water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

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

LOSKOP IRRIGATION BOARD 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: Loskop Irrigation Scheme - Water Management Plan

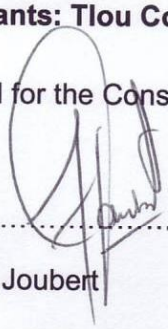
Authors: Toriso Tlou, Pr. Eng

Francois Joubert

Revision	Date	Report Status
Draft 1	18/07/2011	First draft for comment
Draft 2	20/11/2012	Second draft for comment
Final	14/03/2013	Final Report

Consultants: Tlou Consulting (Pty) Ltd in association with Schoeman and Vennote

Prepared for the Consultants by:



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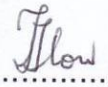

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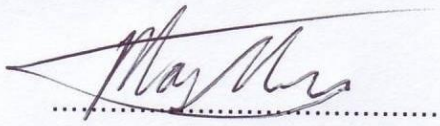

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Director: Water Use Efficiency

WMP accepted by Loskop IB

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Chief Executive: J van Stryp

Accepted on behalf of Loskop IB

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ACKNOWLEDGEMENTS

This report was prepared by Messrs Toriso Tlou and Francois Joubert with the valuable assistance, guidance and inputs from the following project members.

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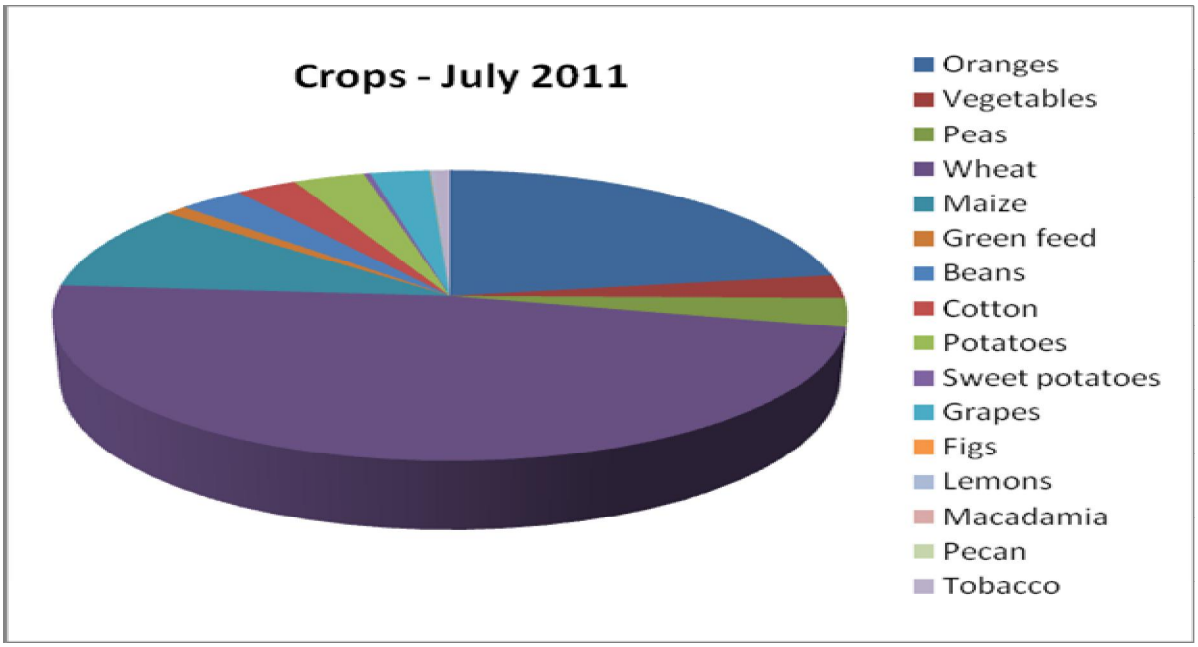
EXECUTIVE SUMMARY

The Loskop Irrigation Scheme was established in the early 1930's with the construction of the Loskop Dam in the Olifants River which was subsequently raised in 1979. The total length of the canal system is 495 km with the main canal being 96 km. Drainage canals in the scheme have a combined length of so amounting to 124 km. Four balancing dams exist on the left bank and three balancing dams on the right bank of the Olifants River.

At present, the Loskop Irrigation Scheme consists of 656 properties with an average scheduling of 25.7 ha each. The total scheduled area is 16 135 ha at a total allocation of 124 million m³/a. The full water quota is 7 700 m³ per hectare per annum. Wheat, vegetables, tobacco, peanuts, cotton, grapes and citrus fruit are main crops that are under irrigation.

