt with in Chapter 12 of the NWA, which stipulates the control measures; dam registration; and regulations to govern the management of the risks that dams inherently pose.

In terms of the Ntabelanga Dam, there are three legal requirements that must be met relating to the construction of a dam:

- Dam safety
  The current Dam Safety Regulations were published in Government Notice R. 139 on 24 February 2012 in terms of section 123(1) of the NWA. These regulations are applicable to all dams with a safety risk. The regulations require a licence to construct; a quality control programme during construction; a licence to impound; an operation and maintenance manual; an emergency preparedness plan; a completion report and certificate; and registration on the DWS database.

- Water Use Licence
  Any new water use as defined in Section 21 of the NWA is subject to licensing. This includes the storage of water as a water use. A written licence is required prior to construction. The water use licence application was prepared during the EIA process.

- Environmental Authorisation
  An environmental impact assessment was carried out to obtain environmental authorisation (EA) for the project from DEA (refer 4.12.2 and 4.12.3 above). Compliance with the conditions of the EA is a requirement for project implementation (before, during and after construction of the dam and associated infrastructure).

The building of the Ntabelanga Dam will be implemented as a Government Waterworks in compliance with Section 109 of the NWA.

5.2 Environmental Compliance

5.2.1 Compliance with Environmental Authorisation

Compliance with the conditions of the environmental authorisation (EA) is compulsory for the implementation of this project (refer 4.12.2 above). It is therefore also necessary to study the environmental impact assessment report (EIR) to ensure that all environmental requirements for the project are met, and impacts due to non-compliance are avoided.

A summary of the main mitigation measures specified in the EIR for design, construction and operation of the Ntabelanga Dam and associated infrastructure are given below. Some of these measures will also be conditions of the EA.

a) *Key mitigation measures to be implemented during the pre-construction (design) phase:*

- Protected tree species Podocarpus fulcatus and P. latifolius were located along the sections scheduled for road upgrades. The following must be ensured:
  - Possible re-alignment of the roads where protected tree species were found, in order to avoid cutting and destroying the trees;
  - Where protected trees will be disturbed, ensure effective relocation of individuals (if possible) to suitable similar habitat; and
  - Permit applications must be obtained from relevant authorities.
- Rescue and relocation of medicinal important floral species, RDL and protected floral species is essential to minimise impacts from inundation.
- RDL faunal species or species of conservational concern found within the operational footprint area must be relocated to similar habitat within the vicinity of the study area with the assistance of a suitably qualified specialist.
- No hunting or trapping of faunal species is to occur.
- The construction footprint needs to remain as small as possible, especially in the sensitive habitats.
- Aquatic bio-monitoring must take place and if any trends are observed where impacts on the aquatic ecology is becoming unacceptable, measures to reduce the impacts must be immediately implemented.
- Baseline studies must be undertaken for noise, air quality, and water quality.
- An investigation must be undertaken by a qualified specialist to determine whether any waterfall dependant plants in the gorge and on the cliff could be significantly impacted and whether they require relocation. All findings of the investigation must be implemented.
- Areas of increased sensitivity, as shown in the sensitivity maps developed (Figures 4 and 5 of the EIR) should ideally be avoided in terms of the placement of infrastructure in order to minimise the footprints within wetland features. Where it is not possible, mitigation measures to limit the impacts (such as ensuring the design of crossings allows for the retention of wetland soil conditions as presented in the EMPR) must be implemented.
- Support structures for pipelines must be placed outside of riparian features, channelled valley bottom wetlands and drainage lines. Should it be essential to place such support structures within these features, the designs of such structures must ensure that the creation of turbulent flow in the system is minimised, in order to prevent downstream erosion. No support pillars should be constructed within the active channels. In order to achieve this all crossings of wetlands should take place at right angles wherever possible.

- Where new roads traverse wetland / riparian habitats, with special mention of drainage lines, channelled valley bottom wetlands and riparian habitat, disturbance to any wetland crossings must be minimised and suitably rehabilitated. The crossing designs of bridges must ensure that the creation of turbulent flow in the system is minimised, in order to prevent downstream erosion. All crossings of wetlands should take place at right angles wherever possible.
- The design of culverts / bridges should allow for wetland soil conditions to be maintained both upstream and downstream of the crossing to such a degree that wetland vegetation community structures upstream and downstream of the crossing are maintained. In this regard, special mention is made of:
  - The design of such culverts and/or bridges should ensure that the permanent wetland zone should have inundated soil conditions throughout the year extending to the soil surface;
  - The design of such culverts and/or bridges should ensure that the seasonal wetland zone should have water-logged soils within 500 mm of the soil surface during the summer rainfall period; and
- Temporary wetland zone areas should have waterlogged soil conditions occurring to within 300 mm of the land surface during the summer rainfall period.
- Ensure that no incision and canalisation of the wetland system takes place as a result of the construction of the culverts.
- It must be ensured that flow connectivity along the wetland features is maintained;
- The Ecological Water Requirements (EWR) as set out in the Reserve Determination Volume 1: River (Report P WMA 12/T30/00/5212/7) for the Ntabelanga Dam, must be adhered to.
- The installation of multiple level outlets, with outlets at intervals not exceeding 6.5 m starting from 7 m below the full supply level of the dam and proper operation is required to mitigate the effect of water quality changes downstream of the proposed dams.
- The archaeological site identified in the proposed Ntabelanga Dam basin should be mapped in detail, with judicious sampling, authorised by a permit from ECPHRA. Thereafter the site may be destroyed once a destruction permit has been issued by ECPHRA.
- A detailed survey of potential Early Iron Age sites should be undertaken once crops have been harvested and vegetation clearance has occurred.
- New roads and pipelines should be realigned as much as possible to avoid structures.
- Fieldwork to identify heritage resources affected by roads and electrical infrastructure must be undertaken, and mitigation measures recommended, once final infrastructural locations and routes have been finalised, surveyed and pegged.
- All graves outside the full supply levels within 300 m of associated infrastructure should be demarcated by the Engineer's environmental representative, in consultation with the next-of-kin, for the duration of construction. These graves should not be disturbed.
- All access roads impacted by inundation must be compensated by providing new roads and bridges.
- The Relocation Policy Framework (RPF) must be implemented in a consultative manner.
- A dedicated Project Management Unit should be set up to manage the project.
- Ensure continued liaison with authorities responsible for potable water distribution.
- The social impacts and institutional arrangements for the proposed commercial irrigated farming scheme (land tenure/ ownership, farming model, farmer identification and support, funding, etc.) needs to be resolved between affected communities and role players before the scheme is implemented.

- A Decisions Register must be established and maintained, and must be available to any member of the public who wishes to access it. The register should include all commitments made to stakeholders during the public participation process, which are recorded in the Issues and Responses Report.
- An employment and skills development policy, maximising employment opportunities and skills development for local communities and promoting gender inclusivity and equity must be developed.
- A procurement policy, promoting business opportunities for local communities and gender inclusivity and equity, must be developed.
- An investigation on the necessity and design specifications for an eel-way should be undertaken and findings implemented.

b) *Key mitigation measures to be implemented during the construction phase*

- An alien vegetation control programme must be implemented, as encroachment of alien vegetation is already apparent in the study area and is expected to increase as a result of the disturbances resulting during the construction process. Rehabilitation of disturbed areas, utilising indigenous wetland vegetation species, will assist in retaining essential wetland ecological services, particularly flood attenuation, sediment trapping and erosion control, and assimilation of nutrients and toxicants, thus reducing the impacts of construction related activities.
- Prohibit the collection of plant material, outside of the proposed dam basins, for firewood or for medicinal purposes during the construction phase by construction staff.
- Restrict vehicles as far as possible to travel on designated roadways to limit the ecological footprint.
- No hunting or trapping of faunal species is to occur.
- The construction footprint needs to remain as small as possible, especially in the sensitive habitats.
- Sections of power lines that require bird diverters must be identified and implemented.
- Aquatic bio-monitoring must take place, starting six months prior to construction activities, and if any trends are observed where impacts on the aquatic ecology is becoming unacceptable, measures to reduce the impacts must be immediately implemented.
- Identified areas where erosion could occur must be appropriately protected by installing the necessary temporary and/or permanent drainage works as soon as possible and by taking other appropriate measures to prevent water from being concentrated in rivers/streams and from scouring slopes, banks or other areas.
- Storm water control measures must provide for erosion and sedimentation control, and for reinforcement of banks and drainage features, where required. Possible measures include the use of gabions or reno mattresses and geotextiles, re-vegetation of profiled slopes, erosion berms, drift fences with hessian and silt traps.
- It must be ensured that flow connectivity along the wetland features is maintained.
- Monitor rivers and wetlands for incision and sedimentation.
- Implement a water quality and quantity monitoring programme.
- The EWR as set out in the Reserve Determination Volume 1: River (Report P WMA 12/T30/00/5212/7) for the Ntabelanga Dam must be adhered to at all times.
- Develop a Water Management Method Statement (WMMS), including measures for water conservation, for approval by the Engineer prior to the commencement of the works.
- Construction personnel accommodation on site must be as limited as possible. Construction workers should as much as possible be recruited from neighbouring communities and transport provided to the construction site(s).

- Local residents should be recruited to fill semi and unskilled jobs.
- Women should be given equal employment opportunities and encouraged to apply for positions.
- A skills development plan should be put in place at an early stage and workers should be provided the opportunity to develop their skills which they can use to secure jobs elsewhere post-construction.
- A procurement policy promoting the use of local business, where applicable, should be put in place to be applied throughout the construction phase.
- Ensure that the appropriate procurement policies are put in place and closely followed.
- Ensure that all consultation is gender inclusive.
- Ensure that the Decisions Register is maintained, and is available to any member of the public who wishes to access it.

c) *Key mitigation measures to be implemented during the operation phase*

- Implement a communication strategy for the implementation phase.
- No hunting or trapping of faunal species by operational staff is to occur.
- Aquatic bio-monitoring must take place and if any trends are observed where impacts on the aquatic ecology is becoming unacceptable, measures to reduce the impacts must be immediately implemented.
- An alien vegetation control programme must be maintained, as encroachment of alien vegetation is already apparent in the study area and special attention needs to be given to areas disturbed during the construction process. Rehabilitation of disturbed areas, utilising indigenous wetland vegetation species, will assist in retaining essential wetland ecological services, particularly flood attenuation, sediment trapping and erosion control, and assimilation of nutrients and toxicants.
- The EWR as set out in the Reserve Determination Volume 1: River (Report P WMA 12/T30/00/5212/7) for the Ntabelanga Dam must be adhered to at all times.
- During operation and maintenance of infrastructure, vehicles must remain on designated roads and not be permitted to drive through sensitive wetland / riparian habitat, particularly on the edges of the dams where loss of wetland habitat and therefore ability of the wetlands to provide ecological services, is already compromised.
- Maintenance personnel must ensure that any tools and/or waste products resulting from maintenance activities are removed from the site following completion of maintenance.
- Regular maintenance of all roads, with specific mention of wetland / riparian crossings, must take place in order to minimise the risk of further degradation to wetland / riparian habitat.
- Ensure that the Decisions Register is maintained, and is available to any member of the public who wishes to access it.
- Maintain the potable water infrastructure, control pollution and curb illegal taps. If no such measures are implemented the community may be worse off as a result of water borne diseases or no water at all.

5.2.2 Environmental Management Programme

An Environmental Management Programme (EMPR) for construction was prepared as part of the EIA process and submitted to DEA for approval.

It is a requirement for project implementation that the EMPR forms part of the tender and contract documentation for construction of the dam and other infrastructure. Compliance with the EMPR is compulsory for all contractors and sub-contractors appointed for this project.

An Environmental Management Plan (EMPL) for the rock quarry and borrow areas (sand and earthfill materials) was prepared as part of the EIA process and submitted to Department of Mineral Resources for approval.

