water affairs

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Water Affairs
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DIRECTORATE: WATER USE EFFICIENCY

CONTRACT NO. WP 10276

DEVELOPMENT AND IMPLEMENTATION OF IRRIGATION WATER MANAGEMENT PLANS TO IMPROVE WATER USE EFFICIENCY IN THE AGRICULTURAL SECTOR

GROOT MARICO GOVERNMENT WATER SCHEME

WATER MANAGEMENT PLAN

FINAL REPORT

March 2013

Prepared by

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Contract Title: Development and Implementation of Water Management Plans to improve water use efficiency in the agricultural sector

Report Title Groot Marico Government Water Scheme - Water Management Plan

Authors Toriso Tlou, Pr. Eng; Francois Joubert

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EXECUTIVE SUMMARY

During the period 1924 - 1929 the Groot Marico scheme was investigated by the then Transvaal Irrigation Department. A provisional scheme, entailing a dam was planned but it was recommended that further and more detailed investigations of the dam site and irrigation areas be made.

The climate of the catchments of Marico, Upper Molopo and Upper Ngotwane is generally semi-arid in the east and dry in the west. The distribution of the Mean Annual Precipitation (MAP) ranges between 600 and 800 in the Marico catchment to between 400 and 600 in the Upper Molopo catchments. The rainfall is strongly seasonal with rainfall occurring as thunderstorms in summer.

The Groot Marico Irrigation Scheme comprises of two main irrigation canals which originates at the Marico-Bosveld and Kromellenboog dams. The canal distribution system includes a balancing dam and secondary canals which deliver water to the irrigators at their farm turnouts through a number of sluice gates and parshalls.

The Marico-Bosveld dam is situated in the Great Marico River and was completed in 1934. The natural MAR is 40 million m3 and the dam has a gross storage capacity of 26.96 million m3 which represents 67% of the MAR. The Kromellenboog Dam is situated in the Klein Marico River and was completed in 1934. The natural MAR is 16.35 million m3 and the dam has a gross storage capacity of 8.96 million m3 which represents 55% of the MAR. The water quality of the dam is poor and has to be diluted with water from the Marico-Bosveld Dam.

Sensitivity analyses showed that the highest assurance of supply to the Groot Marico GWS is achieved when 90% of the scheme's water requirements are supplied from Marico Bosveld Dam and the remaining 10% of the demand is supplied from Kromellenboog Dam.

The total canal lengths are some 162 km comprising of the Western canal (28.3 km), Eastern canal (12.4 km) and branch canals (58.1km), all lined, serving a total scheduled area of 2 444 hectares with a full irrigation water quota of 12 953 200 m3/annum. Water supply to water users is based on "delivery on request" where each water user (irrigator) must submit a written request on a weekly basis and the water is delivered to some 309 abstraction points along the canal systems.

Economic activity is based on commercial irrigated agriculture and the types of crops cultivated within the area of operation of the scheme are presented in the following table.

Crop	% of Total crop area under irrigation
WHEAT	29
SOYBEAN	20
VEGETABLES-SUMMER	17
LUCERNE	11
VEGETABLES- WINTER	10
TOBACCO	1
CHILLIES	1

Water balance assessment

Using the information obtained from the Water Use Efficiency Accounting Reports (WUEARs), previous studies and consultation with the management of the scheme, a water budget for the Groot Marico GWS was prepared. The water budget is an important tool for analysing the water management issues provided adequate and reliable data is available. At a scheme level there was sufficient data to determine a water budget based on the Water Administration System (WAS).

The total losses on the scheme amount to 31.29%. Of the total losses, 54.3% or 2.5 million cubic metres can be classified as unavoidable losses while 45.7% or approximately 2.1 million cubic metres are avoidable losses. The bulk of the avoidable losses (1.3 million cubic metres) are operational losses and leakages.

Existing water conservation measures

The Marico Bosveld GWS has been implementing measures to improve the management of delivery to the irrigators. These measures include annual maintenance of the irrigation canals to reduce avoidable water losses, as well as having flow measurements in place to audit the water delivery. The Water Administration System (WAS) has been in operation for a number of years on the scheme and the WAS Release Module is also utilised. The generation of the WUEARs through WAS started in October 2009. The structure can be classified as average to poor and certain sections are in need of some urgent refurbishment. The "Marico Bosveld Canal Refurbishment Program" has recently being initiated to address the problems with the aging infrastructure.

Best Management Practice - water losses

An evaluation of the expected water losses based on the existing canal infrastructure and assuming the infrastructure is sufficiently maintained was conducted for the Marico Bosveld GWS. The analysis indicated that the unavoidable water losses due to evaporation losses *and seepage is 2.5 million m^3/a, which translates to 17% of the total volume of water released into the canal system.*

A Water Research Commission (WRC) study conducted in 2010 (Report TT465/10) provided guidelines on the desired range of operational losses that have to be included in order to determine the BMP for operational and distribution efficiency (Reinders 2010). On the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 1.47 million m^3/a based on the average inflow into the canals. The expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses was set at 27% of the total releases into the canal system or 3.97 million m^3/a.

Water management issues

The water budget analysis discussed in the previous chapter has helped to identify several key water management issues. The water budget analysis did reveal that on an annual basis, there is sufficient water to meet the Groot Marico GWS's irrigation demands.

In addition to the water budget analysis, discussions were held with the management and other people who are knowledgeable about the Groot Marico GWS. This was done to determine the key issues the scheme is facing. The key issues identified are:

(a) *There is a lack of adequate flow measurement data perform a detailed water budget analysis at scheme level. The scheme makes regular measurements of flows into the scheme and at the major diversions but this is insufficient. One of the major issues is the fact that the canal end return flows are not measured.*

(b) *Although a measuring system is in place, the data is used for monitoring purposes only and the data is not incorporated into the WAS system automatically. Currently it is not possible to easily conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention.*

(c) *It is currently difficult (if not impossible) to disaggregate the losses. There is a differentiation in the water balance assessment (WUEARs) between the tail water return flows, seepage and evaporation losses which are all based on estimates and not accurate measurements. The remaining avoidable losses such as leakage, spills and over delivery to users were also estimated by subtracting the tail water ends, seepage and evaporation losses from the total losses. The accuracy of the seepage and evaporation losses remains questionable and the accuracy of the theoretical calculations should be verified.*

(d) *In order to properly develop the Groot Marico water management plan it would have been ideal if a detailed assessment of the overall condition of the facilities was conducted. A project has however been initiated (by DWA) to undertake the refurbishment of the canal system and results of the Inception Phase will inter alia include a condition assessment which will be included in this report once it becomes available.*

(e) *Balancing dams decrease the pressure on the canal system and allows for shorter delivery periods to water users. They also intercept any surplus water in the system*

and act as backups to supplement supply should shortages arise (canal breaks, etc.). The Groot Marico GWS has a limited balancing system in place which limits the security of water supply during shortages or major canal failures.

Water Management Plan

Water saving targets

The set targets for the Groot Marico GWS are illustrated in the table below.

Description	System inflow ($x\ 10^6m^3$)	Present situation - Losses				Acceptable water losses		Water savings targets	
		Unavoidable losses ($x\ 10^6m^3$)	Avoidable losses ($x\ 10^6m^3$)	Total Losses ($x\ 10^6m^3$)	% of total volume released	Annual volume ($x\ 10^6m^3$)	% of total volume released	Annual volume ($x\ 10^6m^3$)	% of total volume released
Seepages		1.6	0	1.6	10.88%	1.6	10.88%	0	0.00%
Evaporation		0.9	0	0.9	6.12%	0.9	6.12%	0	0.00%
Filling losses Leakages Spills Over delivery Other		0	1.3	1.3	8.84%	1.47	10.00%	0.63	4.29
Canal end returns		0	0.8	0.8	5.44%	0		0	
Total	**14.7**	**2.5**	**2.1**	**4.6**	**31.29%**	**3.97**	**27.01%**	**0.63**	**4.29%**
% of total volume released into system		**17.01%**	**14.29%**	**31.29%**					

Based on the projected water saving targets, the Groot Marico GWS can achieve a 4.29% reduction in irrigation water losses relative to the 2011 levels in a relative short period.

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans and by revising the maintenance regime is some 0.63 million m^3/a.

In order to lower the losses to below 27%, refurbishment of the canal infrastructure is required. For the long term a further 2.3 million m^3/a saving is envisaged by refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.

The priority water management measures to improve irrigation water use efficiency in Groot Marico GWS include the following:

I. *Measure return flows.*
II. *Expand the water accounting report to undertake sub-scheme water budgets within the GWS.*
III. *Undertake ponding tests to determine seepage as accurately as possible.*
IV. *Revise and improve current maintenance procedures and actions.*
V. *Undertake study to identify suitable locations for additional balancing capacity.*

VI. *Incorporate all relevant data in a custom Management Information System.*
VII. *Investigate possibility of incentive based water pricing.*

Conclusions and recommendations

In terms of WC/WDM the development of a Water Management Plan is in itself a BMP as it force water users and institutions to start thinking and planning. The main aim of a water management plan is to conserve water, to improve water supply services to the water users and to enable irrigators to use their water more efficiently in the sort and long term. The development and implementation of water management plans are progressive processes and although the initial plan may be very basic and lacking information, the completeness will improve when it is reviewed and revised by the Management each year.

The Goals for the WMP have been set and the WUA believes that the targets and objectives set in the WMP are achievable through proper oversight by the Manager and support from the DWA.

This WMP must be seen as a first generation plan and has to be reviewed and updated on an annual basis. Based on the projected water saving targets, the Groot Marico GWS can achieve a 4.29% reduction in irrigation water losses relative to the 2011 levels in a relative short period.

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans is some 0.63 million m^3*/a.*

For the long term a further 2.3 million m^3*/a saving is envisaged by optimising the operations and refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.*

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ABBREVIATIONS

AIC	Average Incremental Cost
BMP	Best Management Practice
DWA	Department: Water Affairs
ET	Evapo-Transpiration
EWR	Environmental Water Requirements
GIS	Geographic Information System
GWS	Government Water Scheme
IB	Irrigation Board
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MISD	Matching Irrigation Supply and Demand
O&M	Operation and Maintenance
RAT	Remote Assessment Tool
RTU	Remote Telemetry Unit
SLA	Service Level Agreement
WARMS	Water Allocation Registration Management System
WAS	Water Administration System
WCC	Water Conservation Coordinator
WCD	Water Control Department
WC/WDM	Water Conservation and Water Demand Management
WCO	Water Control Officer
WMA	Water Management Area
WMP	Water Management Plans
WUA	Water Use Association
WUEAR	Water Use efficiency Accounting Report

GLOSSARY OF TERMS

Application efficiency	The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent.
Applied water:	Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries
Conduit:	Any open or closed channel intended for the conveyance of water.
Conservation:	Increasing the efficiency of energy use, water use, production, or distribution.
Consumptive use (evapo-transpiration)	Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called: Crop requirement, crop irrigation requirement, and consumptive use requirement.
Conveyance loss:	Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation and transpiration by plants growing in or near the channel.
Conveyance system efficiency:	The ratio of the volume of water delivered to irrigators in proportion to the volume of water introduced into the conveyance system.
Cropping pattern:	The acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops.
Crop water requirement:	Crop consumptive use plus the water required to provide the leaching requirements.
Crop irrigation requirement:	Quantity of water, exclusive of effective precipitation, that is needed for crop production.
Crop root zone:	The soil depth from which a mature crop extracts most of the water needed for evapo-transpiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in mm or m. This soil depth may be considered as the rooting depth of a subsequent crop, when accounting for soil moisture storage in efficiency

calculations.

Deep percolation: The movement of water by gravity downward through the soil profile beyond the root zone; this water is not used by plants.

Demand scheduling: Method of irrigation scheduling whereby water is delivered to users as needed and which may vary in flow rate, frequency, and duration. Considered a flexible form of scheduling.

Distribution efficiency: Measure of the uniformity of irrigation water distribution over a field.

Distribution loss: See conveyance loss.

Distribution system: System of ditches, or conduits and their appurtenances, which conveys irrigation water from the main canal to the farm units.

Diversion (water): Removal of water from its natural channels for human use.

Diversion (structure): Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream.

