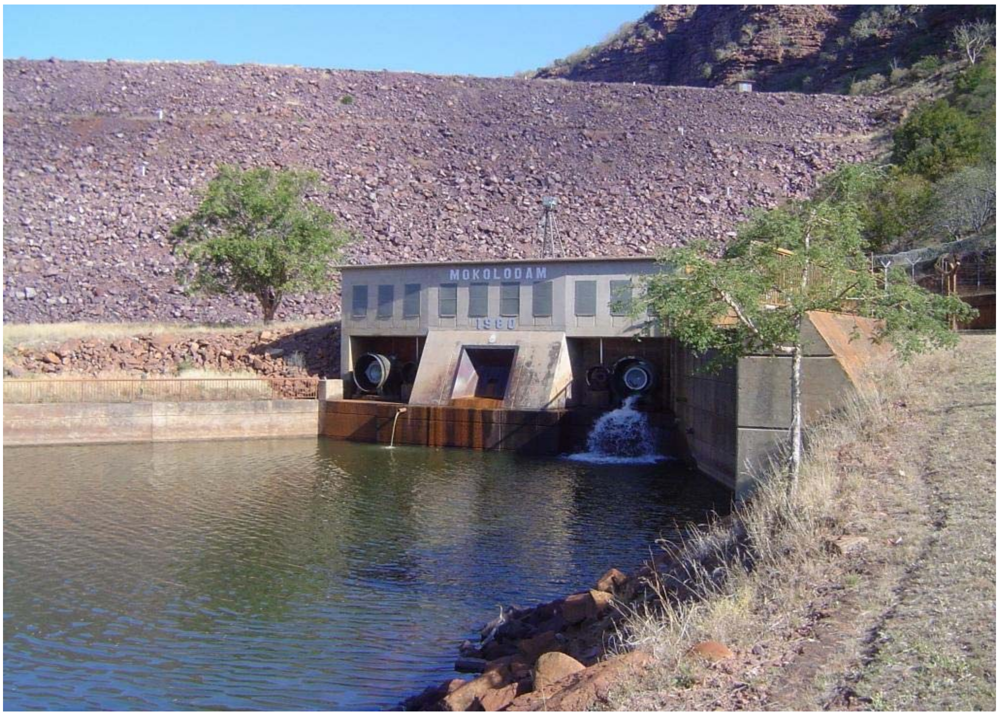
REPORT NUMBER: P RSA A000/00/9209

Department of Water Affairs

Chief Directorate: Integrated Water Resource Planning
Directorate: Options Analysis

MOKOLO AND CROCODILE (WEST) WATER AUGMENTATION PROJECT (MCWAP) FEASIBILITY STUDY: TECHNICAL MODULE

Project No. WP9528



SUPPORTING REPORT No5
MOKOLO RIVER DEVELOPMENT OPTIONS
PRE-FEASIBILITY STAGE

October 2009

Lead Consultant: Africon

In association with: KV3, VELAVKE

LIST OF REPORTS

REPORT NO	DESCRIPTION	REPORT NAME
FEASIBILITY STAGE		
P RSA A000/00/8109	Main Report	MCWAP FEASIBILITY STUDY TECHNICAL MODULE SUMMARY REPORT
P RSA A000/00/8409	Supporting Report 8A	GEOTECHNICAL INVESTIGATIONS PHASE 1
P RSA A000/00/8709	Supporting Report 8B	GEOTECHNICAL INVESTIGATIONS PHASE 2
P RSA A000/008509	Supporting Report 9	TOPOGRAPHICAL SURVEYS
P RSA A000/00/8609	Supporting Report 10	REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER
P RSA A000/00/8209	Supporting Report 11	PHASE 1 FEASIBILITY STAGE
P RSA A000/00/8309	Supporting Report 12	PHASE 2 FEASIBILITY STAGE
PRE-FEASIBILITY STAGE		
P RSA A000/00/8809	Supporting Report 1	WATER REQUIREMENTS
P RSA A000/00/8909	Supporting Report 2	WATER RESOURCES
P RSA A000/00/9009	Supporting Report 3	GUIDELINES FOR PRELIMINARY SIZING, COSTING AND ECONOMIC EVALUATION OF DEVELOPMENT OPTIONS
P RSA A000/00/9109	Supporting Report 4	DAMS, ABSTRACTION WEIRS AND RIVER WORKS
P RSA A000/00/9209	**Supporting Report 5**	**MOKOLO RIVER DEVELOPMENT OPTIONS**
P RSA A000/00/9309	Supporting Report 6	WATER TRANSFER SCHEME OPTIONS
P RSA A000/00/9409	Supporting Report 7	SOCIAL AND ENVIRONMENTAL SCREENING
INCEPTION STAGE		
P RSA A000/00/9609	Inception	INCEPTION REPORT

REFERENCE

This report is to be referred to in bibliographies as:

Department: Water Affairs, South Africa, 2008. Mokolo Crocodile (West) Water Augmentation Project (MCWAP) Pre-Feasibility Study. Mokolo River Development Options. Prepared by Africon in association with Kwezi V3 Engineers, Vela VKE, WRP Consulting Engineers and specialists.

DWAF Report No. **P RSA A000/00/9209**

REPORT DETAILS PAGE

Project name:	***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)***
Report Title:	***Pre-Feasibility Study Report 5 - Mokolo River Development Options***
Author:	***JH vd Mescht (KV3)***
DWA report reference no.:	***P RSA A000/00/9209***
PSP project reference no.:	***WP 9528***
Status of report:	***Final***
First issue:	***December 2008***
Final issue:	***October 2009***

PSP

Approved for PSP by:

J Pienaar
Study Leader

PROJECT CO-ORDINATION AND MANAGEMENT TEAM
Approved for Project Coordinator by:

SC Vogel
Project Coordinator & Manager

DEPARTMENT OF WATER AFFAIRS (DWA)
Approved for Chief Directorate: Integrated Water Resources Planning by:

OJS van den Berg
Chief Engineer: Options Analysis North

LS Mabuda
Acting Chief Director: Integrated Water Resources Planning

PREFACE

The Mokolo (Mogol) River catchment is part of the Limpopo Water Management Area (WMA). The Mokolo River originates close to Modimolle (Nylstroom) and then drains to the north into the Limpopo River. The Mokolo Dam (formerly known as the Hans Strijdom Dam) is the largest dam in the catchment. The dam was constructed in the late 1970s and completed in July 1980, to supply water to Matimba Power Station, Grootegeluk Mine, Lephalale (Ellisras) Municipality and for irrigation downstream of the dam. Based on the water infrastructure, the current water availability and water use allows only limited spare yield existing for future allocations for the anticipated surge in economic development in the area.

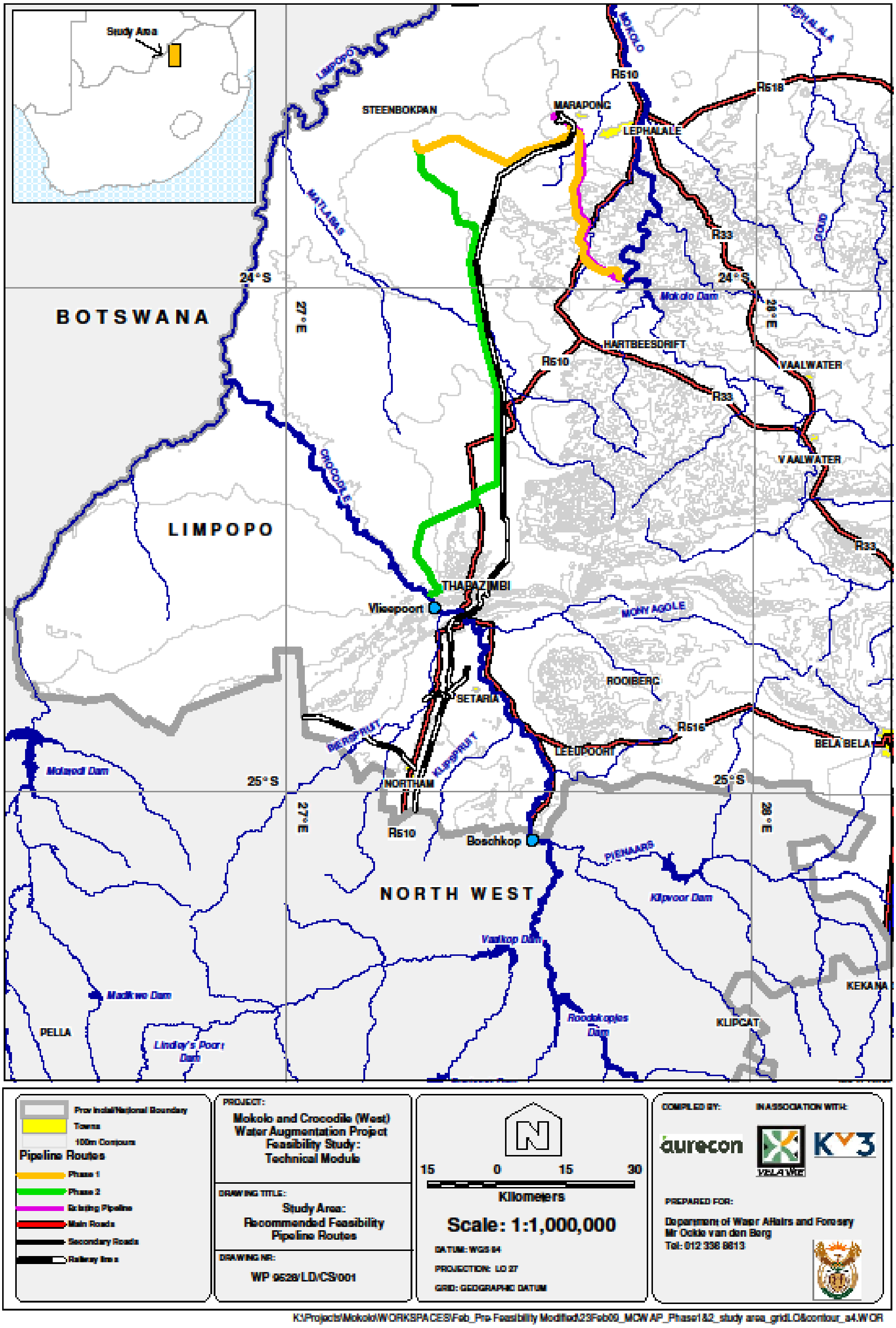
There are a number of planned and anticipated consequential developments in the Lephalale area associated with the rich coal reserves in the Waterberg coal field for which additional water will be required. These developments include inter alia the development of further power stations by Eskom, the potential development of coal to liquid fuel facilities by Sasol and the associated growth in mining activities and residential development.

