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Water Affairs and Forestry

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

Project No. WP9528

SUPPORTING REPORT NO. 10

REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER

Lead Consultant: Africon

In association with: KV3, VELA VKE

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 A000/00/8509	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

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REPORT DETAILS PAGE

Project name:	***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)***
Report Title:	**Report 10 – Requirements for the Sustainable Delivery of Water**
Author:	***BC Viljoen; C Sellick; A Bell; R Chantler; A Muller***
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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.

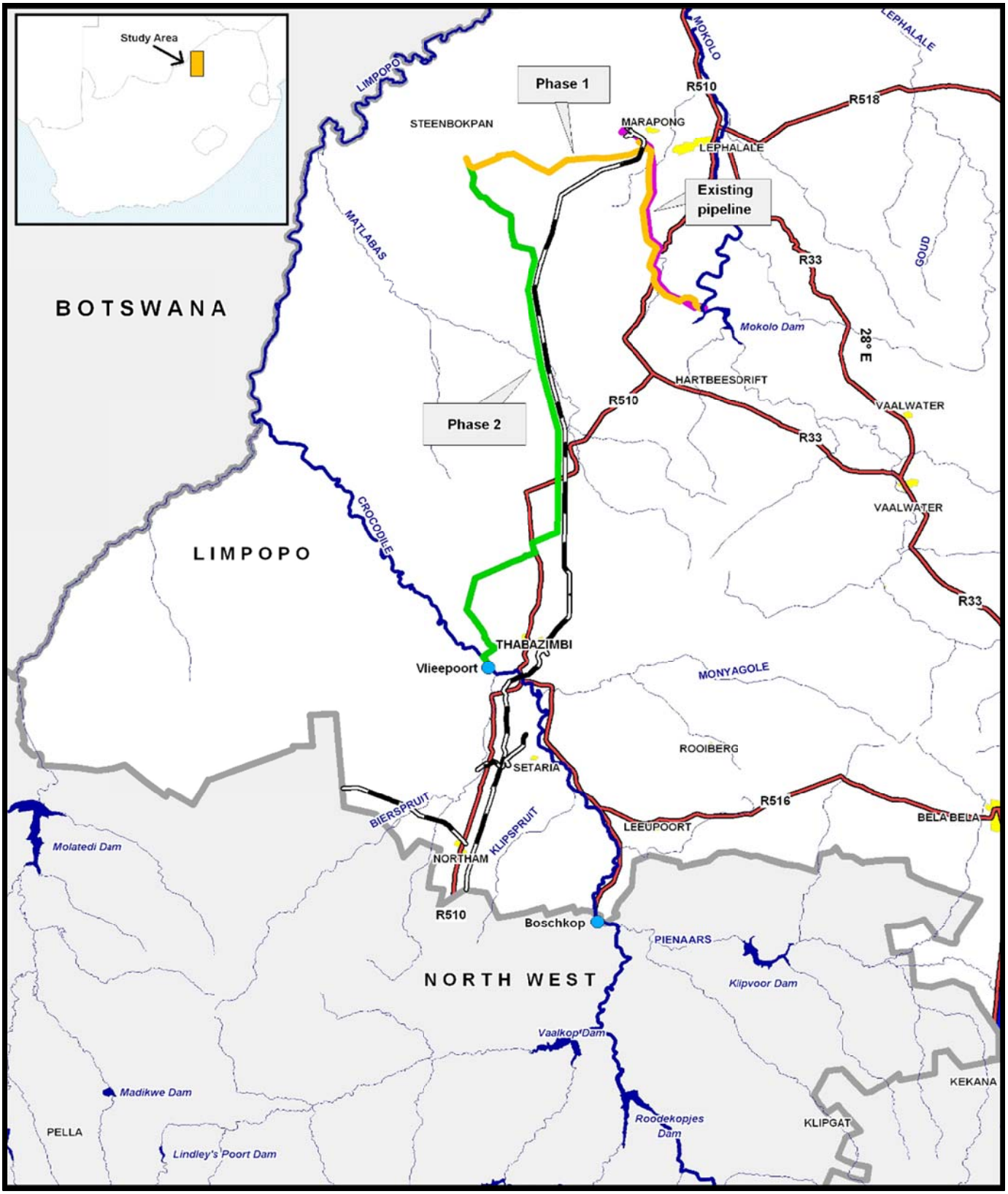
The Department of Water Affairs (DWA) commissioned the Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP) to analyse the options for transferring water from the Crocodile River (West). In April 2008, the Technical Module of this study was awarded to Africon in association with Kwezi 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 Steenbokpan and Lephalale area. Options to phase the capacity of the transfer pipeline (Phases 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 the Phase 1 and Phase 2 Schemes were presented to DWA during

October 2008 and draft reports were submitted during December 2008. The 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 a draft Feasibility report during October 2009 to the MCWAP Main Report in November 2009.

This report (P RSA A000/00/8609) covers the requirements for the sustainable delivery of water that have been performed for Phase I of the MCWAP.


Study Area
Phase 1
Phase 2
Existing pipeline
BOTSWANA
LIMPOPO
NORTH WEST
LIMPOPO
MOKOLO
LEPHALALE
STEENBOKPAN
MARAPONG
LEPHALALE
R510
R518
R33
GOUD
MATLABAS
Mokolo Dam
28° E
HARTBEESDRIFT
R510
VAALWATER
R33
VAALWATER
R33
CROCODILE
THABAZIMBI
Vlieepoort
MONYAGOLE
ROOIBERG
SETARIA
BIERSPRUIT
KLIPSPRUIT
R516
LEEUPOORT
BELA BELA
Molatedi Dam
NORTHAM
R510
Boschkop
PIENAARS
Klipvoor Dam
Vaalkop Dam
KEKANA
Madikwe Dam
PELLA
Roodekopjes Dam
KLIPGAT
Lindley's Poort Dam

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

REPORT 10: REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER

Project No. WP9528

EXECUTIVE SUMMARY

INTRODUCTION

There are a number of planned and anticipated consequential developments in the Lephalale area and up to Steenbokpan in the west that are associated with the rich coal reserves in the Waterberg coal field. These developments fall within the Mokolo River catchment and will require substantial amounts of additional water supplies. Unfortunately, the availability of water in this area is severely limited and water will have to be imported from the Crocodile River (West). Both these rivers are main tributaries of the Limpopo River, which is shared by South Africa and its neighbouring states of Botswana, Mozambique and Zimbabwe.

BACKGROUND

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 only large dam in this area and the only source of surplus water that is readily available to augment the water supplies to the Lephalale area at an early stage, but the surplus water is far too little to supply the eventual water requirements in this area.

The Crocodile River (West) catchment is part of the Crocodile River (West) / Marico WMA. The Crocodile River (West) originates in the northern suburbs of Johannesburg and drains to the north-west into the Limpopo River. The Hartebeespoort, Klipvoor, Roodekopjes and Vaalkop Dams on the Crocodile River (West) and its tributaries, are all significant dams in this WMA. The natural runoff from the catchments of these dams is already fully allocated to supply existing users, and any new demands will have to be met by the increased effluent return flows from the Gauteng area. This water will have to be transferred from the Crocodile River (West) to the Mokolo catchment to augment the supplies to the Lephalale area. This will occur by means of the proposed ***Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)****.*

MCWAP INFRASTRUCTURE DEVELOPMENT

The MCWAP will be developed in the following two phases:

- ***Phase 1:*** *Augment the water supply directly from the Mokolo Dam to supply partly in the growing water requirements in the area between Lephalale and Steenbokpan.*

  The Phase 1 works comprise the existing infrastructure, a new Mokolo pumping station and a new pipeline which will be constructed and commissioned parallel to the existing pipeline from Mokolo Dam to the point of supply close to Matimba Power Station. It is aimed at optimising the utilisation of water from the Mokolo Dam. This augmentation could be implemented in the shortest possible time.

- ***Phase 2:*** *The Phase 2 works will comprise transferring return flows from the Crocodile River (West) catchment to the point(s) where it is required near Lephalale. It is proposed that the implementation of this phase runs concurrently to Phase 1, but it will take longer to implement. The required infrastructure includes a diversion weir and associated Low-lift pump station on the Crocodile River (West) (Vlieëpoort) near Thabazimbi. It also includes desilting and balancing storage facilities from where a High-lift pump station will feed water into a large diameter pressure and gravity pipeline system to the demand centres in the Lephalale and Steenbokpan areas (Sub-phase 2A). A second pipeline and additional pumping capacity (Sub-phase 2B) may be constructed at a later stage, when required. Phase 2 infrastructure will connect to the Phase 1 infrastructure. Water will be delivered to the storage facilities of users.*

  As part of Phase 2, an abstraction and river flow monitoring and management system needs to be implemented on sections of the Crocodile River (West) and its tributaries. This will comprise the Crocodile River (West) from the Hartebeespoort Dam to Vlieëpoort and the Moretele River from Klipvoor Dam to the confluence with the Crocodile River (West). This system will monitor abstraction from the rivers and manage releases and flow in the said rivers, in order to ensure the adequate supply of water at Vlieëpoort for abstraction and the equitable supply to irrigation and the environment.

PURPOSE AND APPROACH OF THE REPORT

The purpose of this report is to describe, in broad outline, the issues that need to be considered in each of the Mokolo and Crocodile River (West) catchments that will be required to ensure a sustainable supply of water at the required level of assurance to the existing new water users in the Lephalale – Steenbokpan development area with due cognisance of:

- *the lawful entitlements of existing users;*
- *the Reserve requirements;*
- *International obligations;*
- *water quality aspects;*

- *the optimal management of the water resources; and*
- *the effective and efficient management of the infrastructure.*

STRUCTURE OF THE REPORT

This report ties the content of five (5) different, almost stand-alone aspects (shown in the Appendices), into a single document. The main body of the report summarises the content of the Appendices in an effort to provide an overview of the salient issues. The appendices can be utilised as stand-alone focussed documents.

This report is presented in four (4) different sections.

- *The first section covers the larger water resources aspects to be considered to ensure that the MCWAP is managed in an equitable and sustainable fashion.*
- *The second section deals with the operational approach and principles concerning the operation and maintenance (O&M) of the MCWAP System with the new and existing infrastructure.*
- *Section three deals with the dams and river management, covering the possible additional works required at existing dams, river management and the data required for such management.*
- *Section four on the institutional arrangements, is a logical corollary of the other sections, namely to provide some thoughts on important aspects to be considered in establishing an acceptable institution (or maybe more than one) to give effect and put into practice what is envisaged in the first sections.*

INTEGRATED WATER RESOURCES MANAGEMENT

CURRENT WATER USERS

Being within a highly populated and industrialised part of the country, it is to be expected that the water uses from the Crocodile River (West) catchment will encompass all possible sectors of Agricultural, Domestic, Industrial, Mining, Recreation, etc. Therefore, it is not surprising that it is home to one of the oldest and well known dams in the country, namely Hartebeespoort, from local runoff which was completed during 1923. It is also not surprising that the available resources are already highly developed and utilised.

Mokolo Dam was completed in 1980 to supply water to the Mining and Electricity Sector in the area and to stabilise the water supply to the Agricultural Sector downstream of the dam. The source is limited and committed with little spare capacity.

Mokolo River Catchment

Currently, the main water users from the Mokolo River catchment are the town of Vaalwater, the irrigators upstream of the Mokolo Dam, the irrigators downstream of the dam that receive water released from the dam into the Mokolo River, and the Lephalale Municipality, Exxaro and Eskom that abstract water directly from the dam.

Due to the changed land use from irrigation to game farming in the catchment of the Mokolo Dam over a number of years, as well as a reduction in illegal water use, the firm yield of the dam increased. There is thus limited scope for increased allocations from the dam, but the increased yield from a raised dam will not be adequate for the expected full demands.

Crocodile River (West)

The Crocodile River (West) as sourced currently has surplus water available above the legal entitlements of the existing users. This river receives a substantial portion of the available yield as return flows from the Gauteng area where the water originates from the Vaal River System.

The main water users from the portion of the Crocodile River (West) catchment downstream of the Klipvoor, Roodekopjes and Vaalkop Dams are the existing users that comprise:

- *The irrigators downstream of the three dams represented by the Crocodile River (West) Irrigation Board (upstream of Vlieëpoort) and the Makoppa farmers (downstream of Vlieëpoort);*
- *The platinum mines and associated settlements to the west of the Crocodile River;*
- *A number of rural towns and villages north and east of the Pilanesberg, and also in the catchment of the Tolwane River (tributary of the Lower Pienaars River) between the Klipvoor and Roodekopjes Dams;*
- *The users supplied from the small Zandriviersdrift and Bierspruit Dams on the Sandrivier and Bierspruit, respectively;*
- *Thabazimbi Local Municipality;*
- *Magalies Water Board receiving water from Vaalkop and Hartebeespoort Dams (flowing through Roodekopjes Dam), supplying domestic and industrial users in the Rustenburg, Sun City, Thabazimbi, etc. areas.*

ECOLOGICAL WATER REQUIREMENTS

The DWA is currently busy with the determination of the preliminary Reserve in terms of Section 18 of the National Water Act (Act 36 of 1998) for both the Mokolo and Crocodile (West) Rivers, in separate processes.