Drainage: Process of removing surface or subsurface water from a soil or area.

Drainage system: Collection of surface and/or subsurface drains, together with structures and pumps, used to remove surface or groundwater.

Drip (trickle) irrigation: An irrigation method in which water is delivered to, or near, each plant in small-diameter plastic tubing. The water is then discharged at a rate less than the soil infiltration capacity through pores, perforations, or small emitters on the tubing. The tubing may be laid on the soil surface, be shallowly buried, or be supported above the surface (as on grape trellises).

Drought: Climatic condition in which there is insufficient soil moisture available for normal vegetative growth.

Dry Period :- A period during which there will be no water flowing in the canal system.

Evaporation: Water vapour losses from water surfaces, sprinkler irrigation, and other related factors.

Evapo-transpiration: The quantity of water transpired by plants or evaporated from adjacent soil surfaces in a specific time period. Usually expressed in

	depth of water per unit area.
Farm consumptive use:	Water consumptively used by an entire farm, excluding domestic use. See irrigation requirement, consumptive use, evapo-transpiration.
Farm distribution system:	Ditches, pipelines and appurtenant structures which constitute the means of conveying irrigation water from a farm turnout to the fields to be irrigated.
Farm loss (water):	Water delivered to a farm which is not made available to the crop to be irrigated.
Geographic Information System (GIS)	Spatial Information systems involving extensive satellite-guided mapping associated with computer database overlays
Irrigation schedule :	This is the list prepared by the Board showing the sequence the Irrigators will lead and dependent on the scheduled area the time period that the Irrigator is entitled to receive water
On-farm:	Activities (especially growing crops and applying irrigation water) that occur within the legal boundaries of private property.
On-farm irrigation efficiency:	The ratio of the volume of water used for consumptive use and leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).
Operational losses:	Losses at the tail ends, sluices not opened or closed on time or opened to big and spills
Operational waste:	Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.
Pan evaporation:	Evaporative water losses from a standardized pan. Pan evaporation is sometimes used to estimate crop evapo-transpiration and assist in irrigation scheduling.
Parshall flume:	A calibrated channel-like device, based on the principle of critical flow, used to measure the flow of water in open conduits. Formerly termed the Improved Venturi Flume.
Percolation:	Downward movement of water through the soil profile or other porous media.

Reservoir: Body of water, such as a natural or constructed lake, in which water is collected and stored for use.

Return flow: That portion of the water diverted from a stream which finds its way back to the stream channel, either as surface or underground flow.

Return-flow system: A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse. Sometimes called a "reuse system.

Run-off This is the water produced when irrigation water is applied to fields at rates and in amounts greater than can be infiltrated into the soil profile.

Request Form : A form on which an Irrigator requests the quantity of water he requires.

Tail end water This is water at the endpoint of a canal

Telemetry Involving a wireless means of data transfer

Water Note A form issued by the Control Officer informing the Irrigator of the quantity of water he will be receiving.

1 INTRODUCTION

1.1 Background

Irrigation agriculture is the biggest water user in the South Africa, using approximately 62% of the current water use nationally. With the increasing competition between existing user sectors, the available water cannot meet the demand under current water use practices and operating conditions in all water use sectors. It is therefore imperative to ensure that available water supplies are used efficiently and effectively to avoid supply shortages and intermittent water supplies, which would have a major impact on the socio-economic growth and development of the country.

The savings that can potentially be made from implementing WC/WDM measures will delay in the need for the development of additional new water supplies, while ensuring that the natural environment is maintained or is not degraded further. The Department of Water Affairs (DWA) identified that, based on preliminary assessment of water losses in the agricultural sector, there was potential to implement measures to improve water use efficiency in the sector. The overall aim in reducing water losses and improving irrigation water use efficiency levels in the Water User Associations (WUAs)/Irrigation Schemes is that the limited available water can be optimally utilised to ensure a high economic return for the scheme area.

The study was commissioned because of the increasing water scarcity in a number of Water Management Areas (WMAs). One of the approaches in addressing the increasing water scarcity and competition for water is to ensure that existing water users utilise their existing water entitlement efficiently. The Department of Water Affairs (DWA) Directorate: Water Use Efficiency, which has the mandate to ensure the efficient use of the water resources in the country by all water use sectors, identified that since the development of the pilot Water Management Plans (WMPs) for improving water use efficiency in irrigation agriculture, no progress had been made by the irrigation sector with respect to the development and implementation of WMPs for that sector.

In order to ensure the irrigation sector review their current water use efficiency levels and develop strategies to improve their water use efficiency, the DWA has identified a need to assist a number of irrigation schemes in developing their irrigation water management plans in order to primarily reduce their water losses. A secondary outcome can be seen as the enablement of irrigators to increase their on-farm irrigation efficiency.

Following the meetings with DWA Directorate: Water Use Efficiency and the DWA Regional Office, this report provides an overview of the water allocation and use situation of the Groot Marico GWS and related institutional arrangements for irrigation water management.

1.2 Study Objectives

The primary objective of the study is the development and implementation of an irrigation WMP for Groot Marico irrigation scheme to improve water use efficiency in the scheme. In order to achieve this objective, the following tasks were undertaken:

- Compilation of a situation assessment of the current water use and irrigation water use practices in the scheme.
- Determination of the irrigation water budget and establishing water use baseline for the irrigation scheme.
- Determination of the irrigation water management issues based on the situation assessment and water budget prepared for the irrigation scheme.
- Identification of opportunities to improve water use efficiency in the scheme.
- Benchmarking of irrigation water use efficiency and setting irrigation water use efficiency targets for the scheme.
- Preparation of an irrigation water management plan for the scheme.
- Capacity building of the WUA to implement the identified opportunities to improve water use efficiency

The development of WMP for the Groot Marico GWS will not only provide a plan for reducing water losses and improve system efficiencies, but if the management plan is implemented and water losses and water demand is reduced, the benefits to the agricultural sector, customers and the catchment in general will include:

- Improved system efficiencies
- Reduction in irrigation water return flows,
- Reduction in system operation and maintenance expenses,
- Potential cost savings due to deferral or downsizing of capital works,
- Benefits which are important but difficult to quantify such as reduced environmental impact resulting from delays in or deferment of construction of water sources and the maintenance of higher water levels in rivers and reservoirs.

1.3 Structure of the report

This report has been structured to first provide a perspective of the Groot Marico Irrigation Scheme as well as the potential for irrigated agriculture in the Marico River catchment. The chapter then provides the overall objective of assessing water conservation and demand management measures in the context of increasing competition between existing water users and the need for water for the environment. This is the focus of **Chapter 1**.

Chapter 2 describes the catchment characteristics of the Marico River catchment in which the Groot Marico Irrigation Scheme is situated. The chapter describes the history of the Groot Marico GWS, the scheduled quotas and current land-use practices in the catchment.

Chapter 3 provides an overview of water distribution infrastructure found in the Groot Marico GWS. The chapter also describes the measurement of flow into and out of the scheme.

Chapter 4 provides a condition assessment of the infrastructure of the Groot Marico GWS.

Chapter 5 describes the scheme operations and operating procedures. Procedures relating to the ordering and delivery of irrigation water are *inter alia* discussed. The procedures for trading and transfers of water are handled as well as the present water pricing structure.

Chapter 6 describes the water balance assessment undertaken for the Groot Marico GWS. The various losses identified on the scheme are also handled in detail.

Chapter 7 of this report describes the existing water conservation and demand management measures that the irrigation sector is currently undertaking.

Chapter 8 describes the key issues that the Groot Marico GWS is facing and also includes the goals of the WUA when WCWDM is contemplated.

Chapter 9 provides the Water Management Plan for the Groot Marico GWS.

Chapter 10 includes the conclusion and recommendations.

2 CATCHMENT CHARACTERISTICS OF MARICO RIVER CATCHMENT

2.1 Overview

The topography of the area is generally very flat with undulating hills in the lower reaches of the Marico River. The Marico and Crocodile Rivers form the headwaters of the Limpopo at their confluence.

The flow in the Marico River is highly variable and intermittent. There are two major storage reservoirs that regulate the flow in the Marico River, namely the Marico Bosveld Dam in the upper catchment and the Molatedi Dam further down-stream. There are several other dams, such as the Klein Maricopoort and Sehujwane Dams, from which water is mainly used for irrigation along the Marico River, particularly downstream of Marico Bosveld Dam.

2.1.1 Climate and rainfall distribution

The climate of the catchments of Marico, Upper Molopo and Upper Ngotwane is generally semi-arid in the east and dry in the west. The distribution of the Mean Annual Precipitation (MAP) ranges between 600 and 800 in the Marico catchment to between 400 and 600 in the Upper Molopo catchments. The rainfall is strongly seasonal with rainfall occurring as thunderstorms in summer. The variation in annual rainfall from the long term mean is especially pronounced in the Marico, Upper Molopo and Upper Ngotwane river catchments (DWAF: 1997).

The average potential Mean Annual Evaporation (MAE) (as measured by A-pan) for the western parts of the Marico catchment and the Upper Molopo and Ngotwane is very high. It is estimated to be as high as 2800mm, with the highest levels occurring in December (DWAF: 2001).

2.1.2 Geology and soils of the catchment

The western portion of Upper Molopo catchment is underlain by Basement granite. This is covered with an increasing thickness of Kalahari sand to the west. A mostly intrusive volcanic rock assemblage (Allanridge lava) lies to the east of Mafikeng. Significant aquifers are present locally north of Slurry. The aquifers tend to be relatively shallow. Groundwater is the only source of water supply for the rural population. In the Upper catchment of the Groot Marico as well as the Upper Ngotwane catchment, the landscape is generally flat to gently rolling due to the Malmani dolomites. The dolomite is intruded by numerous dolerite dykes that have effectively sub-divided the dolomite into a series of compartments, which may or may not be hydraulically linked. Groundwater is widespread, especially in chert rich horizons and karst zones where borehole yields greater than 5l/s are common, and yields of 20l/s are feasible.

The NE portions of catchments of A10A, A31A, and A31D, A10B, A31F, G, H, J, A32A, B, and C are underlain by sandstone, quartzite, shale, diabase and andesite of the Pretoria Group.

The following soils types occur in the Marico catchment:

- Moderate to deep clay loam soils occur in most of the Upper Molopo catchment with moderate to deep sandy soils in the lower reaches of the D41A catchment. The moderate to deep clay loam soils are not the ideal soils for irrigation farming because although they have a reasonably high water holding capacity they are not readily penetrable by water.

- Moderate to deep clay loam soils with undulating topography occurs in the Marico (with the exception of the lower Marico) and Upper Ngotwane catchments. These soils are also not very suitable for irrigation farming, also due to their low permeability.

- Overgrazing in some portions of the catchment results is excessive soil erosion and loss of land cover. This has an impact on groundwater recharge. Irrigation farming is generally practised along the Groot Marico and its tributaries.

- Moderate to deep sandy loam soils in general flat terrain occur in the lower Marico. These soils are ideal for irrigation farming because they provide a good balance between the ability to convey water and ability to retain water. This is the area where most of the irrigation is taking place.

