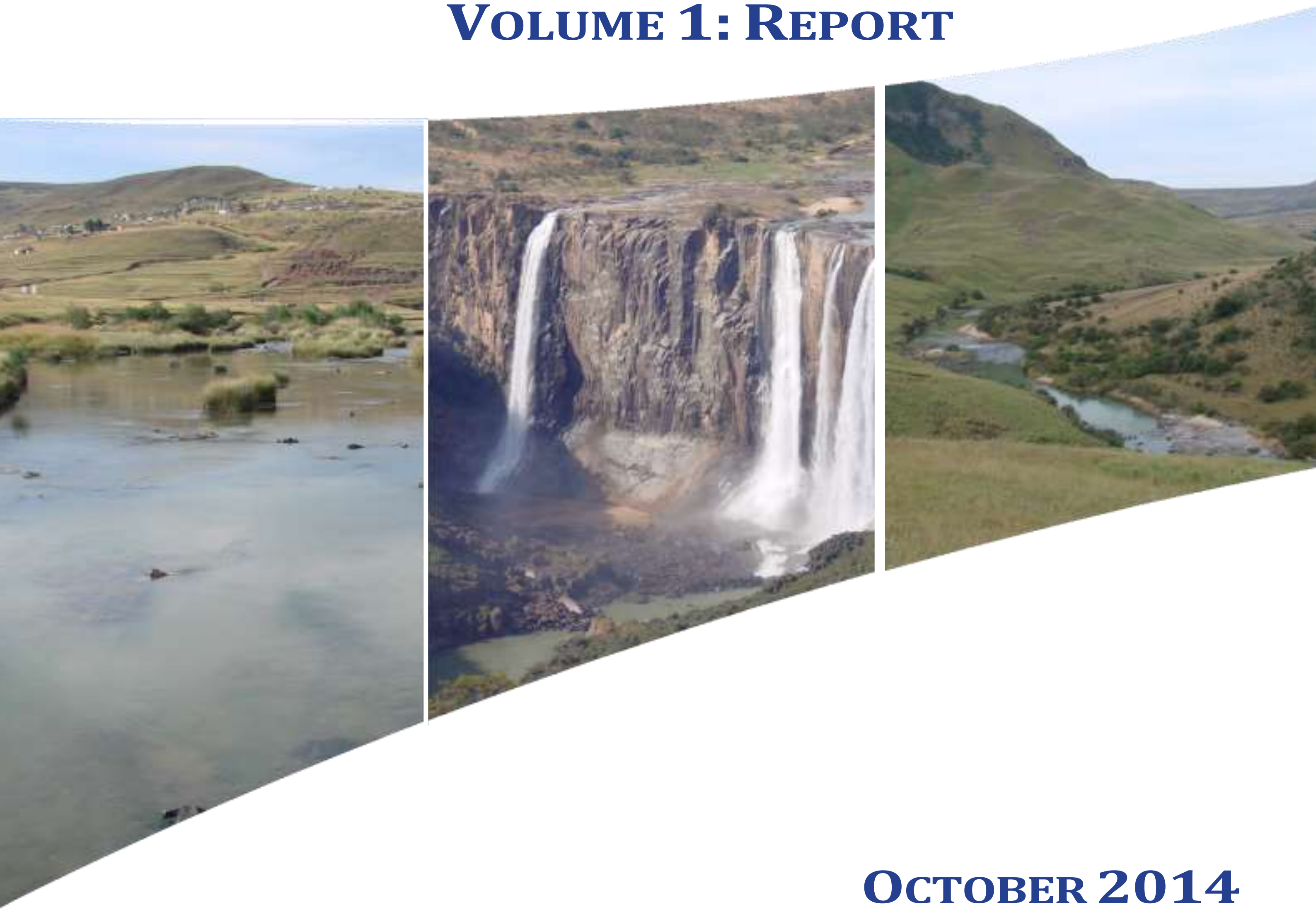
P WMA 12/T30/00/5212/4

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: OPTIONS ANALYSIS

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT

MAIN REPORT
VOLUME 1: REPORT



OCTOBER 2014

FEASIBILITY STUDY FOR THE MZIMVUBU WATER PROJECT APPROVAL

Report title:	***Main Report***
Authors:	*A Pepperell, S Johnson and other team members*
Project name:	***Feasibility Study for the Mzimvubu Water Project***
DWS Report Number:	*P WMA 12/T30/00/5212/4*
PSP project reference number:	*002819*
Status of report:	*Final*
First Issue:	*April 2014*
Second Issue:	*October 2014*
Final issue:	*October 2014*

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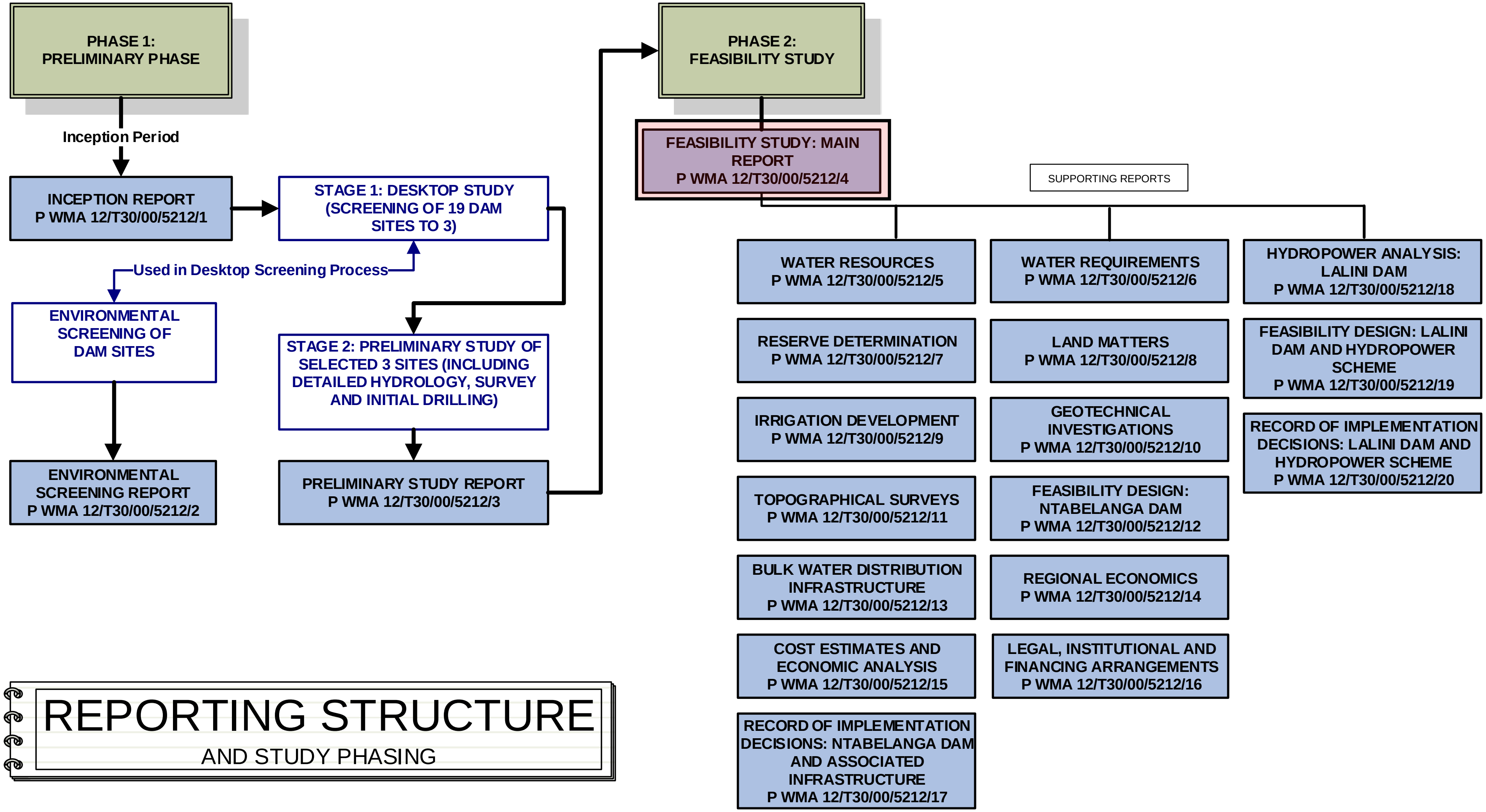
LIST OF REPORTS

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


PHASE 1:
PRELIMINARY PHASE
Inception Period
INCEPTION REPORT
P WMA 12/T30/00/5212/1
STAGE 1: DESKTOP STUDY (SCREENING OF 19 DAM SITES TO 3)
Used in Desktop Screening Process
ENVIRONMENTAL SCREENING OF DAM SITES
STAGE 2: PRELIMINARY STUDY OF SELECTED 3 SITES (INCLUDING DETAILED HYDROLOGY, SURVEY AND INITIAL DRILLING)
ENVIRONMENTAL SCREENING REPORT
P WMA 12/T30/00/5212/2
PRELIMINARY STUDY REPORT
P WMA 12/T30/00/5212/3
PHASE 2:
FEASIBILITY STUDY
FEASIBILITY STUDY: MAIN REPORT
P WMA 12/T30/00/5212/4
SUPPORTING REPORTS
WATER RESOURCES
P WMA 12/T30/00/5212/5
WATER REQUIREMENTS
P WMA 12/T30/00/5212/6
HYDROPOWER ANALYSIS: LALINI DAM
P WMA 12/T30/00/5212/18
RESERVE DETERMINATION
P WMA 12/T30/00/5212/7
LAND MATTERS
P WMA 12/T30/00/5212/8
FEASIBILITY DESIGN: LALINI DAM AND HYDROPOWER SCHEME
P WMA 12/T30/00/5212/19
IRRIGATION DEVELOPMENT
P WMA 12/T30/00/5212/9
GEOTECHNICAL INVESTIGATIONS
P WMA 12/T30/00/5212/10
RECORD OF IMPLEMENTATION DECISIONS: LALINI DAM AND HYDROPOWER SCHEME
P WMA 12/T30/00/5212/20
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
REPORTING STRUCTURE
AND STUDY PHASING

REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation South Africa (2014). ***Feasibility Study for the Mzimvubu Water Project: Main Report***

DWS Report No: P WMA 12/T30/00/5212/4

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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

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
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 Affairs
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
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
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
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
million m^3	Million cubic metres
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
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
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RWI	Regional Water Institution
RWU	Regional Water Utilities
SAWS	South African Weather Service
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
WEF	Water Energy Food
WRYM	Water Resources Yield Model
WSA	Water Services Authority
WSP	Water Services Provider
WTE	Water Trade Entity
WUA	Water User Association

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) or 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 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.

1.1 Study 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.

1.2 Study Programme

The 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.

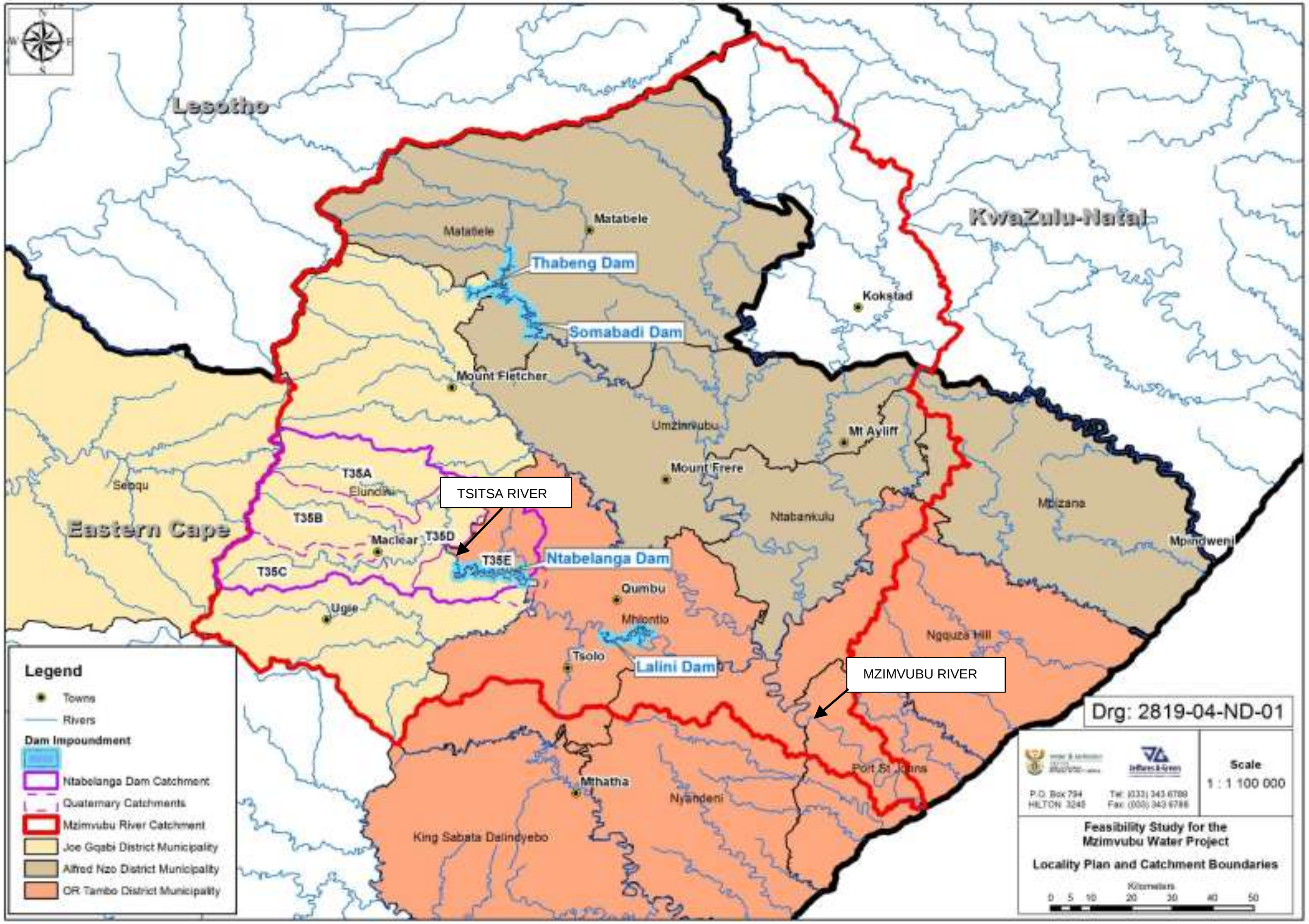


Figure 1-1: Location of Mzimvubu Catchment Area

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, and 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.

1.2.1 *Inception Phase*

The aim of the inception phase 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 (Report Number P WMA 12/T30/00/5212/1) which also constituted the final TOR for the study.

1.2.2 *Preliminary Study Phase*

The Preliminary Study Phase was divided into two stages:

(1) Desktop Study; and
(2) 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 dam development option to be taken forward into Phase 2 of the study.

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

- Stakeholder involvement;
- Environmental screening;
- Water requirements investigations;
- Hydrological investigations;
- Geotechnical investigations;
- Topographical survey investigations; and
- Selection process.

Several selection criteria were proposed to facilitate the selection of the three most suitable dam sites for further investigation. These criteria covered technical, economic, social and environmental considerations.

The criteria used are listed below:

- Technical and Economic Considerations
  a) Yield;
  b) Capital cost;
  c) Unit Reference Value (URV) of water produced;
  d) Accessibility;
  e) Hydropower potential (capex/MW);
  f) Sedimentation;
  g) Forestry potential;
- Environmental and Social Considerations
  a) Potential for irrigated agriculture;
  b) Potential for domestic water supply;
  c) Environmental impacts; and
  d) Job creation.

The potential for the proposed development options (dams) to provide water for inter-catchment transfers (i.e. augmentation of the Orange and Vaal River Systems) was considered. However the study entitled "Assessment of the Ultimate Potential Future Marginal Cost of Water Resources in South Africa, 2010", undertaken by DWA, clearly indicated that the use of water from the Mzimvubu River for this purpose is very expensive and highly unlikely. On this basis it was deemed pertinent to not include this as a selection criterion for the proposed development of a multi-purpose storage structure on the Mzimvubu River.

The above criteria were work-shopped at Project Steering Committee (PSC) and at regional stakeholder level, and values derived from previous reports and from additional desktop analyses were allocated to each of the 19 potential dam site developments to provide scored rankings of the development options.

These additional analyses included an Environmental Screening process for which the findings are provided in a separate DWS Report Number P WMA 12/T30/00/5212/2.

Following a further screening process to take into account, inter alia, strategic development issues along the coastal N2 corridor, and the potential usage of the Tsita River for hydropower development, it was determined and agreed that the highest ranked three dam sites would be taken forward for further investigation.

These were:

- Ntabelanga dam on the Tsitsa River (tributary of the main Mzimvubu River);
- Thabeng dam on the Kinira River (tributary of the main Mzimvubu River); and
- Somabadi dam on the Kinira River (tributary of the main Mzimvubu River).

Further comparison of the three dam sites was undertaken and this was complemented by additional information in the form of detailed hydrological analysis, topographical surveys of the dam sites and basins, and focussed geotechnical investigations at each of the dam sites to check for any potential fatal flaws.

Localities of these three dam sites are shown on Figure 1-1.

Additional multi-criteria decision analysis was then undertaken and discussed with the stakeholders, which significant criteria included:

i. Populations Served;
ii. Land Requirements;
iii. Irrigation Opportunities;
iv. Job Creation Opportunities;
v. Impacts on Existing Infrastructure;
vi. Other Regional Water Supply Schemes Existing or Planned; and
vii. Ability to Work Conjunctively with Other Major Schemes.

The analysis was undertaken for two water demand growth scenarios, namely a moderate growth rate, named the base case, and a high demand growth which supplied a greater population.

The "traffic light" colour coding method used in Tables 1-1 to 1-3 shows the simple ranking of the economic criteria that was undertaken between the three dams. No differential weighting was applied to these criteria as this requires qualitative rather than quantitive analysis to be undertaken, which might artificially skew results.

Table 1-1: Comparison of Dams by Numerical & Economics Analyses – Base Demand Case

BASE CASE CRITERIA			
Numbers and Economics	**Ntabelanga**	**Thabeng**	**Somabadi**
Population Served for this Scenario	**134 633**	**111 564**	**97 303**
Total Population within 50 km of Dam	**223 686**	**94 666**	**116 337**
Irrigatable Areas within Limits Set (ha)	**504**	**1062**	**1062**
Cost of Dam for Water Supply only (R'million)	**386**	**489**	**500**
Total Demand Supplied (million m³/a)	**7.83**	**9.19**	**8.59**
Total Water Available @ 98% (million m³/a) (minimum dam)	**26.80**	**24.80**	**21.32**
URV of Raw Water Supplied (no hydropower) (R/m³)	**6.79**	**8.58**	**7.34**
Is the above Dam Self-Sufficient for Hydropower?	**No**	**No**	**No**
Incremental cost of Raising Dam & Hydro-Plant (R'million)	**219**	**278**	**270**
Levelized cost of Energy Produced by Raising Dam (R/MWh)	**4 334**	**4 690**	**4 917**

Table 1-2: Comparison of Dams by Numerical & Economics Analyses – High Demand Case

HIGH CASE CRITERIA			
Numbers and Economics	**Ntabelanga**	**Thabeng**	**Somabadi**
Population Served For This Scenario	**223 686**	**294 784**	**273 743**
Total Population Within 50 km Of Dam	**223 686**	**94 666**	**116 337**
Irrigatable Areas within Limits Set (ha)	**2 634**	**2 200**	**1 933**
Cost of Dam for Water Supply only (R'million)	**386**	**489**	**500**
Total Demand Supplied (million m³/a)	**21.97**	**23.62**	**21.47**
Total Water Available @ 98% (million m³/a) (minimum dam)	**26.80**	**24.80**	**21.32**
URV of Raw Water Supplied (no hydropower) (R/m³)	**2.37**	**2.99**	**2.88**
Is the above Dam Self-Sufficient for Hydropower?	**No**	**No**	**No**
Incremental cost of Raising Dam & Hydro-Plant (R'million)	**474**	**534**	**656**
Levelized cost of Energy Produced by Raising Dam (R/MWh)	**3 245**	**3 418**	**4 777**

The other criteria evaluated for each dam and ranked in a similar manner are listed below.

Table 1-3: Comparison of Dams Based on Other Criteria – Both Demand Cases

Other Criteria (Environmental/Resettlement, Jobs, etc)	Ntabelanga	Thabeng	Somabadi
Area of Land Inundated (km^2) – No Hydropower	7.5	7.8	5.8
Impacts Existing Nat'l Road and Other Infrastructure?	Lower	High	Moderate
Other Regional Schemes & Sources Existing/Planned?	Yes	Yes	Yes
Able to Work Conjunctively with Other Major Schemes?	Yes	No	No
SANBI Ecosystem Risk Assessment Results (Catchments)	Lower	Higher	Higher
Job Creation (Estimated Nos. Incl. Catchment Mang't)			
Temporary During Construction	200 to 300	200 to 300	200 to 300
Permanent Water Supply Operational Staff	30 to 50	30 to 50	30 to 50
Permanent on Irrigated Agriculture Schemes (Base Case)	50	106	106
Permanent on Irrigated Agriculture Schemes (High Case)	263	220	193

Whilst these other criteria show close rankings between the three dams, Ntabelanga in general scored more green ratings than the other two dams, and the significance of Ntabelanga being the only scheme able to work conjunctively with the potential Lalini hydropower scheme made it particularly stand out above the other two dams.

This latter option involves the operation of the Ntabelanga dam conjunctively with a hydropower scheme downstream on the same river, comprising a new dam at Lalini, located close to and above the Tsitsa Falls. The Lalini scheme (using Lalini dam only) was identified as a best option of many investigated by ESKOM in their Eastern Cape study dated 2004.

This additional conjunctive use option was discussed by DWS and ESKOM at a meeting held on 25 January 2013. The Department of Energy were also informed and have also participated in discussions with DWS in this regard.

Preliminary analyses undertaken at that stage indicated that there could be economies of scale and other cost-benefits in constructing a "large" Ntabelanga dam to regulate flow to a hydropower scheme at Lalini Dam.

The general arrangement of this potential conjunctive usage scheme is shown in Figure 1-2.

Additional hydrological models were therefore included in Phase 1 with the hydropower module of the WRYM model to investigate two options:

a) A stand-alone Lalini Dam scheme with dam size 0.78 × MAR. This scheme was expected to produce some 30 MW of continuous output (and possibly up to 150 MW peaking power at a load factor of 15%)
b) Using a larger Ntabelanga Dam (1.18 × MAR) conjunctively with a small Lalini Dam (0.15 × MAR). This scheme was expected to produce some 30 MW continuous output at Lalini and a further 2 MW average (maximum 5MW) output at Ntabelanga (with again possibly up to 150 MW peaking power at the same load factor).

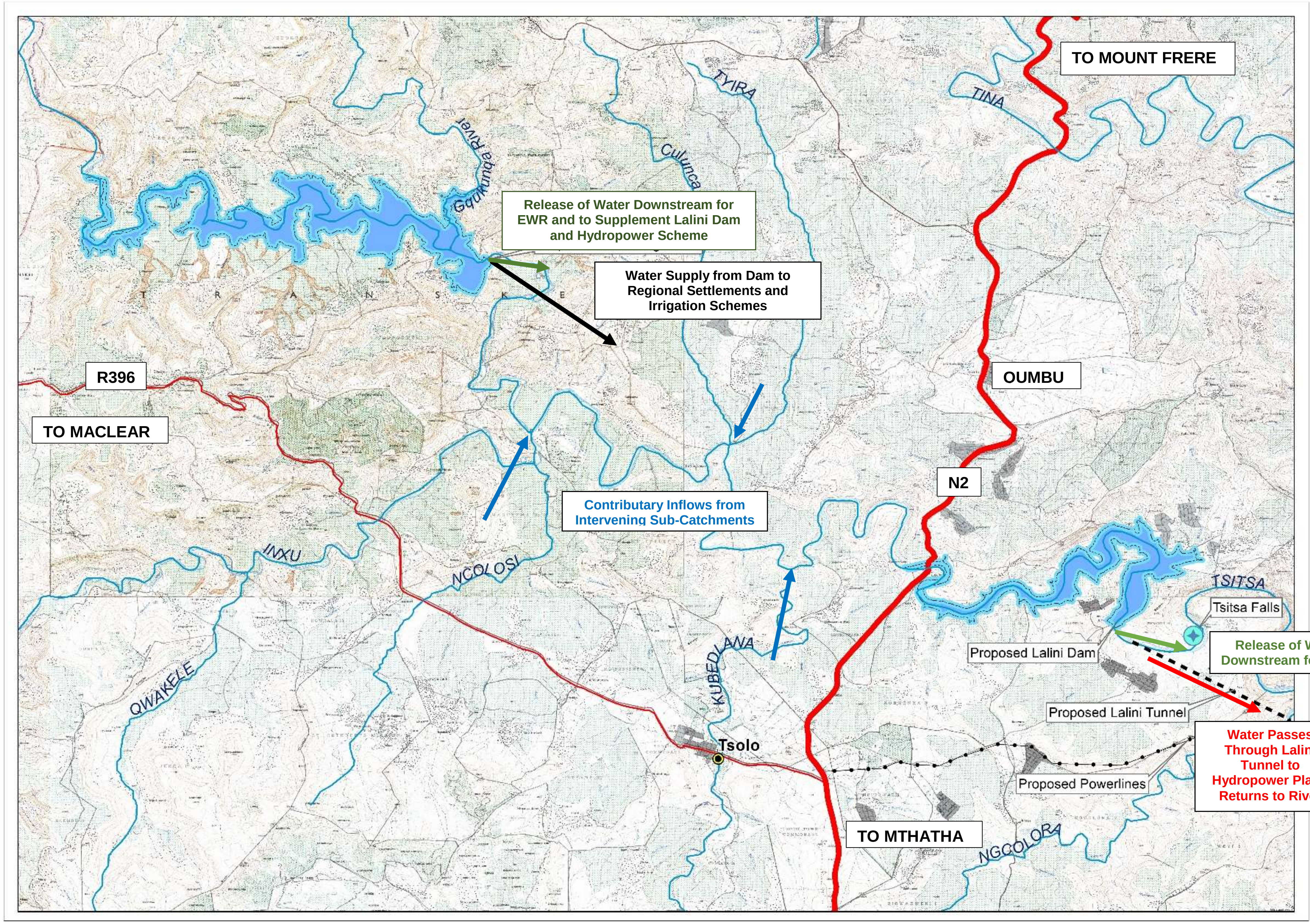


Figure 1-2: Layout of Potential Ntabelanga-Lalini Conjunctive Hydropower Scheme

At the Preliminary Study stage, the above analysis did not take into account the reserve requirements of the river systems downstream of the Ntabelanga and Lalini dams. These requirements play a significant part regarding how much water can be diverted through the hydropower plants and returned back to the river in any particular month, and this is especially pertinent during low flow months, or particularly dry years.

High level cost estimations were undertaken, and the incremental costs of implementing the conjunctive scheme over and above building the basic Ntabelanga Dam for water supply only were calculated.

This is discussed in sections below and 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 1-4.

Table 1-4: Comparison of Levelized Cost (URV) of Power Produced by the Hydropower Options

					LEVELIZED COST OF POWER FOR INDICATED DISCOUNT RATES (R/kWh)					
	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 showed that developing the Ntabelanga hydropower option only was 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 was 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, showed 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 conjunctive use hydropower analysis was undertaken, based upon the largest capacity Ntabelanga Dam and for a range of Lalini Dam capacity options.

The Reserve Determination, to determine Environmental Water Requirements (EWR), and operating rules were also revisited to include the Lalini Dam site, given that hydropower releases have a significant impact upon the riparian hydrology downstream of the proposed dam site and hydropower tunnel exit point.

The analysis and findings are given in the Hydropower Analysis: Lalini Dam Report No. P WMA 12/T30/00/5212/18, 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.

1.2.3 *Phase 1 Conclusions and Recommendations*

In terms of purely economic comparison of the three dam site options, Ntabelanga was clearly the highest ranked option, having the lowest capital cost and lowest URV for water produced for all configurations considered above.

Having said this, it was noted that the URV's of raw water produced by all three dams (of "minimum size") were high if only potable and irrigation water requirements are taken into consideration.

Whilst the ranking was less clearly indicated when considering the other impacts described above, the overall conclusion and recommendation based upon the criteria considered above was that the Ntabelanga dam was the best single option to be taken forward into Phase 2 of this study.

The additional benefit that Ntabelanga had over the other two options was that it was well located to operate conjunctively and cost-beneficially with a potential hydropower scheme on the same river. It was noted that if such additional use could be realised, then the URV of water produced would reduce accordingly and the dam would become economically viable.

The Ntabelanga Dam was determined to have the best yield per unit volume of water stored, due to the lower stream flow CV, a lower required sedimentation allowance and a lower EWR requirement when compared to the Somabadi and Thabeng dams.

The selection of this as the preferred dam also had the unique advantage of being able to be operated conjunctively with the potential hydropower scheme downstream of the Ntabelanga Dam at the Lalini Dam, located just above the Tsitsa Falls.

An economic viability and financial sustainability analysis resulted in the selection of the Ntabelanga Dam as the preferred option (see Preliminary Study Report no. P WMA 12/T30/00/5212/3).

Following discussion and consideration of the above findings, it was concluded that a stand-alone dam at Ntabelanga on the Tsitsa River to supply potable and irrigation water requirements only would be unlikely to be economically viable, but if developed conjunctively with the potential Lalini Dam and hydropower scheme, could deliver a viable solution meeting the multi-purpose social and economic upliftment objectives of the scheme.

It was therefore recommended that Phase 2 of this Feasibility Study focus on the development of the larger-sized Ntabelanga Dam to be used conjunctively with the potential Lalini Dam and hydropower scheme.

The economic viability and financial sustainability of the selected dam was investigated in more detail in the Phase 2 study, which included revisiting the water requirements and existing water infrastructure in much more detail, as well as the cost-benefits of the scheme. This included consideration of social upliftment, improved services, irrigated agriculture potential, and other job creation opportunities.

1.2.4 *Phase 2 – Feasibility Study*

This phase comprised a full feasibility study on the preferred Ntabelanga Dam and associated infrastructure described above.

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, domestic water supply and hydropower);
- Topographical survey (over and above that undertaken during the Preliminary Study);
- Geotechnical investigation (more detailed investigations than during the Preliminary Study);
- Dam and appurtenant infrastructure feasibility design;
- Potable and irrigation water distribution infrastructure feasibility design;
- Hydropower scheme and associated infrastructure design
- Cost estimates and economic analysis;
- Land matters;
- Public participation;
- Regional economics; and
- Legal, institutional and financial arrangements.

1.2.5 *Detailed Investigations for Lalini Dam and Hydropower Scheme*

Following a variation order which extended the study programme to the end of October 2014, further detailed investigations were undertaken for the second dam on the Tsitsa River at Lalini (some 3.5 km above the Tsitsa Falls) and its hydropower scheme, which would be operated conjunctively with the Ntabelanga Dam to generate significant hydropower for supply into the national grid.

1.2.6 *Environmental Impact Assessment*

An Environmental Impact Assessment (EIA) of the conjunctive scheme was undertaken in parallel to the feasibility study by an independent Professional Services Provider (PSP). This has resulted in an environmental impact report being submitted to the Department of Environmental Affairs (DEA) for authorisation.

The findings and recommendations of the EIA are included in the suite of reports Nos. P WMA 12/T30/00/5314/1 to 17.

1.3 Purpose of this Report

This report summarizes the findings and recommendations of all of the individual tasks undertaken on the Feasibility Study and is therefore effectively an executive summary of the other feasibility study reports, namely Report Numbers P WMA 12/T30/00/5212/1 to 20.

2. WATER RESOURCES

2.1 Introduction

A water resources assessment was undertaken when comparing three dam development options in Phase 1 of the study and subsequently reviewed and updated once a single preferred development option had been selected.

The review and update were undertaken during Phase 2 of the study. This section of the report is structured in a similar manner to the phased approach and is split into the Phase 1 and Phase 2 water resource assessments.

Please refer to Water Resources Report No. P WMA 12/T30/00/5212/5 for more details.

2.2 Preliminary Study

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 proposed Ntabelanga Dam is located on the Tsitsa River within the quaternary catchment T35E and has a contributing catchment area of 1 967 km^2. The proposed Thabeng Dam is located on the Kinira River and straddles three quaternary catchments, namely T33C, T33D and T33E and has a contributing catchment area of 2 135 km^2. The proposed Somabadi Dam, which is also located on the Kinira River, is located within the quaternary catchment T33E and has a contributing catchment area of 2 380 km^2.

The yield modelling exercise required various inputs in order to accurately represent each system. These inputs included rainfall, evaporation, simulated and stochastic stream flows, Environmental Water Requirement (EWR) allocations, sedimentation volume allocations and dam basin characteristics (see Topographical Survey Report No. P WMA 12/T30/00/5212/11). The EWR requirements were determined through a Rapid Reserve Determination of each site (see Reserve Determination Report no. P WMA 12/T30/00/5212/7). The results of this were used in the yield modelling of the three dams and were as follows:

- Somabadi Dam - Class C EWR, equating to a 29.08% of the MAR;
- Thabeng Dam - Class C EWR, equating to a 29.08% of the MAR; and
- Ntabelanga Dam - Class D EWR, equating to a 15.90% of the MAR.

The sedimentation for the three dam sites was determined using the Rooseboom method (1992), which was used to determine the conceptual 50-year sediment volume (V_{50}) that needs to be allocated into the total dam storage capacity. Due to the extremely high sediment loads in the rivers and the large-scale erosion within the catchment, the 95% non-exceedance V_{100} values were adopted, rather than the V_{50} value as is the norm, for each dam. The following summarises the V_{100} sediment volumes adopted for each dam:

- Somabadi Dam: 42.80 million m^3;
- Thabeng Dam: 38.44 million m^3; and
- Ntabelanga Dam: 29.30 million m^3.

Monthly rainfall files were created for each quaternary catchment within the Kinira and Tsitsa River catchments. This was used as input into the rainfall-runoff modelling and the yield modelling exercises. The mean annual quaternary catchment rainfall ranged from just below 720 mm to marginally under 1 000 mm in the Kinira River catchment and from slightly lower than 800 mm to marginally under 1 100 mm in the Tsitsa River catchment.

The rainfall-runoff modelling was undertaken using the WRSM2000 model. The quaternary catchments were simulated using calibrated catchment parameters that represent the climatic and physiographic conditions. The models for both catchments were calibrated against available gauged stream flow data. The Kinira River catchment system was calibrated against recorded data from stream flow gauges T3H002 (1949 to 2009) located at the outlet of quaternary catchment T33C and T3H007 (1984 to 2009) located at the outlet of quaternary catchment T33G.

The Tsitsa River catchment system was calibrated against recorded data from stream flow gauges T3H009 (1964 to 2009) located at the outlet of quaternary catchment T35C and T3H006 (1983 to 2003) located at the outlet of quaternary catchment T35K. The calibrations were considered sufficient for use in this phase of the study.

The mean annual quaternary catchment runoff for the Kinira River catchment ranged from 50.59 million m^3 in T33C (area of 368.1 km^2) to 145.68 million m^3 in T33F (area of 438.7 km^2).

The mean annual quaternary catchment runoff for the Tsitsa River catchment ranged from 42.45 million m^3 in T35F (area of 359.6 km^2) to 110.29 million m^3 in T35H (area of 521.0 km^2).

Both river systems, including all three dam sites, were simulated using the Water Resources Yield Model – Information Management System (WRYM-IMS) in order to quantify the sustainable yield of each dam site for a variety of proposed dam volumes. A range of dam volumes were simulated at each site (typically five scenarios ranging from 0.10 x the Mean Annual Runoff [0.10 MAR] to 1.50 MAR[1]), each accounting for existing water uses, sedimentation and EWR allowances. These simulations presented a range of yields at various assurances of supply.

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

This was confirmed in the economic analysis of the three options (see Preliminary Study Report No. P WMA 12/T30/00/5212/3). Hence, a more detailed water resources assessment was undertaken on the Ntabelanga Dam, with a higher level assessment being undertaken of the hydropower generation potential of the Tsitsa River at Lalini (in the vicinity of Tsitsa Falls).

[1] The Phase 1 MAR values were reviewed in Phase 2 following an update of the detailed hydrology. Therefore a 1.5 MAR Ntabelanga Dam as described in Phase 1 analyses, had the same capacity as a 1.18 MAR_{PD} Ntabelanga Dam in Phase 2 onwards. MAR_{PD} refers to the present day MAR (i.e. not naturalized).

2.3 Detailed Feasibility Study

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 second dam at Lalini (Tsitsa Falls).

New monthly rainfall files were created for each quaternary catchment within the Tsitsa River catchment. The change came about due to the inclusion of additional rainfall gauges of shorter duration. These additional short gauged records were used in the patching process of the longer gauges used in Phase 1 and to increase the variability between the final quaternary catchment rainfall files.

The Phase 2 assessment resulted in a more realistic rainfall distribution across the catchment due to the increase in variability between the individual rain gauge sites. The results from the rainfall analysis given in Table 2-1 were used in the rainfall-runoff and yield modelling exercises which had a positive impact by increasing the available stream flow across the catchment due to an overall increase in rainfall depth.

Table 2-1: 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 area increased from 334.0 to 380.3 km^2 and IAPs' area 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 V_{50} values of 35.7 and 32.1 million m^3, respectively.

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

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 yield analyses.

The simulated natural mean annual stream flow was modelled to be 428.49 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 reflected 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, based on the high requirement scenario) 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 volumes were assessed from 0.10 MAR_{PD} to 1.50 MAR_{PD}. It was noted that above 1.18 MAR_{PD}, water level in the basin would overtop a saddle of land, cutting off a main access road to the southern shore of the dam reservoir. It was therefore considered undesirable to raise the water level beyond this capacity (requiring a saddle dam) and it was agreed that the 1.18 MAR_{PD} capacity should be the maximum considered for Ntabelanga Dam.

The Ntabelanga Dam can supply the year 2050 water requirement scenario of 60.2 million m^3/a at a 98% assurance of supply from a relatively small impoundment of 60.0 million m^3 ($\approx$ 0.15 MAR_{PD}). Any increase in impoundment volume above 60.0 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 requirements scenario from the Ntabelanga Dam accounts for the provision of the following water uses:

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

The chart in Figure 2-1 summarises the results of the WRYM analysis for a range of dam storage capacities and for various levels of assurance of supply.

A series of hydropower scenario analyses were also undertaken for varying dam sizes and combinations at the Ntabelanga and Lalini Dam sites. These are described in Section 11 of this report.

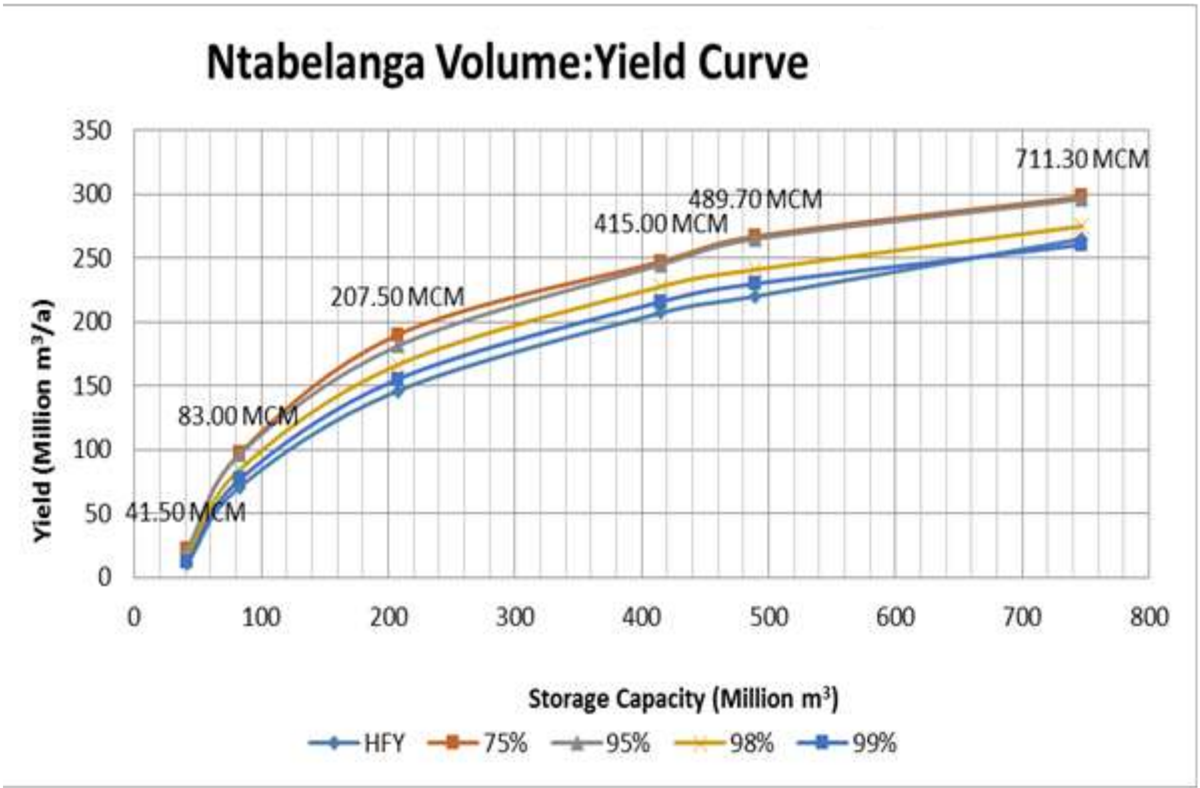


Figure 2-1: Final Yield versus Volume Curve (Ntabelanga Dam)

2.4 Conclusions and Recommendations

2.4.1 Water Resources Assessment Conclusions

- The Ntabelanga Dam can supply the projected 2050 potable and irrigation water requirement of 60.2 million m^3/a at a 98% assurance of supply from a relatively small impoundment of 60.0 million m^3 (≈ 0.15 MAR).
- Any increase in impoundment volume above 60.0 million m^3 has a significant impact on increasing the yield due to the large proportional increase in live storage once the dead storage allocation has been overcome.
- The water requirement projections for the Ntabelanga Dam accounts for the provision of the following water uses:

  - Category C EWR from Ntabelanga Dam, based on the Intermediate Reserve Determination;
  - Raw water supply for end user potable water (see Water Requirements Report No. P WMA 12/T30/00/5212/6 and Bulk Water Infrastructure Report No. P WMA 12/T30/00/5212/13); and
  - Irrigation potential (see Irrigation Development Report No. P WMA 12/T30/00/5212/9).

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

[2] *In the case of EWR, the MAR is stated in terms of a naturalized flow regime*

In spite of the limited development identified within the catchment, an ecological category C was still considered to be appropriate to use as the reserve requirement, due to the high sedimentation rates in the system, which limits biotic proliferation within the riparian areas (mainly due to the impacts of sedimentation on the biota's required habitat).

- Sedimentation volumes over 50 years were accounted for based on an assessment of the Ntabelanga Dam catchment using the WRC (2010) methodology. The sedimentation V_{50} value used in this study was 35.704 million m^3.
- The simulated natural mean annual stream flow was modelled to be 428.49 million m^3/a at the Ntabelanga Dam site, with the present day mean annual runoff at the same site being slightly lower at 415.0 million m^3/a. This proportionally low reduction in MAR highlights the relatively small development within the catchment. Thus, indicating the potential for water resource development.
- A gross storage volume of 60.0 million m^3 is the recommended impoundment if only the high scenario domestic and irrigation requirements are to be supplied.
- Sedimentation volumes for the Lalini Dam over 50 years were accounted for based on an assessment of the incremental contributing catchment of the Lalini Dam, below the Ntabelanga Dam. The incremental sedimentation V_{50} value used in this study was 31.185 million m^3, which resulted in a total allowance of 66.889 million m^3 in both dams.
- The simulated natural mean annual stream flow at the Lalini Dam site was modelled to be 868.63 million m^3/a, with the present day mean annual runoff at the same site being slightly lower at 828.0 million m^3/a. This proportionally low reduction in MAR highlights the relatively little development within the catchment.
- The average hydropower generation potential at the Lalini Dam and the two small hydropower plants ranges from 23 to 27 MW, depending on the combination of dam storage volumes simulated between the Ntabelanga and Lalini dams. There are only limited gains in hydropower output above a Lalini Dam storage volume equivalent to some 0.28 MAR_{PD}.
- The Tsitsa River system can be utilised for a multi-purpose use (i.e. the Ntabelanga Dam and the Lalini Dam) due to the high water resources availability in the catchment. The consumptive uses could sustainably include, inter alia:

  - Potable water supply;
  - Irrigation; and
  - Hydropower.

2.4.2 Recommended Design Flood and Safety Evaluation Flood Hydrology

The DWS reviewed and commented on submitted flood memoranda and the agreed RDF and SEF have been used in determining the spillway, freeboard and other safety aspects of each dam. These figures are given in Table 2-2.

Table 2-2: Agreed Flood Criteria

Flood Criteria	Ntabelanga Dam	Lalini dam
RDF (m^3/s)	2 500	3 500
SEF (m^3/s)	5 530	7 100

The design flood memoranda are included as Appendices to each of the Dam Feasibility Design reports – Nos. P WMA 12/T30/00/5212/12, and P WMA 12/T30/00/5212/19.

3. RESERVE DETERMINATION: RIVERINE

3.1 Introduction

This section summarises Volume 1 of the Reserve Determination Report No. P WMA 12/T30/00/5212/7.

3.2 Background

The National Water Act (NWA) No. 36 of 1998 requires that before water use authorisations can be granted to utilise a particular water resource, it is necessary to determine the reserve for the relevant ecological component of the resource that will be impacted by the proposed water use. This requires the implementation of Resource Directed Measures (RDM) to protect the water resources of the country.

The construction of the Ntabelanga dam has been proposed in the Tsitsa catchment in quaternary catchment T35E. The proposed dam will have both direct (i.e. hydraulics) and indirect impacts (i.e. geomorphology, habitat integrity and response variables) on the downstream aquatic ecosystem. These impacts necessitate that the reserve (ecological and basic human needs) are determined for the catchment to ensure adequate protection of the water resources.

Therefore, an Intermediate level Ecological Water Requirement (EWR) assessment was undertaken in the Tsitsa River in order to determine the effects of modified flows in the system due to Ntabelanga Dam. This report provides the results of the preliminary determination of the quantity and quality requirements of the reserve on an Intermediate Level for the Tsitsa River. Activities and tasks for this ecological reserve determination study were undertaken in accordance with the appropriate approaches and methodologies for rivers as prescribed by the Chief Directorate: Water Ecosystems of the Department of Water and Sanitation.

3.3 Results

The water resources of the Tsitsa River at the EWR site downstream of the Ntabelanga 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).

These changes were observed in both abiotic (i.e. the Desktop Reserve Model (DRM), the Physicochemical Assessment Index (PAI) and Index of Habitat Integrity (IHI)) and biotic (i.e. Macro-invertebrate Response Assessment Index (MIRAI), Fish Response Assessment Index (FRAI) and Specific Pollution sensitivity Index (SPI)) assessments. The overall confidence in these results is medium.

The system has a moderate Ecological Importance and Sensitivity. This is primarily driven by:

a) The unique Barbus anoplus-type minnow likely to be present in the system as high waterfalls both up and downstream create barriers to fish movement, thus enabling the development of an Evolutionary Significant Unit;
b) Oligoneuridae were sampled during the survey (these macro-invertebrates are dependent on high velocities); and
c) Perlidae and Prosopistomatidae being present in the system.

The Recommended Ecological Category (REC) is a C.

The results as obtained with the Desktop Reserve Model (SPATSIM, version 2.12) and accepted by the various specialists for the recommended ecological category are summarised in the Table 3-1.

Table 3-1: Key EWR Data for the Tsitsa River/Reserve

EWR DESCRIPTOR	VALUE
Quaternary Catchment	T35E
EWR Site Co-ordinates	30.606°S; E 29.755°E
Ecological Category	C
MAR_{NAT} for Quaternary Catchment Area	428.49 million m^3
Total EWR	87.249 million m^3 (20.36 %MAR)
Maintenance Low flows	50.517 million m^3 (11.79 %MAR)
Drought Low flows	23.991 million m^3 (5.60 %MAR)
Maintenance High flows	36.732 million m^3 (8.57 %MAR)
Overall confidence	Medium

3.4 Conclusions and Recommendations

The Tsitsa River is moderately modified: impacted by both catchment scale processes (e.g. sedimentation) and localised impacts (e.g. alien invasive vegetation). It is critical that the recommended ecological water requirements are met. This will allow management to maintain the REC of a C.

It is recommended that a baseline water quality monitoring programme be initiated. The results from this programme will inform the EcoSpecs[3] and Thresholds of Potential Concern[4] (TPC) and allow for potential re-calibration once sufficient baseline data has been collected.

Furthermore, it is recommended that the biomonitoring programme include quarterly sampling of:

- Macroinvertebrates (per the SASS5 protocol[5] (Dickens and Graham, 2002) by a Department of Water and Sanitation Accredited SASS5 practioner);
- Benthic diatoms; and
- Fish.

These measures will allow for analysis of ecological trends in the system in response to the proposed Ntabelanga dam.

The findings herein are based on scenarios and models run at the time of respective workshops. Additional scenarios may need to be run in the future and modifications made accordingly, if appropriate.

[3] *EcoSpecs are measureable criteria that are set for the ecological categories of various driver and response components including hydrology, geomorphology, water quality, fish, aquatic invertebrates and riparian vegetation, which are used in ecological monitoring programmes.*

[4] *Thresholds of potential concern (TPC's) are a set of operational goals that together define the spatial and temporal variation in ecological conditions for which the particular ecosystem is managed. TPC's thus represent the upper and lower limits along a continuum of change in selected environmental indicators. Taken together, TPC's define the envelope of desired conditions within which ecosystem changes are managed.*

[5] *South Africa has a well-established macroinvertebrate bio-monitoring protocol for rivers called SASS5 (South African Scoring System Version 5).*

Please note that a further reserve determination study was undertaken of the Tsitsa River at the proposed Lalini hydroelectric scheme site below the Tsitsa Falls. This additional study was undertaken following the Ntabelanga Dam site study, under the separate EIA PSP contract.

The findings and EWR recommendations of that additional study may be found in DWS Report: Rapid Reserve Determination: Tsitsa River at Lalini (No. P WMA 12/T30/00/5314/17).

4. RESERVE DETERMINATION: ESTUARINE

4.1 Introduction

This section of the report is a summary of the findings of Volume 2 of the Reserve Determination Report No. P WMA 12/T30/00/5212/7 covering the Mzimvubu River Estuary, prepared in support of the broader feasibility study for the Mzimvubu Water Project. The assessment has followed the methods supported in Version 2 of the Reserve Determination methods outlined by the DWS.

It is reiterated that the 1.5 MAR reference throughout this section of the report stemmed from the fact that the reserve determination was undertaken during the Phase 1 investigations. After review of the hydrology of the Tsitsa River in Phase 2, this same dam capacity was re-designated as a 1.18 MAR_{PD} capacity dam. MAR_{PD} refers to the Present Day Mean Annual Runoff value.

Summer and winter sampling of the abiotic and biotic features of the estuary were undertaken to provide supporting information for the study in determining the Present Ecological Status of the estuary, as well as assessing a series of future water use scenarios and the likely impact these may have on the estuary, and to recommend an Ecological Management Category.

4.2 Study Assumptions

The brief was undertaken based on the following assumptions:

- The simulated run-off scenarios, representative of river inflow at the head of the Mzimvubu Estuary included the reference condition, the present state and a range of additional scenarios as were agreed between the feasibility study PSP and DWS;
- The accuracy and confidence of an Estuarine Ecological Water Requirements study is strongly dependant on the quality of the hydrology. The overall confidence in the hydrology supplied to the estuarine study team was considered to be low as there are no measured flow data records available on this system – at least not close to the head of the estuary; and
- The findings of this study only pertain to the water use scenarios (1-3) described in section 4.5 herein. A number of different water use scenarios are included as part of the hydrology report and the riverine EWR but these were not assessed for impact to the estuary (ecological consequences).

4.3 Present Ecological Status

The Present Ecological Status (PES) of the Mzimvubu Estuary was determined to be a B (as the estuary has an Estuarine Health Index Score of 83, (i.e. 83% similarity to natural condition)), meaning that the estuary is “largely natural with few modifications”.

4.4 Estuary Importance

The Ecological Importance Score (EIS) for the estuary takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account, and the overall score was 82, which corresponds to a rating of “highly important”. In addition, the estuary is identified as a desired protected area in the Biodiversity Plan for the National Biodiversity Assessment.

A number of features contributed to the high importance score of the estuary, including that:

- Significantly, this is the only Water Management Area not linked to another Water Management Area through cross-catchment transfers and is largely unregulated;
- This catchment has been identified as supplying high levels of ecological services nationally, and SANBI is currently undertaking an assessment of the economic importance of the system;
- The confirmed use of the estuary by Zambezi sharks (Carcharhinus leucas), White steenbras (Lithognathus lithognathus) and Dusky kob (Argyrosomus japonicus) species as a pupping/nursery ground, given that these are species of conservation and fisheries concern, and that available nursery habitat for these species is highly limited in South Africa;
- The significant role that this estuary plays in the delivery of sediments and nutrients/detritus to the marine environment, elevating the importance of this estuary in geological terms to the local beaches and marine environments.

Given that the PES for the Mzimvubu Estuary is a B, and that the estuary is rated as “Highly important”, the Recommended Ecological Category for the estuary is an **A or Best Attainable State.**

4.5 Assessment of Future Water Use Scenarios

Three potential future water use scenarios were assessed as part of the Reserve Determination for the estuary (note that these are different from those assessed for the riverine EWR)

1. A small dam (0.1 MAR) at Ntabelanga;
2. A medium dam (0.5 MAR) at Ntabelanga; and
3. A large dam (1.5 MAR) at Ntabelanga.

The scenario assessments determined that water use scenarios 1 – 3 would likely retain the Mzimvubu Estuary in its Present Ecological Status of a B (“largely natural with few modifications”), although Scenario 3 would be likely to bring this into a low-scoring B.

4.6 Management Recommendations

The study resulted in a series of recommendations for the future management of the estuary aimed at maintaining and/or improving the estuarine health of the Mzimvubu River. These recommendations addressed the key abiotic and biotic conditions that have resulted in a PES that is lowered from the reference state of the estuary. These recommendations included:

- Returning some variability to the mouth dynamics through removal of the access road behind the area formerly known as “First Beach”, which has effectively entrained the estuary mouth;
- Reinstating local sediment dynamics (also through the removal of the abovementioned access road), given the realistic possibility that the loss of “First Beach” may be reversed, potentially re-establishing this once-popular recreational beach for the town of Port St John’s;
- Land-use management regulation within the estuarine functional zone that focuses on restricting the loss of further habitat within this zone and the estuary floodplain up to the 10 m contour (or 10 m above mean sea level);

- The rehabilitation of disturbed areas of the estuary floodplain/functional zone where impacts are reversible, and rehabilitation would significantly enhance the functional integrity and importance of the estuary as a whole;
- The establishment of a programme for Invasive Alien Plant management within the estuary floodplain, which would make a significant contribution towards addressing this and enhancing the functional importance of the floodplain as a feature of the estuary;
- The management of fishing pressure in the estuary through the possible partial closure of the estuary to fishing in order to protect important fish stocks and sensitive habitats;
- Addressing possible point source pollution risks from the canalised creek that flows from the town of Port St John's, as the study has suggested that this canal may be compromising water quality to some extent.

4.7 Conclusion

The fact that the Ntabelanga Dam site is located on the tributary Tsitsa River some 200 km above the Mzimvubu River mouth, controls just 10% of the total Mzimvubu catchment area, and would ultimately reduce the total Mzimvubu River MAR by just 2%, it follows, prima facie, that the Ntabelanga Dam's impact and influence on the Mzimvubu Estuary ecology and hydraulics would not be a fatal flaw in its implementation.

Given that the PES for the Mzimvubu Estuary is a B, in order for the Mzimvubu Estuary to be maintained in an A or Best Attainable State, it would be preferred that the water use scenario presented in Scenario 2 (a medium dam of 0.5 MAR at Ntabelanga) is implemented.

However the likely Scenario 3 (implementing the larger 1.5 MAR[6] capacity Ntabelanga Dam) will still result in an ecological state of B albeit with a lower score.

The addition of hydropower plants at both Ntabelanga and Lalini dams are non-consumptive, and will follow an operational regime that will mimic naturalized environmental flows. This should therefore not change this ecological state at the estuary locality.

The development scenario would need to be implemented in combination with the additional land-use recommendations outlined above in order to address the key issues that are leading to the lowered PES of the estuary.

> Please note that a further reserve determination study has been undertaken of the Tsitsa River at the proposed Lalini hydroelectric scheme site below the Tsitsa Falls. This additional study was undertaken following this Ntabelanga Dam site study under the separate EIA PSP contract.
>
> The findings and EWR recommendations of that additional study may be found in DWS Report: Rapid Reserve Determination: Tsitsa River at Lalini (No. P WMA 12/T30/00/5314/17).

[6] *Eventually designated as a 1.18 MAR_{PD} capacity dam in Phase 2*

5. IRRIGATION DEVELOPMENT

5.1 Introduction

This section summarises the findings of studies undertaken to investigate the irrigation development potential and associated infrastructure requirements of the preferred dam site as determined under the feasibility study. For more detail, please refer to the Irrigation Development Report No. P WMA 12/T30/00/5212/9.

5.2 Identification of High Irrigation Potential Lands

Following a screening and ranking process undertaken in Phase 1, the three dam sites selected for further consideration and study were Somabadi, Thabeng, and Ntabelanga. This process is described in detail in the Preliminary Study Report No. P WMA 12/T30/00/5212/3.

An initial desktop GIS exercise was carried out to identify high potential irrigable soils according to certain criteria, for purposes of comparison of these dam sites.

The criteria were:

- High potential soils according to soil form, depth, texture;
- Slope < 12%;
- Elevation < 60 m above the river at the dam site, or in the river below the dam site;
- Distance < 5 km from the dam wall or either side of the river below the dam site; and
- Water deficit – medium to high water stress (shortage of natural rainfall).

A field verification exercise was carried out and the verified land areas meeting these criteria were 504 ha for Ntabelanga Dam, and 1 062 ha for each of Thabeng and Somabadi dams.

The three dams were compared using the above data as well as several other selection criteria, and Ntabelanga Dam emerged as the top ranked dam, when all factors were taken into account. This was the dam selected at the end of Phase 1 of the study for further investigation.

In Phase 2 of the study, the focus was on the area to be supplied with water by the Ntabelanga Dam, and in this case the economic criteria of distance from the water source and elevation above the water source were adjusted in the GIS analysis, to cast the net wider and to find more potentially suitable agricultural land for irrigation. This relaxation of criteria took into account the social upliftment purpose of the project and was implemented to widen the area and the number of people that could benefit from the scheme.

Further analysis and fieldwork was undertaken, and 7 708 ha of high potential soils were identified in the Ntabelanga supply area, as modified for existing land use. Much of the land was situated around the town of Tsolo to the south east of the dam. This more detailed field verification exercise was carried out as described in Appendix A of the Irrigation Development Report No. P WMA 12/T30/00/5212/9, following which 3 675 ha of suitable irrigable lands were confirmed.

A critical review of where these lands lay relative to the dam, and forming contiguous soil bodies together resulted in a final estimate of 2 868 ha of irrigable land which could be supplied with water from the Ntabelanga Dam. This involved an extensive soils auguring and testing exercise to determine the soil profiles, types and locations of these higher potential irrigable land areas. These high potential areas are shown in Figure 5-1.

Two remote “outlier” areas 10 and 12 were noted. Area 10 is far from the proposed raw water source and has a low proportion of the higher soil classes. Area 12 has a significant area of high class soils but is at a straight line distance of 12 km, and at an elevation some 440 m above the raw water pumping station. The terrain between the pump station and area 12 is particularly mountainous and highly problematical for pipeline construction. An intermediate booster pumping station would also be required. This area is not considered viable with regard to being supplied with water from the Ntabelanga Dam.

Areas 1, 8, 9 and 13 are close enough to the dam and river, and could be irrigated directly from source using portable “quick-fit” abstraction and distribution infrastructure.

Most of the high potential farming units are located in and around the urbanised centre of Tsolo, at a distance of some 17 km away from the Tsitsa River, and at an elevation between 130 and 220 m above the river level at the nearest point.

This means that raw water supply to the lands in the Tsolo area would need to be conveyed via pipeline and pumped from the source, which will have significant operation, maintenance and energy cost implications.

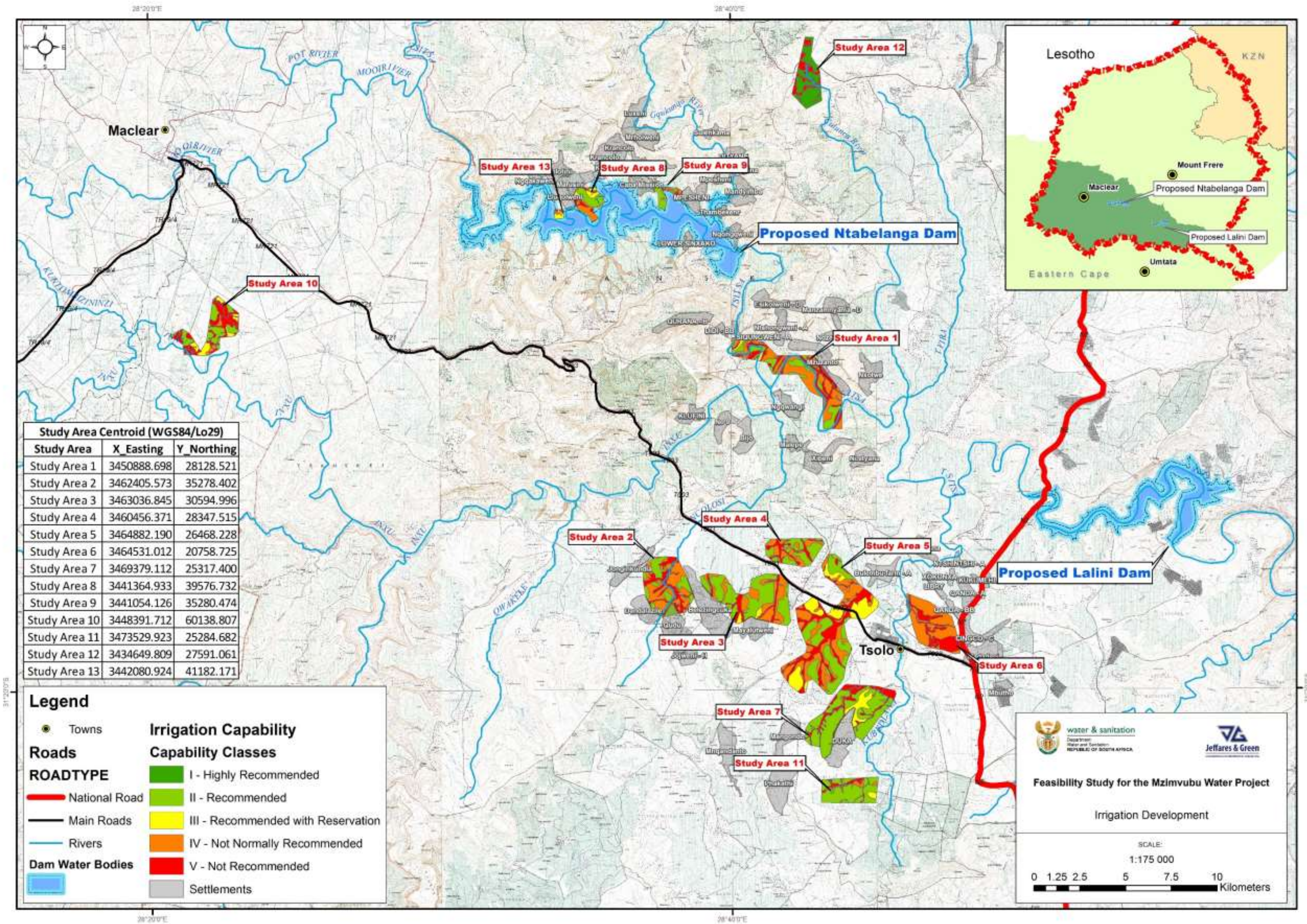
This is summarised in sections below, and analysed in detail in the Water Requirements Report No. P WMA 12/T30/00/5212/6, Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13, and the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

5.3 Agricultural Economics

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/T30/00/5212/9. A typical crop planting scenario 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 allocable costs, and not a measure of profit. This calculation, however, was based upon a unit cost of water delivered to edge of field of R0.40/m^3, which is significantly less than the R1.14/m^3 cost of supply estimate given in sections below.

Clearly some subsidization of this unit cost of raw water as well as capital costs must be made if the irrigation schemes are to be viable and sustainable. The Department of Rural Development and Agrarian Reform suggests that a figure of R0.25/m^3 would be a reasonable target to ensure that gross margins are attractive enough to encourage investment into commercial irrigated agriculture.

This emphasizes the need to subsidize the Ntabelanga scheme with revenue gained from the energy sales generated by the Lalini Dam and hydropower scheme.



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 5-1: Land Identified as Having High Irrigation Potential

The Eastern Cape Wild Coast Development initiative includes a proposal to develop a Special Economic Zone (SEZ) in the area adjacent to the Mthatha Airport. The focus of this SEZ would be agri-processing, and if implemented this offers a major opportunity for the Tsolo area to become a main supplier of fresh produce to this SEZ. If this is realised, then the choice of crops to be grown on the proposed farming units could be matched with the market requirements of the Mthatha SEZ.

In terms of the market potential of crops grown in the Tsolo area, it was the Department of Rural Development and Agrarian Reform's opinion that demand would greatly exceed supply in this regard.

Clearly the farms should be of a size which can grow irrigated field crops and irrigated pastures, with a small area of around 10 hectares set aside for vegetable crops. The market potential will control the size of the vegetable crops. A mixed farming enterprise is therefore indicated. A possible employee structure per 60 ha mixed enterprise irrigation farming unit is presented in the Irrigation Development Report No. P WMA 12/T30/00/5212/9, 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 other seasonal direct jobs.

5.4 Land and Agrarian Reform

The farming enterprises are proposed to be developed as commercially run irrigation farming units. This would 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 would require the introduction of new technology to the area, and would also 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 would 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.

Determination of farming unit size has been made 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 an average of 60 ha per farming unit. The 2 868 ha of irrigable land around the Ntabelanga Dam can thus be reasonably grouped into 45 farming units.

Whilst every pocket of land that has been identified as being of high irrigation potential has a different shape and topography, a generic farm layout was developed to show a typical setup arrangement and mix of crops that could be grown. This is shown in Figure 5-2.

Irrigation of land used to graze livestock is not considered a viable option. However, as shown on Figure 5-2, it may be viable to grow high nutritional lucerne and/or ryegrass as forage crops under irrigation for sale to livestock owners.

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.

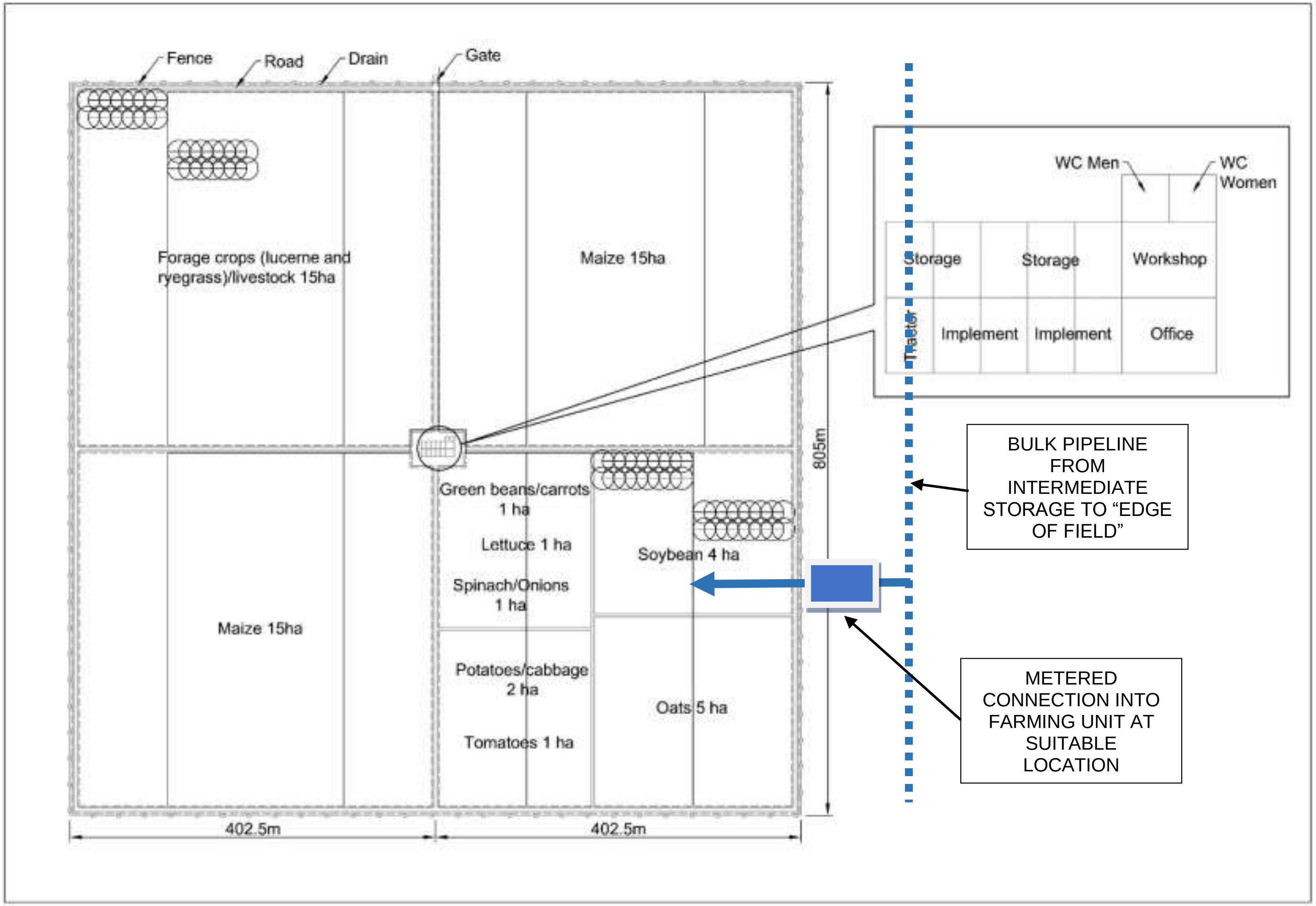


Figure 5-2: Typical Arrangement of a 60 ha Farming Unit

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 Jongilisiwe 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. A typical average 60 ha farming unit will potentially have a turnover of some R3 to 5 million per annum.

5.5 Conclusion

2 868 ha of high potential irrigable land has been identified which could be supplied with water from the Ntabelanga Dam. This land can be reasonably grouped into 45 farming units of approximately 60 ha each.

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. 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;
- The need for extensive consultation with Traditional Leaders and the affected people in the areas to be developed; and
- Extensive investment in training, facilitation, and support services.

The economics of the identified development option are based upon:

- Grant funding of the bulk water supply infrastructure to ensure that the water supplied is affordable;
- Reduction of power, operation and maintenance costs through the beneficial usage of the hydropower revenue generated by the Lalini Dam and hydropower scheme; and
- The maximising of the potential market opportunities, if the SEZ is developed at the Mthatha Airport.

6. WATER REQUIREMENTS

6.1 Introduction

This section summarises the bulk potable, irrigation, and hydropower generation water requirements which are described in detail in the Water Requirements Report No. P WMA 12/T30/00/5212/6.

The report describes the water requirements for potable and irrigation usage within the area to be supplied by the Ntabelanga Dam, which was selected as the preferred dam site, and for which the feasibility design is described in Report No. P WMA 12/T30/00/5212/12. Water requirements for the Lalini Dam and hydropower scheme (to be operated conjunctively with the Ntabelanga Dam) are also discussed and summarized (see Report Nos. P WMA 12/T30/00/5212/18 and 19).