ASSURANCE OF SUPPLY

The primary objective of the successful operation of MCWAP is to establish and maintain the required assurance of supply to all water users receiving water from the system. The system supplies multiple water user sectors, each with different assurance of supply requirements which must be accommodated in the analysis procedures and operating rules applied by DWA.

A challenge in future would be to address the expectations that evolved during recent years amongst all user groups in the Crocodile River (West) catchment with regards to the level of assurance they have enjoyed.

EXISTING WATER RESOURCE AND INFRASTRUCTURE MANAGEMENT ARRANGEMENTS

Mokolo River

The water supply from the Mokolo Dam to the domestic and industrial users is managed by Exxaro. They own and operate the existing raw water pipeline and related infrastructure from the Mokolo Dam to the end users. They also own and operate the Zeeland Water Treatment Works (WTW). As Exxaro has permanent staff on the site, they are actually also the operator of the dam in practice. They make the release of water to the downstream irrigation as per the operating rules and instructions from DWA, in consultation with the Mokolo Irrigation Board.

The Mokolo Irrigation Board is responsible for the regulation of the releases from the dam and the abstraction by the irrigators directly from the river and from the alluvial aquifer. The Irrigation Board is in the process of being transformed into a Water User Association (WUA).

Crocodile River (West)

The water resource regulatory function of DWA in this catchment is managed by the North-West Regional Office of DWA.

The water supply to the Agricultural Sector from the Hartebeespoort canal system is managed by the Hartebeespoort Irrigation Board, and receives its water from the Hartebeespoort Dam.

The irrigators downstream of the Klipvoor and Roodekopjes Dams up to the so-called "Hugo" Weir forms part of the Crocodile River (West) Irrigation Board.

Downstream of the "Hugo" Weir and up to the Limpopo River, there is also substantial irrigation development. This area is called the Makoppa area. Irrigation in this area is dependent on run of river flow only and is not supported by releases from any storage dams and other regulating measures in this area are the responsibility of DWA – North-West Region.

MANAGEMENT OF THE MOKOLO AND CROCODILE RIVER (WEST) CATCHMENTS

The yield of the Mokolo Dam is vulnerable to possible increased irrigation development in the catchment. This will need to be controlled intensely; a function currently the responsibility of DWA – Limpopo Region.

The MCWAP will require the integrated management of the MCWAP infrastructure, together with the existing infrastructure such as the different dams, rivers, etc. It will also require the integrated and coordinated management of the Mokolo and Crocodile River (West) catchments.

APPROACH TO THE OPERATION OF THE MCWAP INFRASTRUCTURE

The Operation and Maintenance Philosophy of the MCWAP infrastructure is described in detail in ***Appendix B: The Assessment of Additional Works required at Upstream MCWAP Water Supply Dams in the Crocodile River (West).*** *This document can be used as a separate report.*

STORAGE AND CONVEYANCE SYSTEMS OF THE MCWAP

In essence, the Mokolo Dam water will primarily be provided to existing consumers such as Matimba Power Station, Municipal users in the vicinity of Lephalale (Ellisras), as well as the new Medupi Power Station (partly), while the Crocodile River (West) Transfer Scheme will provide water to the new consumers such as Eskom and Sasol.

Mokolo Dam Transfer Scheme (Phase 1)

The new and existing gravity pipelines will deliver water into the terminal reservoirs serving the consumers supplied from the Mokolo Dam Scheme (i.e. Lephalale/Zeeland WTW, Matimba Power Station, Medupi Power Station, and possibly some needs of the Steenbokpan consumers).

Crocodile River (West) Transfer Scheme (Phase 2)

The water to be transferred from the Crocodile River (West) will be released from Hartebeespoort Dam, via the Roodekopjes Dam, as well as from Klipvoor, Roodeplaat and possibly Vaalkop Dams. Water for the MCWAP will be abstracted at the Vlieëpoort abstraction works, which is located some 134 km downstream of Roodekopjes Dam on the Crocodile River (West) where it will be abstracted and pumped to the end users.

OPERATIONAL APPROACH AND PRINCIPLES

Integrated System

The whole MCWAP will have to be operated as an integrated system irrespective of who owns or operates each component of the system.

Infrastructure Availability and Redundancy

The operating procedures and maintenance plans must support the principle of achieving a long-term minimum availability of 95% which relates in the worst case to a single event of non-supply not exceeding 18 days.

User Terminal Reservoirs

Bulk users will be required to provide their own Terminal Reservoirs with 16 to 18 days of storage.

Centralisation of MCWAP Operations

Since it is envisaged that both transfer systems (i.e. Crocodile River (West) and Mokolo Dam) will be managed as an integrated system (perhaps by the same Authority), it is proposed that both the transfer schemes are controlled and managed from one operational control centre, conveniently located more or less at the centre of operational activities (i.e. Vlieëpoort/Thabazimbi or Lephalale).

Diversity of User Groups and Levels of Assurance

The system supplies multiple water user sectors, each with different assurance of supply requirements, which will be accommodated in the resource operating rules and scheme procedures applied by DWA.

Honour Existing Lawful Use and Reserve Requirements

The MCWAP aims to satisfy most of the water demands of the new anticipated developments from the increasing source of return flows from the Gauteng area. Operating rules for both the Mokolo and the Crocodile River (West) systems will be developed by DWA in a separate process and must take cognisance of this and ensure that existing lawful use is respected and protected. Similarly, it is a legal requirement that provision is made for meeting the requirements of the Reserve.

MAINTENANCE

A proactive approach to maintenance in the form of a preventative maintenance plan would be essential on a scheme of this magnitude and strategic importance. A schedule of the maintenance is provided in ***Appendix A: Operation and Maintenance Philosophy****.*

DAMS AND RIVER MANAGEMENT

BETTERMENTS TO EXISTING WATER RESOURCES INFRASTRUCTURE

Storage Dams

The water requirements for Phase 2 of the MCWAP Transfer Scheme will be supplied by releases from dams in the Crocodile River (West) upstream of the abstraction works at Vlieëpoort. The dams identified as potential primary water sources are Hartebeespoort and Roodekopjes Dams on the Crocodile River (West), Roodeplaat and Klipvoor Dams on the Moretele (Pienaars River) and Vaalkop Dam on the Elands River.

Additional Outlet Capacity Requirements

The assessments done, show that:

- *The primary supply node, the Hartebeespoort Dam - Roodekopjes Dam node, would need support from the Moretele River soon after commissioning of Phase 2 of the MCWAP.*
- *If releases for MCWAP started with Hartebeespoort and Roodekopjes Dams close to Full Supply Level (FSL), the introduction of the Kilpvoor Dam – Roodeplaat Dam node could be postponed by a year to end of 2016.*
- *The latest date at which additional outlet capacity would need to be provided at Hartebeespoort and Roodekopjes Dams would be 2015, but that could be delayed to as late as 2025, depending on the degree of support that could be provided from Klipvoor and Roodeplaat Dams.*

Balancing Storage in the Crocodile River

In the context of the scheme at large, the buffer storage at Vlieëpoort is limited. The total river distance between Roodekopjes and Vlieëpoort is 134 km and to make any flow adjustments in the order of 7 to 9 days to be effected, depending on the nature of the adjustments.

To improve the management of the river reach and to ensure more efficient use of the available water, a study should be conducted to establish whether balancing storage between Roodekopjes and Vlieëpoort could add value to the system.

Decision Support Systems

In order to ensure that water released from the Roodekopjes and/or Klipvoor Dams reach the abstraction weir at Vlieëpoort to meet the required abstraction for MCWAP, proper management thereof will be required. A proper River Management System will need to be designed and implemented. Such system will utilise a bouquet of decision support systems.

Decision support systems will be required by DWA (or a River Management Authority(ies)) to manage those water supplies, releases, river flows and abstractions. Water resource allocation models should be utilised to determine water allocations and possible curtailments to the various users and river flow management models should be utilised to manage releases, river flows and abstractions. Some of these models will be incorporated into the operating rules, but the balance needs to be captured in the design of a River Management System.

IMPROVED DATA ACQUISITION AND MONITORING

Flow Measurement: Two sets of data should be collected, each with its own specific application and different levels of confidence attached to it. The data sets are:

- *Real and near real time data (electronic acquirement); and*
- *On-site monitoring and historic data.*

Extensive improvements to "Hugo's" Weir will be required to allow flow measurement to the DWA standards.

It is also recommended that a new river flow gauging station be constructed in the Crocodile River (West) at the first suitable site downstream of Vlieëpoort. In addition to the above, new river flow gauging station, provision should also be made at this stage for at least one other new river flow gauging station in case operational experience indicates that such a gauging weir will improve the efficiency with which the river system is managed and diffuse losses and unauthorised uses can be estimated.

Flows from the Bierspruit and Sandrivier should also be measured to ensure that these flows are allowed to pass the Vlieëpoort abstraction works. The motivation for these additional gauging weirs is provided in Part 4 of this report.

Supporting communications infrastructure provided should be based on a fibre optic and Global System for Mobile Communications (GSM) network. The gauging weirs should be included in the fibre optic network to ensure that real time data is available at all times. The meters installed at the user abstraction points should be adequately served by a GSM network.

Communication: Day-to-day communication with affected parties should take place by means of the proposed web site, telephone, tele-fax and e-mail facilities. These facilities should be available to the User Representatives and the River Management Authorities. In addition, the proposed Communication Forms, comprising User Representatives and the River Management Authorities, should be established where specific issues can be discussed.

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Groundwater Abstraction Measurement and Monitoring

It is also recommended that borehole water level monitoring be instituted at Vlieëpoort to compliment surface flow measurements and to ensure that the alluvial aquifer downstream of Vlieëpoort would not be negatively impacted on by the proposed Vlieëpoort abstraction works. Such monitoring would have to start well in advance of the proposed MCWAP construction work to establish base line conditions.

Continued borehole water level monitoring would be required after construction of the abstraction works to confirm the adequacy of releases from the abstraction weir to recharge the aquifer downstream of Vlieëpoort.

INSTITUTIONAL

WATER RESOURCE MANAGEMENT

National Government, namely DWA as the custodian of the water resources of the country and acting through the Minister, is responsible for managing the water resources of the country. DWA will be responsible for the overall water resource management in the Crocodile River (West) and Mokolo River catchments, receives and evaluates water requirements and incorporates these requirements into the water resource management plan and inter alia, issue water use licenses and directives accordingly. In this regard, DWA and the to-be-established Catchment Management Agencies (CMAs) need to perform a regulatory function. The Minister may establish suitable institutions in order to achieve the objectives mentioned above.

- *DWA – National Water Infrastructure Branch (NWIB);*
- *Water Boards and Water Users Associations (WUAs);*
- *CMAs; and*
- *Any other body nominated by DWA and approved by the Minister.*

Institutional Management

Institutional management in the MCWAP context needs to be considered along the following main components:

- *Water Resource Management;*
- *River Management; and*
- *Scheme Infrastructure Management, i.e. operations and maintenance (O&M) of works.*

INSTITUTIONAL CONCEPTS

Requirements have been laid down to ensure that through the sound management of the water resources and the infrastructure, a sustainable supply of water to all water users in the Lephalale-Steenbokpan area is achieved. All of this can only be accomplished if the necessary institutional arrangements are put in place. It will be necessary to have a dedicated authority(ies) to manage the water allocated by DWA to the MCWAP, to manage the use of the allocated water by the users supplied from the MCWAP and to manage, operate and maintain the MCWAP.

Centralised Control

The operation of a scheme of this nature will require strong management, liaison and leadership skills, as well as a competent support team to plan dam releases, manage and monitor water usage and to operate and maintain the extensive infrastructure. Because of the interdependencies and to give effect to the principle of an integrated systems approach, it stands to reason that a dedicated team located within the management area should be provided.

River Management

The river flows along the river reaches downstream of the Klipvoor, Roodekopjes and Vaalkop Dams as far downstream as Vlieëpoort with various users taking water along the rivers.

MCWAP Scheme Management

As far as the management of water supply schemes or projects themselves are concerned, these can be managed and operated by either:

- *Water Authorities, such as Water Boards or other utilities; or*
- *DWA – National Water Infrastructure Branch (NWIB).*

At least three management options are possible and need to be investigated further:

i. *Dedicated team provided by DWA (or Trans-Caledon Tunnel Authority (TCTA));*
ii. *DWA (or TCTA) contracting a concessionaire or a team from the private sector to work under their auspices; or*
iii. *A dedicated MCWAP Authority needs to be created along the lines of Komati Basin Water Authority (KOBWA) and other similar authorities.*

INSTITUTIONAL OPTIONS

A wide spectrum of institutions is available to perform the functions of Water Resource Management, River Management and Scheme Management. Apart from those provided for in the NWA (1998) and the Water Services Act (Act 108 of 1997), such as Water Boards, Water User Associations, etc., other options are also available. A good example of an institution performing such a function is KOBWA. KOBWA was created in terms of a special Treaty. The creation of such bodies is provided in Section 162 of the NWA. KOBWA provides a similar service in the Komati River Basin as the specialist service that will be required with the management of KOBWA and the water resource issues.