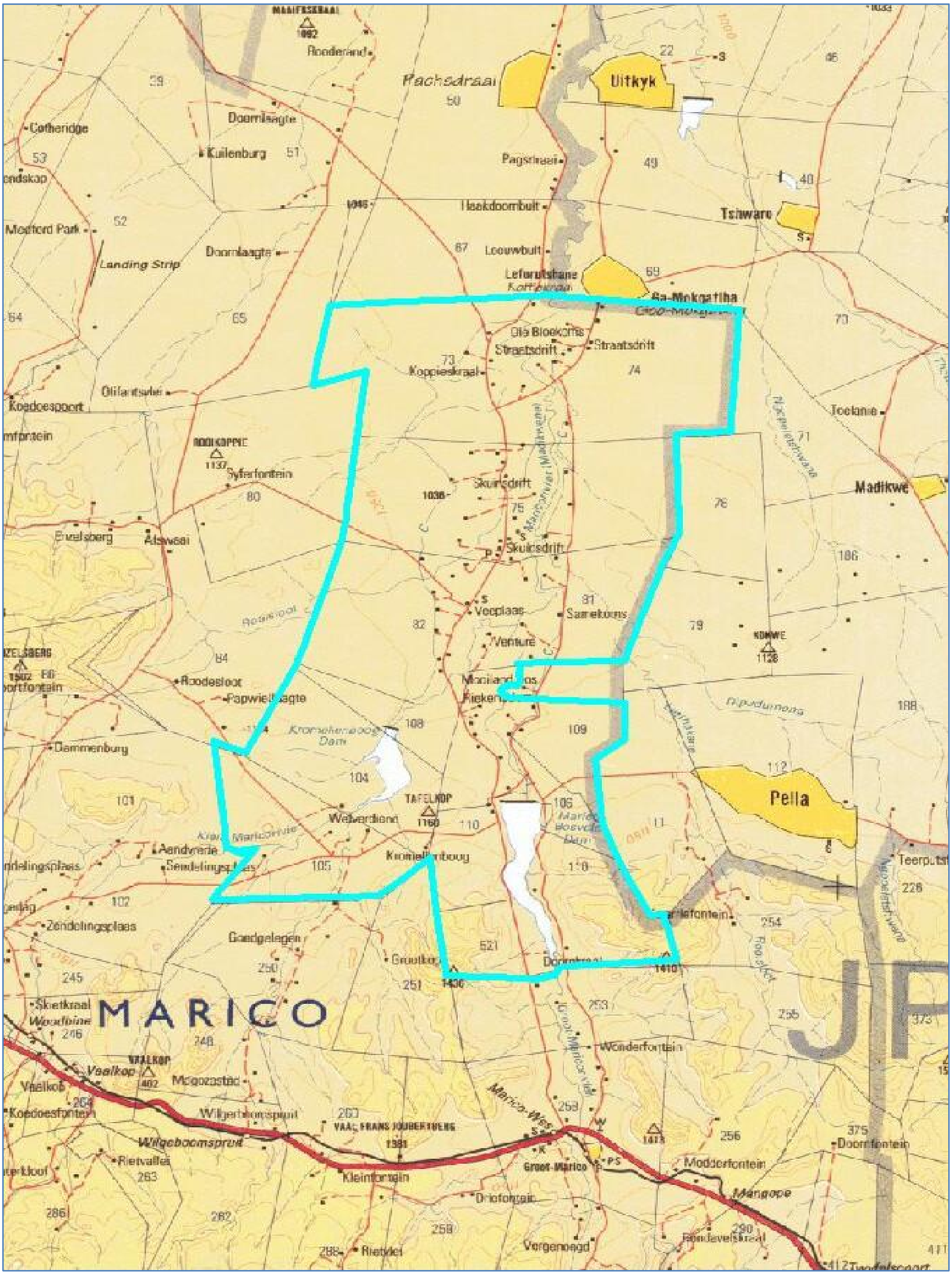

Figure 2-1: Location Map of the Groot Marico GWS

2.2 History of the Groot Marico GWS

During the period 1924 - 1929 the scheme was investigated by the then Transvaal Irrigation Department. A provisional scheme, entailing a dam was planned but it was recommended that further and more detailed investigations of the dam site and irrigation areas be made.

The scheme receives an allocation of 13,37 million m^3/ annum of water from the Marico-Bosveld (80%) and Kromellenboog (10%) dams.

The allocation of water from the dams is ordered twice a day from the dam manager who releases the quota into the canals or into the river. The annual quota starts of the 1st of October, when the Department looks at the water availability in the dam. The quota is then determined on the basis of water availability. In dry years the irrigation board may only receive a small percentage of their quota. Thus in the drought of 1992 for instance, only 20% of the water allocation was released into the irrigation system. In dry years the canals only flow for 24 to 36 hours a week and because of low levels of pressure, the losses are very high.

The distribution of water is administered through variable water pressure at different sluice gates. The board measures the pressure and a certain pressure is deemed to correspond with a specific quantity of water - 50 m^3/hour, 70 m^3/hour and 100 m^3/hour. The sluices are operated by hand, in increments of 12 hours and because of varying pressure in the system.

In 1998, following a reorientation of priorities within the Department of Water Affairs away from further expenditure towards the overheads of irrigation schemes such as Hartbeespoort, the farmers on the water scheme were encouraged to form an irrigation board so that the responsibility for the infrastructure could be transferred to them. Part of the cutback in departmental expenditure involved cutting approximately 1 000 members of the staff of government water schemes off the payroll and thus in many cases the staff members continued their employment as salaried members of the irrigation board.

Initially this idea of irrigation management transfer reportedly met with a lot of resistance amongst the farmers because they felt that the department had allowed the canals to fall into disrepair and now they were being saddled with the responsibility for a decrepit system.

The Groot Marico Government Water Scheme has not been transformed into a Water User Association yet.

2.3 Water use permits / licenses and contracts

When National Water Act (Act 36 of 1998) came into effect in 1998, irrigation boards were required to submit applications for the transformation into Water User Associations (WUA).

Policy proposals regarding the treatment of scheduled irrigation allocations on Government and Irrigation Board schemes as existing lawful water use in terms of section 33 of the NWA, 1998, were approved by the Minister on 10 May 1999. Under this policy, all lawful scheduling in terms of sections 63 and 88 of the Water Act (1956) on Government and Irrigation Board schemes, which has been annually paid for before 1 January 1999, was declared as existing lawful use in terms of section 33 of the NWA, 1998. The Policy also stated that all unexercised water uses must be exercised within three years after the promulgation of the Act to be considered as existing lawful water use

In Circular 18 of 2001 the Director General stated that "all lawful scheduling in terms of section 63 and 88 of the WA for which all due water use rates and charges were paid on 30 September 1998, should be treated as existing lawful water uses in terms of section 33 of the WA. As there is no authority for the Minister to attach conditions to a declaration of an existing lawful water use, the three-year period to develop unutilised water allocations as granted in terms of Circular 59 of 1999 is hereby withdrawn. These unutilised rights can be treated as existing lawful water use until compulsory licensing is required." The entitlement to use water on the scheme is therefore the continuation of existing lawful use. The GWS therefore functions under the rules and regulations of the previous Water Act until the scheme is transformed and compulsory licensing is required.

2.4 Irrigated areas and types of crops

The types of crops cultivated within the area of operation of the Groot Marico GWS are provided in Table 2-1.

Table 2-1: Crops under irrigation - Groot Marico GWS

Crop	% of Total crop area under irrigation
WHEAT	29
SOYBEAN	20
VEGETABLES-SUMMER	17
LUCERNE	11
VEGETABLES- WINTER	10
TOBACCO	1
CHILLIES	1

3 INVENTORY OF THE EXISTING WATER INFRASTRUCTURE

3.1 Overview

The Groot Marico Irrigation Scheme comprises of two main irrigation canals which originates at the Marico-Bosveld and Kromellenboog dams. The canal distribution system includes a balancing dam and secondary canals which deliver water to the irrigators at their farm turnouts through a number of sluice gates and parshalls.

3.2 Marico-Bosveld Dam

The Marico-Bosveld dam is situated in the Great Marico River and was completed in 1934. The natural MAR is 40 million m^3 and the dam has a gross storage capacity of 26.96 million m^3 which represents 67% of the MAR. Sensitivity analyses showed that the highest assurance of supply to the Marico Bosveld GWS is achieved when 90% of the scheme's water requirements are supplied from Marico Bosveld Dam and the remaining 10% of the demand is supplied from Kromellenboog Dam.

Figure 3-1 Spillway - Marico-Bosveld Dam

3.3 Kromellenboog Dam

The Kromellenboog Dam is situated in the Klein Marico River and was completed in 1934. The natural MAR is 16.35 million m^3 and the dam has a gross storage capacity of 8.96 million m^3 which represents 55% of the MAR. The water quality of the dam is poor and has to be diluted with water from the Marico-Bosveld Dam.

Figure 3-2 Kromellenboog Dam

3.4 Irrigation conveyance infrastructure

Figure 3.1 below provides the conveyance and distribution infrastructure of the Groot Marico Irrigation Scheme. The whole irrigation conveyance infrastructure is concrete lined. Water is mainly released from the Marico-Bosveld Dam into the canal system.

There are six wards in the scheme and each water ward has a ward manager who is responsible for the water distribution management of the specific ward. The canal infrastructure comprises of secondary canal systems, an active balancing dam on the West canal. Water is delivered to the farmers through pressure regulating sluices which are set on a daily basis. The dam setting is changed on a twelve hourly interval. The aim of the water distribution is to make water available at a specific time for a predetermined period of time at a fixed flow rate to a certain point to the best advantage of the irrigators .

The total canal lengths are some 162 km comprising of the Western canal (28.3 km), Eastern canal (12.4 km) and branch canals (58.1km), all lined, serving a total scheduled area of 2 444 hectares with a full irrigation water quota of 12 953 200 m^3/annum. Water supply to water users is based on “delivery on request” where each water user (irrigator) must submit a written request on a weekly basis and the water is delivered to some 309 abstraction points along the canal systems.

Figure 3-3 Main canal from Kromellenboog Dam

Figure 3-4 Main canal from Marico-Bosveld Dam

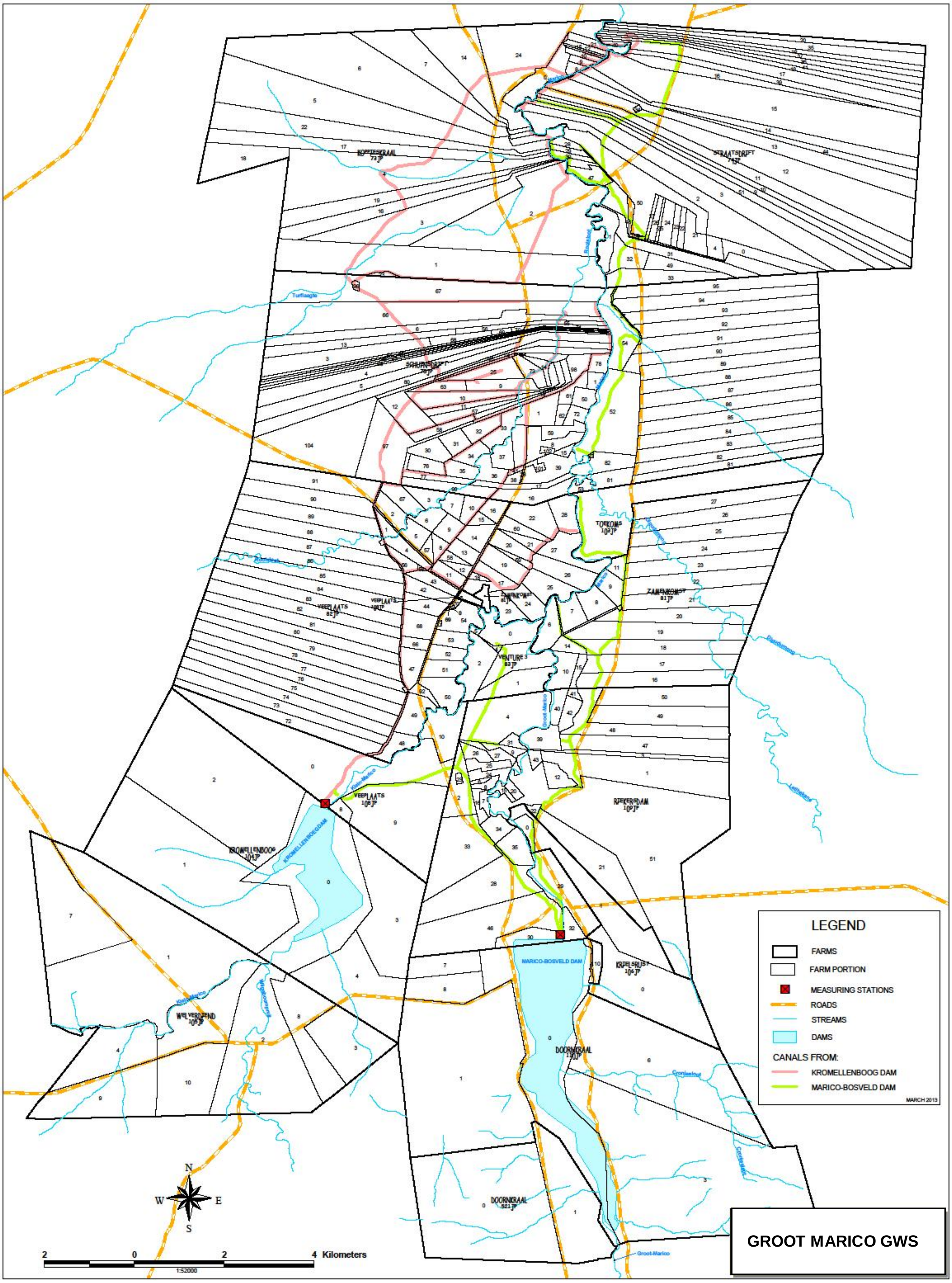

Figure 3-5: Groot Marico GWS Infrastructure

3.5 Irrigation storage and regulation system

The irrigation scheme includes one balancing dam situated on the west canal with a capacity of 24 000 m³. Unfortunately the dam cannot operate at its full capacity due to algae growth, pollution and silt. It will be ideal to clean this dam to such a degree that optimum use is enabled or possibly enlarge it order to increase the balancing capacity.