It was confirmed and agreed that the sizing and modus operandi of the Ntabelanga Dam and its associated works would take into account its multi-purpose role, namely:

i. To supply potable water to an estimated current population of 502 822 people (rising to some 726 616 people in 2050), and other potable water consumers in the region;
ii. To supply raw water for irrigation of some 2 868 ha of high potential agricultural land;
iii. To generate hydropower locally at the dam wall to reduce the cost of energy consumption when pumping water;
iv. To provide sufficient flow of water downstream of the Ntabelanga Dam to meet environmental water requirements for an ecological category C; and
v. To provide additional balancing storage volume and consistent downstream flow releases to enable a second dam at Lalini (just above the Tsitsa Falls) to generate significant hydropower for supply into the national grid.

6.2 Domestic Water Supply Area

In Phase 1, the domestic water supply area was initially defined as the area adjacent to and below the Ntabelanga dam wall extending to the watersheds on either side of the catchment.

This initial study water supply area was as shown on Figure 6-1, and includes information (shown in blue lines) of the existing water supply infrastructure taken from information gained from the DWA All Towns Study, and from information supplied by the District Municipalities.

Most of these schemes are supplied from local sources including small streams, springs, and groundwater, but many of these suffer with source unreliability, high maintenance, and limited coverage of the population served. As can be seen, there are also many areas where no formalized water supplies exist, which form a high proportion of the study supply area.

In the course of this study, additional settlements located on the other side of the Tsitsa River watershed boundaries were also considered in order to maximise the benefit of the reliable water source, and treated water supply offered by the dam and its bulk water infrastructure to improve the water services delivery to these neighbouring areas.

These additional supply areas were first defined in the Ntabelanga Dam Potential Supply Area Investigation Study commissioned by the Amatola Water, as Implementing Agent for OR Tambo District Municipality, and undertaken by Aurecon in 2011.

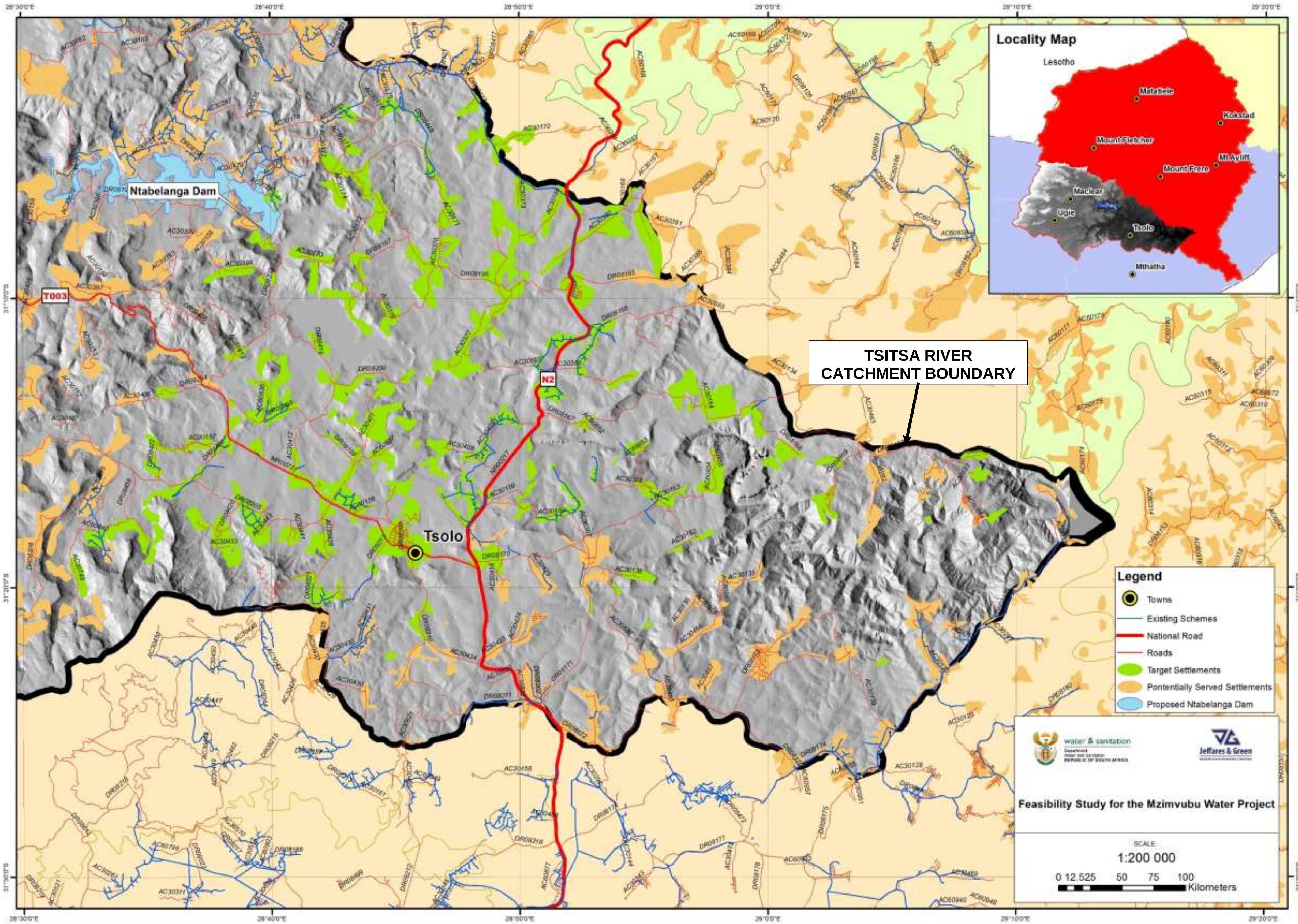


Figure 6-1: Initial Ntabelanga Potable Water Supply Area

Following on from Phase 1 of this study, meetings and discussions were held with Amatola Water, their PSP, Aurecon, and other DM representatives, to confirm the potential extent of the domestic water supply area based upon using the Ntabelanga Dam as the main source, and to agree design criteria for assessment of the long-term water requirements through to the planning horizon of 2050.

This significantly increased the potential area of supply and the number of households to be supplied from that which was used for the Preliminary Study in Phase 1. This extended area of supply included settlements in and around the Mount Frere area as well as in the Joe Gqabi DM.

The subsequently expanded potential supply area is shown in Figure 6-2. This extended supply area boundary should itself not be considered to be a specific definition of the settlements that could be supplied from the Ntabelanga Dam, but is an indication of the likely extent of community water supply systems that could be supplied by gravity from the Ntabelanga secondary bulk water supply system. Indeed, water could possibly be supplied to settlements outside of this indicative boundary by booster pumping if this is deemed to be more efficient than developing other separate bulk water supply systems.

6.3 Potable Water Requirements

In developing the potable water requirements for this study area, consideration was made as to how the physical components of the bulk water distribution infrastructure should be implemented, operated, and zoned, and the breakdown of water demands used for design was thus matched to the zoning of the infrastructure to be developed.

Also, for the purposes of identifying the maximum raw water requirements to be supplied by the dam, the water supplied by the existing scheme sources was not deducted from the total. This is also justified on the basis that many of the existing smaller schemes would have previously been designed on the basis of relatively low water demand per capita, some could be reaching their design life, some would have source reliability issues, or might need extensive plant and pipeline replacement.

The figures derived herein therefore represent an “upper” demand growth scenario. The detailed design and implementation of such infrastructure should include a review of the water requirements and consider the optimum packaging and phasing of infrastructure components in order to defer capital expenditures until actually required. Given that a key objective of this project is to stimulate economic development and to create jobs, then this upper demand growth scenario can also be justified on the basis that water consuming commercial and industrial development should also be stimulated under the same economic development initiative. This social and economic upliftment objective is one of the key reasons that this project has been given Strategic Integrated Project (SIP) status by the Presidential Infrastructure Coordinating Commission (PICC).

The design horizon for this project is to year 2050. The assumption made is that the dam will be functional and in operation and be able to deliver the projected requirements, with the bulk infrastructure for conveyance of potable water to the various users being developed as soon as possible.

In practice, it is likely that the actual bulk water distribution infrastructure would be implemented in phases, with primary and secondary pipelines and reservoirs being developed at the same time as the dam and water treatment works, but the tertiary lines to the many settlements in the supply area, being implemented in stages under the usual bulk infrastructure grant funding available to the respective DMs.

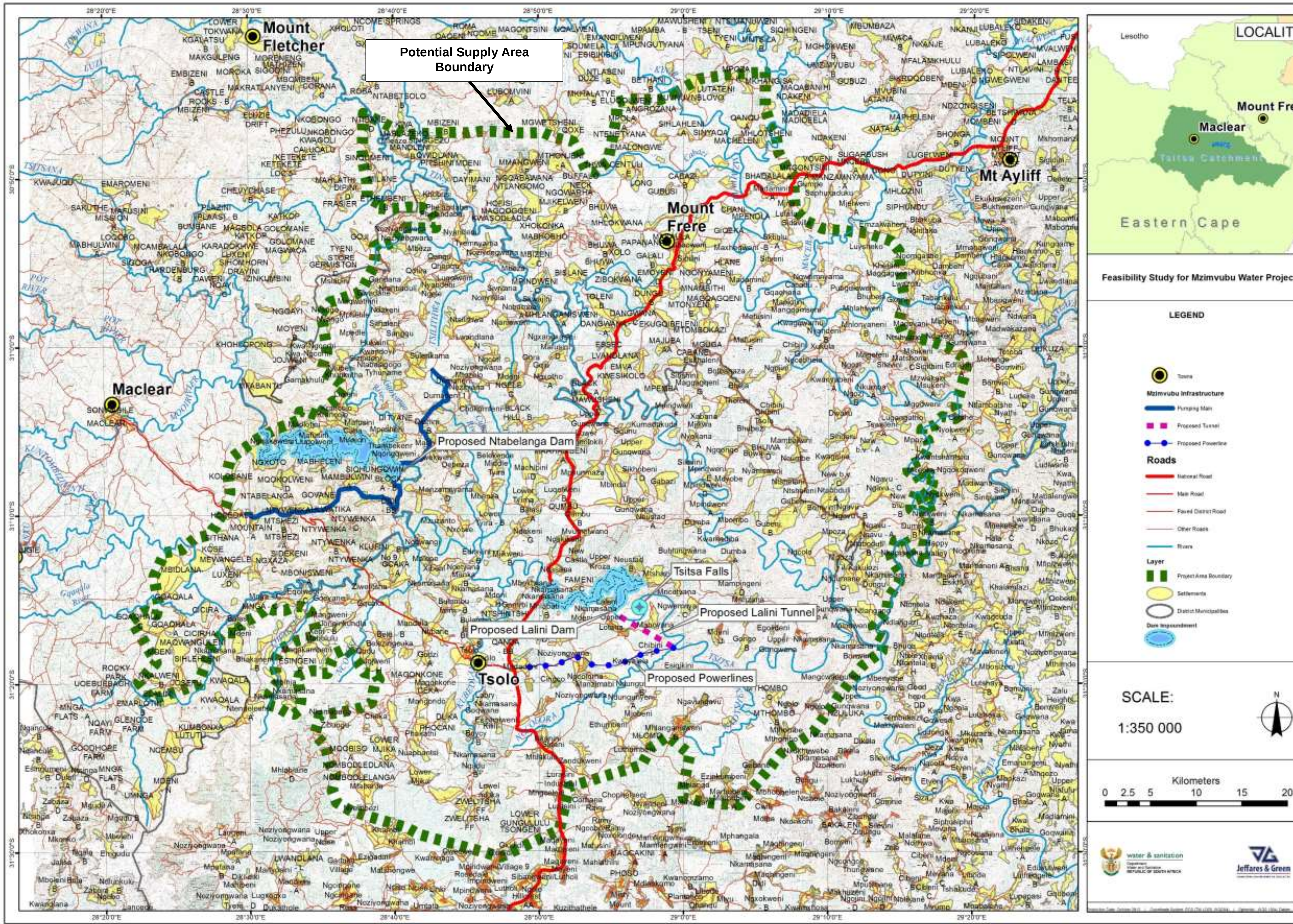


Figure 6-2: Extended Domestic Water Supply Area Boundary

Population growth projections have been developed from the latest national census databases together with other information provided by the DWS and District Municipalities in the project area. The annual population growth rate used was 1% p.a. in line with the planning documentation for the project. The population figures on Table 6-1 show an estimated current population in the project area to be supplied of 502 822 which is projected to increase to 726 616 in the year 2050. This is broken down into four supply zones that can be feasibly supplied by gravity from four command reservoirs as determined during the implementation planning of the bulk water distribution system. These Zones are as indicated on Figure 6-3.

Should this population growth rate be higher or lower than projected, then the date when the proposed system would reach its full capacity would be earlier or later. Given that the projections are considered to be an upper demand scenario, the likelihood is that the infrastructure as planned would have a longer lifespan than 2050 before needing to be augmented.

Table 6-1: Population Estimates and Growth Projections

	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**	**657 796**	**726 616**

The Ntabelanga Dam and its bulk potable water distribution infrastructure would thus be required to supply the following:

- The current supply area population shown in the table above with an estimated population of 502 822 people in 102 724 households; and
- Population growth projections to year 2050, bringing the total population supplied to 726 616 in 148 443 households.

Table 6-2 shows this same projection broken down by the areas of jurisdiction of the three DMs being supplied by the scheme.

Table 6-2: Population and Household Projections

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**	**657 796**	**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	**102 724**	**110 133**	**121 655**	**134 384**	**148 443**

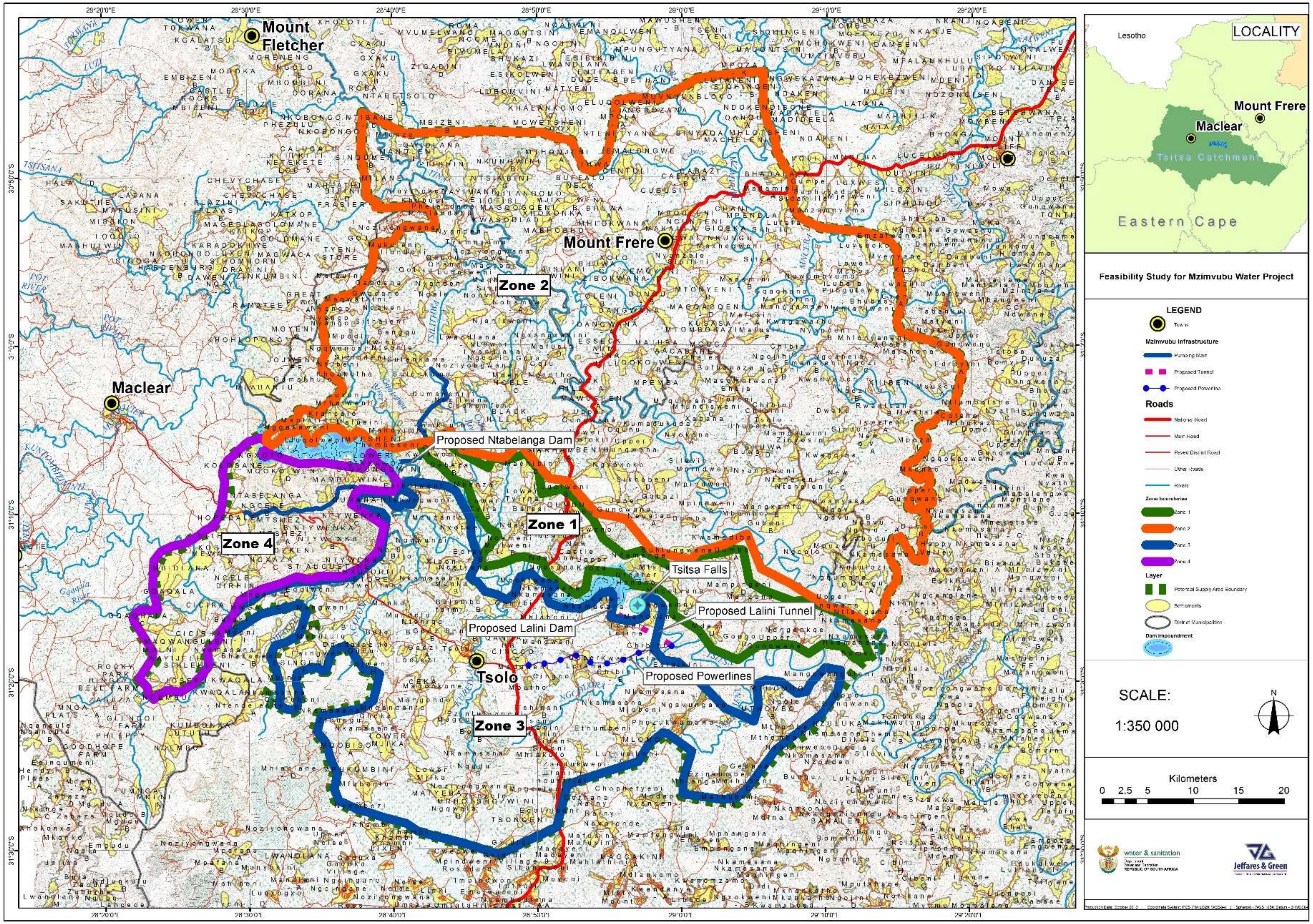


Figure 6-3: Supply Zones for Infrastructure Planning

A list of all settlements included in the supply area is given in Appendix A of the Water Requirements Report No. P WMA 12/T30/00/5212/6. The list details the following:

- The name of each settlement to be supplied;
- Its census category as regards rural and urban settlement type;
- Its District Municipality; and
- The population and growth projection from current figures through to the planning horizon year 2050.

6.4 Water Requirements Criteria

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

- Domestic water requirement – rural: 60 litres per capita per 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 water supply: 1.2 x Annual Average Daily Demand (AADD)
- 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 summer peak factor is described as a factor to cater for higher water use in the summer period. This recommended factor of 1.2 is applied to the design of the water treatment works, primary pumping system and reservoirs, while the bulk peak factor of 1.2 is a recommended factor to cater for the inflow into bulk storage as well as gravity flow between one command reservoir and another command reservoir. This bulk peak factor is applied to the design of the bulk pipelines, but does not change the overall water requirement on source. On pumping mains this can also be achieved by delivering a day's requirement in 20 hours of pumping. This allows adequate spare capacity in the pumping system in order to recover quickly from interruption or failure of the system operation.

The local daily peaks encountered in the reticulation system at settlement level are catered for in local bulk reservoirs which are designed for 48 hours storage, feeding into elevated tanks which themselves balance out hourly peak requirements.

These particular criteria are more relevant to the bulk infrastructure planning as is described in Report No. P WMA 12/T30/00/5212/13, but are included herein as a water requirement criteria guideline.

The breakdown of water volumes supplied to the three DMs, and growth to 2050, is given in Table 6-3.

Table 6-3: 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 6-4 summarises the growth projection of domestic water requirements, including allowances for conveyance losses, but excluding water treatment losses.

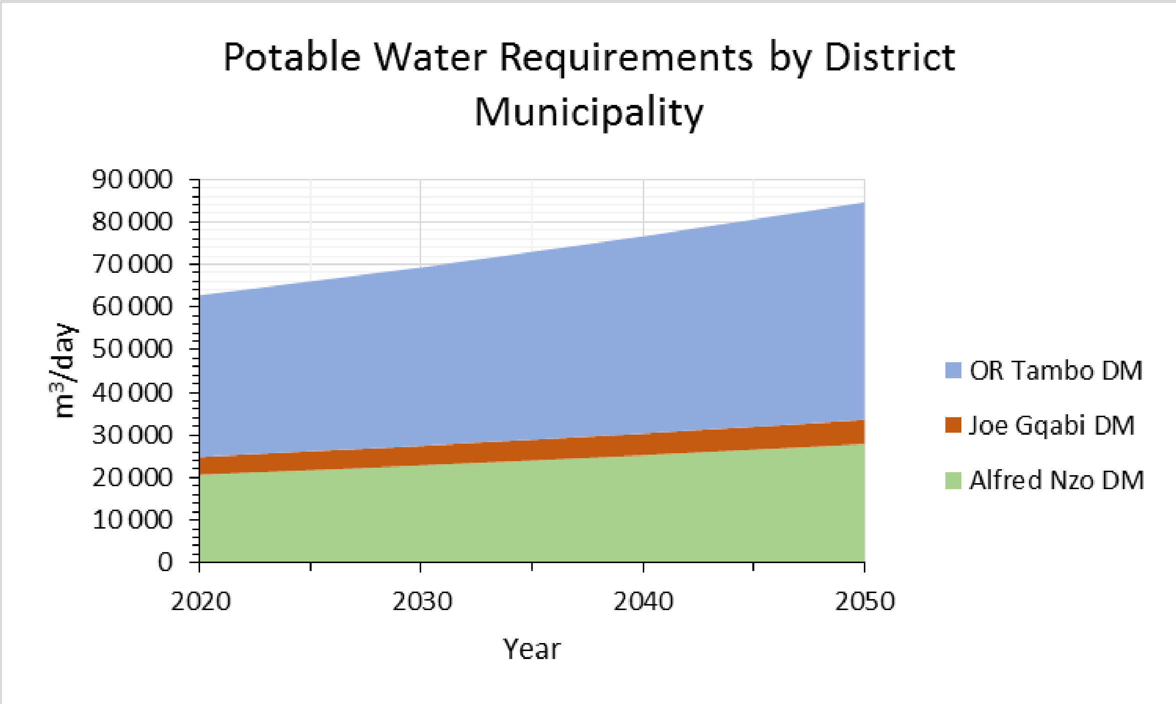


Figure 6-4: Potable Water Requirements by District Municipality

The starting point of the projection assumes a fully developed bulk water delivery distribution network by the year 2020.

If this completion date or the expected demand uptake is later than this, then certain works (e.g. water treatment works (WTW), installed pumping plant, and bulk water storage facilities) could be developed in stages.

However, the actual economics of such staged development will be dependent upon the amount of available initial grant funding as well as the expected "roll-out" of the tertiary distribution system and rate of uptake of water connections as determined during the detailed design stage of the project.

From the above table, and adding allowances for treatment losses, the total average daily water requirement for domestic purposes in the year 2050 is expected to be **32.4 million m^3/annum**.

6.5 Agricultural Water Requirements

As described above, it was estimated that some 2 868 ha of viable irrigable land could be supplied with bulk raw water from the proposed Ntabelanga Dam.

The climate of the Tsolo area is characterised by mean daily maximum temperature of 22°C, a mean minimum temperature of 9°C, and a mean temperature of 16°C. Mean annual precipitation is 780 mm, total annual evapotranspiration is 1 659 mm and mean humidity 65%. Frost does occur and occasional snow on the higher lying areas cannot be ruled out. Crops tolerant of a cool climate must therefore be considered.

A range of crops suited to the climate were considered, together with expected yields and water requirement per crop. For a mixed enterprise farming operation, a range of crops could be planted on varying areas. A typical irrigation water use was therefore determined based upon a likely planting scenario. This resulted in an irrigation rate of 619 mm/a, in an average year.

An upper limit of irrigation requirement has been determined by considering a reference crop with a crop factor of 1 planted year round. The upper limit was 1 141 mm/a for this reference crop.

The total water requirement determined for this upper limit was used to size the bulk water distribution system's capacity. For a total irrigated area of 2 868 ha, it was thus estimated that the maximum water requirement from the dam would be 32.7 million m^3/a.

In order to model average annual operating costs and to estimate the average annual irrigation water abstraction from the Ntabelanga Dam, an average irrigation application rate of 880 mm/a (i.e. (1 141 + 619) / 2) was applied to the above irrigable areas, which after allowing 10% for losses, gave an annual irrigation raw water requirement of **27.8 million m^3/annum**.

6.6 Total Bulk Water Supply Requirements

Taking the two bulk water supply components described above, Table 6-4 summarizes the total water requirements from the Ntabelanga Dam before other considerations are included.

This annual average raw water requirement was applied to the WRYM yield model, together with the Environmental Water Requirements value developed to meet the ecological category C classification recommended by the Reserve Determination team and as given in Report No. P WMA 12/T30/00/5212/7.

6.7 Water Requirements for Hydropower

The primary focus for the hydropower component of the study was to investigate a conjunctive use scheme that would include the Lalini Dam downstream of the initially proposed Ntabelanga Dam. The Lalini Dam would be used primarily for hydropower generation (after allowing the EWR downstream of the dam to be maintained) with the objective being to seek to improve the financial viability of the scheme as a whole through the provision of an additional income stream from energy sales.

Table 6-4: Summary of Raw Water Demand on Ntabelanga Dam

TREATED BULK WATER SUPPLY REQUIREMENTS				
Bulk Supply Service Reservoir	**Population Served in Year 2050**	**Average Requirement**	**Conveyance Losses**	**Total Required**
		litres/capita/day	**%**	**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
Mvlimwlano 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	**32.42**
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	**27.76**
Grand Total Raw Water Requirement at Ntabelanga Dam			million m^3/a	**60.18**

NB: for hydropower modelling scenario, total requirement has been rounded to 60 million m^3/a

The proposed infrastructure configuration to generate hydropower is summarised in sections below, and is described in detail in Report No. P WMA 12/T30/00/5212/19. In summary, this comprises a balancing storage and flow diversion facility at the identified Lalini dam site (some 3.5 km along the river centreline upstream of the Tsitsa Falls, and the development of a 7.9 km long conduit (comprising a pipeline laid partly in the ground and partly in a tunnel) to convey diverted river flow through a drop in elevation of approximately 300 m to a hydro-electric plant (HEP), and back into the Tsitsa River in the gorge downstream of the Tsitsa Falls.

The hydropower assessment of the Lalini Dam, including the simulation of the Ntabelanga Dam as a balancing dam upstream, required a slightly different modelling configuration when compared to the domestic and irrigation supply only configuration, in order to assess the hydropower generation capabilities at Lalini.

The analysis undertaken produced results which showed that the simulated base load (average) hydropower generation from the Lalini Dam ranged from 12.5 MW to 50 MW, depending on the status of the river in terms of season, drought or flood conditions, and the combination of storage capacity options for the Ntabelanga and Lalini Dams. Given the physical dam capacity constraints which are limited by topography and environmental and social impacts, the preferred installed capacity solution was determined to be some 37.5 MW.

The outcome of the investigations indicated that hydropower generation potential at the Lalini Dam, with Ntabelanga Dam acting as a regulating dam for the production of hydropower at Lalini, is potentially cost-beneficial in a multi-purpose scheme. The optimum solution was shown to be one where the Ntabelanga Dam was constructed to a maximum capacity of 1.18 MAR_{PD} (Mean Annual Runoff based upon present day conditions), as constrained by topographical limitations, with the Lalini Dam capacity set at 0.28 MAR_{PD}.

The current and future water requirements for domestic water users and irrigation potential (combined and rounded to 60 million m^3/a) could, however, be met in all of the hydropower scenarios presented. The above analysis also made allowances for the continuous maintenance of the recommended EWR for the river reaches below both these dams

For the recommended conjunctive scheme where this maximum capacity Ntabelanga Dam was analysed, hydropower generation of an average of 1.57 MW and 1.83 MW is also possible at the Ntabelanga Dam and Lalini Dam respectively.

Given that Lalini Dam is currently solely to be used for hydropower and is purely a storage balancing component, it is not normal to use the terminology of “yield” other than in terms of an energy yield.

From the hydropower model with the recommended 37.5 MW installed capacity, the following water requirements resulted:

1. An average of 297.3 million m^3/a would be required to be released from the dam as EWR; and
2. An average of 291.2 million m^3/a would be passed through the main hydropower plant conduit, through the plant, and then returned back to the river downstream of the Tsitsa Falls.

The remaining unused inflow is either stored in the dam or passes over the spillway as spills.

Table 6-5: Average Water Balance at Each Dam

Reconciliation of Average Annual Water Usage at each Dam by 2050 (million m^3/a)							
	MAR_{PD}	**Potable Water**	**Irrigation**	**EWR**	**Mini Hydropower**	**Main Hydropower**	**Spills and Evaporation**
Ntabelanga Dam	415	32	28	87	uses EWR release	none	268
Lalini Dam*	828	-	-	297	uses EWR release	291	240

**NB: There is no net abstraction from the river by the Lalini Dam as the water used for hydropower is returned to the river at the main HEP*

7. GEOTECHNICAL INVESTIGATIONS

7.1 Introduction

This section summarises the geotechnical investigations undertaken during Phases 1 and 2 of the feasibility study, which eventually focussed on the selection of a single dam site, at Ntabelanga. Full details of these investigations are given in the Geotechnical Investigations: Ntabelanga, Somabadi and Thabeng Dam Sites Report No. P WMA 12/T30/005212/10.

A two-phase feasibility level dam site geotechnical investigations on the Mzimvubu Water Project commenced during October 2012. From reconnaissance level studies previously undertaken, three potential dam sites were shortlisted, namely the Thabeng, Somabadi and Ntabelanga sites.

The Phase 1 geotechnical and site selection feasibility investigations entailed an initial visual appraisal of each of the shortlisted sites considering a number of influence factors, followed by limited rotary core drilling, comprising one borehole on either side of the river at each of the three sites. The factors considered in the selection process included the following:

- Topography and valley shape;
- Accessibility of equipment for investigation and construction purposes;
- Geology and founding conditions. This considered the influence of lithology and geological structure on the integrity of the foundation, stability and water tightness;
- The availability of construction materials for earthfill, rockfill and concrete dam types within the future impoundment basin of a dam constructed at the sites; and
- The effects of a dam constructed at the site on the local environment and infrastructure.

Rotary core boreholes were positioned above each river bank on the dam flanks and drilled to depths of about 40 m each. Water pressure tests were carried out in the boreholes, generally at 3 m intervals or such other stage lengths as deemed appropriate.

The following sections focus on the investigations undertaken for the selected dam site at Ntabelanga.

7.2 Foundation Investigations

At the Ntabelanga site both the visual appraisals and the subsequent drilling indicated a potentially good dam site. The drilling results indicated suitable founding conditions on dolerite below depths of between 4 m to 6 m on the chosen alignment. Water pressure tests gave generally low lugeon values indicating negligible water loss and hence relatively low grout takes.

Generally high Rock Quality Designation (RQD) and low fracture frequency values indicate good quality, competent dolerite. The drilling undertaken did not indicate any fatal flaws at the two positions drilled, in the form of faulting or other geological features that could compromise founding conditions or water-tightness of the foundation.

The valley profile and founding conditions encountered appear to be equally suitable for the construction of earthfill, rockfill or concrete dam alternatives. Construction materials for alternative dam types also appear to be readily available within the future impoundment basin.

Following comparative suitability assessments the Ntabelanga site was considered to have the most consistent founding conditions, where the foundation along the major proportion of the dam axis will be in dolerite.

Construction materials for alternative dam types also appeared to be more readily available within the future impoundment area of the Ntabelanga site. From the results of the Phase 1 assessment, the Ntabelanga site was selected as the preferred dam site for the more detailed Phase 2 Geotechnical Investigation.

7.3 Phase 2 Investigations at Ntabelanga Dam

The Phase 2 geotechnical investigation focussed on the preferred single dam site, namely the Ntabelanga site. It entailed the undertaking of further drilling, trial pitting, testing, geophysics and the investigation of potential construction materials sources.

The Phase 2 investigation of the Ntabelanga site initially considered two alternative dam alignments approximately 200 m apart. These are as indicated on Figure 7-1.

The Line 1 or upstream alignment corresponds with that investigated during Phase 1.

The centre-line for the Line 2 or downstream alignment coincides with the “nose” of the right abutment hill whence the valley immediately widens into a floodplain. This would allow a shorter side channel spillway discharge chute, would provide slightly easier access and more working space for construction, and would mean that the infrastructure immediately downstream (possibly hydropower house, pumping station, administration buildings, water treatment works) would be located closer to the dam wall but away from any potential backwater flooding effects below the dam.

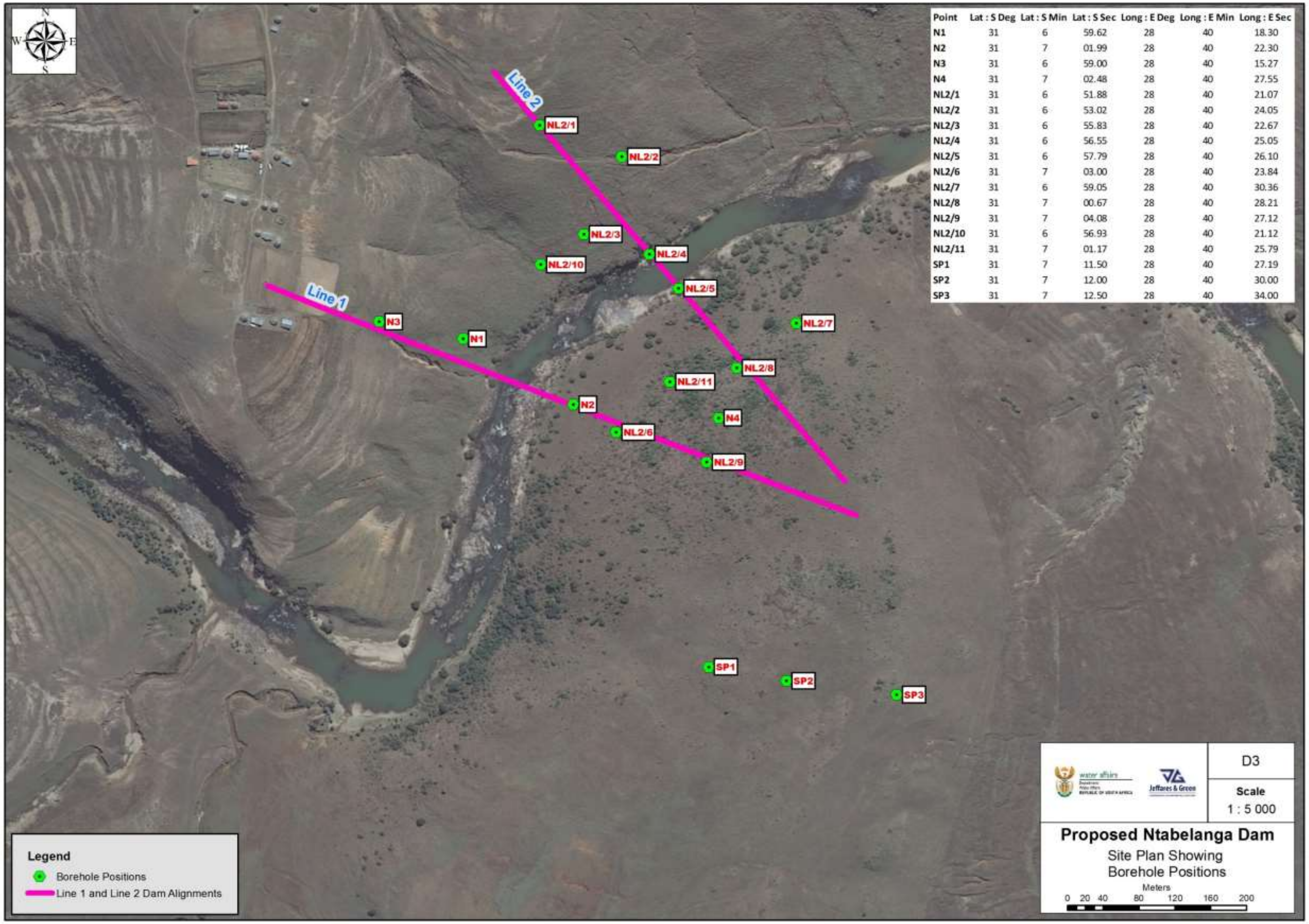
Based upon consideration of the results of the geotechnical investigation and other related factors such as avoidance of structural lineaments, Line 1 was selected as the preferred alignment.

Subsequently, consideration was given to a possible third alignment a short distance upstream of the Line 1 alignment. This would require further verification during the detailed design investigations.

Drilling and trial pit investigations and sampling was also undertaken at three potential spillway options, and in order to ascertain construction materials sources. These are as indicated on Figures 7-2 and 7-3.

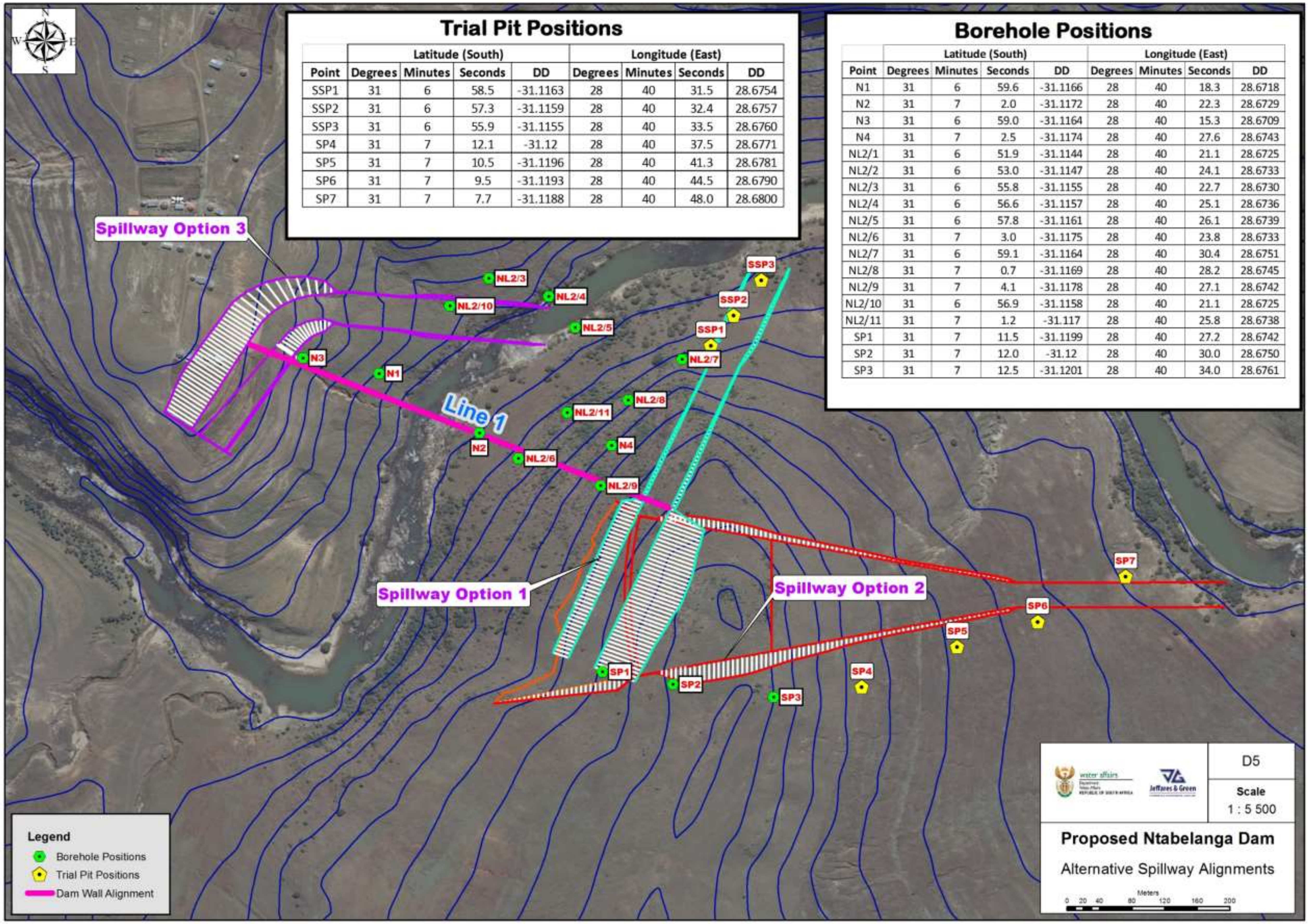
The Phase 2 investigations entailed the following:

- The rotary core drilling of an additional 16 boreholes with a total drilling length of 458.8 m;
- The undertaking of 720 m of seismic refraction and 810 m of electrical resistivity surveys. The surveys were conducted parallel to and transverse to the Line 1 alignment;
- Trial pitting at the dam site and in identified borrow pits to assess founding conditions for the dam and appurtenant structures and undertake suitability assessments of potential construction material sources; and
- Sampling of materials for laboratory testing.



Point	Lat : S Deg	Lat : S Min	Lat : S Sec	Long : E Deg	Long : E Min	Long : E Sec
N1	31	6	59.62	28	40	18.30
N2	31	7	01.99	28	40	22.30
N3	31	6	59.00	28	40	15.27
N4	31	7	02.48	28	40	27.55
NL2/1	31	6	51.88	28	40	21.07
NL2/2	31	6	53.02	28	40	24.05
NL2/3	31	6	55.83	28	40	22.67
NL2/4	31	6	56.55	28	40	25.05
NL2/5	31	6	57.79	28	40	26.10
NL2/6	31	7	03.00	28	40	23.84
NL2/7	31	6	59.05	28	40	30.36
NL2/8	31	7	00.67	28	40	28.21
NL2/9	31	7	04.08	28	40	27.12
NL2/10	31	6	56.93	28	40	21.12
NL2/11	31	7	01.17	28	40	25.79
SP1	31	7	11.50	28	40	27.19
SP2	31	7	12.00	28	40	30.00
SP3	31	7	12.50	28	40	34.00

Figure 7-1: Alternative Ntabelanga Dam Wall Alignments



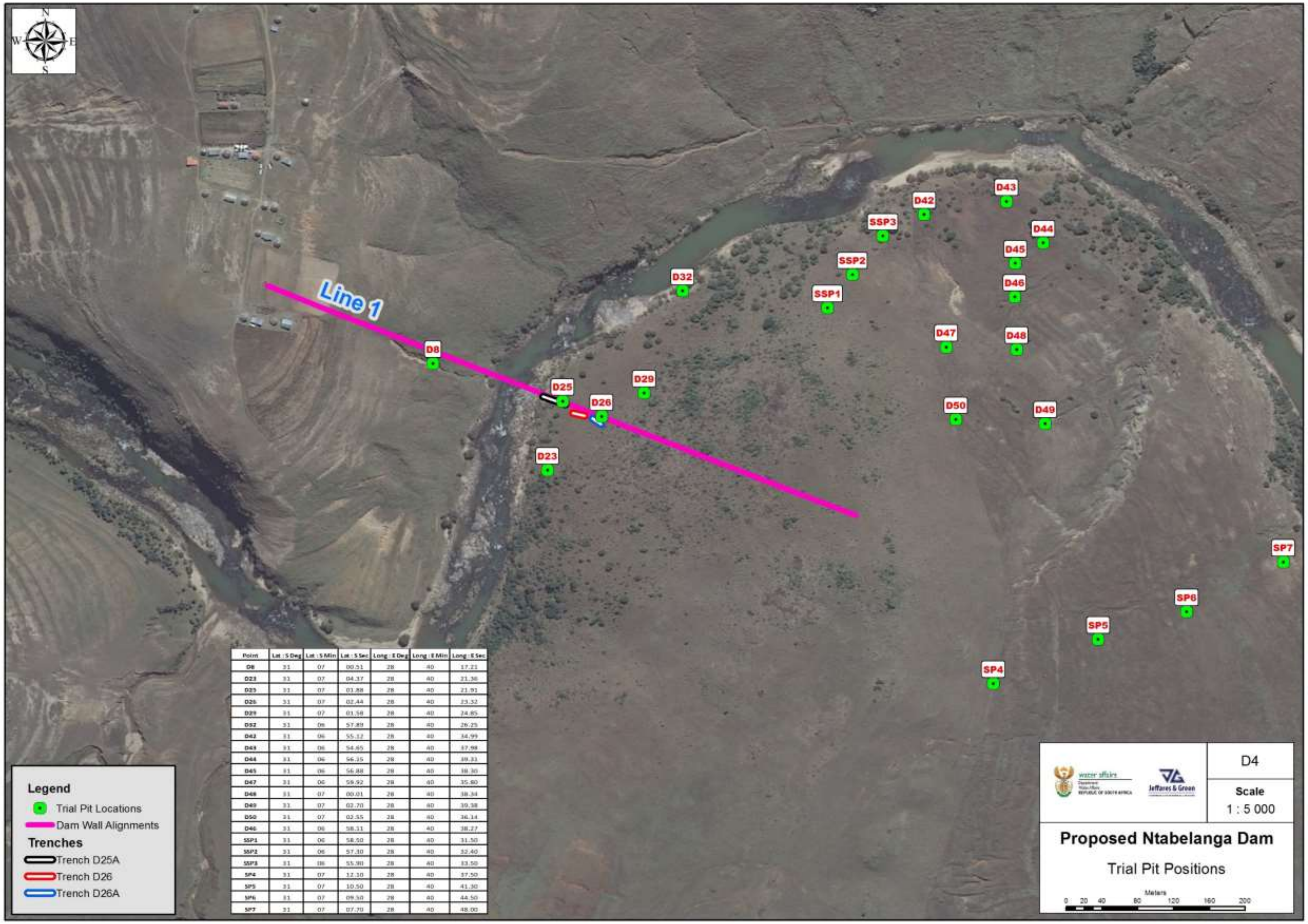
Trial Pit Positions

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
SSP1	31	6	58.5	-31.1163	28	40	31.5	28.6754
SSP2	31	6	57.3	-31.1159	28	40	32.4	28.6757
SSP3	31	6	55.9	-31.1155	28	40	33.5	28.6760
SP4	31	7	12.1	-31.12	28	40	37.5	28.6771
SP5	31	7	10.5	-31.1196	28	40	41.3	28.6781
SP6	31	7	9.5	-31.1193	28	40	44.5	28.6790
SP7	31	7	7.7	-31.1188	28	40	48.0	28.6800

Borehole Positions

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
N1	31	6	59.6	-31.1166	28	40	18.3	28.6718
N2	31	7	2.0	-31.1172	28	40	22.3	28.6729
N3	31	6	59.0	-31.1164	28	40	15.3	28.6709
N4	31	7	2.5	-31.1174	28	40	27.6	28.6743
NL2/1	31	6	51.9	-31.1144	28	40	21.1	28.6725
NL2/2	31	6	53.0	-31.1147	28	40	24.1	28.6733
NL2/3	31	6	55.8	-31.1155	28	40	22.7	28.6730
NL2/4	31	6	56.6	-31.1157	28	40	25.1	28.6736
NL2/5	31	6	57.8	-31.1161	28	40	26.1	28.6739
NL2/6	31	7	3.0	-31.1175	28	40	23.8	28.6733
NL2/7	31	6	59.1	-31.1164	28	40	30.4	28.6751
NL2/8	31	7	0.7	-31.1169	28	40	28.2	28.6745
NL2/9	31	7	4.1	-31.1178	28	40	27.1	28.6742
NL2/10	31	6	56.9	-31.1158	28	40	21.1	28.6725
NL2/11	31	7	1.2	-31.117	28	40	25.8	28.6738
SP1	31	7	11.5	-31.1199	28	40	27.2	28.6742
SP2	31	7	12.0	-31.12	28	40	30.0	28.6750
SP3	31	7	12.5	-31.1201	28	40	34.0	28.6761

Figure 7-2: Ntabelanga Dam Alternative Spillway Alignments



Point	Lat : S Deg	Lat : S Min	Lat : S Sec	Long : E Deg	Long : E Min	Long : E Sec
D8	31	07	00.51	28	40	17.21
D23	31	07	04.37	28	40	21.36
D25	31	07	01.88	28	40	21.91
D26	31	07	02.44	28	40	23.32
D29	31	07	01.58	28	40	24.85
D32	31	06	57.89	28	40	26.25
D42	31	06	55.12	28	40	34.99
D43	31	06	54.65	28	40	37.98
D44	31	06	56.35	28	40	39.33
D45	31	06	56.88	28	40	38.30
D47	31	06	59.92	28	40	35.80
D48	31	07	00.01	28	40	38.34
D49	31	07	02.70	28	40	39.38
D50	31	07	02.55	28	40	36.14
D46	31	06	58.11	28	40	38.27
SSP1	31	06	58.50	28	40	31.50
SSP2	31	06	57.30	28	40	32.40
SSP3	31	06	55.90	28	40	33.50
SP4	31	07	12.10	28	40	37.50
SP5	31	07	10.50	28	40	41.30
SP6	31	07	09.50	28	40	44.50
SP7	31	07	07.70	28	40	48.00

Figure 7-3: Other Ntabelanga Trial Pit Positions

Cross-sections at the two Ntabelanga Dam wall alignments are given in Figures 7-4 and 7-5, which summarise the borehole core logging results of the above investigations. Locations of identified construction materials borrow areas and quarries are indicated on Figure 7-6.

7.4 Construction Materials Availability and Suitability

The geotechnical and materials investigations undertaken during Phase 2 considered the following potential dam types:

- Concrete faced rock-fill (CFRD) dam;
- Earth core rock-fill (ECRD) dam;
- Earth core earthfill embankment dam (EF);
- Roller compacted concrete (RCC) dam; and
- Composite Central Bathtub Spillway (CCS).

The construction materials requirements for the various dam types were calculated according to embankment or wall configuration and cross section. These are:

CFRD:	1.3 million m³ of rock aggregate
	100 000 m³ of sand
ECRD:	1.1 million m³ of rock aggregate
	260 000 m³ of core
	100 000 m³ of sand
EF:	65 000 m³ of rock aggregate
	2.1 million m³ of shell (general shoulder fill)
	50 000 m³ of core
	25 000 m³ of sand
RCC[#]:	500 000 m³ of rock aggregate
	200 000 m³ of sand
CCS:	1 million m³ of rock aggregate
	20 000 m³ of shell (general shoulder fill)
	200 000 m³ of core
	150 000 m³ of sand

[#] Majority of these quantities constitutes the concrete volume

Competent, hard dolerite rock underlies the middle to upper right flank, generally occurring near to the surface at depths of under 1m or as sporadic surface outcrop. Tests conducted on the core samples indicate high strength rock with a low degree of alteration. These demonstrate that the rock will provide good foundations and will be suitable for both the production of rock fill and concrete aggregate.

The reserves of potentially good quality dolerite in the hill to the east and south east of the dam, of which the right flank is a part, are extensive and far in excess of the required quantities for any of the above listed dam alternatives.

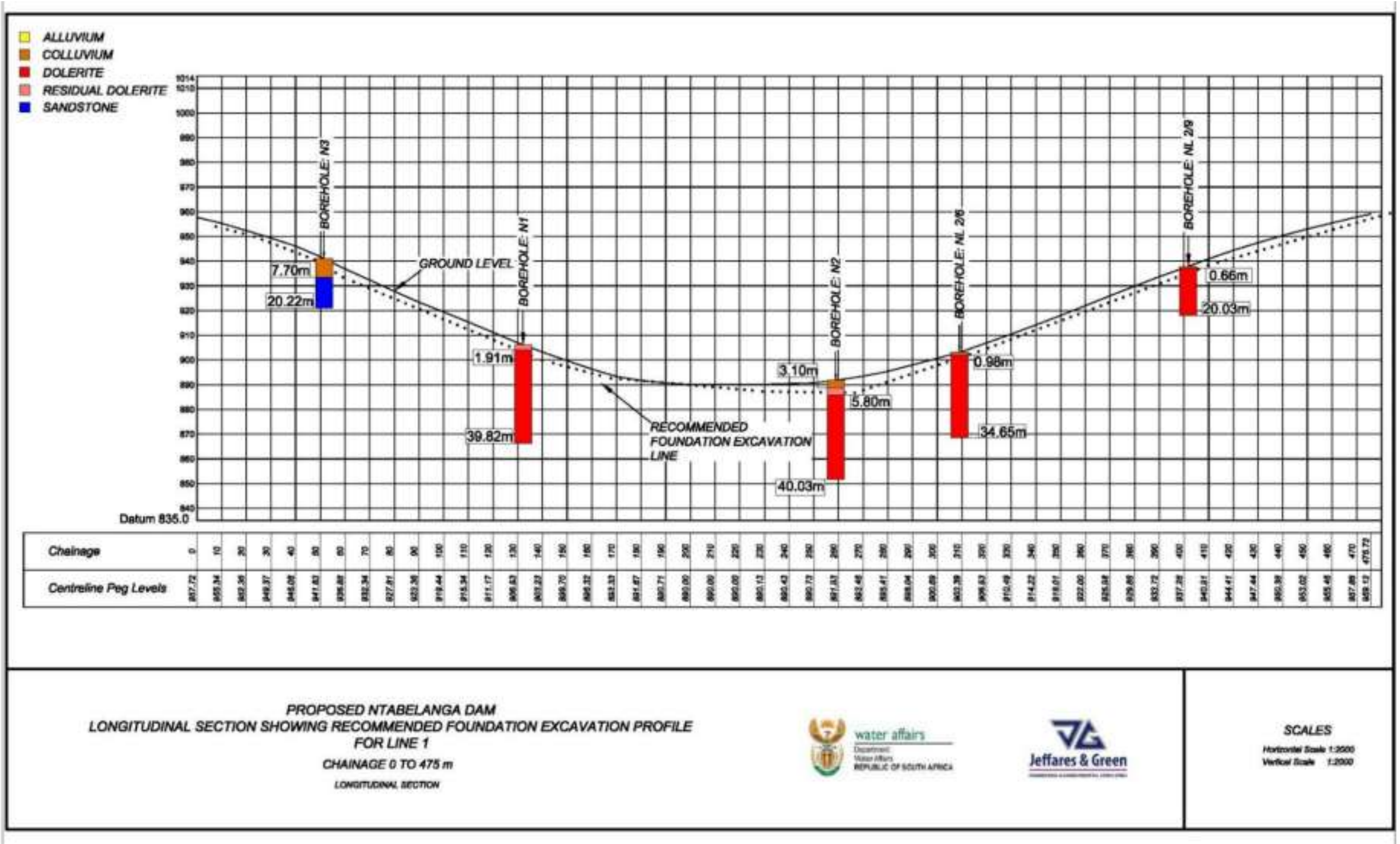


Figure 7-4: Line 1 –Core Log Summary and Recommended Foundation Profile

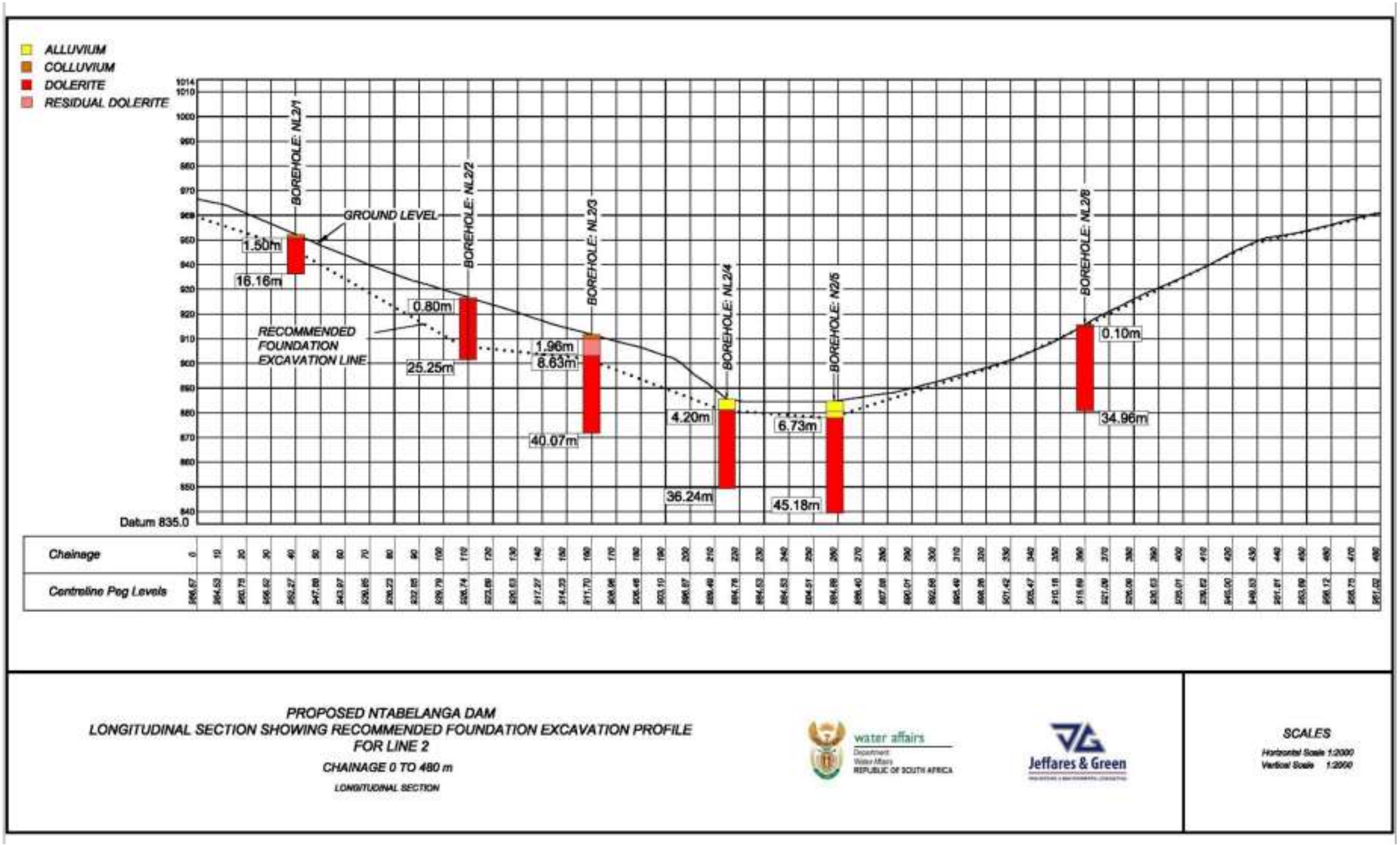
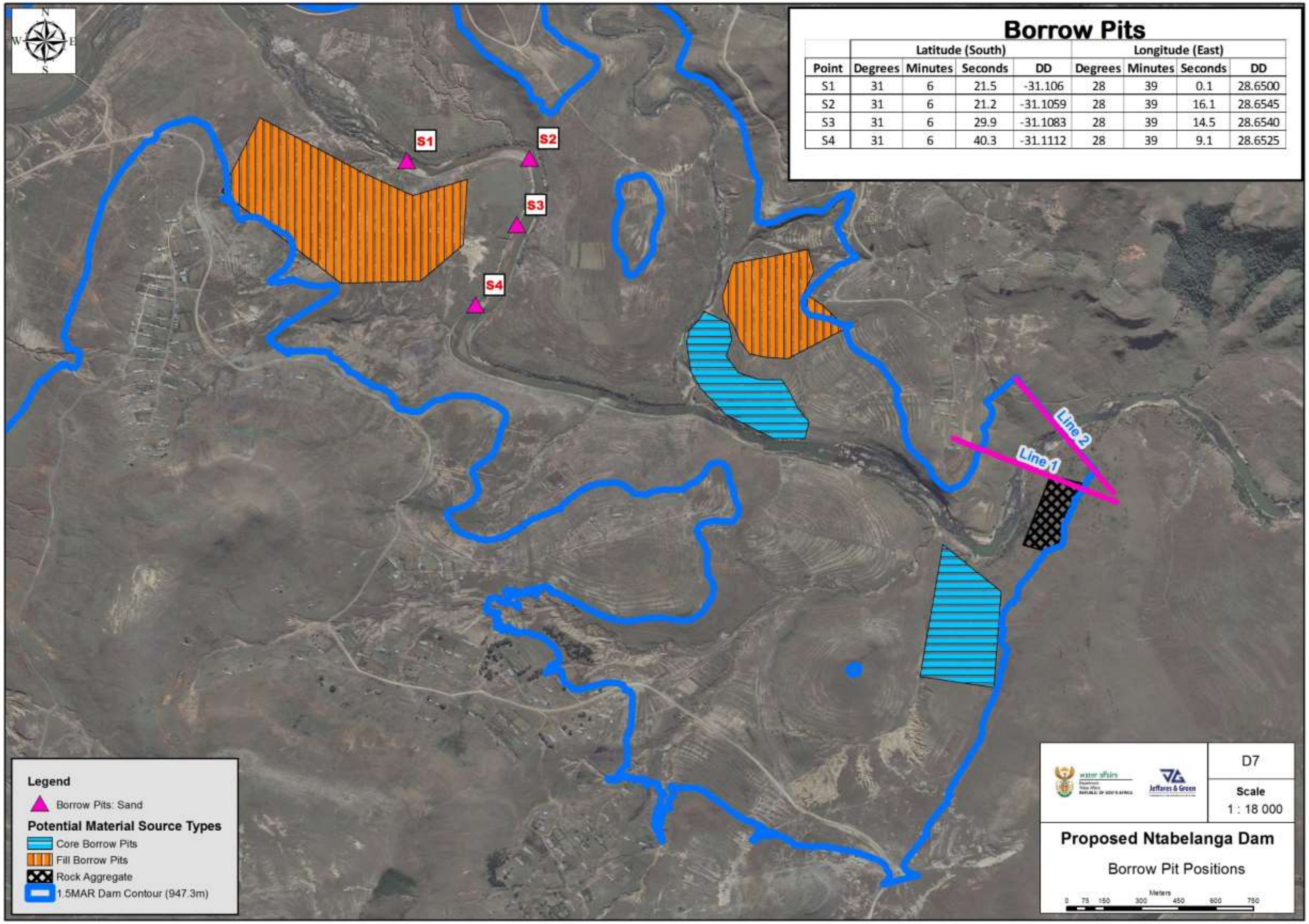


Figure 7-5: Line 2 –Core Log Summary and Recommended Foundation Profile



	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
S1	31	6	21.5	-31.106	28	39	0.1	28.6500
S2	31	6	21.2	-31.1059	28	39	16.1	28.6545
S3	31	6	29.9	-31.1083	28	39	14.5	28.6540
S4	31	6	40.3	-31.1112	28	39	9.1	28.6525

Figure 7-6: Potential Borrow Areas and Quarries

Drilling indicated that a quarry located on the right flank upstream of the dam and within the basin would yield adequate rock aggregate for the construction of both the dam and the appurtenant concrete structures. The spillway configuration could be designed to duplicate as a quarry.

Extensive sand deposits occur in the Tsitsa River upstream of the dam. The Tsitsa River in the project area generally flows in a relatively incised channel with sand deposits confined to the river channel. Therefore the deposits are relatively narrow and would require selective seasonal exploitation during the dry season. Indications are that in excess of the required volumes of sand for construction purposes for any of the dam alternatives can be acquired from the Tsitsa River within the future impoundment basin. However, the grading of this sand material is too fine for usage in filters or concrete unless it is blended with other coarser materials such as rock crusher run material.

Reddish brown, clayey hill-wash deposits associated with dolerite occur in relative abundance throughout the project area. These were tested from within the basin and found to be suitable for use as core. Indications are that sufficient reserves of good quality core material will be available in the project area for the construction of an embankment dam.

The shell requirements for the earth embankment dam (EF) option are of the order of 2.1 million m^3. Sedimentary rocks comprising mainly mudrock with intercalated sandstone are widely distributed within the basin and were tested for suitability as embankment shell. These materials tended to break down under compaction rendering them insufficiently permeable for use as pervious fill, and only marginally suitable for use as semi-pervious fill.

Whilst the latter could be used as embankment fill material, this would mean designing the embankment with very shallow slopes, significantly increasing the cost of the earthworks and hence overall dam costs, above the values used to compare dam types.

Consideration could be given to the investigation of extensive sandstone deposits in the surrounding hills or weathered dolerite, but these occur well outside of the future impoundment basin and the exploitation of the large quantities required would have long haul distances (with significant cost implications) and could have significant environmental impacts. These factors have been allowed for in the rates used in the cost estimates, and significantly increase the cost of an earthfill dam option. The paucity of suitable shell material within the basin is thus viewed as a significant constraint to the construction of an earth embankment dam.

For an embankment dam, including the earthfill and rockfill options, two alternative side-channel spillway alignments on the upper right flank were initially proposed, and a third alternative was proposed on the left flank (see Figure 7-2). All of these options required significant excavations to be undertaken and the investigations were structured to assess their suitability for being designed as unlined channels and suitability to duplicate as a rock quarry.

Spillway Option 1 proposes a spillway channel cut into the upper right flank and orientated south to north. The first approximately 330 m of the spillway axis along the hill crest display visible outcrop and sub-outcrop. This coupled with the drilling results, which indicate competent, near surface dolerite along this section implies good potential as an aggregate source.

Deeper soils and weathering profiles were apparently down the hill-slope further along the spillway axis. The transported and residual soils are particularly deep towards the end of the spillway chute before the outfall into the river. This implies a need to concrete-line the spillway chute to provide protection against excessive erosion. Dolerite outcrop is visible in the river.

Spillway Option 2 proposes an excavation cutting through the hill upstream of the dam in an easterly direction. Dolerite outcrops and sub-outcrops are visible along the first approximately 190 m of the spillway axis and drilling also indicates a shallow rock head profile.

Spillway Option 2 offers better founding conditions along the alignment of the lower chute than spillway Option 1, but the large quantities of rock excavation would be far in excess of the quantities required for the embankment construction and concrete aggregates. This would create the problem of disposal and spoiling of the excess quantities.

Spillway Option 3 proposes a side channel cut into the left flank, perpendicular to the dam axis on the upper left flank, then curving just in front of the downstream dam toe to intersect the river. There is sub-outcrop of sandstone on the upper left flank, but the remainder of the spillway alignment is underlain by a relatively thick mantle of transported and residual soils.

This upper spillway side-channel would be excavated in sandstone. From mid-slope, the chute and stilling basin excavation would be in dolerite. Being located on the steeper left flank, the depth of excavation, particularly along the western face would be deeper than the corresponding spillway option on the right flank, namely spillway Option 1.

The sandstone cores derived from the boreholes failed some durability tests and would not be suitable for rock-fill purposes, and would also not be suitable for use as crushed aggregate. Dolerite derived from excavation would be suitable for use as rock-fill and concrete aggregates, although it is doubtful that this option would provide sufficient hard rock dolerite for the project requirements, necessitating an additional hard rock source to supply the shortfall. This would ideally be located on the right flank, where two spillway options are situated.

An RCC or CCS dam alternative would be designed with a central in-channel spillway. The aggregate for the RCC dam and for the spillway of the CCS dam would require a separate rock aggregate source, again ideally located on the mid to upper right flank, where the other spillway options are sited.

The conclusions drawn following these geotechnical and materials investigations were that the founding conditions at the dam site and the materials availability within the impoundment basin would be suitable for the construction of all of the alternative dam types mentioned above.

The exception is the earthfill option for which large quantities of embankment shell material would possibly need to be sourced from outside of the basin, with significant haulage cost and potential environmental impacts. The alternative to this would be a very conservative design for the embankment which would also lead to significantly increased construction cost.

Further site and materials investigations will be required to properly inform the detailed design process.

8. FEASIBILITY DESIGN: NTABELANGA DAM

8.1 Introduction

This section summarises the feasibility design of the dam as described in Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12.

8.2 Dam Location

A review of the location of the Ntabelanga Dam wall, identified both in previous studies and in Phase 1 of this study, was undertaken both using topographical mapping as well as field reconnaissance. The proposed Ntabelanga Dam is located approximately 55 km north of Mthatha on the Tsitsa River, at co-ordinates 31° 7' 1.40"S, 28°40' 20.45"E (see Figure 8-1).

It was concluded that there were no better upstream dam wall locations available with regard to river valley shape (which affects dam wall length), geology/founding conditions, close proximity to construction materials, and the depth verses volume characteristics of the impoundment.

Both upstream and downstream of the primary dam site, the valley widens and flattens, and the next suitable dam site location downstream was actually one of the others previously eliminated in the Phase 1 screening process (Malepelepe).

Therefore the more detailed Ntabelanga Dam wall siting investigations focussed on the narrowest part of the Tsitsa River valley just before the valley widens.

8.3 Dam Type Analysis

It was deemed important to consider the range of possible dam type options before committing to the further core drilling to be undertaken in Phase 2. The selected dam type options also determined what other geotechnical investigations (including materials sourcing and geophysics) should be undertaken in parallel with the core drilling.

All previous studies and Phase 1 of this study had considered only earth embankment/clay core (earth fill) options. In this feasibility analysis, the study team considered several other options, as well as various spillway arrangements.

The following dam types were investigated in Phase 2:

- Roller compacted concrete (RCC) dam;
- Concrete faced rock fill dam (CFRD);
- Earth core rock fill dam (ECRD);
- Earth fill 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, channels cut through the hill, or central spillway were also investigated.

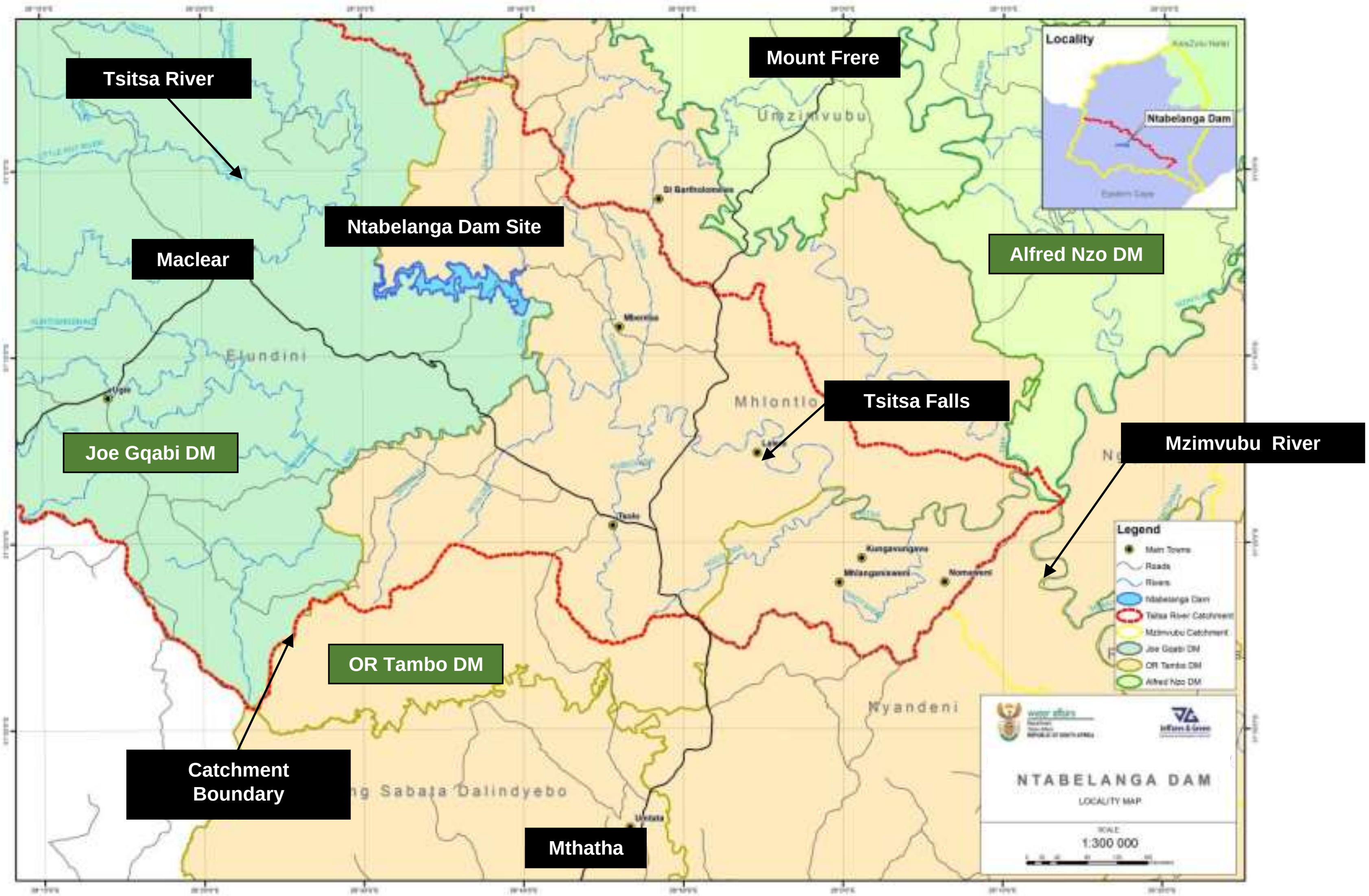


Figure 8-1: Location of Ntabelanga Dam

Key factors used in determining the optimum dam type were as follows:

- Availability of sufficient quantities and quality of construction materials in the vicinity of the dam wall;
- Constructability issues, especially relating to dealing with river flow during construction;
- The ability of DWS to design and construct the dam in-house;
- Spillway location and capacity requirements;
- Operational requirements and outlet works arrangements;
- Environmental impacts; and
- The cost of the works.