A critical success factor for the management of MCWAP will be to mobilise the required human and financial resources to perform the management function, including operation, maintenance, monitoring, control, etc. In this regard, it will be necessary to investigate options whereby the large users of MCWAP can be considered as active partners in the management, i.e. be involved in resourcing, involved on the Boards, etc. Some important options, issues and proposals for an institutional framework are discussed in ***Appendix E*** *and the relationships shown in the diagram in Chapter 7 - Figure 7-1.*

CONCLUSIONS AND RECOMMENDATIONS

The MCWAP Phase 1 and Phase 2 infrastructure need to be operated as an integrated scheme, with consolidated tariffs, allocations, etc. Such a MCWAP Scheme also needs to be managed in an Integrated Water Resource Management approach with the existing users on the river systems. In this regard, is it of crucial importance that the management

of river flows and abstractions along the Crocodile River (West) be incorporated in the management of the MCWAP.

The objective of MCWAP to supply water to new users without affecting the legal entitlements of existing users will pose challenges to the management of the water resources and the management of the MCWAP infrastructure. The high level of expectations of existing users in terms of assurance of supply will require continuous communication with the parties and management of potential conflicts. The institutions responsible for those functions need to be properly resourced to deal with such challenges.

Water resources management will be a critical success factor for MCWAP. The catchment of Mokolo Dam needs to be properly controlled to prevent any further development that can impact negatively on the runoff to Mokolo Dam. Likewise, the monitoring and control of abstraction from the Crocodile River (West) will need to be managed intensively.

As the water, utilised from the Crocodile River (West), is made available in the river as return flows, effective and efficient measures need to be in place to control the water quality, i.e. pollution control measures and actions need to be managed well. It is of crucial importance that adequate resources be made available to perform this function. Technical and legal expertise will be required.

The Reserve determination will need to be finalised for the implementation of the operating rules and the MCWAP Scheme. The monitoring of the Reserve requirements should be an important responsibility of the Authority managing the MCWAP.

Operating rules for the Mokolo and Crocodile (West) Rivers need to be finalised whereby the assurance of supply to the users, procedures for determining annual allocations, etc. is to be formalised. In this regard, a variety of decision support tools needs to be developed for the Authority that will manage the system in future.

Additional infrastructure will be required. The outlet capacities of at least the Hartebeespoort, Roodekopjes and Klipvoor Dams will need to be investigated further. Betterments to the outlet structures will most probably be required.

The upgrading of existing water resource infrastructure will most probably be required. The outlet capacities of at least the Hartebeespoort, Roodekopjes and Klipvoor Dams will need to be investigated further. Betterments to the outlet structures may be required. Additional flow gauging will be required on the Bierspruit and Sandrivier close to the confluence with the Crocodile River (West). The accurate measurement and control of abstractions will be a crucial factor. All irrigation abstraction needs to be fitted with meters and control mechanisms. It is recommended that the above capital requirements be

incorporated in the capital costs of MCWAP Phase 2. It should be attended to during the design stage.

In the case of the Mokolo River, none of the gauging weirs further downstream of Mokolo Dam is functional and would make water flow measurement control and management more complex. Station A4H013 would be very useful in this regard and it should be investigated if it can be re-instated or an alternative site developed.

Flow measurement at the end of the Crocodile River (West) Irrigation Board's area would be very valuable. The existing structure at "Hugo's" Weir (A2H116), which is located some 20 km upstream of Vlieëpoort, is ideal, but considerable betterments should be undertaken to improve the weir structure to DWA standards and to install the latest flow gauging instrumentation. The present installation appears to have stopped functioning in 1995 and was only capable of measuring flows up to 7 m^3/s.

The alluvial aquifer in the Crocodile River (West) and Mokolo River sustain the current irrigation use, and is an important source. The monitoring of the groundwater in the alluvium will be very important, specifically in the proximity of the Vlieëpoort Weir. It is recommended that a proper groundwater monitoring system be developed for the river and implemented as a matter of priority.

Regarding the future institutional management of MCWAP and the water resources serving this area, it will require new challenges to institutions. The water resources management of DWA in these catchments will require more resources in skilled and dedicated staff. The management of MCWAP and the management of the abstraction from the rivers will also require an order of magnitude increase in intensity of the management function and cost in relation to what is currently operational in the area. Focused and dedicated staffing will be required.

The challenge for the institutional arrangement will be to resource the institution properly in terms of budgeting, equipment, human resources, etc. In this regard, it is important that a partnership is sought between DWA and the large users for the management of MCWAP.

There are a number of institutional options available, including Water Boards, concessionaires, dedicated authorities such as Basin Water Authority, etc.

It is recommended that the institutional arrangements be investigated in consultation and close cooperation with the users and the Irrigation Boards (WUAs).

MOKOLO AND CROCODILE RIVER (WEST) WATER AUGMENTATION PROJECT (MCWAP) FEASIBILITY STUDY

REPORT 10: REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER

Project No. WP9528

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

APPENDICES

LIST OF ABBREVIATIONS

CMA	Catchment Management Agency
CRW	Crocodile River (West)
DWA	Department of Water Affairs
FCSV	Fixed Cone Sleeve Valve
FSL	Full Supply Level
GSM	Global System for Mobile Communications
IFR	Instream Flow Requirements
IWRM	Integrated Water Resource Management
KOBWA	Komati Basin Water Authority
MCWAP	Mokolo and Crocodile River (West) Water Augmentation Project
MR	Mokolo River
NWIB	National Water Infrastructure Branch
NWA	National Water Act (Act 36 of 1998)
OC	Overspill Crest
O&M	Operation and Maintenance
PLC	Programmable Logic Controller
RMA	River Management Authority
RMF	Regional Maximum Flood
SCADA	Systems Control and Data Acquisition
SMA	Scheme Management Authority
TCTA	Trans-Caledon Tunnel Authority
USAID	United States Agency for International Development
VSD	Variable Speed Drive
WMA	Water Management Area
WTW	Water Treatment Works
WUA	Water User Association

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

REPORT 10: REQUIREMENTS FOR THE SUSTAINABLE DELIVERY OF WATER

Project No. WP9528

1. INTRODUCTION

There are a number of planned and anticipated consequential developments in the Lephalale area and up to Steenbokpan in the west that are associated with the rich coal reserves in the Waterberg coal field. These developments fall within the Mokolo River catchment and will require substantial amounts of additional water supplies. Unfortunately, the availability of water in this area is severely limited and water will have to be imported from the Crocodile River (West). Both these rivers are main tributaries of the Limpopo River, which is shared by South Africa and its neighbouring states of Botswana, Mozambique and Zimbabwe.

1.1. Background

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 only large dam in this area and the only source of surplus water that is readily available to augment the water supplies to the Lephalale area at an early stage, but the surplus water is inadequate to supply the eventual water requirements in this area.

The Crocodile River (West) catchment is part of the Crocodile River (West) / Marico WMA. The Crocodile River (West) originates in the northern suburbs of Johannesburg and drains to the north-west into the Limpopo River. The Hartebeespoort, Klipvoor, Roodekopjes and Vaalkop Dams on the Crocodile River (West) and its tributaries, are all significant dams in this WMA. The natural runoff from the catchments of these dams is already fully allocated to supply existing users, and any new demands will have to be met by the increased effluent flows from mainly, the Gauteng area. This water will have to be transferred from the Crocodile River (West) to the Mokolo catchment to augment the supplies to the Lephalale area. This will occur by means of the proposed **Mokolo and Crocodile River (West) Water Augmentation Project (MCWAP)**.

1.2. MCWAP Infrastructure Development

The MCWAP will be developed in the following two phases:

- **Phase 1:** Augment the water supply directly from the Mokolo Dam to supply partly in the growing water requirements in the area between Lephalale and Steenbokpan.

  The Phase 1 works comprises of the existing infrastructure, a new Mokolo pump station and a new pipeline which will be constructed and commissioned parallel to the existing pipeline from Mokolo Dam to the point of supply close to Matimba Power Station. It is aimed at optimising the utilisation of water from the Mokolo Dam. This augmentation could be implemented in the shortest possible time.

- **Phase 2:** The Phase 2 works will comprise transferring return flows from the Crocodile River (West) catchment to the point(s) where it is required near Lephalale. It is proposed that the implementation of this phase runs concurrently to Phase 1, but it will take longer to implement. The required infrastructure includes a diversion weir and associated Low-lift pump station on the Crocodile River (West) (Vlieëpoort) straddling the farms Hanover 667, Donkerpoort 344 and Mooivallei 342 near Thabazimbi. It also includes desilting and balancing storage facilities from where a High-lift pump station will feed water into a large diameter pressure and gravity pipeline system to the demand centres in the Lephalale and Steenbokpan areas (Sub-phase 2A). A second pipeline and additional pumping capacity (Sub-phase 2B) may be constructed at a later stage, when required. Phase 2 infrastructure will connect to the Phase 1 infrastructure. Water will be delivered to the storage facilities of users.

As part of Phase 2, an abstraction and river flow monitoring and management system needs to be implemented on sections of the Crocodile River (West) and its tributaries. This will comprise the Crocodile River (West) from the Hartebeespoort Dam to Vlieëpoort and the Moretele River from Klipvoor Dam to the confluence with the Crocodile River (West). This system will monitor abstraction from the rivers and manage releases and flow in the said rivers, in order to ensure the adequate supply of water at Vlieëpoort for abstraction and the equitable supply to irrigation and the environment.

The full MCWAP Phases 1 and 2 will be operated as an integrated system.

2. PURPOSE AND APPROACH OF THE REPORT

2.1. Objective of the Project

The objective of the MCWAP is to implement feasible options to transfer water from the Mokolo River and Crocodile River (West) to Lephalale and Steenbokpan without impacting on the legal water entitlements of existing users.

2.2. Purpose of the Report

The purpose of this report is to broadly describe the matters that need to be considered and the measures that need to be in place in order for the project to reach its objectives. In this regard, the focus is on the management and operational measures that are required not only for the new MCWAP infrastructure, but the entire system. These measures are required in the management of the Mokolo and Crocodile River (West) catchments to ensure a sustainable supply of water at the required level of assurance to the existing and new water users in the Lephalale – Steenbokpan development area. The aspects covered in the separate documents relate to the measures required to be able to manage the important component of using the Crocodile River (West) as conduit, the operational requirements for MCWAP and also cover some input on institutional arrangements that may be considered. In the management of the MCWAP, due cognisance must be taken of:

- The lawful entitlements of existing users;
- The Reserve requirements;
- International obligations;
- Water quality aspects;
- The optimal management of the water resources; and
- The effective and efficient management of the infrastructure.

In the Mokolo catchment, as well as the Crocodile River (West) catchment, the water allocation to the different water users is made in different quantities and at different levels of assurance. The legal entitlements of the existing users are from the natural surface runoff originating in the various sub-catchments, whereas the allocation from the Crocodile River (West) to the new water users will be based on the return flows originating in the Gauteng area.

The common denominator amongst all users is the need for sustainability of and equity in water supply. This is the important fundamental principle that must form the base on which to found the management of the water resources in this area. In both the Mokolo and the Crocodile River (West) catchments, it would be essential to manage MCWAP in the context of a holistic, integrated approach that encompasses both catchments. This Report highlights some important aspects in this regard.

Regarding the institutional aspects, it needs to be noted that the institutional management must still be investigated. Inputs from a technical perspective are made for such a process. For ease of reference, the institution responsible for management of the MCWAP infrastructure is referred to as Scheme Management Agency (SMA). The body(ies) responsible to manage aspects relating to the rivers are referred to as a River Management Agency (RMA). The overall controlling institution to oversee the above, is referred to as the MCWAP Authority.

3. STRUCTURE OF THE REPORT

This report ties the content of five (5) different, almost stand-alone aspects (shown in the Appendices), into a single document. The main body of the report summarises the content of the appendices in an effort to provide an overview of the salient issues. The appendices can be utilised as stand-alone focussed documents.

This report is presented in four (4) different sections.

- The first section covers the larger water resources aspects to be considered to ensure that the MCWAP is managed in an equitable and sustainable fashion.
- The second section deals with the operational approach and principles concerning the operation and maintenance (O&M) of the MCWAP System with the new and existing infrastructure.
- Section three deals with the dams and river management, covering the possible additional works required at existing dams, river management and the data required for such management.
- Section four on the institutional arrangements is a logical corollary of the other sections, namely to provide some thoughts on important aspects to be considered in establishing an acceptable institution (or maybe more than one) to give effect and put into practice what is envisaged in the first sections.

In none of the sections is it the intention to provide final ready-made solutions to the matters raised, but rather highlight the important matters that need to be addressed in more detail.

4. SECTION 1: INTEGRATED WATER RESOURCES MANAGEMENT

The one fundamental requirement to ensure that a sustainable and equitable supply of water to all user groups is achieved will be to adopt the basic principles of Integrated Water Resource Management (IWRM). Although there is no one universally agreed definition of IWRM, there is a great deal of common ground in most definitions. It is basically a participatory planning and implementation process, based on sound science, which brings together stakeholders to determine how to meet the long-term needs for water resources while maintaining essential ecological services and economic benefits (United States Agency for International Development (USAID) definition).