The conditions and requirements contained in the EMPL shall be incorporated into the tender documents for the quarry and borrow areas for Ntabelanga Dam. These conditions and requirements are compulsory during the development, operation and closure of the quarry and borrow areas.

6. MZIMVUBU WATER PROJECT INSTITUTIONAL ARRANGEMENTS

6.1 Current National Water Institutional Arrangements in South Africa

Figure 6-1 shows the current water institutional arrangements in South Africa. The various key roleplayers are described below.

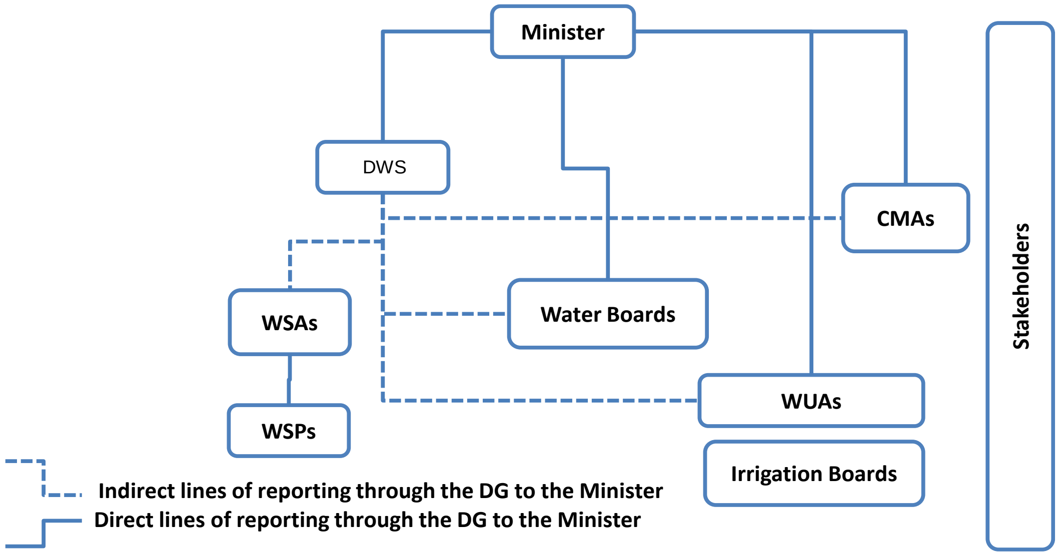


Figure 6-1: Current Water Institutional Arrangements in South Africa

6.1.1 Department of Water and Sanitation

The Department of Water and Sanitation (DWS) is responsible for the planning and implementation of this project as well as water sector policy, support and regulation.

6.1.2 Water Boards

Water Boards are state-owned regional water services providers who may provide both bulk services to more than one Water Services Authority area (regulated directly by DWS) and retail services on behalf of Water Services Authorities (regulated by contract with the Water Services Authority). The Minister of Water and Sanitation is the primary regulator of a Water Board.

6.1.3 Catchment Management Agency

Catchment Management Agencies (CMA) undertake water resource management at a regional or catchment level and involve local communities, within the framework of the national water resource strategy. Regulation of CMAs is the responsibility of the Minister of Water and Sanitation.

6.1.4 Water User Associations

Water User Associations (WUA) operate at a restricted localised level, and are in effect co-operative associations of individual water users who wish to undertake water related activities for their mutual benefit. A water user association may exercise management powers and duties only if and to the extent these have been assigned or delegated to it. Regulation of WUAs is the responsibility of the Minister of Water Affairs.

6.1.5 *Irrigation Board*

Irrigation boards were established in terms of law in force before the commencement of the NWA. The Act mandates that a board may continue to exist until it is declared to be a water user association or until it is disestablished in terms of the law by or under which it was established. The NWA contends that Irrigation Boards must submit a proposal to transform to a WUA, within 6 months of commencement of the NWA.

6.1.6 *Water Services Authorities*

Water Services Authorities (WSA) can be a metropolitan municipality, an authorised district municipality or an authorised local municipality which is responsible for ensuring provision of water services within their area of jurisdiction. Whilst these municipalities and their WSAs fall under the responsibility of the Department of Cooperative Government and Traditional Affairs, the DWS also plays a regulatory, monitoring and evaluation role for the WSAs.

6.1.7 *Water Services Provider*

A Water Services Provider (WSP) is a WSA or any person who has a contract with a Water Services Authority or another water services provider to sell water to, and/or accept wastewater for the purposes of treatment from, that authority or provider (bulk water services provider); and/or has a contract with a Water Services Authority to assume operational responsibility for providing water services to one or more consumers (end users) within a specific geographic area (retail water services provider). Management of a WSP is through a contract with a WSA.

6.2 Changes Proposed in the National Water Policy Review (30 August 2013)

6.2.1 *Establishment of Regional Water Utilities*

The Minister of Water and Sanitation is responsible for the effective development and management of regional bulk infrastructure. The Department of Water and Sanitation has proposed the establishment of Regional Water Utilities as contained in the National Water Policy Review document dated 30 August 2013. The purpose of these institutions will be to plan, build, operate, support and maintain regional bulk infrastructure.

It is envisioned that Regional Water Utilities can fill the current gap where WSAs have no or limited capacity for managing and developing regional bulk infrastructure. According to the Strategic Framework for Water Services (2003), water boards are able to operate at a regional level as a bulk water services provider. The role and structure of water boards may change over time with the development of Regional Water Utilities.

6.2.2 *Disestablishment of Water User Associations and Irrigation Boards*

The transformation of Irrigation Boards to Water User Associations has been slow, with 129 that have still not transitioned since 1997. Transformed WUAs have also not sufficiently achieved participation of other users such as municipalities. In addition, the DWS is finding it challenging to provide oversight to a large number of WUAs. As a result of these, and other reasons, the DWS has decided that as CMAs are established in WMA, the WUAs and IBs will be disestablished and functions will be delegated to CMAs and Regional Water Utilities.

6.3 Current Water Institutional Arrangements in Project Area

6.3.1 Department of Water and Sanitation Regional Offices

The DWS Eastern Cape Region has offices in King Williams Town and East London. The DWS officials are responsible for the governance of the water resources, and the planning of regional bulk infrastructure in the area. In addition, due to the fact that the Umzimvubu-Tsitsikamma CMA is not functional as yet, the EC DWS office fulfils these functions as well. The operation of DWS dams in the province is contracted to Amatola Water.

6.3.2 Amatola Water Board

Amatola Water is one of 20 water boards and utility organisations belonging to the South African Association of Water Utilities and mandated by the South African Government to operate as a water services provider to municipal authorities and certain other water customers, as provided for in national water legislation.

The utility`s primary business activity is to service the bulk treated water requirements of urban, peri-urban and rural communities situated within a gazetted services area (see blue boundary in Figure 6-2[2]) which is some 43 400 km² in extent and is located within the central region of the Eastern Cape Province of South Africa. With its headquarters in East London in the Eastern Cape Province, Amatola Water operates eleven water treatment plants and seven sub-regional, bulk distribution networks in a designated services area of 45 794 km² covering most of the Amathole and part of the Chris Hani District Municipalities.

It offers comprehensive contract services to municipalities for water abstraction, treatment, bulk supply and water quality monitoring for domestic, industrial and agricultural use. In response to market demands and opportunities Amatola Water has developed its supplementary servicing capability.

Service agreements are devised for the operation and maintenance of customer-owned water treatment plant and reticulation installations. Amatola Water supports these services with complementary managerial, technical, laboratory and related specialist advisory services tailored to the needs of major industrial and other institutional customers (www.amatolawater.co.za).

6.3.3 Catchment Management Agency

No CMA is established in the catchment as yet.

6.3.4 Water User Associations

No WUAs are established to date. Considering the intent of DWS to disestablish WUAs, it is not recommended to establish such bodies.

6.3.5 Irrigation Boards

No Irrigation Boards are established in the area.

6.3.6 Water Services Authorities

The three WSAs that will benefit from the Mzimvubu Water Project are: OR Tambo DM; Alfred Nzo DM; and Joe Gqabi DM. The WSA has the ultimate responsibility to ensure service delivery in their jurisdiction, and more specifically are responsible for the governance of any WSP; water services development planning; and the technical and financial sustainability of the infrastructure. The historical poor performance of some of the WSAs in performing these functions is a concern.

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[2] *From presentation to Portfolio Committee on Water Affairs and Forestry 2006*

Figure 6-2: Amatola Water Area of Operation

6.3.7 Water Services Providers

The OR Tambo DM and the Alfred Nzo DM both perform the WSP function in their jurisdiction. Joe Gqabi DM, has contracted the local municipalities within its jurisdiction to perform this function. The part of the Mzimvubu Water Project that falls within Joe Gqabi DM lies in the Elundini LM.

6.4 Agricultural, Land and Energy Related Institutions

6.4.1 Department of Agriculture, Forestry and Fisheries (DAFF)

The Department of Agriculture, Forestry and Fisheries (DAFF) has a key role to play in the planning and the operational phases of this project. One of the key recommendations is to utilise the Mzimvubu Water Project to catalyse agricultural development in the area.

This can only be successful if the DAFF are integrally involved in the planning of how this should happen, the considerable change management that will need to occur to implement the plans, the identification of funds to subsidise the capital investment needed, and the ongoing support to the farmers into the future. This involvement will most likely be spearheaded by the Directorate: Cooperatives and Enterprise Development.

6.4.2 Local Agricultural Associations

There are many agricultural groups functioning in the project footprint area. All these groups need to be made aware of the project, and offered the opportunity to participate meaningfully in the proposed plans for the agricultural development in their area. From the DAFF website, a list of co-operatives in the area is listed in Table 6-1 below. These all need to be contacted to establish their exact location and determine whether they fall within the affected area. This is unlikely to be an exhaustive list.

6.4.3 Department of Rural Development and Agrarian Reform

The Department of Rural Development and Agrarian Reform (DRDAR), like DAFF, has a key role to play in the planning, implementation and operational phases of this project. Significant land reform recommendations have emanated from discussions with the Department, and will require the consultation of many communities on tribal land in the area. With the recommendation that the area move from small subsistence farming, to irrigated agriculture on larger commercial farms, the DRDAR will need to spearhead the transformation process.

6.4.4 Department of Energy

The Department of Energy (DoE) is responsible for ensuring that diverse energy resources are available, in sustainable quantities and at affordable prices in support of economic growth and poverty alleviation. It must further provide for energy planning, increased generation and consumption of renewable energies, and contingency energy supply. The DoE has an important role to play in the decision making regarding the hydropower plant planning, ownership, management, and the provision of electricity into the national grid.

6.4.5 National Energy Regulator of South Africa (NERSA)

As the energy regulation body of South Africa, National Energy Regulator of South Africa (NERSA) is an important stakeholder in this project. Any decisions regarding the selling of electricity generated from the hydropower plant must first be approved by NERSA before it can be implemented.