In order to assess materials requirements, quantities were calculated for all of the above dam types, based upon typical design criteria (foundation excavation depths, embankment slopes, etc), which were undertaken for all of the above dam types and their spillway options.

The results of these analyses produced a ranking of dam types as shown in Table 8-1.

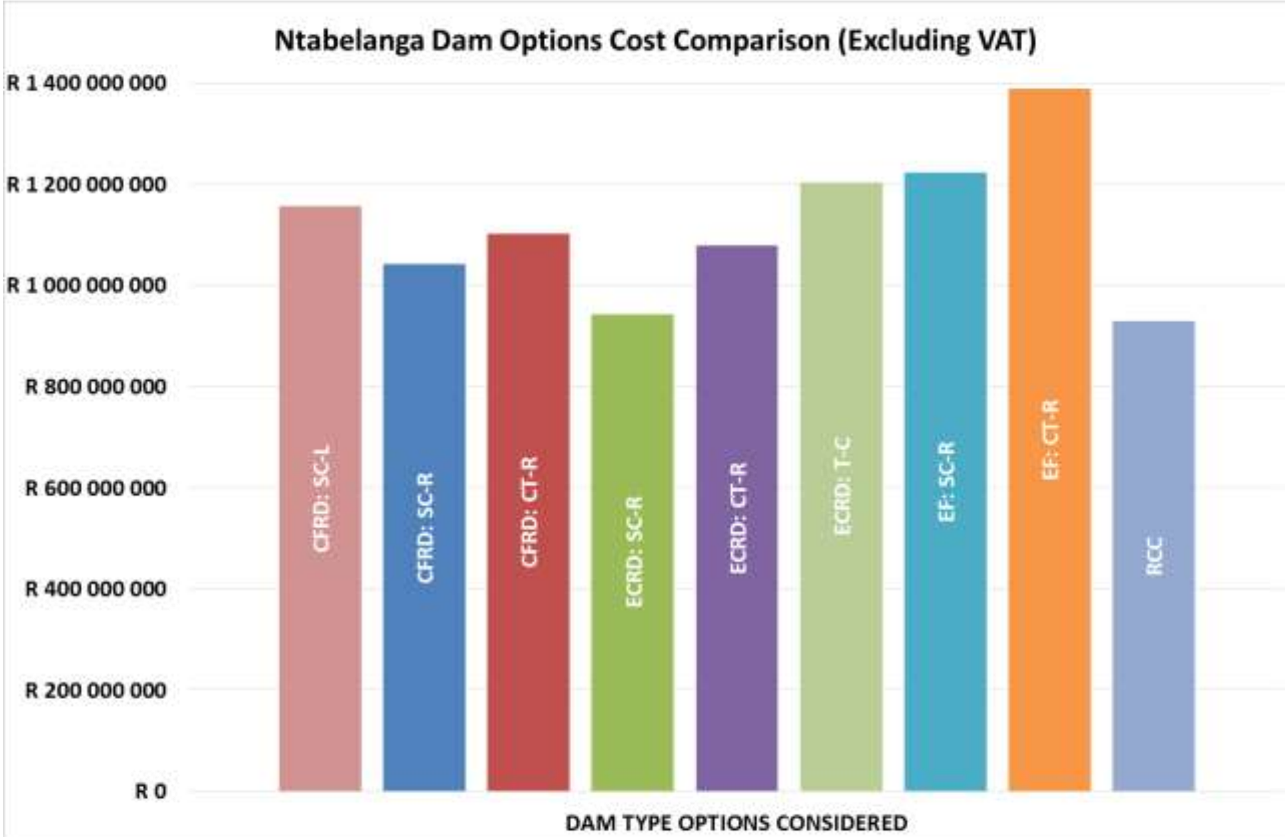
Table 8-1: Capital Cost Comparison of Dam Type and Spillway Options

Option No.	Dam Wall Type	Spillway Type	Capital Cost (R'million)		
			Low	Medium	High
1	CFRD	Side Channel on Right Flank	932	1 043	1 153
2	CFRD	Cut-Through on Right Flank	989	1 103	1 218
3	CFRD	Side Channel on Left Flank	1 036	1 158	1 279
4	**ECRD**	**Side Channel on Right Flank**	**848**	**944**	**1 040**
5	ECRD	Cut Through on Right Flank	977	1 079	1 181
6	Earth fill	Side Channel on Right Flank	1 147	1 224	1 301
7	Earth fill	Cut Through on Right Flank	1 305	1 390	1 474
8	**RCC**	**Central Ogee**	**769**	**929**	**1 089**
9	CCS	Composite Central Channel Spillway	1 009	1 203	1 397

(green)	Lowest
(yellow)	Second Lowest

The green highlighted cells show the lowest cost option for each costing scenario. For the low and medium rate ranges of major quantity unit rates this is Option No. 8, an RCC dam, with Option No.4, the ECRD dam with a Side Channel Spillway cut through the Right-hand Flank, coming second lowest. Only for the highest rates does this ranking reverse.

Figure 8-2 shows the comparative costs of all the options for the medium rates case, as well as main materials quantity information and how much excavated material needs to be disposed of to spoil.



Percentage of lowest cost option	125%	112%	119%	102%	116%	129%	132%	150%	100%
Cost Excluding VAT (R'million)	1 158	1 043	1 103	944	1 079	1 203	1 224	1 390	929
Total rock excavation used in embankment (m^3)	450 000	780 400	1 186 179	815 600	927 600	166 700	0	0	382 381
Total rock excavation to spoil (m^3)	0	0	452 500	0	737 300	0	858 400	1 716 650	39 413
Total all materials to spoil (m^3)	187 700	79 000	610 500	79 000	895 300	23 000	978 200	1 915 350	0

Figure 8-2: Dam Options Cost Comparison

As can be seen in Figure 8-2 which used the "medium rates" scenario, which is considered to be a reasonable assumption given the nature of the dam site and proximity to construction materials, the **RCC** and **ECRD (with right hand side channel spillway)** options are 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 are concerned, and other factors were therefore considered to inform the decision-making process.

8.4 Other Dam Type Selection Considerations

The following considerations were made:

- 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.

8.5 Conclusion on Dam Type Selection

Taking the various decision-making factors into consideration, it was concluded that the preferred dam type is the RCC solution.

This would provide for a simplified operational layout, 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 National Water Resource 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 were analysed in more detail were based on the **RCC solution**.

A draft Scope of Work for detailed design of the works was prepared that allowed for a further review of the dam type and this decision could therefore be re-evaluated in the detailed design stage in the light of more detailed analysis based on additional geotechnical information.

A general arrangement and elevations of the proposed RCC dam solution is given in Figures 8-3 and 8-4.

8.6 Dam Characteristics

The proposed Ntabelanga Dam has the following characteristics:

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.
Emergency drawdown minimum 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
Storage below MOL (V_{50} sedimentation):	37 million m^3
Surface area of lake behind dam:	31.5 km^2
Backwater reach upstream of dam:	15.5 km

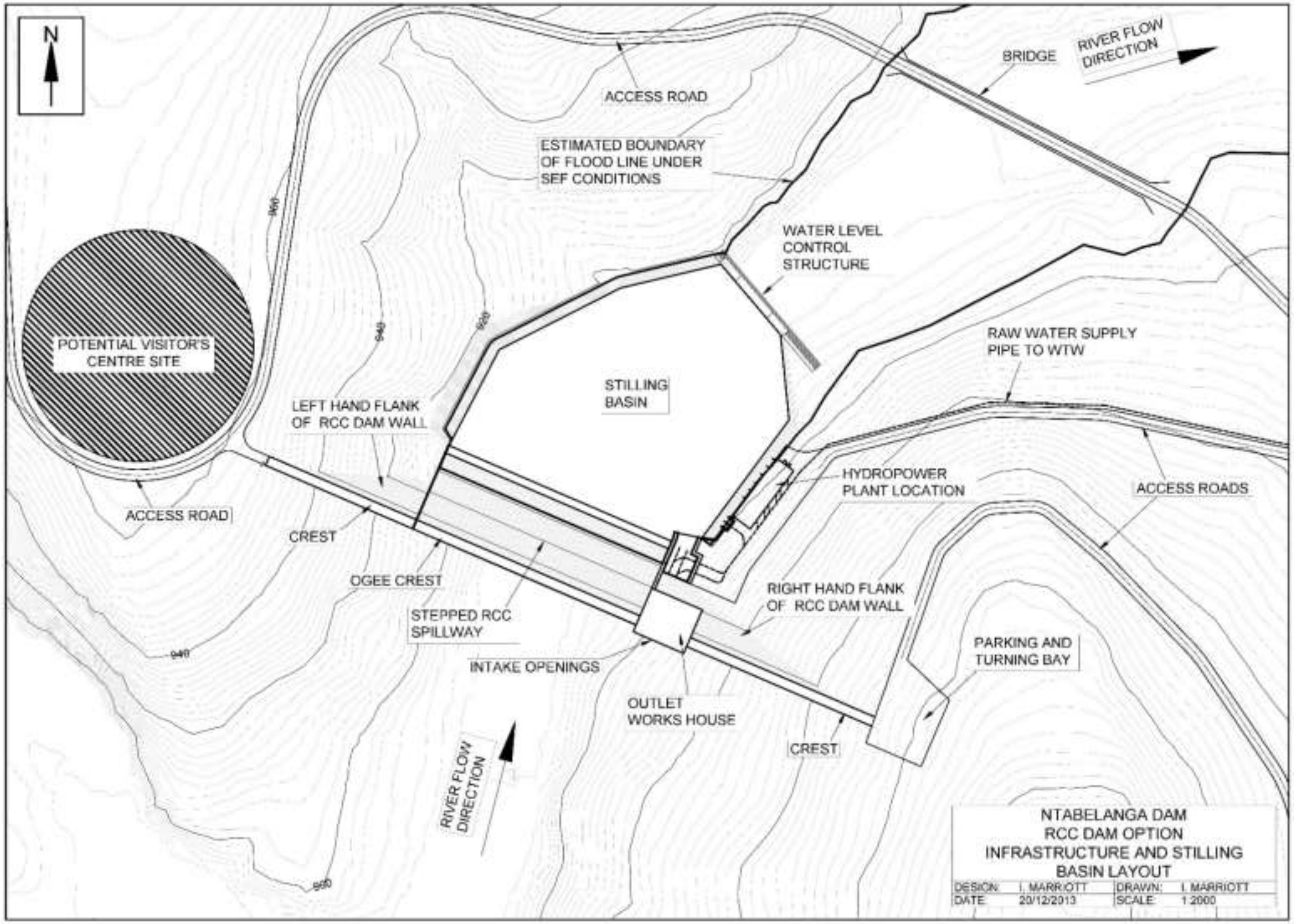


Figure 8-3: Proposed RCC Dam Layout Plan

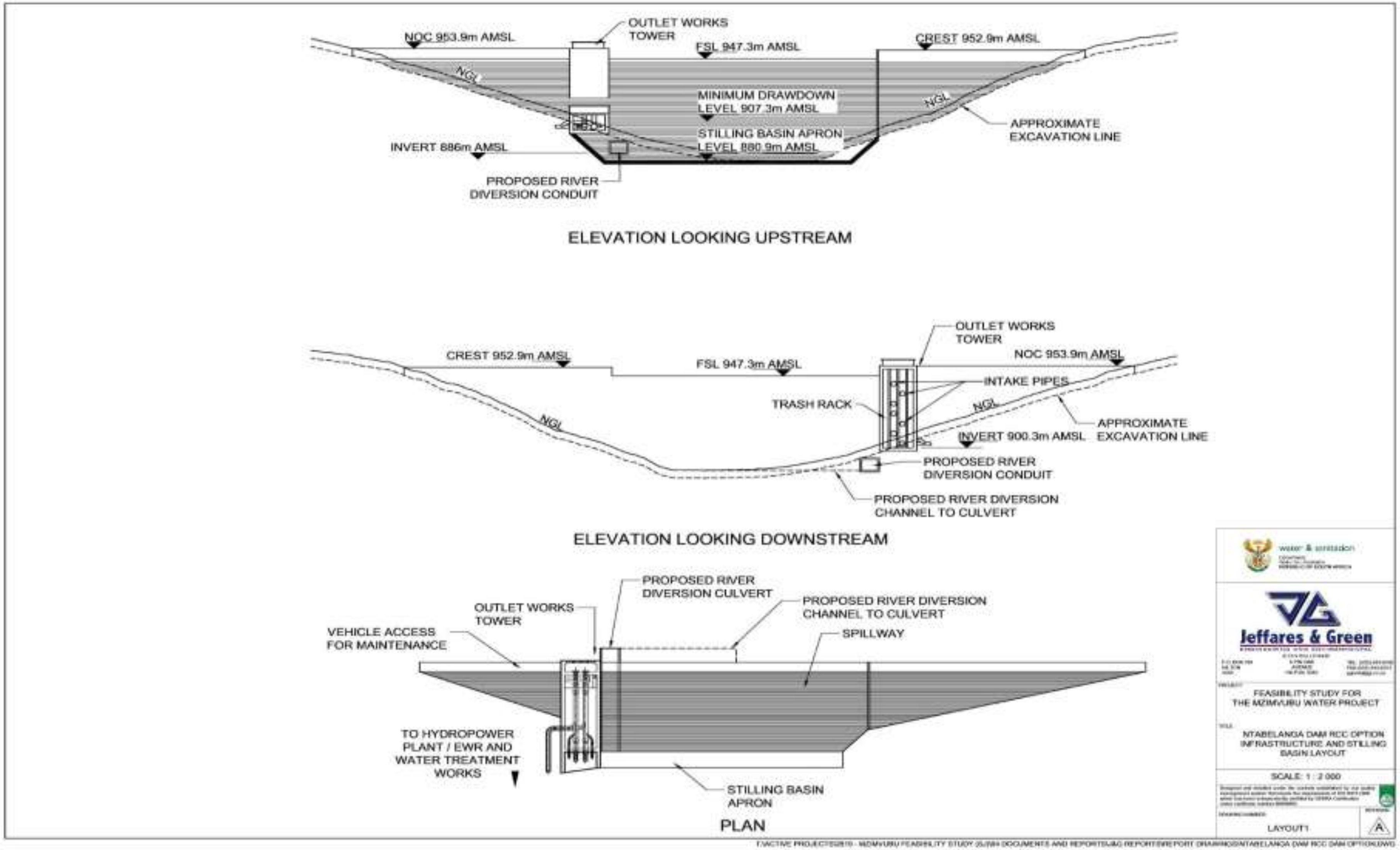


Figure 8-4: Proposed RCC Dam Elevations

The dam wall height, impoundment volume, and downstream risk factors for the Ntabelanga Dam put this structure into a Category 3 dam under gazetted Dam Safety Regulations.

The flood criteria for design of this dam are as follows:

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

The above dam capacity fully meets the potable and irrigation water requirements as well as providing regulated flow releases in the river below the dam to meet the EWR requirements, to generate an average of 1.6 MW of hydropower at the dam wall, and to assure sufficient river flow downstream for the Lalini Dam and Hydropower Scheme.

8.7 Feasibility Design

The Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12 describes the design process for the dam, its outlet works, pumping stations and conveyance systems supplying water to the infrastructure above, as well as the hydropower plant at the dam itself.

Included in that report is a description of how the river will be diverted during construction via a conduit built into the spillway structure as shown in Figure 8-4, which will be permanently plugged once the dam structure is completed and impoundment begins.

8.8 Associated Infrastructure

In addition to the dam and its outlet and conveyance works, the feasibility design also includes the layouts and requirements for the following associated infrastructure:

- Water treatment works location;
- Raw water pump station to the irrigation systems;
- Staff Housing;
- Local road upgrades and realignments;
- Road bridge across the river downstream of the dam;
- Wastewater treatment plant;
- Temporary water supply;
- Main access roads to national roads;
- EWR release facility;
- Hydropower plant;
- Flow gauging stations;
- Power supplies;
- Other access roads to dam crest; and
- Potential location of a Visitor's Centre.

An overall perspective of the dam and its associated infrastructure is given in Figure 8-5.

Budget provisions have also been allowed for a 10 year land care and catchment management programme which is being undertaken by the Eastern Cape Department of Environmental Affairs, as well as the potential funding of in-field equipment and development of the proposed irrigated agriculture farming units.

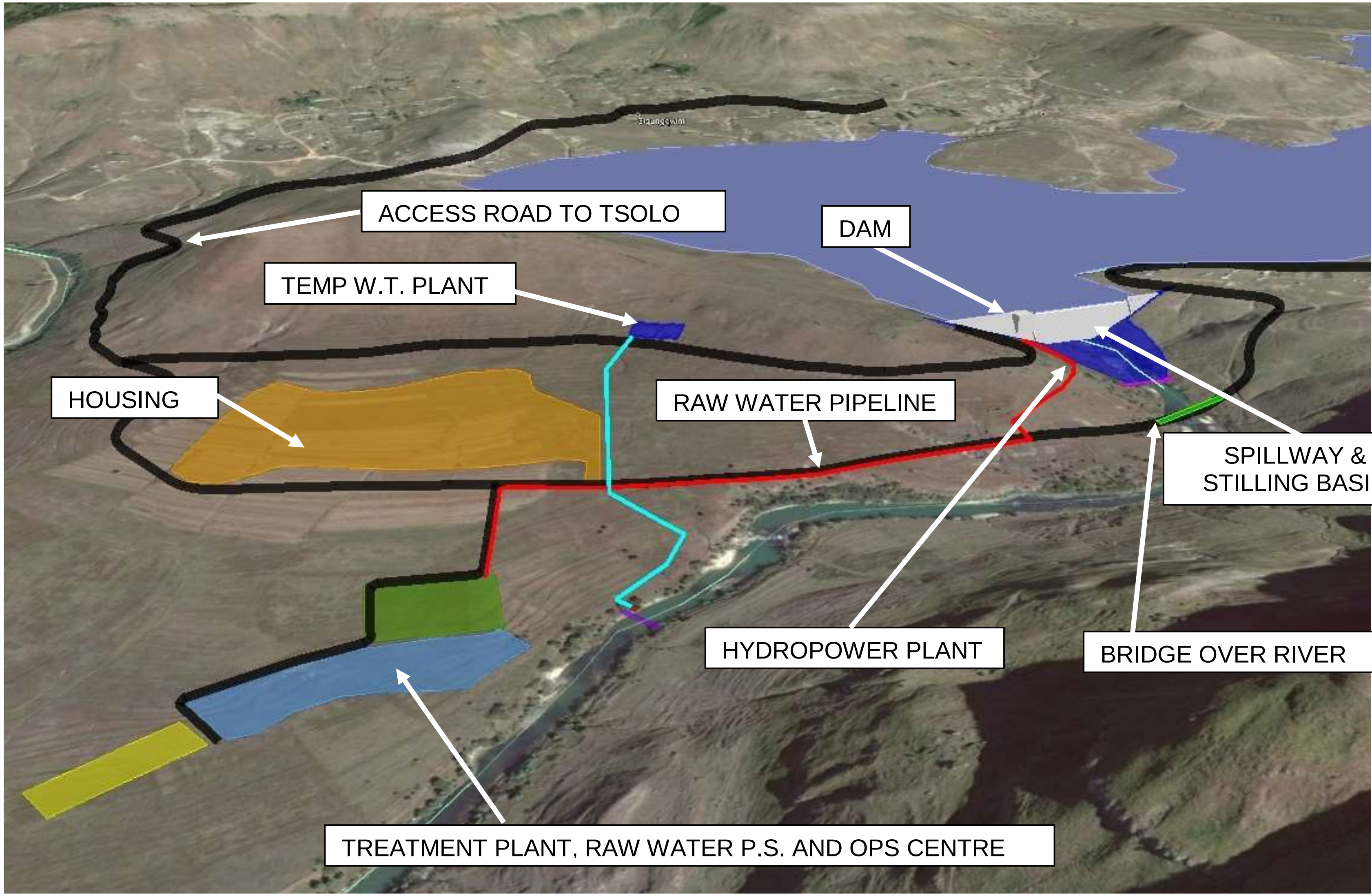


Figure 8-5: Aerial perspective of the Ntabelanga Dam and Associated Infrastructure

8.9 Ntabelanga Dam Mini-Hydropower Plant

The environmental water requirements (EWR) released from the Ntabelanga Dam into the river downstream creates an opportunity for some additional hydropower to be generated at this location. The Hydropower Analysis Report No. P WMA 12/T30/00/5212/18 describes the conjunctive scheme hydropower modelling simulations undertaken and indicates that up to 5 MW can be generated in the wetter months, with seasonal availability of EWR determining outputs that can be achieved in other seasons.

It should be noted that, on average, the full monthly power output targets were met in greater than 70% of the simulation months, and that there were very few months in the total 90 year simulation period whereby the HEP plant would have to be taken off-line altogether.

Table 8-2 and Figure 8-6 provide the results of the modelling run undertaken for the Ntabelanga dam HEP (5MW installed capacity option) when used conjunctively with the Lalini dam and hydropower scheme.

Table 8-2: Model Results: Ntabelanga Dam HEP

Month	Monthly Target (MW)	Avg HP Output (MW)	Avg 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**	

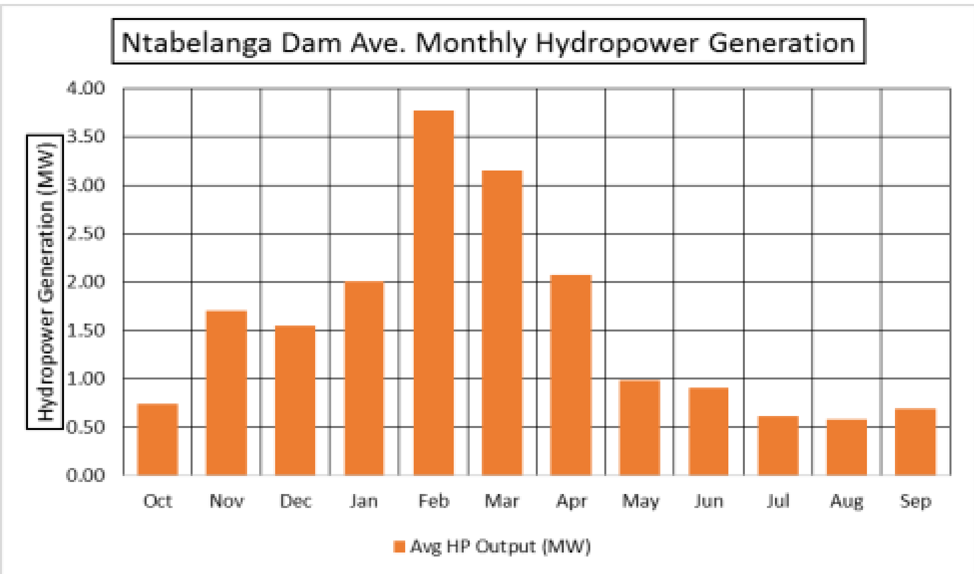


Figure 8-6: Ntabelanga Dam HEP Average Monthly Hydropower Generation

Hydropower plant suppliers were contacted to recommend which types of turbines should be used for this application and provided the following options:

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 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).

Each turbine set is equipped with a tachometer for speed control, 2 temperature sensors (1 per bearing) to check bearing temperature and also 2 vibration sensors (1 per bearing).

Typical "Andritz" pump-turbine units suggested were:

Pump - Turbine FPT40-700 T1, T3 & T5 with asynchronous generator.
Pump - Turbine FPT40-700 T2, T4 & T6 with synchronous generator.

The final decision of which supplier of turbines would be made following a competitive tendering process, and these quoted turbines are only by way of an example.

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

Table 8-3: Lalini Mini-Hydropower Plant Output Performance

Scenario	Head (m)	Flow (m^3/s)	Duty	Power Output (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

Figure 8-7 shows a proposed layout of the hydropower turbine house together with the inlet and outlet pipework arrangements.

When the hydropower plant is not in use, release of water for EWR purposes can still be made via a sleeve valve in the main dam outlet works.

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.

8.10 Cost Estimate

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 8-4.

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.

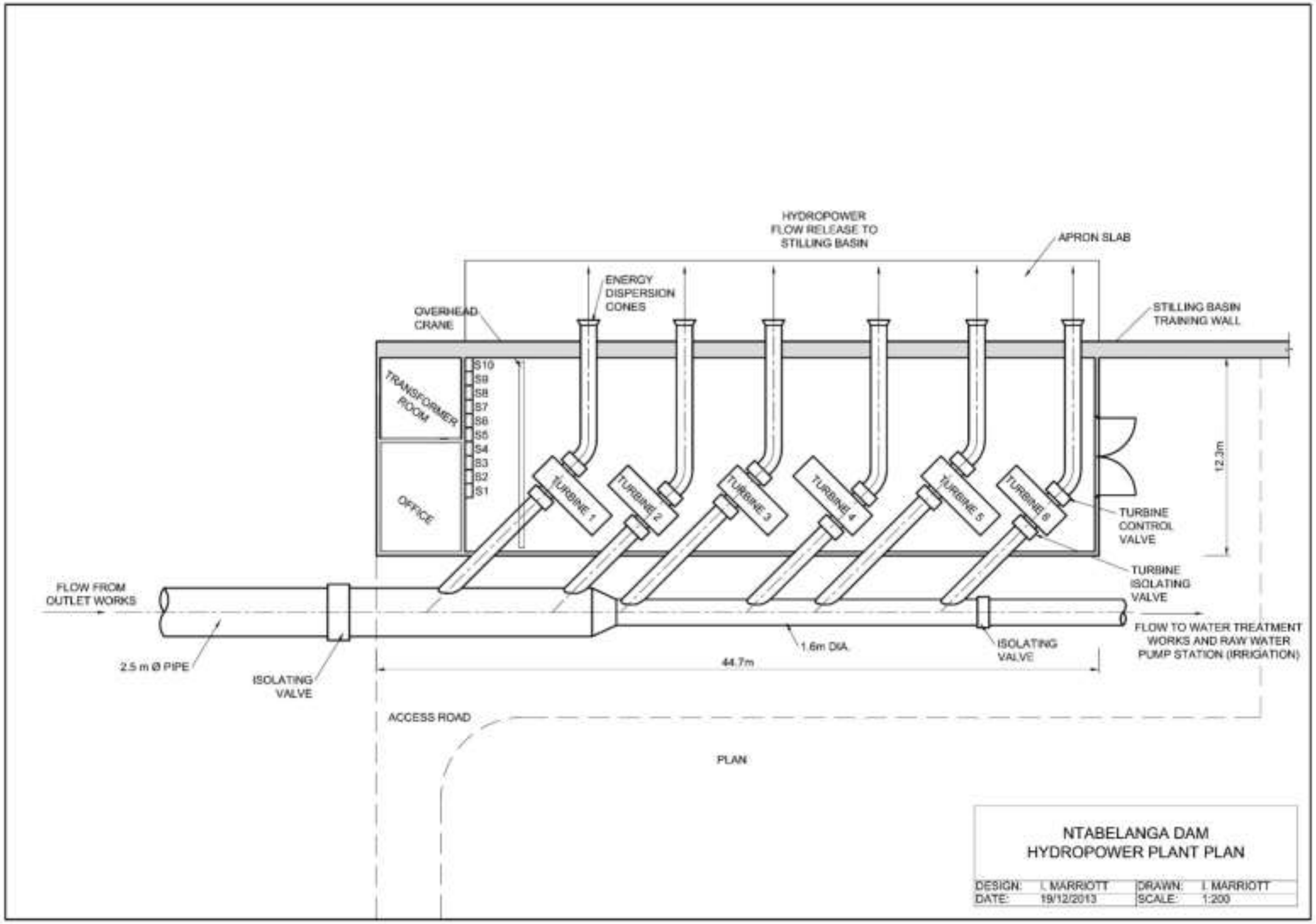


Figure 8-7: Proposed Layout of Ntabelanga Dam Hydropower Plant and EWR Discharge Point

Table 8-4: Capital Cost Estimates

COMPONENT	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 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 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**
In-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 cash flow 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 volatile nature of the economy at the moment;

- 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 an R8.4 billion project increases escalation cost by R38.5 million (at 5.5% p.a.)

8.11 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 been sourced from those currently applied to similar works operated by Amatola Water.

Energy costs (pumping, etc.) are based upon an 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 8-5 summarizes these annual operating and maintenance costs, but these should be treated with caution pending decisions being made on the eventual institutional arrangements.

Table 8-5: 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/YEAR 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	
Lalini Dam and Hydropower Scheme	29.9	6.8	3	3	
TOTALS: R'MILLION/ANNUM	**84.3**	**41.5**	**64.6**	**78.5**	**7.7**

9. BULK WATER DISTRIBUTION INFRASTRUCTURE

9.1 Introduction

This section summarises the Ntabelanga bulk potable and irrigation water distribution systems, including the water treatment works, as described in detail in the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/13.

9.2 Section Overview

The above report outlines the feasibility stage design of the bulk water supply infrastructure for both domestic potable water, and irrigation raw water, including the design criteria adopted, population and household demographics, preliminary design of the scheme, preliminary cost estimates and power requirements for the scheme.

The project footprint is defined as being the area of supply that is possible from the dam system extending outside the catchment into three District Municipalities (DM), 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.

The design criteria adopted are the normal standards used for most water supply infrastructure projects in South Africa. The reference documents used are the "Guidelines for the Development of Human Settlements" (Department of Housing) and the DWS "Technical Guidelines for the Development of Water and Sanitation Infrastructure".

Unit water demands and peak factors were taken from these publications. The unit water demands of 60 litres per capita per day (ℓ/c/d) and 125 ℓ/c/d for rural and urban demands respectively, are in line with the guideline design documents. Water loss allowances in the conveyance systems and at the Water Treatment Works are according to the above DWS guidelines.

More details on the projection of water requirements of this area are given in the Water Requirements Report No. P WMA 12/T30/00/5212/6. The settlements to be supplied with water and their population growth projections are included in Appendix A of that report.

9.3 Domestic Bulk Water Distribution

The design horizon for this project is to the year 2050. The assumption made is that the commissioning of the dam and its water treatment works would coincide with the completion of the bulk water distribution infrastructure for conveyance of water to all of the customers to be served within the supply area. It is assumed that the actual bulk water distribution infrastructure will be implemented in phases, with Primary and Secondary pipelines and reservoirs being developed at the same time as the dam and water treatment works, and the tertiary lines to the many settlements in the supply area, being implemented under the usual bulk infrastructure grant funding available to the respective DMs, with a target of reaching all settlements by 2020 or earlier, if such funding can be made available.

Population figures have been developed from national census databases together with the other information provided by the DWS and DMs in the project area. The annual population growth rate is 1% in line with the planning documentation for the project. The population figures show the population in the project area to be supplied to be 502 822 which increases to 726 616 by the year 2050.

The projected average daily water demands from the scheme for domestic purposes increase from an average of 62 764 m^3/day in 2020 to 84 596 m^3/day in year 2050. The peak demands range from 75 316 m^3/day in 2020 to 101 515 m^3/day in the year 2050. See Water Requirements report.

A water treatment works (WTW) with capacity to supply the above water requirement would be constructed close to the Ntabelanga Dam, and would be supplied with raw water by a gravity pipeline fed from multiple draw-offs at the dam outlet works. For details of this raw water supply arrangement, please see Dam Feasibility Design Report No. P WMA 12/T30/00/5212/12.

The location of this water treatment works relative to the dam is shown on Figure 9-1, and a conceptual layout and hydraulic flow regime of the water treatment works itself is shown on Figures 9-2 and 9-3. The treatment processes envisaged are conventional and will include:

- Flocculation;
- Coagulation;
- Settlement in Clarifiers;
- Filtration in Rapid Gravity Filters; and
- 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 processes 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.

Treated water will be transferred from the clear water pumping stations PS1 and PS3 at the water treatment works to four primary command reservoirs. Treated water will then be delivered to the projected 726 616 consumers predominantly by gravity via the secondary bulk conveyance pipelines and command reservoirs, which feed the tertiary lines to villages and urban centres such as Tsolo and Mount Frere.

The bulk infrastructure required for the scheme is split operationally into four supply zones taking into consideration the logical routing of main bulk supply pipelines, the terrain and elevation variations, and the pattern of the settlements to be supplied within the project area. This is shown in Figure 9-4.

This system is further split into primary, secondary and tertiary infrastructure. The primary infrastructure consists of the water treatment works (supplied with raw water from the Ntabelanga Dam), potable water pumping stations from the treatment works to transfer water to primary command reservoirs, and the bulk water pipelines delivering from this primary storage to the downstream bulk water infrastructure.

Secondary infrastructure links these primary command reservoirs to the secondary command storage reservoirs, which then, via the tertiary lines, feed the village reservoirs located at the settlements. The design approach is to assume the need to construct a new village reservoir at each settlement, but some of the secondary command reservoirs are existing, albeit that some of these storage facilities will need to be expanded to meet minimum storage requirements.

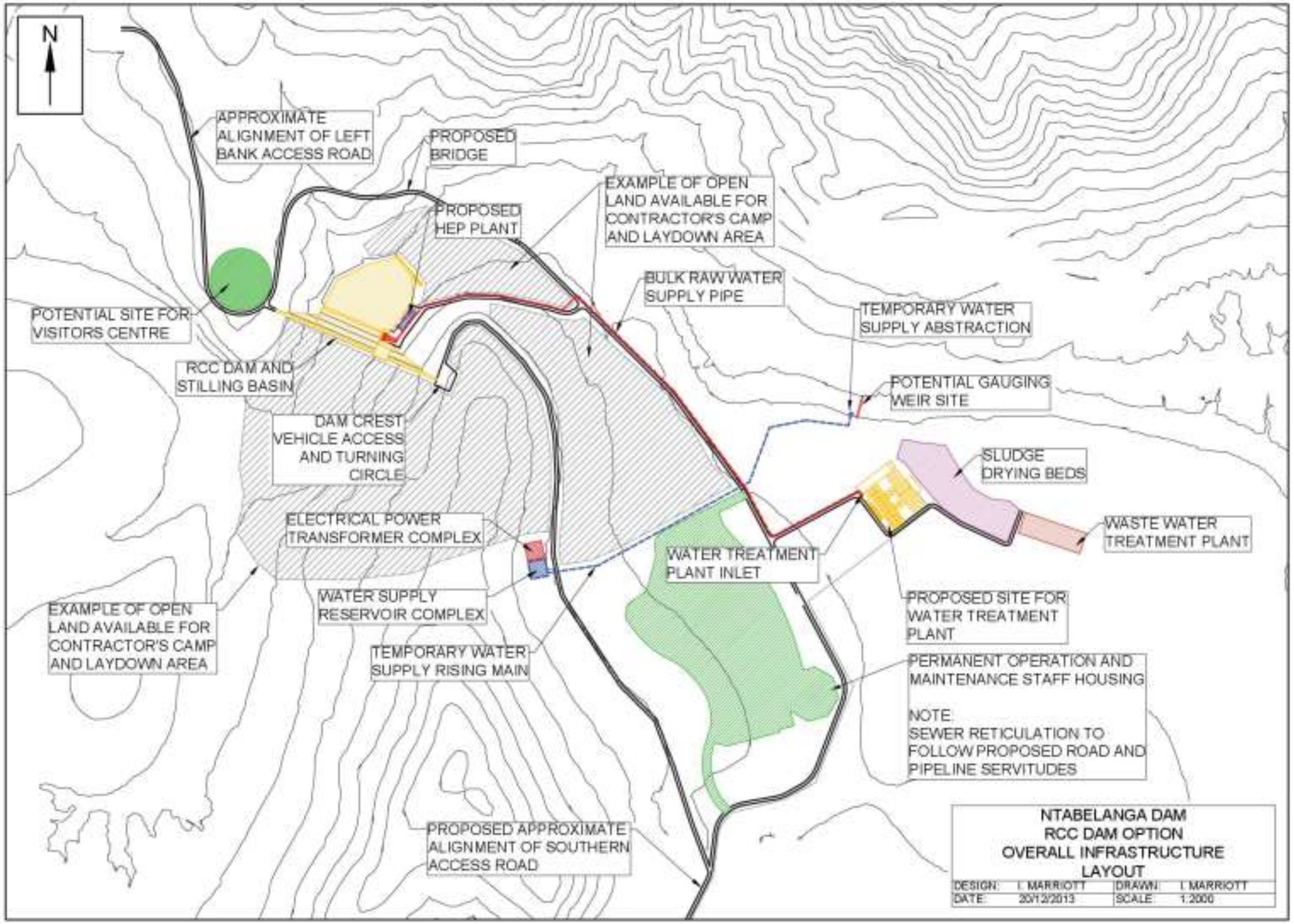


Figure 9-1: Location of Water Treatment Plant Relative to the Dam

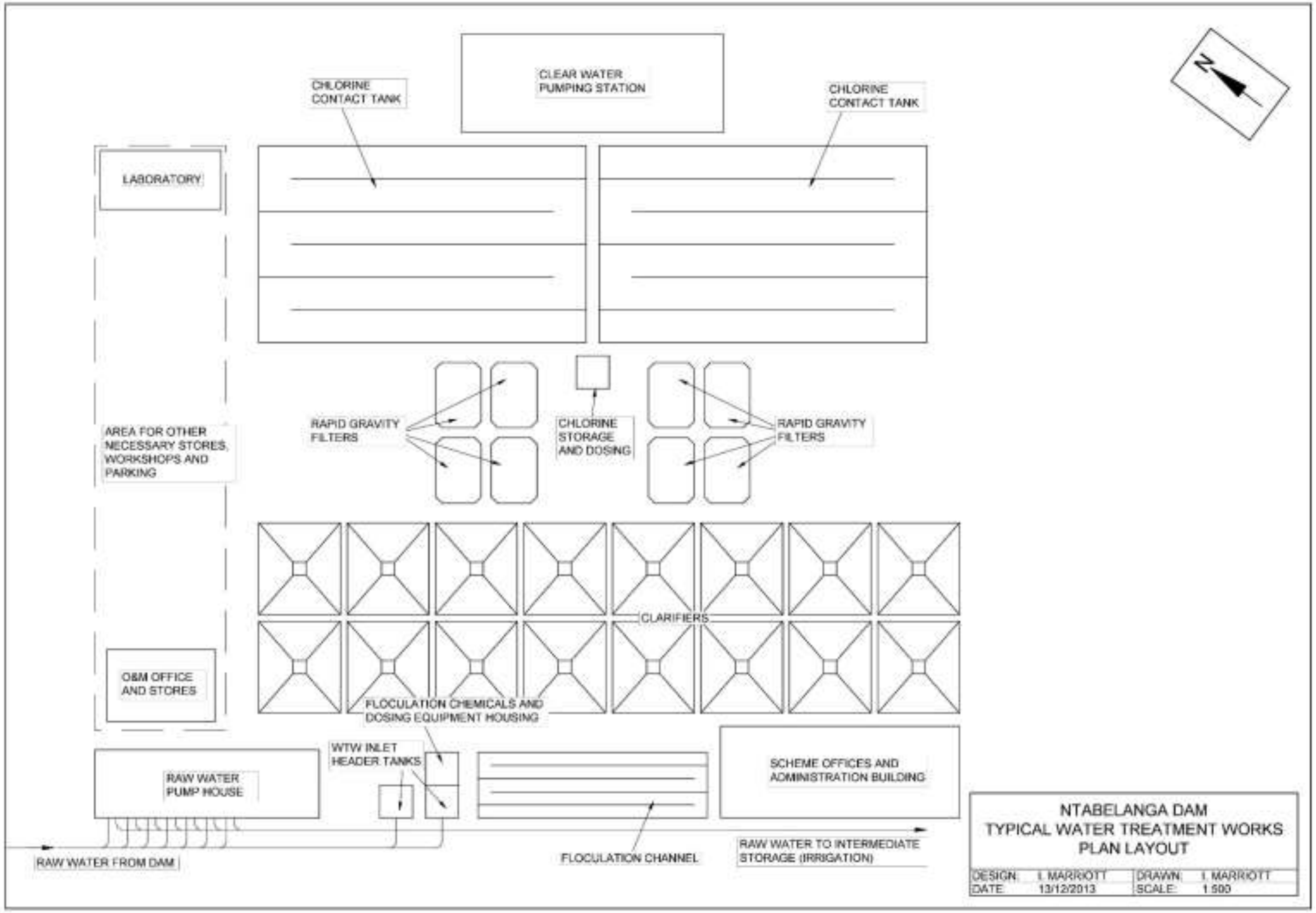


Figure 9-2: Typical Arrangement of the Water Treatment Works

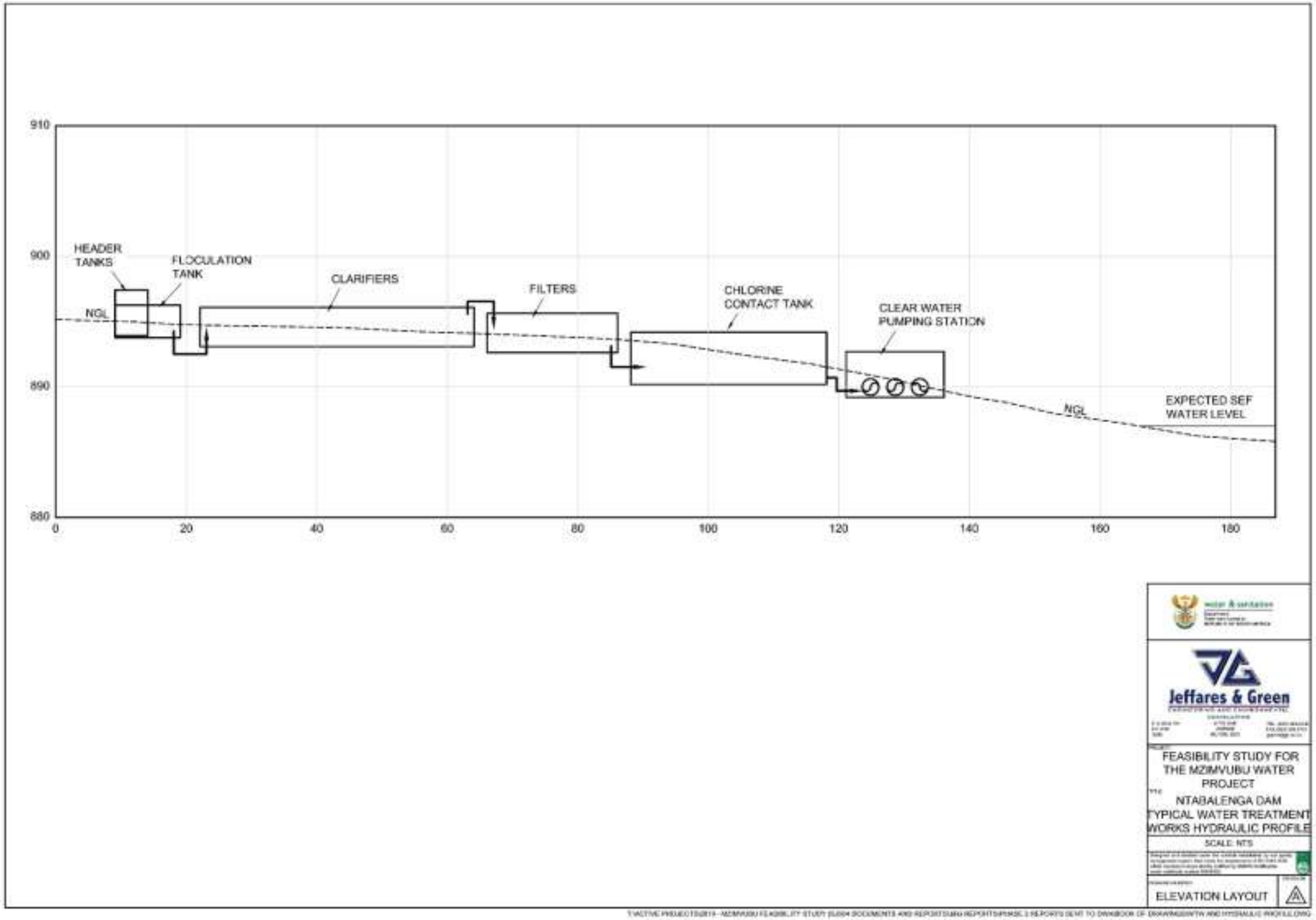


Figure 9-3: Hydraulic Flow Diagram through Ntabelanga WTW

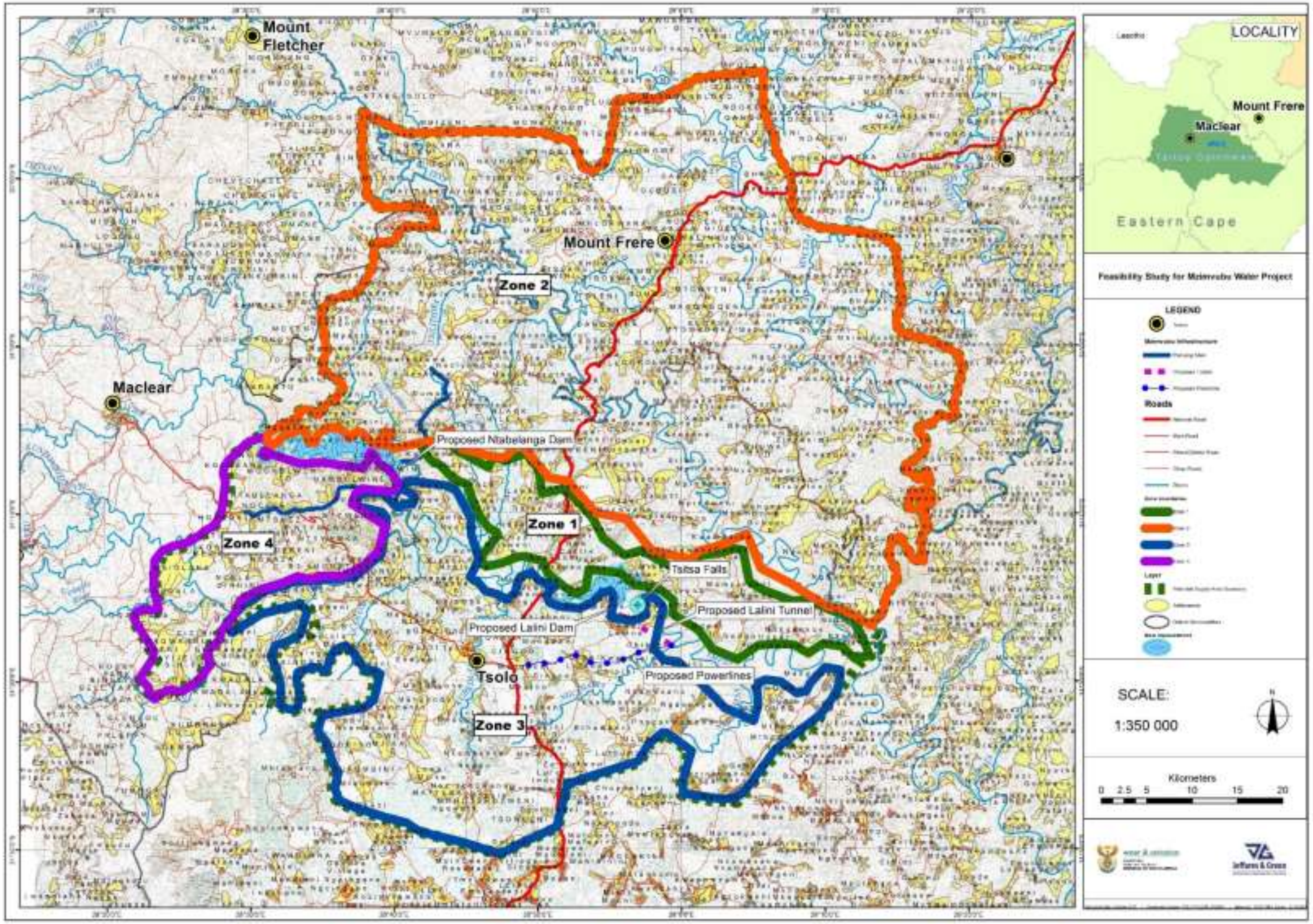


Figure 9-4: Supply Zones for Infrastructure Planning

The DWS Guidelines require 48 hrs of total system annual average daily demand (AADD) to be available in bulk storage, and this has been allowed for as follows:

Village bulk storage:	24 hrs x AADD
Secondary command reservoirs:	8 hrs x AADD
Primary command reservoirs:	16 hrs x AADD

Pipelines range in size from 50 mm diameter to 900 mm diameter. The materials chosen for pipelines are High Density Polyethylene (HDPE) for the smallest pipelines, Polyvinylchloride (PVC) for the range from 75 mm to 355 mm, and steel pipelines for all high pressure, above ground, pumping applications, and for sizes greater than 355 mm.

The usage of HDPE and PVC pipes for the smaller diameters, and modular systems for the smaller reservoirs will allow the usage of a labour-based construction approach for the tertiary lines and for parts of the secondary system, thus providing job creation opportunities.

The proposed reservoirs range in capacity from 10 m^3 to 750 m^3 in the respective secondary and tertiary systems with the command reservoirs in the primary system being in the order of 2 500 m^3 to 33 000 m^3. The proposed reservoir construction materials range from pressed steel tanks for capacities less than 500 m^3, modular pre-fabricated systems for the medium sized reservoirs, and conventional reinforced concrete reservoirs for the capacities greater than 2 000 m^3.

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

A schematic layout of the primary bulk water distribution system is given in Figure 9-5, and the same layout is also shown in map format in Figures 9-6 and 9-7. The capacity of these main components is shown on Figure 9-5, 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 water treatment works (WTW), treated water would be pumped from pumping station 1 (PS1) via a rising main going north to primary command reservoir 1 which would then gravity feed the bulk water distribution system designated as Zone 1 in Figure 9-4. Example details of typical pumping stations and storage reservoirs are given in the main text of this report.

A pumping station (PS2) would lift water from primary command reservoir 1 to primary command reservoir 2 which is located at a higher elevation. From this reservoir, water would be 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 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 would be pumped from pumping station PS3 at the WTW to primary command reservoir 3 from where gravity fed bulk mains would transfer water to the settlements in Zone 3.

A pumping station (PS4) at primary command reservoir 3 would pump water in a westerly direction to the higher lying primary command reservoir 4, which would 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 9-4.

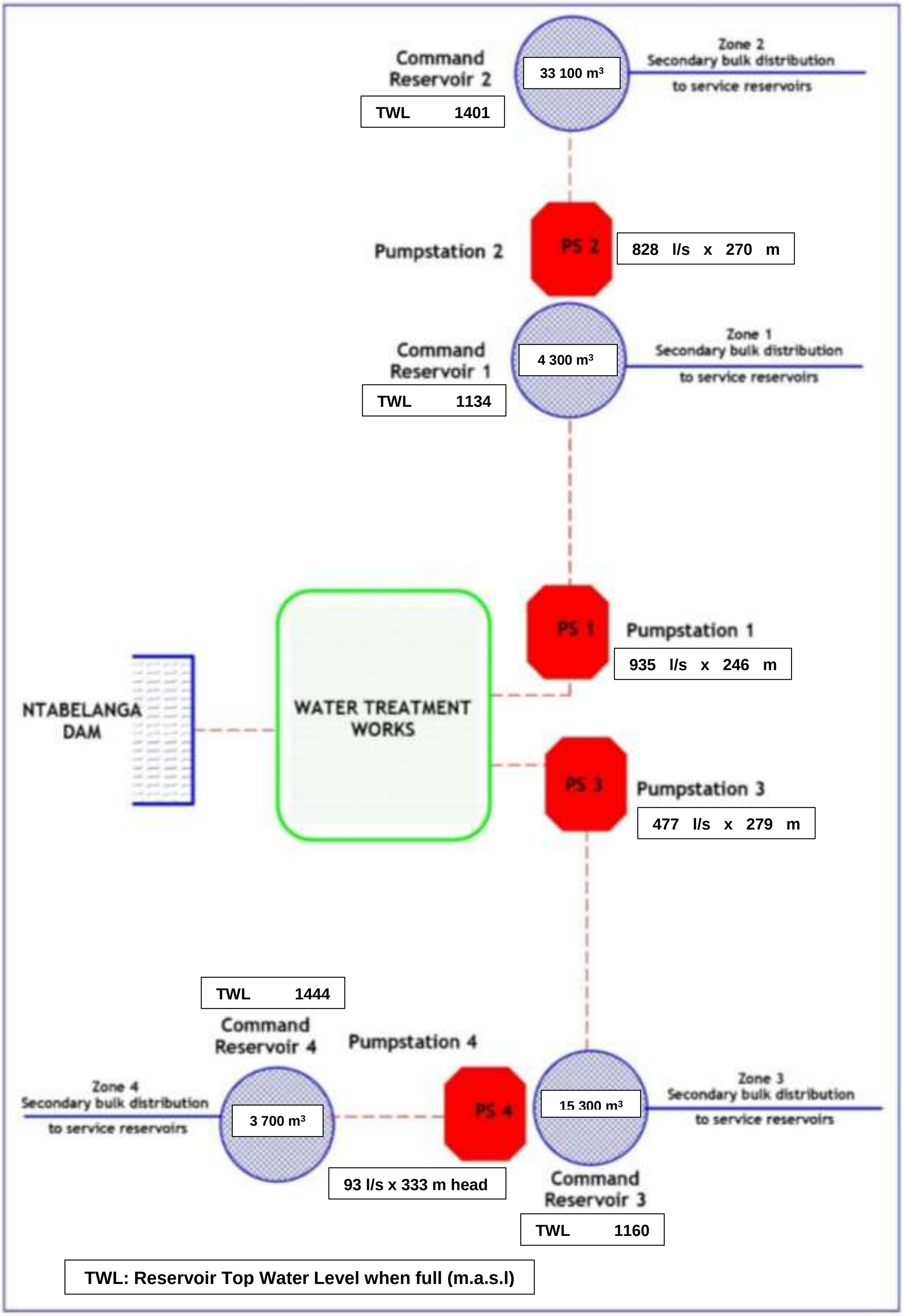


Figure 9-5: Diagram of Primary Bulk Water Distribution System

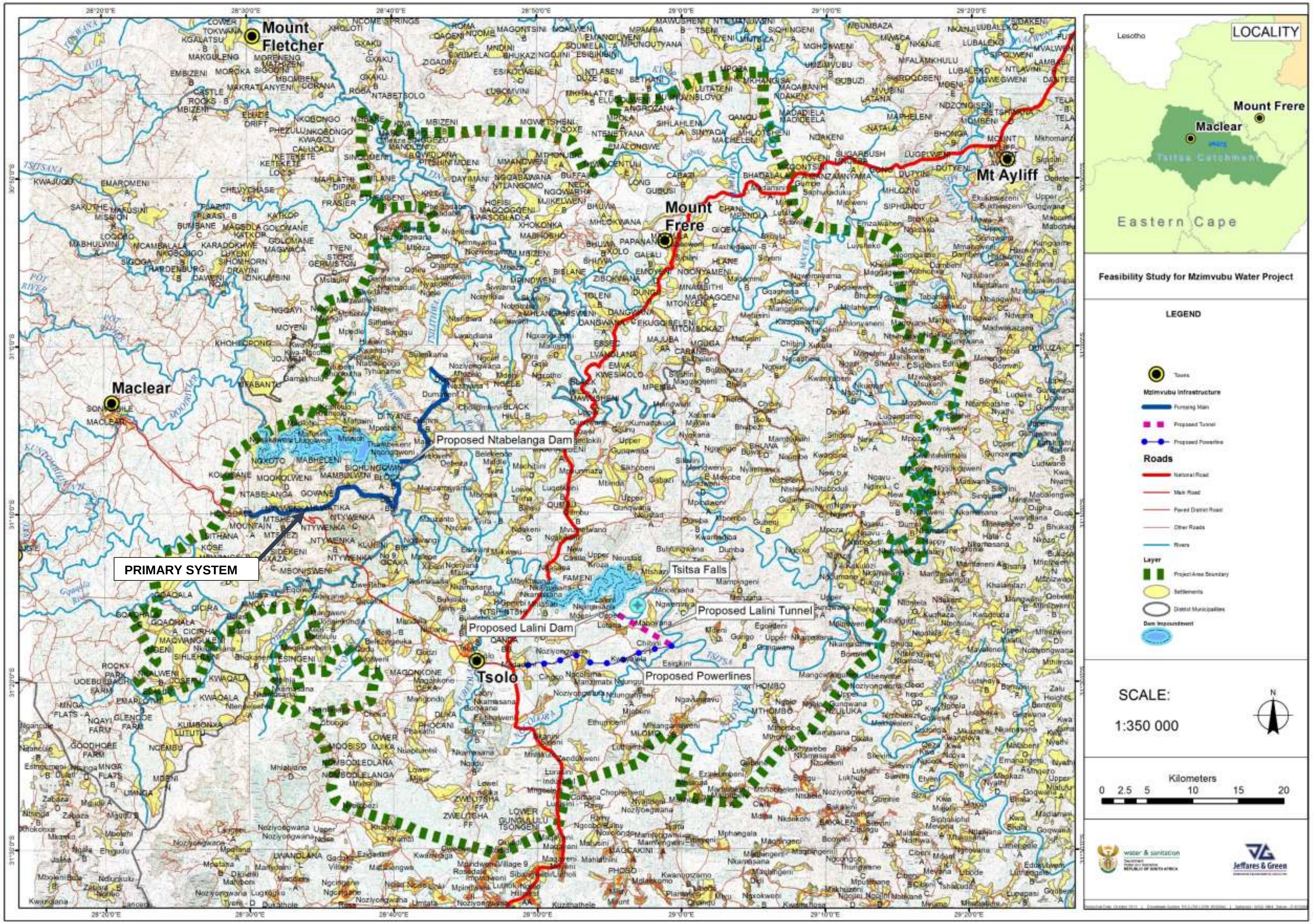


Figure 9-6: Layout of Scheme and Supply Area

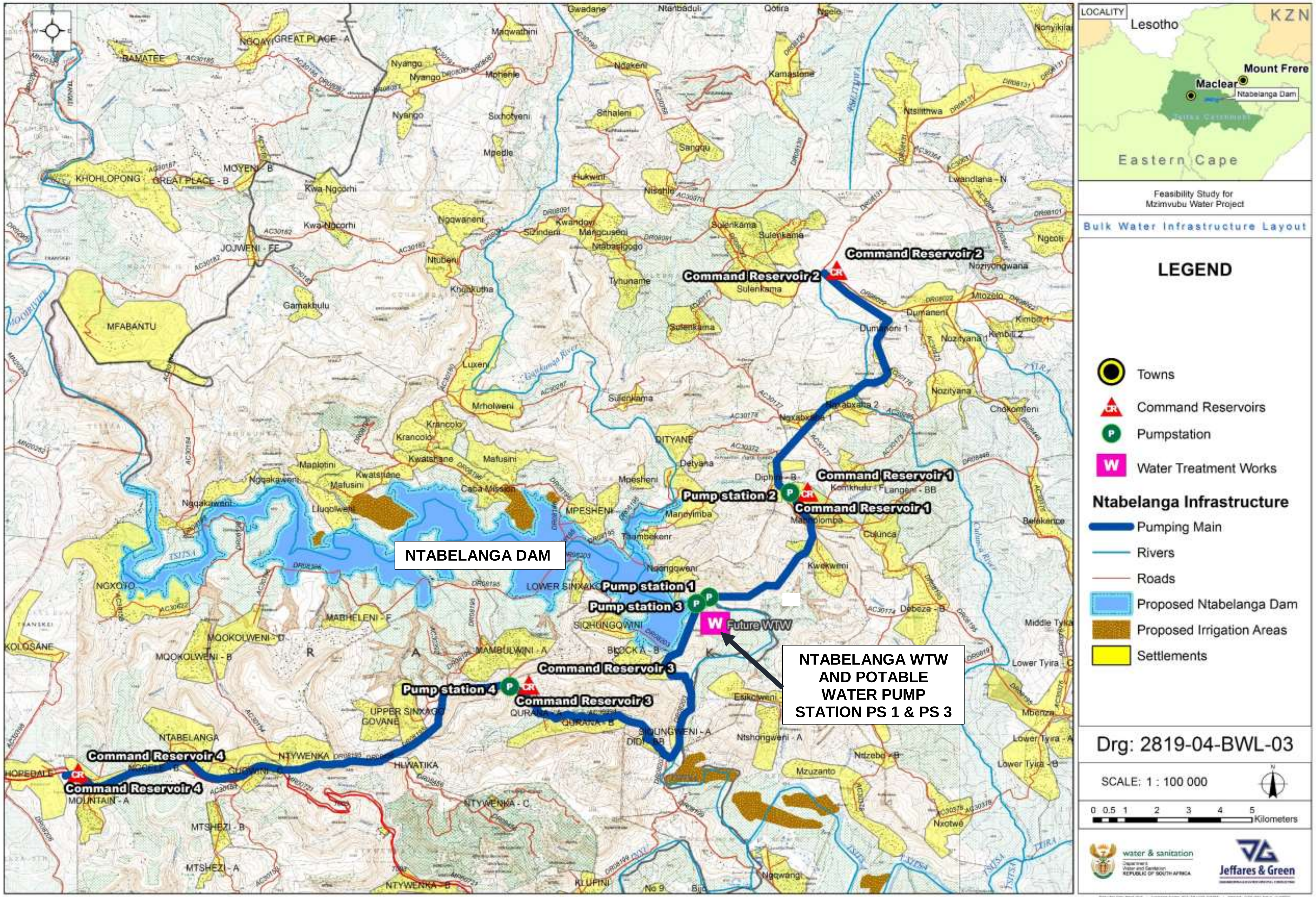


Figure 9-7: Primary Bulk Potable Water Pipelines, Pumping Stations and Command Reservoirs

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 9-8. 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.

Figure 9-9 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 DMs planning and implementation of these systems that is currently underway.

9.4 Hydraulic Modelling of the Bulk Water Distribution System

The hydraulic modelling of the bulk water distribution system has been undertaken using the Dynamic Network Analysis Hydraulic Modelling module of Civil Designer software by Knowledge Base.

This simulates the whole system dynamically using the design criteria described above.

The analysis has been run using the 2050 water demands, and has been checked that the system provides the required service levels under a peak summer demand factor of 1.2.

The system is optimised from “bottom up”. Each village/settlement end node comprises a village reservoir with 24 hrs x annual average daily demand (AADD) storage capacity, delivering a diurnal water demand profile with an hourly peak factor of 2.

Each of these village tanks would have a top inlet and inlet flow control valve, with a standard flow control characteristic to ensure that the reservoir does not overflow or run dry.

The sizes of tertiary lines feeding all of these tanks from the secondary bulk lines and command reservoirs were optimised using iterative model runs to ensure that they are the smallest size that can still supply the tanks under peak summer flow conditions, with a minimum residual head at each tank inlet valve of 10 m.

Most of these tertiary lines are supplied by gravity, either from branch connections from the secondary bulk distribution pipelines, or directly supplied by the primary and secondary command reservoirs.

The primary command reservoirs have been sized at 16 hrs x AADD, and the secondary command reservoirs at 8 hrs x AADD to ensure that the total requirement of 48 hrs x AADD is provided for the system as a whole.

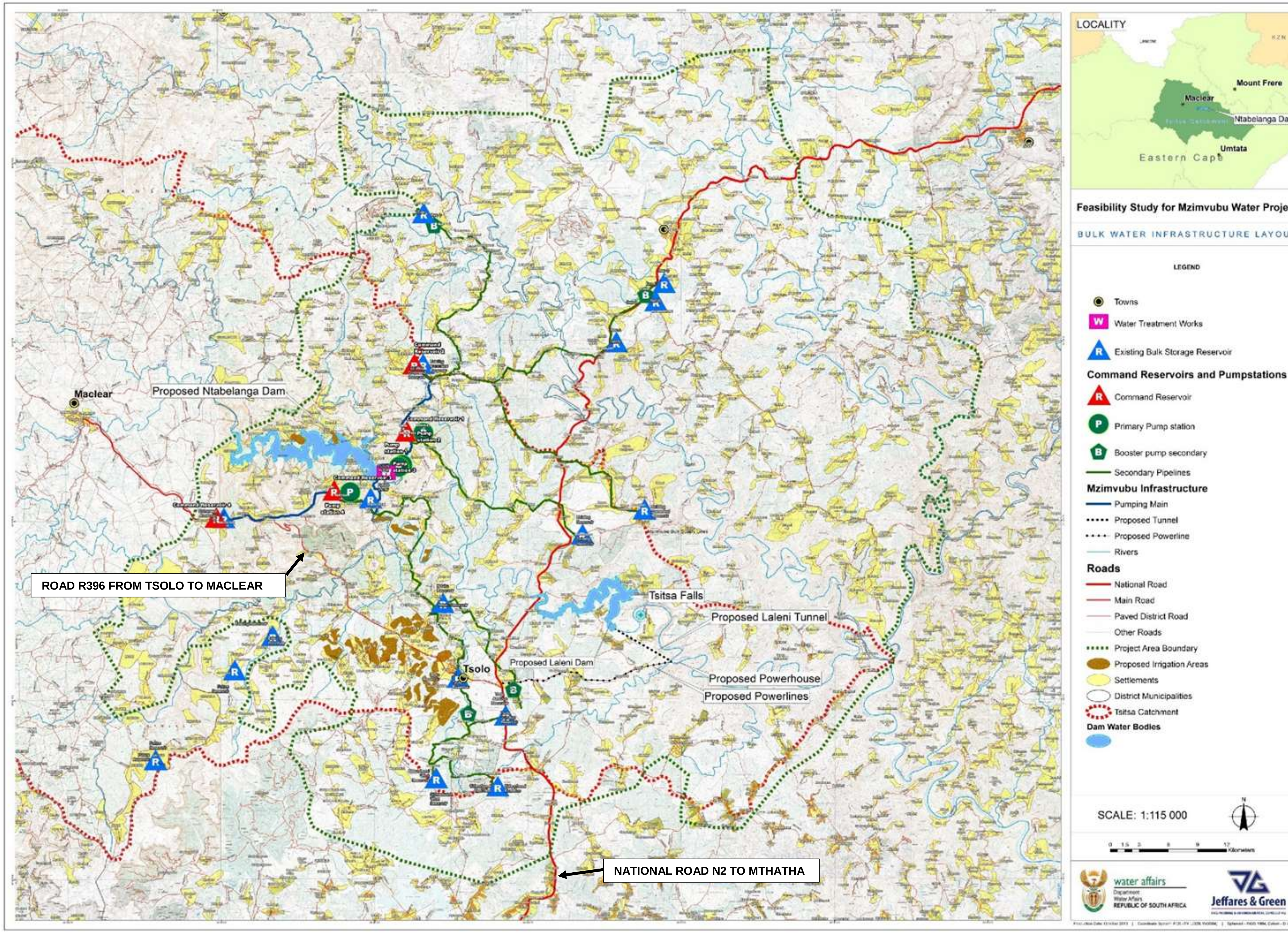


Figure 9-8: Secondary Bulk Potable Water Distribution Pipelines and Command Reservoirs

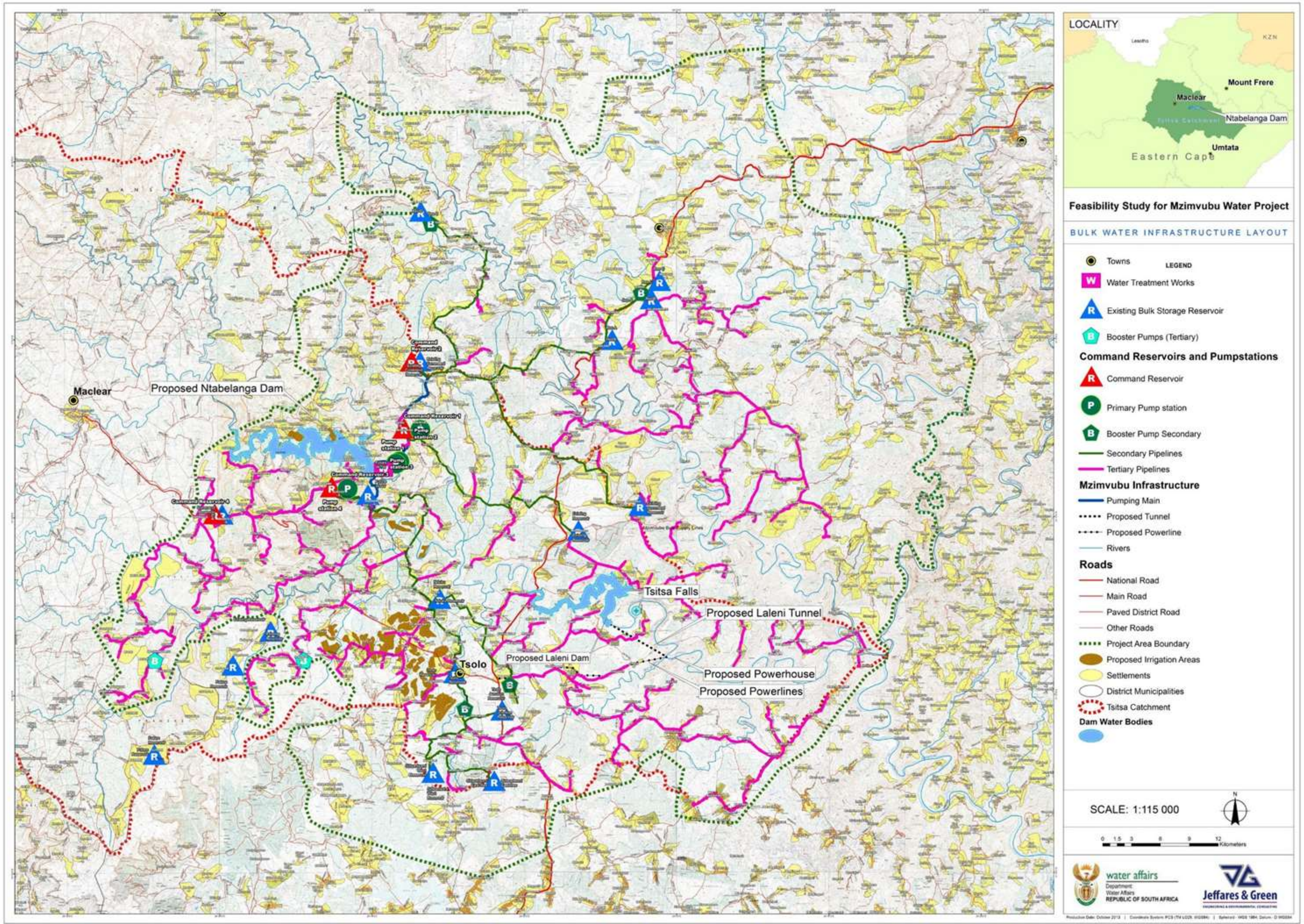


Figure 9-9: Layout of Potential Tertiary Pipelines

Similarly, the secondary bulk infrastructure pipelines that are fed by the primary command reservoirs have also been sized using the same iterative modelling process to ensure that adequate residual pressures are available at the inlets of all of the secondary command reservoirs under peak summer flow conditions.

The secondary command reservoir locations include sites where existing reservoirs already supply some existing schemes. As the extent of supply of most of these sites will increase, the storage capacity of existing storage sites would be increased to provide the minimum strategic storage recommended under the DWS Design Guidelines.

In undertaking the design process, it was noted that some sections of the bulk water distribution system will require some additional pumping where gravity flow is not possible due to terrain. Therefore three booster pumping stations have been included in the system.

More detailed layouts and alignments for the primary and secondary systems are given in the Main Report: Volume 2: Book of Drawings Report No. P WMA 12/T30/00/5212/4.

9.5 Cost Estimates for Potable Water Supply

From the feasibility design process, quantities were taken of the proposed infrastructure and an engineer's estimate was undertaken to establish the capital costs for the implementation of this infrastructure.

The cost estimates for the primary and secondary bulk potable water distribution systems (including pumping stations, pipelines, and reservoirs) are given in Table 9-1.

These are at current (2014) price levels and allowance must also be made in the project budgeting for price escalation to the date of construction, the quantum of which will be dependent upon the implementation programme and timing of such expenditure.