Some of the principle components of IWRM, as set out by USAID, include:

- **"Managing water resources at the basin or watershed scale.** This includes integrating land and water, upstream and downstream, as well as groundwater, and surface water.
- **"Optimising supply.** This involves conducting assessments of surface and groundwater supplies, analysing water balances, adopting wastewater re-use, and evaluating the environmental impacts of distribution and use options.
- **"Managing demand.** This includes adopting cost recovery policies, utilising water-efficient technologies, and establishing decentralised water management authorities.
- **"Providing equitable access to water resources** through participatory and transparent governance and management. This may include support for effective water users' associations, involvement of marginalized groups, and consideration of gender issues.
- **"Establishing improved and integrated policy, regulatory, and institutional frameworks.** Examples are implementation of water quality norms and standards, and market-based regulatory mechanisms.
- **"Utilizing an inter-sectoral approach to decision-making**, where authority for managing water resources is employed responsibly and stakeholders have a share in the process."

4.1. Current Water Users

Being within a highly populated and industrialised part of the country, it is to be expected that the water uses from the Crocodile River (West) catchment will encompass all possible sectors of Agricultural, Domestic, Industrial, Mining, Recreation, etc. Therefore, it is not surprising that it is home to one of the oldest and well known dams in the country, namely Hartebeespoort, from local runoff which was completed during 1923. It is also not surprising that the available resources are already highly developed and utilised.

Mokolo Dam was completed in 1980 to supply water to the Mining and Electricity Sector of the economy and to stabilise the water supply to the Agricultural Sector downstream of the dam. The source is limited and committed with little spare capacity.

4.1.1. Mokolo River Catchment

Currently, the main water users from the Mokolo River catchment are the town of Vaalwater, the irrigators upstream of the Mokolo Dam, the irrigators downstream of the dam that receive water released from the dam into the Mokolo River, and the Lephalale Municipality, Exxaro and Eskom that abstract water directly from the dam.

Due to the changed land use from irrigation to game farming in the catchment of the Mokolo Dam over a number of years, as well as a reduction in illegal water use, the firm yield of the dam increased. There is thus limited scope for increased allocations from the dam, but the increased yield from a raised dam will not be adequate for the expected full demands.

It is possible that the Mokolo Dam would also be able to supply water to partially satisfy the initial construction water needs of the new developments planned for the Lephalale area. During the early stages of development, as a bridging arrangement, the abstraction from the dam can be higher than the firm yield for a short period before Phase 2 can be implemented and water can be transferred from the Crocodile River (West). This can, however, only happen if the implementation of Phase 2 is finalised.

4.1.2. Crocodile River (West)

The Crocodile River (West) as sourced currently has surplus water available above the legal entitlements of the existing users. This river receives a substantial portion of the available yield as return flows from the Gauteng area where the water originates from the Vaal River System.

The complexity of the whole Crocodile River (West) catchment system and sub-systems is demonstrated in the schematic layout shown in **Figure 4-1**. The abstraction for this transfer scheme is to be from the Lower Crocodile River (West) System which is demarcated as section D in the schematic layout. See more detail in **Appendix B: The Assessment of Additional Works required at Upstream MCWAP Water Supply Dams in the Crocodile River (West)**.

In the upper reaches of the Crocodile River (West), major agricultural developments have taken place, obtaining water mainly from the Hartebeespoort Dam. During recent years, this dam also became a major attraction for recreational activities and expensive property developments have taken place on the shores of the dam.

Water requirements in the Brits–Rustenburg–Thabazimbi corridor in the central part of the Crocodile River (West) catchment, are also expected to grow significantly, driven by new mining projects.

The main water users from the portion of the Crocodile River (West) catchment downstream of the Klipvoor, Roodekopjes and Vaalkop Dams are the existing users that comprise:

- The irrigators downstream of the three dams represented by the Crocodile River (West) Irrigation Board (upstream of Vlieëpoort) and the Makoppa farmers (downstream of Vlieëpoort);
- The platinum mines and associated settlements to the west of the Crocodile River;
- A number of rural towns and villages north and east of the Pilanesberg, and also in the catchment of the Tolwane River (tributary of the Lower Pienaars River) between the Klipvoor and Roodekopjes Dams;
- The users supplied from the small Zandriviersdrift and Bierspruit Dams on the Sandrivier and Bierspruit, respectively;
- Thabazimbi Local Municipality;
- Magalies Water Board receiving water from Vaalkop and Hartebeespoort Dams (flowing through Roodekopjes Dam), supplying domestic and industrial users in the Rustenburg, Sun City, Thabazimbi, etc. areas.

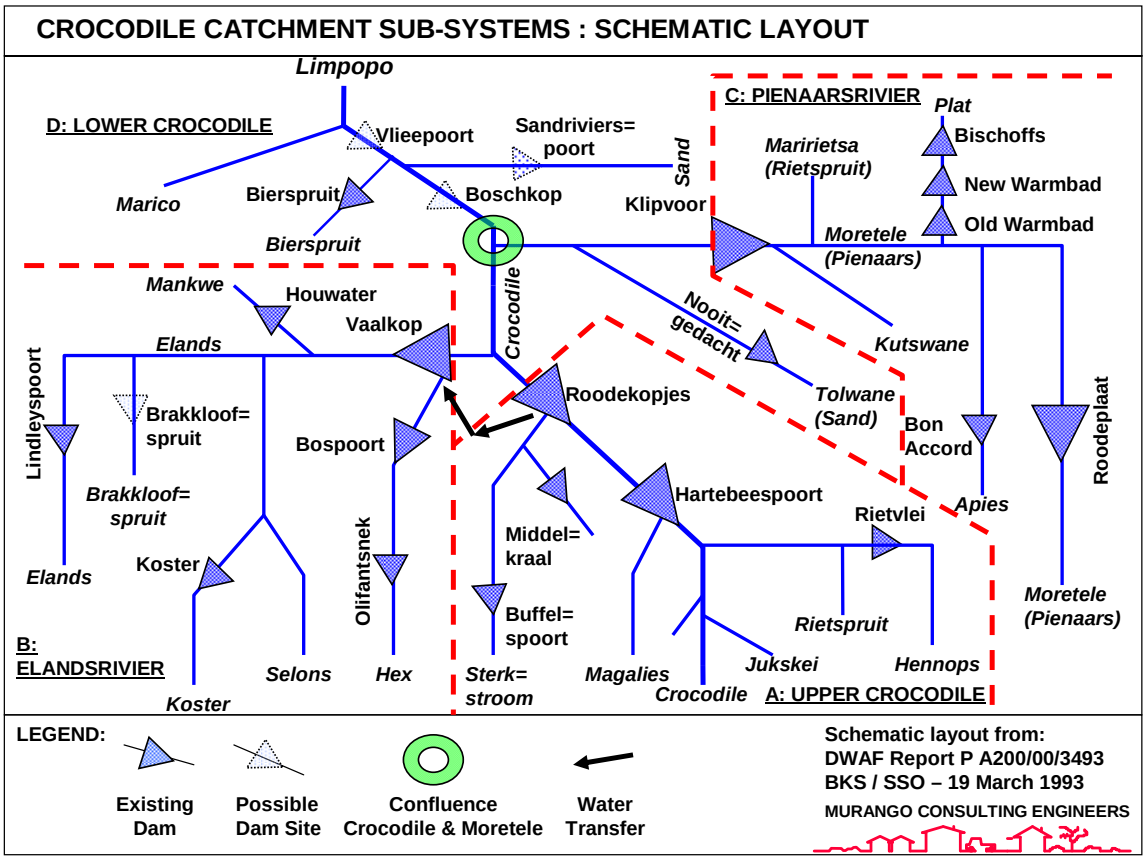

Figure 4-1: Crocodile River Catchment Schematic Layout (Courtesy BKS/SSO)

The existing users along the Crocodile River (West) downstream of the Vaalkop, Roodekopjes and Klipvoor Dams are supplied from the river. These users rely on releases from the above dams and accruals from the catchments downstream of the dams. MCWAP water requirements will also be released from these dams.

In future, most of the water requirements for the new developments towards Lephalale/Steenbokpan would be supplied, via the MCWAP, from the Crocodile River (West) catchment by making use of return flows that originates in the Gauteng area.

4.2. Ecological Water Requirements

The need for making water available to sustain the ecological functioning of river systems will have to be determined and implemented in accordance with the National Water Act (Act 36 of 1998). Releases will vary in volume and flow rate from time to time.

The DWA is currently busy with the determination of the preliminary Reserve in terms of Section 18 of the National Water Act, 1998 for both the Mokolo and Crocodile (West) Rivers, in separate processes.

4.3. Assurance of Supply

The primary objective of the successful operation of MCWAP is to establish and maintain the required assurance of supply to all water users receiving water from the system. The system supplies multiple water user sectors, each with different assurance of supply requirements which must be accommodated in the analysis procedures and operating rules applied by DWA.

Water is a scarce commodity in the catchment of the Mokolo River, and the planned industrial developments to be supplied by MCWAP will mostly be classified as strategic from a national perspective. This means that a high level of assurance of water supply (99,5% or better) must be maintained at all times for the strategic industrial users of the MCWAP in the Lephalale – Steenbokpan area. At the same time, the legal entitled levels of assurance of supply to the other users should not be affected. Use of all water resources will therefore have to be, in accordance to new operating rules and mechanisms for the management, monitoring and control thereof, should be in place.

It is not possible nor does it make economic sense to manage a resource such that there is no risk of failure. Therefore, operating rules that are to be developed must be based on the principle that water supply will be restricted during severe drought events. Application of restrictions is a measure to protect the assurance of supply. The basis, on which the restrictions will be implemented, will vary for the different water user sectors and the criteria will have to be developed and accepted by the various users.

A challenge in future would be to address the expectations that evolved during recent years amongst all user groups in the Crocodile River (West) catchment with regards to the level of assurance they have enjoyed. In order to satisfy the requirements of the users from the different sectors, the legal entitlement of the existing users, the requirements of the new strategic users and the Reserve, etc., it is important that proper operating rules for the system will need to be established, i.e. for the Mokolo and Crocodile (West) Rivers.

4.4. Existing Water Resource and Infrastructure Management Arrangements

4.4.1. Mokolo River

The water resources of this catchment is managed and controlled by the Limpopo Region of DWA. This catchment forms part of the Limpopo River WMA. The DWA Limpopo Region performs the regulatory functions and drives the water use licensing, validation and verification processes.

The water supply from the Mokolo Dam to the domestic and industrial users is managed by Exxaro. They own and operate the existing raw water pipeline and related infrastructure from the Mokolo Dam to the end users. They also own and operate the Zeeland Water Treatment Works (WTW). As Exxaro has permanent staff on the site, they

are actually also the operator of the dam in practice. They make the release of water to the downstream irrigation as per the operating rules and instructions from DWA, in consultation with the Mokolo Irrigation Board.

The Mokolo Irrigation Board is responsible for the regulation of the releases from the dam and the abstraction by the irrigators directly from the river and from the alluvial aquifer. The Irrigation Board is in the process of being transformed into a Water User Association (WUA).

4.4.2. Crocodile River (West)

The water resource regulatory function in this catchment is managed by the North-West Regional Office of DWA. The largest effort in terms of water quality control and licensing is concentrated in Gauteng, namely the catchments of the Hartebeespoort and Roodeplaat Dams.

The water resource infrastructure at Hartebeespoort Dam is managed by the National Water Infrastructure Branch (NWIB) of DWA. The management of the Roodekopjes and Klipvoor Dams is the responsibility of DWA, but for practical reasons, is performed by staff from the Crocodile River (West) Irrigation Board. Similarly, the management of the Vaalkop Dam is performed by the Magalies Water Board from their facilities at the dam.

The water supply to the Agricultural Sector from the Hartebeespoort canal system is managed by the Hartebeespoort Irrigation Board, and receives its water from the Hartebeespoort Dam.

The irrigators downstream of the Klipvoor and Roodekopjes Dams up to the so called “Hugo” Weir forms part of the Crocodile River (West) Irrigation Board. They abstract their water directly from the river and from sand points in the alluvium. Abstraction from boreholes in a defined area close to the river is also considered to be abstraction from the river. The Crocodile River (West) Irrigation Board manages and regulates the water releases into the river and control the abstraction for irrigation. The Irrigation Board is in the process of being transformed into a WUA.

Downstream of the “Hugo” Weir and up to the Limpopo River, there is also substantial irrigation development. This area is called the Makoppa area. Irrigation in this area is dependent on run of river flow only; it is not supported by releases from any storage dams and the licensing and other regulating measures in this area are the responsibility of DWA – North-West Region.

4.5. Management of the Mokolo and Crocodile Catchments

The yield of the Mokolo Dam is vulnerable to possible increased irrigation development in the catchment. This will need to be controlled intensely; a function currently the responsibility of DWA – Limpopo Region.

Similarly, the availability of return flow water in the Crocodile River (West) is dependent on proper monitoring, management and control of water use in the Crocodile River (West) catchment. This responsibility is currently shared by DWA – North-West Region and the relevant Irrigation Boards.