Table 6-1: Local Agricultural Associations

Name of Business	Main Activity	Legal Status	Contact Details	Province	District	Municipality
4. IKAHENG COMMUNITY GARDEN	Vegetables	Association	MATHAPELO MONYANE - 0793278723	Eastern Cape	Ukhahlamba	Elundini
6. MASAKHANE POULTRY PROJECT	Poultry	Association	NOKWAKHA MZAMO - 0837576957	Eastern Cape	Ukhahlamba	Elundini
13. ZIZAMELE NAMBA AGRIC. PROJECT	Vegetables	Association	MASONTATHA VICTORIA LOUIS - 0769538488	Eastern Cape	Ukhahlamba	Elundini
17. CELUCENDO VEGETABLE PROJECT	Vegetables	Association	NONKOSOMBUSO MEMEZA - 0721438667	Eastern Cape	Ukhahlamba	Elundini
27. IKAHENG COMMUNITY GARDEN	Vegetables	Association	MATHAPELO MONYANE - 0793278723	Eastern Cape	Ukhahlamba	Elundini
43. MASAKHANE KHALAZEMBE	Vegetables	Association	NOMTHUTHUZENI MZOZOYANA - 0729526222	Eastern Cape	Ukhahlamba	Elundini
44. MASAKHANE KHALAZEMBE	Vegetables	Association	NOMTHUTHUZELI MZOZOYANE - 0729526222	Eastern Cape	Ukhahlamba	Elundini
65. PHILA UPHILISE	Vegetables	Association	NTENTESA N - 0720406237	Eastern Cape	Ukhahlamba	Elundini
90. ZAMA ZAMA FOOD SECURITY PROJECT	Vegetables	Association	NOSANGO MTANGAYI - 0784803213	Eastern Cape	Ukhahlamba	Elundini
91. ZAMAKULUNGA PROJECT	Vegetables	Association	MARIGOLD MABALEKA - 0722244498	Eastern Cape	Ukhahlamba	Elundini

Name of Business	Main Activity	Legal Status	Contact Details	Province	District	Municipality
95. ZAMUKUHLE PROJECT	Vegetables	Association	NTEBOHENG KHAUOE - 0825304675	Eastern Cape	Ukhahlamba	Elundini
97. ZIBENZA ZIBUDLA	Wheat	Association	NTEBOHENG KHAUOE - 0825304675	Eastern Cape	Ukhahlamba	Elundini
5. MKWEZO MASSIVE	Crops	Association	MR S.C TIMAKWE - 0732232699	Eastern Cape	O R Tambo	King Sabata Dalindyebo
12. ZIZAMELE KRANCOLO COOPERATIVE	Maize	Association	MR G SASA - 0726259664	Eastern Cape	O R Tambo	King Sabata Dalindyebo
50. MATHEKO WOOL GROWERS ASSOCIATION	Wool Producers	Association	MR A NDZENDZE - 0785839259	Eastern Cape	O R Tambo	King Sabata Dalindyebo
71. SIPHAMANDLA PROJECT	Poultry	Association	KHANYISWA PHEMPELE - 0839811088	Eastern Cape	O R Tambo	King Sabata Dalindyebo
94. ZAMOKUHLE PROJECT	Vegetables	Association	NTEBOHENG KHAUUOE - 0825304675	Eastern Cape	O R Tambo	King Sabata Dalindyebo
32. KIKEWWG FARM	Crops	Association	SD MARARENI - 0848919846	Eastern Cape	Alfred Nzo	Matatiele

6.4.6 ESKOM

ESKOM is the national electricity supplier in South Africa. As such, it is an important institutional stakeholder in the planning and implementation stages of this project.

There are various options as far as the extent of involvement of ESKOM as an owner and/or operator of the envisioned hydropower plants, or at least as the operator of the national grid for transmission of surplus electricity generated by the plant.

6.5 Possible Institutional Arrangements for the Mzimvubu Water Project Infrastructure

6.5.1 Ntabelanga Dam

The DWS can operate and maintain the Ntabelanga dam or contract this function to Amatola Water as it does for 21 other dams in the EC Province.

This could be facilitated through an addendum to the current dam management contract.

Alternatively, if the DWS establish a Regional Water Utility, this function may be delegated to this new body. The DWS will remain the owner of the dam regardless of the management arrangement chosen.

6.5.2 Regional Primary and Secondary Bulk Infrastructure

Amatola Water has cemented its reputation as a high quality water management institution through its consistent good performance in the Blue Drop certification programme. Although the water board does not operate any infrastructure within the project footprint area, the water board works closely with all of the DMs.

Amatola Water would be the obvious institution to take on the ownership and management of the water and waste water treatment works, and the regional bulk infrastructure associated with the Mzimvubu project. This regional bulk infrastructure also includes the raw water system that is planned for the distribution of water for agricultural purposes. The ownership, management and operations of this could reside with Amatola Water up to the property boundaries of each planned farm.

Alternatively, if the DWS establish a Regional Water Utility, these functions may be delegated to this new body.

6.5.3 Tertiary Potable Water Distribution Networks

Amatola Water, together with engineering consultants, are in the process of planning and implementing regional bulk water schemes for provision of potable water to the end users, which schemes include many of the settlements in the proposed Ntabelanga Dam water supply area. These schemes are being implemented on the basis of integration with the proposed Ntabelanga Dam primary and secondary bulk water pipeline system.

Preliminary layouts have been developed for the tertiary network that can deliver water from the primary and secondary systems to the DM's customers. The final design and implementation of these tertiary systems will remain the responsibility of the DMs who are the applicable Water Services Authorities (WSA) in the area – namely Alfred Nzo District Municipality, OR Tambo District Municipality, and Joe Gqabi District Municipality.

This infrastructure, once it is built and commissioned, will be owned, operated and maintained by these WSAs. Thereafter, all capital and operations and maintenance responsibilities will reside with these WSAs. They will need to ensure sufficient revenue is generated from consumers, coupled with grant income from the fiscus to manage this infrastructure in a sustainable manner.

These WSAs may sub-contract part or all of the functions to operate and maintain the infrastructure to a third party, but still remain legislatively responsible for the function.

The capability and capacity of the three DMs to manage the tertiary infrastructure from the Mzimvubu Water Project needs to be reviewed and strengthened.

6.5.4 Irrigation Raw Water Infrastructure

Bulk raw water supply infrastructure for irrigation purposes will be provided to the border of each of the proposed new farming units. The construction, management and operation of the on-farm developments will be the responsibility of the farm owner. The recommendation is that the new farmers be provide with the necessary financial and technical support until they are able to run viable commercial farming enterprises independently.

6.5.5 Hydropower Scheme

The hydropower scheme is considered to be an essential element in the long term sustainability of the Mzimvubu Water Supply project, as it has the potential of providing a significant and continuous surplus income stream to subsidise the costs associated with the capital investment, and the operation and maintenance of the infrastructure. Careful consideration as to whether, and through what mechanisms, DWS can retain ownership of the plant is required. Investigation into these options has not yet been undertaken.

The options as they are seen at present include, but are not limited to:

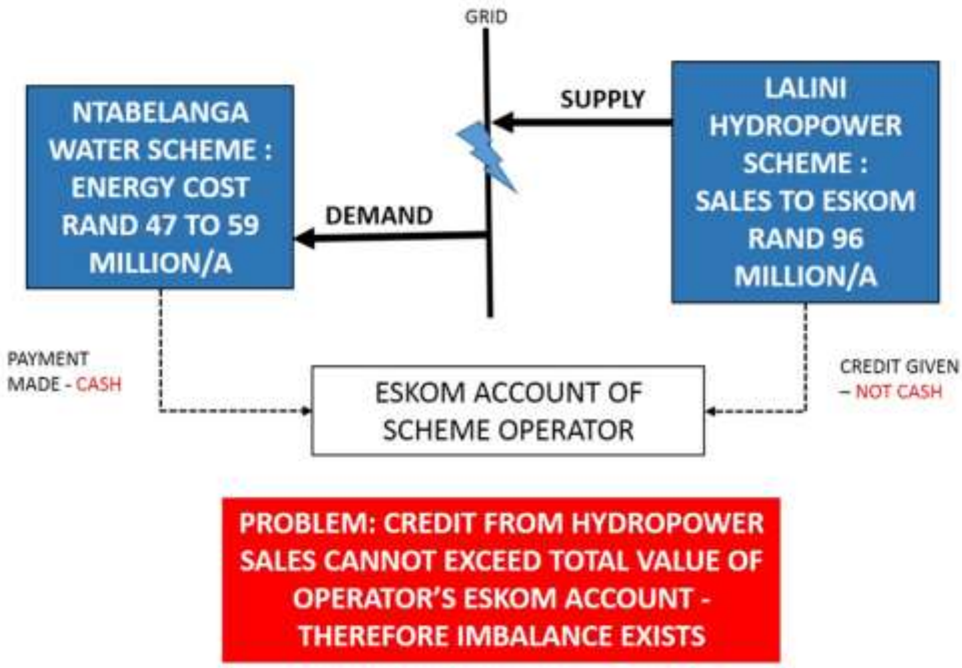
- DWS own, manage, operate and maintain the hydropower plant,
- DWS retain ownership, but enter into an agreement with a public (ESKOM) or private (IPP) body to manage and operate the hydropower plant, or
- The hydropower plant is transferred to ESKOM who own, manage and operate the plant.

The first two options would require a bilateral trade/wheeling arrangement with ESKOM. Bilateral trading involves generators and buyers (typically large customers) entering into bilateral contracts for the sale of electricity. Wheeling will occur when there is a bilateral trade and involves the transportation of electrical energy over the networks of a party that is not the owner of that energy.

The wheeled power is injected by the “seller” (a generator) into the network of the party owning the network and extracted by the “buyer” (an electricity consumer) at a point of delivery (POD) on the network. A wheeling arrangement does not directly reduce the capacity required on the network and therefore network access charges are payable by the generator for the cost of the delivery of the energy to the buyer. This is illustrated in Figure 6-3.

The “wheeling” transaction results in a financial reconciliation on the ESKOM bill for the energy bought under the bilateral trade and includes the use-of-system charges associated with the delivery of the energy (wheeling charges) (ESKOM Wheeling of Energy Brochure, September 2012).

This transaction does not involve ESKOM paying the independent generator in cash for the energy delivered into the grid. Instead, a credit is given to the generator entity for its normal power consumption. This means that if the energy delivered into the grid has a value greater than that billed to the generator by ESKOM, there would be an imbalance and no additional cash payment would be forthcoming from ESKOM. As an example, it is likely that the revenue from the energy delivered to the grid from the Ntabelanga and Lalini conjunctive scheme would exceed the total energy consumption bill of Amatola Water which would mean that a wheeling arrangement would probably not be viable.



Note: Financial figures given are for illustration purposes only

Figure 6-3: Basic Concept of the Wheeling of Energy

6.5.6 Amatola Green Power

Amatola Green Power (Pty) Ltd (AGP) is an electricity trading company based in Port Elizabeth operating independently from ESKOM or municipalities, subject to the Electricity Act and the National Electricity Regulator. The technology and energy sources that AGP utilises for the generation of electricity are environmentally friendly, reducing the emission of Green House Gasses into the atmosphere, hence the reference to Green Power.

In February 2009 the National Energy Regulator of South Africa (NERSA) awarded AGP with a license to trade Green Power within the framework of the voluntary willing buyer, willing seller market (License No TRD01/ELC/09). The license is very restrictive in its conditions and in order to record a successful transaction, the trader has to submit proof of compliance with the license and the market rules to NERSA.

AGP rents the electrical networks from ESKOM and Municipalities via wheeling agreements which are entered into and pays a fee where required.

AGP could have a role to play in the Mzimvubu Water Supply Project in the wheeling of power generated by the proposed hydropower plants.

The final decision as to the institutional arrangements for the hydropower plant should be based on the option that has the highest financial return to maximise the economic benefits for DWS, and the Eastern Cape, but must also be sustainable from an institutional perspective.

6.6 Implications of the Revised Raw Water Pricing Strategy

The Raw Water Pricing Strategy (2007) is under review at present. The information below is taken from the Revised Water Pricing Strategy for Raw Water – new elements/approaches (August 2013), and the Revised Water Pricing Strategy for Raw Water III – Draft for Comment (September 2013). Several of the proposed changes have an implication for the Mzimvubu Water Project. The report also includes relevant elements that will be retained from the existing Strategy.