More details of this process are given in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

It should be noted that the extent of the DWS-implemented potable water components of the Mzimvubu Water Project is the Ntabelanga dam and associated infrastructure, the water treatment works, and the primary and secondary systems only.

A cost estimate for the Ntabelanga WTW having the daily peak demand output capacity for the water requirement projected in 2050 (101 515 m^3/day) is R817 152 000 including VAT, but this is also at current price levels and excludes escalation to date of construction.

Analysis of the tertiary lines was undertaken purely to ensure that correct budgetary allowance and implementation programme has been made for delivery into these systems. The DM's are responsible for the delivery of water from the secondary reservoirs to the households.

Table 9-2 gives the cost estimate of the tertiary potable water distribution system.

Analysis of the unit reference value of this scheme has been undertaken and is reported in the Cost Estimates and Economic Analysis Report.

Table 9-1: Capital Costs – Primary and Secondary Bulk Water System

ITEM	COMPONENT	PRIMARY SYSTEM COST (R)				SECONDARY SYSTEM COST (R)				TOTAL (R)
		ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 1	ZONE 2	ZONE 3	ZONE 4	
1	Pipelines	60 117 760	99 224 769	80 782 214	44 233 915	97 519 488	200 148 761	227 791 205	0	809 818 112
2	Pumpstations	20 000 000	20 000 000	20 644 000	16 500 000	0	0	8 814 000	0	85 958 000
3	Reservoirs	6 500 000	71 500 000	30 000 000	11 000 000	0	23 500 000	0	0	142 500 000
4	Electrical supply	10 000 000	10 000 000	7 500 000	5 000 000	0	0	2 500 000	0	35 000 000
	Sub-Total	**96 617 760**	**200 724 769**	**138 926 214**	**76 733 915**	**97 519 488**	**223 648 761**	**239 105 205**	**0**	**1 073 276 112**
5	Contingencies (15%)	14 492 664	30 108 715	20 838 932	11 510 087	14 627 923	33 547 314	35 865 781	0	160 991 417
	Sub-Total	**111 110 424**	**230 833 484**	**159 765 147**	**88 244 002**	**112 147 411**	**257 196 075**	**274 970 986**	**0**	**1 234 267 528**
6	Engineering/EMP Costs (12%)	13 333 251	27 700 018	19 171 818	10 589 280	13 457 689	30 863 529	32 996 518	0	148 112 103
	Sub-Total	**124 443 675**	**258 533 502**	**178 936 964**	**98 833 282**	**125 605 100**	**288 059 604**	**307 967 504**	**0**	**1 382 379 632**
	VAT 14%	17 422 114	36 194 690	25 051 175	13 836 660	17 584 714	40 328 345	43 115 451	0	193 533 148
	Total (Rand)	**141 865 789**	**294 728 193**	**203 988 139**	**112 669 942**	**143 189 814**	**328 387 949**	**351 082 954**	**0**	**1 575 912 780**

Note: Current (2014) price levels - Excludes escalation to date of construction

Table 9-2: Capital Costs – Tertiary Bulk Water System Only

ITEM	COMPONENT	TERTIARY SYSTEM COST (R)				TOTAL (R)
		ZONE 1	ZONE 2	ZONE 3	ZONE 4	
1	Pipelines	164 061 029	439 024 905	413 039 272	108 386 050	1 124 511 256
2	Pumpstations	0	0	4 238 000	2 184 000	6 422 000
3	Reservoirs	13 455 000	46 135 000	30 955 000	12 975 000	103 520 000
4	Electrical supply	0	0	3 750 000	1 250 000	5 000 000
	Sub-Total	**177 516 029**	**485 159 905**	**451 982 272**	**124 795 050**	**1 239 453 256**
5	Contingencies (15%)	26 627 404	72 773 986	67 797 341	18 719 257	185 917 988
	Sub-Total	**204 143 433**	**557 933 891**	**519 779 613**	**143 514 307**	**1 425 371 244**
6	Engineering/EMP Costs (12%)	24 497 212	66 952 067	62 373 554	17 221 717	171 044 549
	Sub-Total	**228 640 645**	**624 885 958**	**582 153 167**	**160 736 024**	**1 596 415 794**
	VAT 14%	32 009 690	87 484 034	81 501 443	22 503 043	223 498 211
	Total (Rand)	**260 650 336**	**712 369 992**	**663 654 610**	**183 239 067**	**1 819 914 005**

Note: Current (2014) price levels - Excludes escalation to date of construction

Of the R1 820 million cost of the Tertiary lines, the three DMs would need to budget for their particular portions of the system as given in Table 9-3. The costs again exclude escalation.

Table 9-3: Split of Budgets Required by DMs to Implement Tertiary Lines

Tertiary Pipelines Funding	Alfed Nzo DM	Joe Gqabi DM	OR Tambo DM	TOTAL
Total cost by DM incl VAT	**R599 861 932**	**R121 298 035**	**R1 098 754 038**	**R1 819 914 005**

Discounted cashflow models were used to calculate the URV of potable water supplied, including all costs from the Ntabelanga Dam, water treatment works, pumping stations, primary and secondary bulk water distribution and storage reservoirs, and tertiary lines to local tanks at each of the settlements to be supplied in the three District Municipalities. At a 10% discount rate, the resulting URV of water supplied = R16.71/m^3.

If only operation, maintenance and periodical plant refurbishment costs are included in the discounted cash flow analysis of the same works, the URV = R2.72/m.^{3}

Given that the latter approach is normally taken with grant funded works, the URV value is within the range normally expected on water supply projects.

9.6 Raw Water for Irrigation Development

As shown on Figure 3-1, some 2 868 ha of high potential irrigable land has been identified, and recommendations have been made to develop commercially run farming units of average size 60 ha.

Some 437 ha of this total are located adjacent to the north shore of the area that would be inundated by the dam, and on each bank of the Tsitsa River downstream of the dam. Irrigation to these areas could be via simple portable abstraction pumps, and quick-coupling systems, and permanent bulk raw water transfer systems would not be needed.

Most of the proposed farming units are located in and around the urbanised centre of Tsolo, at a distance of some 17 km away from the Tsita River and at an elevation of between 130 and 220 m above the river level.

This means that raw water supply to these areas would need to be conveyed via pipeline and pumped from the source.

For these Tsolo irrigation areas totalling 2 451 ha, and allowing for up to 20 hours per day pumping[7] to achieve the required daily application totals for the suggested cropping patterns, this requires the following water transfer pumping rates:

- Peak daily pumping rate: 1.06 m^3/s
- Average pumping rate: 0.81 m^3/s

The above are based on net application rates ranging between 619 mm to 1 141 mm per annum, plus allowance for losses, with a "typical" application of 880 mm per annum used for economic analysis purposes.

Four bulk water infrastructure options were investigated, as shown in Figures 9-10 to 9-13. Two options have been investigated as raw water abstraction locations.

1. At the Ntabelanga Dam raw water outlet works (Options 1 and 3).

2. At an abstraction weir and pumping station located on the Tsitsa River downstream of the dam, and as close to Tsolo as possible (Options 2 and 4).

For each these two source options, a further two scenarios were investigated:

i. Pumping from source to a single reservoir located at a high point at the end of the rising main, with the fields irrigated under the residual pressure in the system en route.

ii. Pumping from source to an intermediate storage tank (open-topped earth-bunded reservoir) at an elevation that can then supply just over 60% of the farming units by gravity, with the remainder at higher elevations fed by booster pumped pipelines from that gravity system.

Optimisation of the pipeline size and pumping arrangement resulted in Option 3 being the preferred solution, i.e. being pumped from the Ntabelanga Dam to the intermediate storage arrangement. The general layout of the recommended Option 3 is given in Figure 9-12.

This resulted in a raw water pumping station at Ntabelanga dam outlet works with 2.7 MW peak power consumption, a 16.4 km x 1 000 mm diameter rising main to intermediate storage, then gravity pipelines and local tanks located at strategic points close to the "edge of fields" of the proposed farming units. In order to reach those farming units that are located at the highest elevations two smaller booster pumping stations of installed capacity 269 kW and 481 kW respectively would be installed.

[7] *Limiting pumping to 20 hours per day avoids peak hour electricity tariffs and significantly reduces energy costs.*

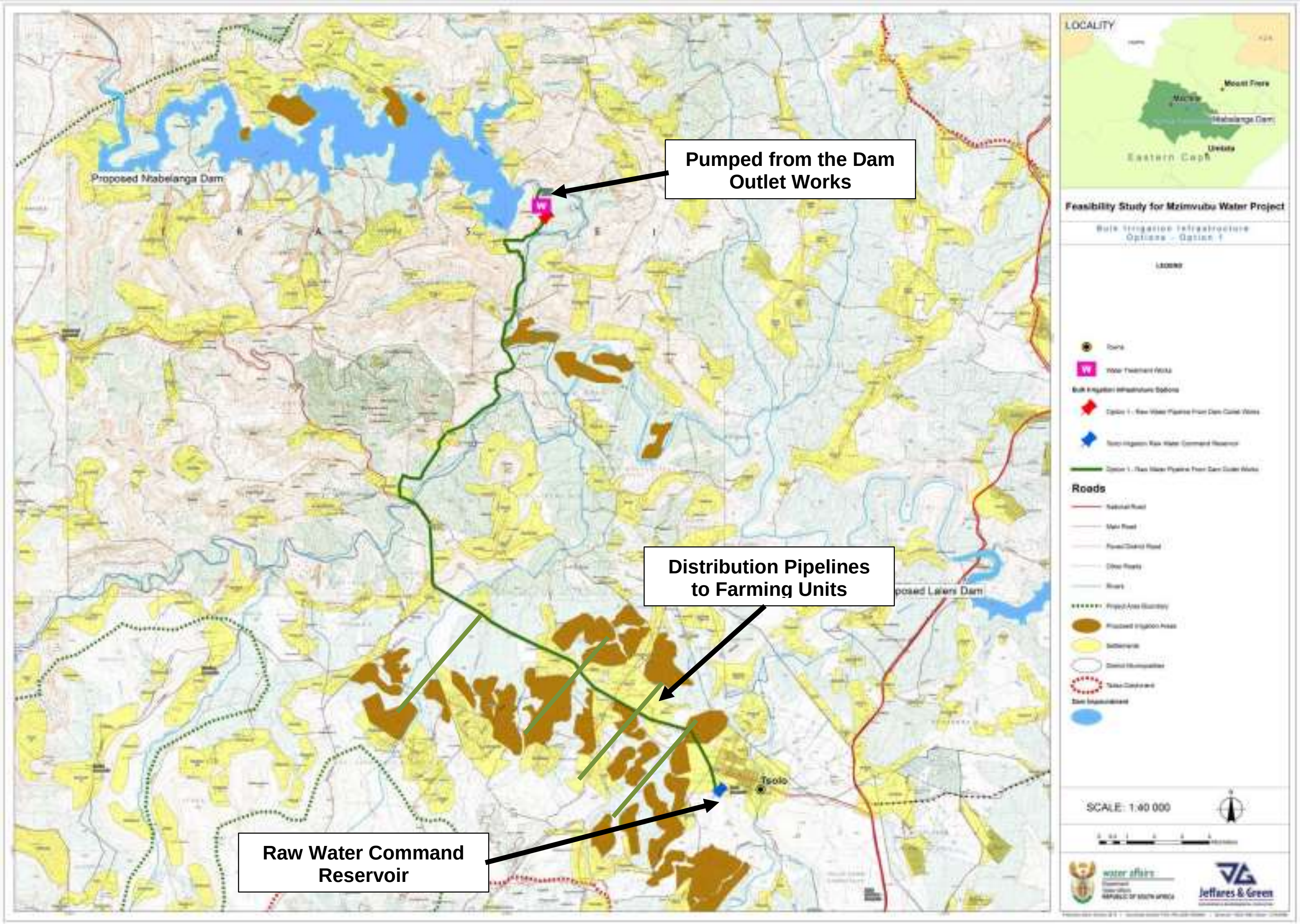


Figure 9-10: Overall Layout Plan of Option 1

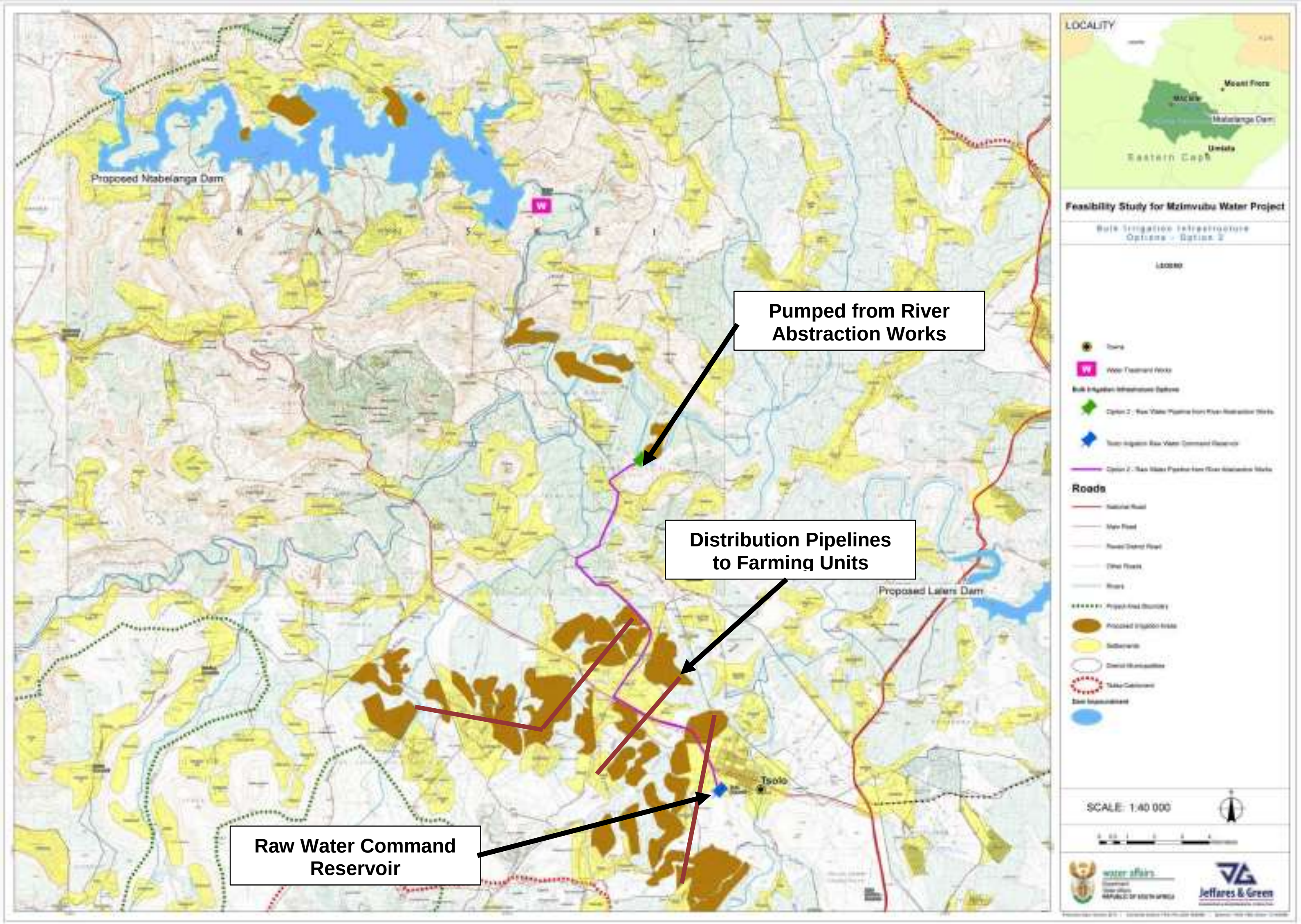


Figure 9-11: Overall Layout Plan of Option 2

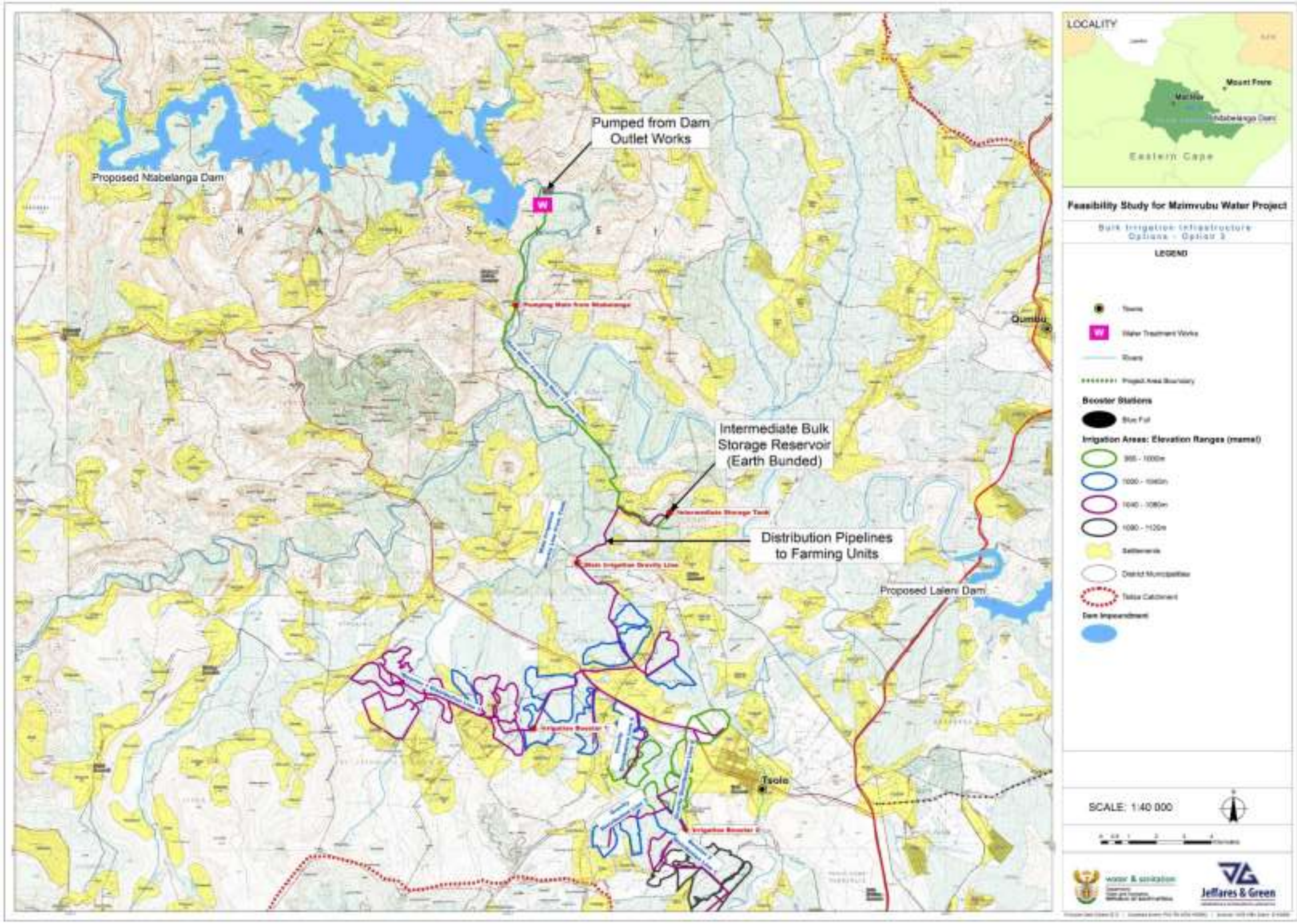


Figure 9-12: Overall Layout Plan of Recommended Option 3

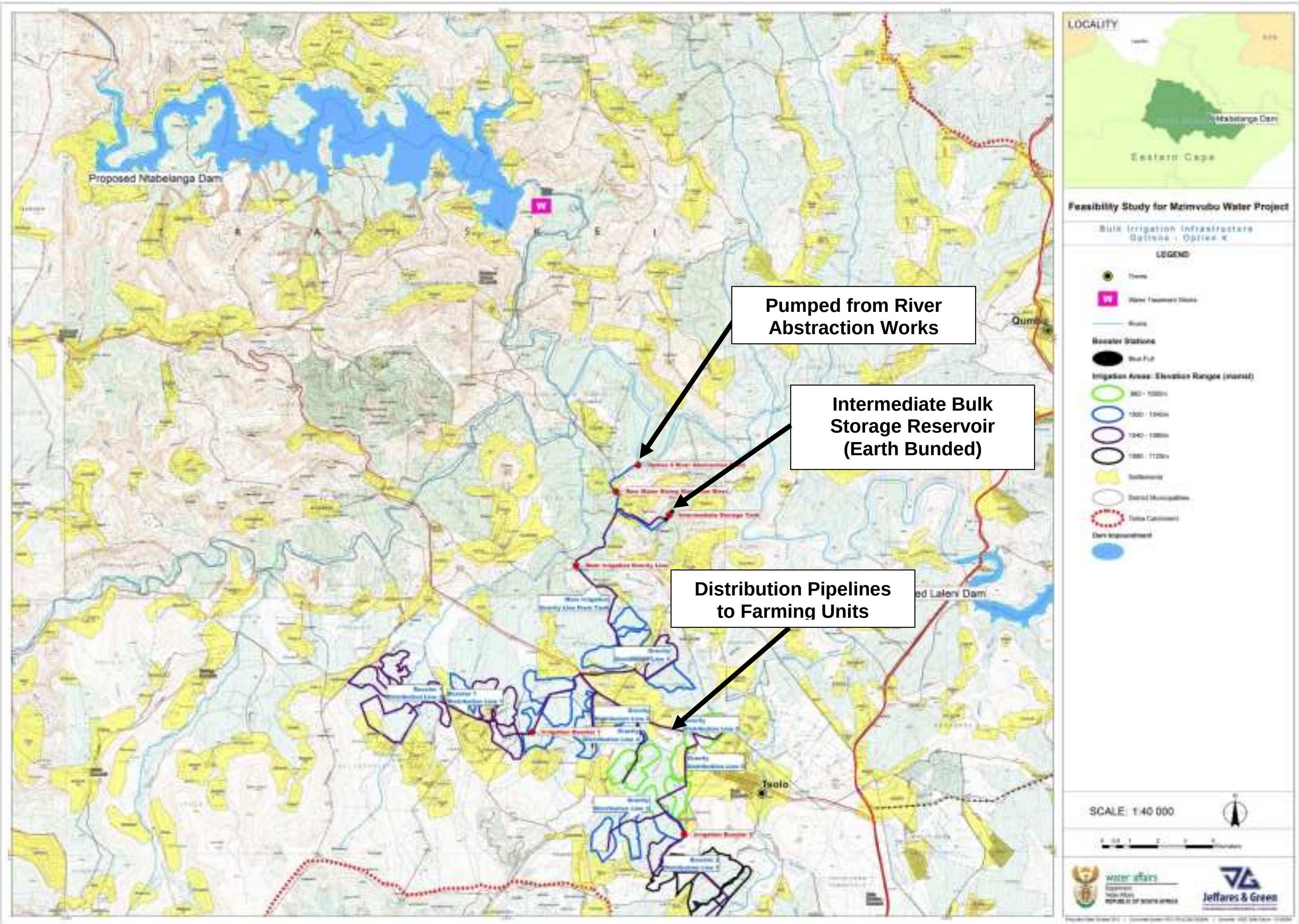


Figure 9-13: Overall Layout Plan of Option 4

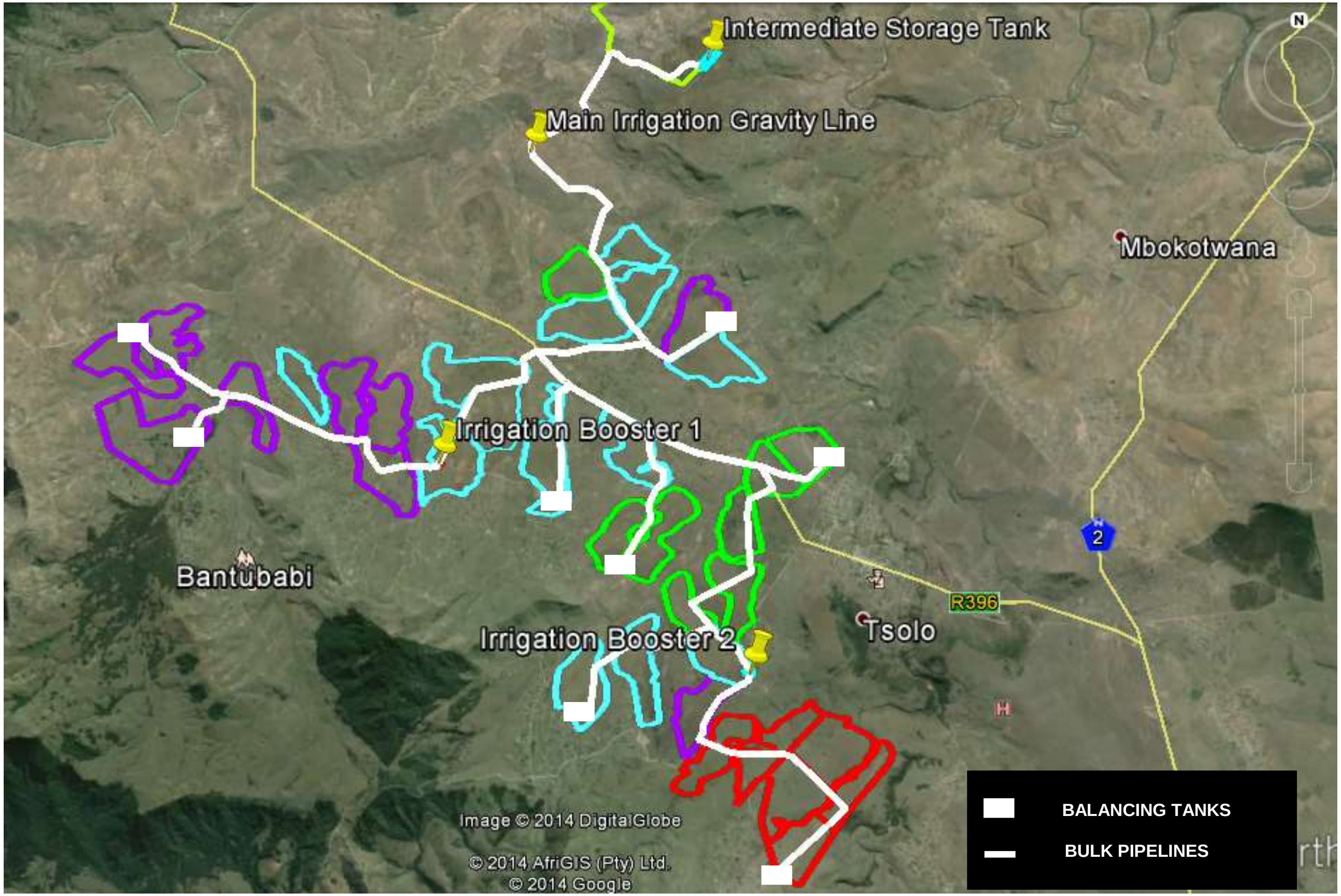


Figure 9-14: Detail of Bulk Distribution to Edge of Field

The capital and recurrent cost estimate for the recommended option is given in Table 9-4.

The raw water conveyance system capital cost requirement for this option is R661 million including VAT, at current (2014) price levels and excluding escalation to the construction date.

Operation and maintenance costs per annum have been estimated using the percentages of capital cost of the various components of the scheme as recommended in the DWS Technical Guidelines. An additional allowance has been made to fund recurrent depreciation replacement items such a pumps, valves, and similar equipment.

Table 9-4: Estimated Capital and Recurrent Costs: Recommended Option

IRRIGATION PIPELINE DIRECT FROM DAM				O&M per year		
ITEM	DESCRIPTION	CAPITAL COST				
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	Electricity 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		R	
	Allowance for M&E depreciation and replacement funding				R	956 505
	Total 1	**R**	**579 405 105**		**R**	**4 957 822**
	14% VAT	R	81 116 715		R	694 095
	Total	**R**	**660 521 820**		**R**	**5 651 917**
O&M Cost for supply of 21 240 366 m^3 to edge of field excluding power						R0.27/m^3
Power Cost per year		**R**	**18 559 958**			R0.87/m^3
Cost for supply of raw water to edge of field including power				**R/m^3**	**R 1.14/m^3**	

This recommended option had the lowest unit cost of raw water supplied at R1.14/m^3. In the marginal cost analyses undertaken for the Irrigation Development Report No. P WMA 12/T30/00/5212/9, the total unit cost of raw water supplied to each farming unit at “edge of field” was R0.40/m^3. This produced an annual net surplus income of approximately R580 000 per 60 ha farming unit.

Given that such a farming unit would also be estimated to consume water at a rate of some 371 000 m^3/per year, then the R0.74 /m^3 increase in unit cost over the R0.40/m^3 figure used in the above calculation would reduce the net surplus income per annum to R305 460.

It should be noted in Table 9-4 that the power cost forms a high proportion of the overall raw water cost, and it is expected that power tariffs will swiftly increase over the next few years at a rate above inflation. This is a risk to the viability of such farming units. Clearly some subsidization of this unit cost of raw water as well as capital costs must be made if the potential irrigation schemes are to be viable and sustainable.

The Department of Rural Development and Agrarian Reform suggests that a figure of R0.25/m^3 would be a reasonable target to ensure that gross margins are attractive enough to encourage investment into commercial irrigated agriculture. This emphasizes the need to subsidize the Ntabelanga water supply scheme with revenue gained from the energy sales generated by the Lalini Dam and hydropower scheme.

The annual revenue earned by the sale of energy from the Ntabelanga-Lalini conjunctive hydropower scheme would be more than double the cost of power consumed by the potable and irrigation water supply schemes combined. This revenue would therefore be sufficient to subsidize all of the water supply power costs as well as being able to cover other operation and maintenance costs and some capital loan or grant repayments. It will be up to the special purpose vehicle institution set up to operate the schemes to decide how this surplus revenue is to be utilized. One objective could therefore be to reduce the cost of raw water supply for irrigation purposes to the target of R0.25/m^3 to ensure that gross margins are attractive enough to encourage investment into commercial irrigated agriculture

In conclusion, if the effective cost of power supplied to the scheme can be reduced through the benefits gained by generation of hydropower at Ntabelanga and Lalini (i.e. cross-subsidized by grant-funded hydropower capital cost), then the viability of irrigated agriculture development within the scheme could still be possible. This key issue is discussed in more detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15, where the overall viability of the multi-purpose scheme is analysed.

9.7 Power Requirements

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 9-5 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 N2 national 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. 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 also complete coverage of power services to all of the settlements in the area.

The Ntabelanga mini-hydroelectric plant (HEP) can only produce circa 1 600 kVA (1.6 MW) on average with a maximum of 5 000 kVA (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.

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.

This same connection can be used to evacuate surplus energy generated by the Ntabelanga mini-HEP back into the ESKOM grid to create revenue for the scheme.

Table 9-5: 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)***
Pumping station PS1	935.27	246	2 257	75%	3 010	3 168	20	23 128 671	19 497 470
Pumping station PS2	827.70	270	2 193	75%	2 924	3 077	20	22 465 459	18 938 382
Pumping station PS3	476.66	279	1 305	75%	1 740	1 831	20	13 368 771	11 269 874
Pumping station PS4	92.69	333	303	75%	404	425	20	3 102 814	2 615 672
Booster pumping station Z3 PS1	170	94	157	75%	209	220	20	1 606 406	1 354 200
Booster pumping station Z4 PS1	12.8	66	8	75%	11	12	20	84 924	71 591
Booster pumping 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 pumping station P1	206	100	202	75%	269	284	20	2 070 836	1 745 715
Booster pumping 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**

** Note: Power costs based upon current average Ruraflex tariffs and are for economic analysis purposes only*
*** kVA is the equivalent of kW once power factor correction losses are applied*

The regional grid access department of ESKOM have been consulted and have confirmed that they can provide a connection to the Ntabelanga dam site in order to provide both construction and operational power requirements.

It was also confirmed that energy generated by the Ntabelanga Dam mini-hydropower plant could be fed back into the ESKOM grid through the same connection via a switching arrangement, and credits given.

The conjunctive use hydropower scheme (i.e. Ntabelanga Dam in conjunction with the Lalini Dam and hydropower scheme), is expected to produce up to 37.5 MW on a base load basis, and this means that a conjunctive scheme would not only be “self-sufficient” in its energy usage for potable and irrigation water supply needs, but can also supply surplus energy into the local ESKOM grid, thus generating surplus revenue which can be used to effect the subsidisation described above.

This is discussed further in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15, and the Lalini Dam Hydropower Analysis Report No. P WMA 12/T30/00/5212/18.

10. GEOTECHNICAL INVESTIGATION FOR LALINI DAM AND HYDROPOWER SCHEME

10.1 Introduction

This section summarises the feasibility level geotechnical investigation undertaken for a proposed dam and hydro-power scheme on the lower Tsitsa River in the Lalini area, which falls within the Mhlontlo Local Municipality. Full details of these investigations are given in the Geotechnical Investigations: Lalini Dam and Hydropower Scheme Report No. P WMA 12/T30/005212/10.

The dam alignment investigated in this study was delineated during a site visit undertaken in May 2014. At this preliminary stage in the design, the dam type and configuration had not been confirmed with certainty, proposed as either a roller compacted concrete (RCC) dam with a central spillway or an earth embankment dam with a side channel spillway cut into the left flank. The final dam height was expected to be between about 50 m and 70 m, depending upon a number of interrelated factors.

The hydro-power component of the project was also in the conceptual stages of design and a number of alternative horizontal and vertical alignments had been proposed. It was understood that the preferred option for the hydropower water transfer conduit is part pipeline and part tunnel, for which an alignment was initially proposed, on which the scope of this investigation was based. Due to the fact that a number of alternative alignments were under consideration, the geotechnical investigation for the hydro-power component of the project was structured to provide an overall appraisal of geotechnical conditions over the general area under consideration for the tunnel route, but concentrating on that which was favoured at the time.

The feasibility level geotechnical investigation of the proposed Lalini Dam and Tunnel entailed the following:

1. The drilling of four rotary core boreholes along the proposed alignment of the dam axis, two on the left flank and two on the right flank. Dolerite outcrop occurs across the river section.

2. The drilling of seven boreholes for the proposed hydro-power scheme, of which four were positioned along or adjacent to the preferred horizontal alignment, one just below the dam to cater for the pipeline section or an alternative tunnel alignment and one to the south west of the preferred tunnel alignment to cater for an alternative longer and deeper tunnel option. Five of the boreholes were inclined 5° off vertical to facilitate the undertaking of core orientation measurements.

3. The drilling of six boreholes in an identified potential rock quarry site.

4. A co-ordinated trial pitting investigation of identified potential borrow pits for earth embankment construction.

5. The excavation of trial pits along the proposed pipeline alignment.

6. Water pressure tests were conducted at representative intervals in all the dam boreholes and in one tunnel borehole.

7. Rock strength tests were conducted on representative borehole core samples, either by means of laboratory unconfined compressive strength (UCS) tests or point load strength index (PLSI) tests conducted on site.

8. Representative samples were retrieved of the unconsolidated materials proposed for earthfill dam construction to facilitate testing and analysis.

9. Water samples were retrieved from selected boreholes and from the Tsitsa River, the former for chemical aggressiveness testing and the latter to assess suitability for use in construction.

10. Associated rock exposure mapping and photography.

10.2 Dam Wall Foundations

Figure 10-1 shows the locations of the boreholes drilled at the Lalini dam site. Figure 10-2 shows a summary of the core logging at these boreholes.

The extent of the geotechnical investigations undertaken along the proposed dam axis have concluded that the site is suitable for the construction of either an earth-embankment dam or a RCC dam, albeit with relatively deep foundation excavation. Based upon the drilling undertaken the foundation invert will vary from between 6 m and 8 m on the upper flanks to between 3 m and 4 m on the lower flanks. Dolerite outcrops across the river section, implying negligible excavation in this area. The results of water pressure tests indicate that minor under-seepage is likely and that a cut-off grout curtain will be required. The need for consolidation grouting was not conclusively proven.

10.3 Construction Materials

The reconnaissance for dam construction materials concentrated on areas falling within the future impoundment basin in order to avoid the negative environmental impacts and rehabilitation requirements associated with exploitation outside of the impoundment area. These areas are as shown on Figures 10-3 to 10-7. As with the Ntabelanga Dam, materials were sought for the several different dam types that were to be considered.

The area investigated as a potential rock quarry lies on the left hand or eastern side of the Tsitsa River, approximately 3.5 km upstream of the dam site. The investigation did prove good quality dolerite, but occurring beneath an excessively thick overburden mantle of unconsolidated, weathered and fractured materials. As a result of this, under normal circumstances the site would be regarded as being marginal for use as a rock quarry, but the use of the overburden materials in road construction, if found suitable, could mitigate the use of the area as a rock quarry. The investigation of road construction materials did not form part of the current geotechnical investigation, but it is a requirement of the overall project.

The naturally occurring sand in the channel of the Tsitsa River was found to be too finely graded for use as either concrete fine aggregate or filter medium. Its use would necessitate blending with an inert crushed rock product. Alternatively sand would have to be acquired from an approved off-site source.

Suitable core material was proved in adequate quantities, a short distance upstream of the dam site within the impoundment basin. The area investigated as a shell borrow pit lies immediately upstream of the dam site, with geology comprising mudrock and intercalated sandstone. The material tested is coarse grained, but with plastic fines, due to the preponderance of mudrock. The use of a tractor-loader-backhoe (TLB) in the investigation also limited the efficiency of excavation in this material and the volumes proved do not meet the volume requirements for shell. Based upon observations made on site the shell requirements, with further detailed assessment, can be optimised in terms of quality and quantity.

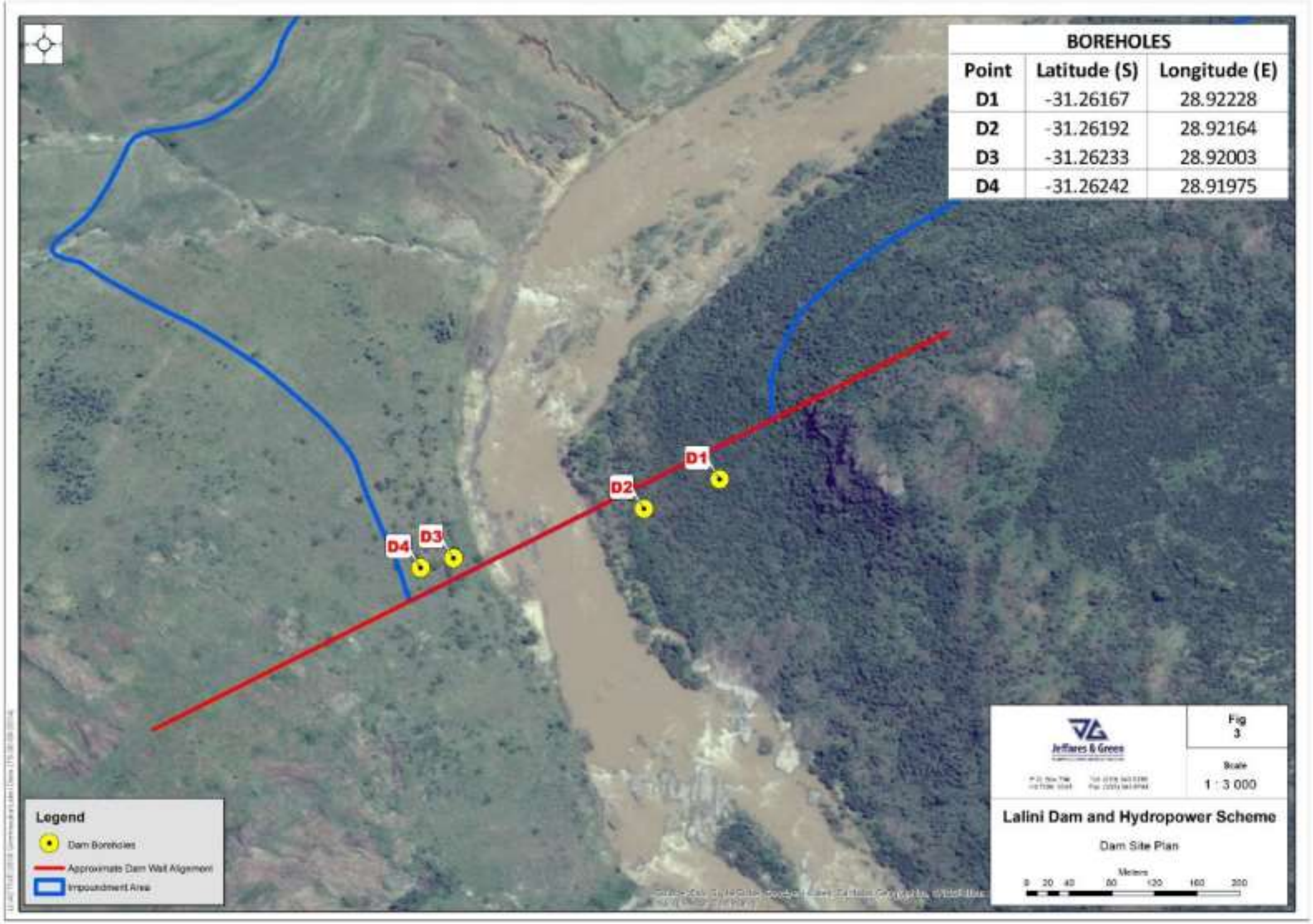


Figure 10-1: Locations of Boreholes Drilled on Lalini Dam Wall Centreline

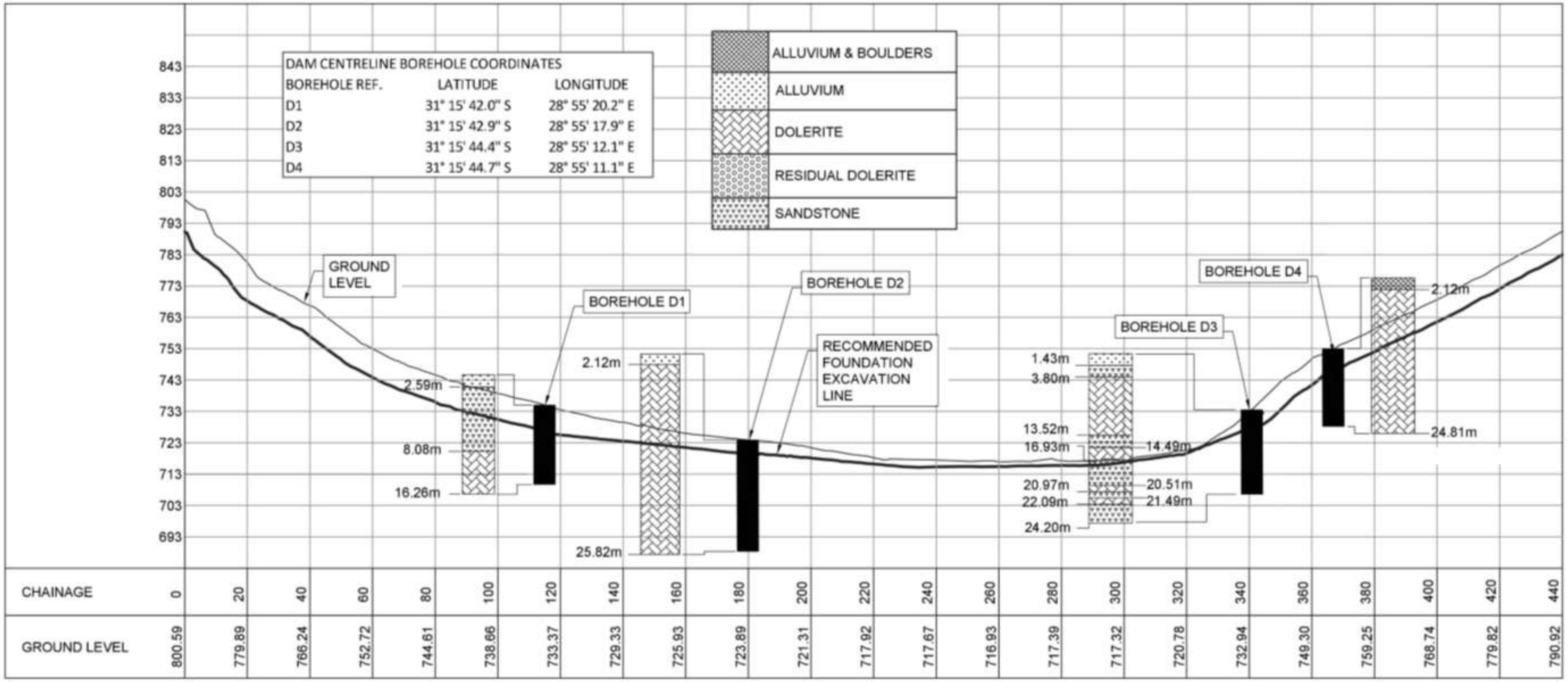


Figure 10-2: Borehole Log Summary along Dam Profile

Figure 10-3: Borrow Pit Locations

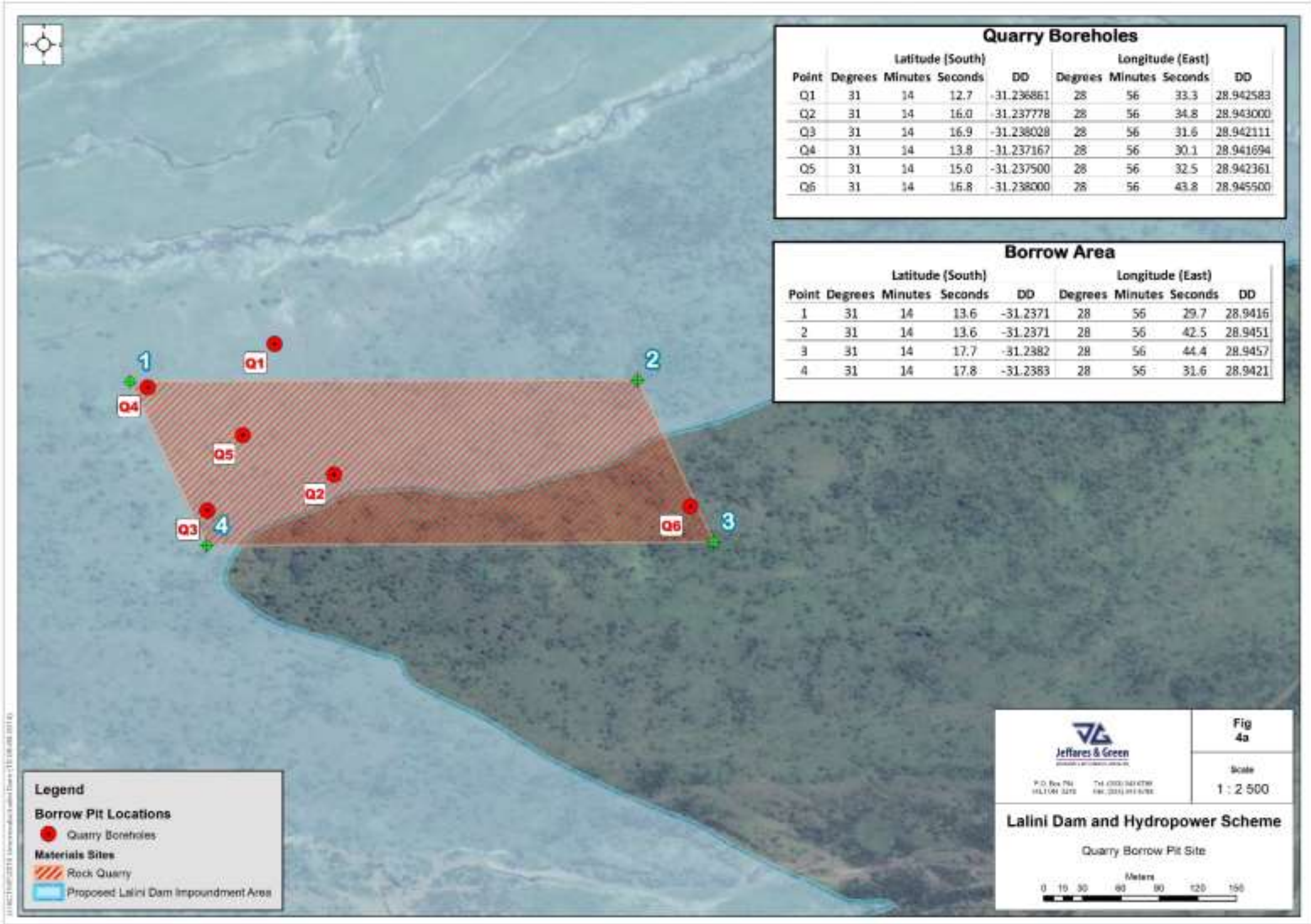
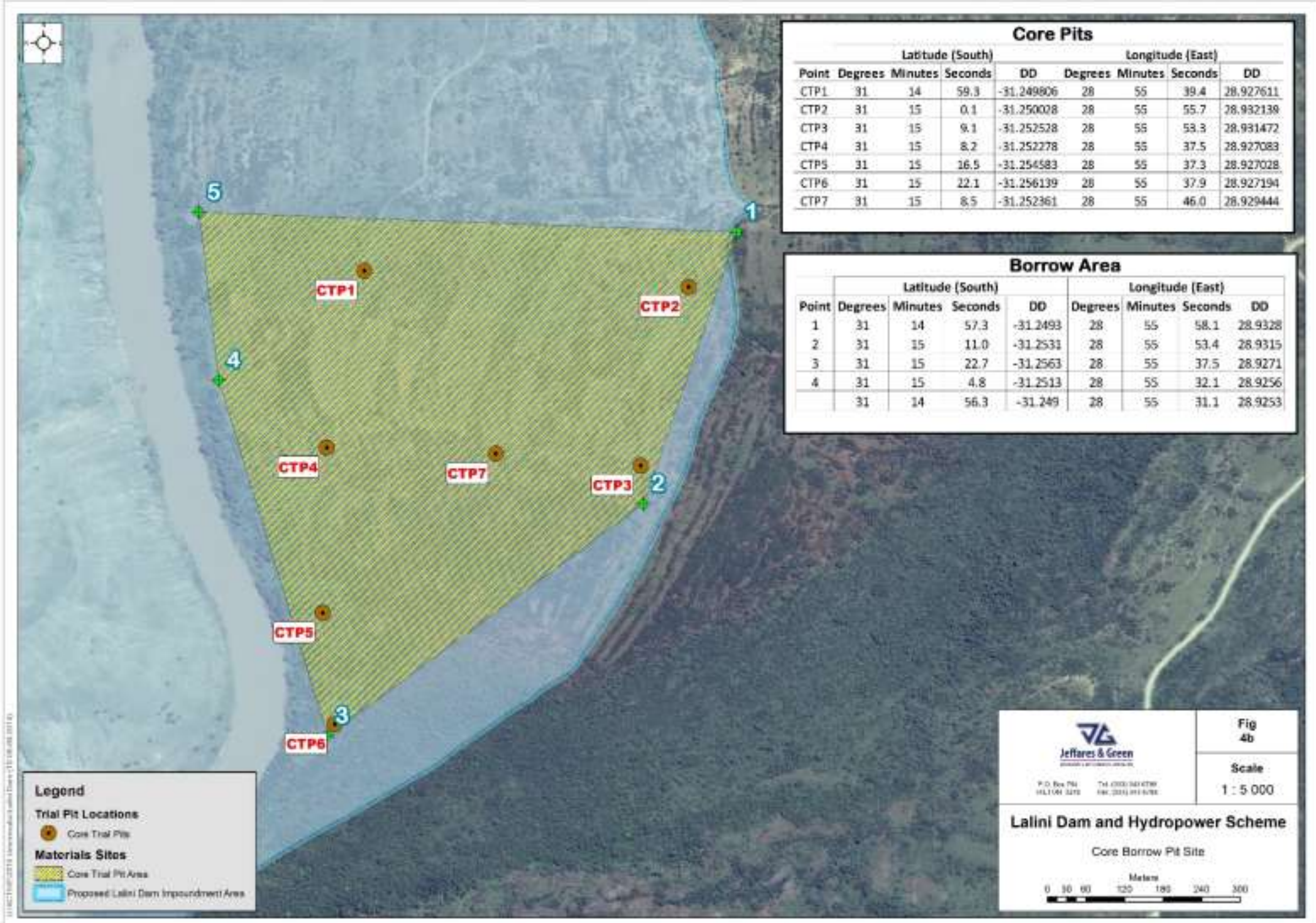


Figure 10-4: Rock Quarry Borehole Sites



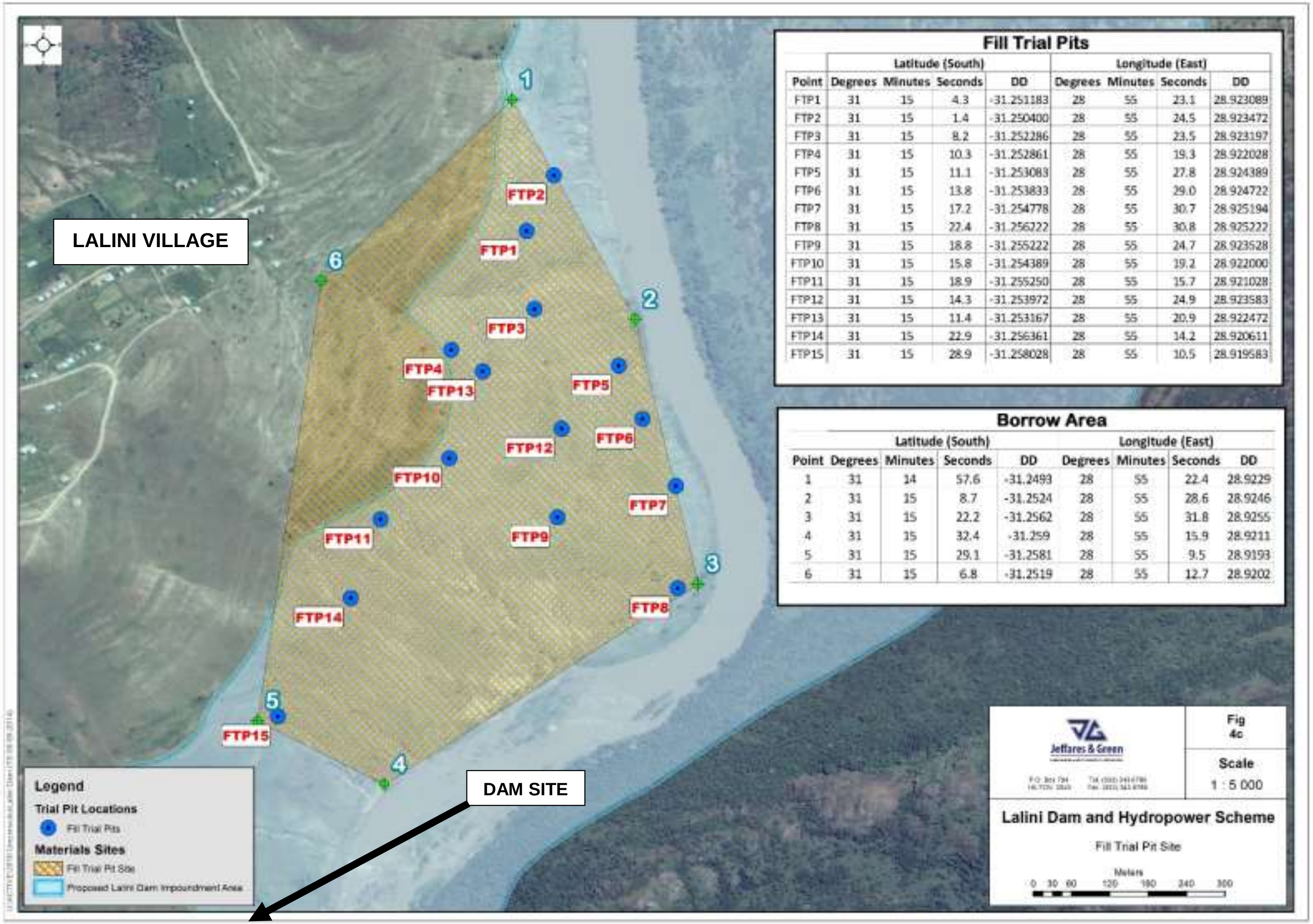
Core Pits

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
CTP1	31	14	59.3	-31.249806	28	55	39.4	28.927611
CTP2	31	15	0.1	-31.250028	28	55	55.7	28.932139
CTP3	31	15	9.1	-31.252528	28	55	53.3	28.931472
CTP4	31	15	8.2	-31.252278	28	55	37.5	28.927083
CTP5	31	15	16.5	-31.254583	28	55	37.3	28.927028
CTP6	31	15	22.1	-31.256139	28	55	37.9	28.927194
CTP7	31	15	8.5	-31.252361	28	55	46.0	28.929444

Borrow Area

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
1	31	14	57.3	-31.2493	28	55	58.1	28.9328
2	31	15	11.0	-31.2531	28	55	53.4	28.9315
3	31	15	22.7	-31.2563	28	55	37.5	28.9271
4	31	15	4.8	-31.2513	28	55	32.1	28.9256
	31	14	56.3	-31.249	28	55	31.1	28.9253

Figure 10-5: Core Borrow Trial Pit Locations



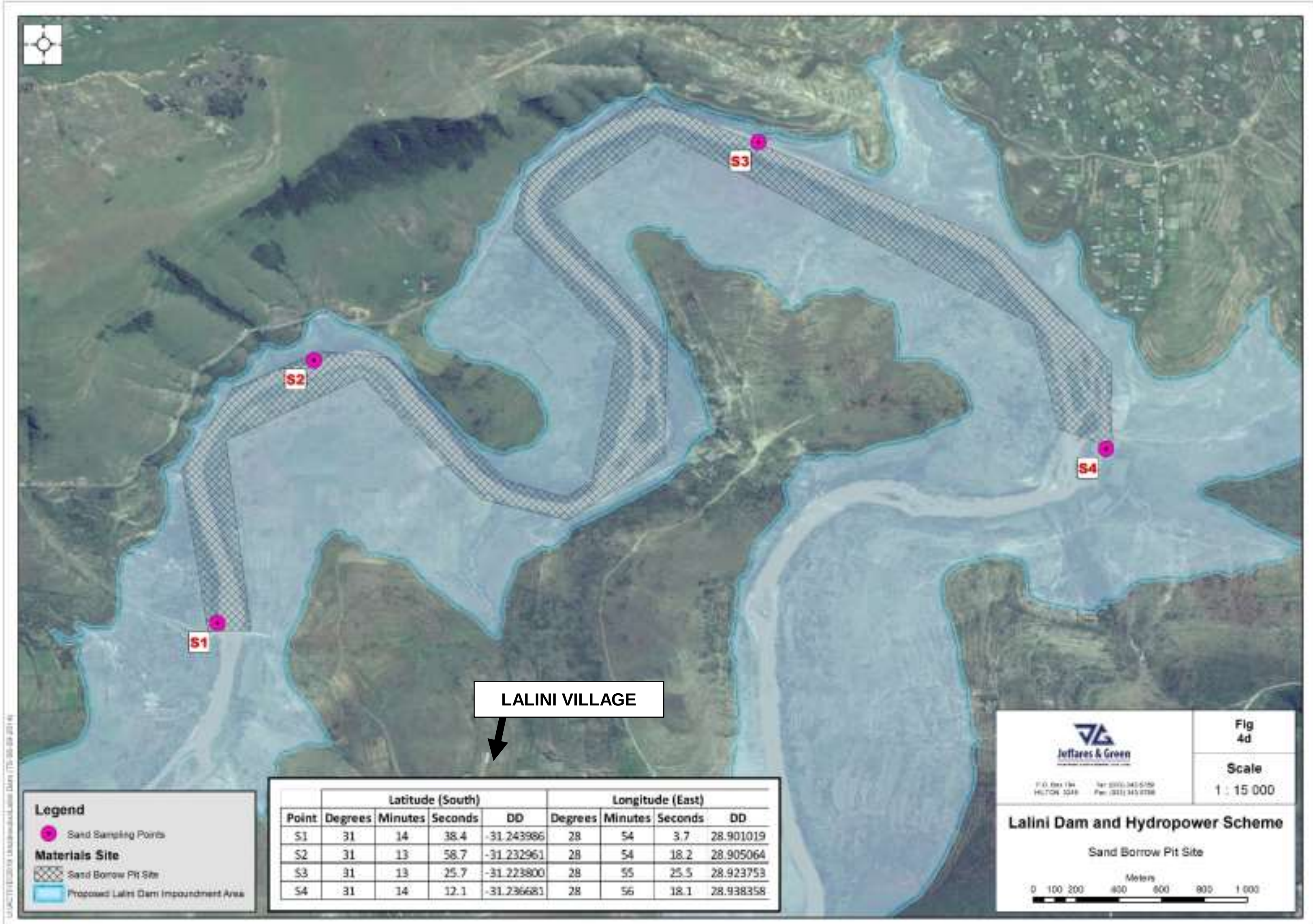
Fill Trial Pits

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
FTP1	31	15	4.3	-31.251183	28	55	23.1	28.923089
FTP2	31	15	1.4	-31.250400	28	55	24.5	28.923472
FTP3	31	15	8.2	-31.252286	28	55	23.5	28.923197
FTP4	31	15	10.3	-31.252861	28	55	19.3	28.922028
FTP5	31	15	11.1	-31.253083	28	55	27.8	28.924389
FTP6	31	15	13.8	-31.253833	28	55	29.0	28.924722
FTP7	31	15	17.2	-31.254778	28	55	30.7	28.925194
FTP8	31	15	22.4	-31.256222	28	55	30.8	28.925222
FTP9	31	15	18.8	-31.255222	28	55	24.7	28.923528
FTP10	31	15	15.8	-31.254389	28	55	19.2	28.922000
FTP11	31	15	18.9	-31.255250	28	55	15.7	28.921028
FTP12	31	15	14.3	-31.253972	28	55	24.9	28.923583
FTP13	31	15	11.4	-31.253167	28	55	20.9	28.922472
FTP14	31	15	22.9	-31.256361	28	55	14.2	28.920611
FTP15	31	15	28.9	-31.258028	28	55	10.5	28.919583

Borrow Area

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
1	31	14	57.6	-31.2493	28	55	22.4	28.9229
2	31	15	8.7	-31.2524	28	55	28.6	28.9246
3	31	15	22.2	-31.2562	28	55	31.8	28.9255
4	31	15	32.4	-31.259	28	55	15.9	28.9211
5	31	15	29.1	-31.2581	28	55	9.5	28.9193
6	31	15	6.8	-31.2519	28	55	12.7	28.9202

Figure 10-6: Embankment Fill Trial Pit Locations



	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
S1	31	14	38.4	-31.243986	28	54	3.7	28.901019
S2	31	13	58.7	-31.232961	28	54	18.2	28.905064
S3	31	13	25.7	-31.223800	28	55	25.5	28.923753
S4	31	14	12.1	-31.236681	28	56	18.1	28.938358

Figure 10-7: Sand Source Sampling Locations

10.4 Hydropower Water Transfer Conduit: Pipeline Section

The selection of the conduit size, material and alignment is described in Section 12. The proposed pipeline section alignment runs from downstream of the dam on the southern side of the Tsitsa River before turning eastwards towards the tunnel inlet portal. Trial pits were excavated at 200 metre intervals along the proposed pipeline route by means of a TLB, to investigate the subsurface material characteristics and excavation conditions. The pipeline alignment and location of these trial pits are shown on Figure 10-8.

Eleven (11) trial pits were excavated to TLB refusal along the proposed pipeline alignment. Longitudinal sections illustrating the geological profile are shown in Figure 10-9 and Figure 10-10.

The transported subsurface material varied from alluvial to colluvial along the proposed pipeline route. The residual materials vary from shale, sandstone and dolerite origin. Boulders were found in most of the trial pits. Refusal of the tractor-loader-backhoe was generally experienced in all the trial pits at relatively shallow depths.

Sandstone, shale and dolerite bedrock was found during the pipeline investigation. Massive, hard dolerite bedrock was found at the first 5 test pits (pipeline trial pit (PTP)1 to PTP5) underlying mostly corestone filled, loose to medium dense, silty sand, residual dolerite and transported, loose, silty sand alluvial with abundant dolerite cobbles and boulders.

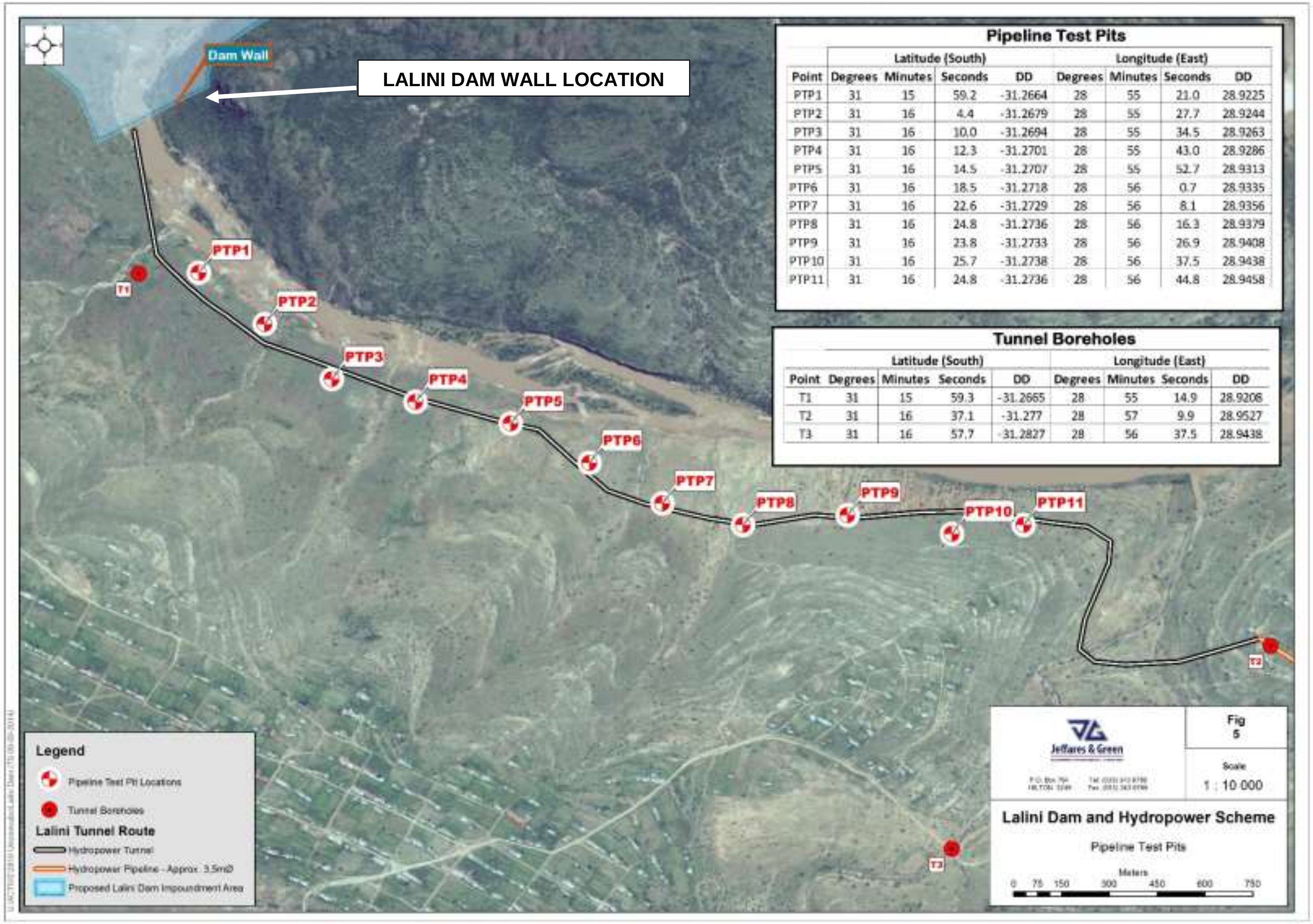
In trial pits PTP6 and PTP7, fine grained, very thinly bedded, very closely jointed, moderately weathered to unweathered, soft to medium hard sandstone bedrock was found. Above the sandstone bedrock, silty sand, loose, intact colluvial was found with abundant boulders and cobbles.

Trail pits PTP8 and PTP9 exhibited completely weathered to moderately weathered, fine grained, very thinly bedded and very closely jointed, medium hard rock shale. Above the shale bedrock, a loose to medium dense, intact, silty sand, colluvial with abundant boulders and cobbles was found.

In test pits PTP10 and PTP11, highly weathered to slightly weathered, fine grained, very thinly bedded, very closely jointed, medium hard sandstone bedrock was found at a relatively shallow depth underlying silty sand, loose, colluvial with abundant cobbles and boulders.

Excavation conditions along the pipeline route categorise as ‘intermediate’ and ‘hard’ according to SANS 2001-BE1: 2008 *“Classes of excavation”,* as specified for restricted excavation, within the depths investigated. Figure 10-9 and Figure 10-10 also present a graphical illustration of the excavatability along the pipeline route.

Dolerite boulders will make excavation difficult along the proposed pipeline route. From the dam wall to the test pit location PTP6 ‘hard’ excavation can be expected from the dolerite bedrock. Blasting of the dolerite bedrock may be required to achieve the required invert level for the pipeline.