The development of new power stations is of high strategic importance with tight timeframes. Commissioning of the first generation unit will start in September 2010 and additional water needs to be available by mid-2011 according to the expected water requirements. A solution addressing the water needs of the Lephalale area must be pursued. The options to augment existing water supplies include transferring surplus effluent return flows from the Crocodile River (West) / Marico WMA to Lephalale and the area around Steenbokpan shown on the map indicating the study area on the following page.

The Department of Water Affairs and Forestry commissioned the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) to analyse the options for transferring water from the Crocodile River (West). In April 2008, the Technical Module of this study was awarded to Africon in association with Kwezi V3, Vela VKE and specialists. The focus of the Technical Module is to investigate the feasibility of options to:

- Phase 1: Augment the supply from Mokolo Dam to supply in the growing water requirement for the interim period until a transfer pipeline from the Crocodile River (West) can be implemented. The solution must over the long term, optimally utilise the full yield from Mokolo Dam.
- Phase 2: Transfer water from the Crocodile River (West) to the Lephalale area. Options to phase the capacity of the transfer pipeline (Phase 2A and 2B) must be investigated.

The Technical Module has been programmed to be executed at a Pre-feasibility level of investigation to identify different options and recommend the preferred schemes, which was followed by a Feasibility level investigation of the preferred water schemes. Recommendation on the preferred options for Phase 1 and Phase 2 Schemes were presented to DWA during October 2008 and draft reports were submitted during December 2008. Feasibility Stage of the project commenced in January 2009 and considered numerous water requirement scenarios, project phasing and optimisation of pipeline routes. The study team submitted draft Feasibility report during October 2009 to the MCWAP Main Report in November 2009. This report (Report 5 – Mokolo River Development Options Pre-Feasibility Stage P RSA A000/00/9209) covers the options that were investigated at pre-feasibility level for Phase 1 infrastructure.


Study Area
STEENBOKPAN
MARAPONG
LEPHALALE
R510
R518
R33
24° S
25° S
27° E
28° E
BOTSWANA
LIMPOPO
NORTH WEST
Mokolo Dam
HARTBEESDRIFT
VAALWATER
THABAZIMBI
Vliespoort
ROOIBERG
SETARIA
LEEUPOORT
BELA BELA
R516
NORTHAM
Boschkop
Molatedi Dam
Klipvoor Dam
Vaalkop Dam
Madikwe Dam
PELLA
Lindley's Poort Dam
Roodekopjes Dam
KLIPGAT
KEKANA
CROCODILE
MATLABAS
MOKOLO
PIENAARS
MOHYAGOLE
Provincial/National Boundary
Towns
100m Contours
Pipeline Routes
Phase 1
Phase 2
Existing Pipeline
Main Roads
Secondary Roads
Railway lines
PROJECT:
Mokolo and Crocodile (West) Water Augmentation Project Feasibility Study: Technical Module
DRAWING TITLE:
Study Area: Recommended Feasibility Pipeline Routes
DRAWING NR:
WP 9528/LD/CS/001
15 0 15 30
Kilometers
Scale: 1:1,000,000
DATUM: WGS 84
PROJECTION: LO 27
GRID: GEOGRAPHIC DATUM
COMPILED BY:
IN ASSOCIATION WITH:
aurecon
VELA VKE
KV3
PREPARED FOR:
Department of Water Affairs and Forestry
Mr Ockie van den Berg
Tel: 012 336 8813
K:\Projects\Mokolo\WORKSPACES\Feb_Pre Feasibility Modified\23Feb09_MCWAP_Phase1&2_study area_gridLO&contour_a4.WOR

LIST OF ABBREVIATION & ACRONYMS

a	Annum
AAD	Average Annual Demand
CTL	Coal-to-Liquid Fuel
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
FBC	Fluidised Bed Combustion
FGD	Flue Gas Desulphurisation
FSL	Full Supply Level
ha	Hectare
MCWAP	Mokolo and Crocodile River (West) Water Augmentation Project
O&M	Operation and Maintenance
P&G	Preliminary and General
PMF	Probable Maximum Flood
PSP	Professional Service Provider
PV	Present Value
ToR	Terms of Reference
URV	Unit Reference Value
WMA	Water Management Area

MOKOLO AND CROCODILE (WEST) WATER AUGMENTATION PROJECT FEASIBILITY STUDY: MOKOLO RIVER DEVELOPMENT OPTIONS PRE-FEASIBILITY STAGE

EXECUTIVE SUMMARY

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long term industrial, commercial and domestic use.

The purpose of this report is to investigate the most feasible and timely solution at pre-feasibility level to augment the water supply to Lephalale and Steenbokpan areas as a first phase while the main transfer scheme from the Crocodile River is implemented. This report also servers to stress the fact that it would possibly not be achievable to implement the full Phase 1 before September 2010.

It should be noted that the route of the pipeline and position of water supply points in this report do not take into account the changes as discussed at the Technical Meeting held on 30 October 2008. The changes proposed at this meeting entails moving the pipeline route to Steenbokpan south of the Eensaamheid coal fault line and will be incorporated in the Feasibility Stage.

Two water requirement scenarios have been compiled for the period up to 2030 i.e.

- *Scenario 4 – Matimba Power Station (FBC), Medupi Power Station (FGD), three (3) new power stations (FGD), coal supply to five (5) power stations, Exxaro project, the associated construction activities and the associated growth in Lephalale and Steenbokpan.*
- *Scenario 8 – Scenario 4 + Sasol development of two CTL plants, the associated construction activities and the associated growth in Steenbokpan.*

This report investigates the Mokolo Dam which is considered to be the only viable source of water that can supply in the water requirements of the interim period until the Crocodile River (West) Transfer System has been constructed. The Mokolo Dam has a long term firm yield of 39.1 Million m³/annum of which 10.4 Million m³/a is allocated for irrigation. The remaining 28.7 Million m³/annum is available to augment the water requirements of the Lephalale and Steenbokpan areas. The exact quantity of water to be provided from the Mokolo Dam depends on which water requirement scenario will be selected and the year in which the Crocodile River (West) Transfer System will be completed. To allow for a worst case scenario, the water requirement for Scenario 8 has been taken at the time of probable first delivery from the Crocodile River (West) (July 2014), i.e. 50,4 Million m³/annum.

It should be noted that the cost calculations for the water transfer infrastructure proposed through this report for the pre-feasibility stage should be within approximately 20% accuracy and have the purpose to serve as a basis for a decision on the preferred option which will be refined in the feasibility stages.

The following two most viable options of transferring water from the Mokolo Dam to the end users during the first phase have been identified and investigated:

a) Construct a pump station and new pipeline from Mokolo Dam to Zeeland, Matimba and Medupi power stations as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities). This pipeline will be constructed parallel (or close) to the existing pipeline for most of the route.

The existing pump station is in a good condition. The motor control switchgear has been replaced in 2006. The pump station is equipped with three 855kW Siemens motors (two in stock) and three Sulzer pumps, Model HPL 45/30 (two in stock). The lime dosing unit was also replaced. The pump station is however situated below the PMF tail water level and has flooded on a previous occasion. It is proposed that the new pump station be constructed north east of the existing pump station above the PMF tail water level. A further aspect that endangers the existing pump station is the erosion damage to the Mokolo Dam spillway. This causes higher backwater levels and it is proposed that this erosion damage is rectified.

b) Construct a weir, abstraction works and a high lift pump station downstream of Mokolo Dam as well as a pipeline to deliver water to Zeeland, Matimba and Medupi Power Stations, as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities).

A mass gravity concrete weir will be provided. The lowest level of the weir overspill crest will be 1,8 m above the average riverbed level and the non-overspill crest level and working platform for the adjacent low lift pump station will be placed at the PMF flood level. The weir overspill crest will be an ogee type crest to maximize the weir discharge capacity and thereby reducing the impact of upstream backwater effects during flood events.

The pipes proposed for installation for the rising mains and gravity mains of both options are steel pipes with Sintakote external coating and epoxy internal lining. Joints will be welded.

Due to the relatively small difference in augmentation required in 2014 between Scenarios 8 and 4, excluding the irrigation (50,4 – 40,3 = 10,1 Million m³/annum) a decision was taken that Phase 1 will only be investigated and implemented utilising the Scenario 8 water requirements. Any surplus capacity will provide redundancy that will enhance overall long-term redundancy of supply.