The water quality control function also needs to be strengthened in future – a function that is currently the responsibility of DWA – North West Region.

The MCWAP will require the integrated management of the MCWAP infrastructure, together with the existing infrastructure such as the different dams, rivers, etc. It will also require the integrated and coordinated management of the Mokolo and Crocodile River (West) catchments.

Dedicated resources (human resources, funding, etc.) will be required in future to perform these functions efficiently and effectively. It is recommended that the future institutional arrangements provide for such resources.

5. SECTION 2: APPROACH TO THE OPERATION OF THE MCWAP INFRASTRUCTURE

The Operation and Maintenance Philosophy of the MCWAP infrastructure is described in detail in **Appendix B**. This document can be used as a separate report.

The MCWAP is briefly described in the introduction, and in more detail in the other reports which form part of the overarching MCWAP Feasibility Report. MCWAP is intended to supply water via existing and new infrastructure from Mokolo Dam to the Lephalale area, as well as via new infrastructure from Vlieëpoort to the new developments in the Lephalale-Steenbokpan area. It is important to note that in both cases, the existing water resources infrastructure such as the dams are actually shared with existing (irrigation) users who are not directly the "clients" of the MCWAP, but will need to be incorporated in the operation of the MCWAP.

In the case of the Mokolo Dam, the sharing will be with the Agricultural Sector where the Mokolo Dam will be the shared facility. In the case of the Crocodile River (West), it is the sharing of infrastructure like Hartebeespoort Dam and other dams with the Agricultural Sector and possibly other users. There are also very significant stretches of river which forms part of the conveyance system for both the MCWAP and other users that must be considered as an integral part of the shared infrastructure. In order for the MCWAP to function, water will need to be released from the Hartebeespoort, Roodekopjes and Klipvoor Dams. The outlet facilities of these dams were broadly investigated and may need some alterations – as described in Section 3.

The following aspects are important considerations in the approach to the operation of the MCWAP.

5.1. Storage and Conveyance Systems of the MCWAP

Water will be provided from two main sources, namely the:

- Mokolo Dam; and
- Return flows in the Crocodile River (West).

In essence, the Mokolo Dam water will primarily be provided to existing consumers such as Matimba Power Station, Municipal users in the vicinity of Lephalale (Ellisras), as well as the new Medupi Power Station (partly), while the Crocodile River (West) Transfer Scheme will provide water to the new consumers such as Eskom and Sasol.

5.1.1. Existing Infrastructure

5.1.1.1. Mokolo Catchment

Water is released from the Mokolo Dam into the river for the Agricultural Sector. There are a number of sub-standard structures constructed by the Irrigation Board at various intervals in the river to ease the management of the flow in the river. Water is abstracted by the farmers with pumps directly from the river and the alluvial aquifer.

Water for Lephalale, Matimba Power Station and the Grootegeluk Coal Mine is pumped from High-lift pumps through a rising main to Wolvenfontein balancing dam from where the water is gravitated to the various end users. The supply system is operated and maintained by Exxaro.

5.1.1.2. Crocodile River (West) Catchment

There are a number of dams in the area upstream of Thabazimbi of which Hartebeespoort, Roodeplaat, Klipvoor, Roodekopjes and Vaalkop Dams are the more important ones, providing water to the Agricultural Sector, Mines in the Rustenburg area and Domestic and Industrial water to towns like Madibeng (Brits), Thabazimbi, Rustenburg, etc.

The Crocodile River and tributaries form an important link to distribute the water to the various users. It is an integral part of the conveyance system and as such, must be seen as part and parcel of the existing infrastructure.

5.1.2. MCWAP Transfer Systems

The overall schematic layout of the MCWAP is shown in **Figure 5-1** below.

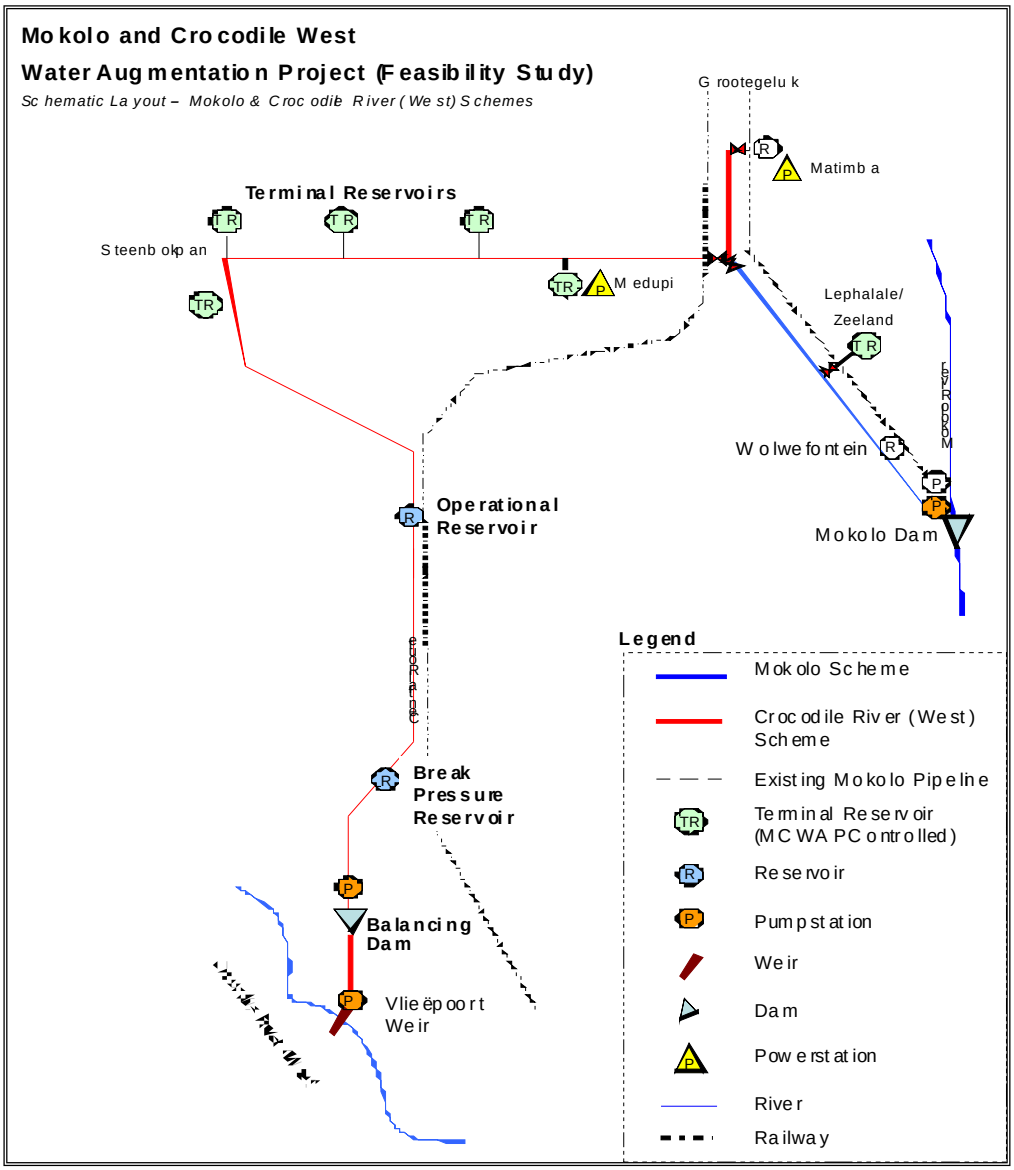

Figure 5-1: Schematic Layout of the MCWAP Scheme

5.1.2.1. Mokolo Dam Transfer Scheme (Phase 1)

The works are described in more detail in **Appendix A: The Operation and Maintenance Philosophy**, but will be optimised during the design process. A new pump station, which will be constructed directly downstream of the existing pump station, will take water directly from the Mokolo Dam via the existing outlet pipes. The new pump station together with the existing pump station will have to provide the total requirements until the completion of the Crocodile River (West) Transfer Scheme (March 2015). The capacity of the new pump station (45 Million m^3/a) will be greater than the ultimate long-term demand plus its 20% "catch-up" requirement from the dam (thus 35,5% greater in capacity), making it more than adequate for redundancy purposes.

There will be two rising mains from Mokolo Dam to Wolvenfontein balancing reservoirs, namely:

- The existing rising main will be retained. It currently has a conservatively accepted capacity of 13,5 Million m^3/a. For permanent retention, the internal lining will need refurbishment once the Crocodile River (West) Transfer Scheme becomes operational; and
- A new pipeline resulting in a total scheme design capacity of about 40 Million m^3/a.

The Wolwefontein reservoir has two compartments with a total storage capacity of 52 000 m^3. It supplies approximately 8,5 hours average annual demand active storage for the design flows before the commissioning of the Crocodile River (West) Transfer Scheme and 12 hours storage after commissioning. This is adequate for operational purposes.

The new and existing gravity pipelines will deliver water into the terminal reservoirs serving the consumers supplied from the Mokolo Dam Scheme (i.e. Lephalale/Zeeland WTW, Matimba Power Station, Medupi Power Station, and possibly some needs of the Steenbokpan consumers).

5.1.2.2. Crocodile River (West) Transfer Scheme (Phase 2)

The water to be transferred from the Crocodile River (West) will be released from Hartebeespoort Dam, via the Roodekopjes Dam, as well as from Klipvoor, Roodeplaat and possibly Vaalkop Dams.

Water for the MCWAP will be abstracted at the Vlieëpoort abstraction works, which is located some 134 km downstream of Roodekopjes Dam on the Crocodile River (West) where it will be abstracted and pumped to the end users. The schematic layout in **Figure 5-1** indicates the main components of the scheme.

A River Management System will have to be implemented to manage water releases from these dams and water use along the Crocodile River (West) to ensure that the water requirements at Vlieëpoort are met at the specified assurance levels. This is described in Section 3.

5.2. Operational Approach and Principles

The infrastructure to be developed for the MCWAP will be extensive and capital intensive. It will supply water to strategic important users within a complex environment. Finance institutions providing the loans, the environmental requirements, the existing water users and the new water users, all set very high demands. It is therefore important that the MCWAP must be operated in an effective and efficient manner to meet all the objectives. Certain fundamental principles must be factored into the development of an Operational Approach. The following are some of the more important aspects to consider:

5.2.1. Integrated System

The infrastructure of the first stages of the MCWAP are characterised by a network of rivers, within two different catchments and two different WMAs, various dams serving existing users, new infrastructure consisting of weirs, pump stations, pipelines, etc. - all forming a complex system of which the components are interdependent. Therefore, it is essential that the various sources be viewed as a system and the water resource operating rules be configured in an integrated/coordinated manner.

Allocations will be made from the system, a systems tariff will apply and the measure to which the supply for, e.g. the Mokolo Dam can support users during downtime on the Crocodile River (West) and visa versa, need to be considered.

Water resource operating rules will have to be developed and applied for the entire system. These rules must be based on system analyses that will have to be undertaken on the basis of the starting storage levels in the dams on the 1st of April of each year or other dates as may be decided upon after consultation with all user sectors. It must also take into account updated system data such as revised water demand projections, implementation dates of maintenance activities and operating rule definitions data that defines particular scenarios. During periods of drought, the analyses may be repeated several times during that year/period to investigate amendments and/or variations to the ruled as required.

The whole MCWAP will have to be operated as an integrated system irrespective of who owns or operates each component of the system.

5.2.2. Infrastructure Availability and Redundancy

The water resource assurance of supply has been addressed in Section 1. There is also an infrastructure availability that must be addressed from an operational point of view. The operating procedures and maintenance plans must support the principle of achieving a long-term minimum availability of 95% which relates in the worst case to a single event of non-supply not exceeding 18 days.

An important aspect that will determine the infrastructure availability is the design capacity of the infrastructure, the redundancy in the pump stations with regard to the number of standby pumps, the buffer storage in the terminal reservoirs of 16 to 18 days, the design capacity of the pipelines, etc. This must be taken into account when the operating rules and maintenance programmes are developed. The dual direction design of the pipeline between Lephalale and Steenbokpan also provides flexibility in the system and thus can provide a higher level of infrastructure availability at some key points.

5.2.3. User Terminal Reservoirs

Bulk Users will be required to provide their own Terminal Reservoirs with 16 to 18 days of storage. The MCWAP will only guarantee the agreed flow (on the basis of an average annual delivery plus allowances for peak flows) and a minimum pressure head at the designated terminal point of the pipeline take-off to the User.

All User Terminal Reservoirs will be level controlled and monitored, not only by the User (Owner), but also by the MCWAP Authority. The details of the control and management mechanisms need to be resolved during the design process and incorporated into the user agreements.

Siltation may occur in the reservoirs and a cleaning system for removal of accumulated sediment should be provided. Cleaning may be required at regular intervals.

The MCWAP system will provide and control the following components in the gravity feed main directly upstream of the consumer's reservoirs:

- An in-line isolating valve with chamber;
- An in-line bulk flow meter with chamber; and
- An in-line flow control valve (with chamber) which will limit the incoming flow to the annual average flow plus 20%.