Figure 3-6 Balancing Dam - West Canal

3.6 Flow Measurement and telemetry system

3.6.1 Measurement of flow into and out of the Scheme

The first measurements are taken at the inlets below the Marico Bosveld and Kromellenboog Dams. There are also two Orpheus mini meters at the main diversions. There are four measuring systems and the data is used by the scheme manager to monitor the flows in the canal system and determine losses between the various measuring stations. The ideal will be to have a telemetry system at each measuring structure and at each canal end point, but it is seen as too expensive at this point in time.

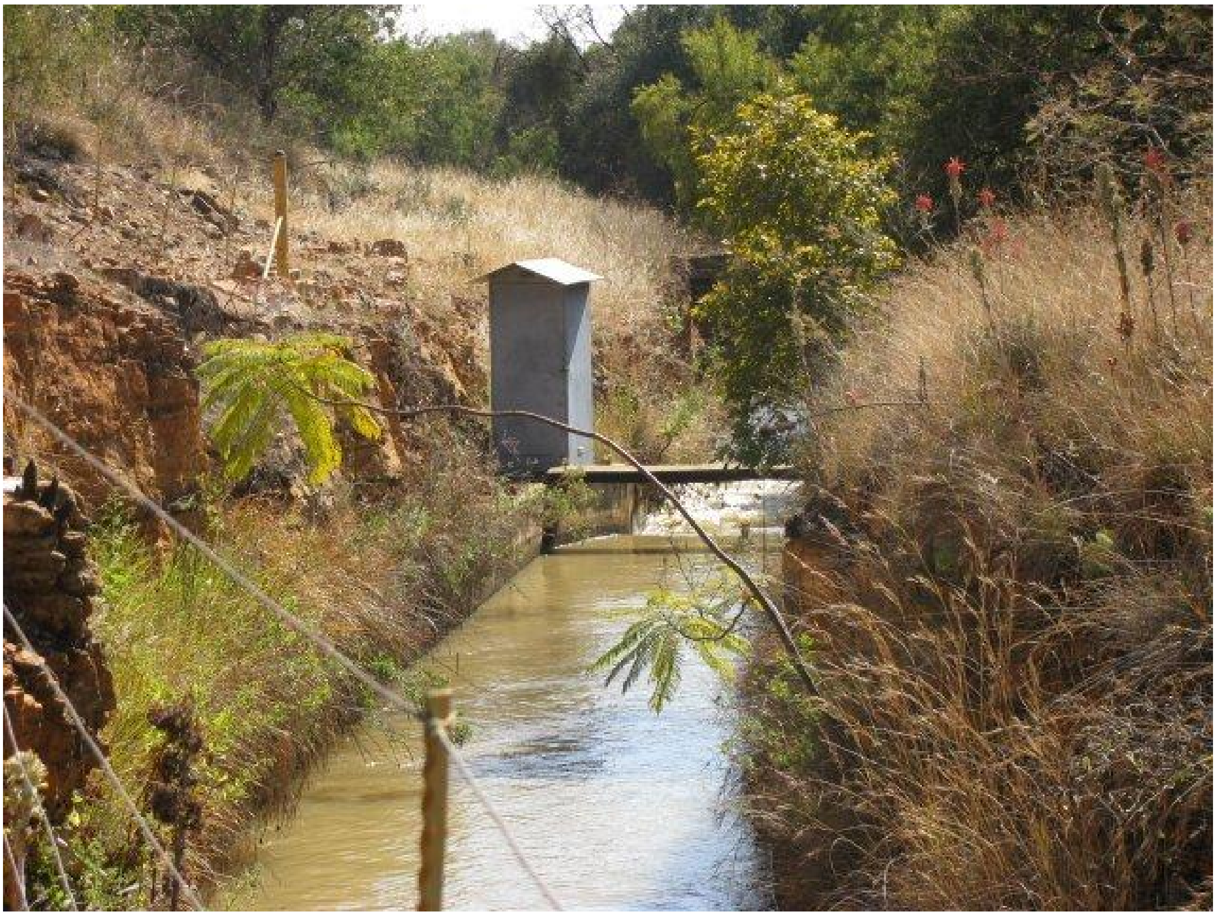

Figure 3-7 Measuring station below Marico-Bosveld Dam

Furthermore the Groot Marico GWS measures the weekly volume of water delivered to the water users using weirs and pressure regulating sluice gates. The quantity of water supplied to individual farmers is regulated by the degree to which the various sluice gates along the canal are opened. Depending on the size of the sluice gate opening, water can be delivered at 50 m^3/hour, 70 m^3/hour and 100 m^3/hour. The sluices are operated by hand, in increments of 12 hours

The volume of water that was actually delivered to farmers can be monitored by comparing the quantity of water ordered from the two dams with the water that is returned to the Marico River. The percentage of water lost can then be calculated and the scheme administrators should also know if any farmer has taken more than his or her allocation.

Figure 3-8 Measuring weir in Marico River

Figure 3-9 Measuring station below Kromellenboog Dam

4 INFRASTRUCTURE CONDITION ASSESSMENT

4.1 Overview

In order to determine the condition of the canal infrastructure a methodology has been developed known as the Rapid Assessment Tool (RAT). This is a combination of methodologies designed to provide a quick and cost-effective analysis of condition within an irrigation scheme.

The main objective of undertaking condition assessment is to define the extent and seriousness of problems contributing to poor conveyance efficiency.

RAT methodologies include surveys, rating of infrastructure, flow measurement, seepage loss tests, and GIS-based mapping and analysis, among other activities. These methodologies are still evolving. Two visual rating procedures have been developed:

- water supply conditions ("head conditions")
- canal conditions

The overall goal of this effort is to provide information which will allow decision makers involved in irrigation resource management to assess and compare the rehabilitation needs of irrigation networks.

4.2 Canal Condition Evaluation

During the course of the project the DWA commissioned a project named **"Marico Bosveld Canal Refurbishment Project"**. Part of this project includes a detailed condition assessment of the conveyance infrastructure and a detailed condition assessment was therefore not undertaken during the development of this WPM. Unfortunately the results were not available at the time of writing this report but will be included as soon as the results are known.

5 SCHEME OPERATIONS AND OPERATING PROCEDURES

5.1 General scheme options

The requests for water from the dams are ordered twice a day from the dam manager who releases the quota into the canals. Water is released from the dam until Friday afternoon and only again on Sunday afternoon in order to reach the lowest abstraction points in time on Monday.

The Groot Marico GWS is scheduled for an area of 2 444 ha. All properties that fall within the Irrigation Scheme, Title Deed information and scheduled areas are shown on the Schedule of Rateable Areas (LRA).

The maximum quota that is annually granted to the irrigators, is 5 300 m³ per hectare. If there is not enough water available to allocate the full 5 300 m³ per hectare for that specific year, a smaller quota will be granted. It is also possible that, when surplus conditions occur, extra water can be bought, if so, water has to be paid for in advance.

The normal water year stretches from 1 October to 30 September the following year. If the granted quota was not fully utilized before the end of the water year, it can be used for a further one (1) month (October) in the next water year. If the granted water is fully used before the end of that specific water year, the new water year's water quota can already be used in the last month (September) of the previous year.

5.2 Water ordering and delivery procedures

Application forms must be completed by the irrigator and placed in the application boxes before 10:00 on Thursdays, preceding the irrigation week water is applied for. Such an application is called a normal application.

The application boxes are opened and emptied directly after 10:00 on Thursdays and a late application will not be taken into consideration before the Monday of the following week.

If an application is not put into the box on the prescribed time and day, the irrigator can go to his Ward Manager for a late application. A late application must be handed in at the Ward Manager's office. For a late application, the blue form must be handed in on Mondays and Wednesdays before 10:00.

The local Ward Manager is only allowed to consider a late application in the following circumstances: If the late application can be fitted into the feeder/flow charts without any negative impact on other irrigators, like a decrease or cancellation of their water use.

An irrigator can cancel his/her entire demand or only a part of it by requesting for a cancellation on a cancellation form at the local Ward Manager's office.

A cancellation can only be considered if there is enough time to bring about the necessary adjustments to the sluice. Water that is already on its way to the irrigator may not be cancelled and will be deducted from the irrigator's quota, whether or not the irrigator has received/taken the water.

If the manager is of the belief that it is in the best interest of all irrigators to cancel all the water, it can be done by request of the manager. In such an event, the individual irrigator does not have to hand in a pink form. Such a cancellation is known as an "automatic cancellation" and normally occurs after good rain on the scheme. The manager delegates the authority to management to make decisions regarding the cancellation of all water.

An irrigator can apply for an increase on his requested water by applying on a blue form at the Ward Manager's office. This application is called a special application (replenishment). The local Ward Manager will only be allowed to consider a special application under the following circumstances:

If the replenishment can fit into the local Ward Manager's supply schedule without other irrigators' demands being decreased or cancelled.

If the replenishment application is handed in on time, which is on Wednesdays before 10:00, so that necessary adjustments can be made.

If a normal application was handed in. Replenishment on late applications will not be considered.

Late applications and replenishments can only be done at the Ward Manager's office on Mondays and Wednesdays before 10:00. Cancellations can be done every day, but must be done before 10:00.

Returned water (short delivery due to operational problems) is limited to the minimum due to management problems and only allowed in extreme cases. Where there are water shortages, the remaining water demands and/or the period of short running must be partially or fully cancelled and the irrigator must hand in a new application as soon as possible hereafter or when needed.

5.3 Water trading - Temporary water transfers

There are periods when existing irrigators exhaust their scheduled quota before the water year and may require additional irrigation water. The current practice is that the irrigator sources for additional water from other irrigators who are not using their full water quota and negotiates for a temporary transfer subject to agreeing compensation for the transfers.

Application for temporary transfer of water for the course of the concerned water year must first be approved by the manager before the water may be provided. If the properties concerned have the same owner, the manager can favorably consider such an application for the transferring of water rights. If the properties concerned do not have the same owner where water rights must be transferred, the manager may only consider the application in the following cases:

- If the applicant can provide proof that he/she is the owner of the one property and the legal tenant of the other. The lease contract must at least stretch to the end of the same water year.
- In the event where all the properties are rented, the irrigator must provide proof that he/she is legally renting all the properties for the same water year.

The transfer must be feasibly practical. The water quota of the property where to the water will be transferred must be used up before transfer can take place. Both the properties that are involved in the transfer must be scheduled under the Groot Marico GWS. The charges of both the properties that are involved in the transfer must be paid up to date and remain that way

5.4 Water pricing structure

5.4.1 Setting of the irrigation pricing

The Department of Water Affairs (DWA) currently sets the water use charge for irrigation water based on the pricing strategy. Therefore the water use charge for the scheme is set based on the total scheduled hectares in the irrigation scheme.

While the costs of supplying water from the dams are high, irrigation farmers were not required to meet many of these costs. Most significantly, they were not required to meet any capital costs. Groot Marico GWS incurs a number of expenses relating to the maintenance and refurbishment of the canal systems and the administration of the scheme. **Table 5-1** summarises the monthly tariffs which the irrigation farmers need to pay.