The baseline figures to be used for planning and sizing the options for Phase 1 delivery from Mokolo Dam has been established using the water requirement figures presented.

- *Phase 1: Scheme delivering form Mokolo Dam*
    - *50,4 (maximum interim water requirement) – 13,5 (safe capacity of the existing pipeline system from the Mokolo Dam) = 36,9 Million m³/a (2014)*

Considering the Reliability and Redundancy requirements the design flow was calculated with due allowance for a downtime period of up to 18 days continuous per year for planned and unplanned closures, consumer peaks as well as a storage dam re-fill peak of 120%. This will enable the storage dams to be re-filled in 90 days following an 18 continuous supply interruption. Losses were assumed to be 2% of the Average Annual Demand (AAD) for the Pre-Feasibility Stage:

- *Design flow = ((Average Annual Demand (AAD) flow – (13,5 Million m³/a)+ losses) x 1,20)*

The following two most viable options of transferring water from the Mokolo Dam to the consumers during the interim period as a first phase were investigated:

The Mokolo Dam pipeline *option would follow a route parallel to that of the existing pipeline except for the section from Mokolo Dam where the pipeline will follow the existing access road. A total length of* ***79.78 km*** *(including the rising main from the Mokolo Dam and the gravity main to the end consumers) will be required including the extension to Steenbokpan. Blasting in close proximity to the existing pipeline may be problematic and needs to be mitigated, especially in the steep and rocky sections at Rietspruitnek and where the pipeline exits the Mokolo River valley. The existing servitude of 15 m wide will have to be widened to a temporary construction width of 30 m and a permanent width of 20 m. Should the new route deviate from the old route, a new servitude will have to be registered. Refer to* ***Appendix B*** *for a layout drawing.*

The Rivers Bend Weir *option can be constructed in the Mokolo River approximately 41 km downstream of Mokolo Dam between the farms Sandier 559L0 and Rivers Bend 591L0 and immediately downstream of the confluence of the Rietspruit. This site was selected on the basis that it is located at the end of the deep and narrow valley section with only a small amount of developed irrigation along the river, and a short rising main to Zeeland. The objective was to minimize river losses and to limit the degree of water resource management that would be required. Refer to the map attached in* ***Appendix B*** *for a layout of the weir site. The low-lift pump station to abstract the sediment laden water from the river, located on the left flank of the weir, will be provided with 2 pumping bays to each accommodate a 750 ℓ/s submersible pump. Degritting and desilting facilities to remove coarse sediment and a balancing dam with 4 hours storage capacity will be provided between the low and high-lift pump stations. Water will be pumped from the high-lift pump station to the Zeeland water treatment works, Matimba raw water dam and Steenbokpan area. The total length of pipeline will be approximately* ***63.23 km****.*

Simulated losses along the stretch of river from the dam to the abstraction site amounted to 17.2% of the total release of 75,4 Million m^3/a from Mokolo Dam.

All the additional releases from Mokolo Dam will therefore be subject to a loss factor of:

- *Mokolo release adjustment factor = 1/(1-0.172) = 1.207*

To further elaborate on the implications of the Abstraction Weir Option the following scenario was investigated:

- *Over utilising Mokolo Dam for a short period to make up for the shortfalls in water delivery anticipated until the Crocodile River (West) Transfer Scheme is implemented. The short term maximum target delivery is 50,4 Million m^3/annum. Of this, 13,5 Million m^3/annum will be transferred by the existing Exxaro Pipeline, leaving 36.9 Million m^3/annum to be transferred by the Phase 1 Scheme.*

For the Interim Scheme (Phase 1), the water balance from commissioning to July 2014 is summarised in the following table:

Item Description	***Over Utilisation of Mokolo Dam (Million m^3/annum)***
Net Balance Available at Weir Option	*36,9*
Associated River Losses (at 17.2%)	*7,6*
Balance Available for Project Use	*44,5*
Transfer via Existing Exxaro Pipeline	*13,5*
Irrigation Requirement (including losses).	*17,4**
Total Required Releases	*75,4*

** The reported irrigation requirement is 10,4 million m³/annum, but the registered total is 1800 ha x 8000 m³/ha/annum which equals 14.4 m³/annum net and 14.4 x 1.207 = 17,4 m³/annum gross.*

With the long term yield of the Mokolo Dam being 39,1 Million m³/annum, it can be seen from Table 6.1 that the Abstraction Weir Option can only supply the required water requirement if Mokolo Dam is over utilised by 93%, i.e. 36,3 Million m³/annum (75,4 – 39,1 Million m³/annum). The lifespan of the dam under these conditions will be very short and the dam will fail before the completion of the main Transfer Scheme. Yield analysis on the dam indicated that the dam will fail in 2014 under normal water requirements from 2010 onwards. The additional losses resulting from the weir option will result in the dam failing earlier.

The following tables summarise the scheme components and information for both alternatives:

Pipeline from Mokolo Dam

Component	***Description***
High lift pump station:	*Static head 228m Total head pumped (peak) = 262m Design Flow = 1 423 l/s*
1000mm of rising main	*5 569m (Design Flow = 1 423 l/s, V = 1.84m/s)*
1000mm of gravity main	*36 380m (Design Flow = 1 423 l/s, V = 1.81m/s)*
800mm of gravity main (Steenbokpan)	*35 974m (Design Flow = 715 l/s, V = 1.41m/s)*
800mm of gravity main (Matimba)	*1 860m (Design Flow = 708 l/s, V = 1.40m/s)*

Rivers Bend Weir and Pipeline

Component	Description
Concrete Weir	*1.5m above riverbed level*
Low lift pump station incl. desilting facility and balancing dam	*2 x 750 ℓ/s submersible duty pumps*
High lift pump station:	*Static head = 118m* *Total head pumped (peak) = 230m* *Design Flow = 1 423 ℓ/s*
1000mm of rising main	*25 394m (Design Flow = 1 423 ℓ/s, v = 1.81m/s)*
800m of rising main (Steenbokpan)	*35 974m (Design Flow = 715 ℓ/s, v = 1.41m/s)*
800m of rising main (Matimba)	*1 860m (Design Flow = 708 ℓ/s, v = 1.40m/s)*

The constructions of a weir, as well as the construction of a pipeline are both listed activities in terms of the National Environmental Management Act, 1998 (Act no. 107 of 1998) (the Act).

Neither of the proposed options have an environmental fatal flaw should the correct mitigation measures be put in place, although the pipeline routes do traverse some sensitive areas where particular care should be taken. These will be pinpointed during a detailed investigation. Rocky areas are most sensitive due to the presence of aloe species as well as the distinct habitat it provides for animal species.

For the weir option, the weir will impact on the flow of the river and therefore the migration of fish species. The decrease in the flow speed will also lead to siltation as well as the alteration of the riverine habitat. The possibility also exists that some terrestrial ecosystems next to the river may be inundated.

Due to the fact that pipeline alignment for the Mokolo Dam option is adjacent to the existing pipeline and the vegetation has recovered along the existing pipeline it is a clear indication that the disturbance of the vegetation is of a temporary nature compared to the permanent impact of the weir on the flow of the river. With mitigation measures the construction of the pipeline will have a minimal lasting effect on the surrounding area. It is therefore considered the most unobtrusive option.

The timing of the project is significant as some of the environmental studies may only be conducted during certain periods of the year. Due to the extent of the project the relevant authority may also require that a Full Environmental Impact Assessment be conducted.

A basic assessment process is the shorter process but can have an extended time due to the specialist investigations that need to be conducted. It can therefore take anything from 6 – 12 months to complete. The timeframe is also subject to the input and comments received during the Public Participation Process.

Should a Full Environmental Impact Assessment be required by the relevant authority the process can be anything from 18 – 24 months.

It is however anticipated that the authority will concur with the Basic Assessment Process.

The following table is a comparison between the two options investigated.

Description	***Pipeline from Mokolo Dam***	***Pipeline from Rivers Bend Weir***
Total Pipeline Length (km)	*79*	*63*
Total Peak Pumping Head (m)	** 262*	*** 230*
Project Cost excl. VAT (April 2008 Values) (R)	***1 340 120 000***	***1 327 115 000***
Discounted Present Value 8% to 2008 (R)	*1 179 872 000*	*1 173 028 000*
URV 8% (R)	***6.73***	***8.18***

Note: * *Static height difference plus friction losses between pump station (874 m) and Wolwenfontein (FSL=1102 m) balancing dams.*
** *This scheme pumps water from the weir (level = 820 m) over a high point (level = 929 m) all the way to the users.*

From the table it can be seen that the capital cost of the River Bend Weir option is approximately R 13 Million less than that of the Mokolo Dam pipeline option, but there is more risk attached to the cost and construction of the weir in the river due to the very limited geotechnical information available and uncertainties concerning river losses. This option will also require a larger Crocodile River (West) Transfer Scheme with the associated operational and maintenance costs. The River Bends Weir option has a higher URV due the replacement cost of the water due to river losses. From an engineering economic point of view the Mokolo Dam pipeline option is the preferred option to be implemented.

MOKOLO AND CROCODILE (WEST) WATER AUGMENTATION PROJECT FEASIBILITY STUDY:

MOKOLO RIVER DEVELOPMENT OPTIONS

PRE-FEASIBILITY STAGE

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. BACKGROUND

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long term industrial, commercial and domestic use.