5.2.4. Centralisation of MCWAP Operations

Since it is envisaged that both transfer systems (i.e. Crocodile River (West) and Mokolo Dam) will be managed as an integrated system (perhaps by the same Authority), it is proposed that both the transfer schemes are controlled and managed from one operational control centre. This Operational Control Centre should comprise the administration offices, a central control room, stores and workshops, and should be conveniently located more or less at the centre of operational activities (i.e. Vlieëpoort/Thabazimbi or Lephalale).

A communications network will link the operations control room to all the main components of both transfer systems. Supporting communication systems required for security and environmental monitoring will also be provided for.

5.2.5. Operational Monitoring

The control and operation of all sites will be monitored and managed by means of a Systems Control and Data Acquisition (SCADA) system from the control room. All sites furthermore are to be capable of local operation and have sufficient redundancy data storage capacity so that, in the event of communications or computer failure, the data will be restored automatically.

All the daily, weekly, monthly and annual reports necessary for operational and revenue purposes, will be available for extraction from the data captured by the SCADA system.

It is envisaged that the Operational Control Centre, together with the functions that will be monitored and controlled/operated at each site, will be manned on a 24-hour day basis.

5.2.6. Diversity of User Groups and Levels of Assurance

The system supplies multiple water user sectors, each with different assurance of supply requirements. These will be accommodated in the resource operating rules and scheme procedures applied by DWA.

5.2.6.1. Mokolo River Catchment

The existing water users obtaining water from the Mokolo Dam is predominately in the Agricultural and Industrial (mining and electricity generation) Sectors with a relative small allocation to the Domestic Sector. The water allocations to all are clearly defined in two White Papers and the normal assurance of supply applies in each case. This is also reflected in the current operating rule for the dam, namely that the strategic Industrial and Domestic Sectors receive water at a higher assurance level of up to 99,5%, whereas the Agricultural Sector receives a full quota whilst the dam is at a level equal or higher than 50% at the decision date (1 April) and irrigation receives no water if the dam is below this level.

5.2.6.2. Crocodile River (West) Catchment

The spectrum of water users in the Crocodile River (West) Catchment is far more diverse. Apart from the normal agricultural and industrial use, recreation is a major contender. The planned industrial developments will mostly be classified as strategic from a national perspective. This means that very high levels of assurance of water supply (99,5%) must be maintained at all times for the strategic users of the MCWAP.

5.2.7. Honour Existing Lawful Use and Reserve Requirements

An existing lawful water use means a water use which has taken place at any time during a period of two years immediately before the date of commencement of the National Water Act, 1998. Provision is made in the National Water Act, 1956 that a person, or that person's successor-in-title, may continue with an existing lawful water use, subject to certain conditions.

The MCWAP aims to satisfy most of the water demands of the new anticipated developments from the increasing source of return flows from the Gauteng area. Operating rules for both the Mokolo and the Crocodile River (West) systems will be developed by DWA in a separate process and must take cognisance of this and ensures that existing lawful use is respected and protected. Similarly, it is a legal requirement that provision is made for meeting the requirements of the Reserve.

5.2.8. Ownership

5.2.8.1. Property Ownership

Property on which the abstraction weir at Vlieëpoort, reservoirs, pump stations and other facilities required for the O&M of the MCWAP, are located, will be acquired by DWA. Only DWA, TCTA and MCWAP staff will have access to these properties.

DWA will also need to acquire servitudes on property which structures associated with MCWAP will be built. These would include the basin of the abstraction weir and possible gauging weirs along the river. The extent of the servitudes will need to be determined to serve the purpose of the structures, whilst limiting the impact on the original property. Access to the properties will be controlled and security fencing will be erected where appropriate.

5.2.8.2. Pipeline Servitudes

Access to pipeline servitudes will not be controlled, but restrictions will be placed on activities inside the servitudes. These will typically include the prohibiting of the erection of permanent structures and the planting of perennial crops (orchards, timber, etc.).

Servitudes will be marked with concrete servitude markers. Existing fencing will be reinstated and gates installed where these fences cross the servitude. The anticipated impacts on game farming would therefore be limited to visual impact of the servitude clearing and regular maintenance and security patrolling.

A service road (to basic standards) will be provided along the servitude for maintenance purposes and will be patrolled on a regular basis.

5.2.9. Communication with Affected Parties and User Representatives

Frequent communication with users and affected parties is a requirement for the effective operation of MCWAP.

Communication Forum(s), comprising User Representatives and to-be-established Authority(ies), should be established where specific issues, particularly those relating to day-to-day operations, can be discussed. A web site is proposed to share information. It will be a day-to-day form of communication with affected parties, in addition to telephone, tele-fax and e-mail communication facilities for use by the User Representatives and the Institutional Authority(ies) (still to be proposed).

In all cases where permanent structures need to be erected, land will be acquired in ownership. The exception will be the pipelines where servitudes will be acquired. One of the primary tasks of the Local Liaison Officer that will be appointed to the MCWAP will be to ensure efficient communication with the surrounding landowners to minimise the

potential long-term impacts of the pipeline servitudes and its use by the staff on the landowners.

5.3. Maintenance

Maintenance is generally divided into the three major engineering disciplines namely: mechanical; electrical and civil. For each of these disciplines, maintenance will be categorised as follows:

- Routine planned maintenance;
- Major breakdown repairs; and
- Minor breakdown repairs.

A proactive approach to maintenance in the form of a preventative maintenance plan would be essential on a scheme of this magnitude and importance. A bullet-by-bullet schedule of the maintenance of the above three categories for Mechanical, Electrical and Civil Components are provided in **Appendix A**. These needs to be further developed during the design of the MCWAP and will be contained in the O&M Manual.

6. SECTION 3: DAMS AND RIVER MANAGEMENT

As described before, the management of the MCWAP infrastructure will need to be integrated with the existing works. In this regard, the extent that the existing works will be able to meet the new requirements of MCWAP was investigated and some works will need betterment. For the proper operation of the works and river management improved systems, mechanisms, procedures and decision support tools are required. The requirements for betterments at the dams are described in **Appendix B**, and the requirements for the river management systems are described in **Appendix C: The Determination and Management of the Water Releases from the Mokolo Dam and the Dams in the Crocodile River (West) and its Tributaries to Supply the MCWAP**, while the need for additional gauging weirs are described in **Appendix D: The Need for Additional Gauging Weirs in the Bierspruit and Sandrivier near the Confluence with the Crocodile River (West)**. The contents of these appendices are briefly summarised in this section.

6.1. Betterments to Existing Water Resources Infrastructure

6.1.1. Existing Pipeline from Mokolo Dam

Since the economics of the retention of the existing rising main in the long term is not yet self-evident, it is recommended that it be investigated during the Design phase. Should refurbishment of the existing rising main be warranted, it will need to happen after the Crocodile River (West) Transfer System becomes operational. The two pipelines will be interconnected to provide flexibility in operation and can be used to reduce the overall energy consumption.

6.1.2. Storage Dams

The water requirements for Phase 2 of the MCWAP Transfer Scheme will be supplied by releases from dams in the Crocodile River (West) upstream of the abstraction works at Vlieëpoort. The dams identified as potential primary water sources are Hartebeespoort and Roodekopjes Dams on the Crocodile River (West), Roodeplaat and Klipvoor Dams on the Moretele (Pienaars River) and Vaalkop Dam on the Elands River.

6.1.2.1. Pertinent Data of Main Supply Dams

The supply dams, their full storage capacity, outlet works discharge capacity and the relevant sub-catchments in which they are located in are detailed in **Table 6-1**.

Table 6-1: Main Supply Dams in the Crocodile River (West) Catchment

Dam Name	River	FSC (Net) (Million m^3)	Discharge Capacity of Dam Outlet Works	
			Discharge [2] (m^3/s)	Annualised [3] (Million m^3)
Upper Crocodile Sub-Catchment:				
Rietvlei Dam	Hennops River	12,3	N/A	N/A
Hartebeespoort Dam	**Crocodile River (West)**	**186,4**	**7,2**	**225,9**
Buffelspoort Dam	Sterkstroom River	10,3	N/A	N/A
Roodekopjes Dam	**Crocodile River (West)**	**102,3**	**7,2**	**226,6**
Moretele River Sub-Catchment:				
Roodeplaat Dam	**Pienaars River**	**41,2**	**8,3**	**261,7**
Klipvoor Dam	**Pienaars River**	**42,1**	**7,0**	**219,1**
Elands River Sub-Catchment:				
Kosterrivier Dam	Koster River	12,8	N/A	N/A
Lindleyspoort Dam	Elands River	14,3	N/A	N/A
Olifantsnek Dam	Hex River	13,7	N/A	N/A
Bospoort Dam	Hex River	15,8	N/A	N/A
Vaalkop Dam	**Elands River**	**56**	**6,3**	**198,7**
TOTALS		**428,0**		

Notes.
1. The dams indicated in **bold** can or would be used to supply the MCWAP. The other dams listed are the remaining dams of some significant size in the sub-catchments.
2. Discharge calculated with dam operating at annual average of 80% of full capacity head at the outlet works, or approximately 66% of FSC.

6.1.2.2. Water Release Requirements

The total release required is the sum of the water requirements of the Phase 2 Transfer Scheme, irrigation requirements of the Crocodile River (West) Irrigation Board, total estimated losses along the river and the estimated Instream Flow Requirements (IFRs) at Vlieëpoort. The Ecological Reserve at Vlieëpoort was provisionally estimated to be in the order of 25 Million m^3/a in the DWA Report No. P WMA 03/000/00/0203; analysis of the gauging weir data at A2H116 confirmed the figure of 25 Million m^3, but the flow simulations that was done to assess river losses (described in Supporting Report 12) resulted in a somewhat higher figure of 28,9 Million m^3/a. The higher figure was used for the assessments done in this report as a conservative approach.

6.1.2.3. Capacity of Supply Dam Outlet Works

For the purposes of calculating outlet discharge capacities at the various dams a minimum long-term dam water level of 66% of FSC was used. Depending on the shape of the storage capacity curve for a particular dam, this was assumed to be on average equivalent to 80% of the maximum available head at the outlet works.

In the calculations to determine whether the outlet capacities of the existing dams are adequate, it was assumed that continuous releases would be made from the dams and that slug releases would not be considered. Slug releases could, however, be an operating option at the Roodeplaat and Hartebeespoort Dams to minimise unauthorised water use, but further investigations would be required to determine the optimum operation, and additional infrastructure may be required at those dams for such operation. This needs to be investigated further during the design stage.

6.1.2.4. Additional Outlet Capacity Requirements

The assessments done, show that:

- The primary supply node, the Hartebeespoort Dam - Roodekopjes Dam node, would need support from the Moretele River soon after commissioning of Phase 2 of the MCWAP.
- If releases for MCWAP started with Hartebeespoort and Roodekopjes Dams close to Full Supply Level (FSL), the introduction of the Kilpvoor Dam – Roodeplaat Dam node could be postponed by a year to end of 2016.
- The latest date at which additional outlet capacity would need to be provided at Hartebeespoort and Roodekopjes Dams would be 2015, but that could be delayed to as late as 2025 depending on the degree of support that could be provided from Klipvoor and Roodeplaat Dams.

On the basis of the assessments done, it is recommended that two 900 mm diameter outlets be added each to the present outlet works at Hartebeespoort and Roodekopjes Dams at a first order estimated cost of R 60 Million. No additional works were anticipated at Klipvoor and Roodeplaat Dams.

6.1.3. Balancing Storage in the Crocodile River (West)

Vlieëpoort will be an important structure in the transfer scheme. The operational/balancing storage reservoir will provide storage for effective systems operation (6 hours annual average delivery), as well as off-channel balancing storage (approximately 1,5 days of annual average delivery) for surplus flows released from the upstream storage dams. This reservoir will be compartmentalised for normal operational and maintenance purposes (i.e. a minimum of two compartments).

In the context of the scheme at large, the buffer storage at Vlieëpoort is limited. The total river distance between Roodekopjes and Vlieëpoort is 134 km. The reaction time between these two points to make any flow adjustments is in the order of 7 to 9 days, depending on the nature of the adjustments. If rain would fall in the catchment downstream of Roodekopjes, it is very difficult to minimise water losses from the system, if the water flowing past Vlieëpoort is considered as a "loss". This water could be viewed as essential for use downstream to the confluence with the Limpopo River and for the ecology, which is not a "loss", but more an uncontrolled flow.

To improve the management of the river reach and to ensure more efficient use of the available water, a study should be conducted to establish whether balancing storage between Roodekopjes and Vlieëpoort could add value to the system.

6.2. Additional Flow Measurement

For the improved management of releases, etc. additional gauging will be required. It is described in detail in **Appendix D** and discussed under paragraph 6.5 – Improved Data Acquisition.

6.3. Decision Support Systems

In order to ensure that water released from the Roodekopjes and/or Klipvoor Dams reach the abstraction weir at Vlieëpoort to meet the required abstraction for MCWAP, proper management thereof will be required. A proper River Management System will need to be designed and implemented. Such system will utilise a bouquet of decision support systems.