Pipeline Test Pits

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
PTP1	31	15	59.2	-31.2664	28	55	21.0	28.9225
PTP2	31	16	4.4	-31.2679	28	55	27.7	28.9244
PTP3	31	16	10.0	-31.2694	28	55	34.5	28.9263
PTP4	31	16	12.3	-31.2701	28	55	43.0	28.9286
PTP5	31	16	14.5	-31.2707	28	55	52.7	28.9313
PTP6	31	16	18.5	-31.2718	28	56	0.7	28.9335
PTP7	31	16	22.6	-31.2729	28	56	8.1	28.9356
PTP8	31	16	24.8	-31.2736	28	56	16.3	28.9379
PTP9	31	16	23.8	-31.2733	28	56	26.9	28.9408
PTP10	31	16	25.7	-31.2738	28	56	37.5	28.9438
PTP11	31	16	24.8	-31.2736	28	56	44.8	28.9458

Tunnel Boreholes

	Latitude (South)				Longitude (East)			
Point	Degrees	Minutes	Seconds	DD	Degrees	Minutes	Seconds	DD
T1	31	15	59.3	-31.2665	28	55	14.9	28.9208
T2	31	16	37.1	-31.277	28	57	9.9	28.9527
T3	31	16	57.7	-31.2827	28	56	37.5	28.9438

Figure 10-8: Hydropower Conduit: Pipeline Section Trial Pits

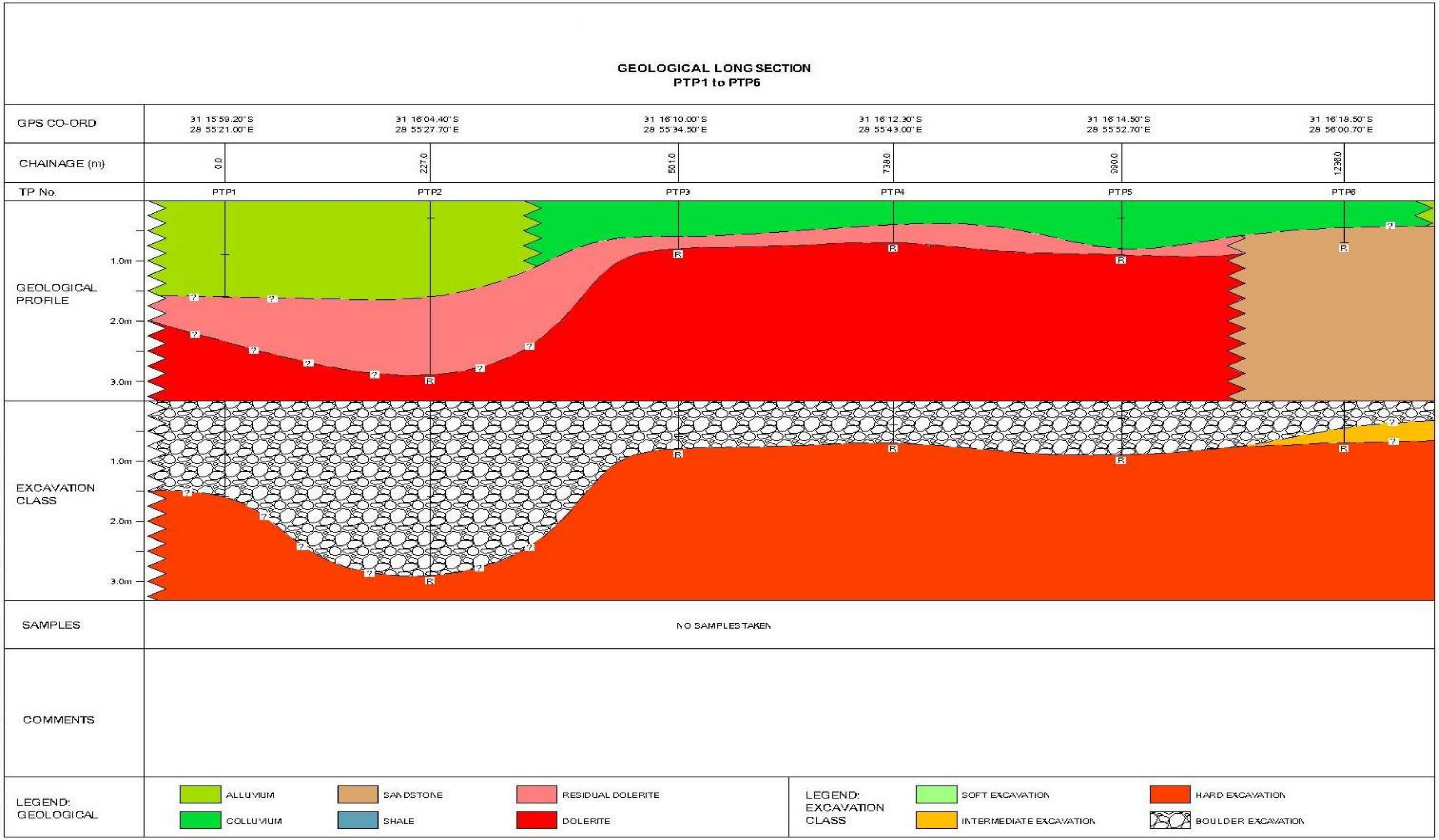


Figure 10-9: Pipeline Geological Longitudinal Section between PTP1 and PTP6

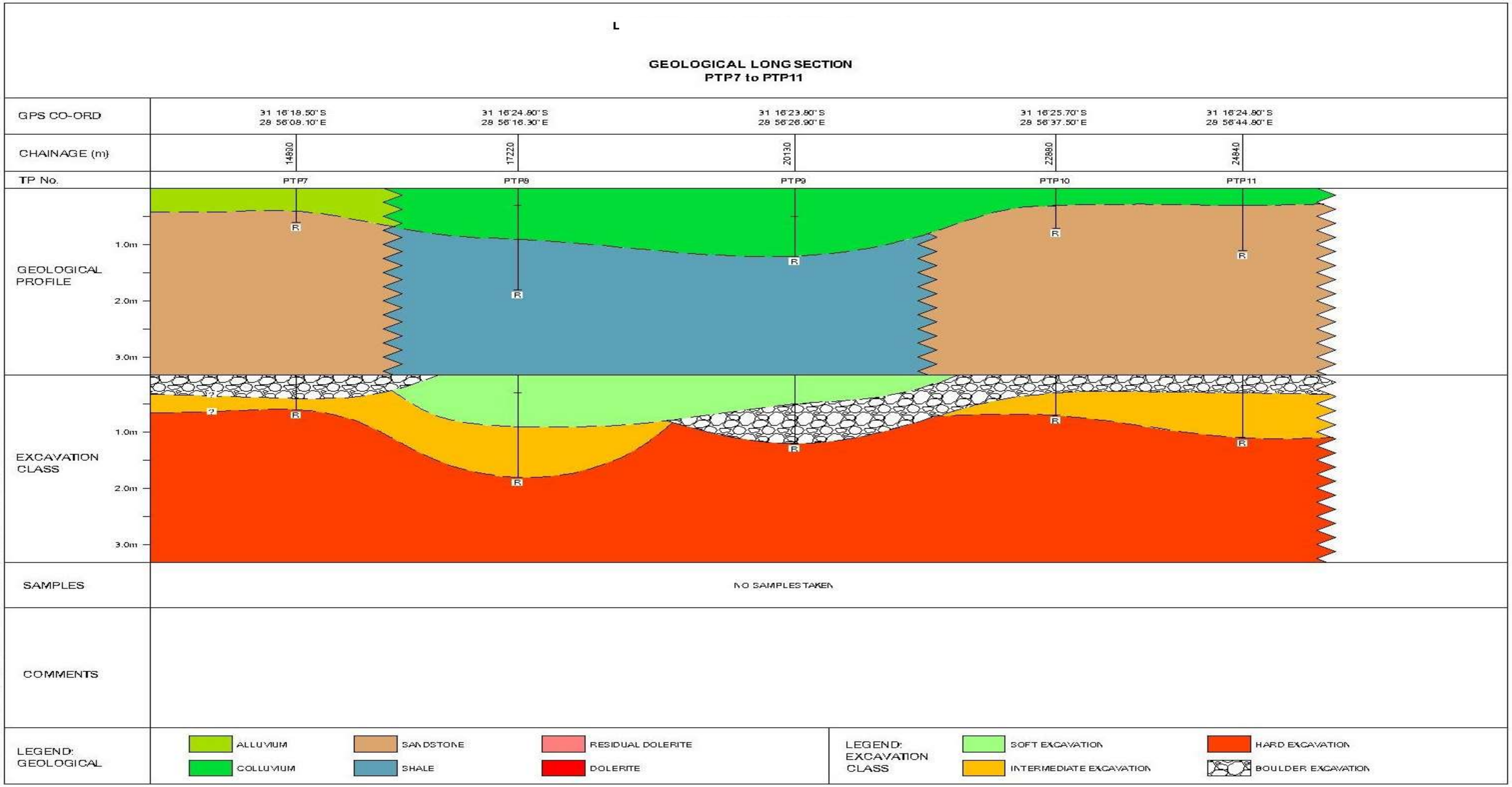


Figure 10-10: Pipeline Geological Longitudinal Section between PTP7 and PTP11

10.5 Hydropower Water Transfer Conduit: Tunnel Section

As described above, the favoured arrangement and alignment of the tunnel at the time of the investigation entailed a pipeline from the dam to the tunnel inlet portal. The length of the pipeline is approximately 3.5 km.

The conceptual alignment of the conduit and sections through two alternative tunnel section arrangements are given on Figure 10-11.

From the tunnel inlet portal to the outlet portal close to the hydroelectric plant, the preferred, deeper tunnel is approximately 4.4 km in length.

The tunnel cross-section is sized so that the hydropower conduit can be constructed as a steel pipeline, which can run continuous from the above-described buried section, through the tunnel. This will allow future access to the pipeline as it passes through the hill, and the tunnel would not need to be constructed as a water pressure retaining structure. On emerging from the tunnel outlet portal, the pipeline would then convey water over the short distance to the main hydroelectric plant (HEP).

This arrangement was the second of two alternative tunnel alignments investigated, and results in a deeper tunnel through the hill and directly to the HEP. Due to budgetary limitations for geotechnical investigations at the feasibility study stage only two drilled along the tunnel alignment were able to penetrate to the full depth of the deeper tunnel, and three of the shallower tunnel. However, the geology encountered and interpreted indicates that good tunnelling conditions should be encountered in competent rock, whichever of the predominant strata are eventually encountered.

Figure 10-12 shows a summary of core logs from the investigation boreholes drilled along the tunnel alignment.

The predominant geology encountered in the tunnel boreholes was sandstone with silty inter-beds and lesser dolerite. The boreholes drilled indicate that for the selected alignment the tunnel would pass predominantly through laminated and inter-bedded sandstone.

Through the tunnel zone of the upper alignment, the rock is competent with a Rock Mass Rating (RMR) value of about 70, based on a drill and blast 4 m high, horse-shoe shaped tunnel section. Analyses indicated that minor degrees of instability associated with the rock structure, requiring nominal support in the form of shotcrete and selected rock-bolting.

Recommendations were made that more detailed geotechnical investigations be undertaken at the Lalini Dam and Hydropower scheme in order to fully inform the detailed design stage of the project.

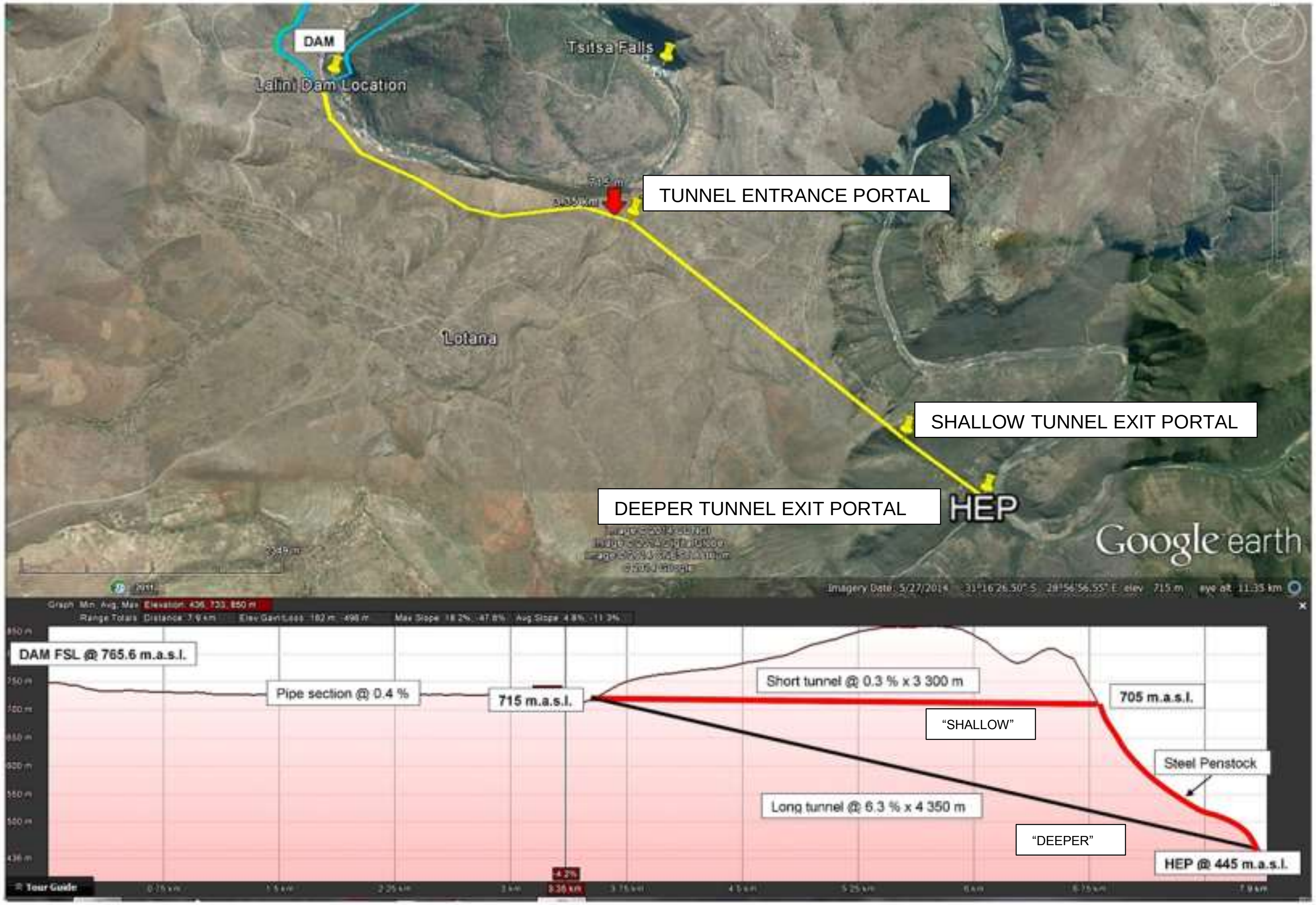
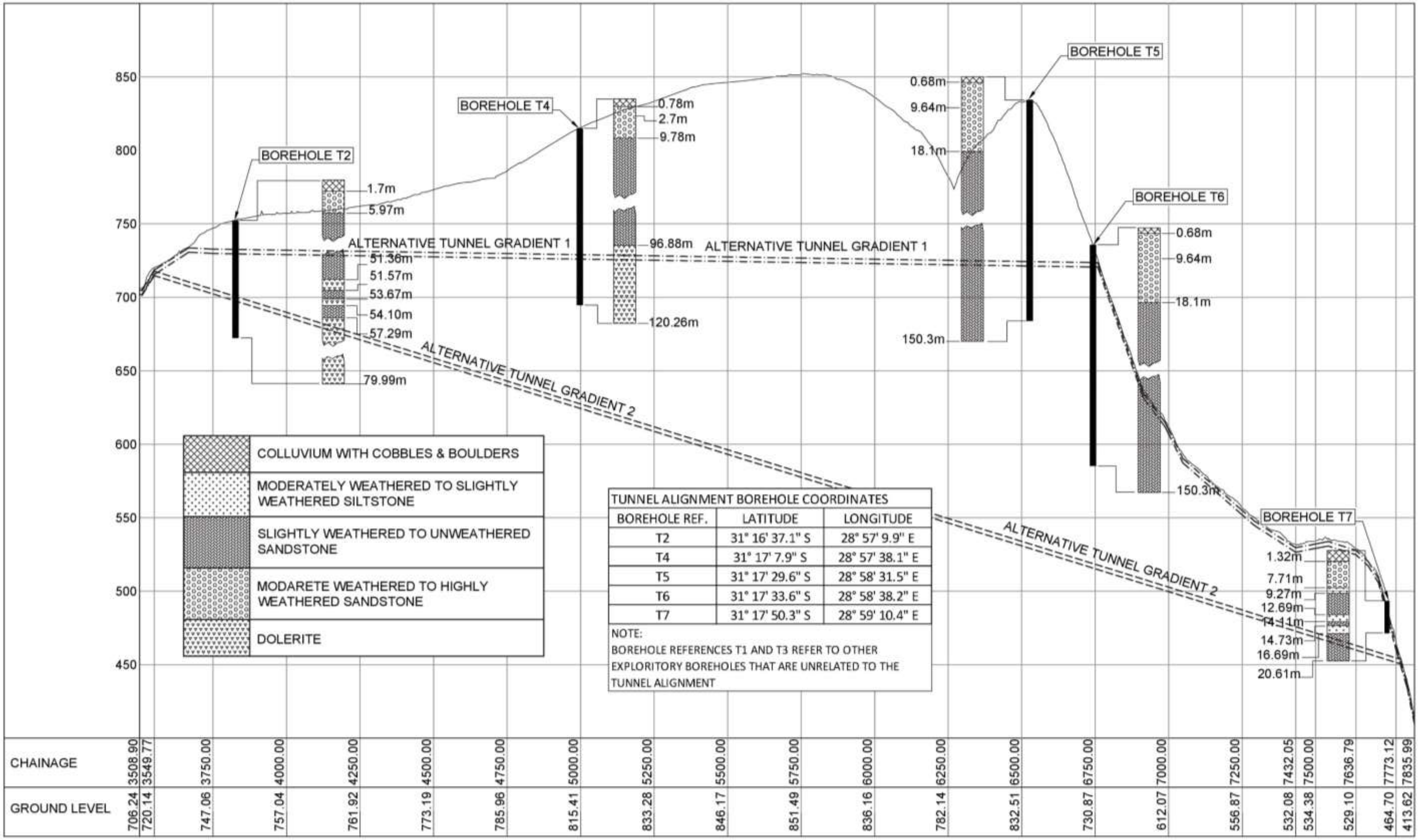


Figure 10-11: Plan and Long Section of Conceptual Pipeline and Tunnel Alignments



TUNNEL ALIGNMENT BOREHOLE COORDINATES		
BOREHOLE REF.	LATITUDE	LONGITUDE
T2	31° 16' 37.1" S	28° 57' 9.9" E
T4	31° 17' 7.9" S	28° 57' 38.1" E
T5	31° 17' 29.6" S	28° 58' 31.5" E
T6	31° 17' 33.6" S	28° 58' 38.2" E
T7	31° 17' 50.3" S	28° 59' 10.4" E

NOTE:
BOREHOLE REFERENCES T1 AND T3 REFER TO OTHER EXPLORITORY BOREHOLES THAT ARE UNRELATED TO THE TUNNEL ALIGNMENT

Figure 10-12: Borehole Log Profiles along Tunnel Section

11. HYDROPOWER ANALYSIS: LALINI DAM

11.1 Introduction

An extension to the feasibility study involved detailed investigations for a second dam on the Tsitsa River at Lalini (3.5 km above the Tsitsa Falls) which would be operated conjunctively with the Ntabelanga Dam to generate significant hydropower for supply into the national grid.

This section summarises the Hydropower Analysis: Lalini Dam Report No. P WMA 12/T30/00/5212/18, which describes the process undertaken to determine the hydropower generation potential of the Ntabelanga and Lalini Dams when operated conjunctively.

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

11.2 Regional Power Supply Situation

In considering the power supply situation in the region, consultations were held with ESKOM's regional grid access department in East London. They confirmed that the demands on the existing grid were such that locally generated power such as that which could be generated at Lalini could be evacuated into the regional grid to supply local consumers, and this would reduce the power supplied into the grid from further away, which in turn reduces transmission losses and releases that energy for supply to other areas.

The limitations in the case of Lalini are that the existing transmission lines that would receive such evacuated energy are 132 kV and this means that evacuation of power at HEP outputs greater than 100 MW would not be possible without major additional transmission systems being constructed.

11.3 Existing Hydropower in the Region

There are two existing mini-hydropower schemes in the Mthatha area which utilize water released from the Mthatha Dam in the next catchment south of the Tsitsa River. These are the First Falls and Second Falls schemes and are operated by ESKOM. They operate in series and are classified as "run-of-river" schemes in that they do not have dedicated balancing storage dams, instead they rely on the water released downstream from the Mthatha Dam, which is the primary source of water supply to Mthatha.

Both of these schemes have experienced problems with flooded infrastructure and studies have been undertaken[8] to resolve these problems and to consider possible increased output capacity upgrades.

First and Second Falls hydroelectric plants (HEPs) have installed capacities of 6 MW and 11 MW respectively but these maximum outputs are only produced at flow rates of 26 m^3/s and 28 m^3/s respectively.

Given that the Mthatha Dam is primarily used for water supply and can only sustain a constant release of 4.5 m^3/s at high levels of assurance, it is clear that the actual effective continuous outputs of these two HEPs would be significantly less than their installed capacities.

[8] *ESKOM (2014), Refurbishment of Eastern Cape Mini Hydro Plants and Investigation of Potential Expansion*

For example, analysis undertaken has shown that First Falls HEP can only produce a firm (95% level of assurance) energy output of 1.225 MW, and a similar situation exists at Second Falls pro rata their installed capacities.

Thus, for a total installed capacity of these two schemes of 17 MW, the firm energy outputs is probably of the order of 3.5 to 5 MW.

The conclusion of the study also stated that it was not economically viable to increase the installed generating capacity of these HEPs.

Given this background, the proposition of increasing the generating capacity of renewable energy in the region by up to a factor of 10 was considered to be highly significant. It would also provide alternatives when considering whether additional funds should be spent on upgrading and maintaining the First and Second Falls HEPs or whether the conjunctive Ntabelanga and Lalini HEP schemes should replace the First and Second Falls schemes altogether. This latter decision is, however, not part of the terms of reference of this study.

11.4 Ntabelanga and Lalini Dams Conjunctive Hydropower Scheme

The basis of approach was that the generating of hydropower could be used to cross-subsidize the significant energy costs required for pumping water for the irrigation and domestic water supply schemes proposed to be supplied from the Ntabelanga Dam.

The mountainous terrain which constitutes the potable water supply area requires a large amount of high-lift pumping resulting in high energy costs.

The agricultural water requirements proposed for the Tsolo area would require lifting the water more than 150 m, which would normally render such a scheme non-viable in terms of the pumping cost component of water supplied, unless hydropower is developed to reduce the net unit cost of water.

The purpose of this second dam and hydropower scheme at Lalini would thus be to generate significant revenue by selling energy into the ESKOM grid, thus generating a net positive income stream which would be used to subsidise the energy and operating costs of the main Ntabelanga water supply and irrigation scheme, thus providing self-sustainability.

A more detailed hydropower analysis and feasibility design study was therefore undertaken to assess the output potential of the Lalini Dam hydropower scheme when used conjunctively with the Ntabelanga Dam. This analysis used the detailed hydrology developed for the catchment and the naturalised and historical flow series that was developed therefrom.

It was confirmed and agreed that the sizing and modus operandi of the Lalini Dam and its associated works would take into account its main role, namely:

a. to generate hydropower both locally at the dam wall and in the Tsitsa River gorge downstream of the Tsitsa Falls, and
b. to provide sufficient flow of water downstream of the Lalini Dam and these hydroelectric plants (HEPs) to meet environmental water requirements for an ecological category B/C.

In order to facilitate this analysis detailed investigations were undertaken of the Lalini Dam component of the scheme, inter alia:

- detailed topographical survey and positioning of the proposed Lalini Dam,
- geotechnical investigations of the dam site, sources of construction materials, and tunnel alignments,
- investigation of various Lalini hydropower scheme configuration options, and
- hydropower modelling simulations of the Lalini hydropower plant and two mini-hydropower plants at Ntabelanga and Lalini dams for the conjunctive scheme.

A reserve determination needed to be completed for the Lalini Dam and hydropower plant sites as the hydropower releases can have a significant impact upon the riverine ecology downstream of the proposed dam site and hydropower tunnel exit point.

This included the undertaking of a rapid determination of the EWR of the Tsitsa River downstream of the Tsitsa Falls, which indicated an ecological class of B/C. This EWR value and its recommended rules of operation were included into a new hydropower simulation model to improve the accuracy of estimation of the potential hydropower outputs of the scheme.

This was undertaken as a part of the independent EIA contract and results are given in that suite of reports. Based upon these findings, Lalini hydropower scheme operating rules were developed to ensure that environmental water requirement (EWR) recommendations were complied with, and these rules were discussed and agreed with the DWS Reserve Determination Directorate.

11.5 Initial Hydropower Analysis

A series of hydropower scenarios were initially undertaken for varying dam sizes and combinations at the Ntabelanga and Lalini Dam sites.

Four scenarios were undertaken for a “maximum” Ntabelanga Dam volume (489.7 million m^3 – 1.18 MAR_{PD}) with a water requirement scenario of 60 million m^3/a, run conjunctively with various Lalini Dam sizes (82.8, 165.6, 414.0 and 621.0 million m^3).

An additional four scenarios were undertaken for a “minimum” Ntabelanga Dam volume (60.0 million m^3 – 0.15 MAR), again with a water requirement of 60 million m^3/a, run conjunctively with various Lalini Dam sizes (207.0, 414.0, 621.0 and 828.0 million m^3).
All eight scenarios aimed to determine the average/base load hydropower generation capability of the combined system at Lalini Dam.

The conclusion of this initial hydropower analysis indicated that between 25 and 30 MW of hydropower could be generated on average, and that the optimum configuration was with the Ntabelanga Dam at its maximum feasible capacity of 489.7 million m^3 or 1.18 MAR_{PD}, and with the Lalini Dam at a minimum capacity of 207.0 million m^3 or 0.18 MAR_{PD}.

This initial analysis is described in Report Nos. P WMA 12/T30/00/5212/12 and 18.

11.6 Further Investigations Undertaken

The basis of this approach was that the generating of hydropower could be used to cross-subsidize the significant energy costs required for pumping water for the irrigation and domestic water supply schemes proposed to be supplied from the Ntabelanga Dam.

The agricultural water requirements proposed for the Tsolo area would require lifting the water more than 150 m, which would normally render such a scheme non-viable in terms of the pumping cost component of water supplied, unless hydropower is developed to reduce the net unit cost of water.

A more detailed hydropower analysis was therefore undertaken to assess the output potential of the Lalini Dam hydropower scheme when used conjunctively with the Ntabelanga Dam. This analysis used the detailed hydrology developed for the catchment and the naturalised and historical flow series that was developed therefrom.

In order to facilitate this analysis detailed investigations were undertaken of the Lalini Dam components of the scheme, inter alia:

- Detailed topographical survey and positioning of the proposed Lalini Dam;
- Geotechnical investigations of the dam site, sources of construction materials, and tunnel alignments;
- Detailed elevation-head-efficiency relationship for the hydropower plant and configuration proposed at the Lalini Dam; and
- Hydropower modelling simulation of the Lalini hydropower plant and two mini-hydropower plants at Ntabelanga and Lalini dams for the conjunctive scheme.

A reserve determination needed to be completed for the Lalini Dam and hydropower plant sites as the hydropower releases may have a significant impact upon the riverine ecology downstream of the proposed dam site and hydropower tunnel exit point. This was undertaken as a part of the independent EIA contract and results are given in that suite of reports.

This included the undertaking of a rapid determination of the EWR of the Tsitsa River downstream of the Tsitsa Falls, which indicated an ecological class of B/C. This EWR value and its recommended rules of operation were included into a new hydropower simulation model to improve the accuracy of estimation of the potential hydropower outputs of the scheme.

The process and results of the improved hydropower potential assessment and the feasibility design of the Lalini Dam and its hydropower scheme are summarised in detail in Report Nos. P WMA 12/T30/00/5212/18 and 19.

11.7 Methodology

The hydropower assessment of the conjunctive use of the Ntabelanga and Lalini Dams on the Tsitsa River was undertaken using detailed hydrology produced in the earlier analyses stage of this feasibility study, as well as new and highly accurate topographical survey data for the Lalini dam basin.

The analysis was undertaken using the previously recommended Ntabelanga Dam capacity (1.18 MAR_{PD}), and for a range of Lalini Dam capacities from 0.10 MAR_{PD} (Mean Annual Runoff based upon Present Day flows) to 0.75 MAR_{PD}.

The optimum Lalini Dam size selection was based on several factors, such as unit power cost, funding requirements, as well as social and environmental impacts.

The main objective of the hydropower generation assessment was to determine the amount of energy that can be produced per year from each dam capacity option assuming that the environmental, domestic and agricultural water requirements are met first.

Given that the two dams are to be operated conjunctively, there could be a trade-off on water allocation. If the eventual domestic and irrigation water demands upon the Ntabelanga Dam were to be less than projected, then more water could be made available for release from the dam to increase hydropower generation. However, such releases would still need to follow the water reserve operating rule recommendations for environmental water requirements at both Ntabelanga and Lalini Dams.

11.8 Results and Conclusions

11.8.1 Hydropower Generation Conclusions

- The Ntabelanga Dam was simulated to supply the potable and irrigation water requirement scenario value, rounded to approximately 60 million m^3/a, which was met 100% of the time in all of the hydropower scenarios. For the purposes of its conjunctive usage with the Lalini Dam and hydropower scheme, the capacity used for the Ntabelanga Dam was 489.7 million m^3, or 1.18 MAR_{PD}.
- The EWR for the Lalini Dam was determined following a reserve determination process undertaken as a part of the EIA study, which considered the river reach below the Tsitsa Falls to be an ecological category B/C due to the potentially sensitive and unique environment downstream of the Tsitsa Falls, and allocating 287 million m^3 (33% MAR) as an annual average.
- The full analysis of the scenarios assessed in this study includes an economic and financial analysis, which includes determination of the cost-benefits of the hydropower component, as described in Report No. P WMA 12/T30/00/5212/15 and 16.

Three hydroelectric plants (HEPs) were modelled:

1. a 5 MW installed capacity mini-HEP just downstream of the Ntabelanga Dam;
2. a 5 MW installed capacity mini-HEP just downstream of the Lalini Dam, and
3. the main HEP at Lalini located in the Tsitsa River gorge and supplied by a 7.9 km long conduit and tunnel.

The two mini-HEPs make use of the water released downstream to meet the EWR, and the head of water available in each dam. This means that they can generate between 0.75 and 5 MW each, depending on the head and flow available at the time.

Two base case options were investigated for the main Lalini HEP, namely:

i) installed capacity 50 MW, and
ii) installed capacity 37.5 MW

The results from the hydropower modelling analyses for the recommended Ntabelanga Dam capacity and the range of Lalini Dam storage volumes given above are presented in Figures 11-1 and 11-2, and Tables 11-1 and 11-2.

The analysis undertaken produced results which showed that the simulated base load (average) hydropower generation from the Lalini Dam ranged from 12.5 MW to 50 MW, depending on the status of the river in terms of season, drought or flood conditions, and the combination of storage capacity options for the Ntabelanga and Lalini Dams.

Given the physical dam capacity constraints which are limited by topography and environmental and social impacts, and capital cost considerations, the preferred installed capacity solution was determined to be 37.5 MW.

The outcome of the investigations indicated that hydropower generation potential at the Lalini Dam, with Ntabelanga Dam acting as a regulating dam for the production of hydropower at Lalini, is potentially cost-beneficial in such a multi-purpose scheme.

The optimum solution was shown to be one where the Ntabelanga Dam is constructed to a maximum capacity of 1.18 MAR_{PD}, as constrained by topographical limitations, with the Lalini Dam capacity set at 0.28 MAR_{PD}.

The energy figures thus produced were incorporated into the economic and financial models undertaken to determine the best conjunctive use solution.

These analyses are described in the Hydropower Analysis: Lalini Dam Report No. P WMA 12/T30/00/5212/18, and in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

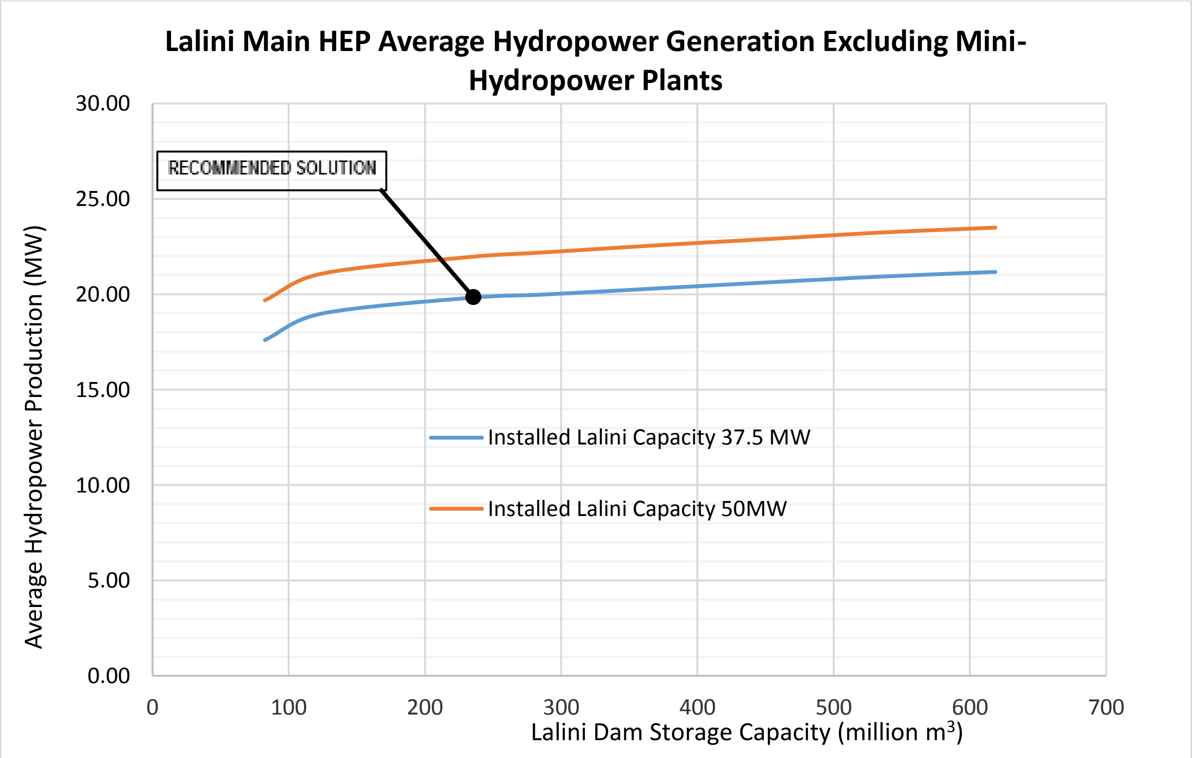


Figure 11-1: Hydropower Output: Lalini Main HEP

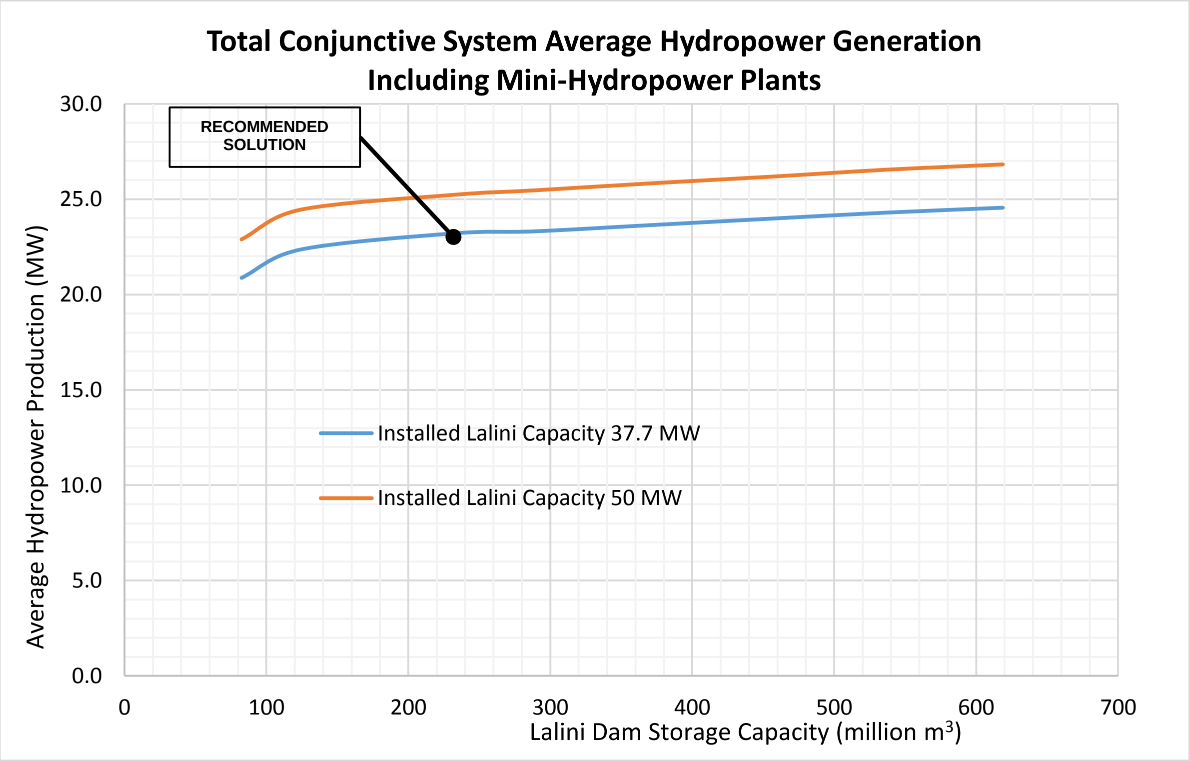


Figure 11-2: Hydropower Output: Including Mini-HEPs

Note: Recommended solution for the conjunctive scheme would produce an average of 23.17 MW.

Table 11-1: Hydropower Generation Results: 37.5 MW Installed

Scenario		Lalini Dam Statistics					Lalini Dam EWR			Ntabelanga Mini-HEP Maximum Installed Capacity	Ntabelanga Mini-HEP Ave. Annual Power Output	Lalini Main HEP Installed Capacity	Lalini Main HEP Ave. Annual Power Output	Lalini Mini-HEP Maximum Installed Capacity	Lalini Mini-HEP Ave. Annual Power Output
No.	Description	FSL	MOL	Gross storage capacity	Live storage capacity	*Area	Class	Requirements		HydroPower	HydroPower	HydroPower	HydroPower	HydroPower	HydroPower
		m.a.s.l	m.a.s.l	million m^3	million m^3	km^2		million m^3/a	% MAR	MW	MW	MW	MW	MW	MW
01	1.18 MAR Ntabelanga + 0.10 MAR Lalini	751.8	745.2	82.5	40.3	7.61	BC	287.1	33.05	5	1.67	37.5	17.60	5	1.60
02	1.18 MAR Ntabelanga + 0.15 MAR Lalini	756.5	745.2	123.8	81.6	9.85	BC	287.1	33.05	5	1.66	37.5	18.98	5	1.71
03	**1.18 MAR Ntabelanga + 0.28 MAR Lalini**	**765.5**	**745.2**	**231.0**	**188.8**	**14.02**	**BC**	**287.1**	**33.05**	**5**	**1.57**	**37.5**	**19.77**	**5**	**1.83**
04	1.18 MAR Ntabelanga + 0.35 MAR Lalini	769.4	745.2	288.8	246.6	15.80	BC	287.1	33.05	5	1.45	37.5	19.99	5	1.87
05	1.18 MAR Ntabelanga + 0.45MAR Lalini	774.2	745.2	371.3	329.1	18.18	BC	287.1	33.05	5	1.40	37.5	20.31	5	1.93
06	1.18 MAR Ntabelanga + 0.55 MAR Lalini	778.4	745.2	453.8	411.6	20.67	BC	287.1	33.05	5	1.35	37.5	20.63	5	1.99
07	1.18 MAR Ntabelanga + 0.65 MAR Lalini	782.3	745.2	536.3	494.1	22.65	BC	287.1	33.05	5	1.31	37.5	20.93	5	2.05
08	1.18 MAR Ntabelanga + 0.75 MAR Lalini	785.8	745.2	618.75	576.56	24.5	BC	287.1	33.05	5	1.28	37.5	21.17	5	2.10

* Surface area at Full Supply Level

Recommended Scheme produces an average of 23.17 MW

Table 11-2: Hydropower Generation Results: 50 MW Installed

Scenario		Lalini Dam Statistics					Lalini Dam EWR			Ntabelanga Mini-HEP Maximum Installed Capacity	Ntabelanga Mini-HEP Ave. Annual Power Output	Lalini Main HEP Installed Capacity	Lalini Main HEP Ave. Annual Power Output	Lalini Mini-HEP Maximum Installed Capacity	Lalini Mini-HEP Ave. Annual Power Output
No.	Description	FSL	MOL	Gross storage capacity	Live storage capacity	*Area	Class	Requirements		HydroPower	HydroPower	HydroPower	HydroPower	HydroPower	HydroPower
		m.a.s.l	m.a.s.l	million m^3	million m^3	km^2		million m^3/a	% MAR	MW	MW	MW	MW	MW	MW
01	1.18 MAR Ntabelanga + 0.10 MAR Lalini	751.8	745.2	82.5	40.3	7.61	BC	287.1	33.05	5	1.65	50	19.68	5	1.56
02	1.18 MAR Ntabelanga + 0.15 MAR Lalini	756.5	745.2	123.8	81.6	9.85	BC	287.1	33.05	5	1.71	50	21.07	5	1.66
03	1.18 MAR Ntabelanga + 0.28 MAR Lalini	765.5	745.2	231.0	188.8	14.02	BC	287.1	33.05	5	1.54	50	21.94	5	1.74
04	1.18 MAR Ntabelanga + 0.35 MAR Lalini	769.4	745.2	288.8	246.6	15.80	BC	287.1	33.05	5	1.47	50	22.20	5	1.79
05	1.18 MAR Ntabelanga + 0.45MAR Lalini	774.2	745.2	371.3	329.1	18.18	BC	287.1	33.05	5	1.41	50	22.57	5	1.85
06	1.18 MAR Ntabelanga + 0.55 MAR Lalini	778.4	745.2	453.8	411.6	20.67	BC	287.1	33.05	5	1.37	50	22.90	5	1.90
07	1.18 MAR Ntabelanga + 0.65 MAR Lalini	782.3	745.2	536.3	494.1	22.65	BC	287.1	33.05	5	1.35	50	23.24	5	1.95
08	1.18 MAR Ntabelanga + 0.75 MAR Lalini	785.8	745.2	618.75	576.56	24.5	BC	287.1	33.05	5	1.34	50	23.49	5	1.99

** Surface area at Full Supply Level*

12. FEASIBILITY DESIGN: LALINI DAM AND HYDROPOWER SCHEME

12.1 Introduction

This section summarises the Feasibility Design of the Lalini Dam and hydropower scheme which is described in detail in Report No. P WMA 12/T30/00/5212/19.

As described in the above report, the dam will have the following purposes:

- Generation of hydropower to be supplied to the national grid; and
- Maintaining Environmental Water Requirements (EWR) downstream of the dam.

The report describes the design process for the dam, its outlet works, pumping stations and conveyance systems supplying water to the infrastructure above, as well as for the hydropower plant at the dam.

12.2 Lalini Dam Location

The location of a dam site at Lalini had been investigated in previous studies, including the 2004 ESKOM study of “Hydropower Potential in the Eastern Cape”. This was further investigated during this feasibility study and confirmed following a site reconnaissance mission.

The preferred site is at a narrowing neck of the Tsitsa River approximately 3.5 km upstream of the Tsitsa Falls, co-ordinates: 31°15'44.76"S and 28°55'15.87"E.

It was concluded that there were no better upstream dam wall locations available with regard to river valley shape (which affects dam wall length), geology/founding conditions, close proximity to construction materials, and the depth versus volume characteristics of the impoundment.

This location also offered several different options for hydropower configurations which are described herein.

Location plans for the Ntabelanga and Lalini Dams are given on Figures 1-1 and 1-2.

12.3 Dam Type Analysis

The hydropower production modelling used theoretical dam storage capacities from 0.10 to 0.75 MAR_{PD} (Mean Annual Runoff using Present Day flows), but it was noted that capacities below 0.25 x MAR_{PD} produced a poor hydropower yield, and those above 0.6 MAR_{PD} overtopped watershed terrain, which would require significant additional saddle dams, as well as drowning some major existing infrastructure and settlements.

The dam type analysis has therefore been undertaken for two alternative dam storage capacities, namely: 0.28 MAR_{PD} and 0.6 MAR_{PD} (1 MAR_{PD} = 828 million m^3/a), but with the main focus on the most likely dam size of 0.28 MAR_{PD}.

It was deemed important to consider the range of possible dam type options before committing to further core drilling to be undertaken. The selected dam type options also determined what other geotechnical investigations (including materials sourcing and geophysics) should be undertaken in parallel with the core drilling.

Taking cognizance of the approach taken for the Ntabelanga Dam, as well as the observations of the dam site during the reconnaissance mission, the following dam types were investigated:

- Roller compacted concrete (RCC) dam;
- Concrete faced rockfill dam (CFRD);
- Earth core rockfill dam (ECRD); and
- Earthfill embankment dam with earth core (EF).

Options regarding spillway alternatives of a left bank side channel, cut-through spillway, and in-wall ogee spillway were also investigated.

Key factors used in determining the optimum dam type were as follows:

- Availability of sufficient quantities and quality of construction materials in the vicinity of the dam wall;
- Constructability issues, especially relating to dealing with river flow during construction;
- Spillway location and capacity requirements;
- Operational requirements and outlet works arrangements;
- Environmental impacts; and
- The cost of the works.

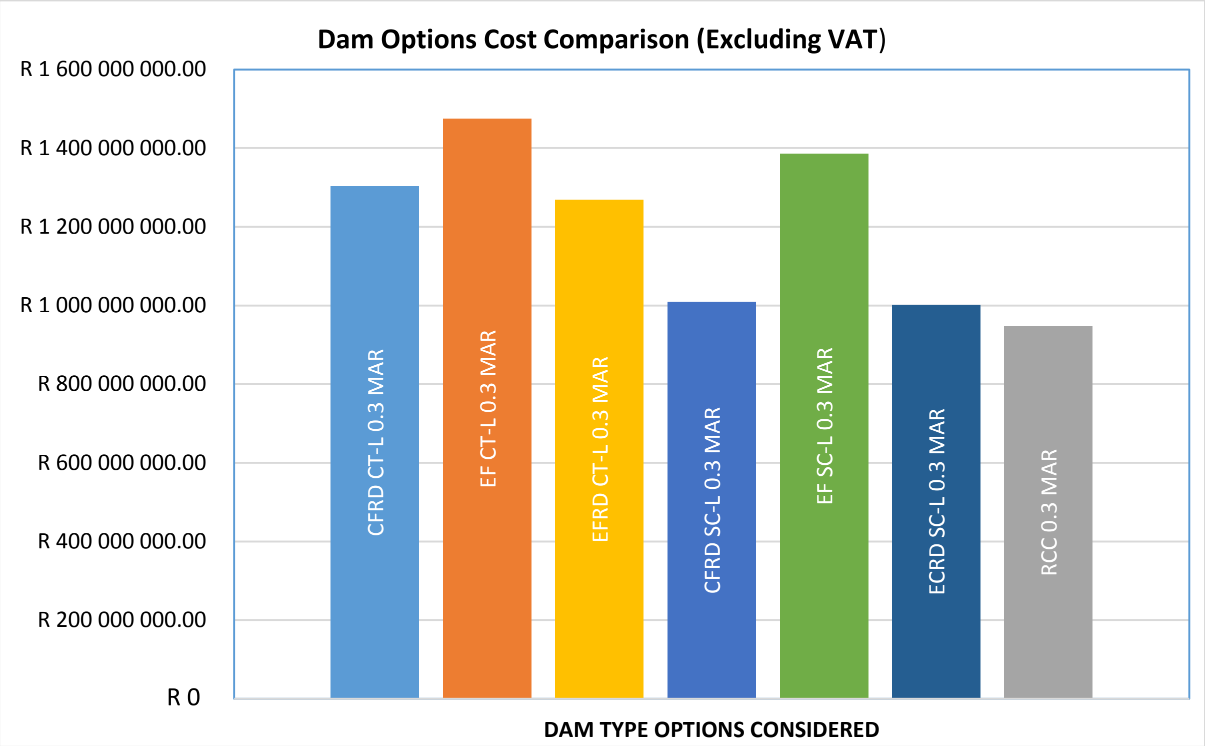
In order to assess materials requirements, quantities were calculated for all of the above dam types, based upon typical design criteria (foundation excavation depths, embankment slopes, etc), which were undertaken for all of the above dam types and their spillway options. The results of these analyses produced a ranking of dam types as shown in Table 12-1.

Table 12-1: Capital Cost Comparison of Dam Type and Spillway Options

Option No.	Dam Wall Type	Spillway Type	Option Nomenclature	Estimated Capital Cost (R'million)		
				Low	Medium	High
1	Concrete Faced Rockfill Dam (CFRD)	Cut-Through on Left Flank (CT-L)	CFRD CT-L 0.3 MAR	1206	1304	1402
2	Concrete Faced Rockfill Dam (CFRD)	Side Channel on Left Flank (SC-L)	CFRD SC-L 0.3 MAR	924	1010	1095
3	Earth Core Rockfill Dam (ECRD)	Cut-Through on Left Flank (CT-L)	ECRD CT-L 0.3 MAR	1178	1268	1358
4	**Earth Core Rockfill Dam (ECRD)**	**Side Channel on Left Flank (SC-L)**	**ECRD SC-L 0.3 MAR**	**923**	**1002**	**1081**
5	Earthfill Dam with Earth Core (EF)	Cut-Through on Left Flank (CT-L)	EF CT-L 0.3 MAR	1385	1475	1564
6	Earthfill Dam with Earth Core (EF)	Side Channel on Left Flank (SC-L)	EF SC-L 0.3 MAR	1296	1386	1475
7	**Roller Compacted Concrete**	**Central Ogee**	**RCC 0.3 MAR**	**826**	**947**	**1069**
			(green)	Lowest		
			(pink)	Second Lowest		

The green highlighted cells show the lowest cost option, which is, for all rate ranges of major quantity unit rates, Option No. 7 – an RCC dam, with Option No.4, the ECRD dam with a Side Channel Spillway cut through the Left-hand Flank, coming second lowest.

Figure 12-1 shows the comparative costs of all the options for the medium rates case, as well as main materials quantity information and how much excavated material needs to be disposed of to spoil.



Percentage of lowest cost option	138%	156%	134%	107%	146%	106%	100%
Cost Excluding VAT R'million	1 304	1 475	1 268	1 010	1 386	1 002	947
Total rock excavation used in embankment (m^3)	1 350 000	17 000	1 100 000	1 350 000	23 000	1 100 000	N/A
Total rock excavation to spoil (m^3)	3 534 000	5 090 000	3 785 000	1 436 000	2 952 000	1 779 000	N/A
Total all materials to spoil (m^3)	3 644 000	5 090 000	3 796 400	1 436 000	2 952 000	1 779 000	N/A

Figure 12-1: Dam Options Cost Comparison

The above scenario used "medium rates" from a range used to test sensitivity, which is considered to be a reasonable assumption given the nature of the dam site and proximity to construction materials, the **RCC**, **CFRD** (with left hand side channel spillway) and **ECRD** (with left hand side channel spillway) options are ranked very closely, with all other options more than 10% higher in cost.

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

12.4 Other Dam Type Selection Considerations

The following considerations were made:

- 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 including the aesthetics.

12.5 Conclusion on Dam Type Selection

Taking the various decision-making factors into consideration, 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 the CFRD or ECRD dam with a side channel spillway options, and would offer the better opportunity for implementation in a shorter time period. A general arrangement and elevations of the proposed RCC dam solution is given in Figures 12-2 to 12-4.

12.6 Dam Characteristics

The proposed Lalini Dam has the following characteristics:

Full Supply Level (FSL):	765.58 m.a.s.l.
Non-Overspill Crest Level[9] – Left flank (NOCL):	770.41 m.a.s.l.
Minimum bed level in river at dam:	717.00 m.a.s.l.
Crest width:	6 m
Minimum operating level (MOL):	740.14 m.a.s.l.
Emergency drawdown minimum outlet level:	735.00 m.a.s.l.
Maximum dam wall height to NOC:	53.41 m
Wall crest length (incl spillway):	371 m
Spillway crest length:	320 m
Gross stored volume at FSL (0.28 x MAR_{PD}):	232 million m^3
Mean Annual Runoff (Present Day) at dam:	828 million m^3
Storage below MOL (V_{50} sedimentation):	31.2 million m^3
Surface area of lake behind dam:	14.5 km^2
Backwater reach upstream of dam:	22.5 km
Hydropower transfer conduit/tunnel length	7.85 km
HEP location elevation	445 m.a.s.l.

The dam wall height, impoundment volume, and downstream risk factors for the Lalini Dam put this structure into a Category III dam under the gazetted Dam Safety Regulations.

The flood criteria for design of this dam are as follows:

1 in 200 year return period Design Flood:	3 500 m^3/s
Safety Evaluation Flood (SEF):	7 100 m^3/s

[9] *Right-hand flank NOCL is 1 m higher than this as left hand flank has been left lower to allow some overspill during the more extreme floods to save construction cost. This must be reviewed again at the detailed design stage.*

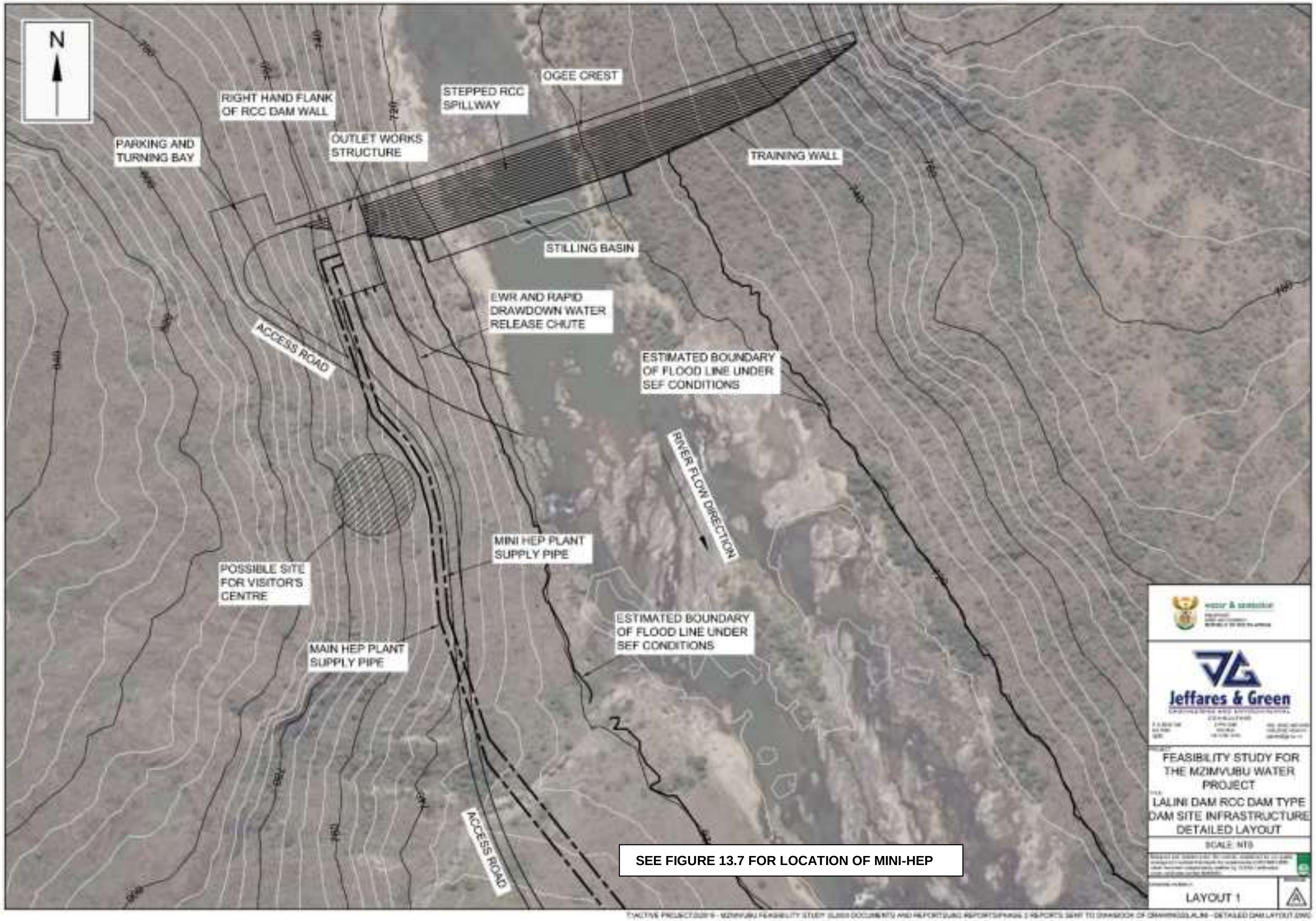


Figure 12-2: Proposed RCC Dam Layout Plan

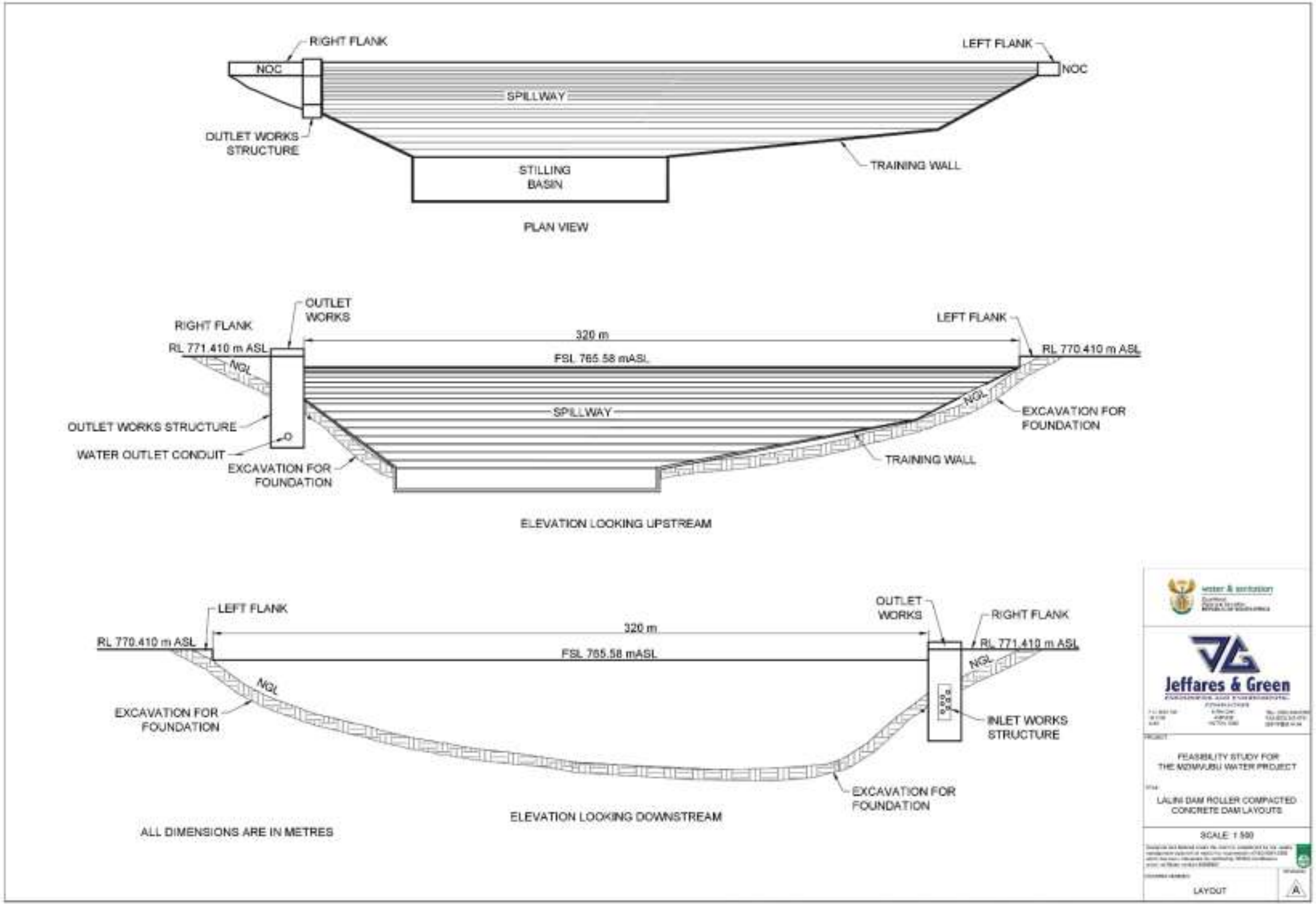


Figure 12-3: Proposed RCC Dam Elevations

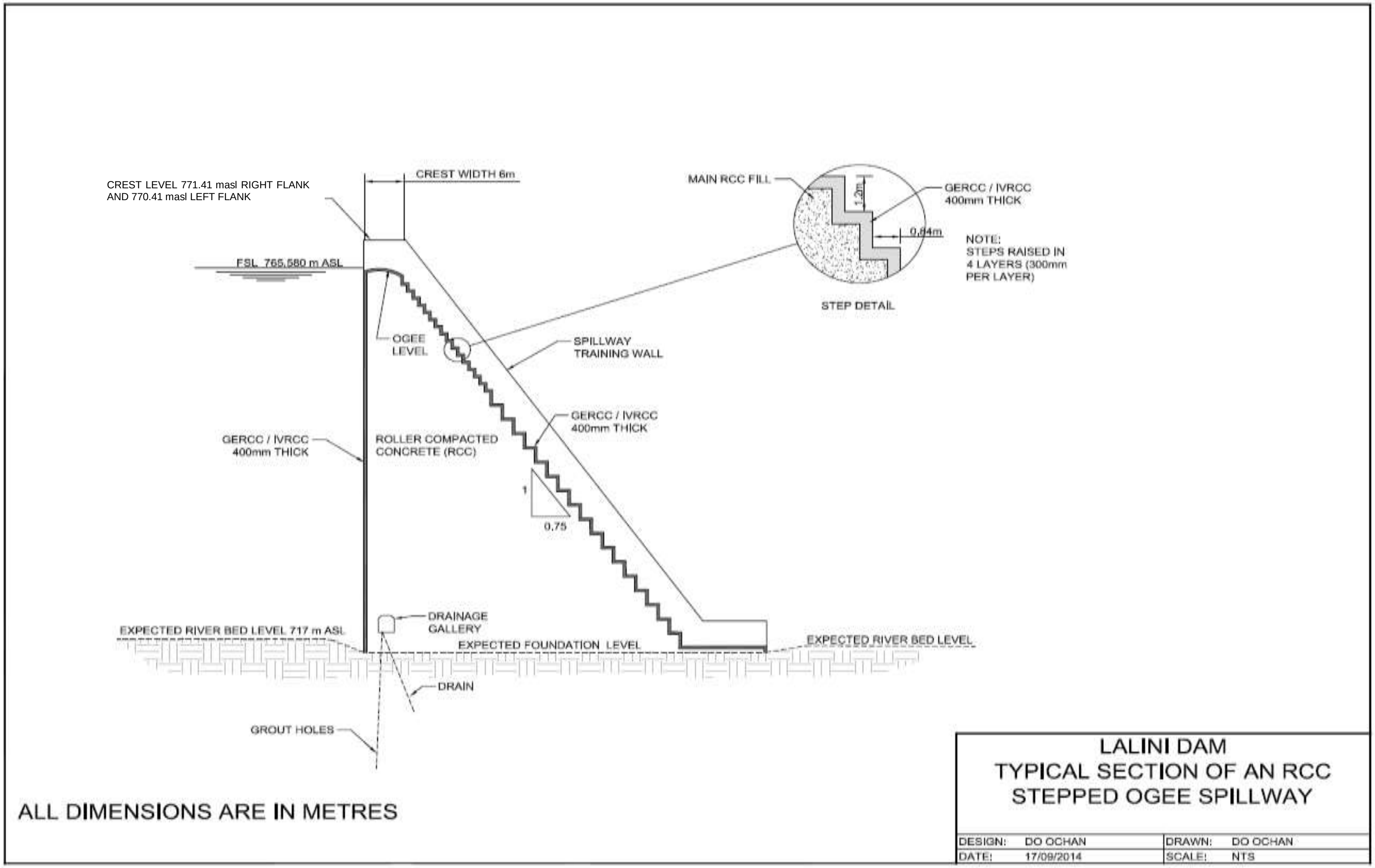


Figure 12-4: Proposed RCC Dam typical section

The dam will provide enough water and effective head required to generate an average of 21.6 MW and a peak output of 37.5 MW of hydropower as well as providing regulated flow releases in the river below the dam to meet the EWR.

12.7 EWR Releases

The Reserve Determination Report No. P WMA 12/T30/00/5212/7 determines the Environmental Water Requirements (EWR) to be released downstream of the Lalini Dam. This included a basic assessment of the expected EWR at the Tsitsa Falls site.

It was based upon running Water Resources Yield Model (WRYM) hydrological simulations and took into account the expected spills during the same period of simulation.

Additional Reserve Determination investigations were undertaken downstream of the Tsitsa Falls by the EIA PSP, and operational rules were developed for the Lalini Dam to comply with the updated EWR thus developed.

The recommended total releases at Lalini Dam are those required to maintain an intermediate ecological category B/C of 287.1 million m^3 per annum (i.e. some 33% of MAR_{NAT}[10]), which equates to an average of some 23.9 million m^3 per month.

The EWR is required to be released according to a seasonal pattern and this also depends on whether the river is in a state of flood or drought. EWR release rules are proposed in the reserve determination report, and release criteria are based upon preceding inflows. These operating rules are described in more detail in the Record of Implementation Decisions: Lalini Dam and Hydropower Scheme P WMA 12/T30/00/5212/20.

Given that water released for EWR can also be passed through a mini-hydroelectric plant just downstream of the dam wall, it was decided to consider both EWR and hydropower releases when determining outlet conduit capacity.

12.8 Hydropower Scheme

Typically, the main scheme components would comprise:

- The Lalini Dam, with inflow supplied by natural runoff from the upstream catchment, as well as both the spillage and the controlled release of water from the Ntabelanga Dam;
- Lalini dam outlet works for the conveyance of raw water to a mini-hydroelectric plant (HEP);
- Lalini dam outlet works to release water downstream to supply Environmental Water Requirements (EWR), and to rapidly draw down the reservoir in an emergency situation;
- A gravity flow raw water conveyance conduit and penstock from the Lalini Dam to the main HEP;
- An HEP plant, control and switchgear, and output transformer station; and
- Inter-connecting power lines to evacuate the energy into the ESKOM grid.

The power lines must be constructed as advance works and configured so that they will also supply power from the national grid to the works during the construction period.

[10] *Mean Annual Runoff based on natural state*

Other associated infrastructure to be developed would be:

- temporary and permanent access roads and servitudes for the construction and operation of the scheme;
- new, replacement or realigned roads, power lines, services, buildings, and other infrastructure impacted by the dam and its impoundment;
- water supply, power supply and telecommunications to the dam, tunnel, and HEP sites for the construction period and operational stage;
- administration and operations buildings;
- operations staff housing;
- wastewater treatment works for the above; and
- solid waste disposal facilities.

As with the Ntabelanga Dam, the release of water for EWR purposes provides an opportunity for additional generation of power at a “mini”-HEP which could be constructed just downstream of the dam, and this is also considered as an option herein to increase the energy produced by the conjunctive scheme.

A visitor’s information centre can encourage tourism and promote economic development by providing visitors with a view of the works and information on the project, including the cultural and tourism activities in the area.

12.9 Scheme Options

Based upon the hydropower analysis undertaken in Lalini Dam Hydropower Analysis Report No. P WMA 12/T30/00/5212/18, the feasibility design focussed on three Lalini main hydropower options:

- Base load station: installed capacity 37.5 MW
- Base load station: installed capacity 50 MW
- Peaking station: installed capacity 150 MW

12.10 Hydropower Plant Sizing

The Hydropower Analysis Report No. P WMA 12/T30/00/5212/18 describes the findings of the modelled hydropower outputs of the Ntabelanga and Lalini Dams when used conjunctively, and recommended an optimum HEP configuration. This analysis was undertaken for the “base load” case of 24 hours/day operations.

The monthly hydropower generating regime is affected by the seasonal variations in river flow, the availability of water in each dam, the operational rules that determine minimum EWR releases at both dams, as well as maximum flow releases at Ntabelanga Dam in the dry season months.

Peaking options have also been considered to determine the cost benefits of operating the scheme to maximize income from energy sales by supplying higher power for fewer hours per day (using the same available daily water allowance) and targeting peak tariff periods.

The recommendations of the cost benefit analysis was to operate the scheme as a base load plant, but to be able to utilize the fully installed capacity for peaking during winter months when prevailing circumstances allow, and if environmentally acceptable.

The result of this was that, for the preferred 0.28 MAR_{PD} Lalini Dam, the HEP plant should have an installed generating capacity of 37.5 MW in the form of 3 x 12.5 MW Pelton wheel turbine generator sets. The resulting hydropower production outputs are as shown on Table 12-2 and Figure 12-5.

Table 12-2: Lalini Main Hydropower Scheme Average Monthly Energy Production

Month	Minimum Target (MW)	Avg HP Output (MW)	Avg Energy Supplied (KWh)
Oct	12.50	18.76	13 959 044
Nov	12.50	23.67	17 043 420
Dec	25.00	22.99	17 102 324
Jan	25.00	21.89	16 283 250
Feb	25.00	23.54	15 963 055
Mar	37.50	24.55	18 268 136
Apr	25.00	22.27	16 035 946
May	12.50	15.69	11 672 893
Jun	12.50	15.83	11 399 591
Jul	12.50	15.95	11 866 003
Aug	12.50	16.04	11 931 220
Sep	12.50	16.46	11 849 343
Total Energy Per Year (kWh)			**173 374 226**
Average Power (MW)		***19.77***	

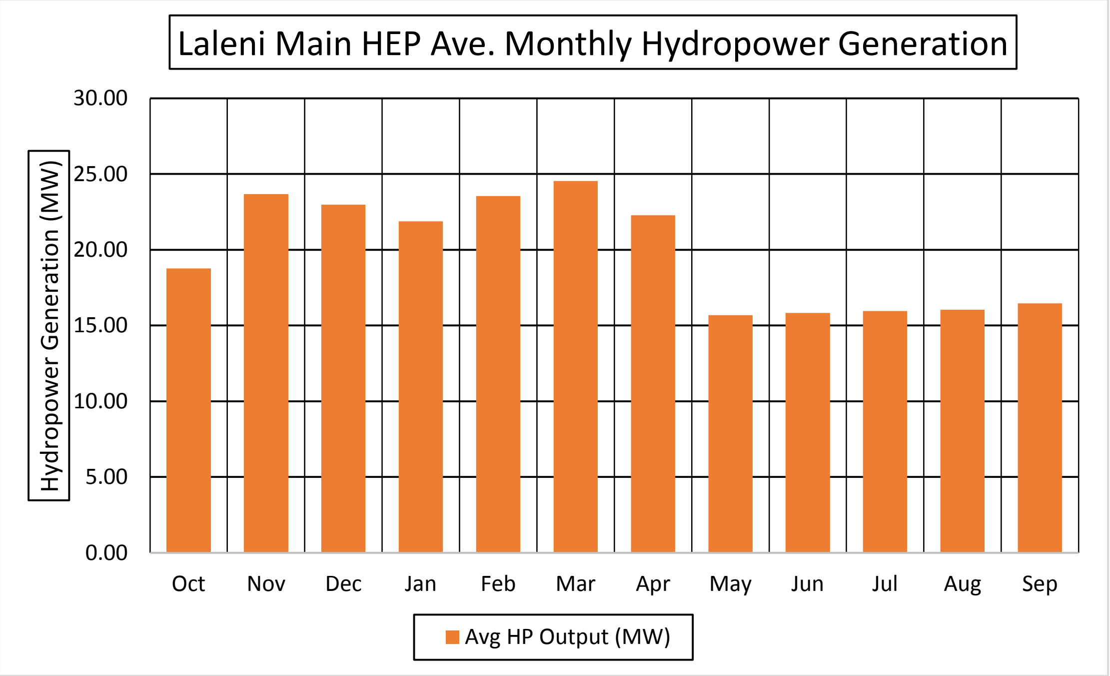


Figure 12-5: Lalini Main HEP Average Monthly Hydropower Generation

12.11 Water Transfer Conduit

Following a reconnaissance mission, three hydropower conduit route options and HEP configurations were investigated as shown in Figure 12-6. After consideration of the advantages and disadvantages of these options, the longer route (Option 3) was selected which had the least environmental and aesthetic impact, an accessible site for the hydroelectric plant (HEP) and the highest generating head which maximises the potential revenue through energy sales.

Figure 12-6: Hydropower Water Transfer Conduit Options

The 7.9 km long conduit routing for Option 3 was optimised once the final Lalini Dam configuration had been confirmed, and was based upon ensuring that gravity flow is maintained at all dam water levels, and pressures are contained within an acceptable working envelope under all operational conditions, which required a surge analysis to be undertaken.

The optimum route required that the conduit pass through an intervening ridge to maintain gravity flow, and this required tunnelling through competent sandstone and dolerite, which was investigated by the core drilling of several boreholes along the planned conduit route.

The eventual solution was to build the first 3.6 km long section of the conduit from the dam outlet to the inlet portal of the tunnel in pipeline laid below ground, and the remainder in tunnel.

The final route and long-section of this solution is shown in Figure 12-7 (selected solution was the longer/deeper tunnel solution).