The Mokolo Dam is considered to be the only viable source of water that can supply in the water requirements of the interim period until the Crocodile River (West) Transfer System has been constructed. The exact quantity of water to be provided from the Mokolo Dam depends on which water requirement scenario will be selected and the year in which the Crocodile River (West) Transfer System will be completed. To allow for a worst case scenario, the water requirement for Scenario 8 has been taken at the time of probable first delivery from the Crocodile River (West) (July 2014), i.e. 50,4 Million m^3/a.

The Mokolo Dam has a long term firm yield of 39,1 Million m^3/a of which 10,4 Million m^3/a is allocated for irrigation. The remaining 28,7 Million m^3/a is available to augment the water requirements of the Lephalale and Steenbokpan areas. In order to provide the short term maximum delivery target of 50,4 Million m^3/a until the Crocodile River (West) Transfer Scheme is implemented, it will therefore be necessary to over utilise the Mokolo Dam for a short period. Yield analysis on the dam indicated that the dam will fail in August 2014 under these over utilised conditions. A proposed solution to extend the life of the Mokolo Dam under the over utilised conditions, would be to buy the irrigation water allocations from the farmers for one or two years. These investigations are currently taken place.

The existing pump station is in a good condition. The motor control switchgear has been replaced in 2006. The pump station is equipped with three 855kW Siemens motors (two in stock) and three Sulzer pumps, Model HPL 45/30 (two in stock). The lime dosing unit was also replaced. The pump station is however situated below the PMF tail water level and has flooded on a previous occasion. It is proposed that the new pump station be constructed north east of the existing pump station above the PMF tail water level. A further aspect that endangers the existing pump station is the erosion damage to the Mokolo Dam spillway. This causes higher backwater levels and it is proposed that this erosion damage is rectified.

Factors considered for the sizing of the pipeline are:

- Allowance for downtime of the conveyance system and the peak required to re-fill the storage dams within 90 days after an 18-day outage period.
- The long term yield of Mokolo Dam (39,1 Million m^3/a).
- The average annual capacity of the existing Lephalale pipeline was taken as 13.5 Million m^3/a considering the present condition of the lining of the existing pipeline. This value will be verified and revised if necessary during the feasibility stage. This capacity was subtracted from the required size for Phase 1. The refurbishment/relining of this pipeline will only take place after Phase 2 (main transfer option) has become operational. The maximum capacity of the existing pump station at the Mokolo Dam is approximately 25,8 Million m^3/a with all three pumps in operations 24 hours a day.

The following most viable options of transferring water from the Mokolo Dam to the consumers as a first phase have been identified and investigated:

a) Construct a pump station and new pipeline parallel or close to the existing from Mokolo Dam to Zeeland, Matimba and Medupi Power Stations, as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities). This pipeline will be constructed parallel (or close) to the existing pipeline for most of the route.

b) Construct a weir, abstraction works and a high lift pump station downstream of Mokolo Dam, as well as a pipeline to deliver water to Zeeland, Matimba and Medupi Power Stations, as well as Steenbokpan (to supply the development of further Eskom power stations, Sasol, and coal mining activities).

2. PURPOSE OF THE REPORT

The purpose of this report is to investigate the most feasible and timely solution at pre-feasibility level to augment the water supply to Lephalale and Steenbokpan areas as a first phase while the main transfer scheme from the Crocodile River (West) is being implemented. The report serves to:

- Confirm the water requirements that were used for the sizing and costing of the Phase 1 infrastructure options.
- Identify the preferred option for Phase 1, to abstract and distribute water to the new development in the Lephalale area.
- Stress the fact that it would possibly not be achievable to implement the full Phase 1 before September 2010.

The report further provides a first-order capital cost estimate and engineering economic analysis, including Unit Reference Values (URVs), for each of the options proposed and includes a list of milestone dates for the various stages of the project. It should be noted that the sizing of components will only be optimized during the Feasibility Stage which will result in a revised higher confidence cost estimate for Phase 1.

It should be noted that the alternative pipeline routes discussed at the Technical Meeting held on 30 October 2008 were not considered when routing the pipelines and selecting the water supply points given in this report. The changes proposed at this meeting entails moving the pipeline route to Steenbokpan south of the Eensaamheid coal fault line and will be incorporated in the Feasibility Stage.

3. WATER REQUIREMENTS

3.1 Projected water requirements

Development from Lephalale westwards towards Steenbokpan and the Botswana border is driven by large coal deposits. Potential large users (Eskom, Exxaro and Sasol) have provided estimates of their expected water consumption for the interim to long term industrial, commercial and domestic use.

Two water requirement scenarios have been compiled for the period up to 2030, i.e.:

- Scenario 4 – Matimba Power Station (Fluidised Bed Combustion (FBC)), Medupi Power Station (Flue Gas Desulphurisation (FGD)), three (3) new power stations (FGD), coal supply to five (5) power stations, Exxaro project, the associated construction activities and the associated growth in Lephalale and Steenbokpan.
- Scenario 8 – Scenario 4 + Sasol development of two Coal to Liquid (CTL) plants, the associated construction activities and the associated growth in Steenbokpan.

Figure 3-1 illustrates the water requirement scenarios for the revised water requirement estimates received in July 2008 for the period up until implementation of Phase 2 (main transfer scheme from Crocodile River (West)). The graph excludes the irrigation water requirement below the Mokolo Dam of 10,4 Million m^3/a.

The water requirement tables (release date 25 August 2008) are attached to this report in **Annexure A**. The tables indicate the contribution of each user to the annual totals. The tables further indicate the split in water requirement between Lephalale and Steenbokpan.

Due to the relatively small difference in augmentation required in 2014 between Scenarios 8 and 4, excluding the irrigation (50,4 – 40,3 = 10,1 Million m^3/a) a decision was taken that Phase 1 will only be investigated and implemented utilizing the Scenario 8 water requirements. Any surplus capacity will provide redundancy that will enhance overall long-term redundancy of supply.

The link to the Steenbokpan area will have to be revisited should the Scenario 4 water requirements be finally decided on.

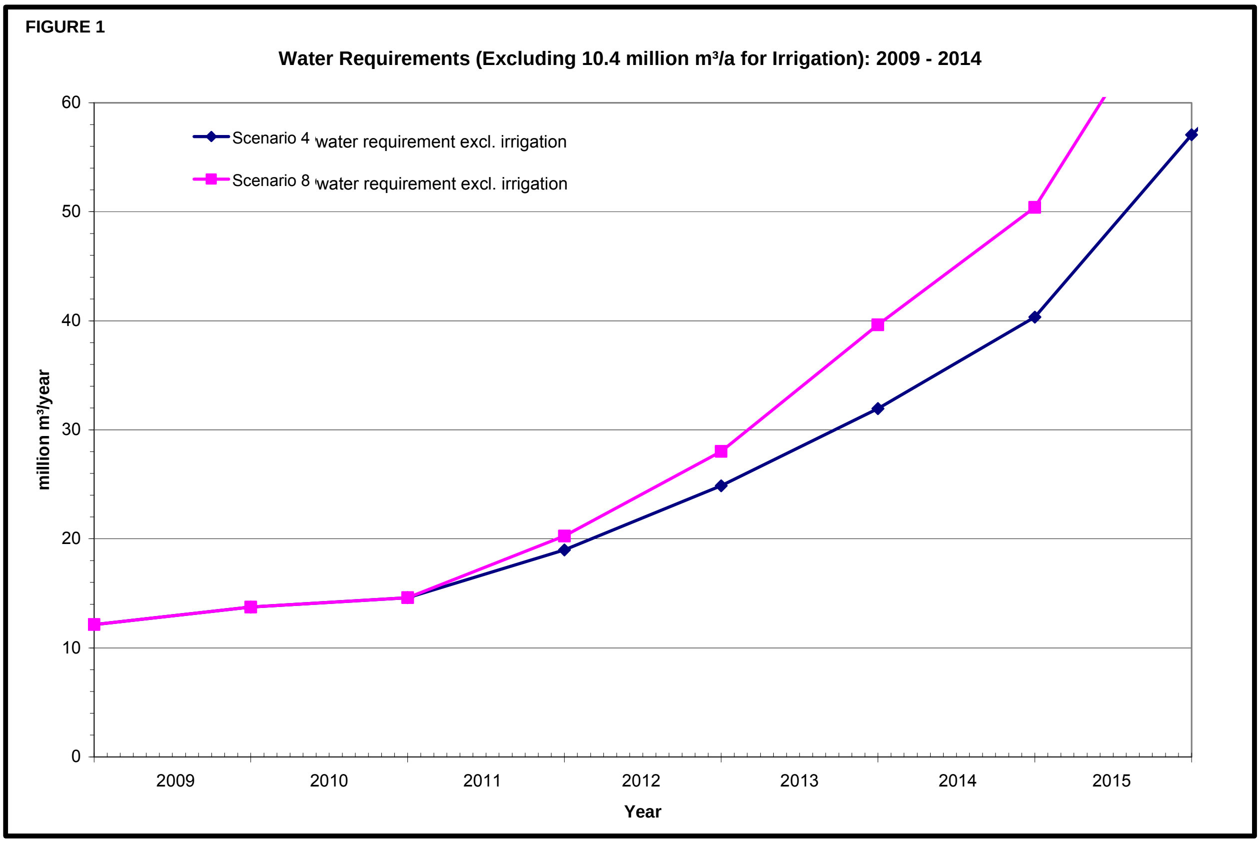


Figure 3-1: Water Requirements (excl. 10.4 Million m³/a for Irrigation): 2009 – 2014

3.2 Transfer Volumes for Sizing Scheme Components

The baseline figures to be used for planning and sizing the options for Phase 1 delivery from Mokolo Dam have been established using the water requirement figures presented.