The strategy focusses on the use of raw (untreated) water from the water resource and/or supplied from government waterworks and the discharge of water into a water resource or onto land. It covers the setting of prices by DWS as well as by water management institutions as defined in the NWA and does not deal with the pricing of water services. However, the raw water charges are imposed on all water users, and thus affect the input costs of water services, and therefore the water services tariffs down the value chain.

6.6.1 Understanding the changes

The new pricing strategy aims to achieve the goals of protecting the poor (equity) and the application of business principles (setting charges based on full cost recovery). The benefits are summarised in Table 6-2 below.

Table 6-2: Proposed Improvements on the Pricing Strategy

User Group	Improvements to the strategy	
	Equity	**Application of Business Principles**
High Assurance Users	Ensures that those users who get the highest assurance of supply pay for that privilege	
Industrial Users	Ensures that users who use water for commercial purposes pay the full cost of water	
Municipal Users	Subsidises the water resources related costs of providing a basic water supply, which are not covered in the equitable share.	Ensures the costs of providing water to the municipality above 50 lcd for the indigent population are fully covered by water use charges
Agriculture Users	Phase in water charges for resource poor farmers over ten years to enable them to establish themselves effectively before having to pay the full costs. Phase in the future infrastructure build charge to commercial farmers over ten years to enable them to adjust to the increase in tariffs.	Ensure that commercial agriculture users pay the full cost of water with transparent and targeted subsidies determined by DAFF and Treasury in relation to national agricultural objectives.

6.6.2 Water Use Categories

The proposed new categories are as follows:

- Stream-flow Reduction Activities
- Agriculture
- Municipal (subdivided into three categories of metros, small towns and poor rural municipalities)
- Industrial/Mining
- High Assurance Use, and
- Hydropower

The main changes in these categories are the split of the formerly Domestic and Industrial category into two separate groups, Municipal and Industrial/Mining, as well as the addition of the High Assurance Use, representing users with an assurance of supply of 99.5%.

A category of hydropower has also been introduced to be able to charge for water use by small scale hydropower plants that are due to be developed as part of the energy mix in the country.

6.6.3 Water Resources Management Charge

Current water use charges are in many cases too low. This results in non-viable institutions, sub-optimal water resources services and overall deterioration of the water resources. There is therefore a need to adjust to higher real charges within a limited time period to accommodate the cost of effective and financially sustainable water management institutions, taking cognisance of affordability constraints within user sectors. There is also a need for fiscal support for the activities of CMAs.

The new raw water pricing strategy therefore introduces a water resources management charge (WRMC) to cover the costs of the management and operations of CMAs. The charges will be based on registered volumes for each user, and will not be subsidised. The calculation of the charge will be per water user category based on the activities and assurance of supply.

Agriculture is at present subsided with regards to the water resource charge via a cap on the maximum charge per m^3. This capping is to be removed over a five year period, decreasing at 20% per annum, and the full WRMC is to be applied after those five years to the irrigation sector with targeted subsidies to be applied as determined by DWS in consultation with DAFF and National Treasury and as supported by fiscal subsidies. Such subsidies will be determined in line with national development objectives, and with transformation objectives relating to race and gender and to the reduction of inequality in South Africa. These subsidies will be paid directly to DWS.

The WRMC for resource poor farmers and tree growers will be phased in over ten years, from the date of registration of the water use, with no charge imposed for the first five years, and the charges then imposed incrementally at 20% per annum until the full charge is imposed by year ten.

6.6.4 *Water Resources Infrastructure Charges*

If water use charges are too low, they will lead to underinvestment, lack of maintenance and unwarranted fiscal subsidies. There is therefore a need to adjust to higher real charges over time to accommodate the cost of investing in supply capacity to meet rising demand and to maintain and refurbish existing infrastructure. There is also a need to invest in economic regulation of infrastructure financing and management. The charges are applicable to all users receiving water from a government waterworks.

The charges will include:

- O&M charge
- Depreciation and Refurbishment Charge
- Future Infrastructure Build Charge (replaces the Return on Assets Charge)
- Basic Human Needs Charge
- Capital Unit Charge

Table 6-3: Water Charges under Different Scenarios

Charge to be Levied	Existing Schemes			New Projects	
	Commercial portion of schemes funded from exchequer	Social portion of schemes funded from exchequer	Funded off-budget and debt has been repaid	Fully or partially funded by Government (social)	Off-budget funded portion of scheme
Operation and Maintenance	Yes	Yes	Yes	Yes	Yes
Depreciation/ Refurbishment	Yes	Yes	Yes	Yes	Yes
Future Infrastructure Build Charge	Yes	No	Yes	No	No
Basic Human Needs Water Resources Charge	No	Yes	No	No	No
Capital Unit Charge	No	No	No	No	Yes

Operation and Maintenance charges will be recovered on a scheme or system basis or on a national basis for the BWC. These charges (which include direct and indirect costs) can be recovered either on an actual cost recovery basis or through an Operations and maintenance Charge that is based on the forecast of annual O&M costs and of water use.

The Depreciation charges will be used to refurbish existing assets on a prioritised basis, as and when required. Thus, the depreciation portion of the revenue will be used for the refurbishment of infrastructure assets from a dedicated refurbishment fund. On schemes funded off budget, the depreciation charge will only be applicable once the loans have been repaid. If refurbishment is required during the repayment period, a refurbishment charge will be arranged by agreement between the parties. The hydropower water use category is exempt from the depreciation charge.

The Future Infrastructure Build Charge (FIBC) is intended to fund infrastructure that is aimed at the stimulus of social and economic development. Where infrastructure development has both a commercial and social use, the FIBC will only fund the social portion, and the remainder of the funding will need to be financed through loans.

The Basic Human Needs Water Charge (BWC) is intended to cover a portion of the water resources related depreciation and O&M costs of ensuring the provision of water for basic human needs.

Water that has the BWC levied on it will not also pay for the FIBC levy. Any water use above the BWC volume for municipalities, and all registered water use by non-natural persons and other enterprises, excluding hydropower, will have to pay the FIBC.

The FIBC levied on agriculture will be phased in over ten years to reach the same level as the other sectors, to give agriculture time to adjust to the considerable change in the cost of water.

The Capital Unit Charge (CUC) is intended to fund the cost of loan funding raised for the development of off-budget schemes. All social users on schemes with CUC levied on will be exempt from paying CUC because it will be subsidised. This charge will apply to all future schemes yet to be developed.

6.6.5 *Specific Application to Hydropower*

Charges for hydropower generation are proposed to be based on c/kWh (cent per kilowatt hour) of energy generated and a fixed charge based on kW installed, instead of the cent per cubic meter of water use charged for raw water abstraction, which is neither practical nor applicable.

If, however, a hydropower generation operator requires water to be released from a dam to generate power at times that such water would NOT be used by other downstream water users, resulting in a loss of water stored in a dam, the abstraction related water resources management and infrastructure charges should apply to this volume of water. In such instances the hydropower generator would need to acquire a water use license for the taking of water which qualifies as a section 21 (a) water use in terms of the NWA.

Small hydropower plants with a capacity of less than 20 MW should be charged as follows:

Table 6-4: Proposed Hydropower Usage Tariffs

	Hydropower plant integrated within DWS's infrastructure at the dam (Scenario A)	**Hydropower plant developed downstream of DWS's infrastructure and downstream of the dam wall (Scenario B)**
Fixed charge	R10.00 / kW per annum	R5.00 / kW per annum
Variable charge	R 0.01 / kWh	R0.01 / kWh

6.6.6 Implications for the Mzimvubu Water Project economic modelling

From the above changes to the raw water pricing strategy, one can see a number of salient points that must be taken into account:

- It is most likely that the benefits of the additional income DWS will generate through the FIBC, BMC and other charges will *not* be realised in time for the project, and loan/grant funding will need to be sourced.
- With the socio-economic status of the people in the project area primarily being indigent, the users will benefit from the way the BWC will be structured, as rural municipalities will most likely only be expected to pay 25% of the charge. This reduction in cost should allow for better sustainability of the WSAs. The funding gap between the BWC and the full cost of providing the water will be subsidised by national grants such as the Equitable Share. The FIBC will need to be paid by the WSAs for all water use above that allocated for basic needs. This highlights the importance of the metering and control of water use to ensure that all water above basic needs is paid for by users.
- The agricultural users that are envisioned to benefit from the new infrastructure, will not be required to pay water use charges for the first 5 years after registration of water use, but thereafter they will be liable in increasing percentage until at year 10 they will be required to cover the full charges as per their registered water use. If it is deemed necessary for some or all of the users to receive subsidies beyond this period, this will need to be resolved by the Department of Agriculture, Forestry and Fisheries.
- If ownership of the hydropower plant resides outside of the DWS, it will be subject to a per kW “water use” charge.

A summary of planned raw water charges for the various water use categories is given in Table 6-5.

6.7 Recommendations

A clear understanding by the implementing entity of current mandates and accordingly roles and responsibilities within the project will be fundamental. It will thus be important to avoid interposing structures or creating entities to undertake roles and responsibilities that are already supposed to be undertaken by existing entities. As a part of the sectoral co-ordination process, terms of reference will need to be provided to each entity or structure that will be involved in the implementation and operation of the scheme.

The role of the Presidential Infrastructure Co-ordinating Commission (PICC) and the impact of the Infrastructure Development Act will need to be taken into consideration, as this may provide for existing inter-governmental platforms being replaced with new approaches. It is assumed that the PICC will continue to co-ordinate the planning and management of the project, presumably through the TCTA, who have been mandated with this role under the SIP3 programme.

The issue of land use reform, expropriation and compensation will need special attention, in particular regarding the change of approach from subsistence farming to commercial farming in the particular areas identified in this study. Both DAFF and the Provincial DRDAR will need to play key roles in this process.

It is suggested that a “Regional Co-ordination Unit” be tasked with co-ordination of sectoral role players at a regional level. At present, the Eastern Cape Socio Economic Consultative Council (ECSECC) has been tasked to champion this project on behalf of the Integrated Wild Coast Development Forum, and it is through this organization that such Provincial co-ordination might best be channelled during implementation notwithstanding recognition of the role that the TCTA is still playing as regards SIP3 co-ordination.

DWS itself must license water use to achieve the broader socio-economic objectives. It currently still has a large role to play in motivation and instigation of the sourcing of grant funding to implement the scheme components prior to any other Special Purpose Vehicle (SPV) or similar body being appointed to manage this process.

In the medium to longer term, the overall scheme components design, construction and operation should be linked, and be managed by a special purpose vehicle/implementing agency, such as the TCTA or a new RWU, as this would have advantages from a risk management perspective. TCTA have undertaken this role very successfully on several large projects, including the Berg River Dam in Western Cape, and would be well qualified to undertake this role. They already have the experience and capabilities to source government grants, donor funding, and other project finance at very beneficial terms and conditions.

The primary and secondary bulk water distribution infrastructure should ideally be operated as a primary function of a water board, and in this case, Amatola Water would be the logical and capable candidate to undertake this role.

The tertiary bulk water supply reticulation currently falls under the function of WSAs. Whilst this can continue, with those WSAs purchasing treated water in bulk from the operator of the primary and secondary system, consideration might be made to instigate a “wall-to-wall” Regional Water Utility that would include the current responsibilities of the WSAs.

In addition to the provision of capital funding for the raw water bulk delivery scheme to the identified irrigation areas, emerging farmers must also be supported directly in the form of advice, training, and possibly financial assistance, on which the Provincial DRDAR will again need to play a key role

It is recommended that the hydropower component be operated within the same ring-fenced conjunctive scheme as the potable and raw bulk water supply components, so that the financing, operation, maintenance and management, and cashflows can be integrated to maximize the economic and social benefits of this region.

This would require the appointment of a specialist service provider with the skills and capacity to manage, operate and maintain the hydropower plant and associated works.