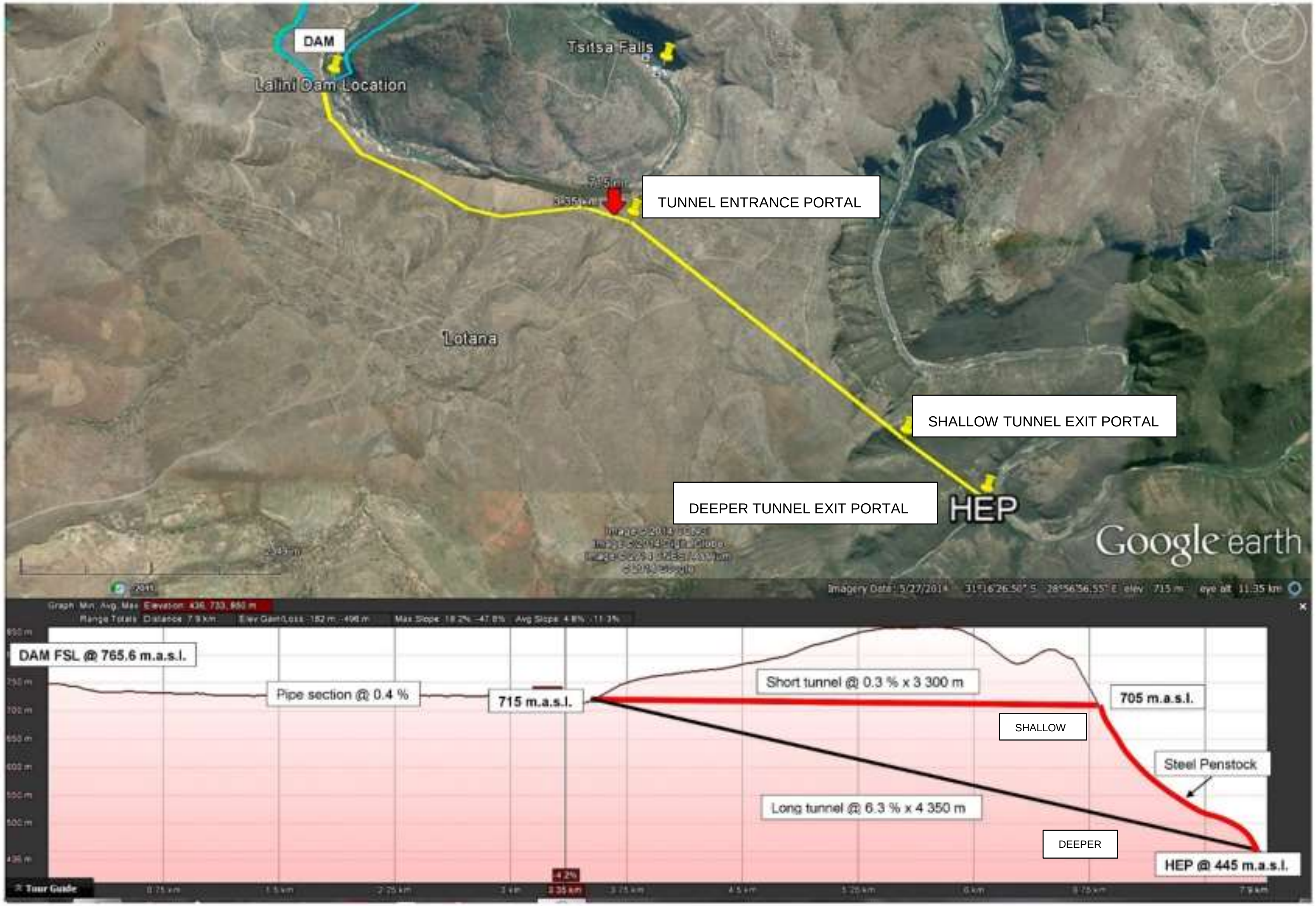


Figure 12-7: HEP Conduit Horizontal and Vertical Alignment Options

12.12 Conduit Material and Sizing

The selection of conduit sizing was based upon:

- Hydraulics: to ensure that head losses were minimized to maintain positive minimum pressures and contain maximum pressures under surge condition, and to maximize power production; and
- Cost benefits: to ensure that the conduit was economically sized based upon a discounted cash flow analysis for various diameters.

Options were also investigated as to whether the tunnel section should be a lined pressure tunnel or a dry tunnel with a pipeline laid through it.

Various conduit materials were also considered based upon the expected range of diameters from 2.5 m to 4.5 m (dependent upon the installed hydropower capacity), and the working pressure which ranged from 70 m to 340 m head of water.

The recommended solution is to construct the conduit in welded steel from dam to HEP, with the first 3.6 km laid just below ground and parallel to the river, and the remainder laid on plinths within a dry drill and blast tunnel, which will allow for future inspection and maintenance of the pipeline.

Optimum pipeline sizes for the above three hydropower options are as follows:

- Base load station: installed capacity 37.5 MW: 2.5 m dia.
- Base load station: installed capacity 50 MW: 3.0 m dia.
- Peaking station: installed capacity 150 MW: 4.5 m dia.

12.13 Hydropower Plant Supply Conduit Configuration

The HEP operational regime rules heavily influence the optimum plant and supply conduit configuration.

Given that the hydropower scheme comprises the conjunctive use of both Ntabelanga and Lalini Dams, the operating rules of both dams as determined by Environmental Water Requirements (EWR) must be considered.

12.13.1 Operating Rules – Ntabelanga Dam

This dam release flows down the Tsitsa River into the Lalini Dam together with the incremental inflow from the intervening catchment areas, thus supplementing the volume in Lalini Dam that can be utilized for hydropower generation and EWR purposes. In-stream losses are allowed for between the Ntabelanga and Lalini Dams.

The amount of water released downstream from the Ntabelanga Dam would be determined by operating rules which the dam operators will need to follow on a weekly basis. Based upon the recommendations of the EWR studies, the minimum amount released is determined by the monthly EWR with the same percentage occurrence as the measured inflow volume, as is given on the EWR flow duration curve for that particular calendar month. Thus the EWR releases will mimic the prevailing rainfall-runoff conditions in the catchment in any particular month, bearing in mind the historical flow patterns that occurred historically over the 90 year simulation period.

The maximum that can be released from the Ntabelanga Dam is generally limited to the simulated naturalized monthly flow with the same percentage of occurrence as the prevailing inflow as determined from the flow duration curves for that same calendar month. The exception to this is where the dam spills, and no constraints are applied.

During the hydropower generation model simulations it was noted that in extreme drought periods, the EWR volumes released did not always satisfy the hydropower generation needs to be sustained by the Lalini Dam balancing storage.

In such cases it was agreed that, even during the dry season months, up to 7 m^3/s could be released from Ntabelanga Dam downstream to sustain a minimum hydropower generation output and the EWR requirements at Lalini Dam.

Hydropower generation is achieved at Ntabelanga Dam by using the available head of water in the dam and passing the EWR releases through the mini-HEP located just downstream of the dam wall before returning this flow back to the river. This HEP diversion is limited to 16 m^3/s as EWR flows above this have a low recurrence interval, and it was considered not worth sizing the HEP plant and its conduit for a larger flow rate than this.

12.13.2 Operating Rules – Lalini Dam

The monthly inflow balancing regime as described for Ntabelanga Dam was modelled in the same way at Lalini Dam. In this case however, there is no potable or irrigation water requirement, but water is instead diverted through a 7.9 km long conduit to the main HEP located in the river gorge downstream of the Tsitsa Falls, and at an elevation of some 300 m below the Lalini Dam site. This arrangement is shown in Figure 12-7. The figure shows two tunnel options of which the deeper, direct option is recommended.

The HEP operational regime options are discussed in detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15, and the Hydropower Analysis: Lalini Dam Report No. P WMA 12/T30/00/5212/18.

As with the Ntabelanga Dam, the amount of water released downstream from the Lalini Dam would again be determined by operating rules which the dam operators will need to follow on a weekly basis. Based upon the recommendations of the EWR studies, the minimum amount released is determined by the monthly EWR with the same percentage occurrence as the measured inflow volume, as is given on the EWR flow duration curve for that particular calendar month.

In this case the water released from the Ntabelanga Dam would alter the natural Lalini inflow regime, and this will need to be taken into consideration when determining the precedent streamflow conditions in the Lalini catchment when setting the percentage occurrence factor to apply to the monthly flow duration curve, and thus the volume of EWR to be released in any particular month.

Hydropower generation is achieved at the Lalini Dam itself by using the available head of water in the dam and passing the EWR releases through the mini-HEP located just downstream of the dam wall before returning this flow back to the river. This HEP diversion is again limited to 16 m^3/s as EWR flows above this have a low recurrence interval, and it was considered not worth sizing the HEP plant and its conduit for a larger flow rate than this.

The hydropower simulation model always allows for the EWR to be released downstream of the Lalini dam before allowing water to be passed through the main HEP system via the conduit shown in Figure 12-7.

In order to determine how much water is to be passed through the main HEP plant, a target hydropower output was set for each month of the year. The model allows this to be undertaken quickly and iteratively until the maximum average energy output per year is achieved.

From the results that this produced it was noted that for a base load (24/7 operations) main HEP there was no merit in installing plant of capacity greater than 50 MW and, furthermore, this maximum installed capacity was often only fully useable in the one wettest month of the year.

In addition, in the drier months of the year, it was shown that the maximum power output would drop to around 5 to 15 MW, due to the need to limit the flow rate of water returned back into the river when mimicking the naturalized flow regime, as well as times in drought cycles when both Ntabelanga and Lalini Dams would be at their lowest levels.

If a typical rule of not exceeding the simulated naturalized flow regime for all months and percentage occurrences were to be strictly adhered to, then the main Lalini HEP scheme would need to be shut down or operated at a very low output level in a significant number of months in the driest years of operation.

The flow rate required to operate a single 12.5 MW turbine unit continuously is some 6 m^3/s. The operational regime proposed was to therefore make use of the available balancing capacity in the dams to pass a minimum of 6 m^3/s through the main Lalini HEP turbines in the particularly low flow dry season months in order to ensure that a minimum of 12.5 MW can always be produced by the main HEP at all times.

However, when strictly limiting the main HEP flow throughput to the naturalized flow regime, it was evident that the power outputs in dry season months would be low for a significant proportion of the years of simulation, which significantly reduced the average power generated by the scheme.

Modelling was undertaken to determine the quantum of water that would be required to be released through the main HEP extra over the naturalized flow regime values, and the percentage occurrence of when this would be required (e.g. 80% actually means this would only be required 20% of the time).

It was shown that this additional release amount averaged less than 3 m^3/s, but in some drought years could be up to the maximum 6 m^3/s, albeit that this would be a rare occurrence.

Table 12-3 shows the additional release amounts required per month for various %age occurrence.

The benefits of this additional release allowance within the EWR rules are that on average, some 10% more power can be generated by the same HEP configuration than if the additional release is not allowed.

This situation was presented to the team undertaking the Lalini EWR study and the consensus was that such releases would not significantly change the ecological regime of the river below the HEP outlet, and therefore could be allowed.

Following review and discussion of the EWR Report, the DWS Reserve Determination office approved the operational regime whereby an additional 6 m^3/s over naturalized flow can be passed from the Lalini Dam through the HEP turbines and released back to the river as and when required, in any month.

Table 12-3: Water Released Through HEP Extra Over Naturalized Flow to Maintain 12.5 MW

	Water Released Over Naturalized Flow (m^3/s) to Maintain 12.5 MW Output at Indicated % Occurrence										
MONTH	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.00	0.00	0.00	0.00	0.30	2.25	2.52	2.81	3.33	4.19	4.70
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.62	3.90
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.49	6.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.62
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.56
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.39
Apr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	5.27
May	0.00	0.00	0.00	0.00	1.55	2.54	3.39	3.46	3.58	3.76	4.24
Jun	0.00	0.00	0.00	1.04	2.35	3.65	3.54	3.85	3.83	4.19	4.78
Jul	0.00	0.00	0.00	0.87	3.11	3.75	3.77	3.79	4.03	4.18	4.96
Aug	0.00	0.00	0.00	1.37	2.48	3.21	3.77	3.82	4.22	4.43	4.58
Sep	0.00	0.00	0.00	3.78	4.82	5.91	6.00	5.78	5.15	5.08	5.40
AVE	0.00	0.00	0.00	0.59	1.22	1.78	1.92	1.96	2.06	2.46	4.62

Table 12-4 shows the resulting average power generated by the main Lalini HEP with this agreed operational regime.

Table 12-4: Main HEP Power Output with Supplementary Release Through HEP (MW)

	HEP Output (MW) - With Supplementary Release - at Indicated % Occurrence										
MONTH	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	37.5	37.5	37.5	19.3	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Nov	37.5	37.5	37.5	37.5	37.1	26.2	18.2	15.7	13.6	12.5	12.5
Dec	37.5	37.5	37.5	37.5	37.5	22.4	18.0	16.9	12.5	12.5	12.5
Jan	37.5	37.5	37.5	37.5	37.5	37.5	25.7	27.0	17.8	13.6	12.5
Feb	37.5	37.5	37.5	37.5	37.5	37.5	33.0	19.5	15.0	18.6	12.5
Mar	37.5	37.5	37.5	37.5	37.5	37.5	37.5	33.1	31.6	19.2	12.5
Apr	37.5	37.5	37.5	37.5	37.5	37.5	23.5	18.8	14.5	12.5	12.5
May	37.5	37.5	23.3	13.7	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Jun	37.5	31.3	18.2	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Jul	37.5	29.3	14.3	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Aug	37.5	37.5	16.1	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Sep	37.5	37.5	14.7	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
AVE	37.52	36.32	29.11	25.67	24.97	22.81	19.24	17.16	14.99	13.66	12.50

In addition to the 37.5 and 50 MW installed capacity options, a further scenario was also investigated whereby the scheme is operated as a peaking station only. In such a case, some 150 MW of power generation would be installed and operated for a limited number of hours per day to focus only on earning the highest tariff rates. In such a case, the conduit size would need to be 4 500 mm dia.

Costing and economic analysis have been undertaken for these scenarios, and the recommended solution is that of the 37.5 MW installed capacity and a 2 500 mm diameter conduit.

12.14 Regulation of Flow below HEP Outlet

When operated as a base load (24/7) station, there would be no need to regulate the recombined EWR and HEP discharges downstream of the HEP plant outlet, as these would fall within the accepted operating rules determined following the Reserve Determination and EWR studies.

Should the base load (37.5 MW) station be operated as a peaking station in the winter/dry season months, then a typical scenario would be that the full installed capacity turbines were operated over (say) 8 peak hours per day instead of 12.5 MW over 24 hours, thus using the same daily volume of water available.

In order to ensure that the recombined flows are balanced, regulated, and normalized back to a 24 hour regime, a regulating dam and storage facility would need to be constructed in-stream with a minimum storage capacity of 16 hours of the daily HEP flow under the prevailing conditions. In this case, this would require a minimum balancing dam capacity of 375 000 m^3.

Should a full-time peaking station be installed (up to 150 MW), then this requirement increases significantly as the peaking operations would be concentrated to 3 to 5 hours per day, and the balancing storage requirement would rise to as high as 2 million m^3.

For the former option, this balancing storage would extend approximately 500 m downstream of the HEP discharge location, and for the latter peaking option this body of balancing storage could extend as far as 1 500 m downstream and require a dam wall height of 15 m or more.

Such in-stream balancing storage would have its own impact on the environment by drowning the river bed flora and fauna at that location and significantly changing its natural state.

It would also be very difficult to adequately regulate outflow rates from this storage. The storage would also act as a sediment trap and would rapidly lose its capacity to regulate flow.

In conclusion, it is considered to be highly unlikely that such a balancing regime would be practical or environmentally acceptable, and this further supports the conclusion that the most likely solution is the 37.5 MW installed capacity and a 2 500 mm diameter conduit, operated as a base load station.

This would still allow for the HEP station to be operated as a peaking station in the winter months in years when the flow regime is not in a drought condition.

12.15 Main Hydropower Plant Configuration

12.15.1 Electro-Mechanical Equipment

Internationally-renowned hydropower plant manufacturers from Europe were consulted to determine suitable hydropower generating plant types, design details, performance, costs, installation requirements and general arrangements.

For the 37.5 MW and 50 MW plant options, and the likely monthly generating regime, it was recommended that three or four 12.5 MW units would be best suited to match the head versus flow regime. The basis of feasibility design presented herein is for the 37.5 MW solution.

The turbines proposed are of the vertical Pelton type with 6 jet nozzles. Depending upon the eventual procurement process and manufacturer selected, the number and configuration of jet nozzles could vary.

The proposed arrangement is overhung, i.e. the turbine runner is mounted directly onto an extended and reinforced generator shaft. All remaining (small) axial thrust and radial loadings on the turbine runner created by rotational speed, jet impact and weight are therefore taken by a suitably designed generator shaft/bearing system. The main cooling of the generator is by water cooling and therefore requires a two cycle cooling system.

Typical arrangements and a photo of plants of a similar capacity are given in Figures 12-8 to 12-11. Please note these are generic examples and not specific to this project.

12.15.2 *Main Hydropower Plant Structure*

The structure to house the HEP is designed to meet the functionality requirements of the plant as well as the construction and installation sequencing required for this type of turbine.
A two-stage basement concrete placement is required, and cut-outs in the basement are required to allow operational valves and turbine jet volute casings to be accessed and maintained.

Channels are also included below the Pelton wheel runner to carry the water away from the plant once the jet energy has been absorbed.

Each of these channels must be able to carry a minimum of 6.5 m^3/s, and upon leaving the structure basement, the flow is discharged down the bank of the river via a stepped energy dissipating cascade system founded on good rock and constructed using reinforced concrete and gabion systems.

Specific spacing of each generator is important to avoid interference with each other with respect to both vibration and high voltage current.

This results in a long and narrow building layout as shown in Figure 12-12. This figure is for a 3 x 12.5 MW turbine solution. If an additional turbine is to be installed, then the building would be proportionately longer.

This building would require adequate lighting, heating, and ventilation and will have a sound-proofed control room at one end.

The generator is the heaviest single component of the generating set, and each would have a weight of some 75 tonnes, with each turbine weighing some 35 tonnes.

The building would be equipped with a suitable overhead crane, and has access doors between each generator set so that transport vehicles can reverse into the building for delivery and replacement of these components.

The HEP building is positioned adjacent to the tunnel exit portal so that the pipeline penstock exiting the tunnel can be connected to the HEP inlet pipework below the hard-standing area.

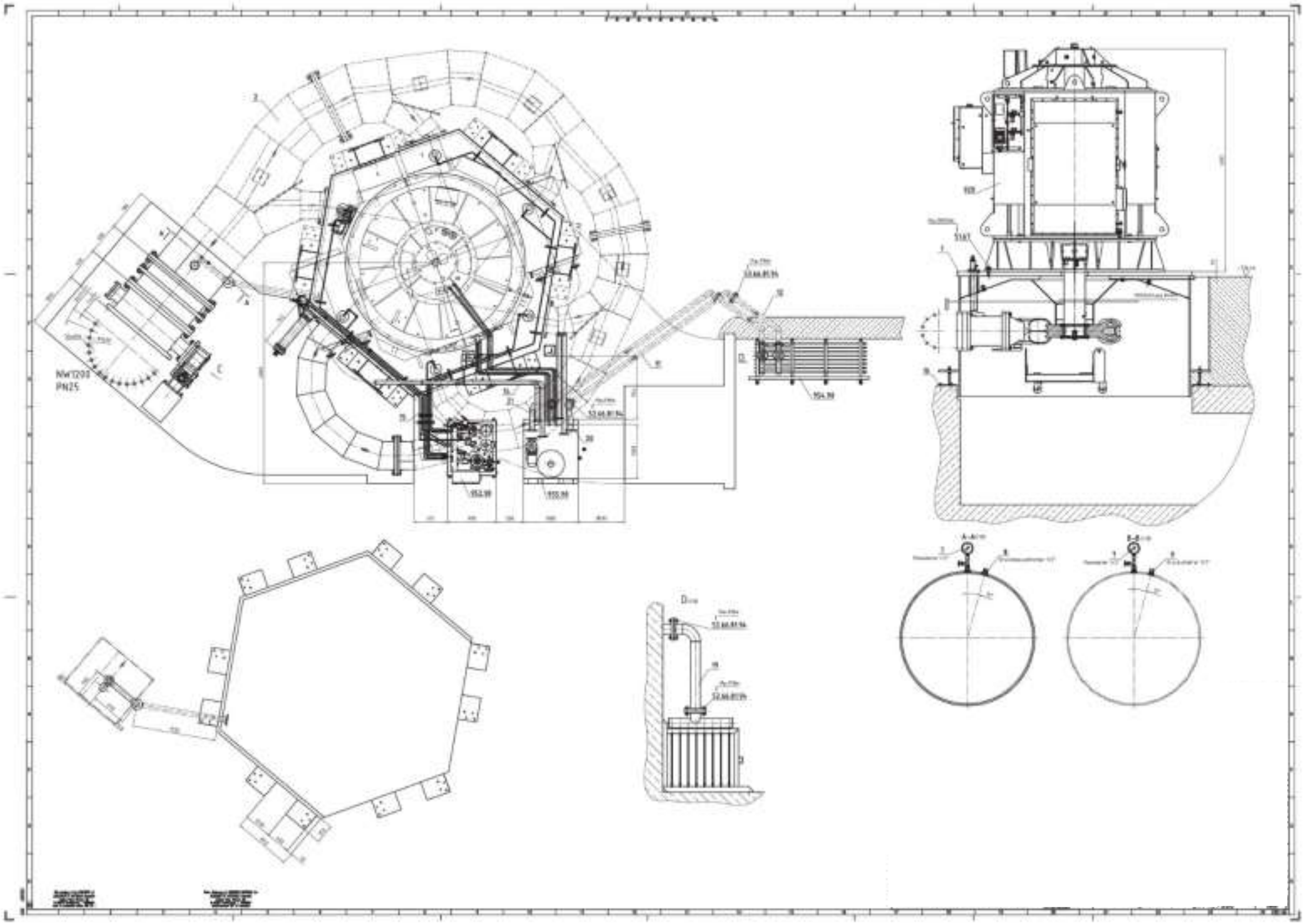


Figure 12-8: Installation Arrangement of a Similar Pelton Wheel Turbine

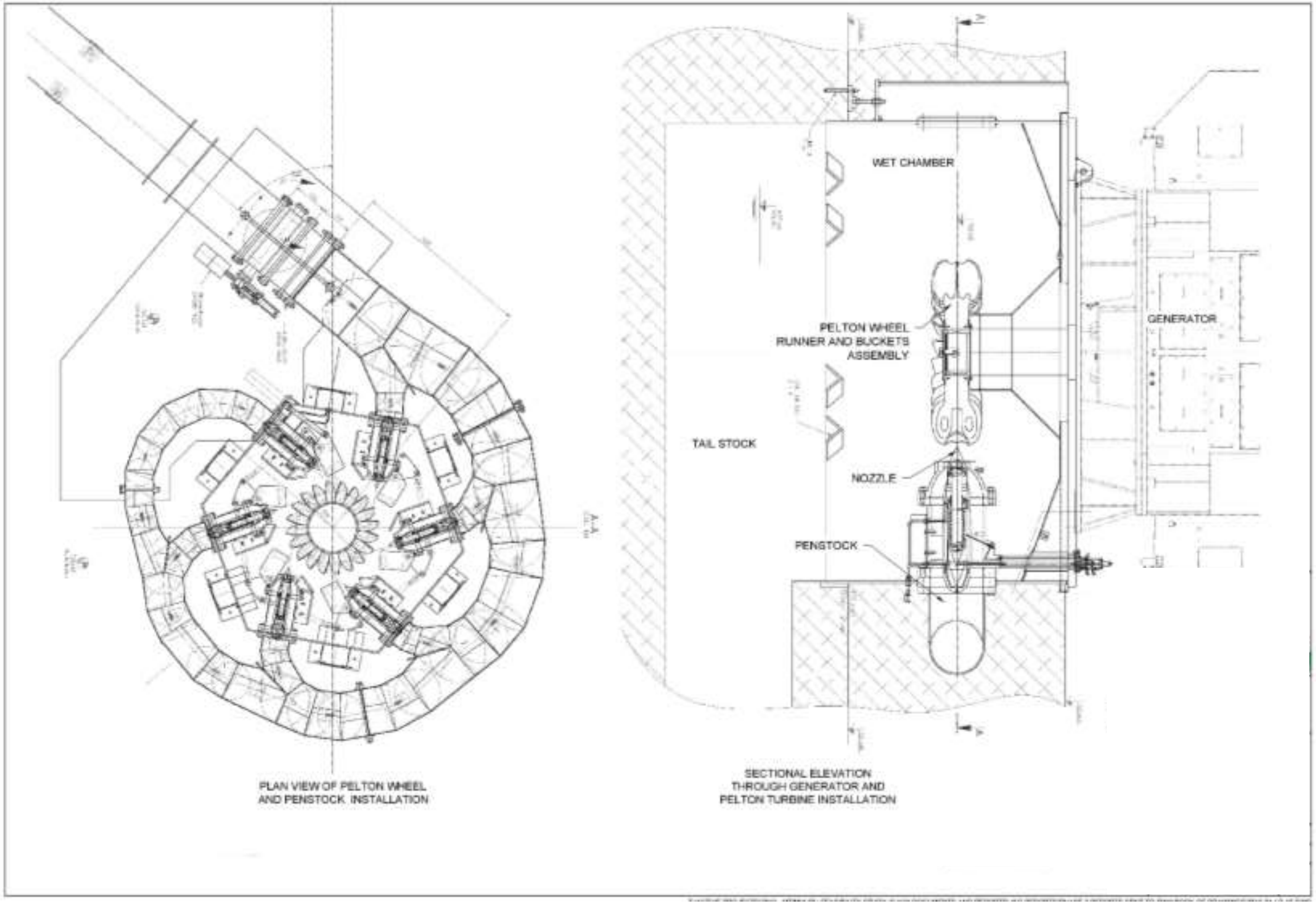


Figure 12-9: Detail of Pelton Runner and Jet Arrangement

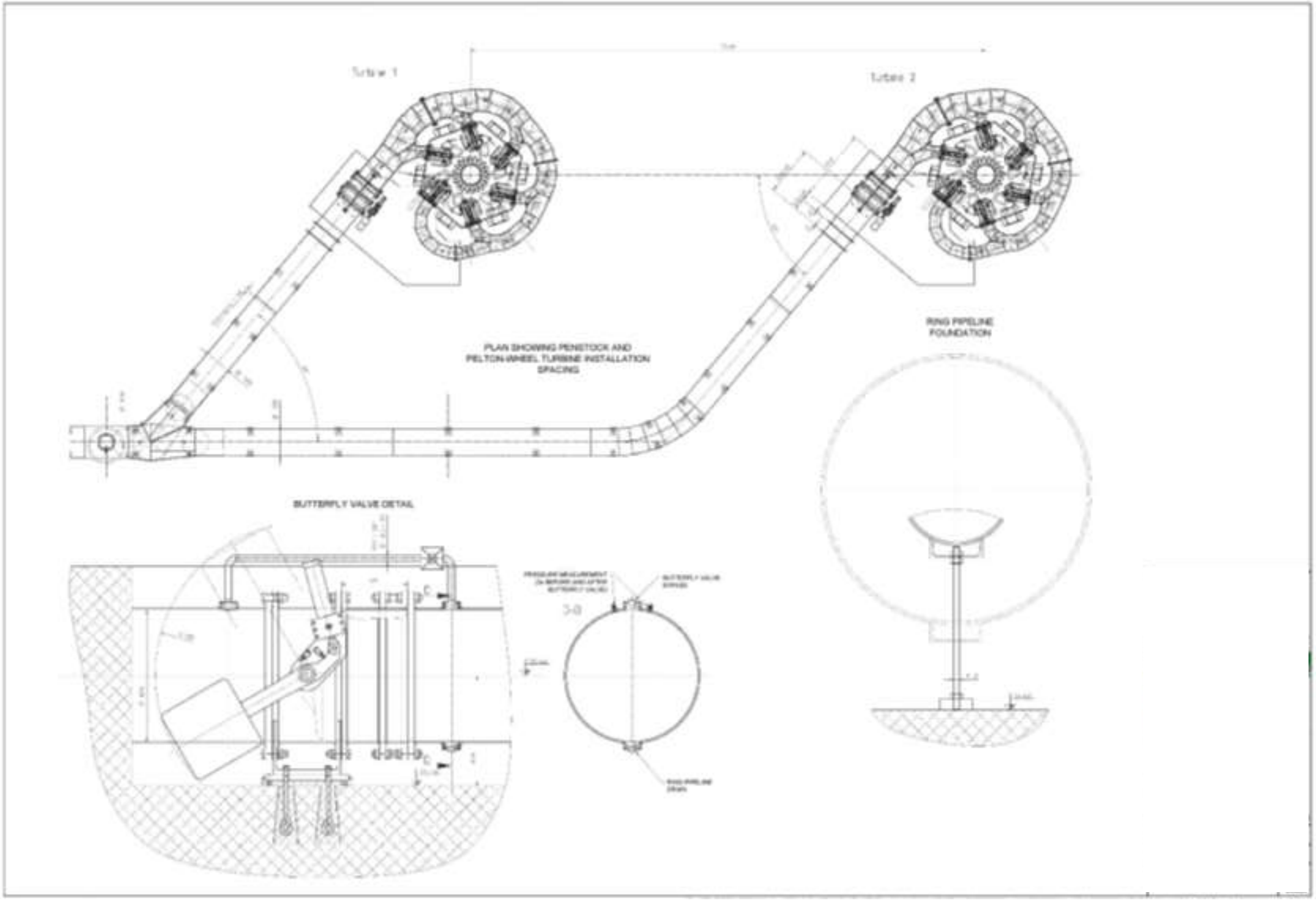


Figure 12-10: Typical Installation of Adjacent Turbines and Main Control Valve

Figure 12-11: Photo of Similar Sized Pelton Wheel Generator Installation

This site layout and cross-section is shown on Figures 12-13 and 12-14.

This shows a diagram of the earthworks and hard-standing areas required between the tunnel and HEP building, as well as the discharge cascades returning hydropower flow back to the river.

This hard-standing platform and access road thereto would be required as a first priority so that the tunnel and HEP building construction can be undertaken.

This will also require a power supply and water supply to be brought to the location for construction and long-term usage.

The water supply would be developed by a package plant abstracting from the river, and the power supply could share the same powerline as would eventually be used to evacuate energy from the HEP into the grid. However, the means of implementing this power supply aspect would be at the discretion of ESKOM.

It is proposed that operators of the HEP would be housed in the same staff housing compound as is to be developed for the Lalini Dam, and would commute via the access road each day.

A small ablution and mess block should be provided at the HEP building.

As shown on the layout diagram, a separate transformer compound is located next to the control room end of the HEP building.

12.16 Lalini Dam Mini-Hydropower Plant

As with the Ntabelanga Dam, the environmental water requirements (EWR) released from the Lalini Dam into the river above Tsitsa Falls creates an opportunity for some additional hydropower to be generated at this location.

The Hydropower Analysis Report No. P WMA 12/T30/00/5212/18 describes the conjunctive scheme hydropower modelling simulations undertaken and indicates that up to 5 MW can be generated in the wetter months, with seasonal availability of EWR determining outputs that can be achieved in other seasons. The results of the analysis for the 0.28 MAR_{PD} Lalini Dam are as shown in Table 12-5 and Figure 12-15.

Table 12-5: Model Results: Lalini Dam HEP

Month	Minimum Target (MW)	Avg HP Output (MW)	Avg Energy Supplied (KWh)
Oct	2.00	1.41	1 047 895
Nov	3.00	1.74	1 251 338
Dec	3.00	2.34	1 742 819
Jan	4.00	3.10	2 303 120
Feb	5.00	3.90	2 644 895
Mar	5.00	3.91	2 910 565
Apr	5.00	1.74	1 249 716
May	4.00	1.22	905 288
Jun	3.00	0.66	476 106
Jul	1.00	0.59	440 637
Aug	1.00	0.54	401 078
Sep	1.00	0.81	585 678
Total Energy Per Year (kWh)			**15 959 136**
Average Power (MW)		**1.83**	

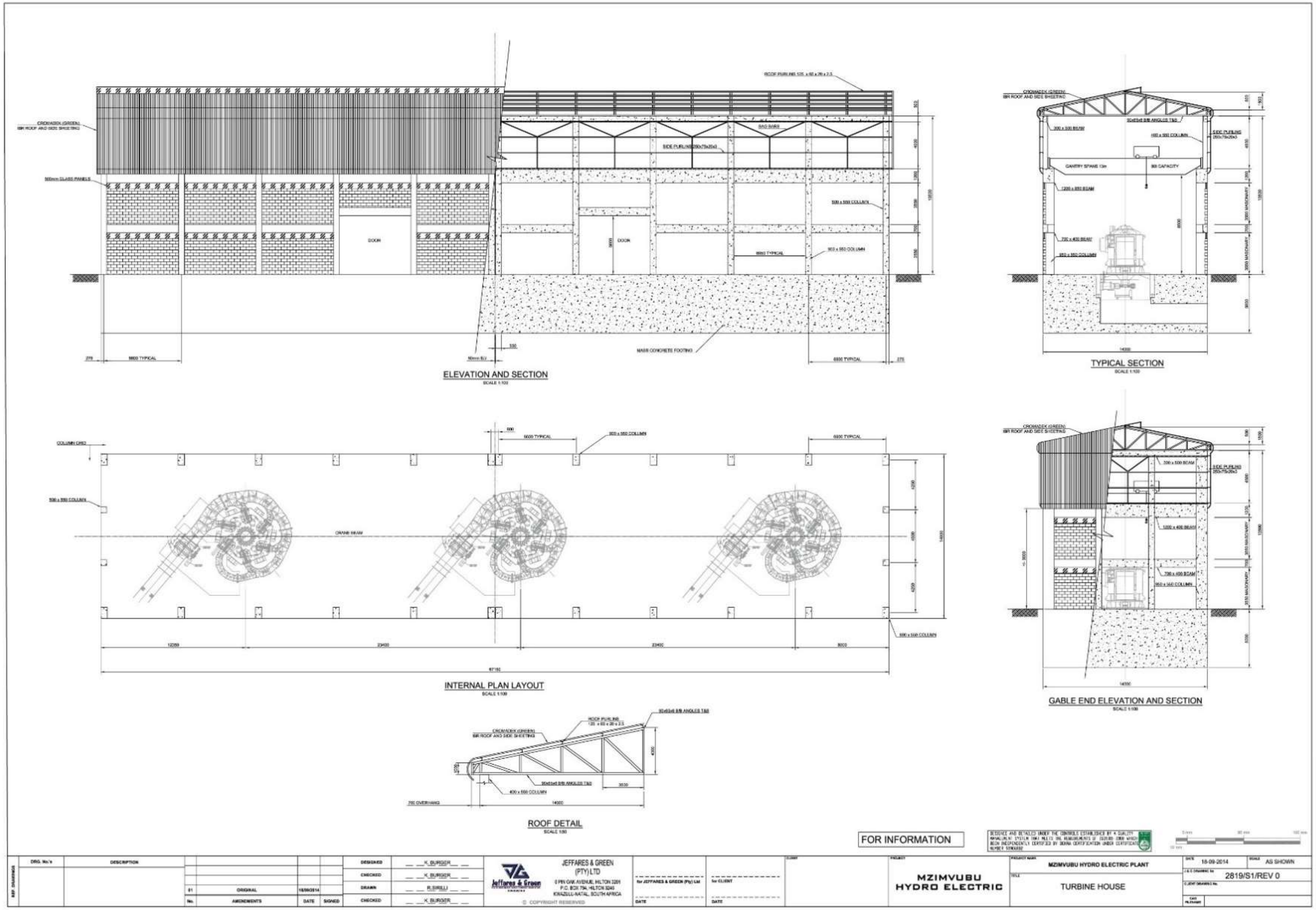


Figure 12-12: Hydroelectric Power Plant Building (3 Turbine Option)

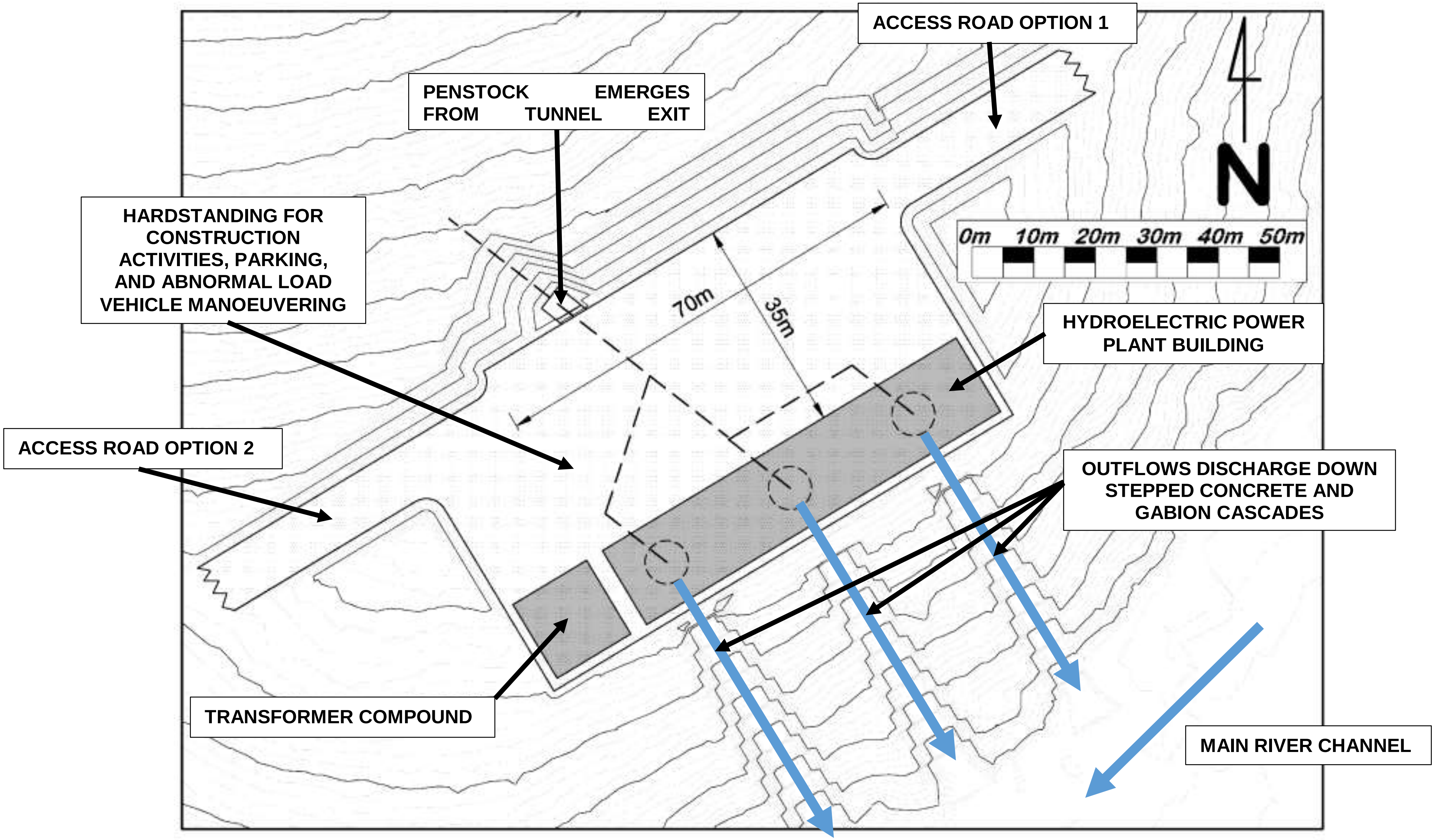


Figure 12-13: Lalini Main Hydropower Plant Site Layout

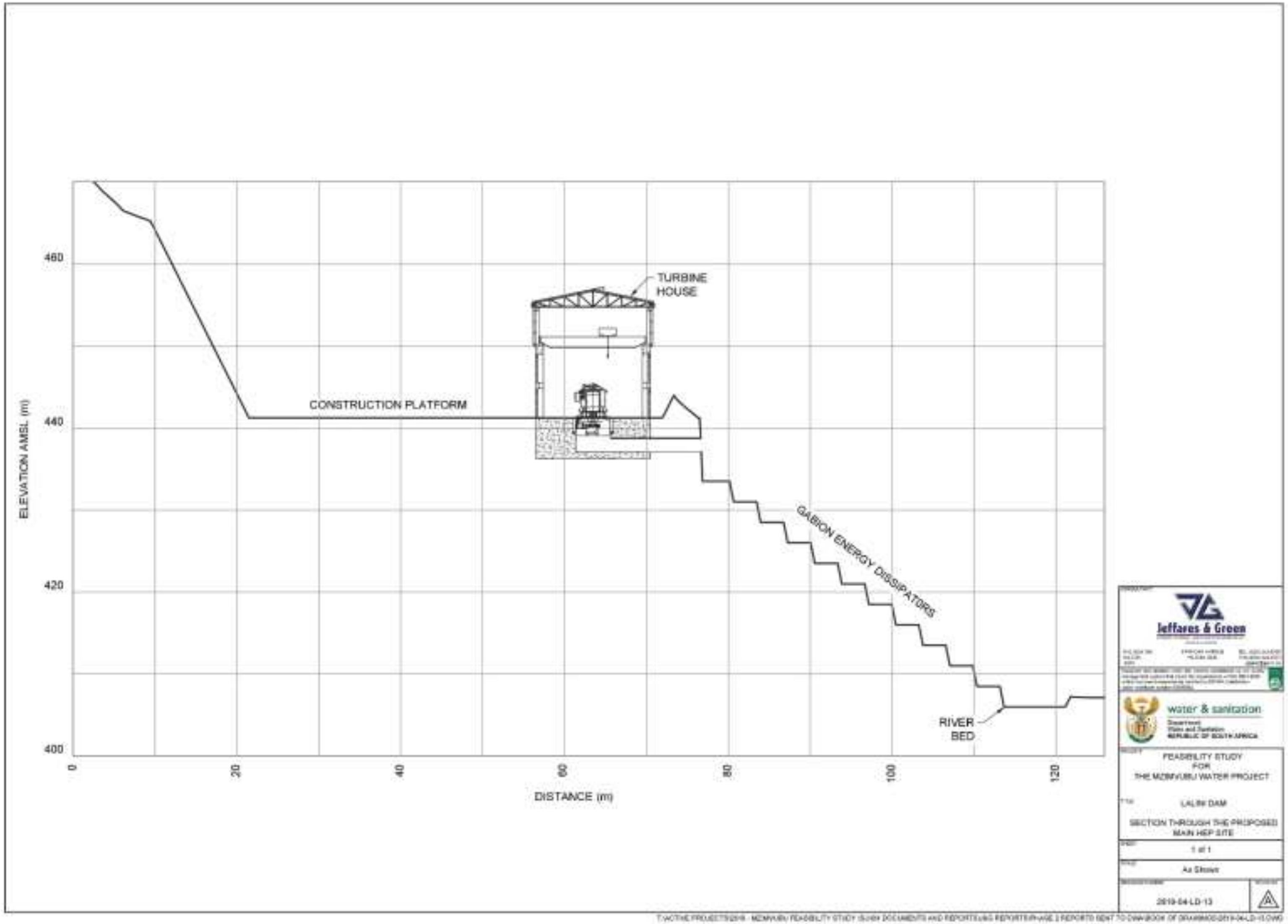


Figure 12-14: Turbine House and Outlet Works Cross-section

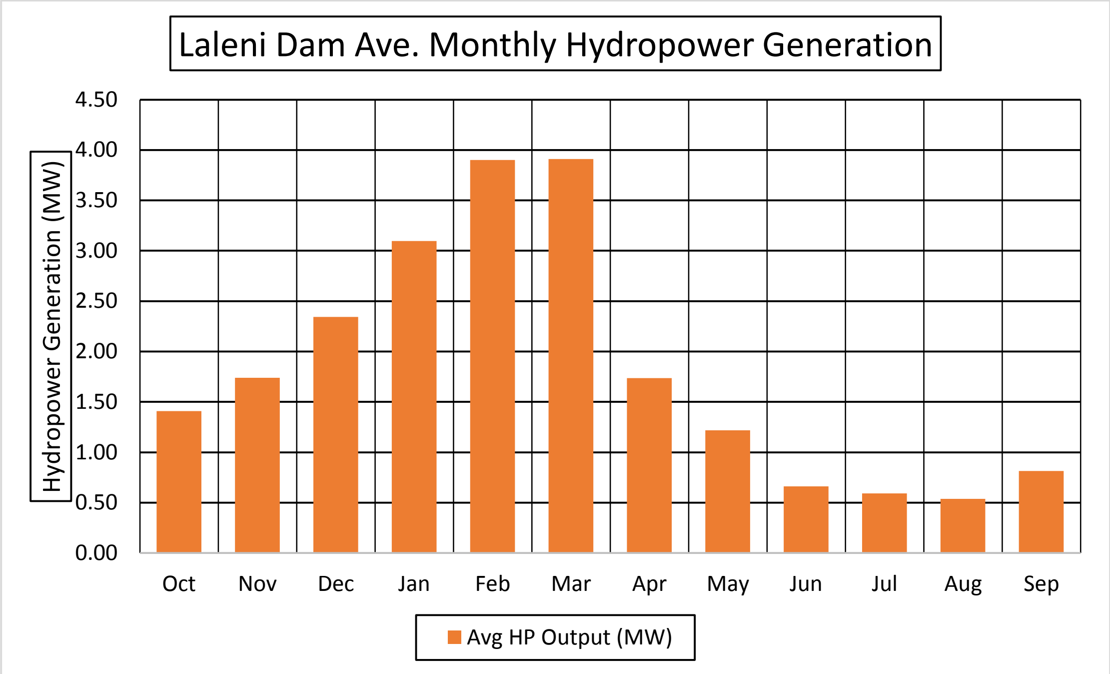


Figure 12-15: Lalini Dam HEP Average Monthly Hydropower Generation

Thus the hydropower plant configuration has been based upon a target operating range of between 1 and 5 MW.

Hydropower plant suppliers were asked to suggest which types of turbines should be used for this application and provided the following options:

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 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).

Each turbine set is equipped with a tachometer for speed control, 2 temperature sensors (1 per bearing) to check bearing temperature and also 2 vibration sensors (1 per bearing).

Typical “Andritz” pump-turbine units suggested were:

Pump - Turbine FPT40-700 T1, T3 & T5 with asynchronous generator.
Pump - Turbine FPT40-700 T2, T4 & T6 with synchronous generator.

The final decision of which supplier of turbines would be made following a competitive tendering process, and these quoted turbines are only by way of an example.

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

Table 12-6: Lalini Mini-Hydropower Plant Output Performance

Scenario	Head (m)	Flow (m^3/s)	Duty	Power Output (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

Figure 12-16 shows a proposed layout of the hydropower turbine house together with the inlet and outlet pipework arrangements.

When the hydropower plant is not in use, release of water for EWR purposes can still be made via a sleeve valve in the main dam outlet works.

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 Lalini Dam are further discussed in detail in the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15.

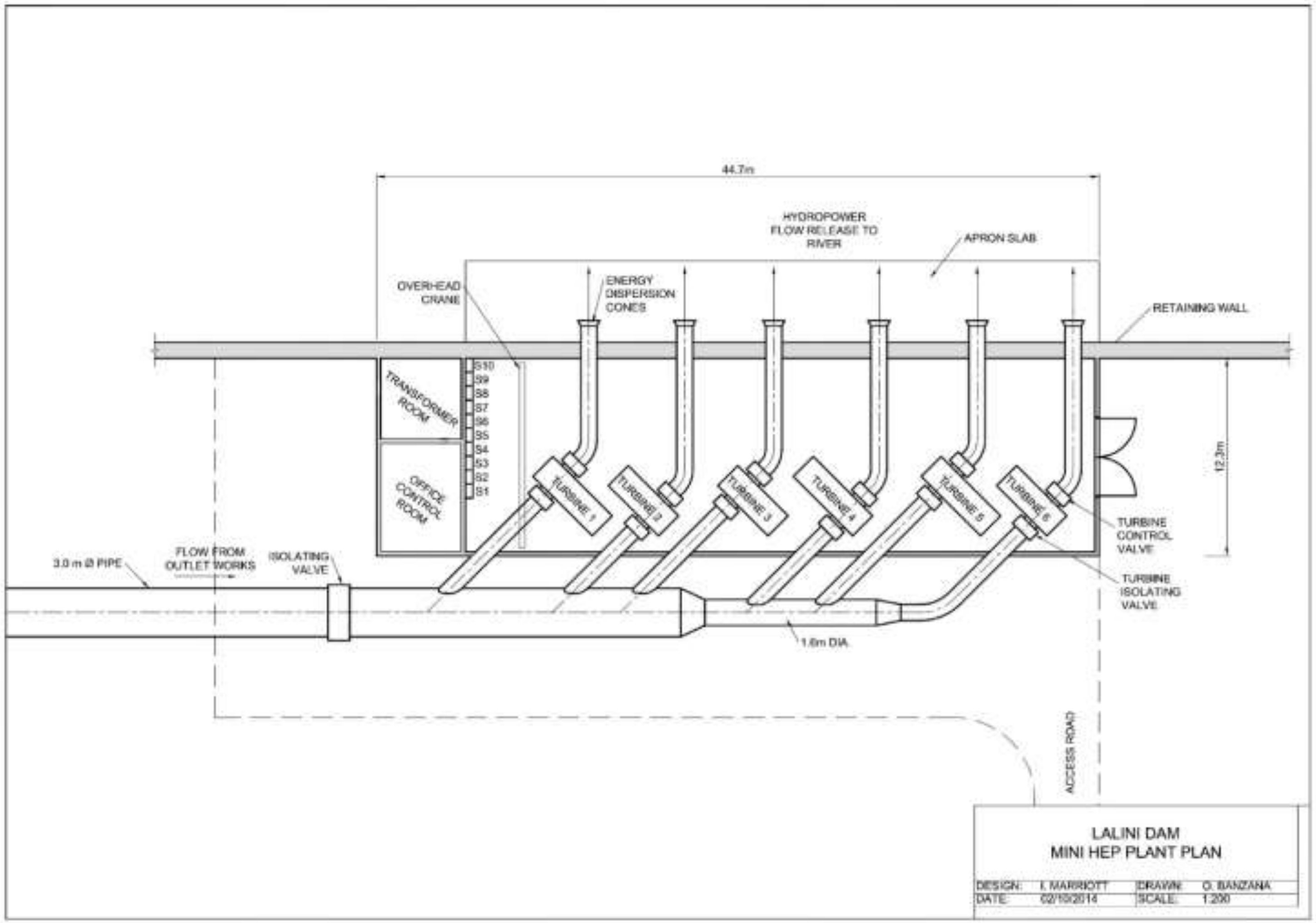


Figure 12-16: Lalini Dam Mini-HEP Layout

13. LAND MATTERS

13.1 Introduction

The independent EIA study for the conjunctive Ntabelanga - Lalini scheme has undertaken a more detailed analysis of the land issues, including relocation, land expropriation, establishment of temporary and permanent servitudes and other mitigation activities. Therefore whilst this report describes these land matters at a feasibility level of detail, the DWS EIA Report No. P WMA 12/T30/00/5314/1 to 17 should be consulted for more detail.

Once the project moves into the detailed design and implementation stage, it is probable that some of the feasibility designs will be revised which will require changes in the boundaries and extents of the expropriation and servitudes described herein.

13.2 Impacts on Land Users

The construction and operation of the proposed Ntabelanga Dam, water treatment works, bulk potable and raw water distribution systems, and its hydropower scheme infrastructure, as well as the Lalini Dam and its hydropower scheme, will impact on the existing land use in this region.

Not only will the main scheme components require the permanent allocation of land, but other associated infrastructure will also require additional land allocations, upgrades or replacement of existing infrastructure, changes in land use, and will have other social impacts.

The new infrastructure that will be built such as the dam, pipelines, waterworks, pump stations, hydroelectric plants and any associated infrastructure will traverse both urban and rural areas resulting in unavoidable impacts to both the environment and communities.

Part of this land will need to be permanently expropriated in order to expand the service provision of bulk water and to generate hydropower. This may negatively impact on the current land use and business activities resulting in the need for compensation of the current land owner/user.

Currently there is no national resettlement and compensation policy in South Africa. The Expropriation Act (63 of 75) provides for the expropriation of land for public use, and the compensation thereof, but this relates to private land only. State-owned land is a complex issue that is not covered, and, instead international and national best practice should guide the process.

Much of the land in the affected project area is State-owned land managed through the tribal authorities, and as a result the process is not governed by specifically written legislation, but by best practice. The process tends to be drawn out, and complex. Outside of the community negotiations, and if the cadastral information is available for all the affected land, the process can take up to 18 months for acquiring the land.

13.3 Roadways to Construct and Operate the Schemes

Some major road works will be required for the construction and long-term operation of the schemes.

In general, road designs, realignments and upgrades have been designed in accordance with the South African Technical Recommendation for Highways (TRH) standards for such work as detailed in the following documents;

1. TRH 4 : Structural design of Flexible Pavements
2. TRH 17: Geometric Design of Rural Roads
3. TRH 20: The Structural Design, Construction and Rehabilitation of Unpaved Roads

The feasibility design of the roads are described in the Feasibility Design: Ntabelanga Dam Report No. P WMA 12/T30/00/5212/12 and the Feasibility Design: Lalini Dam and Hydropower Scheme Report No. P WMA 12/T30/00/5212/19.

13.3.1 Roads and Bridges at Ntabelanga Dam and Associated Works

The existing roads shown as local gravel roads (north and south bank) of the Ntabelanga basin (shown on Figure 13-1) are existing low quality access roads to the local settlements, and are normally affected by inclement weather. Some sections of the existing gravel roads will be inundated by the reservoir water level and will need to be realigned.

The main 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. These locations are also shown on Figure 13-1.

All of these local gravel roads and drainage structures will 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 roads described as secondary roads to the Tsolo and Maclear direction are currently low quality gravel 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 improved transport routes to the larger centres of Maclear, Tsolo, Mthatha and beyond, for those most affected by the project.

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 unplanned maintenance to vehicles using the road.

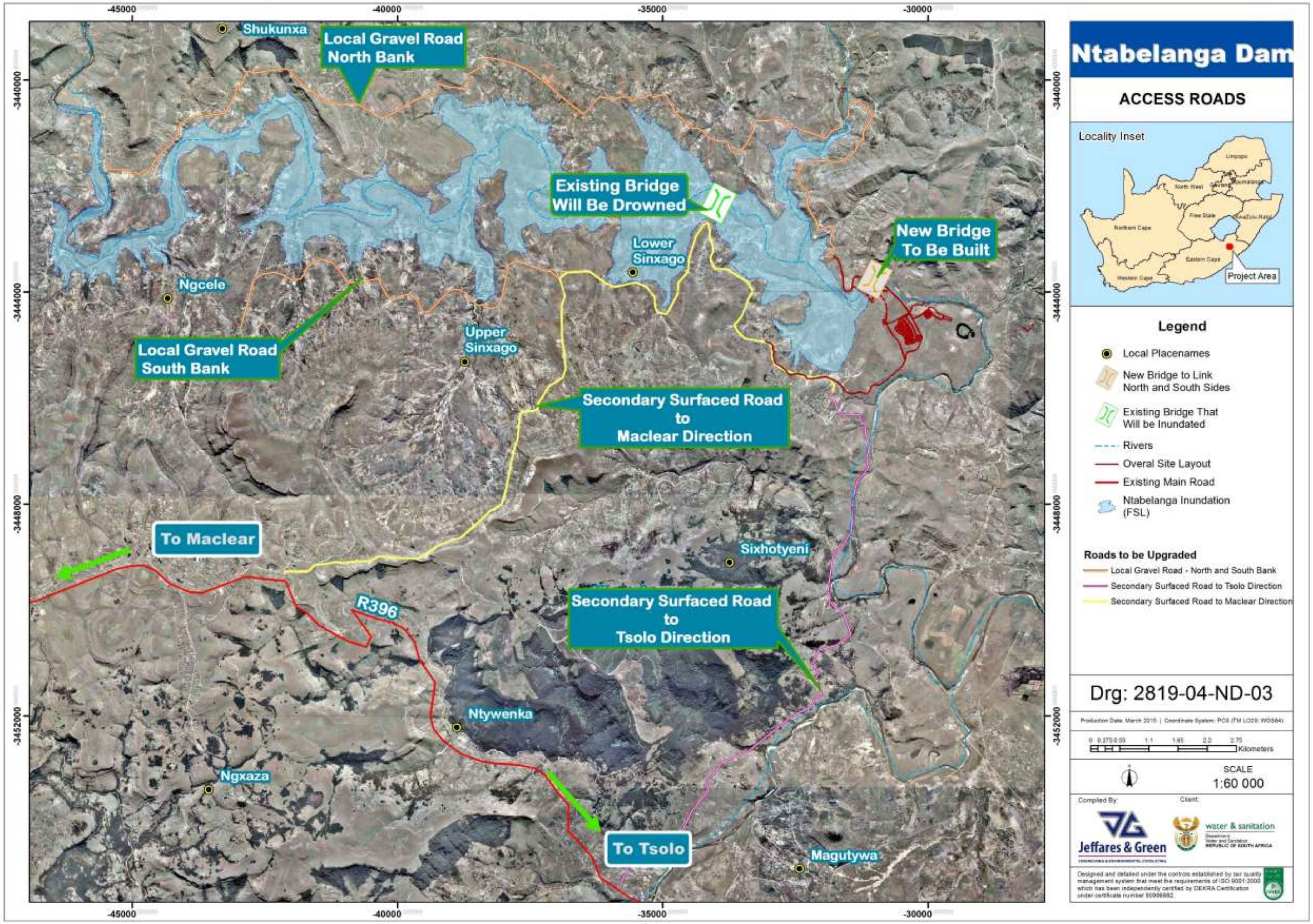


Figure 13-1: Permanent Road Upgrades before and during Ntabelanga Scheme Construction

These upgrades will be to a higher standard than the other roads above, and will be two lane carriageways (one each way) with 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.

Figure 13-2 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 in 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 road 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 site (as bounded in light blue) as a whole would need to be expropriated in its entirety, and the boundaries of this land required are given below. 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.

13.3.2 Roads and Bridges at Lalini Dam and Associated Works

a) Main Access Road

Figure 13-3 shows the existing District Road DR 08170 linking the N2 national road near to the Tsolo to Maclear road junction with the villages of Lotana and Lalini in the vicinity of the dam and hydropower infrastructure locations.

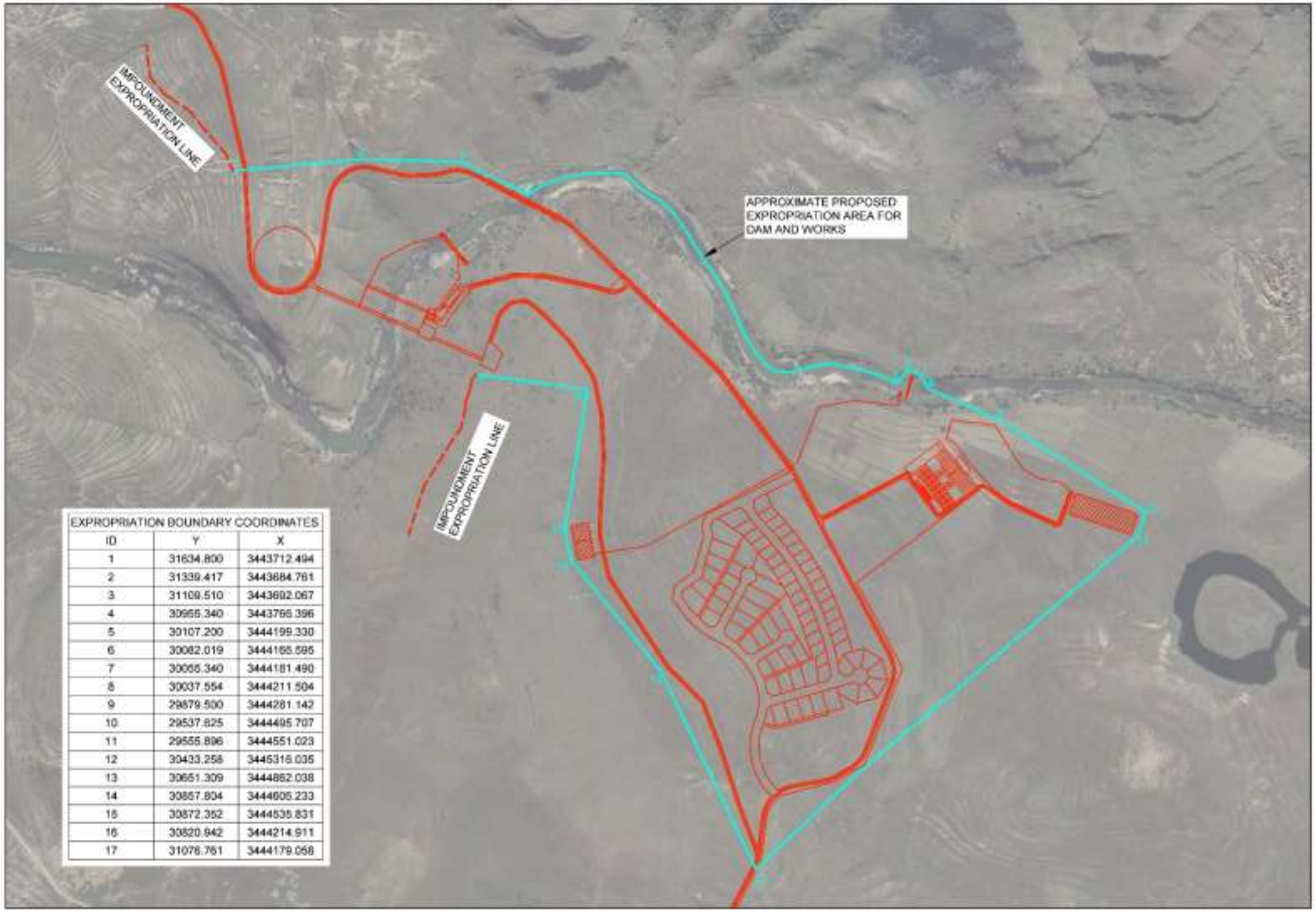
This existing gravel road also services the settlements of Madadeni, Gwali, Upper Lotana, Cingcosdwadeni, Ngcolorha, Manzimabi, Mahoyana, and Mbutho.

This 17.4 km "Main Access Road" provides the best access to the dam and tunnel construction sites from the main road and does not have any major bridge crossings to contend with. Some donga crossings would need to be widened and upgraded to carry heavy loads.

In addition to construction traffic, this road would be the main route used for the delivery of the heavy electromechanical components of the HEP, which will require abnormal load vehicles able to transport loads of up to 100 tonnes.

Thus it is proposed that this road be upgraded geometrically and structurally to cater for heavy construction traffic and abnormal vehicles that are anticipated to be used in the construction activities. This district road would, however, remain a gravel surfaced road. Provision has been made in the costing to refurbish the upper base courses to a high standard gravel road once construction has been completed in order to ensure that the road is handed back to the Provincial Roads Department in an acceptable state.

From this main access road, several new roads will need to be constructed for both construction and permanent access purposes. These are shown on Figure 13-4.



EXPROPRIATION BOUNDARY COORDINATES		
ID	Y	X
1	31634.800	3443712.494
2	31339.417	3443684.761
3	31109.510	3443692.067
4	30965.340	3443766.396
5	30107.200	3444199.330
6	30082.019	3444165.595
7	30065.340	3444181.490
8	30037.554	3444211.504
9	29879.500	3444281.142
10	29537.825	3444495.707
11	29555.896	3444551.023
12	30433.258	3445316.035
13	30661.309	3444862.038
14	30857.804	3444605.233
15	30872.352	3444535.831
16	30820.942	3444214.911
17	31076.761	3444179.058

Figure 13-2: Expropriation Area (light blue) for Ntabelanga Dam Wall and Appurtenant Works

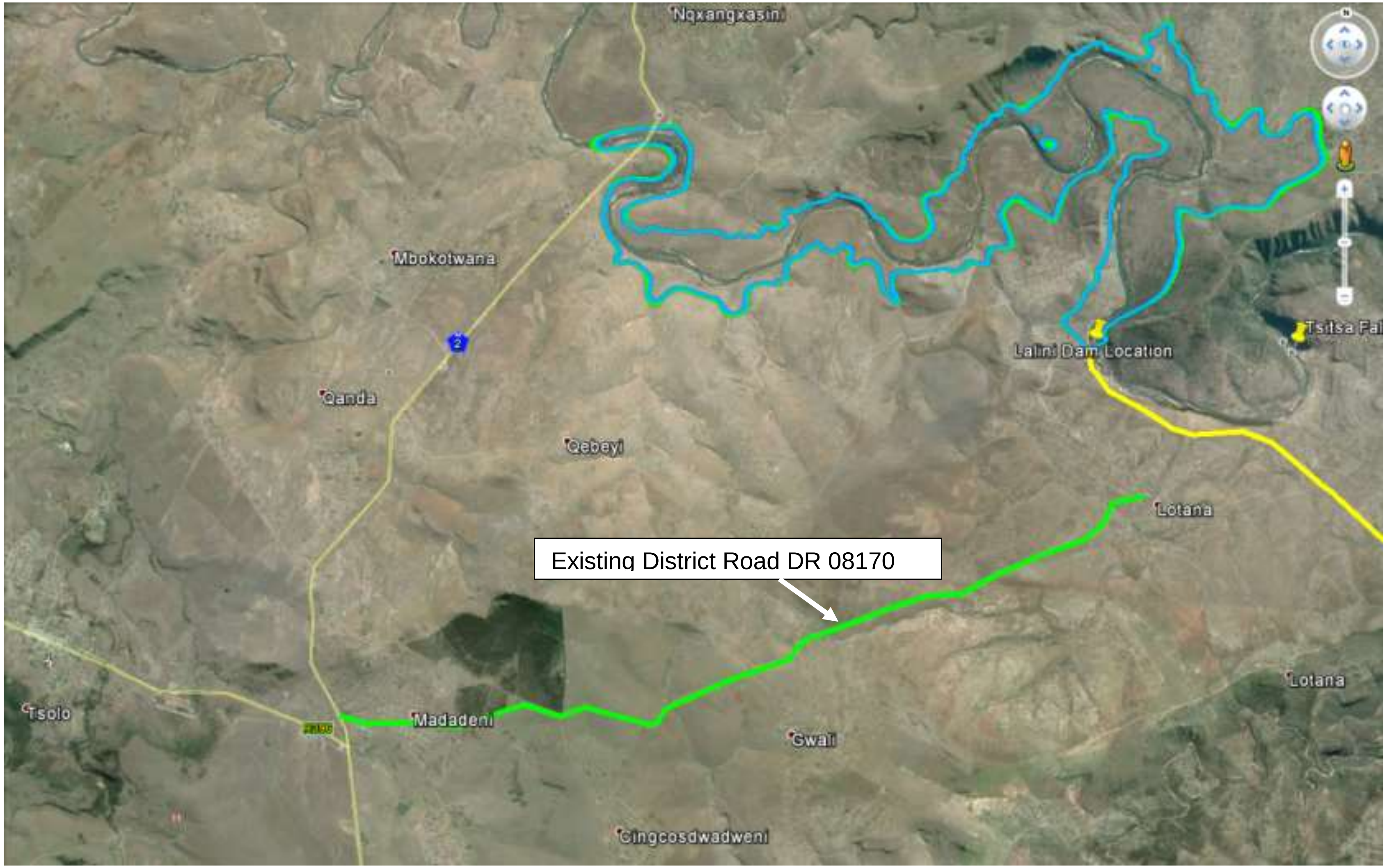


Figure 13-3: Main Access Road to Lalini Infrastructure Construction Locations

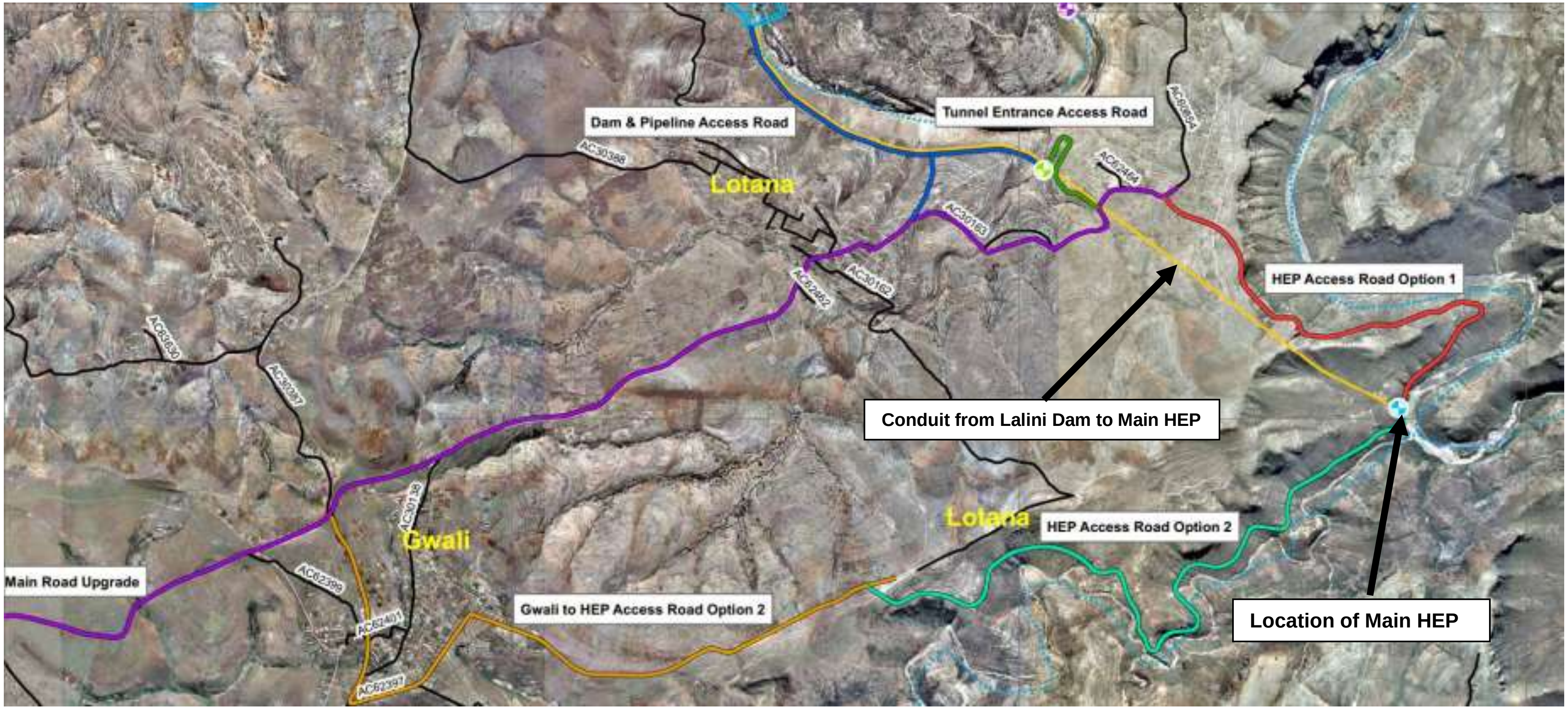


Figure 13-4: Main Access Road and Other Roads to Lalini Scheme Construction Sites

b) Dam and Pipeline Access Roads

The 4.2 km roads shown in blue will be new roads. These roads will be initially established as gravel haul roads for use by normal construction vehicles. However as this will be the main permanent access route to the Lalini Dam and mini-hydropower plant, the road would be upgraded to a double sealed surface, once main construction activities have ceased.

c) Tunnel Entrance Portal Access Road

This 1.3 km road shown in dark green will be a new road to the upper entrance to the tunnel. The road would be constructed as a gravel haul road for use by normal construction vehicles. It will mainly be used during the construction of the tunnel portal section, and during the delivery and installation of the pipeline section within the tunnel. As frequent access to the tunnel in the future would not be required, this could remain a gravel road.

However, as this section of road is relatively short it is recommended that this also be upgraded to a double sealed surface, once main construction activities have ceased.

d) Access to the Main HEP and Tunnel Exit Portal

The access road to the main HEP building and outlet portal of the tunnel is the highest priority road. This road has exacting requirements in terms of gradients and load carrying capacity, and yet has to traverse the most difficult terrain on the whole project.

This road will be used as the main construction haul link for the tunnel and HEP building construction. It will also be the route along which the abnormal loads (greater than 70 tons) travel when delivering the hydropower electro-mechanical and transformer components, and for servicing and replacement of such plant in the future.

Two options were investigated, and these are shown as HEP Access Road Option 1 (red) and HEP Access Road Option 2 (light green) in Figure 13-4.

Option 1 provides serious challenges in that it requires large cuts and fills to be constructed at significant costs. Therefore Option 2 was also investigated. Option 2 follows the valley wall of a south west tributary of the Tsitsa River flowing from Gwali to the HEP location.