- Phase 1: Scheme Average Annual Demand (AAD) delivering form Mokolo Dam
  - 50,4 (maximum interim water requirement) – 13,5 (safe capacity of the existing pipeline system from the Mokolo Dam) = 36,9 Million m³/a (2014)

The volumes to be transferred are indicated in the following table (July 2008 estimates and excluding the irrigation water requirement).

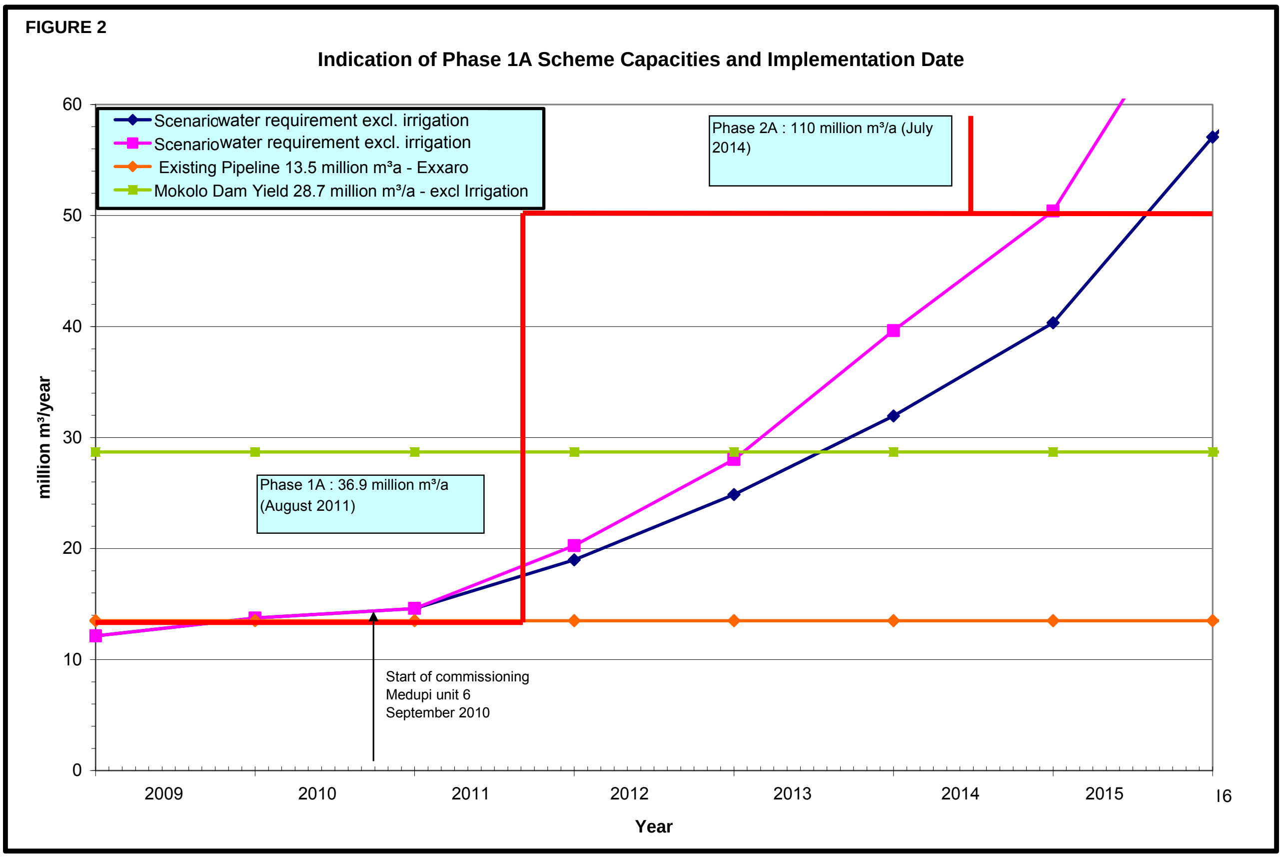


Figure 3-2: Indication of Transfer Volumes and Implementation Dates

4. ASPECTS OF RELIABILITY AND REDUNDANCY

4.1 Introduction

The strategic importance of the users that will account for the bulk of the water consumption requires that the risk of failure in the supply of water is kept to a minimum. Sufficient reliability and redundancy must therefore be provided in the water supply system.

The Terms of Reference (ToR) requires the transfer systems to be designed for 95% reliability, which is 18 days maximum downtime per annum for whatever reason. As a consequence of this constraint storage capacity must be designed into the system to ensure that strategic customers will not have a higher risk of a water supply shortage (i.e. 99.5% assurance of supply or hydrologic reliability).

4.2 General criteria

The following general criteria were applied when designing for reliability and redundancy:

- The transfer systems shall be designed for 95% system availability, implying that the scheme shall have 100% reliability if it is inoperative for up to 18 days of any one year, and the scheme capacity adjusted to allow the full annual requirements to be supplied in 347 days.
- No allowance for 18 days storage exists at Zeeland Water Works exists and will be considered for the Feasibility Stage. If redundancy storage is not supplied at the Zeeland Water Works, redundancy will also not be available for water supplied from Mokolo Dam for downstream users.
- No allowance was made in this report for the cost of redundancy storage facilities at the end users. This cost will be included in the Crocodile River (West) Transfer Options report for options comparison purposes. These storage facilities will be funded and implemented by the users.

Allowing for a scheme to be inoperative continuously for 5% of the time during any one year (18 days) will be sufficient to cater for the following situations:

- Pump station failures if there had been severe damage such as flooding of the electrical equipment; etc.
- Constructing temporary by-passes to repair pipeline linings and joints; and
- The time required to restore power supplies after major interruptions such as bushfires, flooding, etc.

5. APPROACH TO IDENTIFYING OPTIONS AND CAPACITY DETERMINATION

5.1 Pipelines

The pipes proposed for installation for both the rising and gravity mains are steel pipes with Sintakote external coating and epoxy internal lining. Joints will be welded.

The following aspects were considered in defining the pipeline routes:

- Abstraction and water supply locations
- Existing roads, as well as boundaries between land owners along the routes
- Historical and planned future mining activities in the area, both sub-surface and open cast
- Site constraints, potential river/stream crossings, road and railway crossings
- Geotechnical overview
- Environmental impacts
- Social impact of pipe line location

The following parameters were utilized in the engineering economic analysis during this investigation:

Table 5-1: Parameters for Economic Analysis

Description	Note/Assumption
Energy Tariff	Megaflex
Discount rate (real)	6.8 and 10%
Annual increase in energy tariffs	20% compounded for initial 5 years, inflation rate thereafter
Analysis period	45 years
Pipe roughness	0.1 mm

- The optimal pipe size was based on 120% of the required average annual transfer capacity of the scheme plus 2% losses at a maximum flow velocity of approximately 1.8 m/s for the rising mains. For the gravity mains the pipe size was determined by the available head.
- The steady state energy grade line was calculated with minimum 15 m at the end consumers. The wall thickness was calculated based on 50% of the material yield strength for the particular grade of steel adopted. A surge analysis was not performed for this investigation and will be addressed in the feasibility design stage.

5.1.1 Design Flow

Considering the Reliability and Redundancy requirements the design flow was calculated with due allowance for a downtime period of up to 18 days continuous per year for planned and unplanned closures, consumer peaks as well as a storage dam re-fill peak of 120%. This will enable the storage dams to be re-filled in 90 days following an 18 continuous supply interruption. Losses were assumed to be 2% of the Average Annual Demand (AAD) for the Pre-Feasibility Stage:

- Q design = ((Q AAD – (13.5 million m^3/a)+ losses) x 1.20)

6. DEFINITION OF OPTIONS

The following two alternative options to deliver water from the Mokolo Dam during the interim period as a first phase were investigated:

6.1 New Pipeline from Mokolo Dam to Matimba T-off and Steenbokpan

A new pump station will be constructed at the Mokolo Dam near the existing pump station but at a higher level above the peak maximum flood (PMF) level. A new bulk power supply line with substation will also be installed.

The pipeline would follow a route parallel to that of the existing pipeline except for the section from Mokolo Dam where the pipeline will follow the existing access road. A total length of 79.78 km (including the rising main from the Mokolo Dam and the gravity main to the end consumers) will be required including the extension to Steenbokpan. Blasting in close proximity to the existing pipeline may be problematic and needs to be mitigated, especially in the steep and rocky sections at Rietspruitnek and where the pipeline exits the Mokolo River valley. The existing servitude of 15 m wide will have to be widened to a temporary construction width of 30 m and a permanent width of 20 m. Should the new route deviate from the old route, a new servitude will have to be registered. Refer to **Appendix B** for a layout.

At an average construction rate of 200 m per day for rocky areas and restricted work space in close proximity of the existing pipeline and 300 m per day for all other sections and allowing for start-up time and the annual break, the total construction period for the pipelines will be approximately 17 months. Taking the expected delivery times for steel pipes and especially variable speed pumps into account, the total construction period will be approximately 18 to 22 months. To supply water in time for the commissioning of Medupi's first unit by September 2010, this means that the contractor must start work no later than 1 March 2009. This currently leaves a maximum of five months to procure professional service providers (PSPs) for and to execute the detail design for upgrading of the dam outlet works, the upgrading of the existing pump station and power supply system and the detail design of the pipeline. In addition to this, the procurement of contractors for the construction of these facilities must also take place in this period and the users will have to supply their on-site storage facilities during this period. The required Environmental Impact Assessments and obtaining of a Record of Decision must also take place in this time period. This is not possible.