Table 5-1: Monthly tariffs as on 11/11/2011

Description	**Value**
VAT (%)	14
Quota (R/ha)	92.74
WRF (R/ha)	0.42
CMC (R/ha)	30.75
Total (R/ha)	**141.26**

6 GROOT MARICO GWS WATER BALANCE

6.1 Introduction

The purpose of a water balance is to summarise the inflows, consumption and outflows from the area of operation of an Irrigation Board/Scheme. During the preparation of the water balance the beneficial and non-beneficial consumptive uses are determined which form the basis for the calculation of performance indications which are necessary in identifying water savings opportunities.

Every water use component in a Scheme/Board is represented in the water balance and the various categories for inflows, consumptive use and outflows are described and discussed below.

6.2 Inflows

The first measurement of water flow takes place at the Marico-Bosveld and Kromellenboog dams where water is released from the dam into the two main irrigation canals. Weekly records of the inflows into the main canals at the Marico-Bosveld and Kromellenboog dam wall were evaluated. The records of the water released from the dam are included in the WAS system and the records of inflows of water into the scheme are based on the total weekly request by all the scheme water users.

6.3 Consumptive use

Consumptive use can be classified as the use that removes the water from the scheme that renders it unavailable for further use. Consumptive use can be classified into two main categories;

Process consumption

Process consumption or productive use is that volume of water that is used to produce the crops and is therefore considered beneficial use.

Non-process consumption

Non-process consumption or non-productive use occurs when water is consumed (depleted), but not by the irrigation of crops. Non-process consumption can further be subdivided in two types of uses, namely;

- Beneficial use, such as water that is used by indigenous riverine vegetation, and
- Non-beneficial use, such as evaporation or deep percolation that cannot be retrieved for productive use.

The supply to individual water users is measured through the variable water pressure at different adjustable sluice gates. Depending on the size of the sluice gate opening, water can be delivered at 50 m^3/hour, 70 m^3/hour and 100 m^3/hour. The sluices are operated by hand, in increments of 12 hours.

6.4 Outflows

As the name suggests, outflow is water flowing out of the system or area of operation of the scheme and can be classified as ether committed or non-committed outflow.

Committed outflow is that part of the outflow that is committed to other uses or users.

Uncommitted outflow is outflow that is available for other or downstream use. Uncommitted outflow can occur as a result of a lack of storage or operational measures.

Actual outflows are not presently measured and the canal end point values are based on estimates from the WUEARs.

6.5 Overall scheme water balance

The water balance is based on information from the Water Administration System (WAS). Distribution sheets are then compiled using WAS and losses are added. The records of inflows which consist of all the sources of water supply to the Groot Marico Irrigation Scheme were provided on a monthly basis.

The outflows consist of all the ways that water is consumed in the scheme. This includes the canal seepage, operational spills, evaporation from the canals and percolation. Consumptive use is based on the delivery to irrigators and other users.

Figure 6-1 is a graphical illustration of the monthly volume of water ordered in the Groot Marico GWS for 2009.

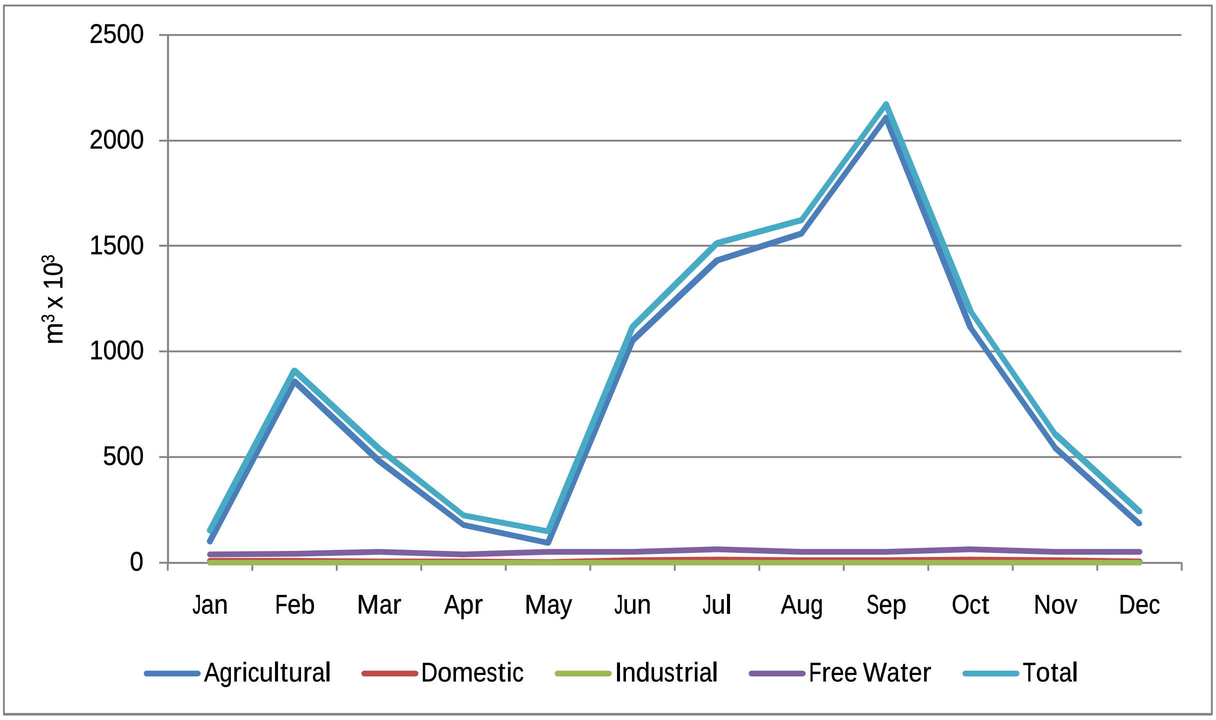

Figure 6-1: Monthly water orders

Using the information obtained from the WUEARs, previous studies and consultation with the management of the scheme, the water accounting report for the Groot Marico GWS is provided in **Figure 6-2**. The volume of water that is requested by the Irrigation Board varies from year to year, as does the cropping pattern for each year.

The consumptive uses include agriculture, domestic (drinking water and stock watering) industrial and municipality, free water, government departments and old furrows. The average consumptive use was 11.8 million m³/a making out 92.4 % of the full quota.

Table 6-1: Groot Marico GWS - Water accounting report

Year	Month	Inflow	Agricultural use requested		Domestic		Industrial		Free Water		State Dep.		Total use	Total losses	Loss as % of inflow	Canal end points	% of inflow	Evap.	% of inflow	Seepage	% of inflow	Efficiency losses & leakages	% of inflow
2009	Jan	560.3	333.3	333.3	12.8	12.8	0.0	0.0	51.2	51.2	0.0	0.0	397.3	163.0	29.1	45.8	8.2	42.2	7.5	52.2	9.3	68.6	12.2
	Feb	226.2	149.1	482.4	3.1	15.9	12.8	12.8	0.0	51.2	0.0	0.0	165.0	61.2	27.1	17.3	7.6	16.0	7.1	19.7	8.7	25.5	11.3
	Mar	669.6	396.5	878.9	3.1	19.0	24.0	36.8	0.0	51.2	0.0	0.0	423.6	246.0	36.7	20.4	3.0	16.0	2.4	19.7	2.9	210.3	31.4
	Apr	226.6	149.1	1 028.0	3.1	22.1	12.8	49.6	0.0	51.2	0.0	0.0	165.0	61.6	27.2	17.3	7.6	16.0	7.1	19.7	8.7	25.9	11.4
	May	531.8	379.0	1 407.0	7.4	29.5	0.0	0.0	24.0	75.2	0.0	0.0	410.4	121.4	22.8	34.4	6.5	24.9	4.7	52.1	9.8	44.4	8.3
	Jun	760.5	559.5	1 966.5	4.5	34.0	0.0	0.0	24.0	99.2	0.0	0.0	588.0	172.5	22.7	48.8	6.4	69.2	9.1	54.8	7.2	48.5	6.4
	Jul	1 963.6	1 432.5	3 399.0	16.1	50.1	0.0	0.0	63.8	163.0	0.0	0.0	1 512.4	451.2	23.0	117.8	6.0	178.7	9.1	163.0	8.3	109.5	5.6
	Aug	2 109.9	1 559.7	4 958.7	12.9	63.0	0.0	0.0	51.0	214.0	0.0	0.0	1 623.6	486.3	23.0	112.9	5.4	192.0	9.1	173.0	8.2	121.3	5.7
	Sep	2 570.5	2 106.6	7 065.3	12.9	75.9	0.0	0.0	51.1	265.1	0.0	0.0	2 170.6	399.9	15.6	133.9	5.2	179.9	7.0	205.6	8.0	14.3	0.6
	Oct	1 872.0	1 445.0	8 510.3	4.5	80.4	0.0	0.0	53.1	318.2	0.0	0.0	1 502.6	369.4	19.7	58.1	3.1	64.1	3.4	135.2	7.2	170.1	9.1
	Nov	1 034.4	701.0	9 211.3	22.0	102.4	0.0	0.0	51.1	369.3	0.0	0.0	774.1	260.3	25.2	48.1	4.7	91.0	8.8	83.8	8.1	85.5	8.3
	Dec	320.7	184.5	9 395.8	6.0	108.4	0.0	0.0	52.1	421.4	0.0	0.0	242.6	78.1	24.4	11.1	3.5	27.6	8.6	23.1	7.2	27.4	8.6
	Total	**12 846.1**	**9 395.8**		**108.4**		**49.6**		**421.4**		**0.0**		**9 975.2**	**2 870.9**	**22.3**	**665.9**	**67.2**	**917.6**		**1 001.9**		**951.4**	
2008	Jan	1 455.3	1 001.0	1 001.0	9.7	9.7	0.0	0.0	40.8	40.8	0.0	0.0	1 051.5	403.8	27.7	84.4	5.8	156.3	10.7	104.2	7.2	143.3	9.8
	Feb	1 312.8	857.1	1 858.1	10.4	20.1	0.0	0.0	41.9	82.7	0.0	0.0	909.4	403.4	30.7	85.9	6.5	155.3	11.8	116.6	8.9	131.5	10.0
	Mar	750.9	481.8	2 339.9	6.4	26.5	0.0	0.0	52.1	134.8	0.0	0.0	540.3	210.6	28.0	44.4	5.9	77.7	10.3	61.7	8.2	71.2	9.5
	Apr	313.1	177.9	2 517.8	6.8	33.3	0.0	0.0	38.7	173.5	0.0	0.0	223.4	89.7	28.6	19.5	6.2	32.5	10.4	25.9	8.3	31.3	10.0
	May	203.0	95.4	2 613.2	3.2	36.5	0.0	0.0	50.7	224.2	0.0	0.0	149.3	53.7	26.5	12.0	5.9	19.2	9.5	15.4	7.6	19.1	9.4
	Jun	1 554.9	1 052.4	3 665.6	12.9	49.4	0.0	0.0	51.1	275.3	0.0	0.0	1 116.4	438.5	28.2	96.9	6.2	152.6	9.8	126.7	8.1	159.2	10.2
	Jul	1 963.6	1 432.5	5 098.1	16.1	65.5	0.0	0.0	63.8	339.1	0.0	0.0	1 512.4	451.2	23.0	117.8	6.0	187.5	9.5	157.2	8.0	106.5	5.4
	Aug	2 109.9	1 559.7	6 657.8	12.9	78.4	0.0	0.0	51.0	390.1	0.0	0.0	1 623.6	486.3	23.0	112.9	5.4	185.8	8.8	152.0	7.2	148.5	7.0
	Sep	2 570.5	2 013.0	8 670.8	12.9	91.3	0.0	0.0	51.1	441.2	0.0	0.0	2 077.0	493.5	19.2	133.9	5.2	229.4	8.9	183.9	7.2	80.2	3.1
	Oct	2 957.2	1 678.0	10 348.8	16.1	107.4	0.0	0.0	63.9	505.1	0.0	0.0	1 758.0	1 199.2	40.6	175.5	5.9	311.4	10.5	246.0	8.3	641.8	21.7
	Nov	1 034.4	667.0	11 015.8	12.9	120.3	0.0	0.0	51.1	556.2	0.0	0.0	731.0	303.4	29.3	49.3	4.8	124.0	12.0	124.0	12.0	55.4	5.4
	Dec	320.7	184.5	11 200.3	5.2	125.5	0.0	0.0	52.1	608.3	0.0	0.0	241.8	78.9	24.6	16.2	5.1	30.7	9.6	19.8	6.2	28.4	8.9
	Total	**16 546.3**	**11 200.3**		**125.5**		**0.0**	**0.0**	**608.3**		**0.0**	**0.0**	**11 934.1**	**4 612.2**	**27.9**	**948.7**		**1 662.4**		**1 333.4**		**1 616.4**	

6.6 Losses

6.6.1 Overview

The determination of operational losses (and mechanisms to minimise it) is one of the most important tools for improving irrigation water use efficiency levels. Higher accuracy in determining these losses can underpin the efforts to decrease losses over the extent of the whole canal distribution system. Decreasing "avoidable losses" from irrigation canals is often the only "relatively" inexpensive method available when contemplating water management measures.