The geometric design criteria for Option 2 were the same as for Option 1, and it was easier to achieve vertical alignment grades ranging between 1.5% and 10%, with the requirement of retaining walls reduced proportionally to that of Option 1.

Whilst this access road provides more suitable operational conditions for the abnormal vehicles, it would be, at 8.1 km long, significantly more expensive to construct than Option 1, which is 5.3 km long.

In addition, Option 2 also requires the upgrading of a further 8.2 km of the existing roads from the main access road at Gwali to the start of the new Option 2 HEP Access Road. Technically Option 2 will be easier to construct, but it will be significantly longer and more expensive, and will also impact a larger area of sensitive vegetation.

Whilst option 1 is the recommendation from the feasibility study, both options should be revisited at detailed design stage in the light of further geotechnical investigations, detailed Environmental Impact studies and more detailed technical and financial optimisation.

e) Gwali to HEP Option 2 Existing Road Upgrade

This 8.2 km long section of road would need to be upgraded if Option 2 were to be adopted. The geometric standards and layer works would be the same as for the Main Access Road.

At this feasibility design level of study, Option 1 has been adopted as being the preferred option, but it is recommended that further detailed investigation and optimisation of the HEP Access Road route be undertaken at the detailed design stage. This optimisation should take all relevant factors into consideration, such as technical aspects, construction difficulty, cost and permanent impact on the environment.

f) Roads and Bridges: Upgrades and Realignment

Other major road works that will be required is the realignment of infrastructure that will become inundated once the Lalini Dam has been commissioned. The layouts of these roads are shown on Figure 13-5.

g) Mtshazi Main Road

The impoundment of Lalini Dam will inundate some existing roads as well as drowning an existing river crossing vehicular bridge. The latter connects the village of Lalini with the settlements of Mtshazi, Shawbury, and the main N2 national road to Qumbu and Mthatha.

District Road DR 08167 shown in pink is a tarred road, is the main access from these villages to the N2, and is also a main tourist route for visitors to the Thina and Tsitsa Falls.

This 10.4 km road is currently in a pot-holed state, and some 40% of the existing route will need to be realigned to ensure that it passes outside of the future inundated area.

h) Lalini Bridge Relocation

The existing link road from the above Mtshazi road to Lalini village crosses the Tsitsa River via a low level single track vehicular bridge, which was constructed by SANRAL. This carries both vehicular and pedestrian traffic and is the main route for Lalini residents to travel to Mtshazi, Shawbury and the main N2 national road.

This existing low level bridge and its section of road will be permanently drowned by the impoundment of Lalini Dam.

Alternative routes were sought to replace this route, which included a new road from Lalini along the south bank of the river and connecting to the N2. Unfortunately this would increase the travelling distance for journeys from Lalini to Mtshazi and Shawbury by 15 km. This would be highly unacceptable for pedestrians which include children going to school. If this option were adopted, then a high level footbridge would also be required to cater for the pedestrian users. This option would however still not be an acceptable solution as far as additional travel distance and time required by the vehicular road users are concerned.

The EIA study team were consulted and it was suggested that in such circumstances the solution should follow the principles of a “like-for-like” replacement. In order to meet the SANRAL standards, the bridge deck soffit would be required to be at an elevation providing 1.4 m freeboard above the 1 in 100 year flood level. This results in a bridge deck length of 450 m.

The alignment of the new link road and bridge is shown in yellow on Figure 13-5. A general arrangement of the proposed bridge is given in Figure 13-6.

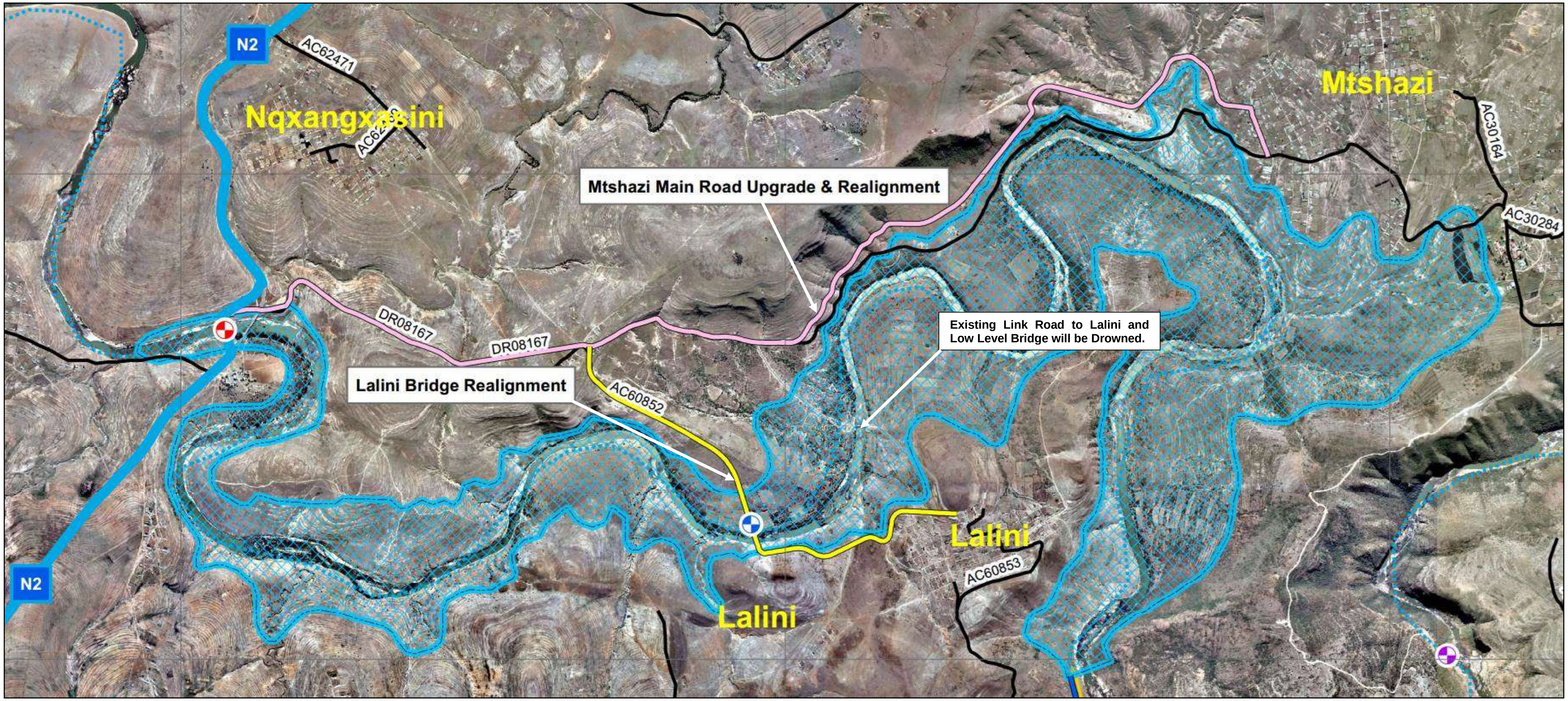


Figure 13-5: Roads/Bridges for Upgrade and Realignment before and during Lalini Works Construction

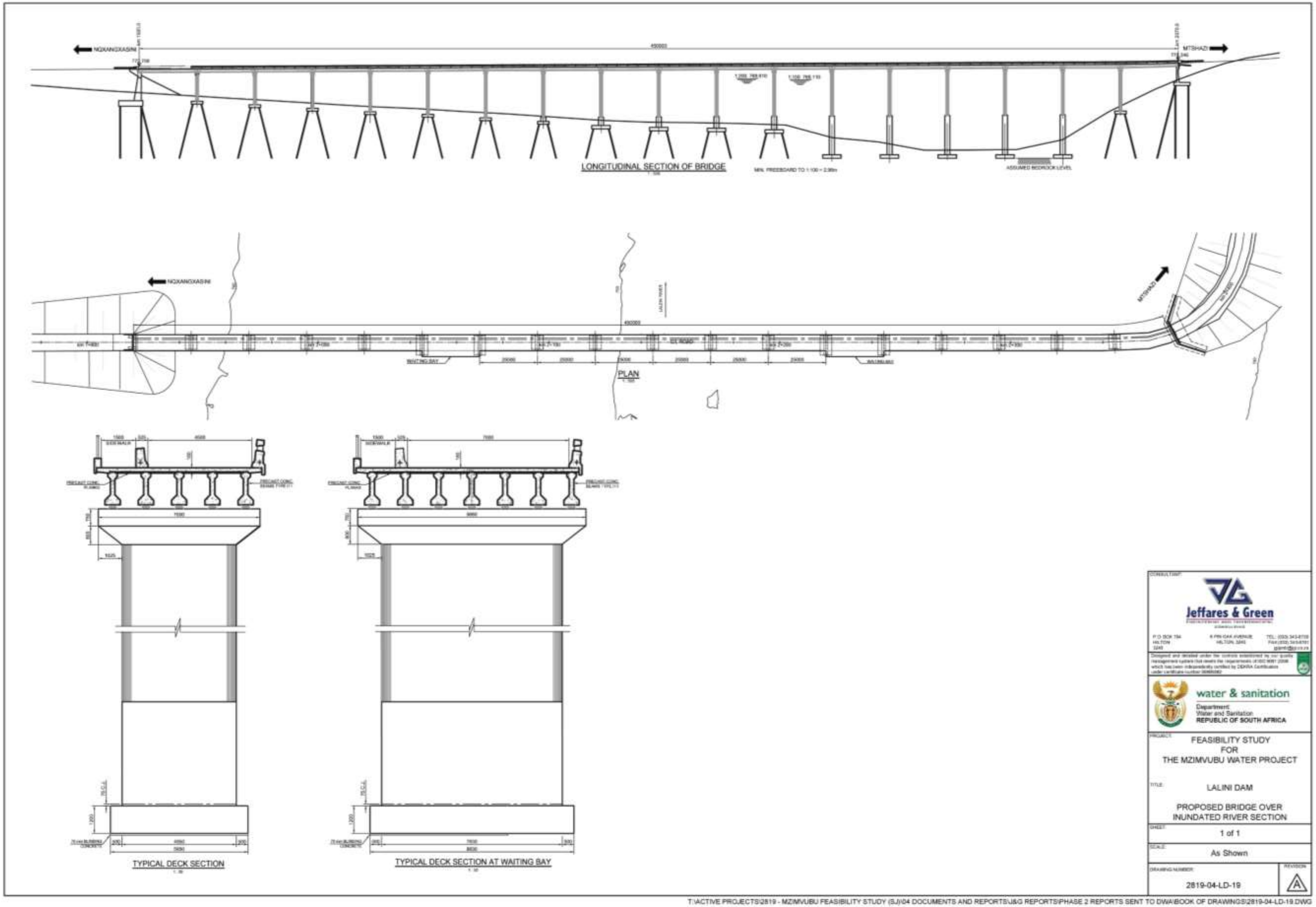


Figure 13-6: Proposed Lalini Bridge over Inundated River Section

This multi-purpose bridge was therefore designed which has a single track vehicular way and a barrier-protected pedestrian walkway. Given the long length of the bridge, the vehicular carriageway has two widened waiting bays for vehicles to pass each other. The bridge must meet SANRAL design standards.

The 4.4 km new link road connecting the bridge to the existing Mtshazi road and to the existing main road into Lalini, would be designed to the same standards and have the same layer works as for the district road DR 08167 above, and would therefore be a tarred surface road.

13.4 Road Servitudes at Ntabelanga and Lalini Schemes

Many of the works to be undertaken would be upgrades to existing road alignments for which servitudes have already been allocated. Where new roads or road realignments are required, the servitude width will be between 20 and 30 m depending upon the standard of the road and the terrain through which it is passing. This will be confirmed during the detailed design stage of implementation.

13.5 Ntabelanga and Lalini Dam Walls and Appurtenant Structures

The Ntabelanga Dam wall and appurtenant structures are those that are shown above on Figure 13-2. This also includes the area of land that will be required to accommodate the proposed visitor's centre on the left flank of the dam wall. Apart from the visitor's centre, no habitable structures or buildings are present, but there is currently some crop growing activity and some fencing in the area where the access road and housing would be located. All of this land would need to be expropriated as Government Water Works.

The Lalini Dam wall and appurtenant structures are those that are shown on Figure 13-7. This also includes the area of land that will be required to accommodate the proposed visitor's centre on the right flank of the dam wall and the operations offices and accommodation village. Whilst one or two dwellings that lie close to the accommodation village might be affected, no other habitable structures or buildings are present, and there is apparently no crop growing activity within the works area boundary. All of this land would need to be expropriated as Government Water Works.

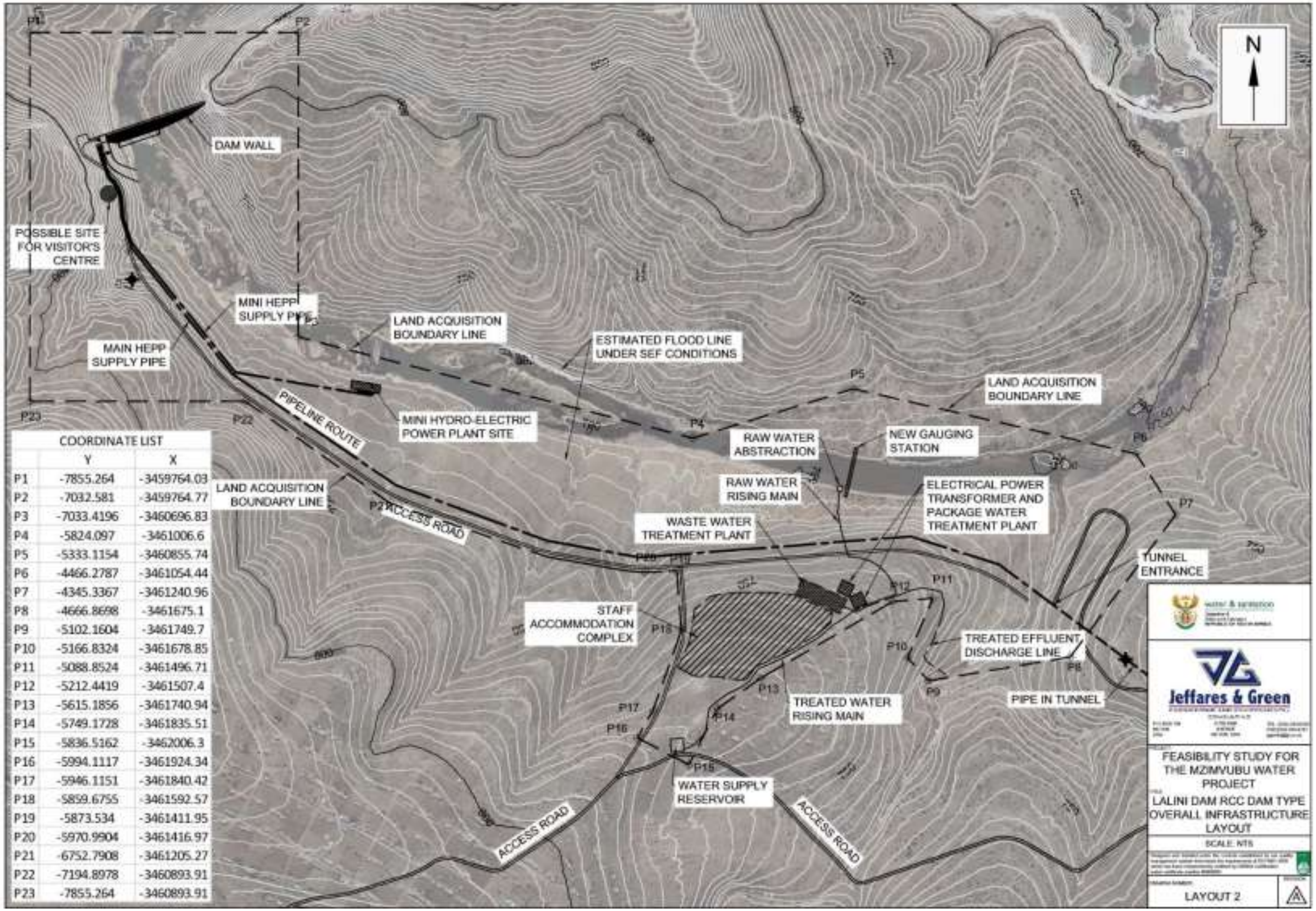
13.6 Lalini Hydropower Conduit Route and Hydroelectric Plant Site

As shown on Figure 13-4, the route of the Lalini hydropower water transfer conduit from the dam to the main hydroelectric plant (HEP) initially runs roughly parallel to the Tsitsa river downstream of the dam wall and will be constructed as a 2 500 mm diameter welded steel pipeline laid in an excavated trench with a normal depth of cover to the crown of the pipe of 1 000 mm.

This conduit would be laid in the same trench as the Lalini Dam outlet works pipeline to the mini-hydropower plant, then continue as a single 2 500 mm diameter pipeline to the main HEP, which is some 7.95 km from the Lalini Dam. At a point 3.5 km from the dam, the pipeline enters a tunnel section within which it will be laid to emerge close to the main HEP.

Given the large diameter of this conduit, a temporary servitude of 30 m width would be required during construction, whence a permanent servitude of 10 m would be required.

The entrance and exit portals of the tunnel will require significant temporary servitudes for working areas during construction but only limited permanent land expropriation at each location to allow access to the tunnel and its pipeline for maintenance purposes.



COORDINATE LIST		
	Y	X
P1	-7855.264	-3459764.03
P2	-7032.581	-3459764.77
P3	-7033.4196	-3460696.83
P4	-5824.097	-3461006.6
P5	-5333.1154	-3460855.74
P6	-4466.2787	-3461054.44
P7	-4345.3367	-3461240.96
P8	-4666.8698	-3461675.1
P9	-5102.1604	-3461749.7
P10	-5166.8324	-3461678.85
P11	-5088.8524	-3461496.71
P12	-5212.4419	-3461507.4
P13	-5615.1856	-3461740.94
P14	-5749.1728	-3461835.51
P15	-5836.5162	-3462006.3
P16	-5994.1117	-3461924.34
P17	-5946.1151	-3461840.42
P18	-5859.6755	-3461592.57
P19	-5873.534	-3461411.95
P20	-5970.9904	-3461416.97
P21	-6752.7908	-3461205.27
P22	-7194.8978	-3460893.91
P23	-7855.264	-3460893.91

Figure 13-7: Land Acquisition for Lalini Dam and Associated Infrastructure

The main hydropower plant (HEP) at Lalini will be located in the Tsitsa River valley downstream of the Tsitsa Falls as shown on Figure 13-4. This will be serviced from the access road described above, and will initially comprise a platform cut into the hillside to form a construction working area at the tunnel exit portal.

This platform will also be excavated deeper to construct the hydroelectric plant building and to lay the steel conduit from the exit point at the tunnel portal into the HEP building. Figure 13-8 shows the layout of these works and the co-ordinates of the land that would need to be expropriated.

13.7 Bulk Potable Water Distribution Pipelines, Bulk Storage and Pumping Station Sites

The primary and secondary bulk potable water distribution system including pipelines, pumping stations and storage reservoirs would be implemented under this DWS project. Preliminary routes of these pipelines are shown in Figure 9-8. The Book of Drawings which is Volume 2 of this report includes more detail of the alignments of the distribution system, and co-ordinates of the alignments are given in the Appendices of the Bulk Water Distribution Infrastructure Report No. P WMA 12/T30/00/5212/14.

Tertiary pipelines which would supply water from the primary and secondary system to the consumers would be implemented by the District Municipalities and be subject to a separate consideration of land matters.

All of these routes are planned at a feasibility study level of detail only, and will be further reviewed by others during the detailed design stage. Some of the secondary pipelines that are included within this feasibility design have recently been constructed and EIA and servitude issues are therefore already dealt with[11].

Many of the existing storage sites will need to be expanded in the longer term and this may require permanent land acquisition for the increased site footprint. The new Command Reservoir sites will each require permanent land acquisition as well as servitudes for access roads, to be finalized during the detailed design stages.

On average, these sites will be approximately 80 m x 60 m in extent (i.e. approximately 0.5 ha). Two of these sites will also include new booster pumping stations and will therefore require a larger footprint, say 100 m x 80 m.

Three other small booster pumping stations will also be required, each of which will also require permanent land acquisition, with an average footprint of 40 m x 30 m.

All of the above sites will require low to medium voltage power supplies. The process followed would be to make application to ESKOM for a connection to each site, and ESKOM then undertake the planning and installation process. ESKOM would therefore deal with land matters and EIA with regard to these power line routings.

As is shown on Table 13-1, some 250 km of pipelines will be constructed, ranging in diameter from 50 to 900 mm. These will be in PVC, HDPE, and steel materials, depending on diameters and pressure classes required. These pipes will normally be laid with a minimum crown cover depth of between 900 and 1 500 mm below existing ground level.

[11] *Details can be obtained from the Implementing Agent - Amatola Water, East London*

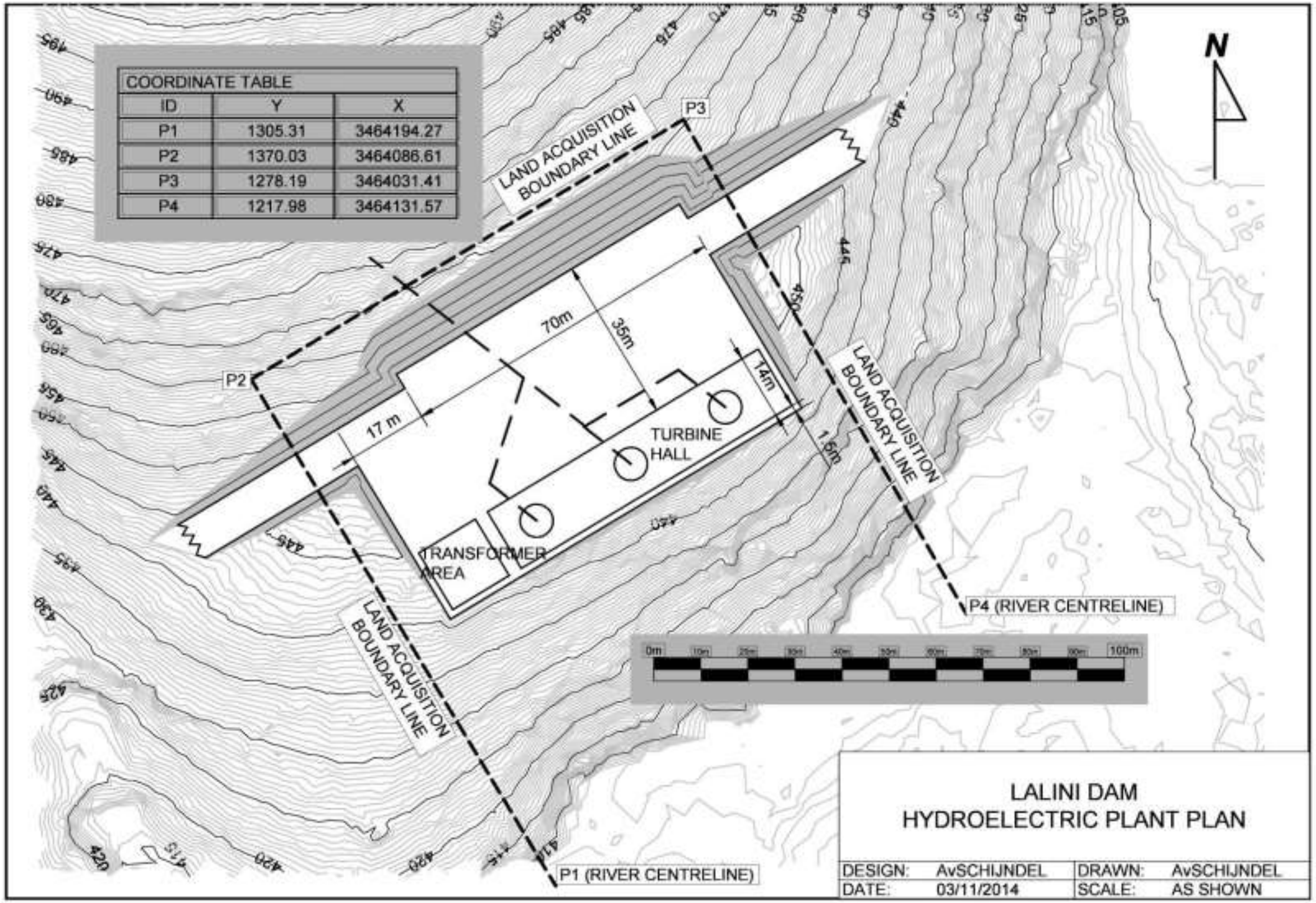


Figure 13-8: Expropriation Area Boundary for Lalini Main Hydropower Plant and Tunnel Portal

The pipeline routes will also feature other structures such as valve, air valve, and scour valve chambers (normally made of brick, concrete rings, or reinforced concrete), which will protrude above ground surface level when completed and need to be accessible by the operational staff at all times. Most of these pipelines are routed along existing tracks and roads, and can normally be aligned to avoid property, graves and other structures as much as possible, although sometimes conflicts are unavoidable and some relocation or compensation will be required.

The pipeline routes will all need a temporary servitude typically of width 20 m during construction, to allow space for the works to take place, and stock-piling of excavated material etc. During the operational phase a permanent servitude of width of between 6 and 10 m would be required (depending on pipeline size and terrain) to allow for operational access to the line at all times.

Where routes unavoidably pass through arable land, permission can often be granted for land-users to continue to grow crops over the alignment, provided deep ploughing or use of heavy plant and equipment is not employed.

It is reiterated that the alignments and operation arrangement of this infrastructure may change during the detailed planning and design stage.

The primary and secondary pipelines will comprise the following:

Table 13-1: Total Quantities and Sizes of Primary and Secondary Pipelines

Primary and Secondary Bulk Pipelines			
Item	**Description**	**Unit**	**Quantity**
1	Pipelines – supply, lay, joint, test, disinfect		
1.1	Bulk Pipelines		
1.1.1	40 HDPE Class 12	m	
1.1.2	50 HDPE Class 12	m	34 103
1.1.3	63 uPVC Class 12	m	2 633
1.1.4	75 uPVC Class 12	m	6 725
1.1.5	90 uPVC Class 12	m	86
1.1.6	110 uPVC Class 12	m	8 925
1.1.7	160 uPVC Class 12	m	10 326
1.1.8	200 uPVC Class 12	m	8 742
1.1.9	250 uPVC Class 12	m	12 100
1.1.10	315 uPVC Class 12	m	17 565
1.1.11	355 uPVC Class 12	m	12 085
1.1.12	400 uPVC Class 12	m	28 044
1.1.13	450 uPVC Class 12	m	4 917
1.1.14	500 steel	m	45 437
1.1.16	600 steel	m	29 261
1.1.17	700 steel	m	11 692
1.1.19	900 steel	m	15 691
		Total	**248 332 m**

13.8 Dam Basin Expropriation Boundary

Figures 13-9 and 13-10 show the probable land expropriation area boundaries for the Ntabelanga and Lalini dam basin areas which will be inundated. The area to be acquired for the dam basin (dam boundary line) is based upon the DWS requirement of *“the 1:100 year flood line (HFL) plus 1.5 m vertical for steep areas or 15 m horizontal for flat areas*”. The settlements that might be impacted by this expropriation requirement are indicated on the figures. The co-ordinates of these preliminary expropriation boundaries are given in Appendices in the Land Matters Report No. P WMA 12/T30/00/5212/8. .

The expropriation line will need to be reviewed during the detailed design and a survey carried out to install permanent beacons defining the expropriated land. This will involve some “smoothing” of the boundary of the expropriated land into straight lines between beacons, and DWS will acquire that land in terms of the surveyed lines.

Given that this project will impact upon the river and its basin upstream of the dam wall, there will be a need to address the relocation and compensation issues for affected persons living near to, or using land within, the river’s riparian zone. Refer to DWS EIA Report Nos. P WMA 12/T30/00/5314/1 to 17.

In the case of the dam basins, the impact on those people that will be affected by the permanently raised water level is difficult to accurately quantify for compensation purposes at this feasibility stage. The land in question will need to be valued by a professional valuator, and the affected parties will be compensated in accordance with the valuator’s report, in accordance with normal DWS practice.

Whilst land use of the riparian zone would not normally have been permitted, it is probable that no actions would have been taken if people had previously made use of this land, and a precedent would thus have been set. Best practice would typically recommend that affected people should be compensated for the loss of land lying within the current riparian zone, although this is not necessarily compulsory.

In this area, the affected land will have been allocated to a Traditional Leader (TL), and with rural development land, the TL as well as the affected parties are compensated for different reasons. It will be important to consult with the correct TL in each area.

As these works are to be gazetted as Government Water Works, and given the expropriation powers likely to become available to Government as provided for under the Infrastructure Development Bill, there would not be a legal requirement to compensate affected people for the particular usage of riparian land. However, given the emotive nature of resettlement and the potential disagreement and unrest that might be caused by an insensitive consultation and compensation policy, great discretion is recommended in this case, and suitable compensation and mitigation measures applied.

DWS have legal powers to expropriate land, and use both the National Water Act and the Constitution in doing so. It is therefore reiterated that it is a legal requirement to compensate all affected parties and this means that different kinds of compensation are often required for different people on the same portion of land.

Provided sufficient cadastral information, etcetera are available, the legally prescribed procedures to be followed in order to acquire portions of such land normally take at least 12 (twelve) to 18 (eighteen) months to get through. The less formalised land allocation and ownership issue that will prevail in this case could easily prolong this acquisition process.

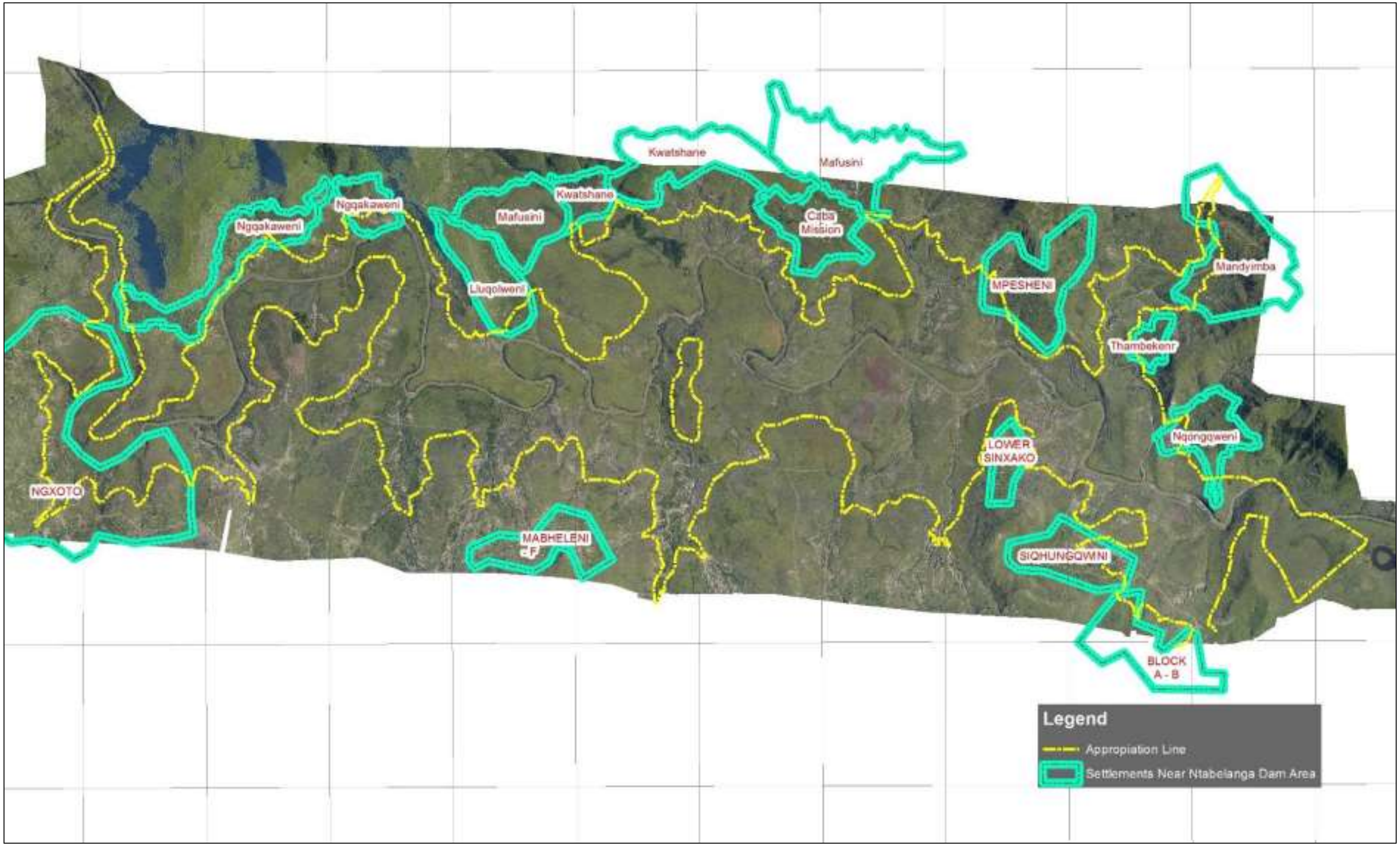


Figure 13-9: Ntabelanga Dam Basin Preliminary Expropriation Area

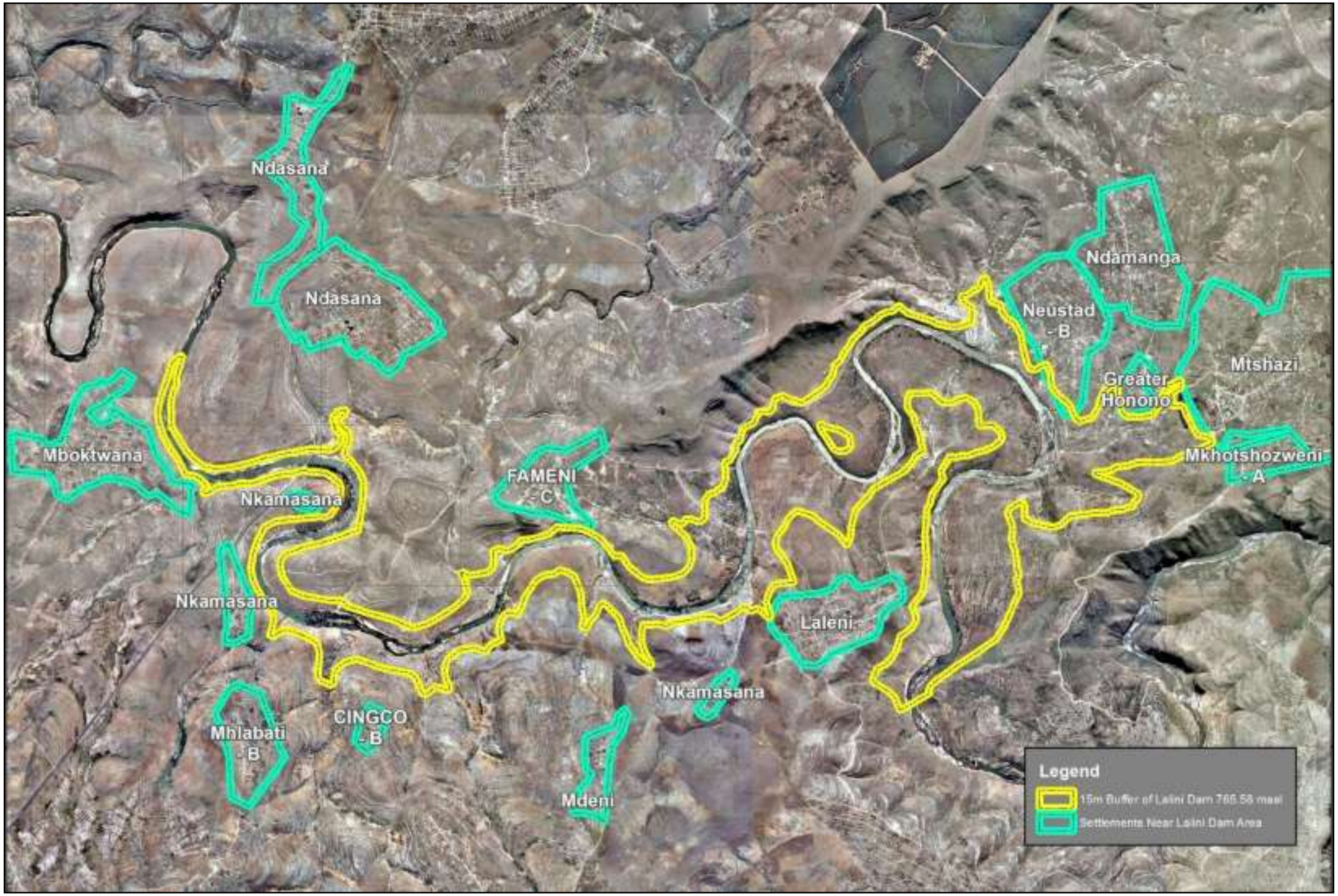


Figure 13-10: Lalini Dam Basin Preliminary Expropriation Area

Negotiations play a big role in such matters and if handled sensitively can allow construction to proceed before all of the land issues are dealt with and finalized. This must be done by an experienced practitioner otherwise unrealistic expectations can occur. The Department of Rural Development and Land Reform (DRDLR) should play a major role in this respect. Compensation paid must be in line with a professional valuator's report as well as DRDLR's policies.

The actual expropriation needs have been identified under the Independent EIA study. These investigations are based upon the footprints and alignments of infrastructure that will be constructed as temporary or permanent works which have been developed at a Feasibility Study level of detail. The detailed design of these works will further optimise the scheme and, as such,the general arrangements, alignments, and footprints of the works will often change.

The final survey lines and control beacons established during the detailed design will inform DWS as to the final nature and quantum of the expropriation and compensation requirements.

Aerial photography of the dam basin and dam wall location was taken in early 2013 (Ntabelanga) and in 2014 (Lalini) and forms a record of land use and existing structures in that particular area at that time, which can be used as a guide for compensation negotiations. However, the basis of compensation is what is on the land at the exact moment the valuator has his meetings with the affected parties.

It should be noted that as soon as affected people in the area realise that there might be infrastructure being developed close to their land, there tends to be opportunistic actions to maximise the potential compensation from the ensuing resettlement or servitude process.

This is unfortunate but can be controlled with the assistance of the local Chief and Councillors, but adherence to protocol and an approved Record of Decision is required. Local development within affected lands cannot be stopped until there is a 100% certainty that the project is going to commence and the project has been gazetted. In the period before the project construction commences it would likely be impossible to prevent people developing lands that would be expropriated. This emphasises the need for the EIA consultation process to not create expectations and to only discuss land issues at an appropriate time.

It is therefore recommended that the consultation process includes a careful recording of current structures and land use, and gives notification to the affected parties that no new development or change of land use should take place in order to leverage more compensation. However, as reiterated above, this must only be undertaken at a time when the project is definitely about to commence.

It is also reiterated that the process to be undertaken must be implemented in close consultation and co-operation with the traditional leaders in the affected areas, and involving the Provincial Departments of Rural Development and Agrarian Reform, Rural Development and Land Reform, and Local Government and Traditional Affairs. The Councillors are the starting point of such a process and the National Departments must be involved as this is State land and not Provincial land. The DRDLR is the custodian of the land.

This will require a dedicated facilitation unit or service provider to be assigned to undertake this process, and significant time and cost will need to be allowed for this process to be implemented. DWS is able to do this as it is a part of their duties on a regular basis.

From the EIA analysis, the estimates are that for the Ntabelanga Dam basin, 62 structures and 19.9 km^2 of cultivated land will be lost. The Lalini Dam basin will result in the loss of 12 structures and 7.6 km^2 of cultivated land.

It would appear that a fairly high proportion of this lost land is not particularly suitable or regularly used for crop production, some is highly eroded and unsuitable for any usage, and a significant proportion is classed as riparian, and should not be used for arable or grazing purposes. This would be revisited during the detailed design process, whence the resettlement of affected people residing in the dam basin falls under the jurisdiction of the National Water Resource Infrastructure Branch of the DWS.

13.9 New Farming Units for Emerging Commercial Farmers

No existing commercial farmers operate in this study area and all farming that is currently undertaken is by resource-poor subsistence farmers. The Irrigation Development component of the study identified a total of some 2 868 ha of high potential land that could viably be developed for commercial irrigated agriculture, of which some 418 ha is located adjacent to the north shore of the dam basin and along the river just downstream of the dam wall, and the other 2 450 ha is located around the Tsolo area. These areas are shown on Figure 13-11.

13.10 Bulk Raw Water Supply to the Irrigation Areas

Raw water supply to the smaller areas around the dam reservoir basin and along the river itself would be via portable abstraction systems, but the main supply of bulk raw water to the Tsolo areas is planned to be via a raw water pumping pipeline directly pumped from the Ntabelanga Dam outlet.

This system would transfer raw water to an intermediate storage reservoir which would be an open earth embankment dam located on a ridge and as shown also on Figure 13-11. The system layout is shown in more detail in the Book of Drawings that forms Volume 2 of this report.

From that storage site, raw water would be gravitated through a system of distribution pipes to the edge of the farming unit field shown on the figure. Most of these pipelines would flow by gravity, but two small booster pumping stations would be required to lift water to outlying farming units that are located at higher elevations. Table 13-2 summarises the diameters and lengths of raw water pipelines to be constructed.

Table 13-2: Irrigation Raw Water Transfer Pipeline from Ntabelanga Dam to Tsolo Area

Pipeline Quantities	
Diameter mm	**Length m**
1 200	9 780
900	2 000
800	9 660
600	4 460
500	3 100
450	5 900
350	1 770
300	9 970
200	2 143
Total:	**48 783**

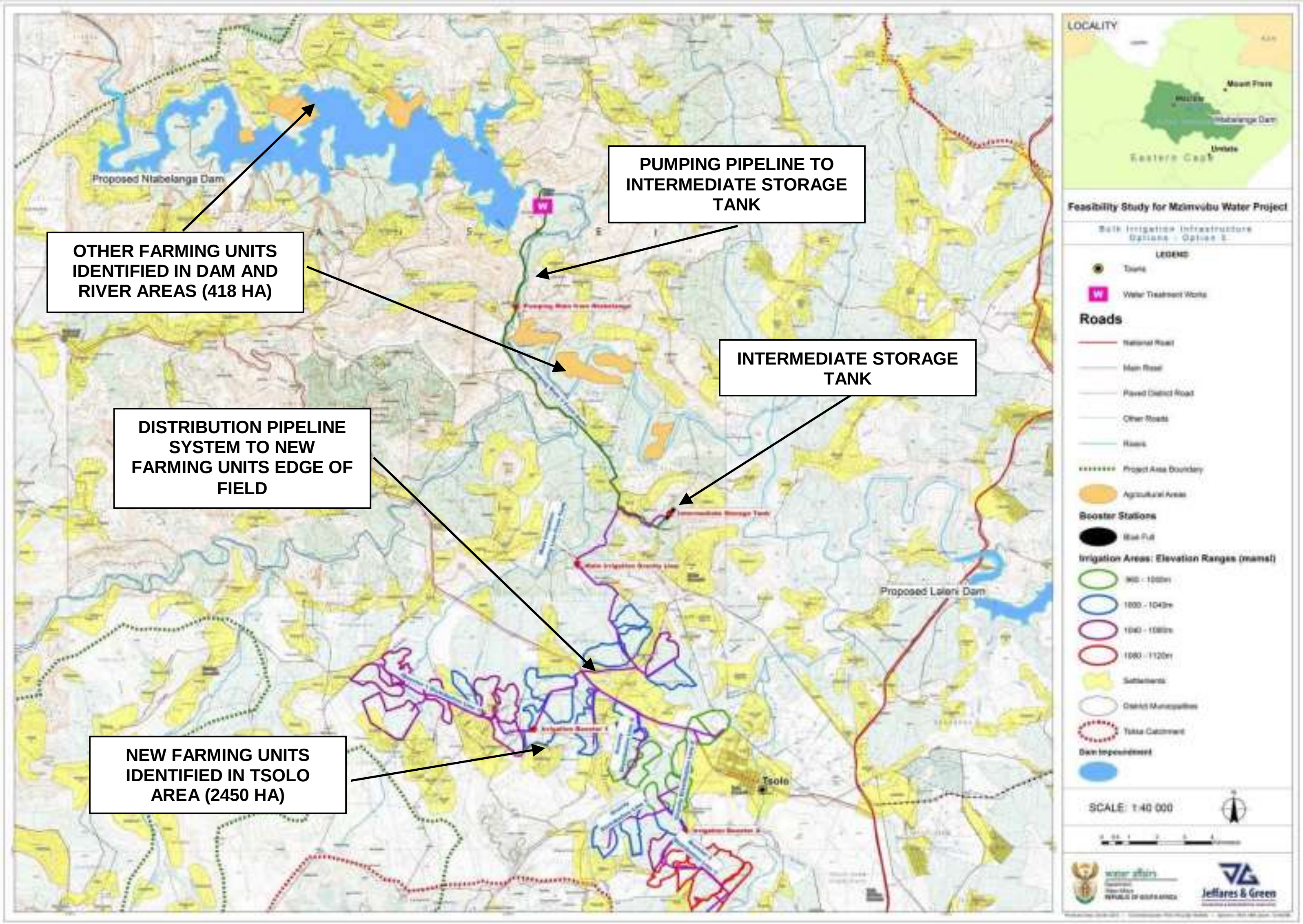


Figure 13-11: Layout of Proposed New Farming Units and Bulk Raw Water Distribution System

The same temporary and permanent servitude rules will apply as is described above for the potable water pipeline system. Two small booster pumping stations will require land to be acquired to the same size as the boosters described above.

The final location, configuration and sizing of the intermediate storage tank will need to be determined once the final number and size of farming units, their water requirements, pumping scheduling and seasonal irrigation pattern requirements have been finalized. At feasibility level this storage has been sized at some 85 000 m^3, which would require a bunded storage tank of dimensions approximately 120 m x 180 m, and this would require the acquisition of land of approximately 3 ha in extent.

13.11 Land Use Reform Requirements for Emerging Farmer Development

It was recommended that for irrigation farms to be feasible they need to be economically viable, implying that they can be operated as stand-alone farms with profits that exceed operating costs. This will empower the farmers to have their own implements, make independent decisions, and will encourage them to become sustainable contributors to the local economy and to become employers within the community. For this reason an average farming unit size of 60 ha was settled upon, which resulted in the potential for up to 45 farming units to be developed in the Tsolo area.

THE DRDLR, DRDAR and DAFF work together on such aspects and they have policies and legislation with which such land use reform processes must comply.

It is proposed that the farming units are established as economically viable commercial irrigation farms. The most reasonable system of land tenure would be a medium-term lease entered into between the State and the farmer. This lease need to be long enough that the farmer can establish themselves on the land, establish a number of enterprises, invest in the farm, and repay any loans raised to finance the investment. The lease should also be long enough that the farmer can take a medium term view in developing the farm. This may entail a few lean years in the early stages of farm development, with more profitable years to follow once the farm has been well established.

A lease period of 20 years should be considered for the system of land tenure. It is important that the lease is linked to agricultural performance, with cancellation of the lease being an option if the farmer fails to establish any agricultural production within (say) 3 years, or if the land is used for non-agricultural purposes.
It is critical that the land allocation under the current system of communal farming is audited and that a land register is set up. This should be done early on in the implementation phase of the project, and should form part of the community consultation process. This will establish a benchmark for the current land use in terms of who has been allocated which land, since what date, what land area, if it is currently being farmed, how much land in total has been allocated, and how much land remains unallocated.

This will form the basis of any discussions around land rights, any compensation payable, any offset arrangements, or any land trading system. Without such a system being set up early on, the process will quickly become mired in squabbles by community members who feel they are being disenfranchised or unfairly removed from their land.

Those people currently using the land to be transformed in this way, will therefore need to be dealt with in a very sensitive manner, and solutions developed should maximize the participation of, and livelihood benefits to, these people, and/or offer alternatives that are equal to, or better than, the situation from which they are being asked to change.

It will be essential to undertake all of the activities in accordance with the existing legislation relevant to the National Departments that are responsible for this function.

13.12 Training and Support Resources

The success of this new approach will hinge on a radical shift in farming methods currently being practiced in the area, and will require the support and buy in from Government at large, applicable Government Departments (such as the DRDAR and DRDLR) and other agencies (Eastern Cape Rural Development Agency) that will assist with support, training, land administration matters and getting community consensus, Traditional Leaders that currently administer the land under the communal farming system, the community who currently reside on and farm the land, and local training institutions that will be required to train and support the farmers. If support is withdrawn from any of the above sections of the community, the venture will almost certainly fail as a commercial proposition. DRDLR and DAFF must be consulted and involved at all stages during the process.

Irrigation farming is not common in the communal areas and communities surrounding the town of Tsolo. It will be viewed as new technology, and it is important that there is appropriate training and extension support of new and emerging farmers if the technology is to be successfully implemented.

A number of resources are available which will be important for the training of new farmers, the support and guidance of farmers as they become established, and the continued support of farmers through extension and advisory services:

- Tsolo Agricultural College;
- Jongiliswe Agricultural College for Traditional Leaders; and
- Eastern Cape Department of Rural Development and Agrarian Reform.

Feedback has been provided during consultative meetings held as part of this study that the technical support in terms of agricultural training and extension support does exist within these institutions listed above. However, no formal business skills training exists. Farms that are 60 ha in size (as proposed) will have annual turnover of R3 to 5 million, and appropriate business skills will be as important as agricultural skill development for the farms to be sustainable. Business courses either need to be developed and offered as courses/modules within the existing training facilities, or new business skill training facilities need to be established in the area. However, these actions should only be implemented once there is concensus and confirmation that commercialized irrigation in the Tsolo area is both viable and has sufficient numbers of people willing to accept the necessary land and agrarian reform implications.

All of the above activities must comply with current policies, legislation and regulations of the DRDLR and DAFF.

13.13 Beneficiary Selection

It has been strongly advocated from the consultative meetings held to date that the process of beneficiary selection needs to be designed to succeed. That is, prospective farmers to be settled on the plots need to have demonstrated:

- Agricultural skills and knowledge to enable them to farm effectively;
- Business skills to be able to farm profitably and sustainably, and to enable them to contribute to the local economy through becoming primary producers and providing employment opportunities;
- Aptitude to become farmers, to work hard, and to remain enthusiastic; and

- Willingness to embrace new technology, and to continue learning as new agricultural technologies evolve.

Commercially successful farmers will not only make best use of the land and the irrigation investment, but will contribute to food security in the area, to the regional economy, and will generate up to 3 375 permanent jobs and up to 1 350 seasonal jobs on the 45 proposed farming units. By contrast, failed farming units would make poor use of the available land, reduce food security, and diminish the leveraging effect that job creation can have on the local economy.

13.14 Concluding Remarks

The above process of land use reform will be complex, and must be handled in an extremely sensitive manner.

The consultation process should be overseen and guided by the Provincial Department of Rural Development and Agrarian Reform, the National Department of Rural Development and Land Reform, and the Department of Agriculture, Forestry and Fisheries, who will consult and co-operate closely with the relevant Councillors, Traditional Leaders and the Department of Local Government and Traditional Affairs. The Regional Land Claims Commissioner would need to be a key role-player throughout the process.

Extensive time and resources will need to be allowed for this process to take its course, and this will very likely be one of the most challenging issues to address on the whole project.

Final land expropriation needs, relocation, and compensation requirements can only be determined once the detailed design has been finalised.

The final land acquisition requirements will be confirmed by the DWS Spatial Land Information Management (SLIM) following the detailed design when they prepare the final servitude data as well as the dam boundary lines. Land Schedules would then be provided by SLIM for acquisition purposes.

14. REGIONAL ECONOMICS

14.1 Introduction

This section summarises the Regional Economics analysis of the scheme which is described in detail in Report No. P WMA 12/T30/00/5212/14.

The report focuses only on the medium term economic benefits associated with construction, irrigation, water supply and hydropower generation of the Ntabelanga and Lalini Dams.

The economic impact analysis considers two distinct phases over the lifetime of the project:

- The construction phase; and
- The operational phase.

14.2 Background

The Mzimvubu Catchment, one of the poorest regions in South Africa, possesses untapped economic potential in the form of its abundant water resources. The eastern part of the Eastern Cape is the region in South Africa with the highest average rainfall and is host to the bulk of South Africa's untapped water, a rare commodity in an otherwise resource abundant nation.

The cost of constructing a dam is significant, requiring many decades of operation to recover the financial cost, if ever. Moreover, dams are criticised because of impacts such as flooding of large areas, and impacts on flow in aquatic and riparian ecosystems, disrupting livelihoods and destroying valuable, potentially arable, land.

However, dams provide many benefits. The primary benefit is in the supply of water for productive uses. Growth of populations, agricultural expansion and commercial and industrial economic activity rely heavily on South Africa's available water resources as a critical input into economic production. The availability of fresh water is increasingly an impediment to economic development. As such, the construction of the Ntabelanga Dam is foundational to the development of the Mzimvubu Catchment, and the large scale development associated with the dam can generate significant economic activity in the region.

Other benefits include hydroelectric power, recreation, flood control, water supply, waste management and navigation.

The construction of a second dam at Lalini downstream of the Ntabelanga Dam offers the opportunity to build a hydropower scheme able to produce up to 37.5 MW which, when used conjunctively with the Ntabelanga Dam, could supply some 202 million kWh into the regional grid, and generate significant revenue which could be used to the benefit of the overall scheme and region.

The above benefits are the tangible, medium term benefits associated with dams, and are relatively easy to measure. The most important benefits of dams however are in the long term economic benefits associated with the development of large infrastructure.

There is a positive and statistically significant correlation between investment in infrastructure and economic performance at country level. Infrastructure investment not only increases quality of life, but, based on the time series evidence in the United States, infrastructure also has positive impact on both labour and economic productivity[12]. Examples of these benefits include the value of time saved by households in collecting water, the reduced burden of water-borne disease, tax revenue accruing to the fiscus and most importantly, the long-term economic impact resulting from the improvement in local infrastructure.

14.3 Project Related Expenditures and Benefits

14.3.1 Construction Phase

The construction phase considers the economic impact of constructing the works over the prescribed construction period, 2015 to 2021. Over this 7-year period, the total expenditure in the construction sector will be R12 330 million on capital expenditure (including professional services, escalation, and VAT).

This includes R5 273 million for a water treatment works and bulk treated water system, R795 million for irrigated agriculture developments, and R450 million for catchment management.

These expenditures will have a highly positive impact on the regional and national economies. These capital expenditures will generate economic activity which will contribute R2 566 million per year to regional and national GDP, and has the potential to create an average of 7 069 direct, indirect and induced jobs per year, during the construction period.

Other sectors indirectly benefitting from the construction phase include:

- The Real Estate sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 4.13% (R2 016 million per year);
- The Wholesale and Retail Trade sectors, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 1.25% (R892 million per year);
- The Manufacturing sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 0.48% (R551 million per year); and
- The Transport sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 1.30% (R351 million per year).

14.3.2 Operational Phase

The operational phase considers the impact of post-construction economic activities in terms of direct impact on agricultural development, water supply and hydroelectric power generation for the period circa 2020 – 2050.

This phase will generate direct economic benefits in Agriculture, Water and Electricity industries which will contribute R778 million per year to regional and national GDP, and has the potential to create between 2 971 – 5 440 direct, indirect and induced jobs per year, depending to the level of labour-intensity applied in the irrigated agriculture activities.

[12] *Aschauer, David Alan (1990). "Why is infrastructure important?" Federal Reserve Bank of Boston, New England Economic Review, January/February, pp. 21-48.*

The key sectors directly benefitting from the operational phase include:

- The Agriculture sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 2.87% (R256 million per year);
- The Electricity sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 4,84% (R272 million per year); and
- The Water sector, which, for the total economic activity in the Eastern Cape Province as a whole, would increase by 12.26% (R216 million per year).

Other sectors indirectly benefitting from the operational phase

- The Manufacturing sector, would increase by 0.33% (R380 million per year);
- The Wholesale and Retail Trade sectors would increase by 0.19% (R133 million per year); and
- The Real Estate sector, which, for the total economic activity in the Eastern Cape province as a whole, would increase by 0.23% (R113 million per year).

14.3.3 Employment Potential

The project holds great potential to improve the livelihoods of local communities and entrepreneurs. A major challenge, especially during construction, will be to design the project to minimise income leakage (i.e. accrual of the project benefits outside the local and regional economies).

Employment in the Eastern Cape will:

- Increase by 0.56% during construction, the additional economic activity resulting from dam construction will create approximately 7 069 full-time equivalent employment opportunities per year, which is equivalent to a total wage bill of R418 million per year, over the construction period.
- Increase by between 0.24% - 0.43% during post-construction. The additional economic activity resulting from post-construction activities will create at between 2 971 and 5 440 full-time equivalent employment opportunities per year, and potentially another 1 350 seasonal jobs in agriculture. This is equivalent to a total wage bill of R240 million per year.

Employment in the local area adjacent to the Project will:

- Increase by 17.7% during construction. (The challenge during the planning and implementation of the project will be to maximise local job creation and minimise income leakage to areas outside the local area.)
- Increase by between 7.5% - 13.7% during post-construction. (These will for the most part accrue within the local area.

The sustainable local economic development opportunities created during post-construction will increase household income by R 579 million per year. This additional household income would have highly significant positive impact on local households. Assuming (for demonstration purposes only) that all the additional household income accrues in the Mhlontlo and King Sabata Dalindyebo LM's, this would increase the total household income in these LM's by 15.18%.

14.4 Conclusion

The breakeven social discount rate of the project is attractive for a project of this nature. The return on investment to the economy can be estimated as the present value of project contribution to GDP against the capital cost of the project over the 2020 - 2050 operational planning horizon. The social discount rate is expected to be lower than financial discount rates. In this case the breakeven social discount rate is 6.54%. This is a favourable discount rate for large infrastructure projects of this nature.

As the Lalini Dam and hydropower study was being completed, the EIA PSP undertook a further economic assessment of the conjunctive scheme, which involved a critique of this Feasibility Study regional economics assessment and some further analysis. The findings of this later study therefore complement the findings of the Feasibility Study and are given in DWS Report No. P WMA 12/T30/00/5314/8.

15. COST ESTIMATES AND ECONOMIC ANALYSIS

15.1 Introduction

This section summarises the Cost Estimates and Economic Analysis of the scheme which is described in detail in Report No. P WMA 12/T30/00/5212/15.

15.2 Overview

This section summarises the cost estimates prepared for the above Ntabelanga-Lalini Conjunctive Scheme components, and the results of economic and financial analyses undertaken on each component and on the fully integrated scheme.

These analyses have been undertaken to optimise sub-components and to test for the viability and sustainability of the scheme, in terms of the Unit Reference Value (URV) of the water supplied by the scheme when comparing different options and also the Financial Impacts of proposed solutions. In particular, the beneficial impact on this viability created by the inclusion of the hydropower component is demonstrated.

Various scenarios are included to show the impact of various proportions of the works being grant funded rather than to have to include capital redemption in the water sales tariff. It is made clear that such a scheme, with its large indigent consumer base, is only sustainable if a significant portion of the works are grant funded. This is the norm in such scattered rural situations, and is especially so given the remote and rugged terrain which comprises the whole of the supply area.

A summary of the implementation cost estimates, and annual cash flow projections are given, with costs escalated from a 2014 costing baseline, to the actual expenditure year, at 5.5% p.a.

The impacts of various possible financing options for the hydropower component of the conjunctive scheme are also presented, with conclusions that a fully or partially grant-funded solution would enable the energy costs of the water supply scheme components to be fully cross-subsidized, as well as providing surplus energy sales revenue, which can be used for repaying either the full grant funding, or loan funding aspects, or otherwise used to fund other development projects in the region.

15.3 Summary of Findings

Table 15-1 shows the overall cost estimate for the Ntabelanga-Lalini Conjunctive Scheme. This summarises the financial requirements for infrastructure implementation, based upon the proposed conjunctive scheme which includes potable and irrigation water supply, as well as the Ntabelanga and Lalini hydropower components, operated as a single ring-fenced project.

As shown, the Department of Environmental Affairs (DEA) allocated a budget of approximately R450 million to be spent over the next 10 years for the catchment restoration and rehabilitation programme which commenced in April 2014. This budget therefore already exists and has been allocated proportionally to the two dams. Also shown is the estimated budget for the implementation of the tertiary pipelines. This component is not part of the DWS responsibility and falls under the jurisdiction of the three District Municipalities and their Implementing Agents. Such funding is normally sourced from the Regional Bulk Infrastructure Grant (RBIG) and Municipal Infrastructure Grant (MIG) programmes.

Table 15-1: Overall Conjunctive Scheme Cost Estimate and Cashflow Projection

COST ESTIMATES		ANNUAL EXPENDITURES R'MILLION									
COMPONENT	**R'million**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Ntabelanga dam and associated works	1 075		81	322	215	215	215	27			
Ntabelanga dam hydropower works	88				9	35	35	9			
Ntabelanga land compensation/mitigation costs	18		1	4	4	4	4	1			
Ntabelanga power transmission	29		3	23	3						
Sub-Total Ntabelanga Dam and Associated Works	1 209		85	349	231	254	254	37			
Engineering and EMP Costs (12%)	145		10	42	28	30	30	4			
Sub-Total Ntabelanga Dam and Associated Works incl Eng & EMP	1 354		95	391	259	284	284	41			
Escalation in Each Year @ 5.5% p.a.*	265		5	44	45	68	87	16			
Sub-Total Ntabelanga Dam and Associated Works incl Eng, EMP & ESC	1 619		100	435	304	352	371	57			
VAT (14%)	227		14	61	43	49	52	8			
Add in R22 million per year for catchment management (no esc)	220	22	22	22	22	22	22	22	22	22	22
Allowance for other offset activities (50% of R100 million)	50				10	15	15	10			
Total Ntabelanga Dam and Associated Works (incl Esc + VAT)	**2 116**	**22**	**136**	**518**	**378**	**438**	**460**	**97**	**22**	**22**	**22**
*** Escalation based upon proportion of capital cost expended in any year, escalated at a rate of 5.5% per annum on a compound basis, from the 2014 cost estimate base year.**											
COMPONENT	**R'million**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Ntabelanga water treatment works	643		32	32	193	193	129	64			
Ntabelanga primary & secondary bulk treated water distribution system	1 234			123	247	370	370	123			
Ntabelanga tertiary bulk treated water distribution system (DM's)	1 425			143	285	428	428	143			
Ntabelanga bulk irrigation water supply system	497				50	149	199	75	25		
Sub-Total Ntabelanga WTW and Bulk Water Systems	3 799		32	298	774	1 140	1 125	405	25		
Engineering and EMP Costs (12%)	456		4	36	93	137	135	49	3		
Sub-Total Ntabelanga WTW and Bulk Water Systems incl Eng & EMP	4 255		36	334	867	1 277	1 260	453	28		
Escalation in Each Year @ 5.5% p.a.*	1 067		2	38	151	305	387	172	13		
Sub-Total Ntabelanga WTW and Bulk Water Systems incl Eng, EMP & ESC	5 322		38	372	1 019	1 581	1 647	625	40		
VAT (14%)	745		5	52	143	221	231	88	6		
Total Ntabelanga WTW and Bulk Water Systems (incl Esc + VAT)	**6 068**		**43**	**424**	**1 161**	**1 803**	**1 878**	**713**	**46**		
COMPONENT	**R'million**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
In-farm irrigation investment costs	**105**						53	53			
Engineering and EMP Costs (12%)	13						6	6			
Sub-Total in-farm irrigation investment costs incl Eng & EMP	118						59	59			
Escalation in Each Year @ 5.5% p.a.*	40						18	22			
Sub-Total in-farm irrigation investment costs incl Eng, EMP & ESC	158						77	81			
VAT (14%)	22						11	11			
Total in-farm irrigation investment costs (incl Esc + VAT)	**180**						**88**	**92**			
COMPONENT	**R'million**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Lalini dam and associated works	802				267	267	267				
Lalini Access Roads and Bridges	487			73	195	195	24				
Lalini land compensation/mitigation costs	50				17	17	17				
Lalini water delivery tunnel, shafts and penstocks	756				113	302	302	38			
Lalini hydropower E&M equipment	175					26	79	61	9		
Lalini hydropower civil works	49						24	24			
Lalini power transmission lines to grid	29			14	14						
Sub-Total Lalini Dam and HEP	2 347			87	607	807	714	124	9		
Engineering and EMP Costs (12%)	282			10	73	97	86	15	1		
Sub-Total Lalini Dam and HEP incl Eng and EMP	2 629			98	679	904	799	138	10		
Escalation in Each Year @ 5.5% p.a.*	648			11	118	216	245	52	4		
Sub-Total Lalini Dam and HEP incl Eng, EMP and Esc	3 277			109	798	1 120	1 045	191	14		
VAT (14%)	459			15	112	157	146	27	2		
Add in R22 million per year for catchment management (no esc)	230	23	23	23	23	23	23	23	23	23	23
Allowance for other offset activities (50% 0f R100 million)	50				10	15	15	10			
Total Lalini Dam and HEP (incl Esc + VAT)	**4016**	**23**	**23**	**147**	**942**	**1 315**	**1 229**	**251**	**39**	**23**	**23**
		2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
GRAND TOTAL ALL COMPONENTS (R'MILLION INCL ESC AND VAT)	**12 380**	**45**	**203**	**1 089**	**2 482**	**3 556**	**3 655**	**1 153**	**107**	**45**	**45**

Allowance has also been made for the potential investment costs for the establishment and equipping of each of the 60 ha (average) farming units, which are expected to be between R3 and 5 million per farming unit. A budget of R4 million including VAT has therefore been allowed per average farming unit, for 45 farms.

There are other potential offset costs which might include:

- Environmental impact offsets including conservation of other crane habitat areas in the Eastern Cape Province to compensate for habitat that will be inundated in that dam basins;
- Improvements to other infrastructure in the region for those directly affected by the works – including upgrades to schools, clinics, water supplies and sanitation, and other community facilities;
- Development of aquaculture;
- Development of tourism and recreational infrastructure; and
- Development of local industries and agri-processing

Each of these aspects will require further studies to determine their specific requirements, viability and cost benefits.

The EIA study investigated the environmental and social impacts, and determined resettlement, mitigations and compensation requirements, as well as these potential offset requirements.

A provisional budget of R100 million has been allowed for environmental offsets which has been evenly distributed between the Ntabelanga and Lalini components of the conjunctive scheme. No provision has been made for the other potential offset costs listed above.

The capital works budgets include allowances for engineering (project management, design and supervision professional services providers) as well as the implementation of the EMP requirements.

Escalation has been calculated from the 2014 baseline to the date of commissioning at 5.5 % p.a., based upon the proposed implementation programme.

A draft implementation programme has been submitted and is under review by DWS. This is included herein as Appendix A.

The cash flows shown on Table 15-1 are based upon this provisional programme. This will need to be regularly reviewed and updated in the light of the most likely implementation programme, which will be dependent upon the way that the various scheme components are packaged, the funding availability, the procurement and approvals processes, and the time taken to resolve the many institutional and social issues that are always a feature of such a large project.

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 ± 20% (an additional percentage should be added to the cost estimates for budgetary purposes);
- Escalation rates could increase or decrease, especially given the volatile nature of the economy at the moment;
- 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 R12.33 billion project increases escalation cost by R57 million (at 5.5% p.a.).

15.4 URV for Potable Water Supply

Discounted cash flow (net present value) analysis was undertaken to produce a Unit Reference Value (URV) of water produced by each scheme and funding option. The analysis was run for the potable scheme including the tertiary lines (Table 15-2) and for the scheme excluding the tertiary lines (Table 15-3).

Table 15-2: URV for Ntabelanga Potable Water Scheme Alone – Including Tertiary Pipelines

URV: POTABLE WATER SCHEME ONLY INCL TERTIARIES				
Scenario	**Components Grant Funded**	**URV of Water Supplied (R/m^3)**		
		6%	**8%**	**10%**
1	Full Capital Redemption	14.21	15.49	16.71
2	Fully grant funded	3.22	2.96	2.72
3	Fully grant funded + 50% Energy Subsidized	2.80	2.57	2.37
4	Fully grant funded + 100% Energy Subsidized	2.37	2.19	2.01

Table 15-3: URV for Ntabelanga Potable Water Scheme Alone – Excluding Tertiary Pipelines

URV: POTABLE WATER SCHEME ONLY EXCL TERTIARIES				
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

The results in Table 15-2 and 15-3 serve as an illustration of the obvious benefits of grant funding and the impacts of partial or full subsidization of the energy costs.

Whilst a URV value does not relate directly to the tariff requirements for a viable scheme, experience on similar bulk water supply schemes has shown that this value should be below R2.00/m^3 in order to produce a unit water cost that would be affordable to the consumer, and financially sustainable from the operations and maintenance viewpoint.

Financial impact models have also been built to test such sustainability and are presented in Section 15.7. As would be expected, the inclusion of the tertiary pipelines significantly increases the URV of water, but the financial impact analysis is based solely upon the DWS-developed scheme which includes delivery of potable water in bulk to the primary and secondary system only.

The tertiary pipelines would be the responsibility of the DMs to implement, and these are normally funded via grants under the RBIG and MIG funding process.

15.5 URV of Bulk Irrigation Water System

Appendix H of the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15 shows the discounted cash flow models used to calculate the URV of potable water supplied, including all costs of abstracting raw water from the Ntabelanga Dam, the raw water pumping station, the intermediate bulk storage reservoir, and gravity pipelines to local tanks at each of the proposed farming units. The delivery of raw water to some of the farm units at higher elevation will also require two small booster pumping stations, which are also included in the analysis. In-field distribution costs and associated equipment are not included, and the URV of water supplied therefore relates to the bulk water to be purchased by the farm unit developers.

Capital redemption scenarios have again been modelled from no grant funding to full grant funding of the various system components. In this case, 50% and 100% subsidy of power cost was therefore also modelled.

Table 15-4 summarises the results of this analysis.

Table 15-4: URV of Irrigation Water System

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

Whilst a URV value 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.

Table 15-4 shows the significant benefit 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 15-5.

Reduction of this unit cost to around R0.25/m^3 by subsidisation of energy (i.e. through the hydropower component), would considerably increase the gross margin produced by each farming unit, and viability of the irrigation component in total.

Table 15-5: Annual Operation and Maintenance Costs for Irrigation Component

RECOMMENDED IRRIGATION SCHEME				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	Electricity 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		R	
	Allowance for M&E depreciation and replacement funding				R	956 505
	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**
O&M Cost to supply 21 240 366 m^3 of raw water to edge of field excluding power					R	0.27/m^3
Power Cost per year		**R**	**18 559 958**		R	0.87/m^3
Cost for supply of raw water to edge of field including power					**R 1.14/m^3**	

15.6 Overall URV of Conjunctive Scheme

The above discounted cash flow/URV models have been combined to test the impact of operating the potable water, irrigation water, and hydropower components as an integrated scheme. The combined URV models are given in Appendix I of the Cost Estimates and Economic Analysis Report No. P WMA 12/T30/00/5212/15

In developing an overall URV for the Ntabelanga-Lalini hydropower components, all of the capital and operating costs of the various components were added together, and a subsidy from the surplus energy income from the hydropower component over the annual energy costs of the water supply components was allowed for.

This had the effect of significantly reducing the overall URV of water supplied as is shown on Table 15-6. Again, the impact of various proportions of grant funding of the capital costs of the conjunctive scheme was also considered. Seven scenarios are shown, ranging from no grant funding (full capital redemption) to full grant funding, only operation and maintenance costs redeemed.

Table 15-6: URV for Fully Conjunctive Ntabelanga-Lalini Scheme – Incl. Tertiaries

URV: ALL WATER SUPPLIED: CONJUNCTIVE SCHEME INCL TERTIARIES				
Scenario	**Components Grant Funded**	**URV of Water Supplied (R/m^3)**		
		6%	**8%**	**10%**
1	None - Full Capital Redemption	11.47	12.95	14.33
2	Lalini Scheme Only	7.78	8.78	9.71
3	Ntabelanga Scheme Only	4.69	5.27	5.81
4	Lalini + Tertiaries	5.86	6.59	7.26
5	Lalini + Tertiaries + Irrigation	5.01	5.64	6.23
6	Lalini + Tertiaries + Irrigation + Prim and Sec Bulk System	3.40	3.80	4.17
7	All Works Grant Funded	0.77	0.82	0.87

Alternatives of only grant funding the Ntabelanga scheme or the Lalini scheme components are shown as scenarios 2 and 3.