Decision support systems will be required by DWA (or a River Management Authority(ies)) to manage those water supplies, releases, river flows and abstractions. Water resource allocation models should be utilised to determine water allocations and possible curtailments to the various users and river flow management models should be utilised to manage releases, river flows and abstractions. Some of these models will be incorporated into the operating rules, but the balance needs to be captured in the design of a River Management System. It is covered briefly here, but described in detail in **Appendix C**.

6.3.1. River Flow Management Models

The following two river flow management decision support models can be envisaged to estimate the daily flow releases required from the dams in real present and future time:

- A steady flow water release model; and
- An unsteady flow simulation model.

6.3.2. Water Resource Allocation Models

The following two water resources allocation decision support models are recommended to be used by DWA at each of the Mokolo Dam on the Mokolo River and the relevant dams in the catchment of the Crocodile River (West), operated as a system or as individual dams (presumably including the runoff from the downstream catchments):

- A long-term water allocation model; and
- A short-term water use curtailment (rationing) model.

6.4. Abstraction and Flow Measurement

Various sets of data will be required to populate the models described above. Account must be kept of water use. This is required to keep track of use relative to weekly, monthly and annual entitlements. It will also provide record of the accumulation or otherwise of unused water in the dams during the water year. The water releases or abstractions from the dams, abstractions from the rivers, river flow and the use of water from boreholes that are hydraulically connected to the river flow must be measured where applicable. These measurements will serve the modelling, management and control of water use and water releases. It will also serve as basis for any legal action.

6.4.1. Mokolo River

A flow measurement that is anticipated to be required is the water abstraction from the Mokolo Dam. In the case of the MCWAP (including the existing delivery scheme), this could be in the suction pipes leading to the two pump stations.

Water released at Mokolo Dam to the Mokolo River must be measured. A suitable measurement point on the pipe network must be established. Consideration should also be given to acquire abstraction data from the irrigators and other users along the river for use in the water resource allocation models. Refurbishment of gauging weir A4H013 may well be required to support this.

6.4.2. Crocodile River (West)

River flows should be measured immediately downstream of each of the Hartebeespoort, Klipvoor, Roodekopjes and Vaalkop Dams to determine the effective water releases from them. In addition, the flow of the Crocodile River (West) should be measured at selected sites between the above dams and Vlieëpoort in order to monitor the flow of water in the system on a real time or near real time basis. This will enable the managers to take remedial action at the earliest possible opportunity whenever it is required to avoid undue loss of water or to avoid shortages within the system, particularly at Vlieëpoort. The flow of the Crocodile River (West) should also be measured at the first suitable gauging site downstream of Vlieëpoort to confirm that the downstream flow requirements are met and to determine the surplus flows, if any.

6.4.3. Data Management

It is envisaged that a facility will be established where all available data will be displayed and archived and from where real time, near real time and historic data can be obtained by the water users and other interested and affected parties.

All real time or near real time flow data should be displayed by means of a SCADA system in the operational control centre, where the operation personnel are expected to be located.

6.5. Reconciliation of Dam Releases and River Flows

Two types of reconciliation procedures should be developed. These are the so-called Operational Reconciliations and the Historical Reconciliations. Each type of reconciliation has a different application and different levels of confidence attached to the output. The reconciliations essentially provide an account of how the available water has been released and consumed downstream. Both types of reconciliations utilise the basic river reach water mass balance relationship. The details of such reconciliations are described in **Appendix C**.

6.6. Improved Data Acquisition and Monitoring

The river system that must be managed is not unduly complex, and does not include many structures that modify the flow regime. Typically, a standard software package would be acquired that is adapted, configured and populated with data relevant to the Crocodile River (West). Such models are currently in use at many irrigation schemes in South Africa and also in certain river systems such as the Komati River and is used to:

- administer water supplied, water requested and water used;
- plan releases for distribution through the systems by estimating the response (travel) times and water losses through the distribution systems; and
- prepare water accounts.

6.6.1. Existing Infrastructure

The existing river flow measurement and recording infrastructure downstream of the Klipvoor, Roodekopjes, Vaalkop and Mokolo Dams are described in detail in **Appendix C**.

The non-functioning stations are not listed, which in the case of the Crocodile River (West) is not considered to be problematic and the working stations should suffice. However, in the case of the Mokolo River, none of the gauging weirs further downstream of Mokolo Dam are functional and would make water mass balance calculations impossible. Station A4H013 would be very useful in this regard and should be re-instated or an alternative site developed.

Flow data at the end of the Crocodile River (West) Irrigation Board area would be very valuable. The existing structure at Hugo's Weir (A2H116) which is located some 20 km upstream of Vlieëpoort is ideal, but considerable betterments should be undertaken to improve the weir structure to DWA standards and to install the latest flow gauging instrumentation. The present installation appears to have stopped functioning in 1995 and was only capable of measuring flows up to 7 m^3/s.

The river flow gauging stations should be of a standard equal to the latest standards adopted by DWA. The condition and appropriateness of the instrumentation should be confirmed. If possible, a fibre optic cable link backed up by a GSM wireless link should be provided to allow for reliable real time recording of flow data.

Attention should also be given to minimising the potential risk of vandalism, particularly of the instrumentation.

Minimum flow measurement requirements for gauging weirs are discussed in **Appendix C** and **Appendix D**. The estimated normal flow measurement range would be 6 to 30 m^3/s, excluding floods, with a measurement sensitivity of 0,25 to 0,50 m^3/s.

6.6.2. Additional Flow Gauging and Monitoring Requirements

Two sets of data should be collected, each with its own specific application and different levels of confidence attached to it. The data sets are:

- Real and near real time data (electronic acquirement); and
- On-site monitoring and historic data.

The real time or near real time data should be imported into the steady flow release model and model predictions compared and adjustments made as may be necessary. Over abstraction on a few consecutive hot days can have a severe impact on available river flow at Vlieëpoort. Real time or near real time data acquisition and daily updating of the flow model is therefore of critical importance.

Both sets of data are required for water use reconciliations that will employ a water mass balance relationship.

6.6.2.1. Surface Water Abstraction Measurement

All pumps abstracting water from the Moretele River, Crocodile River (West) and the Elands River downstream of the Klipvoor, Roodekopjes and Vaalkop Dams and from the Mokolo River downstream of Mokolo Dam should be fitted with water and power consumption meters. The water meters should cumulate the total volume of water abstracted from the river on a continuous basis and preferably also indicate the rate of flow. The power consumption meters should function on the same basis and would be

used as a cross-check on the water consumption figures. The water meters should be of the ultrasonic, magnetic or similar type to minimise the possibility of malfunctions. The water and power consumption meters should preferably allow for wireless interrogation.

6.6.2.2. Groundwater Abstraction Measurement and Monitoring

Likewise, all pumps that are abstracting water from boreholes that have hydraulic connectivity to the nearby Moretele River, Crocodile River (West), Elands River and Mokolo River should be fitted with meters of the types described in Section 6.6.2.1.

The quantification of the flow in the Crocodile River (West) alluvial aquifer would be difficult unless extensive geo-hydrological modelling is undertaken. It may also be possible to undertake geophysical measurements (for example with flux, acoustic or electrical methods) or more direct measurements using borehole flow meters to improve estimates of water movement in the aquifer through Vlieëpoort.

A more practical approach would be to undertake continuous borehole water level monitoring to record levels both upstream and downstream of the Vlieëpoort abstraction works. It is also recommended that borehole water level monitoring be instituted at Vlieëpoort to compliment surface flow measurements and to ensure that the alluvial aquifer downstream of Vlieëpoort would not be negatively impacted on by the proposed Vlieëpoort abstraction works. Such monitoring would have to start well in advance of the proposed MCWAP construction work to establish base line conditions.

Continued borehole water level monitoring would be required after construction of the abstraction works to confirm the adequacy of releases from the abstraction weir to recharge the aquifer downstream of Vlieëpoort.

6.6.2.3. River Flow Measurement

The river flow gauging stations discussed in **Appendix C** are relatively well positioned for managing the river flow downstream of the Klipvoor, Roodekopjes and Vaalkop Dams to Vlieëpoort. However, it is considered necessary to construct a new river flow gauging station in the Crocodile River (West) at the first suitable site downstream of Vlieëpoort for the reasons indicated previously. All the river flow gauging station data should be relayed on a real time or near to real time basis to a central point for monitoring of the river flows and to enable the Authority-to-be to manage the abstraction process.

In addition to the above new river flow gauging station, provision should also be made at this stage for at least one other new river flow gauging station cum balancing storage structure on the main stem. This may be required in case further studies or operational

experience indicates that such infrastructure will improve the efficiency with which the river system is managed and diffuse losses and unauthorised uses can be estimated/calculated.

The Bierspruit and Sandrivier are the only two remaining significant watercourses along the Crocodile River (West) downstream of Roodekopjes Dam that has not been dammed (or gauged). The confluences of these two rivers with the Crocodile River (West) are located downstream of Hugo's Weir and upstream of Vlieëpoort. This means that the contributions made by the Sandrivier and Bierspruit to the flow in the Crocodile River (West) are not known other than through run-off calculations and cursory visual observations. The flows and specifically floods emanating from the two catchments could therefore have a significant impact on river flow patterns and riverine environment along the Crocodile River (West) downstream of Vlieëpoort. Flows from the Bierspruit and Sandrivier should also be measured to ensure that these flows are allowed to pass the Vlieëpoort Abstraction Works. The motivation for these additional gauging weirs is provided in **Appendix D** of this Report.

The quality of all the river flow gauging stations listed above, including the instrumentation, will have to be confirmed and upgraded if necessary.

6.6.3. Water Quality Monitoring

Water quality must be monitored in the Mokolo River and the Crocodile River (West) Systems at least on a weekly basis. In the case of the former, routine measurements should be taken at Mokolo Dam, and on the latter, at all five of the significant dams, in the river at one of the gauging weirs before or within the Crocodile River (West) irrigation area and at Hugo's Weir.

6.6.4. Meteorological Data and Weather Forecasts

The requirements for weather stations have not been addressed since weather data, current and forecast; can be obtained from the SA Weather Bureau and also from various web sites. This data can be used to forecast evaporation and evapo-transpiration losses from the river systems.

Droughts, floods events and climatic (temperature, wind, cloud cover, humidity, etc.) conditions will impact heavily on water usage and execution plans will consequently require re-evaluation and modification at intervals and even sometimes at very short notice. Specially equipped meteorological stations should be erected at points selected in consultation with the weather services and the Agricultural Sector.

6.6.5. Operational Control Centre

As described in paragraphs 5.2.4 and 5.2.5, it is proposed to have a centralised control centre to manage MCWAP and that it is fitted with a SCADA system. The SCADA

system will be programmed to give planning, operational, costing and reports for a variety of purposes. The following facilities will also be available:

- Full operational control of all sites.
- Monitoring of river releases and flows. Facilities to allow crosschecking of water balance, water use and system losses will also be included.
- The control of the abstraction of surplus river flows into off-channel storage where applicable to optimise water usage.

6.6.6. Telemetry

Supporting communications infrastructure provided should be based on a fibre optic and Global System for Mobile Communications (GSM) network. The gauging weirs should be included in the fibre optic network to ensure that real time data is available at all times. The meters installed at the user abstraction points should be adequately served by a GSM network.

6.6.7. Data Processing, Display and Archiving

It is recommended that the Authority responsible for the management of MCWAP establish an internet web site where all available data will be displayed and from where real time, near real time and historic data can be obtained by the water users and other interested and affected parties.

Typical data to be displayed include:

- Water abstraction allocations and actual abstractions;
- Planned and actual releases;
- Diffuse accruals and outflows;
- Evaporation and evapo-transpirations losses; and
- Cumulative gauged flow volumes.

7. SECTION 4: INSTITUTIONAL

The Technical Team were required to provide inputs regarding the institutional requirements from the technical perspective and provide some thoughts as a straw dog on possible institutional arrangements.

The inputs are included with the status of a discussion document and are attached as **Appendix E**: The Institutional Requirements and Options for the Management of MCWAP. The salient points are duplicated here.

7.1. Water Resource Management

National Government, namely DWA as the custodian of the water resources of the country and acting through the Minister, is responsible for managing the water resources of the country. The Minister has the ultimate responsibility to fulfil certain obligations relating to the use, allocation and protection of and equitable and sustainable access to water resources. Based on the above, DWA will be responsible for the overall water resource management in the Crocodile River (West) and Mokolo River catchments, receives and evaluates water requirements and incorporates these requirements into the water resource management plan and inter alia, issue water licenses and directives accordingly. In this regard, DWA and the to-be-established Catchment Management Agencies (CMAs) need to perform a regulatory function.

The NWA, 1998 is also clear that in certain cases and when the need arises, the Minister may establish suitable institutions in order to achieve the objectives mentioned above. Therefore, it is possible that water allocations, abstraction control, water releases, management operation and maintenance of water infrastructure, etc. could be managed and operated under the directives of the Minister by either:

- DWA – NWIB;
- Water Boards and Water Users Associations;
- CMAs; and
- Any other body nominated by DWA and approved by the Minister.

7.1.1. Institutional Management

The NWA, 1998 requires that the nation's water resources must be protected, used, developed, conserved, managed and controlled. These guiding principles also recognise the need to share some water resources with other countries, and the need to promote social and economic development through the use of water. These will apply to the MCWAP specifically.