Options to phase the construction of this pipeline by first increasing the capacity of the existing Lephalale pipeline with interconnections to a new pipeline to Rietspruitnek will therefore have to be considered. With the maximum capacity of the existing pump station at the Mokolo Dam being approximately 25.8 Million m^3/a with all three pumps in operations 24 hours a day, water could then be delivered at a rate higher than the capacity of the current pipeline which will buy some time. This aspect will be addressed as part of the Feasibility stage.

6.2 Rivers Bend Weir and Pipeline to Matimba T-off and Steenbokpan

The Rivers Bend Weir can be constructed in the Mokolo River approximately 41 km downstream of Mokolo Dam between the farms Sandier 559L0 and Rivers Bend 591L0 and immediately downstream of the confluence of the Rietspruit. This site was selected on the basis that it is located at the end of the deep and narrow valley section of the river with only a small amount of developed irrigation along the river. The objective was to minimize river losses and to limit the degree of water resource management that would be required. Refer to the map attached in **Appendix B** for the position and a layout of the weir site.

As no geological field investigation has been done for this site to date assessments of foundation conditions have been based on the results of a geological desk study and reports from local landowners. Weir founding conditions were consequently assumed to be on deep alluvial sands, approximately 12m deep. Foundation stabilization with jet grouting is proposed to improve bearing pressures for the weir structure, to provide a partial cut-off and reduce the permeability of the sand bed. A mass gravity concrete weir will be provided. The lowest level of the weir overspill crest will be 1,8m above the average riverbed level and the non-overspill crest level and working platform for the adjacent low lift pump station will be placed at the PMF flood level. The weir overspill crest will be an ogee type crest to maximize the weir discharge capacity and thereby reducing the impact of upstream backwater effects during flood events.

The low-lift pump station to abstract the sediment laden water from the river, located on the left flank of the weir, will be provided with 2 pumping bays to each accommodate a 750 ℓ/s submersible pump plus two standby pumps in storage. A desilting channel facility and balancing dam with 4 hours storage capacity will be provided between the low and high-lift pump stations. Water will be pumped from the high-lift pump station to the Zeeland water treatment works, Matimba raw water dam and Steenbokpan area. The total length of pipeline will be approximately 63.23 km. The total construction time will then be 15 months.

The proposed abstraction site is upstream of the current irrigation area of about 1 800 ha. No downstream flow gauging station exists. A hydrodynamic model was set up to simulate the losses. By using the calibrated Crocodile River losses upstream of the Boschkop site, the losses on the Mokolo River were simulated for historical dam releases and for historical releases plus an additional 1 m3/s. Initially it was assumed in the simulations that the proxy evaporation loss factor used to estimate the river losses would be the same as the reach upstream of the Boschkop site on the Crocodile River. The derivation of a Mokolo River proxy evaporation loss factor as obtained from the Crocodile River calibration resulted in a very high evaporation factor that was considered to be over conservative since there are very few users along the river downstream of Mokolo Dam up to the proposed abstraction works. The reach does not include a dolomite zone as on the Crocodile River. Additional simulations were therefore carried out for a release with only the river surface evaporation and an estimated irrigation requirement based on the current small irrigation area between the dam and the proposed weir. For an average historical dam release of 33,4 Million m^3/a, the river loss was found to be 3,7 million m^3/a on average, which is equivalent to 11,1%/a. If the river flow increases by 1 m^3/s due to possible increased future release patterns to 64,9 Million m^3/a, the calculated loss would be 5,6 Million m^3/a, or 8,6%/a. However, if the Exxaro observed release pattern is calibrated it is found that the proxy evaporation loss factor is 2,7. This is probably realistic considering possible seepage, illegal use and evapo-transpiration. The different losses considered were:

- evaporation losses on the river surface area (which could increase slightly with future increased water releases),
- evapo-transpiration losses,

- seepage from the river,
- return flows from irrigation, and
- possible irrigation use more than the allocation (based on historical use patterns).

Of these losses only the evaporation loss would be significant in an incremental flow analysis. As the flow width is a function of total flow and channel geometry the accuracy of the simulation results would also be affected by the level of detail contained in the geometric model. More consistent results would be obtained from a more detailed model, but for the purposes of the current pre-feasibility study the present model, which was based on ortho-photo interpretation, was considered to be adequate.

The adjusted simulated losses from the river between the dam and the abstraction site amounted to 17.2% of the total release from Mokolo Dam of 75.4 Million m³/a.

Any additional releases from Mokolo Dam for abstraction purposes will therefore be subject to a factor:

- Mokolo release adjustment factor = 1/(1-0.172) = 1.207

To further elaborate on the implications of the Abstraction Weir Option the following scenario was investigated:

- Over utilising Mokolo Dam for a short period to make up for the shortfalls in water delivery anticipated until the Crocodile River (West) Transfer Scheme is implemented. The short term maximum target delivery is 50.4 Million m³/a. Of this 13.5 Million m³/a will be transferred by the existing Exxaro Pipeline, leaving 36.9 Million m³/a to be transferred by the Phase 1 Scheme.

For the Interim Scheme (Phase 1) the water balance is summarized in Table 6.1 below.

Table 6-1: Net Transfer Volumes for the Weir Option

Item Description	Over Utilisation of Mokolo Dam (Million m^3/a)
Net Balance Available at Weir Option	36.9
Associated River Losses (at 17.2%)	7.6
Balance Available for Project Use	44.5
Transfer via Existing Exxaro Pipeline	13.5
Irrigation Requirement (including losses)	17.4*
Total Required Releases	75.4

* The reported irrigation requirement is 10.4 Million m³/a, but the registered total is 1800 ha x 8000 m³/ha/a which equals 14.4 m³/a net and 14.4 x 1.207 = 17.4 m³/a gross.

With the long term yield of the Mokolo Dam being 39.1 Million m³/a, it can be seen from Table 6.1 that the Abstraction Weir Option can only supply the required water requirement if Mokolo Dam is over utilized by 93%, i.e. 36.3 Million m³/a (75.4 – 39.1 Million m³/a). The lifespan of the dam under these conditions will be very short and the dam will fail before the completion of the main Transfer Scheme. Yield analysis on the dam indicated that the dam will fail in 2014 under normal water requirements from 2010 onwards. The additional losses resulting from the weir option will result in the dam failing earlier.

The costs of the losses associated with the Weir option were assumed as R2.00/m³ for water from the Mokolo Dam. An additional R4.50/m³ was added to replace the water through an increase in capacity of the Crocodile River (West) Transfer Scheme.

Due to the remoteness of the river valley between Mokolo Dam and the Abstraction Weir and the minor extent of irrigation in the valley, it is unlikely that water resource management measures over and above those already employed by the Mokolo Irrigation Board will be of benefit to safeguard releases or to reduce losses.

The estimated construction period required for the weir is approximately 21 months (75 weeks plus allowance for weather delays), and is based on the following assumptions:

(i) Site Establishment = 12 weeks

(ii) River diversion = 12 weeks, of which 3 weeks fall on the critical path.

(iii) Jet Grouting = 4 400 m @ 2 rigs working at 100/week = 22 weeks, of which 17 weeks fall on the critical path.

(iv) Concrete = 4 000 m^3 @ 2 team working at 10m^3/day = 40 weeks' of which 30 weeks fall on the critical path. A rollcrete option could be investigated to reduce the construction period.

(v) M&E Works = 13 weeks

(vi) Total Duration = 75 weeks.

(vii) The construction schedule will be sensitive to the impacts of the rainy season and construction delays due to high river levels should be allowed for. Depending on the commencement date of construction an allowance of 3 months per rainy season falling in the construction period would be prudent. The start date for construction is crucial as this should be determined on the basis that all the work in the river channel (jet grouting and concrete work) should be done in the dry season. This option also does not have the alternative to phase the construction as for the Lephalale pipeline by first increasing the capacity of the existing Lephalale pipeline with interconnections and a parallel pipeline at Rietspruitnek that could shorten the time to deliver water at a rate higher than the capacity of the current pipeline.

For planning purposes an overall construction period of 2 years is recommended. The same construction period for the pump station as for the Mokolo pipeline applies, which could be 18 - 22 months taking into account the lead time for the pump station equipment.

6.3 Layout of Options

The pipeline routes that were evaluated for this investigation are summarized below:

Refer to **Appendix B** for the reference nodes and **Appendix C** for the longitudinal sections of the pipelines and schematic diagrams indicating flows, diameters, lengths, velocities and headloss.

Table 6-2: Pipeline Routes

Option Number	Description	Flow Routing (Pipe Section No – Refer to Appendix B)
Phase 1		
1A (i) Interim Measure Mokolo Dam	• Abstraction at Mokolo Dam. • Conveyance to users.	1-2-3-4-5-6-7-8 14-13 24-25A-25B
1A (ii) Interim Measure Lephalale Weir	• Abstraction at Lephalale Weir. • Conveyance to users.	18-4-5-6-7-8 14-13 24-25A-25B

The following tables summarize the scheme components for both alternatives.