A survey of crops under irrigation was conducted in 2001 and a graphical representation of these crops is presented in the following figure.



The irrigation scheme is divided into eight wards with seven wards on the left bank and one ward on the right bank. The water supplied to irrigators is based on a weekly request system. Irrigators submit their request by the close of business on Thursday for their requirements for the following week. The water is delivered through the 794 delivery points within the scheme. There are balancing dams to reduce the transit time between the source of supply and the irrigators. The water delivery system is flexible, allowing irrigators to alter their requirements (when possible) by giving at least 24 hours notice. The scheme is operating over weekends in periods of high demand to eliminate start-up and shut-down losses.

The volume of water that is requested by the irrigators in the Loskop IB area varies from year to year, as does the cropping pattern for each year. For the past seven water years the irrigation water applied for has ranged from 89 million m3/a in 2004/05 to 122 million m³/a in

2006/07. Over the past seven years, irrigators have been requesting on average 82.5% of the total scheduled quota of 124 million m^3/a. A breakdown of the historic water use is presented in the table below.

Canal section	Water use sector	Water year							Average
		2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	
Left	Irrigation	79.45	86.59	108.34	92.73	94.25	92.11	86.42	91.41
	Industry	7.20	3.90	1.76	1.64	3.22	18.38	11.50	6.80
	Domestic	0.66	0.60	0.65	0.00	0.00	0.00	0.00	0.27
Total: Left bank		**87.32**	**91.09**	**110.75**	**94.37**	**97.47**	**110.49**	**97.93**	**98.49**
Right	Irrigation	9.76	9.75	13.97	9.86	11.47	11.77	9.70	10.90
	Industry	0.08	0.10	0.14	0.15	0.42	1.43	1.10	0.49
	Domestic	0.19	0.17	0.19	0.00	0.00	0.00	0.00	0.08
Total: Right bank		**10.04**	**10.02**	**14.30**	**10.01**	**11.88**	**13.20**	**10.80**	**11.46**
Left & Right	Irrigation	89.21	96.35	122.31	102.59	105.72	103.88	96.12	102.31
	Industry	7.28	4.00	1.90	1.79	3.63	19.81	12.60	7.29
	Domestic	0.86	0.77	0.84	0.00	0.00	0.00	0.00	0.35
Grand Total		**97.35**	**101.12**	**125.05**	**104.38**	**109.35**	**123.69**	**108.72**	**109.95**

Water balance assessment

Using the information obtained from the Water Use Efficiency Accounting Reports (WUEARs) for Oct 2004 to Aug 2011, previous studies and consultation with the management of the IB, a water budget for the Loskop IB 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 average water losses have been 21% of the released water from the dam into the canal system. This translated to an average of approximately 31.2 million m^3/a water losses in the Loskop Irrigation Board.

Total losses on the left bank (West) canal are roughly 8.7% more than the losses on the right bank (East) canal. This can be attributed to the fact that the West canal serves a much larger area and has a much bigger conveyance system than the East canal. The ground formation of the right bank canal has a much lower clay content than that of the left bank canal where the first 20km is problematic and the canal structure more likely to fail or crack due to soil movement.

Existing water conservation measures

The Loskop IB has been implementing measures to improve the management of delivery to the irrigators and to minimise water losses. These measures include (a) detailed flow metering/measurement, (b) efficient operation and maintenance of the canal infrastructure, (c) successful action against aquatic weeds, (d) good balancing system, (e) operating the scheme over weekends.

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 Loskop IB canal system. The analysis indicated that the unavoidable water losses due to evaporation losses and seepage is 17.5 million m^3/a, which translates to 11.7% of the total volume of water released into the IB 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 14.85 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 21.78% of the total releases into the canal system or 32.6 million m^3/a.