Avoidable losses occur as a result of inefficient management in the operation of the canal system and can mainly be attributed to poor canal maintenance (leaks), incorrect headwork and inefficient runtime release determination, inaccurate water measuring structures and other restricting factors such as algae growth, etc.

Unavoidable losses from canal systems can be attributed to seepage and evaporation and is related to the surface area of water in the canal, wetted perimeter area of the canal and to the structural condition of the canal network.

The outflows consist of all the ways that water is consumed in the scheme. This includes the canal seepage, operational spills, evaporation from the canals, percolation and delivery to the irrigators and other users.

6.6.2 Gross Water losses

The total monthly losses summarised by main canal for the period January 2008 to December 2009 are shown in Table 6-2. The values in this table reflect the total losses and include seepage, evaporation, leakage and operational losses (including canal end return flows). It therefore reflects the difference between the volume that was ordered by the water users and the volume of water released into the inlets of the two main canals.

Table 6-2: Groot Marico GWS - Historical monthly losses

Month	Inflow (m^3+10^3)	Losses (m^3+10^3)	% Loss
Jan-08	1 455.3	488.2	33.5
Feb-08	1 312.8	489.3	37.3
Mar-08	750.9	255.0	34.0
Apr-08	313.1	109.2	34.9
May-08	203.0	65.7	32.4
Jun-08	1 554.9	535.4	34.4
Jul-08	1 963.6	569.0	29.0

Month	Inflow *(m^3+10^3)*	Losses *(m^3+10^3)*	% Loss
Aug-08	2 109.9	599.2	28.4
Sep-08	2 570.5	627.4	24.4
Oct-08	2 957.2	1 374.7	46.5
Nov-08	1 034.4	352.7	34.1
Dec-08	320.7	95.1	29.7
Jan-09	560.3	208.8	37.3
Feb-09	226.2	78.5	34.7
Mar-09	669.6	266.4	39.8
Apr-09	226.6	78.9	34.8
May-09	531.8	155.8	29.3
Jun-09	760.5	221.3	29.1
Jul-09	1 963.6	569.0	29.0
Aug-09	2 109.9	599.2	28.4
Sep-09	2 570.5	533.8	20.8
Oct-09	1 872.0	427.5	22.8
Nov-09	1 034.4	308.4	29.8
Dec-09	320.7	89.2	27.8

The data shown in is graphically represented in Figure 6-2.

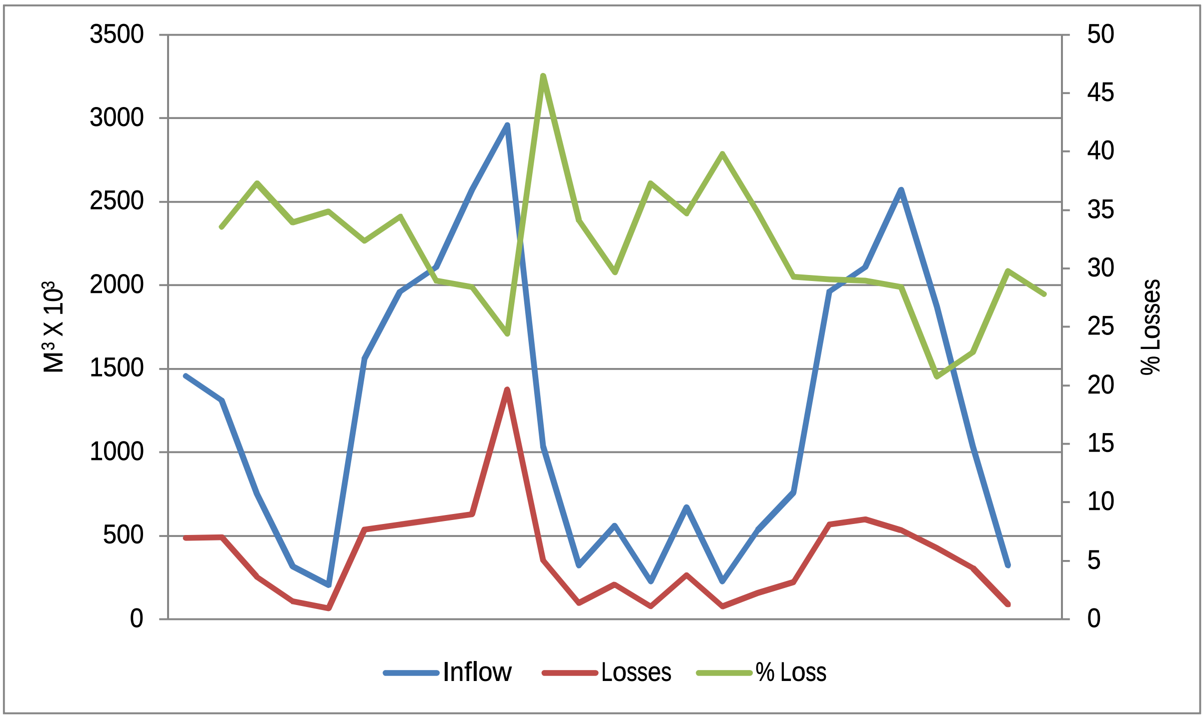

Figure 6-2: Monthly losses

The **average** water losses have been 31.8% of the released water from the dam into the canal system. This translated to an **average** of approximately 4.8 million m^3/a water losses in the Groot Marico GWS. This volume mainly refers to the water losses that are difficult to measure including the unavoidable water losses as well as some of the avoidable losses. These include canal evaporation losses, seepage in the primary canals and distribution canals, percolation, leakage and start-up and shut-down losses, sudden drop in demand (rainfall).

6.6.3 Conveyance losses

Conveyance losses within a canal system can be defined as the difference between the water released at the canal inlets and the water delivered to the farm boundary. Conveyance losses are made up of unavoidable and avoidable losses.

Unavoidable losses

Unavoidable losses takes place on a continual basis and the bulk of unavoidable losses are made up of seepage and evaporation losses.

Avoidable losses

Avoidable losses include items such as leakages and spills and include operational losses and wastages resulting from inter alia, inefficient management of the system and other factors such as algae growth, etc.

The main losses occurring within Marico Bosveld GWS served by canal distribution networks include the following;

6.6.3.1 Seepage losses:

Seepage losses from concrete lined, half lined and earth canals are normally expressed in l/s per 1 000 m^2 and appear to fluctuate between approximately 0.35 l/s per 1 000 m^2 wetted area and 1.9 l/s per 1 000 m^2 (Reid, Davidson and Kotze (1986). For design purposes Butler (1980) suggested a value of 1.9 l/s per 1 000 m^2 wetted perimeter and this could result in an unavoidable loss rate of up to 15%. The depth of the ambient water table also has an effect on seepage losses. In an area where generally high water table levels are found, canal seepage decreases to roughly 5% of the input volume (Streutker, 1981 and Muller, 1984). Other factors that have an effect on seepage losses are *inter alia*, Soil characteristics, water depth in the canal, flow speed, soil capillary tension, amount of sediment, etc.

For Marico Bosveld GWS the estimated values of the seepage loss as a percentage of the calculated total loss were recorded in the monthly WUEARs. The average seepage losses over the seven years were 7.9 % of the inflow into the scheme.

6.6.3.2 Evaporation losses

The evaporation loss, expressed as a percentage of total inflow, is usually very low and has been estimated at approximately 0.3% of total inflow volume (Reid, Davidson and Kotze :1986).

For the Marico Bosveld GWS the estimated values of the evaporation loss as a percentage of the calculated total loss were recorded in the monthly WUEARs. The average evaporation was 8.6 % of the inflow on the canal system. This percentage is a lot more than the estimated 0.3 % mentioned above. The average inflow into the scheme was 14.7 million m^3/a and 0.3 % thereof translates to a volume of 44 100 m^3/a.

6.6.3.3 Operational wastage:

Apart from the two losses described above there are also other losses on the canal system which can be classified as avoidable losses. Such losses include start-up and shut-down losses, water not used (outflows) due to unexpected drops in demand and losses due to incorrect metering. These losses are estimated to fluctuate between 9% and 17% (Reid, Davidson and Kotze, 1986).

6.6.3.4 Leaks and Spills:

Leaks normally occur on broken sections of the canals and on the top sections of the canal body and can be as a result of maintenance problems and the general deterioration of the canal network due to its age.The determination of the volume of water that is lost as a result of leakages and spills is very difficult to calculate and can only really be determined through accurate measuring. Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network due to its age. An important factor that has a marked effect of leakages is therefore the water depth in a canal system. The top section of irrigation canals are more exposed to the elements and general wear and tear (small breakages, chips, etc.) than the lower section resulting in higher leakages when the canal is running close to or at full capacity.

Although management aims to operate the system within a range of 35% to 85% of the design capacity, the water demand during peak periods, sediment and weed/algae growth necessitates periodic operation of the system at peak capacity, resulting in high leakages and spills.

The average operational losses and leakages for the Marico Bosveld GWS over the period were estimated at 8.7 % of the inflow. This estimation was taken as the result of subtracting all the other losses (seepage, evaporation and canal ends) from the total losses (difference between ordered and released).

6.6.3.5 Aquatic weeds and algae:

Aquatic weed and algae growth in irrigation canal systems is fast becoming one of the major operational headaches in scheme management, especially on those schemes where water is becoming progressively eutrophic. Du Plessis and Davidson (1996) list the following impacts of excessive aquatic weed growth on irrigation canal systems:

(i) A negative influence on hydraulic capacity and flow speeds in the canals. This decrease in canal capacity occurs particularly when the water demand is at its highest.

(ii) Overestimation of the amount of water supplied because of the artificially increased water levels that are measured at calibrated weirs.

(iii) Water loss because of the flooding of canals.

(iv) Impediment of floodgate (sluice) working at dividing structures.

(v) Water logging of long-weirs occurs.

(vi) Structure (slab) failure of concrete-lined irrigation canals due to flooding.

(vii) Aquatic weed fragments occlude irrigation systems and filters at water purification plants.

(viii) The mechanical removal of the biomass is extremely labour intensive, expensive and mostly ineffective.

A comprehensive study regarding aquatic weeds was undertaken by Modjadji Vegetation CC and their final report *"Compliance audit on the management of aquatic weeds in South African waterways"* was released in November 2007 (DWAF/RSA/01-0707). This report will not try to repeat the findings of the Modjadji Vegetation CC but specific detail will be discussed when necessary

Table 6-3 provides a summary of the various losses on the canal distribution network of the Groot Marico GWS. It is important to note that the categories included in the table are shown on the WUEARS and that a further breakdown of the losses were not possible.

Table 6-3: Groot Marico GWS - Breakdown of water losses

Description	**Unavoidable losses** *(m^3*10^3)*	**Avoidable losses** *(m^3*10^3)*	**Total losses** *(m^3*10^3)*	**% of total losses**
Seepages	1.6		1.6	34.7%
Evaporation	0.9		0.9	19.6%
Operational & leakages		1.3	1.3	28.3%
Canal end returns		0.8	0.8	17.4%
Total	**2.5**	**2.1**	**4.6**	**100%**
% of total losses	**54.3%**	**45.7%**	**100%**	
% of total volume released into system	**17.01%**	**14.29%**	**31.29%**	

From the data presented Table 6-3 it is evident that the total losses on the scheme amount to 31.29%. Of the total losses occurring on the scheme, 54.3% or 2.5 million cubic metres can be classified as unavoidable losses while 45.7% or approximately 2.1 million cubic metres are avoidable losses. The bulk of the avoidable losses (1.3 million cubic metres) are operational losses and leakages.