One other option that could be considered would be to invite interest in suitable IPP investors to bring partial equity into the financing equation (i.e. a PPP arrangement), although this might not be attractive to such IPPs due to a limited internal rate of return.

Table 6-5: Summary of the Planned Raw Water Charges per Water Use Category

WATER USE CATEGORY	WATER RESOURCE MANAGEMENT CHARGES	INFRASTRUCTURE RELATED CHARGES	WASTE DISCHARGE CHARGES	PHASING IN OF CHARGES
Municipal and Industrial	Full cost recovery on abstraction and waste discharge related costs	On-budget GWS: Depreciation; FIBC, O&M Off-budget GWS: CUC, Refurbishment, and O&M; and FIBC post payment of loans;	Full costs of mitigation charge	WRM charges in place Waste discharge charges to be implemented after registration of waste users as per catchment specific plans
High Assurance Use	Full cost recovery on abstraction and waste discharge related costs	On-budget GWS: Depreciation; FIBC, O&M Off-budget GWS: CUC, Refurbishment, and O&M; and FIBC post payment of loans;	Full costs of mitigation charge.	WRM charges in place Waste discharge charges to be implemented after registration of waste users as per catchment specific plans
Stream Flow Reduction Activities: Commercial growers	Excludes cost of Dam Safety Control and waste discharge management	N/A	N/A	N/A
Stream Flow Reduction Activities: Resource poor growers	Excludes cost of Dam Safety Control and waste discharge management; Waived for first 5 years after registration and phased in over the five year period that follows. Subsidy starts at 100% for five years, then reduces by 20% annually.	N/A	N/A	No charge for forest plantations ≤ 10 hectares. WRMC Phased in over ten years

WATER USE CATEGORY	WATER RESOURCE MANAGEMENT CHARGES	INFRASTRUCTURE RELATED CHARGES	WASTE DISCHARGE CHARGES	PHASING IN OF CHARGES
Irrigation: Commercial farmers	Full recovery of allocated costs	GWS: Full recovery of Depreciation plus O&M on existing schemes. FIBC phased in over 5 years. Full financial cost recovery for new schemes. Targeted subsidies to be provided as determined by DAFF and National Treasury	N/A	FIBC to be phased in over 10 years
Irrigation: Resource poor farmers	Waived for first 5 years after registration and phased in over the five year period that follows. Subsidy starts at 100% for five years, then reduces by 20% annually.	GWS: FIBC, O&M and Depreciation charges waived for a 5 year period and phased in over the year period that follows on existing and new schemes. Subsidy starts at 100% for five years, then reduces by 20% annually. Capital subsidies available under certain conditions. Targeted subsidies to be provided by DWS for water resources infrastructure or purchase of water allocations.		Consumptive charges Subsidised for 10 years from date of registration. Subsidy starts at 100% for five years, then reduces by 20% annually. WRMC: Phased in over 10 years
Hydropower		Fixed charge in installed capacity and variable charge per kilowatt hour		All charges immediate on registration or authorization of water use

The institutional and financial flow diagram in Figure 6-4 assumes the overall management of the conjunctive scheme by a Special Purpose Vehicle (SPV) such as the TCTA, and shows the various organisations involved in the scheme, the flow of revenue from energy and bulk water sales, financing arrangements, and operational roles and responsibilities should the recommended model be adopted.

The PICC, Inter-Ministerial Committee (IMC) and three key departments (Department of Energy (DoE), DWS and DAFF) all play an important role in oversight and regulation - ensuring that the project is planned, constructed and managed to the standards required in national legislation, and fulfils the agreed regional priorities for economic growth and social upliftment. Co-ordination and co-operation at this senior level is essential if the project is to be successful.

The SPV is central to the project, playing a hands-on oversight and co-ordination role, is responsible for contractual management of the services providers, and a regional co-ordination role with all the relevant stakeholders in the Eastern Cape.

Importantly, the SPV is also responsible for initiating and managing the financing of the project, and the repayment of any loans/grants as required. This critical planning aspect of the project will be a determining factor for the finalization of institutional and contractual arrangements. Due to the nature of the role that this SPV needs to play right from the initiation of project design, it is imperative that the appointment of such an organization to fulfil this role is done as a matter of urgency.

The financing and implementation of all the capital components of the conjunctive scheme (but not the tertiary systems, which would be the responsibility of the WSPs/DMs) would fall under the SPV.

Once the scheme has been implemented and commissioned, the operating costs of the SPV will be covered through the net income generated from the energy sold into the ESKOM grid. The TCTA is an already established organization that specializes in these functions and would be a clear front-runner in the choice of an SPV company.

One option would be that ESKOM would purchase the power generated by the two hydropower schemes, and all the income from these sales will be paid to the SPV. In turn, ESKOM would invoice all energy costs for the entire project to the SPV (and not the water supply scheme operators). However, ESKOM only allow this on the basis of crediting existing user accounts, and the surplus generated would not be made available to the SPV in the form of cash payment.

A preferred solution would be that Amatola Green Power purchase the energy produced by the hydropower plants in cash and recoup their purchase cost in the form of sales of green energy certificates (see the Legal, Institutional and Financing Arrangements Report No. P WMA 12/T30/00/5212/16).

In turn, ESKOM would invoice the SVP for all energy consumed by the project (and not the water supply operators).

Apart from its own operational costs, the SPV could also appoint an outsourced hydropower scheme operator to operate and maintain the Ntabelanga-Lalini conjunctive hydropower scheme, which costs would also be borne by the SPV from its net surplus energy income. It is also possible that, through recruitment of suitably qualified and skilled staff and training of others, the hydropower operations could be undertaken in-house by the dam and bulk water supply operator.

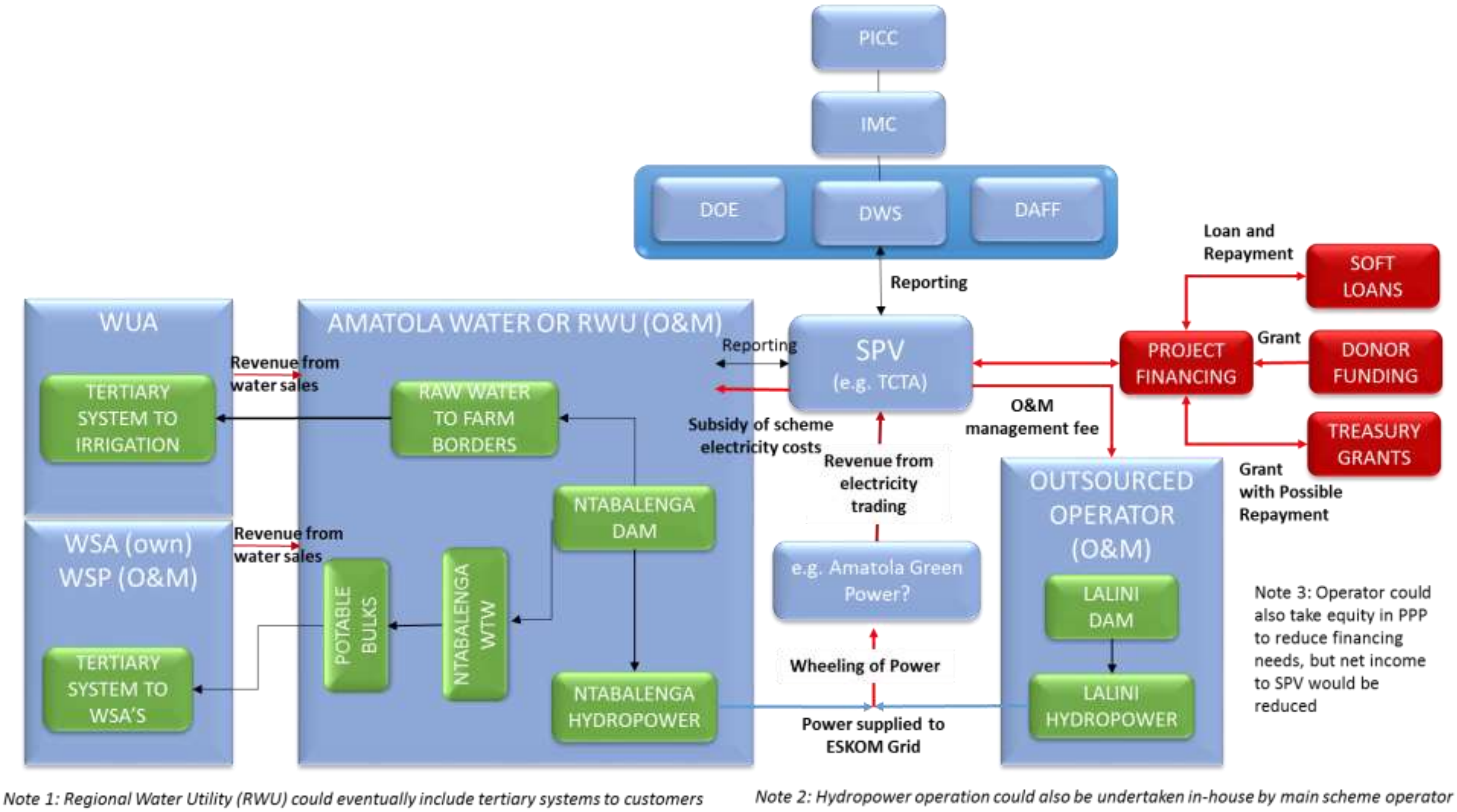


Figure 6-4: Institutional Roles and Responsibilities and Financial Flow Diagram

The power production could be purely a contracted operation and maintenance service, in which case the capital funding would be funded entirely through the finance raised by the SPV. Alternatively, this finance could be partly provided by the operator via a PPP arrangement, although the financing models indicate that any repayable finance above 25% of capital cost would nullify the surplus revenue benefits accruing to cross-subsidize the overall conjunctive scheme. Thus, the difference will be that the PPP option would offer less opportunity to cross-subsidize the energy costs of the water supply scheme components, but this would on the other hand require less grant funding.

The main purpose of the hydropower components of the scheme are therefore to generate sufficient surplus income to finance the SPV operation, to repay loans or even grant funding, and to subsidize the power cost for the production and delivery of bulk raw and potable water.

As is shown on the economic and financial modelling the degree of capital grant funding required will mostly depend upon the affordability cost of water supplied to irrigation and potable water users, and the financial sustainability that this brings to the water supply operator's business.

The Ntabelanga dam and associated water supply scheme would be funded by the finance sourced through the SPV, but would need to be managed and operated by a regional water utility – at present a function fulfilled by Amatola Water. If they continued to be the operator, Amatola Water would need to cover its operation and maintenance costs through the revenue generated from water sales. Their overall costs of water provision would be significantly reduced due to the subsidized provision of electricity (possibly up to 100% subsidy).

The same operator would also be required to operate the Ntabelanga hydropower plant as well as the delivery of bulk raw water to the new farming units.

A Water User Association (WUA) would represent these new farmers, and they, and the WSAs/DMs would have to pay the operator – e.g. Amatola Water - for the bulk water provided. These organisations will need to ensure that they collect sufficient revenue to cover these bulk water purchases as the operator will rely solely on this income to cover the cost of the operation and maintenance.

Thus the benefit from the surplus energy income will be passed down the value chain to these end users, as the water supply operator will have very low or no energy costs to incorporate into their bulk water charge, thus keeping the bulk water tariff significantly lower.

Cognisance must be taken that whilst the bulk potable water supply scheme would likely proceed with very high priority, and would be commissioned within a similar timescale to the other major scheme components, the same might not be the case for the irrigation scheme.

In this latter case, a significantly sensitive and lengthy process will be required to deal with the land reform issues, and to identify and establish new emerging commercial farmers. This process could have many pitfalls along the way, and it is still a possibility that the irrigated agriculture component of the project would either not be realized at all, or would take much longer to come to the commissioning stage.