Water management issues

The compilation of a water budget and subsequent analysis thereof and discussions with the parties involved in the operation and management of the scheme assisted in the determination of the key issues the scheme is facing. The main water management issues identified include the following;

a) *The DWA has two telemetry systems at the outlet from the dam into each canal but it does not always correspond with the water that is requested by the scheme and therefore the board has their own telemetry system. The Loskop Irrigation Scheme has Android Telemetry Systems installed only at the Loskop Dam wall. The data obtained from the telemetry system is not directly imported into the Water Administration System (WAS) to undertake water accounting reports. On the rest of the scheme there are no other telemetry systems installed and flows and levels are therefore manually captured on the WAS system.*

b) *Not all of the WAS models are used by the Loskop IB. The WAS water release module is currently not being utilised by the Board.*

c) *The Loskop IB has gathered and generated their own detailed datasets, ranging from individual sluice detail to water user address information. 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.*

d) *In the Loskop Irrigation Scheme, the DWA still owns the irrigation infrastructure including the main, primary and branch canals. However, the IB operates the irrigation infrastructure as an agent of the DWA and undertakes the normal*

maintenance of the irrigation infrastructure. At present there is no formal Service Level Agreement in place.

e) *Pollution upstream of Loskop Dam is a major concern. Although the Department of Water Affairs has already employed countermeasures to minimise pollution, it is the Board's opinion that action against transgressors is not sufficiently enforced and strict enough.*

f) *Besides the indigenous vegetation taking over in the river system and resulting in losses, alien vegetation is intruding the river system river below Loskop Dam. The eradication of such plants is however outside the jurisdiction of the Board.*

Water Management Plan

Water saving targets

The targets for the Loskop IB are illustrated in the table below.

Description	System inflow ($x\ 10^6 m^3$)	Present situation - Losses				Acceptable water losses		Water savings targets	
		Unavoidable losses ($x\ 10^6 m^3$)	Avoidable losses ($x\ 10^6 m^3$)	Total Losses ($x\ 10^6 m^3$)	% of total volume released	Annual volume ($x\ 10^6 m^3$)	% of total volume released	Annual volume ($x\ 10^6 m^3$)	% of total volume released
Seepages		17.049		17.049	11.48%	17.0	11.48%	0	0.00%
Evaporation		0.449		0.449	0.30%	0.449	0.30%	0	0.00%
Filling losses									
Leakages									
Spills			12.383	12.383	8.08%	14.85	10.00%	-1.156	-0.78%
Over delivery									
Canal end returns			1.311	1.311	0.88%				
Other			0.000	0.000	0.00%	0	0.00%	0	0.00%
Total	**148.5**	**17.498**	**13.694**	**31.192**	**20.75%**	**32.348**	**21.78%**	**-1.156**	**-0.78%**
% of total volume released into system		**11.78%**	**9.22%**	**20.75%**					

Based on the projected water saving targets, the Loskop IB is already within the acceptable range in term of losses. This however does not mean that further improvements are not possible. The short-term aim is therefore to maintain the losses within the acceptable range .

The priority water management measures to improve irrigation water use efficiency on the Loskop Irrigation Board include the following:

(i) Linking the existing telemetry system with WAS (water released into the two main canals).
(ii) Expand WUEAR to enable water budget analysis at both scheme and sub-scheme level.
(iii) Fully implement the Release Module of WAS.
(iv) Review current maintenance procedures.
(v) Address pollution problems.

(vi) Formalise Service Level Agreement.
(vii) Develop and implement a comprehensive Management Information System.
(viii) Implement incentive based pricing.

Conclusions and recommendations

The Water Management Plan forms the backbone of actions that have to be taken in increasing the efficient use of water within the Loskop Irrigation Board.

The intention of the Water Management Plan not to burden the IB and its officials with administrative tasks, but rather to promote a culture of using water as effectively and efficiently as possible. The plan will allow the IB to improve on current water management practices and to profit from their efforts.

The Water Management Plan is living document and close and ongoing co-operation between the IB and DWA is essential to the ultimate success of the WMP and also the goals and strategic objectives of the DWA Directorate: Water Use Efficiency.

The Goals for the WMP have been set and the IB believes that the targets and objectives set in the WMP are achievable through proper oversight by the CEO 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 Loskop IB is already within the acceptable target (21.8%) with present losses in the order of 20.8%.

This however does not mean that the Scheme is operated as efficiently as possible but the incremental costs associated with reducing the losses substantially, is prohibitively expensive.

The Loskop IB has identified various measures to improve the efficiency and effectiveness and a revision of the plan within a year will show whether these measures had a marked effect on losses.

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ABBREVIATIONS

DWA	Department: Water Affairs
ET	Evapo-Transpiration
GIS	Geographic Information System
GWS	Government Water Scheme
IB	Irrigation Board
SLA	Service Level Agreement
WAS	Water Administration System
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WMP	Water Management Plans
WUA	Water Use Association
WUEAR	Water Use 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, and/or by cropping existing 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 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 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.
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

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 sector. Therefore it has become a major imperative that there is a need to ensure that available water supplies are used efficiently and effectively to avoid supply shortages and intermittent water supplies. This will have a major impact on the socio-economic growth and development of the country the scarce water resources of the catchments.