6.6.4 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the average estimated avoidable water losses have been 2.1 million m^3. This amount may be due to a number of factors.

- *Meter reading errors*: With the current method of manual reading of the depth of flows by the WCOs, there is a likelihood of meter reading errors due to human error. The implementation of telemetry systems may reduce the avoidable losses.
- *Scheduling of deliveries.* The other reason could be that, although there is weekly scheduling of deliveries and water is delivered only when needed, it is a very complicated process of trying to match the deliveries with the water applications. This happens particularly when the irrigators change their requests and there may be a time lag in adjusting the volume required not only at the sluice but through the canal system.
- *Volume of water ordered*: There is potential for significant water losses to take place if the volume of water ordered is very small compared to the minimum amount to reduce water losses.
- *Leakage in the canal structure*: Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network due to its age.

7 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

7.1 Overview

The Marico Bosveld GWS has been implementing measures to improve the management of delivery to the irrigators. These measures include annual maintenance of the irrigation canals to reduce avoidable water losses, as well as having flow measurements in place to audit the water delivery. These existing water management measures are discussed in more detail below.

7.2 Flow metering/measurement

The Groot Marico GWS has installed flow measurements at the critical diversion points to measure how much water is diverted at different points of the irrigation scheme. The existing infrastructure is however not sufficient to ensure that detailed water budgets can be conducted at sub-scheme level.

7.3 Full implementation of WAS

The Water Administration System (WAS) has been in operation for a number of years on the scheme and the WAS Release Module is also utilised. The generation of the WUEARs through WAS started in October 2009.

7.4 Canal refurbishment program

The overall condition of the canal infrastructure can be classified as average to poor and certain sections are in need of some urgent refurbishment. The Marico Bosveld Canal Refurbishment program has recently being initiated to address the problems with the aging infrastructure.

8 WATER MANAGEMENT ISSUES AND GOALS

8.1 Overview of the management issues

The water budget analysis discussed in the previous chapter has helped to identify several key water management issues. The water budget analysis did reveal that on an annual basis, there is sufficient water to meet the Groot Marico GWS's irrigation demands.

In addition to the water budget analysis, discussions were held with the management and other people who are knowledgeable about the Groot Marico GWS. This was done to determine the key issues the scheme is facing. The key issues identified are discussed in more detail in the following sections of this chapter.

8.2 Flow measurements

8.2.1 Adequacy of flow data

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. **Figure 8.1** below, provides the extent of flow measurement that is ideal for conducting an irrigation scheme water budget. The availability of flow measurements helps inform both the water user and the scheme manager about the quantity, timing, and location of water use and therefore enables the scheme to conduct a water budget not only at scheme level but also for sub-schemes within the irrigation scheme.

As illustrated **in Figure 8.1** below, it would be ideal to have flow measurements at the inlet to the primary canals as well as at the tail water ends. This would assist in determining the water losses in each section of the canal system, as well as the operational spills if there are any.

As indicated in **Figure 3.2**, there is a lack of adequate flow measurement data perform a detailed water budget analysis at scheme level. The scheme makes regular measurements of flows into the scheme and at the major diversions but this is insufficient. One of the major issues is the fact that the canal end return flows are not measured.

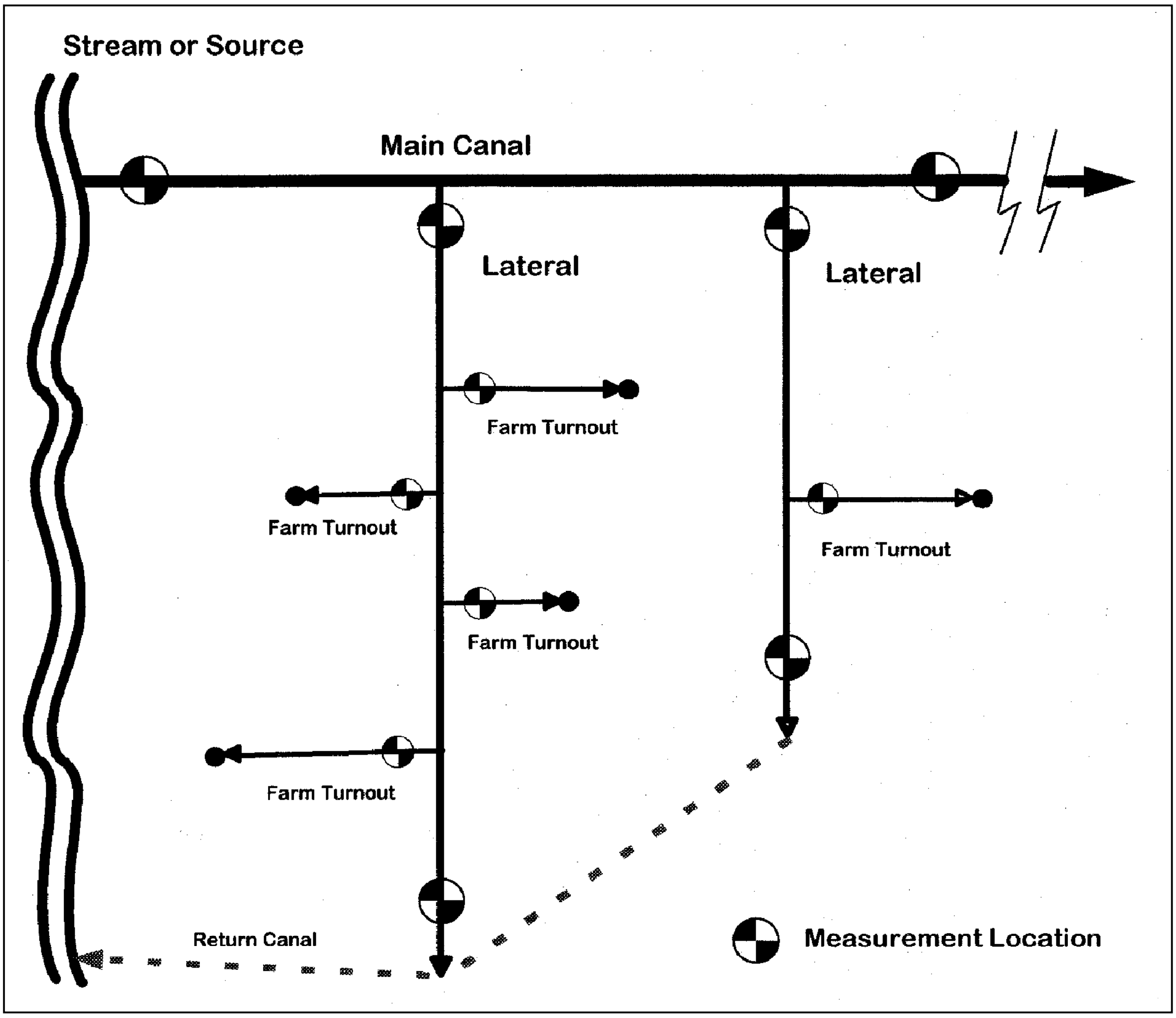

Figure 8-1: Irrigation Scheme with ideal water measurement system

Source: Bureau of Reclamation

Management Goal 1

The objective to address the above irrigation water management issue is to ensure that the following is achieved by the Groot Marico GWS:

(i) Continuation of regular measurement of flows into and in the canal system.

(ii) Ensuring that all measuring devices in the scheme are in good operating condition and regularly calibrated.

(iii) Install a telemetry system on existing structures which will inter alia allow for the automatic importation of telemetry data into WAS. The flows and levels are intended to be sent by telemetry system to the scheme offices for direct input into the WAS programme. This can then be used to undertake automatic reporting on water losses.

(iv) Measure return flows.

8.3 Irrigation water budget and balance assessment

8.3.1 Sub scheme assessment

Although a telemetric monitoring system is in place, the data is used for monitoring purposes only and the data is not incorporated into the WAS system automatically. Currently it is not possible to easily conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention.

Management Goal 2

The goal to address the above issue is to ensure that all the flow measurements in the scheme are included in determining water budgets. This will enable the scheme management to undertake comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified.

8.3.2 Disaggregating losses

It is currently difficult to disaggregate the losses. There is a differentiation in the water balance assessment (WUEARs) among the tail water ends, seepage and evaporation losses which are all based on estimates and no accurate measurements. The remaining avoidable losses such as leakage, spills and over delivery to users were also estimated by subtracting the tail water ends, seepage and evaporation losses from the total losses. The accuracy of the seepage and evaporation losses remains questionable and the accuracy of the theoretical calculations should be verified.

Management Goal 3

The goal to address the above issue is to ensure that all the flow measurements in the scheme are included in determining water budgets. This will enable the scheme to undertake comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified. Dimensions of the canal structure at different sections with varying flow rates and flow depths will have to be provided in order to do a more accurate determination of the seepage and evaporation losses. The accuracy of the seepage losses remains questionable and it is proposed that ponding tests be done to verify the accuracy of the theoretical calculations.

8.4 Infrastructure related issues

8.4.1 Condition of infrastructure

In order to properly develop the Groot Marico water management plan it would have been ideal if a detailed assessment of the overall condition of the facilities was conducted. As previously indicated, a project has been initiated to undertake the refurbishment of the canal system and results of the Inception Phase will be included in this report once it becomes available. There are however major sections in the structure requiring attention. Leakage and canal losses may be taking place on these sections or at the joints between the different canal sections. The DWA is responsible for maintenance and refurbishment of the canal structure in the dry weeks but time is too little to attend to all the problem sections before supplying water to the users again.

Management Goal 4

Undertake detailed condition assessment in order to identify critical canal sections with high losses. Revise current maintenance regime.

8.4.2 Limited scheme balancing capacity

Balancing dams decrease the pressure on the canal system and allows for shorter delivery periods to water users. They also intercept any surplus water in the system and act as backups to supplement supply should shortages arise (canal breaks, etc.). The Groot Marico GWS has minimal balancing capacity.

Management Goal 5

The Groot Marico GWS has a limited balancing system in place which limits the security of water supply during shortages or major canal failures. The goal is to investigate the possibility of creating additional storage capacity which will assist in operating the system as effectively as possible.

8.5 Institutional Water Management Issues

8.5.1 Updating and implementation of the Water Management Plan

The Manager of the Groot Marico GWS will amongst others, be responsible for the annual updating and implementation of the Water Management Plan (WMP) for the scheme. The roles and responsibilities of the Scheme Manager for the updating and implementation of the WMP will be the following:

- Take flow measurements and conduct a detailed water balance assessment on a monthly basis at scheme and sub-scheme level
- Compile Water Use Efficiency Accounting Reports and submit it on a monthly basis to the DWA Regional Office
- Develop improved water saving targets
- Do recommendations on observations regarding water conservation issues and report to the Chief Executive: SAAFWUA and DWA on ways to address the identified issues
- Develop activities that build on and complement other WC/WDM initiatives taking place at other water schemes
- Present water conservation information and training to irrigators and inform other scheme managers about success stories undertaken by the scheme
- Maintenance and modernisation of the irrigation infrastructure
- Liaise with DWA and other scheme managers to ensure consistent, efficient and effective deployment of water conservation messages, resources and services throughout the scheme
- Monitor the plan and schedule for implementing water conservation program components
- Report quarterly to DWA on the implementation status of the WMP regarding actions taken to reduce water losses and achievements towards achieving water saving targets, goals and objectives.
- Annually review and update of WMP with a water conservation program for the scheme with goals, objectives, action steps, measures, and timelines taking into consideration the latest measured data and the measures that have already been implemented.

Management Goal 6

Implementation, monitoring, reviewing and updating of the WMP by the Scheme Manager and reporting by him/her on the status of water losses, water saving targets, goals and objectives.