Should this happen, in addition to the lower job creation potential, the downside would be that the water supply operator would not receive the revenue from these bulk raw water supply sales. On the upside, the water supply operator would not incur the costs of operating and maintaining these particular components.

The upside would be further enhanced in that the significant finance required to construct the irrigation components would not be needed, and the energy demand of the raw water pumping would also be less, which would in turn increase the net revenue to the scheme from energy sales. This in turn would increase the amount of subsidy available to improve the sustainability of the potable water supply component and/or could also produce surplus income to repay loans and even grants. The resulting benefits would be that the bulk water supply operator would be able to viably deliver water at a lower bulk water tariff, and the cost of water delivered to the communities would be reduced.

Another matter to consider is that in order to receive the benefits and surplus revenue from the hydropower components, these should also be ready for commissioning as soon as possible so that the cross-subsidies thus produced are available as soon as possible. If not, then some other “bridging” arrangements might be required to fill this subsidization gap.

Local content of goods and services provided to implement and operate the conjunctive scheme should be maximized to prevent leakage of such economic and employment benefits to other parts of the country, or even abroad. This will maximize the intended upliftment benefits of the project on this region.

6.8 The Way Forward

Budgets for further engineering, facilitation and other studies have been allowed for in the cost estimates, but these activities will need to be urgently initiated, managed and implemented, in a co-ordinated manner.

This will require the co-ordination, planning and management entity to delegate responsibility for this to a dedicated Project Implementation Unit, who themselves will need to co-ordinate with all of the other sectoral roleplayers.

Future activities that will need to be undertaken include, inter alia:

- ✓ *Appointment of an Implementing Agent/SPV to co-ordinate, plan and manage the integrated scheme components.*
- ✓ *Implementation of the EMPR for the works to be constructed, and appointment of service providers to manage and monitor these processes.*
- ✓ *Preparation and implementation of the Relocation Action Plan based upon the Relocation Policy Framework prepared during the EIA process.*
- ✓ *Coordination with the Catchment Restoration and Management Programme – spearheaded by the Department of Environmental Affairs.*
- ✓ *Discussions with DoE, ESKOM and Amatola Green Power regarding the establishment of the principles, terms and conditions and the subsequent application for the establishment of a “wheeling” arrangement for the power produced by the Ntabelanga and Lalini hydropower schemes.*
- ✓ *Applications to ESKOM for power supplies to the works.*
- ✓ *Discussions and agreement with Amatola Water and the three affected DMs, DAFF, and the Eastern Cape Department of Rural Development and Agrarian Reform regarding future institutional arrangements for the ownership, funding, operation and management of the water supplies sourced from the Ntabelanga Dam.*

- ✓ *Additional geotechnical investigations to inform the design of the Ntabelanga Dam, the Lalini Dam, the other associated capital works, and hydropower components.*
- ✓ *Detailed design and tender documents of Ntabelanga Dam and appurtenant works.*
- ✓ *Detailed design and tender documents of the Ntabelanga water treatment works, primary and secondary potable water distribution systems, and bulk raw water distribution system.*
- ✓ *Detailed design and tender documents of other works.*
- ✓ *Detailed design and tender documents of Lalini Dam and appurtenant hydropower works.*
- ✓ *Appointment of a facilitation unit to manage the consultation and implementation process for land reform and irrigation development.*
- ✓ *Development of a Sustainable Water Utilization Plan that should, inter alia, spell out potential tourism and aquaculture spinoffs from the scheme.*
- ✓ *Appointment of a facilitation unit to provide advice, training and financial assistance to new emerging farmers who would be investing in the new irrigated farm units.*
- ✓ *Procurement and appointment of contractors to construct the capital works – several different contracts.*
- ✓ *Procurement and appointment of Construction Administration and Supervision service providers – several different contracts.*

The above list covers the currently envisaged main activities, and others may arise as the implementation process proceeds.

The complexities surrounding the set up and management of a multi-purpose scheme should not be under estimated. Lessons from previous projects across Africa should be taken to heart, and robust, yet flexible legal, institutional and financial arrangements need to be put in place to maximise the resilience and sustainability of the project into the future.

7. PROJECT COSTS

7.1 Ntabelanga Dam Capital Costs

The cost estimate for the Ntabelanga Dam and its associated infrastructure, water supply and irrigation schemes, land care programme, and in-field development of irrigated farming units, is given in Table 7-1.

This does not include any of the Lalini Dam and hydropower scheme infrastructure which is dealt with in a separate Report No P WMA 12/T30/00/5212/19. This dam is, however, sized to provide adequate flow releases downstream when operating conjunctively with the Lalini Hydropower scheme component.

Table 7-1: Ntabelanga Dam Capital Cost Estimates

NTABELANGA DAM	R'million
Ntabelanga dam and associated works	1 075
Ntabelanga dam hydropower works	88
Ntabelanga land compensation/mitigation costs	18
Ntabelanga power transmission	29
Sub-Total Ntabelanga Dam and Associated Works	*1 209*
Engineering and EMP Costs (12%)	*145*
Sub-Total Ntabelanga Dam and Associated Works incl Eng & EMP	*1 354*
Escalation in Each Year @ 5.5% p.a.	*265*
Sub-Total Ntabelanga Dam and Associated Works incl Eng, EMP & ESC	*1 619*
VAT (14%)	227
Add in R22 million per year over 10 years for catchment management (no esc)	220
Allowance for other offset activities (50% of R100 million)	50
Total Ntabelanga Dam and Associated Works (incl Esc + VAT)	**2 116**
NTABELANGA BULK DISTRIBUTION	
Ntabelanga water treatment works	643
Ntabelanga primary & secondary bulk treated water distribution system	1 234
Ntabelanga tertiary bulk treated water distribution system (DM's)	1 425
Ntabelanga bulk irrigation water supply system	497
Sub-Total Ntabelanga WTW and Bulk Water Systems	*3 799*
Engineering and EMP Costs (12%)	*456*
Sub-Total Ntabelanga WTW and Bulk Water Systems incl Eng & EMP	*4 255*
Escalation in Each Year @ 5.5% p.a.	*1 067*
Sub-Total Ntabelanga WTW and Bulk Water Systems incl Eng, EMP & ESC	*5 322*
VAT (14%)	745
Total Ntabelanga WTW and Bulk Water Systems (incl Esc + VAT)	**6 068**

…. (cont.)

Table 7-1: Capital Cost Estimates (cont.)

ON-FARM DEVELOPMENTS	
On-farm irrigation investment costs	**105**
Engineering and EMP Costs (12%)	*13*
Sub-Total in-farm irrigation investment costs incl Eng & EMP	*118*
Escalation in Each Year @ 5.5% p.a.	*40*
Sub-Total in-farm irrigation investment costs incl Eng, EMP & ESC	*158*
VAT (14%)	22
Total in-farm irrigation investment costs (incl Esc + VAT)	**180**
GRAND TOTAL NTABELANGA (R'MILLION INCL ESC AND VAT)	**8 364**

More detailed costing breakdowns and cashflow projections for each individual project component are given in Report No. P WMA 12/T30/00/5212/15.

It should be noted that there are several risks involved in the accuracy of the above cost estimate:

- Estimating at feasibility level at best has a confidence level of ± 10%
- Escalation rates could increase or decrease, especially given the currently volatile nature of the economy;
- Rand foreign exchange rates are also volatile and this will affect the cost of all imported materials, services and equipment;
- The timing of the various components implementation may change which, if later, would increase the escalation cost; and
- The amount of non-grant finance is unknown, and if significant will increase costs, depending on the terms of such loans, interest rates and foreign exchange rates.

One example of the impact of the above risks is that every month's delay in fully implementing a R8.4 billion project increases escalation cost by R38.5 million (at 5.5% p.a.).

7.2 Estimated Operation and Maintenance Costs

Operation and maintenance costs will to some extent depend upon the institutional arrangements set up to operate the scheme, and the structures and management costs of the one or more entities involved. Economies of scale can be lost if the management and operation of the works is split between several different organisations. An estimate has been made of the likely management, maintenance and operational costs of these works based upon current costs and salary scales.

Maintenance costs per annum are based upon the percentages of capital cost recommended in DWS's Water Supply Planning and Design Guidelines. Operational staffing costs have be sourced from those currently applied to similar works operated by Amatola Water.

Energy costs (mainly for pumping) are based upon a current average tariff per kWh using ESKOM's Ruraflex tariff, and assuming that pumping would be restricted to non-peak hours (i.e. up to 20 hours pumping per day). This is the current tariff used for pumping by Amatola Water in this region.

Table 7-2 summarizes these annual operating and maintenance costs, but these should be treated with caution pending decisions being made on the eventual institutional arrangements.

7.3 Project Financing Options

Given the results of the economic analyses, that this is a Strategic Infrastructure Project, and that the majority of beneficiaries are in the indigent category, it is clear that significant grant subsidization funding of the project will be required. This would cover the main capital works, but may also need to include financial assistance to the prospective investors in the proposed commercial farming units.

The Department of Water and Sanitation is currently undertaking a project to *Revise the Pricing Strategy for Water Use Charges and Develop a Funding Model for Water Infrastructure Development and Water Use and a Model for the Establishment of an Economic Regulator.*

The funding model envisioned in the above study is one that must focus on the mechanisms and sources to access capital required to develop proposed infrastructure as well as the income required to repay this capital. The final product will be a cost accumulation model that can assess the financial implications of alternative funding options to meet demand.

According to the deliverable "Financial Model User Manual" (March 2013):
"A key function of the model is to determine the impact of a new scheme on:

- *The tariffs to be charged (split between Irrigation and Domestic & Industrial) and as determined by the Pricing Strategy,*
- *The grant funding required (determined by policy considerations relating to social versus economic infrastructure), and resulting from any short-fall on tariffs, and*
- *The projected cash flows over twenty years, demonstrating debt utilisation and distinguishing between capital, operating and debt repayment flows. The cash-flow should also distinguish between sources of revenue (tariffs, up-front payment from users, loans and grants).*

The following inputs are required by the model to generate the above outputs:

- *The projected capital costs (including timing of cash flows)*
- *Operations and maintenance costs (for twenty years)*
- *Cost of capital (Weighted Average Cost of Capital – WACC)*
- *Expected growth rates in utilisation of water supplied by the scheme (Year 1 usage plus expected growth rate thereafter). The volume utilised will need to be split per Scheme Management Parameters (SMP) and per irrigation, domestic and industrial usage. As a default, the existing system ratio will be applied to the new scheme.*
- *Available funding. As a default the model will assume that no grant funding is available. However if it is indicated that a percentage of the scheme is for social users who cannot afford to pay, then this percentage of the capital costs should be indicated as a grant requirement, with the remaining balance allocated to the tariff calculation. The model can also incorporate the input of a maximum tariff. An output generated will then be the grant funding required to make the project sustainable".*

The financial implications of various institutional arrangement options are given in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15, and the Legal, Institutional and Financing Arrangements Report No. P WMA 12/T30/00/5212/16.

Table 7-2: Annual Management, Operation, and Maintenance Cost Estimate (2014 Price Levels)

COMPONENT	ANNUAL MAINTENANCE COSTS (R'MILLION)	ANNUAL OPS STAFFING COSTS (R'MILLION)	POWER COSTS/ANNUM (R'MILLION)		TREATMENT COSTS/ANNUM (R'MILLION)
			ON COMMISSIONING	BY 2050	
NTABELANGA DAM + MINI HYDRO + ASSOCIATED INFRASTRUCTURE	8	4.2	3	3	
NTABELANGA WTW AND POTABLE BULK WATER SYSTEM (PRIMARY ONLY)	20.1	12.3	36	48.9	7.7
NTABELANGA POTABLE BULK WATER SYSTEM (SECONDARY)	9	4.1	2.5	3	
NTABELANGA POTABLE BULK WATER SYSTEM (TERTIARY)	12	11.6	1.5	2	
NTABELANGA IRRIGATION SYSTEM (DELIVERY TO EDGE OF FIELDS)	5.3	2.5	18.6	18.6	
TOTAL R'MILLION PER ANNUM	**54.4**	**34.7**	**61.6**	**75.5**	**7.7**

8. PROJECT IMPLEMENTATION PROGRAMME

The current implementation programme is given in Appendix C. This will be regularly reviewed and updated by DWS as the implementation of the project proceeds.