Institutional management in the MCWAP context needs to be considered along the following main components:

- Water Resource Management;
- River Management; and
- Scheme Infrastructure Management, i.e. Operations and Maintenance of works.

7.2. Institutional Concepts

In the preceding sections the requirements have been laid down to ensure that through the sound management of the water resources and the infrastructure, a sustainable supply of water to all water users in the Lephalale-Steenbokpan area is achieved. All of this can only be accomplished if the necessary institutional arrangements are put in place. It will be necessary to have a dedicated authority(ies) to manage the water allocated by DWA to the MCWAP, to manage the use of the allocated water by the users supplied from the MCWAP and to manage, operate and maintain the MCWAP.

Some institutional arrangements are suggested in the discussion document on institutional requirements and options for the management of MCWAP - attached as **Appendix E**.

7.2.1. Centralised Control

The operation of a scheme of this nature will require strong management, liaison and leadership skills, as well as a competent support team to plan dam releases, manage and monitor water usage and to operate and maintain the extensive infrastructure. Because of the interdependencies and to give effect to the principle of an integrated systems approach, it stands to reason that a dedicated team located within the management area should be provided.

The management team will also require certain delegated authority to enable it to perform its functions.

7.2.1.1. River Management

The flow requirements along the river reaches downstream of the Klipvoor, Roodekopjes and Vaalkop Dams as far downstream as Vlieëpoort, the abstractions from the Mokolo Dam and the Crocodile River (West), will need to be planned, operated, monitored and controlled. This dedicated management of the river flows, dam releases, etc. is needed to ensure water supply to the existing users and the MCWAP users. In addition, it needs to operate and maintain the MCWAP. A strong Authority will be required to perform all these functions.

Three distinctly different functions must be performed by such an Authority(ies):

- Management of the river flows in the Crocodile River (West), some or all of these actions can be delegated to a body or authority specifically constituted for this purpose;
- Management of releases from the Mokolo Dam and flows in the Mokolo River, which can be delegated to a body or authority specifically constituted for this purpose and named, for instance, the Mokolo River Management Authority (RMA); and
- Abstracting water from the Mokolo Dam and the Crocodile River (West) at Vlieëpoort and managing its supply and distribution to the users supplied by the MCWAP, which can be delegated to a body or authority specifically constituted for this purpose.

The mentioned functions could be exercised by a single authority, or subsets of a single umbrella organisation.

7.2.1.2. MCWAP Scheme Management

As far as the management of water supply schemes or projects themselves are concerned, these can be managed and operated by either:

- Water Authorities, such as Water Boards or other utilities; or
- DWA – National Water Infrastructure Branch.

At least three management options are possible and need to be investigated further:

i. Dedicated team provided by DWA (or TCTA);
ii. DWA (or TCTA) contracting a concessionaire or a team from the private sector to work under their auspices; or
iii. A dedicated MCWAP Authority to be created along the lines of KOBWA and other similar authorities.

The MCWAP Authority would be responsible for the planning and management of dam releases made upon directives given by DWA, abstraction of water from the Crocodile River (West) and Mokolo Dam and delivery of raw water to the consumers in the Lephalale - Steenbokpan area with due regard to the following:

- Environment;
- Security;
- Reliability of supply (specified as 99,5% for the strategic users);
- Managing the releases from Kilpvoor, Roodekopjes and Vaalkop Dams and water supplies in the Crocodile River (West) downstream of the dams in a transparent and accountable manner;
- Managing the releases from Mokolo Dam in a transparent and accountable manner; and

- Managing the water supplies to the users from the MCWAP in a transparent and accountable manner.

7.2.2. Accountability

Whether the management of the MCWAP-scheme is operated by DWA, a single or multiple Management Authority(ies) established in terms of the NWA, 1998, this institution(s) will be accountable to the whole spectrum of water users. The requirement would be to have an efficient organisation providing a sustainable and equitable service of water supply to the users as described.

7.3. Institutional Options

A wide spectrum of institutions is available to perform the functions of Water Resource Management, River Management and Scheme Management. Apart from those provided for in the NWA (1998) and the Water Services Act (Act 108 of 1997), such as Water Boards, Water User Associations, etc., other options are also available. A good example of an institution performing such a function is KOBWA. KOBWA was created in terms of a special Treaty. The creation of such bodies is provided for in Section 162 of the NWA. KOBWA provides a similar service in the Komati River Basin as the specialist service that will be required with the management of MCWAP and the water resource issues.

A critical success factor for the management of MCWAP will be to mobilise the required human and financial resources to perform the management function, including operation, maintenance, monitoring, control, etc. In this regard, it will be necessary to investigate options whereby the large users of MCWAP can be considered as active partners in the management, i.e. be involved in resourcing, involved on the Boards, etc. Some important options and proposals for an institutional framework are discussed in **Appendix E**. **Figure 7-1** shows a possible institutional framework that can be considered.

It is considered very important to have representatives of the different users and stakeholders such as the Municipalities, Mines and Industry, Eskom, etc., involved in the management of the project. They should not only be major contributors that covers the operational cost, but should also have a voice at Board level in governance issues such as the budgeting, decision-making and the management of the functions. The possible representatives and relationships are indicated in **Figure 7-1**.

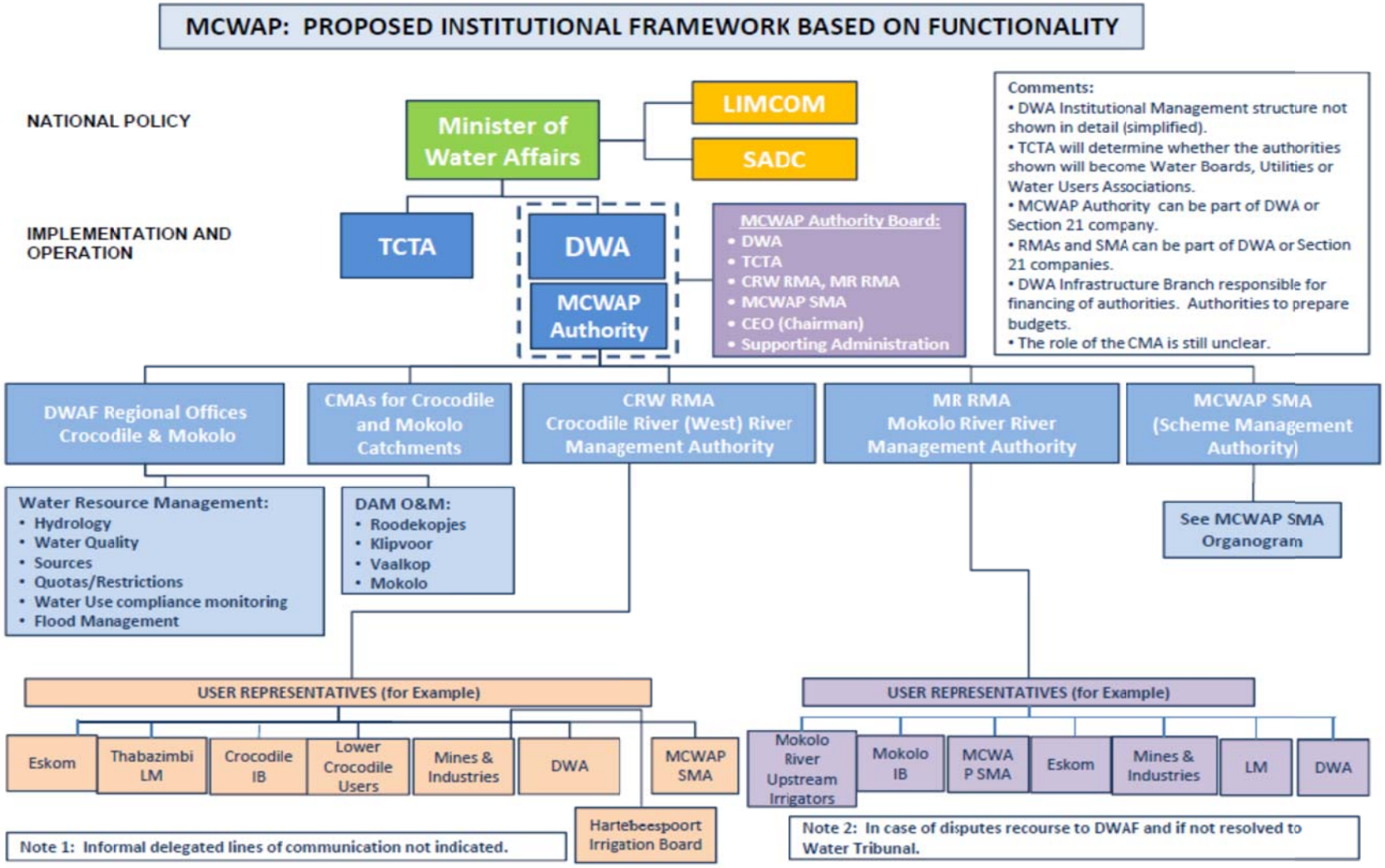

Figure 7-1: Proposed Functional Institutional Framework

8. CONCLUSIONS AND RECOMMENDATIONS

The MCWAP Phase 1 and Phase 2 infrastructure need to be operated as an integrated scheme, with consolidated tariffs, allocations, etc. Such a MCWAP Scheme also needs to be managed in an Integrated Water Resource Management approach with the existing users on the river systems. In this regard, is it of crucial importance that the management of river flows and abstractions along the Crocodile River (West) be incorporated in the management of MCWAP.

The objective of MCWAP to supply water to new users without affecting the legal entitlements of existing users will pose challenges to the management of the water resources and the management of the MCWAP infrastructure. The high level of expectations of existing users in terms of assurance of supply will require continuous communication with the parties and management of potential conflicts. The institutions responsible for those functions need to be properly resourced to deal with such challenges.

Water resources management will be a critical success factor for MCWAP. The catchment of Mokolo Dam needs to be properly controlled to prevent any further development that can impact negatively on the runoff to Mokolo Dam. Likewise, the monitoring and control of abstraction from the Crocodile River (West) will need to be managed intensively.

As the water, utilised from the Crocodile River (West), is made available in the river as return flows, effective and efficient measures need to be in place to control the water quality, i.e. pollution control measures and actions need to be managed well. It is of crucial importance that adequate resources be made available to perform this function. Technical and legal expertise will be required.

The Reserve determination will need to be finalised for the implementation of the operating rules and the MCWAP Scheme. The monitoring of the Reserve requirements should be an important responsibility of the Authority managing the MCWAP.

Operating rules for the Mokolo and Crocodile (West) Rivers need to be finalised whereby the assurance of supply to the users, procedures for determining annual allocations, etc. is to be formalised. In this regard, a variety of decision support tools need to be developed for the Authority that will manage the system in future.

The upgrading of existing water resource infrastructure will most probably be required. The outlet capacities of at least the Hartebeespoort, Roodekopjes and Klipvoor Dams will need to be investigated further. Betterments to the outlet structures may be required. Additional flow gauging will be required on the Bierspruit and Sandrivier close to the

confluence with the Crocodile River (West). The accurate measurement and control of abstractions will be a crucial factor. All irrigation abstraction needs to be fitted with meters and control mechanisms. It is recommended that the above capital requirements be incorporated in the capital costs of MCWAP Phase 2. It should be attended to during the design stage.

In the case of the Mokolo River, none of the gauging weirs downstream of Mokolo Dam are functional and would make water flow measurement control and management more complex. Station A4H013 would be very useful in this regard and it should be investigated if it can be re-instated or an alternative site developed.

Flow measurement at the end of the Crocodile River (West) Irrigation Board's area would be very valuable. The existing structure at "Hugo's" Weir (A2H116) which is located some 20 km upstream of Vlieëpoort is ideal, but considerable betterments should be undertaken to improve the weir structure to DWA standards and to install the latest flow gauging instrumentation. The present installation appears to have stopped functioning in 1995 and was only capable of measuring flows up to 7 m^3/s.

The alluvial aquifer in the Crocodile River (West) and Mokolo River sustain the current irrigation use, and is an important source. The monitoring of the groundwater in the alluvium will be very important, specifically in the proximity of the Vlieëpoort Weir. It is recommended that a proper groundwater monitoring system be developed for the river and implemented as a matter of priority.

Regarding the future institutional management of MCWAP and the water resources serving this area, it will require new challenges to institutions. The water resources management of DWA in these catchments will require more resources in skilled and dedicated staff. The management of MCWAP and the management of the abstraction from the rivers will also require an order of magnitude increase in intensity of the management function and cost in relation to what is currently operational in the area. Focussed and dedicated staffing will be required.

The challenge for the institutional arrangement will be to resource the institution properly in terms of budgeting, equipment, human resources, etc. In this regard, it is important that a partnership is sought between DWA and the large users for the management of MCWAP.

There are a number of institutional options available, including Water Boards, concessionaires, dedicated authorities such as Basin Water Authority, etc.

It is recommended that the institutional arrangements be investigated in consultation and close cooperation with the users and the Irrigation Boards (WUAs).

REPORT DETAILS PAGE

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