Table 8-1: Groot Marico GWS: Identified water management issues

Item No.	Issue description	Comments
1	Lack of measurement and no telemetry systems. The flow measurements taking place on the diversion points within the scheme are being manually read due to the absence of a telemetry system. Errors can easily be made this way.	Install telemetry equipment.
2	Not possible to conduct water budgets on a sub-scheme/ward level. If this is undertaken it may highlight sections that require specific attention.	Break down losses per sub-scheme/ward.
3	Not possible to disaggregate losses.	Break down losses per sub-scheme. Ponding tests to calculate seepage losses.
4	Parts of the canal structure are in a poor condition resulting in leakages and spills which contribute to the avoidable losses. These areas can only receive attention during well planned dry weeks when farmers have made provision for irrigation when there is no water in the canal.	Detailed canal condition assessment. Revision of current maintenance regime.
5	Limited scheme balancing capacity.	Constructing additional storage capacity (balancing dams) which will assist in operating the system as effectively as possible.
6	Updating and implementation of the Water Management Plan	Implementation, monitoring, reviewing and updating of the

Item No.	Issue description	Comments
		WMP is responsibility of the Scheme Manager as well as scheduled reporting by him/her on the status of water losses, water saving targets, goals and objectives.

9 GROOT MARICO GWS WATER MANAGEMENT PLAN

9.1 General

9.1.1 Legal provision for developing and implementing a WMP

The development and implementation of a Business Plan is a legal requirement to be undertaken by a WUA in terms of section 21 of Schedule 4 of the National Water Act (Act 36 of 1998). The constitution of a WUA - referred to schedule 5 for model constitution - outlines the principle functions to be performed by the WUA and will include the following:

Prevent water from any water resource being wasted;

(i) Exercise general supervision over water resources

(ii) Regulate the flow of water course

(iii) Investigate and record quantities of water.

(iv) Supervise and regulate the distribution and use of water from a water resource.

The Business Plan for a Scheme will thus incorporate a Management Plan setting out standards and Best Management Practices. Another key clause in the National Water Act is Section 29(1), which reads as follows:

"A responsible authority may attach conditions to every general authorisation or licence -

(b) relating to water management by:

> (i) specifying management practices and general requirements for any water use, including water conservation measures;
>
> (ii) requiring the monitoring and analysis of and reporting on every water use and imposing a duty to measure and record aspect of water use, specifying measuring and recording devices to be used;
>
> (iii) requiring the preparation and approval of and adherence to, a water management plan."

In light of the above legal requirements, the Groot Marico GWS has developed a WMP in terms of the provisions of the act to enable it to manage the irrigation water in the scheme effectively and efficiently.

9.2 Setting of water savings targets

In order to evaluate the candidate water management measures it was important to first of all determine the water loss target by incorporating not only the unavoidable water losses but also determining the attainable level of water losses based on the Best Management Practices (BMP) that can be achieved in the Groot Marico GWS.

A Water Research Commission (WRC) study which was conducted in 2010, has provided guidelines of the desired range of operational losses due to metering errors, canal filling losses after each dry period that have to be included in order to determine the BMP for operational and distribution efficiency (Reinders 2010). This is additional to the unavoidable losses determined in the previous sections. This desired range is expressed as a percentage of inflow into the irrigation scheme. The desired range for operational losses (i.e. metering errors, canal fillings, etc.) is 10% of the inflow into the irrigation scheme.

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 1.47 million m^3/a based on the average inflow into the canals. This together with the unavoidable losses has been used in setting the water saving and water loss targets. The unavoidable water losses in the Groot Marico GWS were determined to be 17% of the total releases into the canal system. This water is additional to the irrigation water use required at the farm edge.

As illustrated in Table 9-1 below, the expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses will be 27% of the total releases into the canal system.

Table 9-1: Target water losses in the Groot Marico GWC

<table>
<tr><th rowspan="2">Description</th><th rowspan="2">System inflow (x $10^6 m^3$)</th><th colspan="4">Present situation - Losses</th><th colspan="2">Acceptable water losses</th><th colspan="2">Water savings targets</th></tr>
<tr><th>Unavoidable losses (x $10^6 m^3$)</th><th>Avoidable losses (x $10^6 m^3$)</th><th>Total Losses (x $10^6 m^3$)</th><th>% of total volume released</th><th>Annual volume (x $10^6 m^3$)</th><th>% of total volume released</th><th>Annual volume (x $10^6 m^3$)</th><th>% of total volume released</th></tr>
<tr><td>Seepages</td><td rowspan="8"></td><td>1.6</td><td>0</td><td>1.6</td><td>10.88%</td><td>1.6</td><td>10.88%</td><td>0</td><td>0.00%</td></tr>
<tr><td>Evaporation</td><td>0.9</td><td>0</td><td>0.9</td><td>6.12%</td><td>0.9</td><td>6.12%</td><td>0</td><td>0.00%</td></tr>
<tr><td>Filling losses</td><td rowspan="5">0</td><td rowspan="5">1.3</td><td rowspan="5">1.3</td><td rowspan="5">8.84%</td><td rowspan="5">1.47</td><td rowspan="5">10.00%</td><td rowspan="5">0.63</td><td rowspan="5">4.29</td></tr>
<tr><td>Leakages</td></tr>
<tr><td>Spills</td></tr>
<tr><td>Over delivery</td></tr>
<tr><td>Other</td></tr>
<tr><td>Canal end returns</td><td>0</td><td>0.8</td><td>0.8</td><td>5.44%</td><td>0</td><td></td><td>0</td><td></td></tr>
<tr><td>Total</td><td>14.7</td><td>2.5</td><td>2.1</td><td>4.6</td><td>31.29%</td><td>3.97</td><td>27.01%</td><td>0.63</td><td>4.29%</td></tr>
<tr><td colspan="2">% of total volume released into system</td><td>17.01%</td><td>14.29%</td><td>31.29%</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Based on the projected water saving targets, the Groot Marico GWS can achieve a 4.29% reduction in irrigation water losses relative to the 2012 levels in a relative short period (3 years and less).

9.2.1 Short term water saving targets

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans and by revising the maintenance regime and algae control is some 0.63 million m^3/a.

9.2.2 Long term water saving targets

In order to lower the losses to below 27%, refurbishment of the canal infrastructure is required. For the long term a further 2.3 million m^3/a saving envisaged by refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.

9.3 Prioritised water management measures

There are numerous water management measures that accomplish the range of the goals identified in the previous section. However, only a few of the measures have the capacity to accomplish the goals to improve irrigation water use efficiency in the Groot Marico GWS.

The priority water management measures to improve irrigation water use efficiency in Groot Marico GWS include the following:

(1) Flow measurement and telemetry infrastructure
   a. Measure return flows.
   b. Expand the water accounting report to undertake sub-scheme water budgets within the GWS.
   c. Undertake ponding tests to determine seepage as accurately as possible.

(2) Canal maintenance and refurbishment
   a. Revise and improve current maintenance procedures and actions.

(3) Infrastructure related
   a. Undertake study to identify suitable locations for additional balancing capacity.

(4) Operation and management related
   a. Incorporate all relevant data in a custom Management Information System.

(5) Financial
   a. Investigate possibility of incentive based water pricing.

9.4 Flow measurement and telemetry infrastructure

9.4.1 Measure return flows

Presently the return-flows at the canal end point are no measured and the values included in the WUEARs are estimates. The return flows are very not high and it is not necessary to install telemetric units at the end points. Orpheus Mini Meters are proposed. If these return-flows are available, water balances can be undertaken at sub-scheme level.

9.4.2 Calculate seepage losses

During the assessment of the canal infrastructure the theoretical values for seepage losses in the system were calculated. Some of these calculations show very high losses and in order to calculate seepage losses as accurately as possible, ponding tests should be undertaken to verify the theoretical values. This task is critical since seepage losses are evaluated as unavoidable losses and incorrect assumptions could hide other losses such as canal leaks.

9.5 Canal maintenance and refurbishment

9.5.1 Investigate present modus operandi during maintenance periods

The GWS is presently undertaking maintenance. The fact that maintenance is undertaken does however not mean that the right things are done right. The present modus operandi when maintenance and repairs are undertaken will therefore be investigated and improved where possible.

9.6 Infrastructure relates issues

9.6.1 Investigate possible additional balancing capacity

The Groot Marico GWS has a limited balancing system in place which limits the security of water supply during shortages or major canal failures. The DWA should investigate the possibility of creating additional storage (balancing) capacity which will assist in operating the system as effectively as possible.

9.7 Operation and management related

9.7.1 Incorporate all relevant data in a custom Management Information System.

The Groot Marico GWS has detailed datasets at their disposal. All these datasets are in standalone databases or spreadsheets and very little thereof are spatially linked. Having all this data in one integrated Management Information System will be a huge benefit and should enable quicker and better informed decision making. The GWS will therefore identify and catalogue all available datasets and assess the possibility to standardise and link these sets to a spatial database. It should even be possible to link results obtained from the WAS system.

9.8 Financial

9.8.1 Investigate possibility of incentive based water pricing

To achieve an incentive for efficient water use, the price of irrigation water must be directly related to the volume delivered unlike the current situation where it is based on the scheduled quota.

In order to encourage irrigators to use water efficiently, incremental water pricing may considered, based on the optimal crop water requirements. The implementation of incentive water pricing in irrigation agriculture, requires that comprehensive regulatory and operational criteria to be met before considering the economic criteria for incentive based pricing of irrigation water. The Groot Marico GWS will investigate the possibility, costs and viability of incentive based water pricing.

10 IMPLEMENTATION PLAN

The evaluation of the potential measures for implementation in the Groot Marico GWS area to improve water use efficiency and reduce water losses indicates that all the measures are economically justified for implementation based on the unit cost of water saved.

The priority for implementation based on the amount of water savings and the average incremental cost of water saved is as follows:

(i) *Incorporating the existing telemetry system with WAS*
(ii) *Measure return-flows*
(iii) *Expand WUEAR to include assessment of sub-sections*
(iv) *Fully implement the Release Module of WAS*
(v) *Ponding tests to establish canal seepage*
(vi) *Revise maintenance procedures and actions during refurbishment periods*
(vii) *Develop and implement a comprehensive Management Information System*
(viii) *Incentive based pricing*

The action plan for implementation is presented in Table 10-1.

Table 10-1: Groot Marico GWC action plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	(i) Start measurement of return flows. (ii) Conduct seepage loss measurements in representative canal segments though ponding tests. Extrapolate results from tested segments to similar segments and revise water budget. (iii) Undertake sub-scheme water budgets (iv) Prioritise areas of significant water losses	Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15 Apr '13 – Mar '15	GMGWS
2	Reduce seepage losses in irrigation canal infrastructure within 5 years	(i) Revise and improve current maintenance procedures	Apr '13 – Mar '15	GMGWS
3	Increase operational efficiency	(i) Link telemetry system with WAS (ii) Undertake study to identify possible additional balancing capacity (iii) Incorporate data in a custom Water Management System	Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15	GMGWS
4	In 3 years, implement incentive pricing structure for	(i) Review current irrigation water pricing strategy (ii) Engage with irrigators on incentive pricing structure (iii) Update water pricing strategy	Apr '13 – Mar '16	DWA/ GMGWS

Priority	Goal	Action Plan	Timeline	Responsible Authority
	the WMA if viable	(iv) Implement water billing based on incentive pricing rate		

11 CONCLUSIONS AND RECOMMENDATIONS

The success of WC/WDM through a WMP will depend on the effective participation of all the participants. A well balanced “carrot and stick” plan will be required based on the principal of a “win win “situation where the benefits of the successes of the water management plan will filter through to the users in one or other form such as less water use charges, more water or the possibility of selling any surplus water etc. In terms of WC/WDM the development of a Water Management Plan is in itself a BMP as it force water users and institutions to start thinking and planning. The main aim of a water management plan is to conserve water, to improve water supply services to the water users and to enable irrigators to use their water more efficiently in the sort and long term. The development and implementation of water management plans are progressive processes and although the initial plan may be very basic and lacking information, the completeness will improve when it is reviewed and revised by the Management each year.

The Goals for the WMP have been set and the WUA believes that the targets and objectives set in the WMP are achievable through proper oversight by the Manager and support from the DWA.

This WMP must be seen as a first generation plan and has to be reviewed and updated on an annual basis. Based on the projected water saving targets, the Groot Marico GWS can achieve a 4.29% reduction in irrigation water losses relative to the 2011 levels in a relative short period.

For the short term which has been taken as 3 years, the total water saving that can be achieved through implementing the flow measurement and monitoring plans is some 0.63 million m^3/a.

For the long term a further 2.3 million m^3/a saving is envisaged by optimising the operations and refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.

12 REFERENCE

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