It should be noted that:

a) the current project implementation programme is regarded as the shortest time for project implementation,
b) the programme assumes sufficient funding is available to implement all components simultaneously, which will result in high cash flow,
c) the project programme would be extended if the Decision Support phase takes longer to implement due to sourcing of funding, institutional arrangements, etc., and
d) the programme could also be extended to reduce the peak cash flow.

APPENDIX A

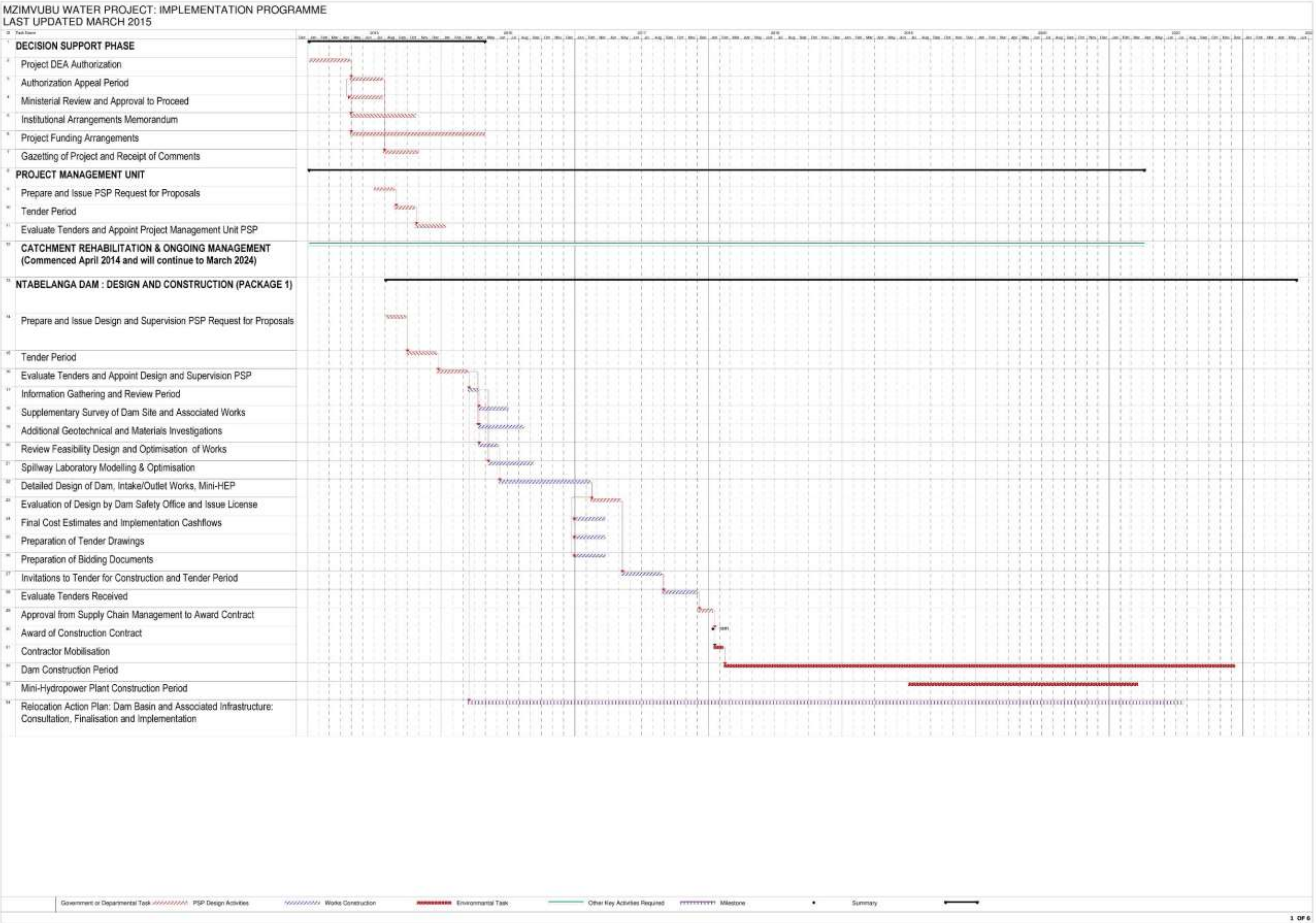
MINISTERIAL PROJECT APPROVAL

APPENDIX B

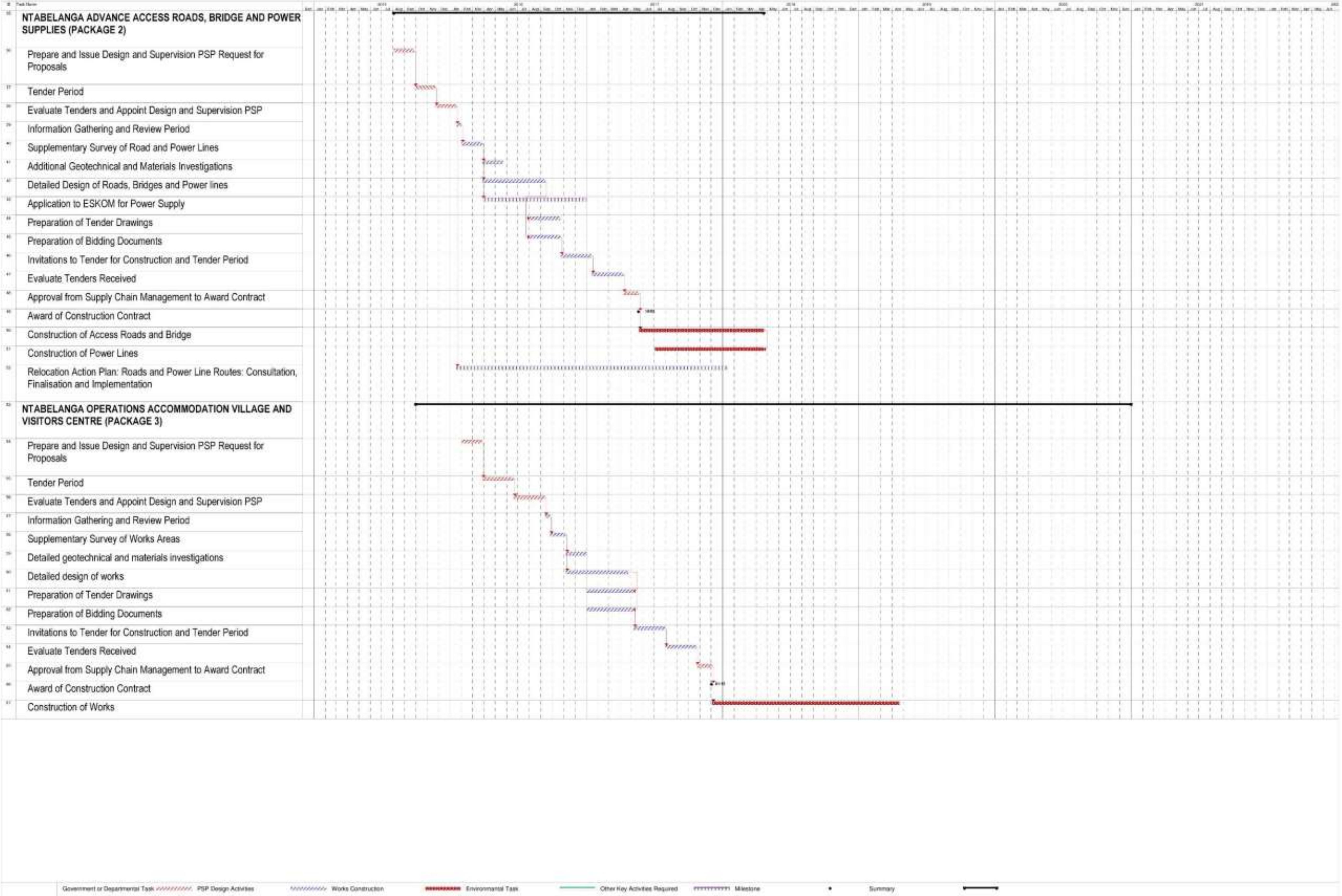
ENVIRONMENTAL AUTHORIZATIONS

APPENDIX C

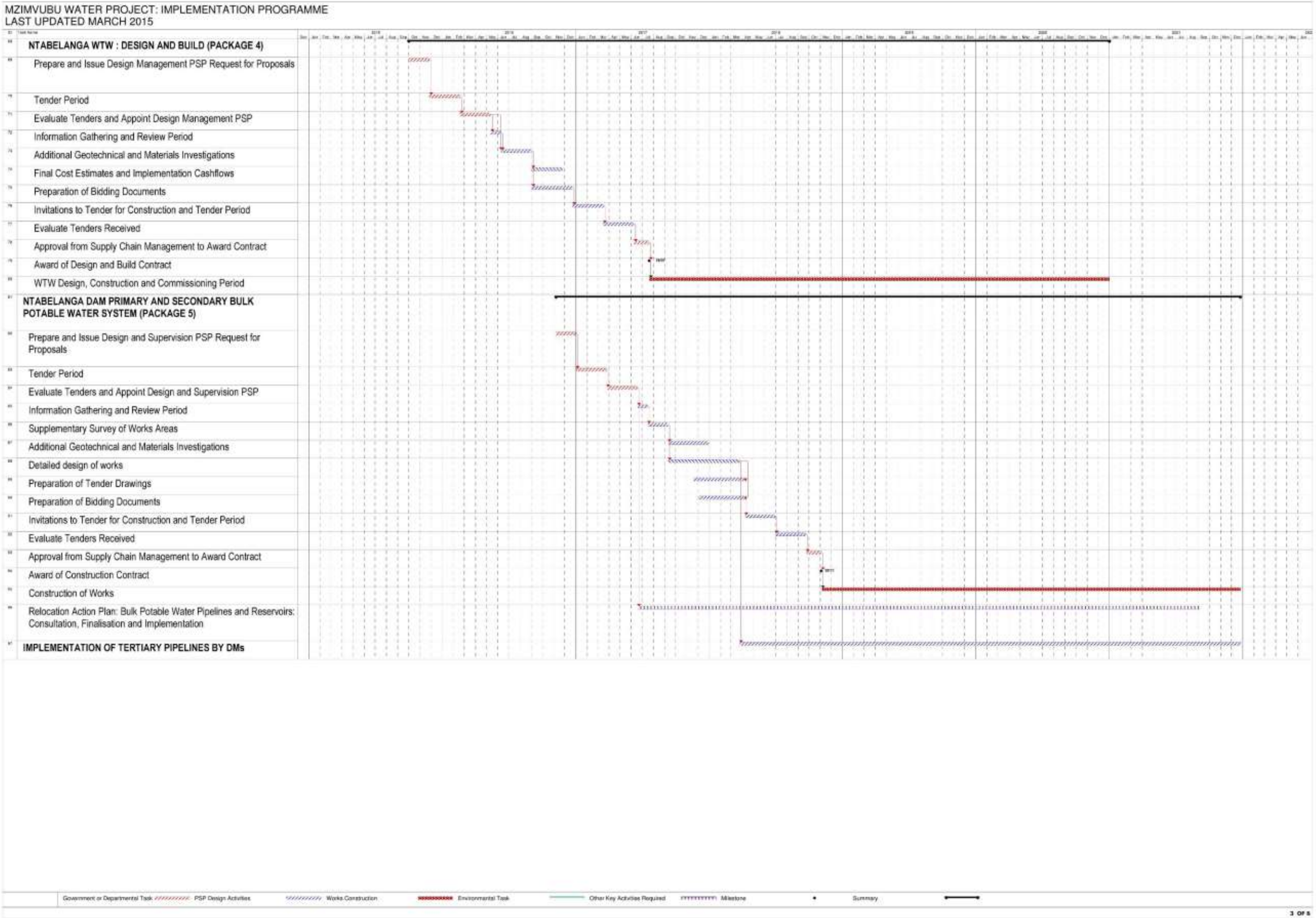
DRAFT IMPLEMENTATION PROGRAMME


MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015
DECISION SUPPORT PHASE
Project DEA Authorization
Authorization Appeal Period
Ministerial Review and Approval to Proceed
Institutional Arrangements Memorandum
Project Funding Arrangements
Gazetting of Project and Receipt of Comments
PROJECT MANAGEMENT UNIT
Prepare and Issue PSP Request for Proposals
Tender Period
Evaluate Tenders and Appoint Project Management Unit PSP
CATCHMENT REHABILITATION & ONGOING MANAGEMENT (Commenced April 2014 and will continue to March 2024)
NTABELANGA DAM : DESIGN AND CONSTRUCTION (PACKAGE 1)
Prepare and Issue Design and Supervision PSP Request for Proposals
Tender Period
Evaluate Tenders and Appoint Design and Supervision PSP
Information Gathering and Review Period
Supplementary Survey of Dam Site and Associated Works
Additional Geotechnical and Materials Investigations
Review Feasibility Design and Optimisation of Works
Spillway Laboratory Modelling & Optimisation
Detailed Design of Dam, Intake/Outlet Works, Mini-HEP
Evaluation of Design by Dam Safety Office and Issue License
Final Cost Estimates and Implementation Cashflows
Preparation of Tender Drawings
Preparation of Bidding Documents
Invitations to Tender for Construction and Tender Period
Evaluate Tenders Received
Approval from Supply Chain Management to Award Contract
Award of Construction Contract
Contractor Mobilisation
Dam Construction Period