6.3.1 Pipeline from Mokolo Dam

Table 6-3: Summary of Scheme Components – Pipeline from Mokolo Dam

Component	Description
High lift pump station:	Static head 228 m Total head pumped (peak) = 262 m Design Flow = 1 423 ℓ/s
1 000 mm of rising main	5 56 9m (Design Flow = 1 423 ℓ/s, v = 1.84 m/s)
1 000 mm of gravity main	36 380 m (Design Flow = 1 423 ℓ/s, v = 1.81 m/s)
800 mm of gravity main (Steenbokpan)	35 974 m (Design Flow = 715 ℓ/s, v = 1.41 m/s)
800 mm of gravity main (Matimba)	1 860 m (Design Flow = 708 ℓ/s, v = 1.40 m/s)

6.3.2 Rivers Bend Weir and Pipeline

Table 6-4: Summary of Scheme Components – Pipeline from River Bend Weir

Component	Description
Concrete Weir	1.5m above riverbed level
Low lift pump station incl. desilting facility and balancing dam	2 x 750 ℓ/s submersible duty pumps
High lift pump station:	Static head = 118 m Total head pumped (peak) = 230 m Design Flow = 1 423 ℓ/s
1 000 mm of rising main	25 394 m (Design Flow = 1 423 ℓ/s, V = 1.81 m/s)
800 m of rising main (Steenbokpan)	35 974 m (Design Flow = 715 ℓ/s, V = 1.41 m/s)
800 m of rising main (Matimba)	1 860 m (Design Flow = 708 ℓ/s, V = 1.40 m/s)

7. ENVIRONMENTAL ASSESSMENT

7.1 Background

The development of new power stations is of high strategic importance and the construction of the first new power station, Medupi, is already underway. The first units at the Medupi Power Station will be commissioned by September 2010. The Crocodile River (West) Transfer Scheme will not be completed in time to meet these dates and it will be necessary to implement interim bridging arrangements to achieve this. The interim arrangements must supply in the requirements until the transfer scheme becomes operational. This is expected by middle 2014.

7.2 Listed Activities

Activities identified in terms of Section 24(2)(a) and (d) of the National Environmental Management Act, 1998 (Act no. 107 of 1998)(the Act), which may not commence without environmental authorization from the competent authority and in respect of which the investigation, assessment and communication of potential impact of activities must follow the procedure as described in Regulations 22 to 26 of the Environmental Impact Assessment Regulations, 2006, promulgated in terms of Section 24(5) of the Act, are listed below.

The constructions of a weir as well as the construction of a pipeline are both listed activities in terms of the Act. The following listed activities are included under Regulation 386 indicating a basic assessment:

1(k) The bulk transportation of sewage and water, including storm water, in pipelines with –

(i) an internal diameter of 0,36 metres or more; or

(ii) a peak throughput of 120 litres per second or more

1(m) any purpose in the one in ten year flood line of a river or stream, or within 32 metres from the bank of a river or stream where the flood line is unknown, excluding purposes associated with existing residential use, but including –

(i) canals;

(ii) channels;

(iii) bridges;

(iv) dams; and

(v) weirs;

4. The dredging, excavation, infilling, removal or moving of soil, sand or rock exceeding 5. cubic metres from a river, tidal lagoon, tidal river, lake, in-stream dam, floodplain or wetland.

Although indicated as a Basic Assessment it is anticipated that several detailed specialist investigations will have to be completed such as fauna, flora and heritage assessments. The timing of the project is therefore significant as some of the studies may only be conducted during certain periods of the year. Due to the extent of the project the relevant authority may also require that a Full EIA be conducted.

A basic assessment process is the shorter process but can have an extended time due to the specialist investigations that need to be conducted. It can therefore take anything from 6 – 12 months to complete. The timeframe is also subject to the input and comments received during the Public Participation Process.

Should a Full EIA be required by the relevant authority the process can be anything from 18 – 24 months.

It is, however, anticipated that the authority will concur with the Basic Assessment Process

7.3 Potential Environmental Impacts of Phase 1 Option i – Mokolo Dam Pipeline

The construction of a pipeline could have numerous environmental impacts including the following:

- Destruction of vegetation
- Faunal habitat loss
- Soil erosion
- Hydrocarbon pollution of soil, ground and surface water
- Air pollution (dust during blasting and drilling)
- Noise pollution

The pipeline alignment especially close to the Mokolo Dam is relatively close to sensitive rocky areas and particular care should be taken to minimize the disturbance of these areas.

Most of the potential impacts could, however, be negated or minimized through proper construction management.

7.4 Potential Environmental Impacts of Phase 1 Option ii – Rivers Bend Weir Option

The proposed Mokolo Weir is situated within the Mokolo River approximately 6 km south of the town of Lephalale. The weir is situated in a broad stretch of river where slow flowing water makes for the formation of reed beds and wetland type habitats.

The construction of a new weir or the expansion of an existing one will have an impact on the flow of the river and therefore affect the ecosystem upstream and downstream of the weir. The peak flows during flood conditions have the potential to overflow the normal floodplain of the river more frequently, damaging the surrounding ecosystems. The migration of fish species will also be disrupted due to the construction of a weir, while the siltation caused by the reduction in flow speed may significantly alter the natural habitat of certain fish species. The reduction in flow speed may also contribute to the introduction of wetland floral species such as reeds. Additional impacts include:

- Flooding of terrestrial ecosystems
- Preventing fish migration

- Altering riverine ecosystem.

The construction of fish ladders on the weir will minimize the impact on the fish migration due to the fact that it may allow fish breach the weir. The flooding of the terrestrial ecosystem is however almost impossible to mitigate.

7.5 Conclusion

Both the proposed options do not have an environmental fatal flaw should the correct mitigation measures be put in place. The pipeline does traverse some sensitive areas where particular care should be taken. These will be pinpointed during a detailed investigation. Rocky areas are most sensitive due to the presence of aloe species as well as the distinct habitat it provides for animal species. The construction of a new pump station at the Mokolo Dam might have a significant impact depending on the location of the facility. The area surrounding the dam has very steep slopes as well as large area of sensitive rocky outcrops. The construction of the pump station will in all likelihood result in the destruction of some of these areas. To minimize this impact the site for the pump station must be identified in conjunction with faunal and floral specialists.

The weir will impact on the flow of the river and therefore the migration of fish species. The decrease in the flow speed will also lead to siltation as well as the alteration of the riverine habitat. The possibility also exists that some terrestrial ecosystems next to the river may be inundated. The weir will also result in the increase in the 1:100 year flood line which will make some of the adjacent land unavailable for use for landowners. It is therefore foreseen that some of the land along the river will have to be acquired by the client. The construction of the pump station will also result in the loss of vegetation along the river. This is however not foreseen to have a significant impact as long as the area of disturbance is kept to a minimum.

Vegetation will have to be cleared for the construction of the power lines to the pump station at the weir site. The area surrounding the weir, except for the area within the riverine system, is not considered sensitive. The construction of a power line will therefore not have a significant environmental impact.

Due to the fact that pipeline alignment is adjacent to the existing pipeline and the vegetation has recovered along the existing pipeline it is a clear indication that the disturbance of the vegetation is of a temporary nature compared to the permanent impact of the weir on the flow of the river. With mitigation measures the construction of the pipeline will have a minimal lasting effect on the surrounding area. It is therefore considered the most unobtrusive option.

8. CAPITAL COST AND ECONOMIC ANALYSES

8.1 New Pipeline and Pump Station from Mokolo Dam

8.1.1 Total Capital Costs

Table 8.1 indicates the total capital costs at April 2008 prices, including landscaping, miscellaneous, Preliminary and General (P&G), contingencies and design fees, but excluding VAT.

Table 8-1: Breakdown of Capital Costs for the Pipeline from Mokolo Dam to Matimba Raw Water Storage Dam and Steenbokpan

Component	Total (R)
Pump Station (Peak pumping head 262 m)	130 784 000
Rising Main	
1000 mm diameter	90 539 000
Gravity Mains	
1000 mm diameter	590 530 000
800 mm diameter	445 137 000
Eskom – Electricity to site	76 430 000
Land Acquisition	6 200 000
Environmental Studies	500 000
TOTAL	**1 340 120 000**

Capital cost and Operation and Maintenance (O&M) was determined on the same basis as for the new infrastructure for the existing Exxaro supply system. This amount was then discounted to a residual value after 30 years. A further amount was added in 2015 for refurbishment of the pipeline. These amounts are reflected in the economic analyses.

8.1.2 Operation and Maintenance

Annual Operation and Maintenance (O&M) costs are based on percentages of capital cost as per VAPS guidelines accepted for this study, and are calculated as follows:

- 0.5% of pipeline capital cost.
- 4% of the electrical and mechanical installation of a pump station.
- 0.25% of the capital cost of civil structures, including the civil portion of pump stations.
- In determining the O&M costs, the cost of replacement of infrastructure, land acquisition, design and supervision fees was excluded.
- Electrical costs were based on the Megaflex Eskom tariff structure.

The annual operation and maintenance costs at April 2008 rates, when the scheme is operating at maximum capacity (excluding overhaul costs of pump station and VAT) are listed in Table 8.2.

Table 8-2: Breakdown of Annual O&M Costs for the Pipeline from Mokolo Dam to Matimba Raw Water Storage Dam and Steenbokpan at Maximum Capacity

Component	Total (R)
Pump Station	
Civil Maintenance	137 800
Mechanical and Electrical Maintenance	2 345 000
Electricity	16 922 000
Rising Main	
1000 mm diameter	394 000
Gravity Mains	
1000 mm diameter	2 568 000
800 mm diameter	1 935 000
Raw Water Cost	82 459 000
TOTAL	**106 760 800**

8.1.3 Discounted Present Value

The present value calculations are detailed in Appendix D1 and summarized in Table 8.3. The capital cost was spread out over two years and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2008.