The same analysis was repeated for the fully conjunctive scheme, but without the tertiary pipeline system included. Table 15-7 shows the results.

Table 15-7: URV for Fully Conjunctive Ntabelanga-Lalini Scheme – Excl. Tertiaries

URV: ALL WATER SUPPLIED: CONJUNCTIVE SCHEME EXCL TERTIARIES				
Scenario	**Components Grant Funded**	**URV of Water Supplied (R/m^3)**		
		6%	**8%**	**10%**
1	None - Full Capital Redemption	9.37	10.60	11.75
2	Lalini Scheme Only	5.51	6.27	6.98
3	Ntabelanga Scheme Only	4.29	4.89	5.45
4	Lalini	5.47	6.22	6.92
5	Lalini + Irrigation	4.63	5.28	5.89
6	Lalini + Irrigation + Prim and Sec Bulk System	3.02	3.44	3.85
7	All Works Grant Funded	0.41	0.49	0.57

As can be expected the exclusion of the tertiary pipelines reduces the URV significantly and under the fully grant funded option almost halves the URV of water supplied.

Comparing the URV of water produced for scenario 2 on Table 15-3 (Ntabelanga scheme only – no energy subsidy as no hydropower included) with the URV of water produced in scenario 7 for the full conjunctive scheme on Table 15-7, shows the impact of the cross-subsidization of energy costs, and the benefit of surplus revenue generated by the conjunctive scheme, which produces (at 8% discount rate) a drop in URV value from R2.96/m^3 to R0.82/m^3.

This finding indicated that there could be significant merit in development of the conjunctive scheme instead of the Ntabelanga scheme only, and it was agreed that both options would be investigated in terms of financial impact assessment.

This is especially pertinent given the high proportion of operating costs that are due to energy charges, and the likely continuing increase in energy costs in the future at much higher a rate than normal inflation.

15.7 Financing and Tariffs Analyses

15.7.1 Basis of Analysis

The financial and tariffs impact models are different from the economic models in that they take into account the financing options, charges, repayment terms and conditions, escalated costs, tariffs and cash flow year on year using realistic bulk water tariffs and projected escalation rates which take into account the current and projected economy indicators.

As with the URV models, these financial models were run for a 30 year simulation from this current year, and it was assumed that the bulk water supply operations would be undertaken by an implementing agent such as Amatola Water, who currently operate similar schemes in this region.

Water tariffs, costs and revenue streams were escalated to the date of expenditure, as follows:

- Capital and O&M cost are escalated at 5.5 % p.a., and
- Energy costs escalated at 8.5% p.a. for 3 years then at 6.5% p.a.

The scheme components analysed excluded the tertiary pipelines in order to replicate the limits of infrastructure that would be operated by the bulk water supply operator (such as Amatola Water), and it would then be up to the Water Services Providers (DMs) to reticulate and deliver the potable water onwards from this bulk supplier's terminal reservoirs to the customers.

In terms of actual sales quantities, the water requirements projections were used and adjusted for expected unaccounted for water in terms of losses, and deducting water supplied as free basic water (the latter estimated as some 25% of the total potable water produced).

Using Alfred Nzo DM as an example, their water supply tariffs to domestic customers allow for the first 6 m^3/month per household free to indigent customers, but they also charge some R1.60/m^3 in this lower consumption band if the customer is determined to be "non-indigent".

Above 6 m^3/month per household consumption, the tariffs increase steeply to R5.50/m^3 for up to 21 m^3/month/household consumption, and to R10.90/m^3 in the next tariff band, and so on up to a maximum of R22.00/m^3.

Commercial/industrial customer tariffs start at R5.70/m^3 in the first 10 m^3/month band, rising to R11.50/m^3 in the next 20 m^3/month band and rising steadily to R28.60/m^3 for consumption above 120 m^3/month.

These tariff bands are set to ensure that the poorer customers are cross-subsidized. In addition, each DM receives annual subsidies through the Local Government Equitable Share programme. These subsidies are to fund the provision of basic services to indigent households, which is currently of the order of R275 per month per indigent household, and of which some R87 per month (average nationally) is typically allocated for water supply services.

The above information was used as an indicator to try to ascertain what bulk potable water supply tariff could be afforded by the DMs that would be supplied by the proposed bulk water supply scheme.

As described in the Legal, Institutional and Financing Arrangements Report No. P WMA 12/T30/00/5212/16, it is recommended that a well-resourced and experienced bulk water supply operator be appointed to operate and maintain the bulk water supply system, and Amatola Water was cited as a strong possibility for this role.

According to Amatola Water's Annual Report 2014, they sell bulk raw water at a tariff of R1.57/m^3, and potable water at a tariff of R6.36/m^3, with a resulting composite average water sales tariff of R5.39/m^3 (2014). This is relatively high when compared with the much larger Water Boards such as Rand Water and Umgeni Water, and reflects the benefits of economies of scale that these larger Water Boards enjoy.

The appointment of Amatola Water to operate and maintain the Ntabelanga bulk water supply scheme would more than double this organisation's annual potable water sales and triple the overall water sales, which would certainly add economies of scale to Amatola's operation, which could mean a lowering of the average bulk water tariff to sustain their business.

15.7.2 Sources of Capital Works Funding

Different sources of capital works funding were investigated in this analysis:

Grant funding: Interest free and with no repayment requirement. The source of such funding would normally be from the National Treasury, although some international agencies can provide grant funding – normally for social upliftment project which otherwise would not be financially viable.

Loan funding: Borrowing funds at a certain interest rate per annum, with a requirement to repay the loan over a period (tenor) normally of the order of 20 to 25 years. The lender would set terms and conditions which would need to be complied with by the borrower. Loans which do not have an agreed fixed interest rate would have a higher risk than those which have fixed interest rates. If the loan funding is to be sourced and repaid in foreign currency, then there would be an exchange rate risk.

Equity funding: An investor raises funding for the purchase of a share in the works for which the investor receives an agreed annual dividend. The equity investment is not repaid but could be traded to other investors as shares.

15.7.3 Financial Analysis for Ntabelanga Bulk Water Supply

This analysis was based upon the infrastructure illustrated on Figure 9-8, and excludes the tertiary pipeline system to be implemented by the DMs.

Taking the above situation into consideration, and in order to test the financial viability of the study scheme options, the initial potable and irrigation water sales tariffs in year 1 (2015) were set at R5.00/m^3 and R0.30/m^3 respectively.

Power cost projections were based upon the estimated initial power consumption, and expected power tariff, in the first year of operation (2020), escalated thereafter at 6.5% p.a. Capital works and associated implementation expenditures were escalated from the 2014-based cost estimates at 5.5% p.a. with annual expenditure cash flow estimated from the projected implementation programme timing.

Figure 15-1 shows that even with all capital costs grant funded, the income from water sales would not be sufficient to sustain the management, operation, maintenance and energy costs of the scheme.

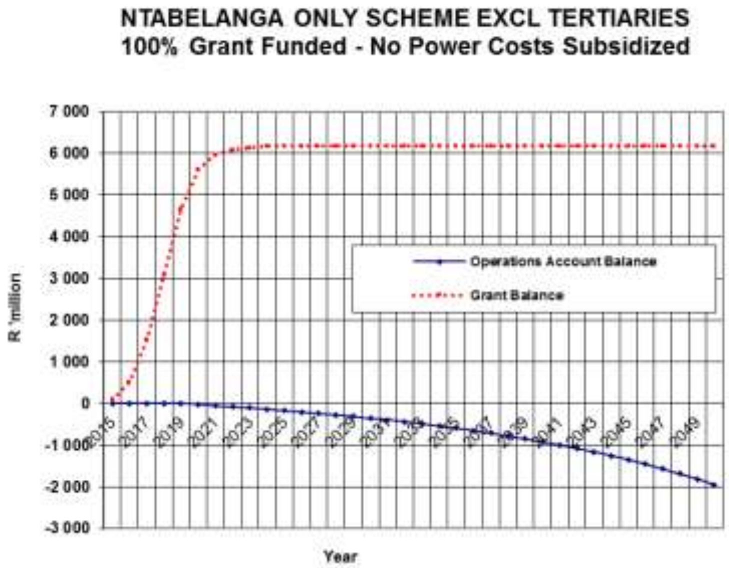


Figure 15-1: Grant Funded Ntabelanga Water Supply Scheme – R5.00/m³ potable initial tariff

The operations account balance shows annual operating losses commencing at R25 million per year in the first year of operation rising to R130 million per year in 2050, with a cumulative loss at that date of some R 2 billion. Thus this scheme would not be financially sustainable in the absence of some subsidy of the management, operation, maintenance and energy costs.

Raising the initial (year 1) bulk water tariff to R6.00/m³ does bring the operating account into balance, but this is likely to be a non-affordable bulk water tariff for the DMs to pay when the additional management, operation and maintenance costs of the tertiary distribution systems are taken into consideration, together with the high proportion of indigent households to be supplied by this scheme. See Figure 15-2.

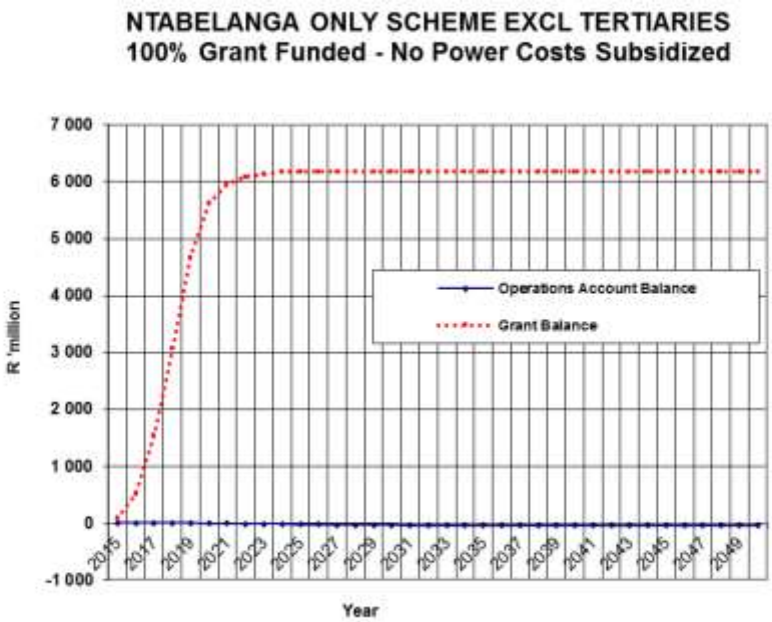


Figure 15-2: Grant Funded Ntabelanga Water Supply Scheme – R6.00/m³ initial tariff

15.7.4 *Grant Funded Conjunctive Scheme Excluding Tertiary System*

This financial impact model was initially run for a fully grant funded situation, and using the same base data as for the Ntabelanga scheme excluding the tertiary system.

Apart from higher capital, operations and maintenance costs, the model also includes credit for the energy sold into the grid from the hydropower components of the conjunctive scheme. This energy would be sold as green energy trading certificates (as with the Amatola Green Power example) and the year 1 (2015) tariff allowed for this was R0.80/kWh, which was then escalated at national escalation rate of 5.5 %p.a. These energy certificates tariff increases are based upon the average annual CPI escalation and not on ESKOM projected tariff increases, and will therefore increase at a slower rate than ESKOM tariffs are expected to increase.

As shown in Figure 15-3, even with water sales tariffs set at ZERO for both potable and irrigation water sold, the revenue generated by hydropower sales alone would be sufficient to financially sustain management, operation, maintenance, and power costs for the conjunctive scheme

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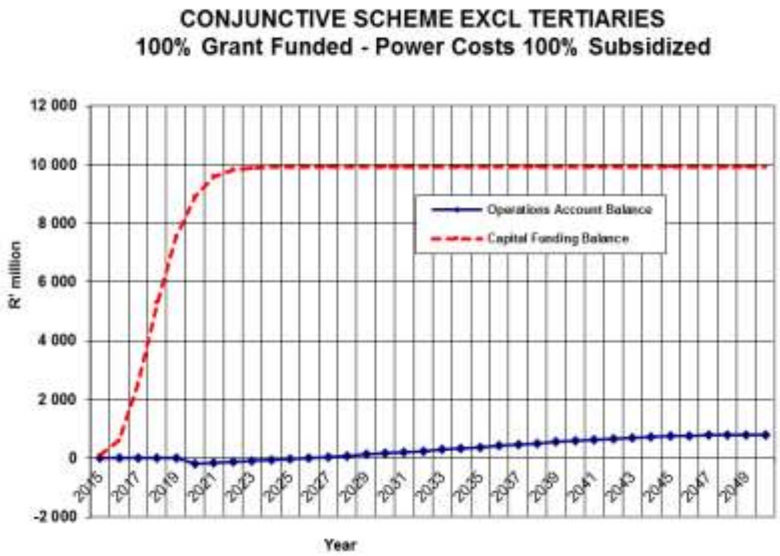


Figure 15-3: Grant Funded Conjunctive Water Supply Scheme – R ZERO/m^3 initial tariff

It is of course not sensible to deliver bulk water at zero tariff and two more scenarios were explored for the fully grant funded conjunctive scheme, setting the bulk potable water tariff to R3.00/m^3 and R5.00/m^3 respectively, and setting the initial irrigation water tariff at R0.30/m^3 in both cases. The results are shown in Figures 15-4 and 15-5.

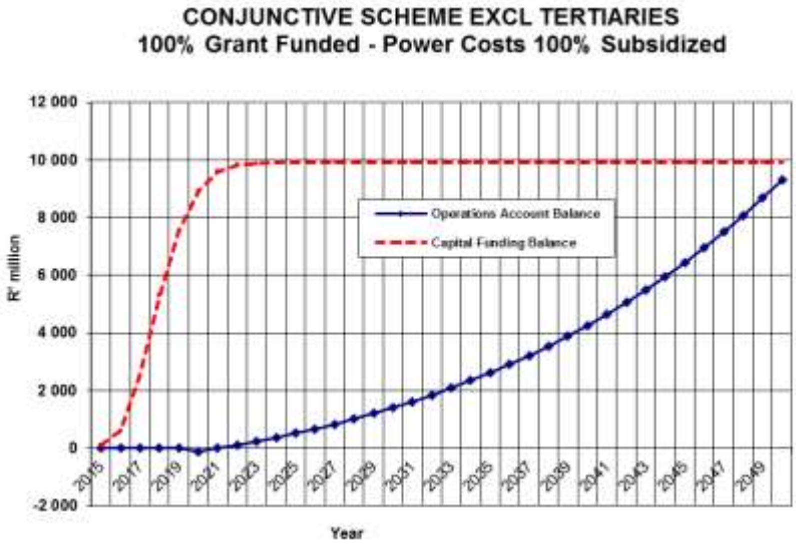


Figure 15-4: Grant Funded Conjunctive Water Supply Scheme – R3.00/m^3 initial tariff

This scenario shows that by charging an initial bulk water tariff equivalent to R3.00/m^3 for potable water and R0.30/m^3 for irrigation water, all recurring costs can be met as well as generating cash surpluses, which over the 30 year period of analysis accumulate to over R9 billion and which could be utilized to either repay the grant funding or put into other social and economic development projects in the region.

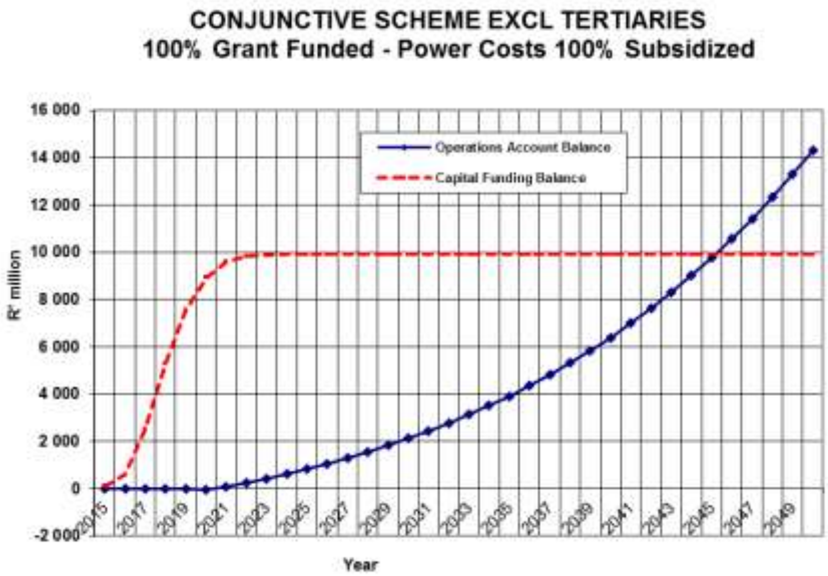


Figure 15-5: Grant Funded Conjunctive Water Supply Scheme – R5.00/m^3 initial tariff

Figure 15-5 shows that increasing the potable bulk water initial tariff to R5.00/m^3 produces even more of cash surplus per annum which would accumulate to more than R14 billion over 30 years.

Under both of these circumstances there would be many options available for the utilisation of such surplus, from the above described usage for other development projects to the simpler action of treating the grant funding as an interest free loan from Treasury, which could be repaid over a given period.

15.7.5 *Other Conjunctive Scheme Financing Options*

The options considered in this respect were as follows:

- Lalini 40% loan funded @ 9% interest p.a. with R3.00/m^3 initial tariff
- Lalini 60% loan funded @ 6% interest p.a. with R3.00/m^3 initial tariff
- Lalini 60% loan funded @ 9% interest p.a. with R5.00/m^3 initial tariff
- Lalini 100% loan funded @ 6% interest p.a. with R5.00/m^3 initial tariff
- Lalini 25% equity funded @ 15% return on investment - with R5.00/m^3 initial tariff

In all cases, it was assumed that the Ntabelanga component would be grant funded, and taking into account the subsidization of annual costs from revenue generated from energy sales by the hydropower components.

Each of these models was run and percentages of Lalini funded by loans adjusted until a stable operations account balance was maintained after meeting all other costs and debt repayment conditions.

This indicates the effect of different loan interest rates as well as the initial tariff impacts upon the size of loan that could be repaid within a reasonable period (less than 30 years).

The findings are summarized in Figures 15-6 to 15-10.

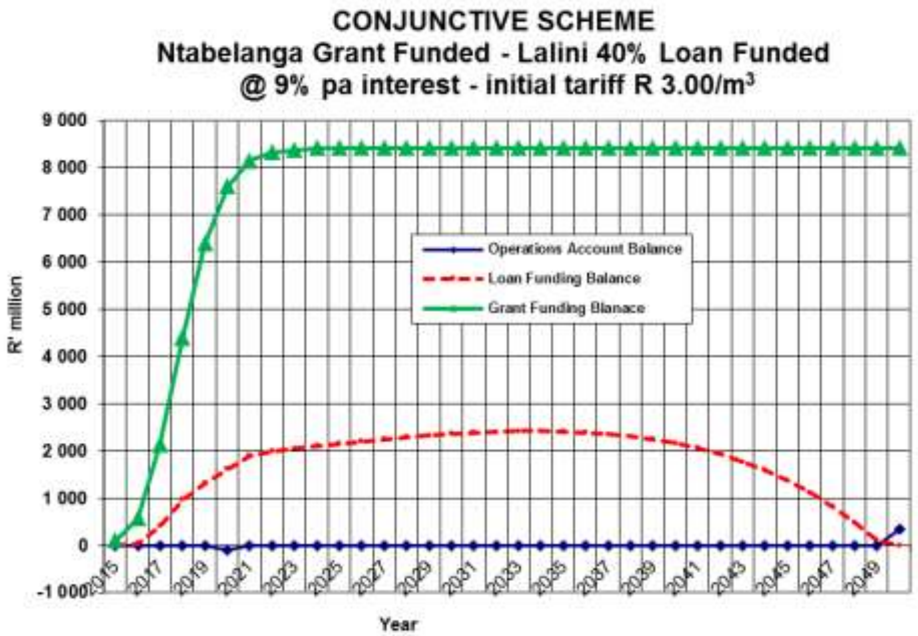


Figure 15-6: Conjunctive Scheme: Lalini 40% Loan Funded @ 9% interest: R3.00/m^3 initial tariff

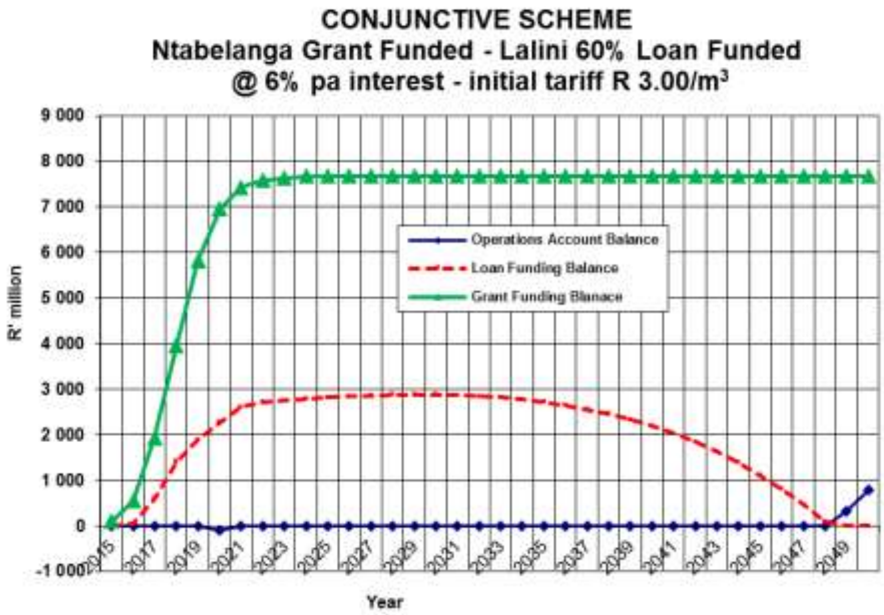


Figure 15-7: Conjunctive Scheme: Lalini 60% Loan Funded @ 6% interest: R3.00/m^3 initial tariff

In these two cases it is indicated that from a relatively low bulk water tariff of R3.00/m^3, a loan of between 40% and 60% of the Lalini component capital cost could be repaid through revenue generated, depending upon the interest terms of such a loan.

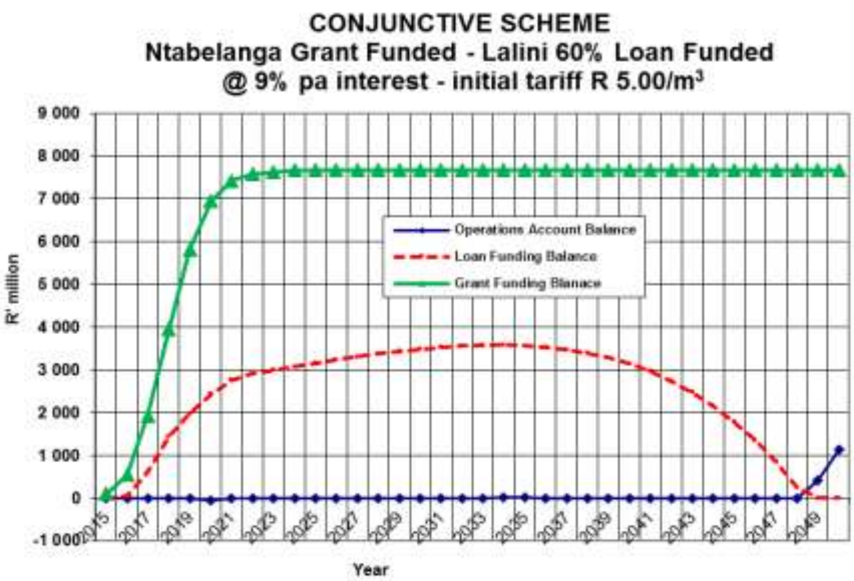


Figure 15-8: Conjunctive Scheme: Lalini 60% Loan Funded @ 9% interest: R5.00/m^3 initial tariff

For a loan of 60% of the Lalini scheme cost to be repaid at 9% interest, the initial tariff would need to be increased to R5.00/m^3.

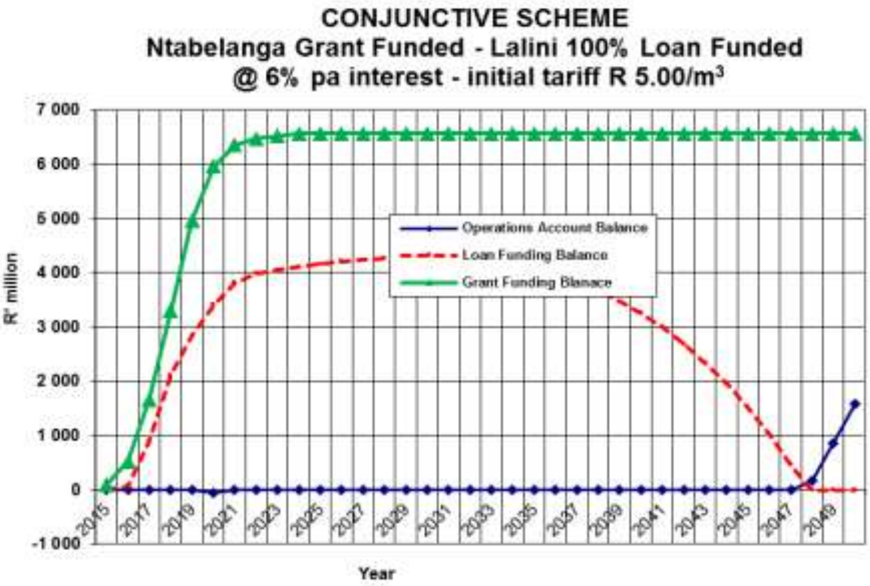


Figure 15-9: Conjunctive Scheme: Lalini 100% Loan Funded @ 6% interest: R5.00/m^3 initial tariff

For a 100% loan for the Lalini scheme cost to be repaid at 6% interest, the initial tariff would again need to be set to R5.00/m^3.

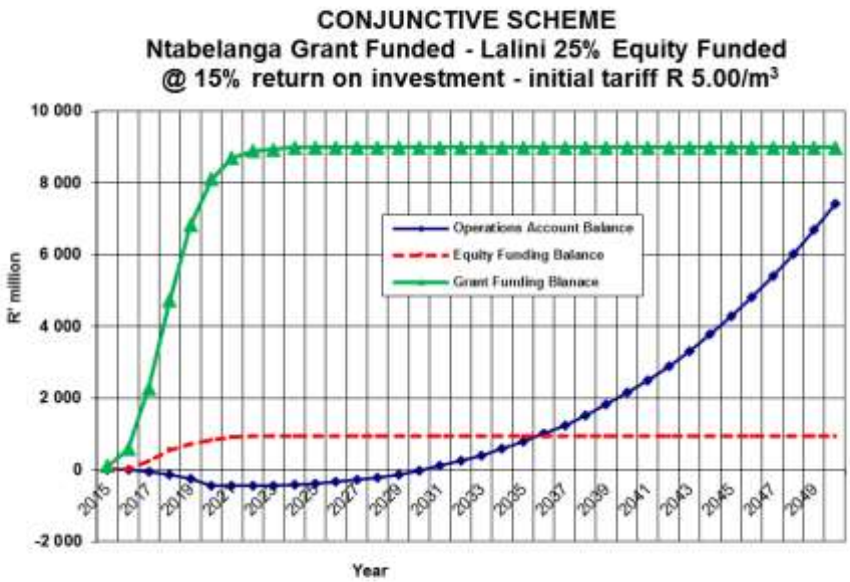


Figure 15-10: Conjunctive Scheme: Lalini 25% Equity @ 15% investment return: R5.00/m^3 initial tariff

Equity investments are another option where the principal capital is not repaid, but an annual dividend (the equity investor's expected return on investment – normally of the order of 15% p.a.) must be paid. In this case it might be attractive for such an equity investor to also be involved in the operation and maintenance aspects, and there are certain entities that specialise in such utilities management. The financial impact model for a 25% equity investment of the Lalini components of the conjunctive scheme would be viable if the initial bulk water tariff was set to R5.00/m^3.

15.8 Summary of Financing and Tariffs Analyses

In summary, the fully grant funded Ntabelanga scheme would require a high starting base for the bulk potable water tariff in order to be financially sustainable. This being of the order of R6.00/m^3 before being further transferred and distributed through a new tertiary pipeline system that would need to be implemented by the DMs. This is therefore not considered a viable solution.

The conjunctive scheme would still require significant grant funding, as is normally the case on regional water supply systems – especially where constructed in mountainous rural areas with a high proportion of indigent households.

Grant funding of the full conjunction scheme including the Lalini hydropower component would allow low bulk water tariffs to be charged (say R3.00/m^3) as well as generating cash surpluses, which over the 30 year period of analysis accumulate to over R9 billion and which could be utilized to either repay the grant funding or put into other social and economic development projects in the region.

If Amatola Water were to become the operator of the conjunctive scheme, this could radically improve their economies of scale which could also have the impact of reducing the overall average cost of bulk water to all of their other customers as well, which would widen the benefits to a larger area than just the Ntabelanga-Lalini region.

If it is considered necessary to reduce the amount of grant funding of the project through the sourcing of loans or equity investments, then there is also potential for this to happen at the same time as keeping the required bulk potable and irrigation water tariffs to a financially viable and sustainable level.

However, the financial burdens imposed upon the scheme due to the need to repay loans, interest, and or equity shareholders dividends, would absorb the potential surplus revenue that could otherwise be used to repay grants and/or to spend on further social upliftment and economic development programmes in this area.

15.9 Conclusion

Given the above results, there is a business case for the implementation of a conjunctive integrated multi-purpose scheme incorporating potable water supply, irrigated agriculture, and hydropower under a single, ring-fenced institutional entity.

This concept has been discussed at several forums including the Project Steering Committee meetings, the Wildcoast Integrated Development Forum, and at the Eastern Cape Socio Economic Consultative Council (ECSECC), who have been tasked with stewardship of the implementation of this project on behalf of the Provincial Government.

A recent critical review of the above study findings was also undertaken by Mr Mike Muller on behalf of ECSECC, who came to similar conclusions.

16. LEGAL, INSTITUTIONAL AND FINANCING ARRANGEMENTS

16.1 Overview

This section summarises the Legal, Institutional and Financing Arrangements of the scheme which is described in detail in Report No. P WMA 12/T30/00/5212/16.

The report documents existing institutional arrangements within the region that have an interest and/or role on the project. This includes institutions inter alia:

- Department Water and Sanitation;
- Department of Agriculture, Forestry and Fisheries;
- Department of Local Government and Traditional Affairs;
- Department of Mineral Resources;
- Department of Rural Development and Agrarian Reform
- Department of Land Affairs
- Department Economic Development, Environmental Affairs and Tourism;
- Provincial Government;
- Local and District Authorities;
- Tribal Authority for the project area.
- Water Boards;
- ESKOM;
- Local Agricultural Societies or Associations; and
- Chamber of Commerce and representatives from Industry;

It is expected that the above organisations would be involved in the project implementation at various levels.

The development of a legal, administrative and financial model was investigated detailing potential responsibilities and ownership options. This was achieved through the assessment and development of the following aspects of the project during Phase 2 of the feasibility study:

- Review legislative impacts on various dam options;
- Assess and advise on legal issues during the planning process with specific focus on:
    - Social impact,
    - HDI impact,
    - Land ownership and occupation, and
    - Environmental impact.
- Develop an implementation plan to ensure legislative compliance;
- Determine Capital and Operational Expenditure (CAPEX and OPEX) costs and develop a financial model
- Investigate alternative funding options for CAPEX;
- Project implementation cash flow analysis; and
- Develop institutional model and staffing organogram for operations phase.

16.2 Key Findings

16.2.1 Legislative Context

The legislative context of the project is very important in the planning processes for this project, and needs to be the basis from which all recommendations on plans, construction, and operation are based.

Due to the multi-purpose nature of the project, it is important to consider the following broader issues:

- water quality and quantity;
- water resources and services institutional considerations;
- environmental regulations;
- energy and more specifically hydropower; and
- land matters.

The legal documents that need to be consulted are:

- Constitution of South Africa (1996)
- National Water Act (NWA) (1998)
- Water Services Act (1997)
- National Water Resources Management Strategy (NWRMS) (2013)
- National Water Policy Review (NWPR) (2013)
- Draft Raw Water Pricing Strategy (2013)
- Infrastructure Bill (IB) (2013)
- National Environmental Management Act (NEMA) (1998);
- National Heritage Resources Act (1999)
- National Forests Act (1998)
- National Environmental Management: Biodiversity Act (2004)
- Expropriation Act (2008)
- National Investment Bill (2014)
- Electricity Regulation Act, DME 2006 (as amended)
- National Energy Act, DME 2008
- Electricity Regulation Act: Electricity Regulations for Compulsory Norms and Standards for Reticulation Services (GN 773), DME 2008
- Electricity Regulations on the Integrated Resource Plan 2010-2030, DoE 2011
- Extension of Securities of Tenure Act (1997)

The Mzimvubu Water Project is a Strategic Integrated Project (SIP) which is viewed as having “significant economic or social importance”. As such, it is subject to the Infrastructure Development Bill B49 of 2013, which provides for special processes in order to ensure fast-tracked approvals. This Infrastructure Bill must be carefully read in conjunction with the other legislation to ascertain the impact it may have on the project.

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 Department of Agriculture Forestry and Fisheries (DAFF) and the Provincial Department of Rural Development and Agrarian Reform (DRDAR) will need to play key roles in this process.

16.2.2 *Institutional Arrangements*

The regulatory and management demands for multipurpose dams are more complex than single purpose projects due to the conflicts of interest amongst the individual users. Consequently, inter- and cross-sectoral co-ordination demands are high, and require strong institutional capacity (refer to http://agriwaterpedia.info).

Food, water and energy nexus considerations need to be on the agenda from the very start of the project. The success and sustainability of the recommended schemes are heavily reliant on the establishment of the most appropriate institutional arrangement for 1) the management and operation of the entire infrastructure, and 2) the management of the social and economic development directly and indirectly related to the project.

These relationships, however should not be developed only once the infrastructure is built, but should be cultivated, and where possible, formalised as soon as possible. It is vital that there is a strong group of champions driving decision making that carefully considers all the stakeholders from the start if this multipurpose dam project is to be successful in the long term.

16.2.3 *Financing Arrangements*

As is the case with most rural potable water supply schemes in Africa, which have high indigent populations with very low incomes, grant funding of the capital costs of the infrastructure is required. The revenue from water sales and from the equitable share usually only being sufficient to meet operation and maintenance costs, recurrent plant replacement costs, and energy costs (predominantly for pumping).

This is again the case for the potable water supply scheme supplied by the Ntabelanga Dam and water treatment works. As shown in Table 15-2, at a 8% discount rate, and for the grant-funded option, the Unit Reference Value (URV) of potable water supplied to each settlement is R2.96/m^3, which, whilst not a direct indicator of required tariff charges is still relatively high as an indicator when considering indigent customers.

It should be noted that, within this R2.96/m^3 URV, some R1.15/m^3, or 38%, is attributable to the cost of energy consumed by the scheme. Subsidization of this energy cost through the addition of a hydropower component would therefore bring down the URV of potable water supplied to the settlements to R2.19/m^3 which is more viable and sustainable.

For the raw water supplied to the potential irrigation schemes near Tsolo, the same situation is found.

Even with full grant funding of the bulk raw water delivery system to edge of field, the unit cost of water supplied is some R0.48/m^3, and in real financial terms, the cost required to meet energy and operation and maintenance costs could be as high as R1.14/m^3.

A cost of between R0.25/m^3 to R0.40/m^3 for bulk raw water supplied is considered to be the maximum desirable/viable to generate sufficient gross margin prospects to encourage investment into the proposed irrigated agriculture farming units.

Of this cost, a significant portion is the energy cost required to lift the raw water from the source to the edge of fields. Again, subsidisation of this energy cost through the addition of a hydropower component could therefore bring down the cost of raw water supplied to the farming units to less than R0.40/m^3 which is far more viable and sustainable.

Hydropower has much higher income prospects than water supply, and there are several financing options discussed for the additional hydropower infrastructure required. Whilst the fully grant funded option obviously shows the highest cross-subsidization and grant redemption potential, mixed grant and loan options could also be viable. Funding models such as were used on the Berg River project should also be considered. Much will depend upon the credit rating of the SPV/implementing agency, and the selection of the institutional model will be key to obtaining such a high credit rating to obtain favourable loan terms and conditions.

The financing models undertaken in this study indicate that most of the infrastructure would need to be grant funded in order to deliver a sustainable project able to produce water at an affordable and economically viable tariff. For the Lalini dam and hydropower component, it is estimated that financing of the infrastructure through repayable loans over 20 years would not be viable if such loans were to constitute more than 25% of the total capital requirement. This situation might improve if longer tenor loans can be secured by Government, but even this is unlikely to sustain significantly higher percentages of capital requirements taken as loans.

There are significant differences between implementing only the Ntabelanga scheme and implementing the conjunctive Ntabelanga - Lalini scheme.

The fully grant-funded Ntabelanga only scheme would require a high starting base for the bulk potable water tariff in order to be financially sustainable. This being of the order of R6.00/m^3 before being further transferred and distributed through a new tertiary pipeline system that would need to be implemented by the DMs. This is not likely to be sustainable to the operator nor affordable to the consumer, and is therefore not considered a viable solution.

16.3 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 inter-posing 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 overall scheme components design, construction and operation should be linked and be managed by a special purpose implementing agency such as the Trans Caledon Tunnel Authority (TCTA) or a new Regional Water Utility (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 Water Services Authorities (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.

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

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 Trans Caledon Tunnel Authority (TCTA), who have been mandated with this role under the Strategic Integrated Project (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. It is through this organization that such Provincial co-ordination might best be channelled during the project 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 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 Regional Water Utility (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.

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, where the Provincial Department of Rural Development and Agrarian Reform (DRDAR) will again need to play a key role

The recommended institutional model and the proposed institutional roles, responsibilities and financial flow diagram in Figures 16-1 and 16-2 assume 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.

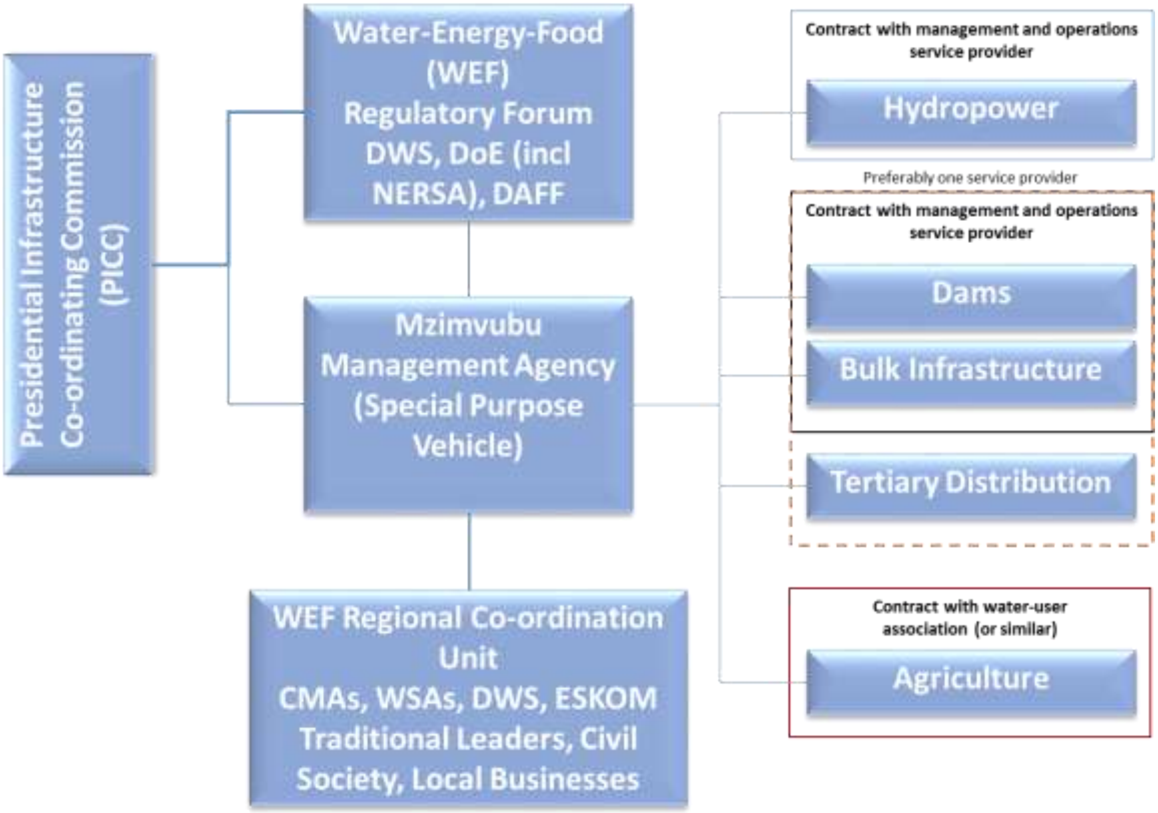


Figure 16-1: Recommended Institutional Model

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 that the project 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 service 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 service provider (e.g. Amatola Water) would operate the dams, water treatment works and bulk water distribution system. It is also feasible that the same service provider could operate and maintain the tertiary lines on behalf of the District Municipalities. Ideally, the hydropower component should also fall under the same service provider, so that the revenue from both energy and water sales can be ring-fenced for cross–subsidization purposes.

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 more than covered through the sales of potable and raw water as well as income generated from the energy sold into the ESKOM grid. However, even though there is this possibility for cross-subsidisation, the institutional and financing model must be flexible to allow the imposition of tariffs on both potable and raw water consumers.

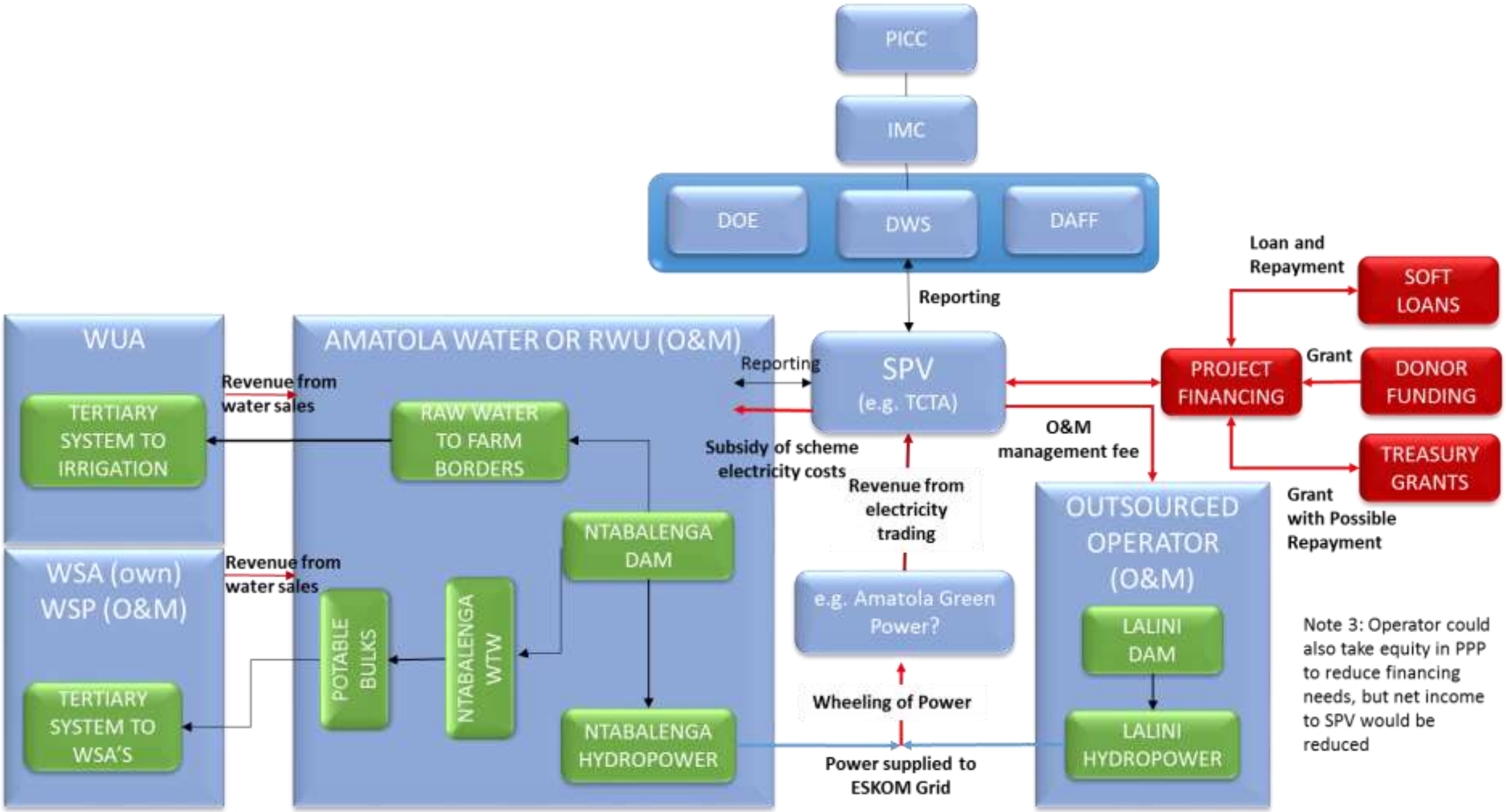
The TCTA is an already established organization that specializes in these functions and would be a clear front-runner in the choice of an SPV company.

It is proposed that Amatola Green Power (or other buyer of the energy) would purchase the power generated by the two hydropower schemes, and all the income from these sales will be paid to the SPV. ESKOM would invoice all energy costs for the entire project to the SPV (and not the water supply scheme operators).

Apart from its own operational costs, the SPV would also appoint an outsourced hydropower scheme operator to operate and maintain the Lalini hydropower scheme, which costs would also be borne by the SPV from its net surplus energy income.

The Lalini power production operator 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.



Note 1: Regional Water Utility (RWU) could eventually include tertiary systems to customers

Note 2: Hydropower operation could also be undertaken in-house by main scheme operator

Figure 16-2: Institutional Roles and Responsibilities and Financial Flow Diagram

As is shown on the economic and financial modelling the degree of capital grant funding required will mostly depend upon the affordability 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 schemes 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). They would also 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 the interests of these new farmers, and the farmers 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, but there is a risk that 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 as commercial farming, or would take much longer to come to the commissioning stage.

Should this happen, in addition to lowering the job creation potential and regional economic development, a further downside would be that the water supply operator would not receive the expected revenue from these bulk raw water supply sales.

The above risks must be realized and taken into consideration from the outset of the implementation of the scheme as they have very significant economic, social and financial cost implications for the whole project.

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.

16.4 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 DWS or a co-ordination, planning and management entity appointed by the DWS 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:

a) Appointment of a DWS Project Manager to oversee the implementation;
b) Appointment of an Implementing Agent/SPV to co-ordinate, plan and manage the integrated scheme components;
c) Obtaining of Environmental Authorization;
d) Approval and implementation of the EMPR for the works to be constructed, and appointment of service providers to manage and monitor these processes;
e) Development and implementation of the Relocation Action Plan based upon the Relocation Policy Framework prepared during the EIA process;
f) Discussions with Amatola Green Power for the sale of power produced by the Ntabelanga and Lalini hydropower schemes;
g) Applications to ESKOM for power supplies to the works;
h) Application to DoE and ESKOM to establish a “wheeling” arrangement to sell power into the local grid;
i) Discussions and agreement with Amatola Water and the three affected DMs regarding future institutional arrangements for the ownership, funding, operation and management of the water supplies sourced from the Ntabelanga Dam;
j) Additional geotechnical investigations to inform the design of the Ntabelanga Dam, the Lalini Dam, the other associated capital works, and hydropower components;
k) Detailed design and tender documents of Ntabelanga Dam and appurtenant works;
l) Detailed design and tender documents of the Ntabelanga water treatment works, primary and secondary potable water distribution systems, and bulk raw water distribution system;
m) Detailed design and tender documents of other works including access roads, bridges, staff accommodation and services, gauging stations, etc;
n) Detailed design and tender documents of Lalini Dam and appurtenant hydropower works;
o) Detailed design of on-farm developments
p) Appointment of a facilitation unit to manage the consultation and implementation process for land reform and irrigation development;
q) Further studies to investigate potential tourism and aquaculture spinoffs from the scheme;
r) 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 ;
s) Procurement and appointment of contractors to construct the capital works – several different contracts; and
t) 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.

17. REFERENCES

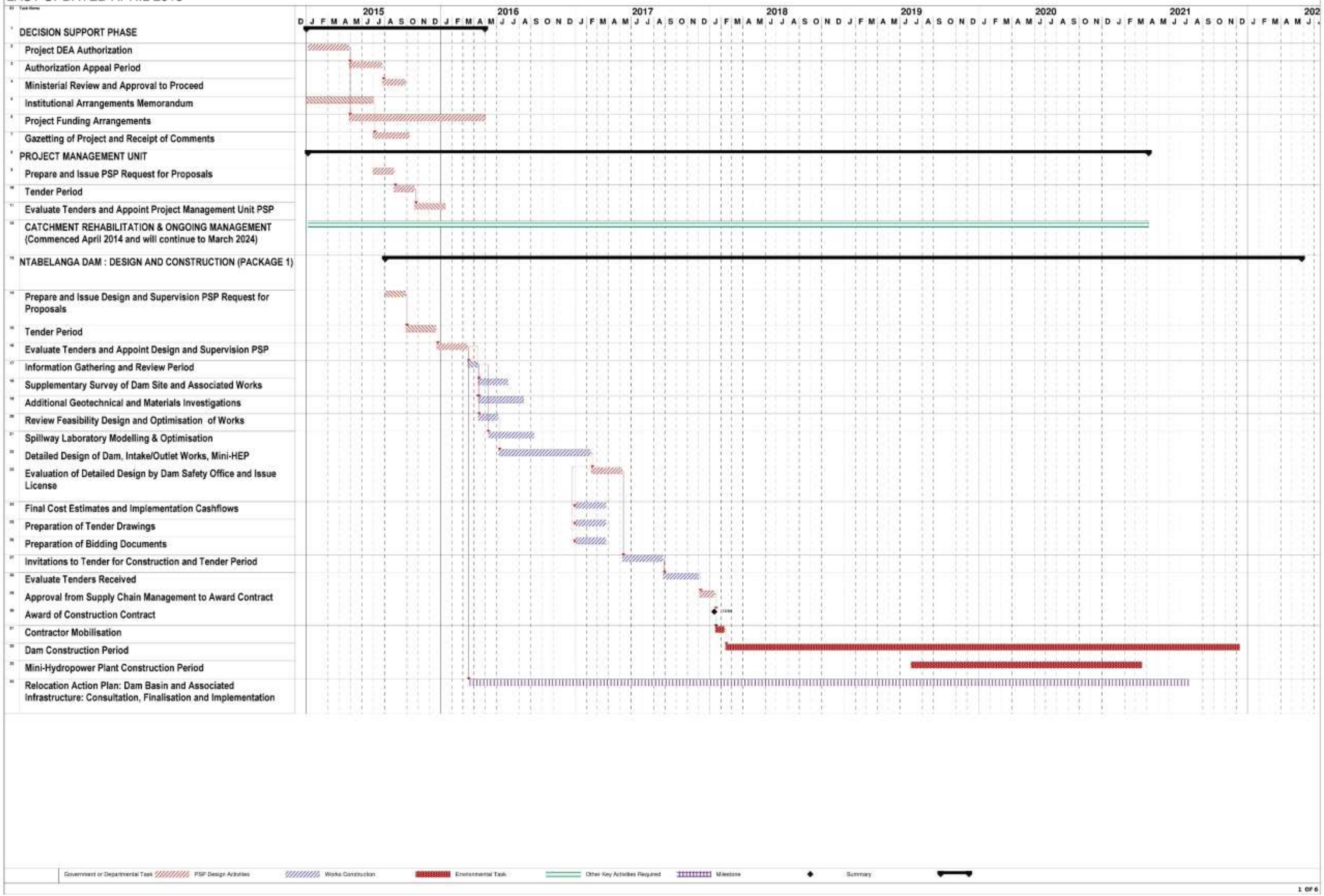
This report is a summarized compilation from the other study reports listed at the beginning of this document.

Specific references are listed in the individual reports.

APPENDIX A

PROJECT IMPLEMENTATION PROGRAMME

MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED APRIL 2015



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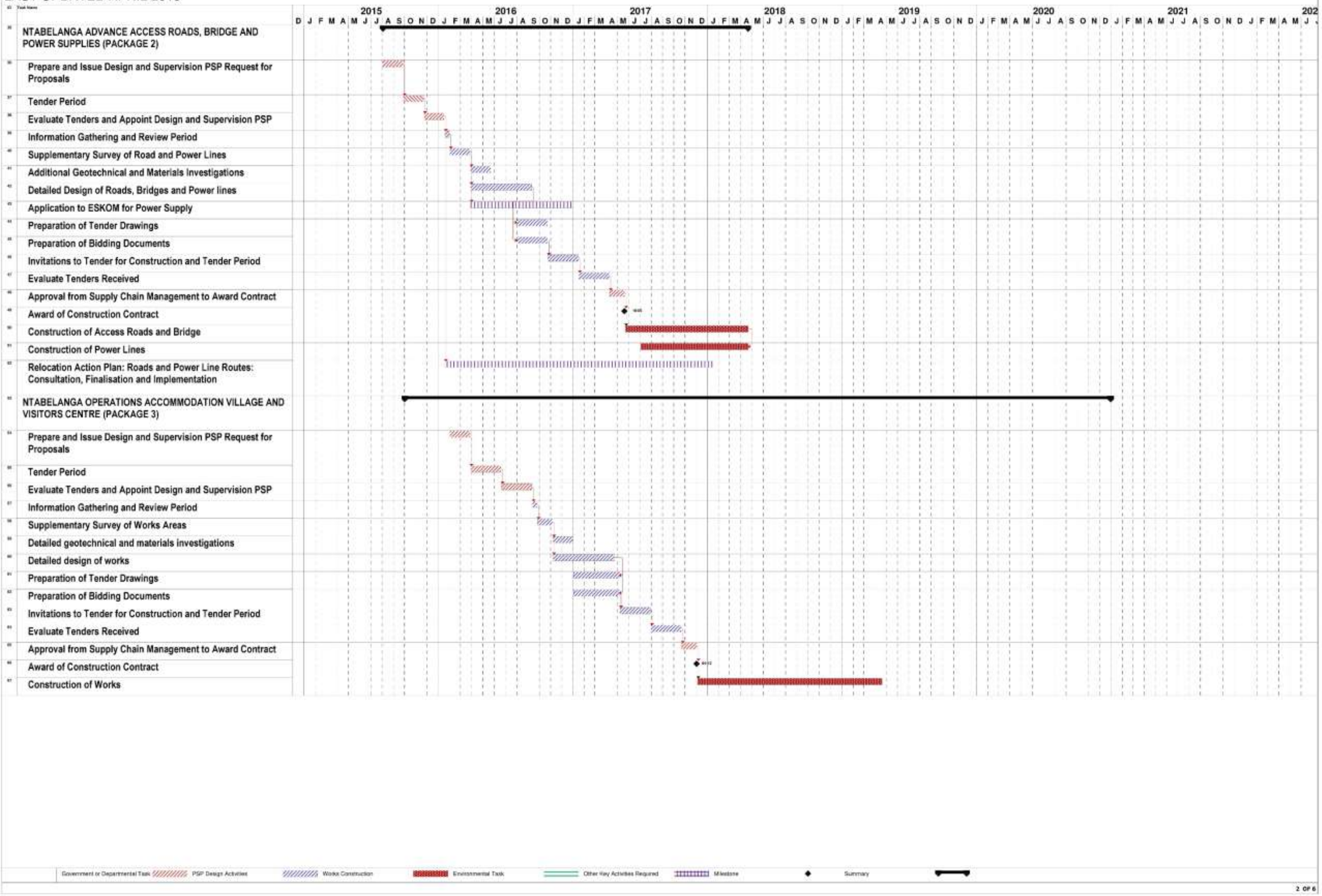
LAST UPDATED APRIL 2015



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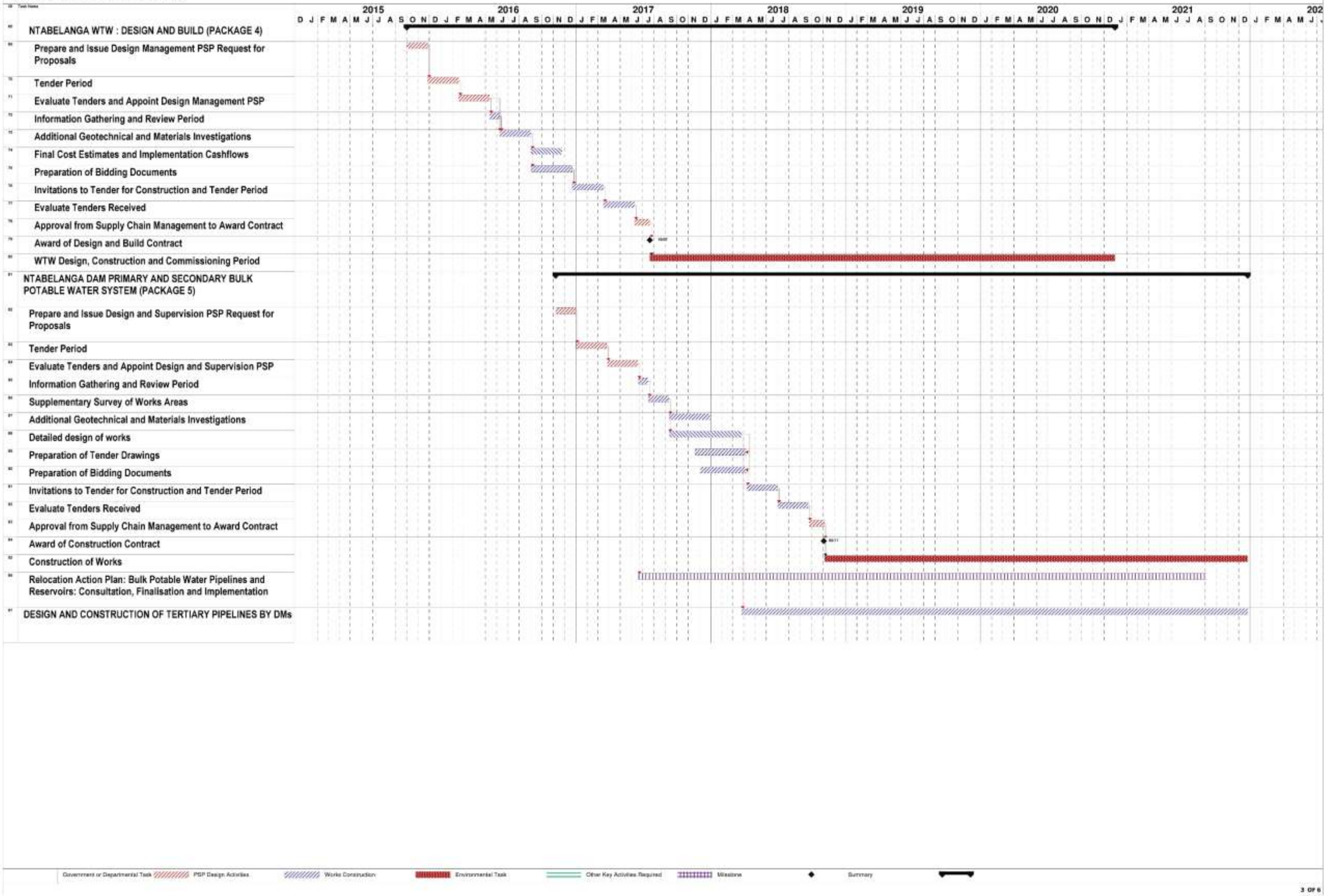

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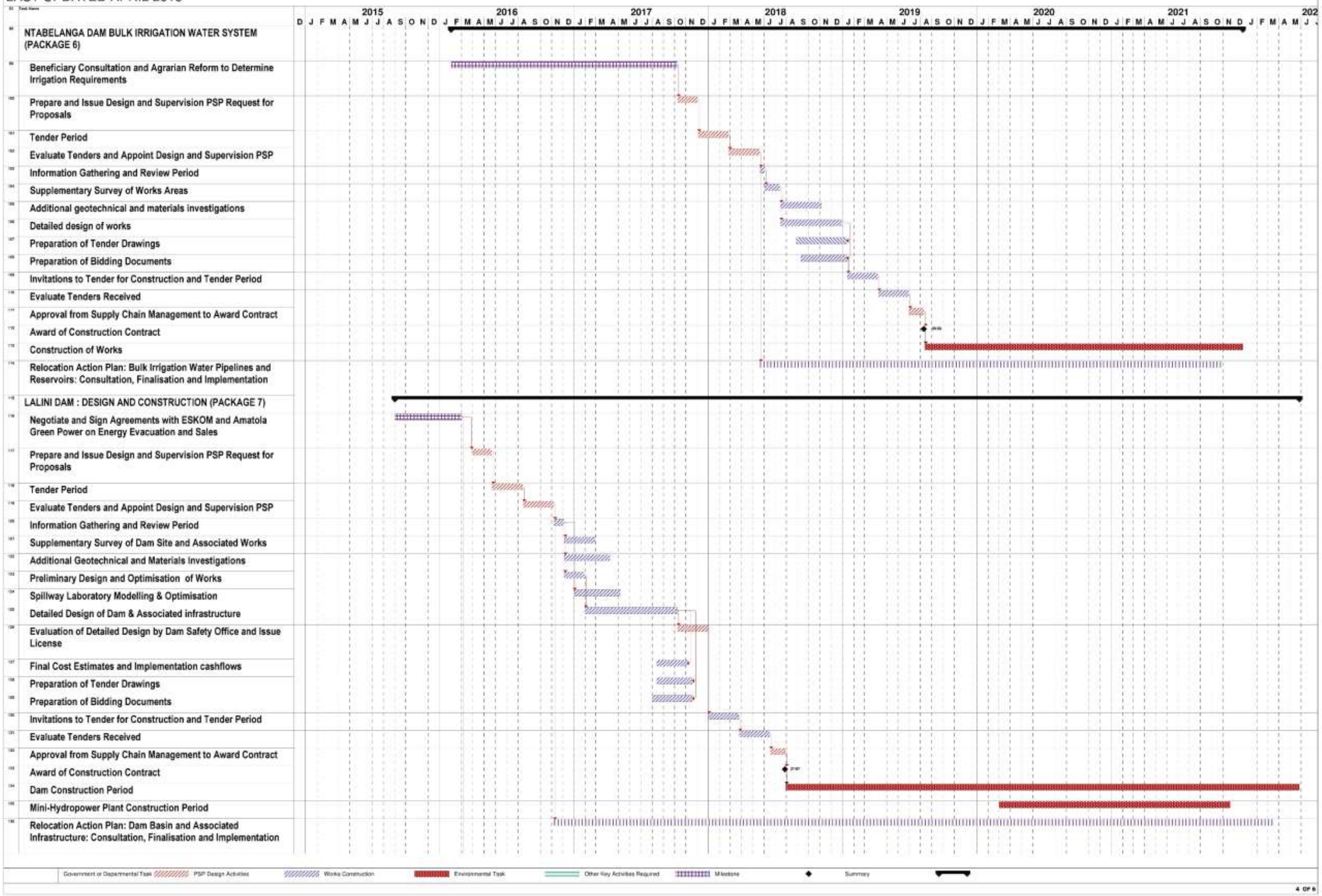

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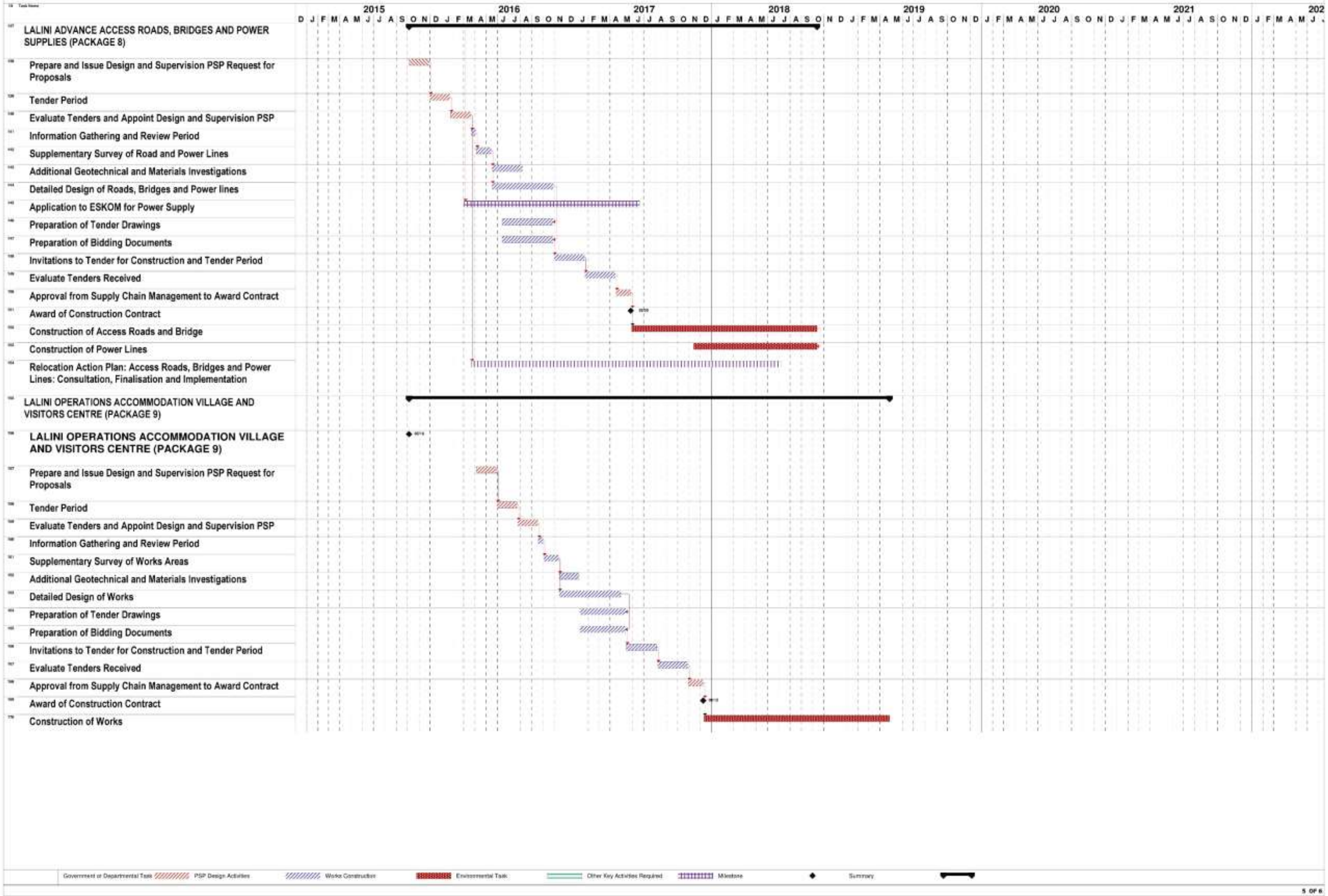

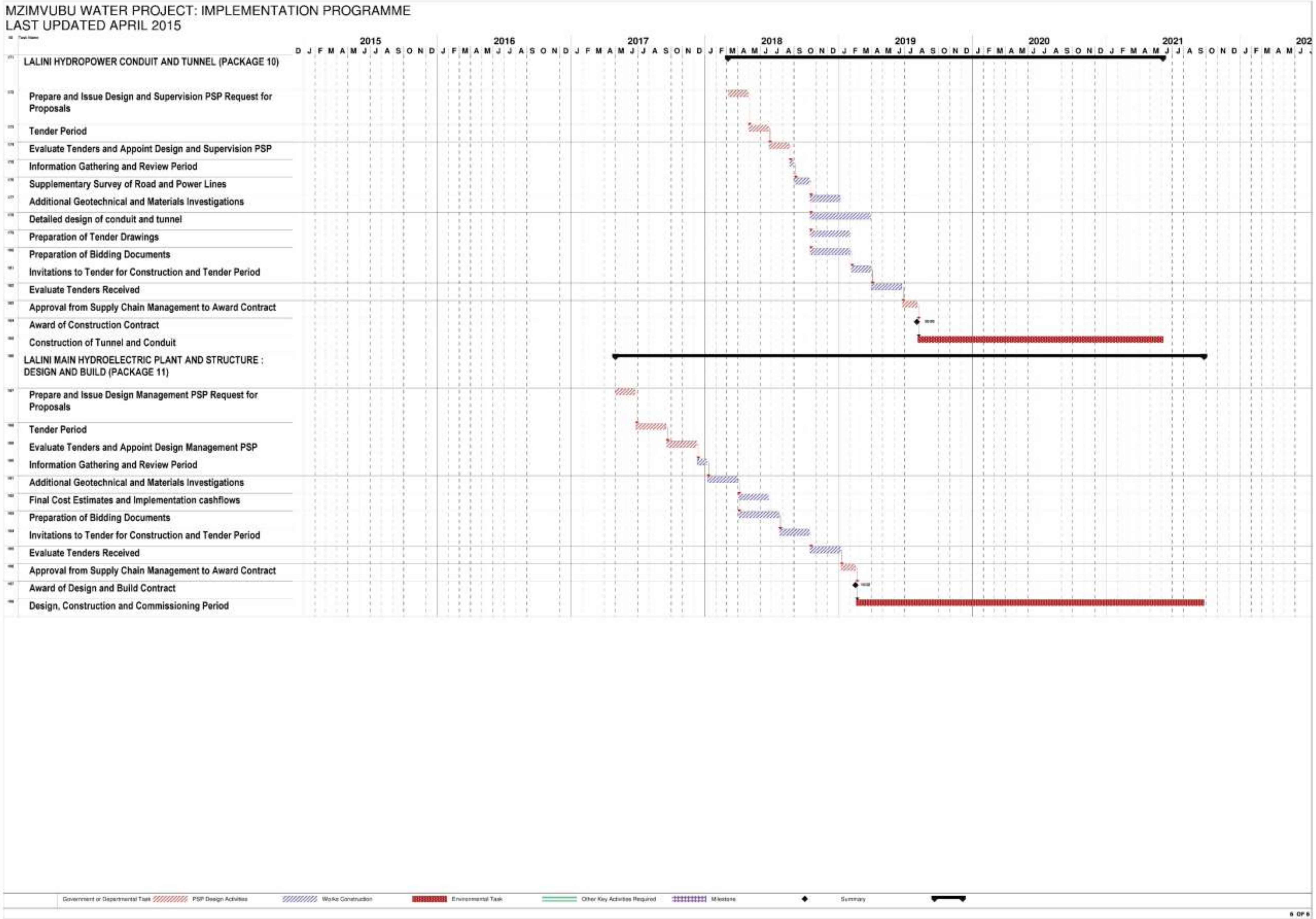
MZIMVUBU WATER PROJECT: IMPLEMENTATION PROGRAMME
LAST UPDATED APRIL 2015
2015
2016
2017
2018
2019
2020
2021
LALINI HYDROPOWER CONDUIT AND TUNNEL (PACKAGE 10)
Prepare and Issue Design and Supervision PSP Request for Proposals
Tender Period
Evaluate Tenders and Appoint Design and Supervision PSP
Information Gathering and Review Period
Supplementary Survey of Road and Power Lines
Additional Geotechnical and Materials Investigations
Detailed design of conduit and tunnel
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 Tunnel and Conduit
LALINI MAIN HYDROELECTRIC PLANT AND STRUCTURE : DESIGN AND BUILD (PACKAGE 11)
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
Design, Construction and Commissioning Period
Government or Departmental Task
PSP Design Activities
Works Construction
Environmental Task
Other Key Activities Required
Milestone
Summary
6 OF 6