Mini-Hydropower Plant Construction Period
Relocation Action Plan: Dam Basin and Associated Infrastructure: Consultation, Finalisation and Implementation
Government or Departmental Task
PSP Design Activities
Works Construction
Environmental Task
Other Key Activities Required
Milestone
Summary
1 OF 6

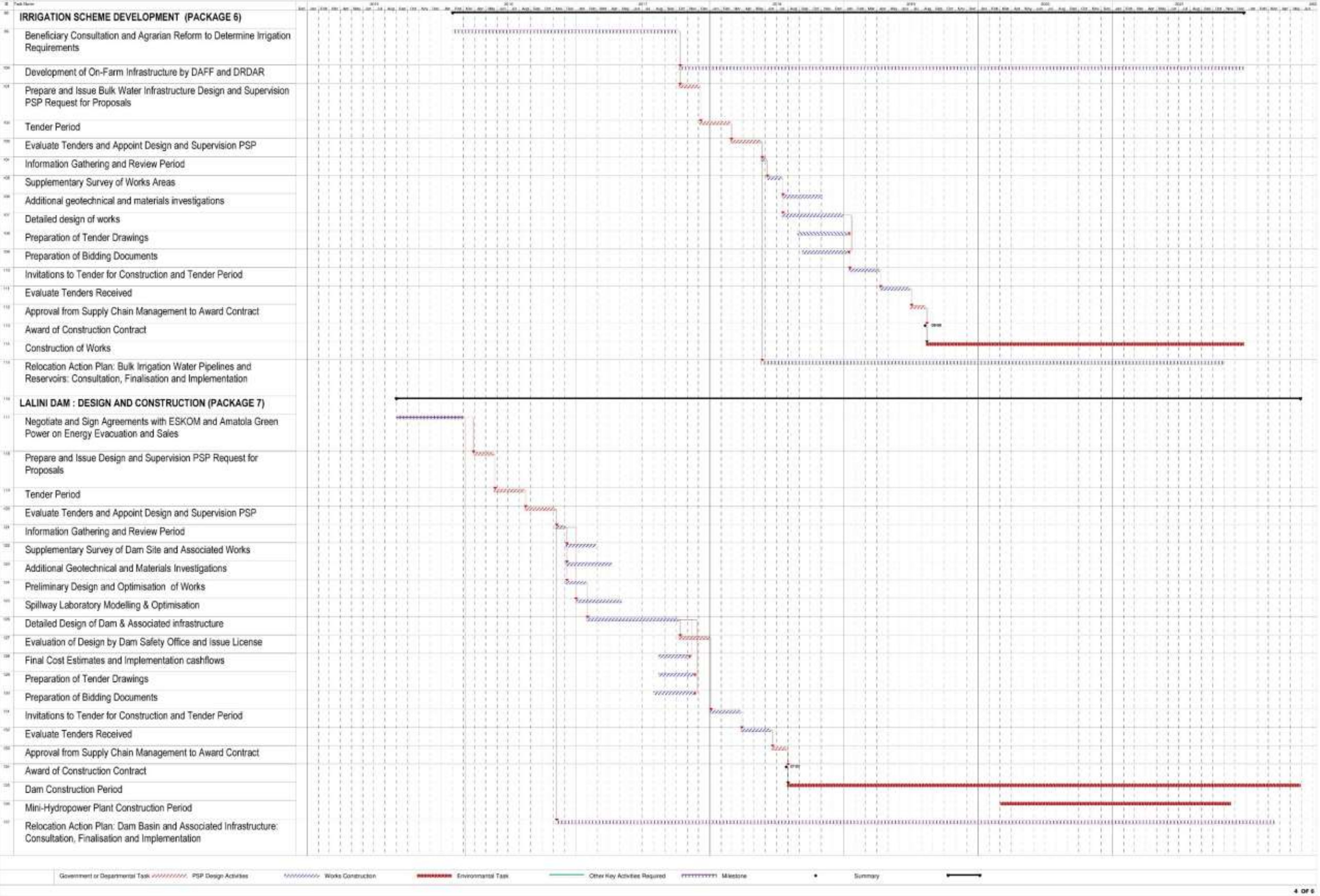
MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015



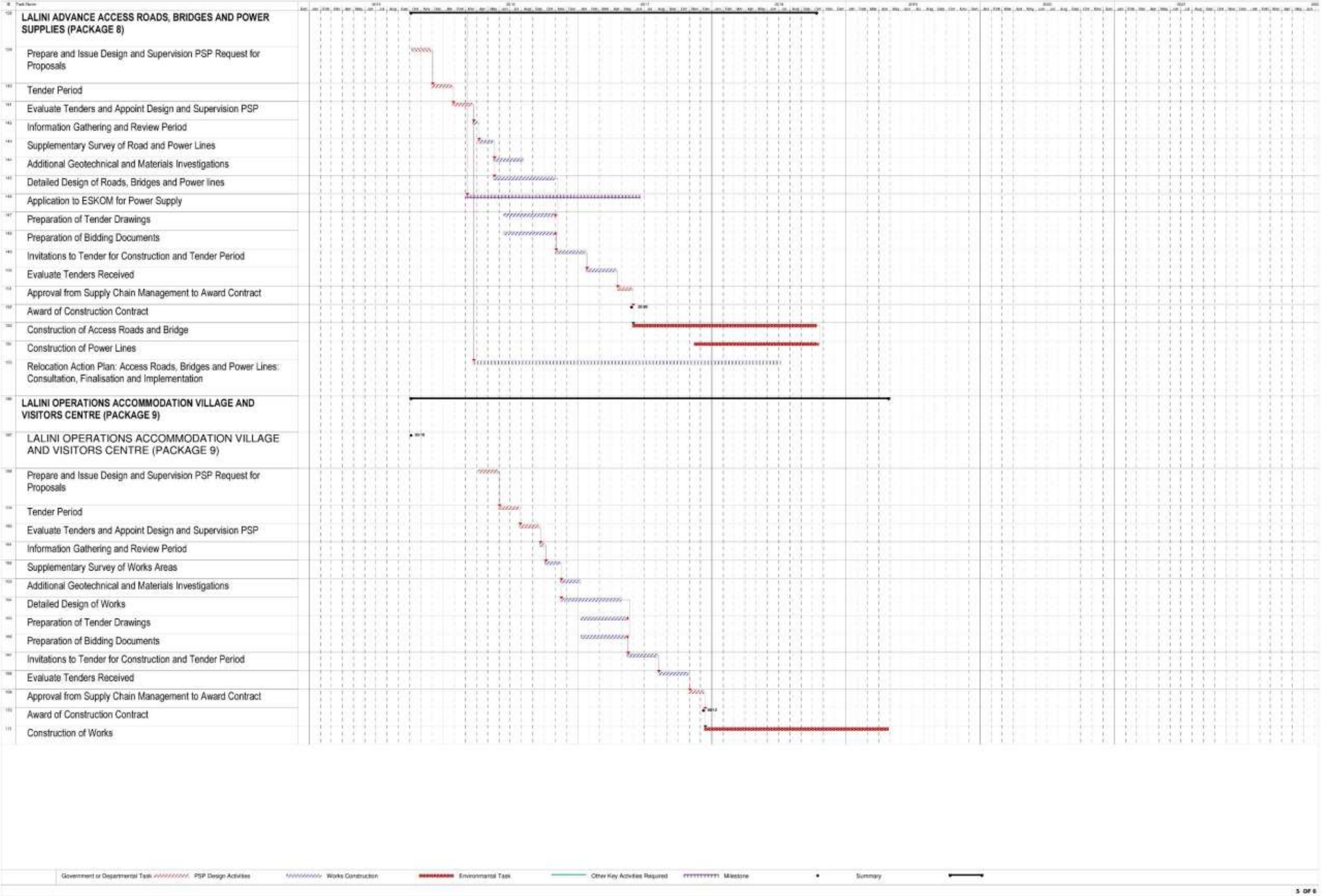
2 OF 6


MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015
NTABELANGA WTW : DESIGN AND BUILD (PACKAGE 4)
Prepare and Issue Design Management PSP Request for Proposals
Tender Period
Evaluate Tenders and Appoint Design Management PSP
Information Gathering and Review Period
Additional Geotechnical and Materials Investigations
Final Cost Estimates and Implementation Cashflows
Preparation of Bidding Documents
Invitations to Tender for Construction and Tender Period
Evaluate Tenders Received
Approval from Supply Chain Management to Award Contract
Award of Design and Build Contract
WTW Design, Construction and Commissioning Period
NTABELANGA DAM PRIMARY AND SECONDARY BULK POTABLE WATER SYSTEM (PACKAGE 5)
Prepare and Issue Design and Supervision PSP Request for Proposals
Tender Period
Evaluate Tenders and Appoint Design and Supervision PSP
Information Gathering and Review Period
Supplementary Survey of Works Areas
Additional Geotechnical and Materials Investigations
Detailed design of works
Preparation of Tender Drawings
Preparation of Bidding Documents
Invitations to Tender for Construction and Tender Period
Evaluate Tenders Received
Approval from Supply Chain Management to Award Contract
Award of Construction Contract
Construction of Works
Relocation Action Plan: Bulk Potable Water Pipelines and Reservoirs: Consultation, Finalisation and Implementation
IMPLEMENTATION OF TERTIARY PIPELINES BY DMs
Government or Departmental Task
PSP Design Activities
Works Construction
Environmental Task
Other Key Activities Required
Milestone
Summary

MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015



MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015



MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED MARCH 2015