Table 8-3: Summary of Present Values (PVs) for the Pipeline from Mokolo Dam – Total Scheme

Discount Rate	Capital (R)	O&M (R)	Total (R)
6%	1 239 316 000	1 117 839 000	**2 357 155 000**
8%	1 179 872 000	842 668 000	**2 022 540 000**
10%	1 124 715 000	660 615 000	**1 785 330 000**

8.1.4 Unit Reference Values

The unit reference value (URV) at April 2008 prices of water has been determined for a discount rate of 6%, 8% and 10% and is based on water transferred to the end consumers for a 45 year period. The URV is not the tariff for the water transferred and is only used to compare options with one another. The results are indicated in Table 8.4.

Table 8-4: Unit Reference Values for the Pipeline from Mokolo Dam – Total Scheme

Discount Rate	Discounted Present Value of Water based on R1.00/m³ (R million)	Discounted Present Value (R)	URV (R/m³)
6%	397.91	2 357 155 000	**5.92**
8%	300.46	2 022 540 000	**6.73**
10%	235.94	1 785 331 000	**7.57**

8.2 Rivers Bend Weir Pump Station and Pipeline

8.2.1 Total Capital Costs

Table 8.5 indicates the total capital costs at April 2008, including landscaping, miscellaneous, P & G, contingencies and design fees, but excluding and VAT.

Table 8-5: Breakdown of Capital Costs for the Pipeline from Rivers Bend Weir to Matimba Raw Water Storage Dam and Steenbokpan

Component	Total (R)
Weir Abstraction Works & Low Lift Pumps	139 484 000
Weir Siltation Works	12 883 000
Weir Balancing Dam	16 199 000
High Lift Pump Station (Peak pumping head 230 m)	94 014 000
Rising Mains	
1000 mm diameter	383 887 000
800 mm diameter	538 928 000
Eskom: Electricity to Site	131 220 000
Land Acquisition	10 000 000
Environmental Studies	500 000
TOTAL	**1 327 115 000**

Capital cost and O&M was determined on the same basis as for the new infrastructure for the existing Exxaro supply system. This amount was then depreciated (30 years old system). A further amount was added in 2015 for refurbishment of the pipeline. These amounts are reflected in the economic analyses.

8.2.2 Operation and Maintenance

Annual Operation and Maintenance (O&M) costs are based on percentages of capital cost as per VAPS guidelines accepted for this study, and are calculated as follows:

- 0.5% of pipeline capital cost.
- 4% of the electrical and mechanical installation of a pump station.

- 4% for the hydro-mechanical equipment of the weir.
- 0.25% of the capital cost of civil structures, including the civil portion of pump stations.
- In determining the O&M costs, the cost of replacement of infrastructure, land acquisition, design and supervision fees was excluded.
- Electrical costs were based on the Megaflex Eskom tariff structure.
- River losses between Mokolo Dam and Rivers Bend Weir to be augmented from Crocodile River (West) Transfer Scheme.

The annual operation and maintenance costs at April 2008 rates, when the scheme is operating at maximum capacity (excluding overhaul costs of pump station and VAT) are listed in Table 8.6.

Table 8-6: Breakdown of Annual O&M Costs for the Pipeline from Rivers Bend Weir to Matimba Raw Water Storage Dam and Steenbokpan at Maximum Capacity

Component	Total (R)
Weir Abstraction Works, Low Lift Pumps, Siltation Works and Balancing Dam	1 414 000
High Lift Pump Station	
Civil Maintenance	71 000
Mechanical and Electrical Maintenance	2 138 000
Electricity	13 360 000
Rising Mains	
1000 mm diameter	1 669 000
800 mm diameter	2 343 000
Raw Water Cost	101 259 000
Losses to be Augmented from Crocodile River (West) Transfer Scheme	42 300 000
TOTAL	164 554 000

8.2.3 Discounted Present Value

The present value consists of the capital costs plus the capitalized cost for operation and maintenance. The capital cost was spread out over two years and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2008. The calculations are detailed in Appendix D2 and summarized in Table 8.7.

Table 8-7: Summary of PV's for the Pipeline from Rivers Bend Weir – Total Scheme

Discount Rate	Capital (R)	O&M (R)	Total (R)
6%	1 232 088 000	1 703 302 000	**2 935 390 000**
8%	1 173 028 000	1 285 304 000	**2 458 332 000**
10%	1 118 220 000	1 008 625 000	**2 126 845 000**

8.2.4 Unit Reference Values

The unit reference value (URV) at April 2008 prices of water has been determined for a discount rate of 6%, 8% and 10% and is based on water transferred to the end consumers for a 45-year period. The URV is not the tariff for the water transferred and is only used to compare options with one another. The results are indicated in Table 8.8

Table 8-8: Unit Reference Values for the Pipeline from Rivers Bend Weir - Total Scheme

Discount Rate	Discounted Present Value of Water based on R1.00/m³ (R million)	Discounted Present Value (R)	URV (R/m³)
6%	397.91	2 935 390 000	**7.38**
8%	300.46	2 458 331 000	**8.18**
10%	235.94	2 126 845 000	**9.01**

8.3 Comparison of Options

The comparison between the options is listed in Table 8.9.

Table 8-9: Comparison of Options

Description	Pipeline from Mokolo Dam	Pipeline from Rivers Bend Weir
Total Pipeline Length (km)	79	63
Total Peak Pumping Head (m)	* 262	** 230
Project Cost excl VAT (April 2008 Values) (R)	**1 340 120 000**	**1 327 115 000**
Discounted Present Value 8% to 2008 (R)	1 179 872 000	1 173 028 000
URV 8% (R)	**6.73**	**8.18**

Note: * Static height difference plus friction losses between pump station (874 m) and Wolwenfontein (Full Supply Level (FSL)=1102 m) balancing dams.
** This scheme pumps water from the weir (level = 820 m) over a high point (level = 929 m) all the way to the users.

From Table 8.9 it can be seen that the capital cost of the River Bend Weir option is approximately R 13 million less than that of the Mokolo Dam pipeline option, but there is more risk attached to the cost and construction of the weir in the river due to the very limited geotechnical information available and uncertainties concerning river losses. This option will also require a larger Crocodile River (West) Transfer Scheme with the associated operational and maintenance costs. The River Bends Weir option has a higher URV due the replacement cost of the water due to river losses. From an engineering economic point of view the Mokolo Dam pipeline option is the preferred option to be implemented.

8.4 Milestone Dates

The following is a list of milestone dates for the proposed project:

Date	Milestone
30-Sep-08	Submission - Phase 1 Reconnaissance Report (Mokolo Transfer Options)
01-Oct-08	Site visit - Phase 1 Mokolo Transfer Options
06-Oct-08	Site Visit – KOBWA
07-Oct-08	TTT Recommendation - Phase 1 preferred option
10-0ct-08	DWAF Management Decision – Phase 1 options
14-Nov-08	Start procurement of Geotechnical services and Surveyor
01-Dec-08	Submission - Pre-Feasibility Recommendations to Ninham Shand
12-Dec-08	Submission - Phase 1 Feasibility Stage, excluding survey and geotechnical data
31-Mar-09	Design Consultant Appointed
30-Apr-09	Submission - Phase 1 Geotechnical Reports and Topographical Survey
07-Aug-09	Submission – Phase 1 Tender Design and Documentation
10-Jan-10	Contractor Appointed - Phase 1 Mokolo Transfer System
10-Jan-11	Deliver Water - Existing Mokolo Pump station and by-passes
08-Aug-11	Deliver Water - Mokolo Phase 1 Pump station operational and new pipeline

9. CONCLUSIONS AND RECOMMENDATIONS

From an engineering point of view the Mokolo Dam pipeline option is the preferred option. It is therefore recommended that a decision be taken to start with the Feasibility Stage.

From an environmental perspective due to the fact that pipeline alignment is adjacent to the existing pipeline and the vegetation has recovered along the existing pipeline it is a clear indication that the disturbance of the vegetation is of a temporary nature compared to the permanent impact of the weir on the flow of the river. With mitigation measures the construction of the pipeline will have a minimal lasting effect on the surrounding area. The Mokolo Dam pipeline option is therefore considered the most unobtrusive option.

In view of the scarcity of water in the area, the high degree of river losses anticipated and the concomitant wastage with its associated cost as well as the higher risk exposure of water delivery associated with the Rivers Bend Weir Option, this Option is not recommended for further consideration. Due to the losses, this option will require a larger Crocodile River (West) Transfer Scheme with the associated operational and maintenance costs.

APPENDIX A

WATER REQUIREMENT TABLES (25 AUGUST 2008)

APPENDIX B

INFRASTRUCTURE LAYOUT PLAN

APPENDIX C

LONGITUDINAL SECTIONS AND SCHEMATIC DIAGRAMS

APPENDIX D

CAPITAL COSTS AND ENGINEERING ECONOMIC ANALYSES

REPORT DETAILS PAGE

Project name:	***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)***
Report Title:	***Pre-Feasibility Study Report 5 - Mokolo River Development Options***
Author:	***JH vd Mescht (KV3)***
DWA report reference no.:	***P RSA A000/00/9209***
PSP project reference no.:	***WP 9528***
Status of report:	***Final***
First issue:	***December 2008***
Final issue:	***October 2009***

PSP

Approved for PSP by:

....

J Pienaar
Study Leader

PROJECT CO-ORDINATION AND MANAGEMENT TEAM

Approved for Project Coordinator by:

....

SC Vogel
Project Coordinator & Manager

DEPARTMENT OF WATER AFFAIRS (DWA)

Approved for Chief Directorate: Integrated Water Resources Planning by:

....

OJS van den Berg
Chief Engineer: Options Analysis North

....

LS Mabuda
Acting Chief Director: Integrated Water Resources Planning