The savings that can potentially be made from implementing WC/WDM measures will enable delay in 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 of 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 [1] 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 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 using sectors identified that since the development of the pilot Water Management Plans (WMPs) for improving water use efficiency in irrigation agriculture, not progress had been made by the irrigation sector develop and implement WMPs for the 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 on the meetings with DWA Directorate: Water Use Efficiency and the DWA Regional Offices this report provides the following:

- Overview of the water allocation and use situation of the Loskop Irrigation Scheme and related institutional arrangement for irrigation water management.

- Any deviations and/or variations from the original proposal are documented in this inception report in developing and implementing the WMPs for the irrigation scheme.
- An update of the scope of work and the methodology for the development and implementation of an irrigation water management plan to improve water use efficiency in the scheme.

1.2 Study Objectives

The primary objective of the study is the development and implementation of an Irrigation Water Management Plan for the Loskop Irrigation Board to improve water use efficiency in the scheme. In order to achieve this objective, the development and implementation of the irrigation WMPs to improve water use efficiency in the agricultural sector, the following aspects have to be considered:

- To undertake a situation assessment of the current water use and irrigation water use practices in the scheme
- Determine the irrigation water budget and establishing water use baseline for the scheme
- Determine the irrigation water management issues based on the situation assessment and water budgets prepared for the 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
- Preparing the irrigation water management plan for the irrigation scheme
- Capacity building of the officials to implement the identified opportunities to improve irrigation water use efficiency

The development of a WMP for the Loskop Irrigation Board 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 catchments in general will include:

- Improved system efficiencies
- Reduction in irrigation water return flows,
- 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 Loskop Irrigation Scheme as well as the potential for irrigated agriculture in the Olifants 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 Olifants River catchment in which the Loskop Irrigation Scheme is situated. The chapter describes the history of the Loskop Irrigation Scheme, the scheduled quotas and current land-use practices in the catchment.

Chapter 3 provides an overview of water distribution infrastructure found in the Loskop Irrigation Scheme. 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 Loskop Irrigation Scheme.

Chapter 5 describes the Scheme operations and operating procedures. Procedures relating to the ordering and delivery of irrigation water are 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 Loskop IB. 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 Loskop IB is facing and also includes the goals of the IB when WCWDM is contemplated.

Chapter 9 provides the Water Management Plan for the Loskop IB.

Chapter 10 includes the conclusion and recommendation for the irrigation sector.

2 CHARACTERISTICS OF THE OLIFANTS RIVER CATCHMENT

2.1 Overview

The Loskop Irrigation Scheme is situated in the Greater Groblersdal and Greater Marble Hall Local Municipalities. **Figure 2.1** presents the locality map of the Loskop Irrigation Board. The Olifants River has its headwaters in quaternary catchment B11A near Bethal in the Highveld of Mpumalanga. The major tributaries of the Olifants River are the Wilge, Elands and Ga-Selati Rivers on the left bank and the Steelpoort, Blyde, Klaserie and the Timbavati Rivers on the right bank . The total catchment area is approximately 54 550 km ^{2}. There are a few major storages in the catchment namely Witbank, Doringpoort, Loskop and Flag Boshielo Dams.

The Olifants River initially flows from gently sloped hills northwards then cuts through the Drakensberg in an easterly direction through the Kruger National Park in the relatively featureless Lowveld region where it joins the Limpopo River in Mozambique and eventually discharges into the Indian Ocean.

2.1.1 Climate and rainfall distribution

Largely attributable to the topography, distinct differences in climate occur. The climate varies from cool in the southern Highveld region of the WMA through temperate in the central parts to sub-tropical east of the escarpment. The rainfall is strongly seasonal occurring mainly in summer. The mean annual rainfall falls in the range 500 mm in the Lowveld region, reaching 1000 mm in the mountains and decreases to 700 mm in the South in the Mpumalanga Highveld region of the WMA. The potential evaporation is well in excess of the rainfall.

2.1.2 Geology and soils of the catchment

The geology consists mainly of hard rock formations, with the occurrence of the Bushveld Igneous Complex the most prominent feature. The eastern limb of this formation cuts through the northern part of the WMA. Rich coal deposits occur in the Upper Olifants Sub-area in the vicinity of Witbank and Middelburg. A large dolomitic intrusion extends along the Blyde River, curving westwards along the northern extremity of the WMA.

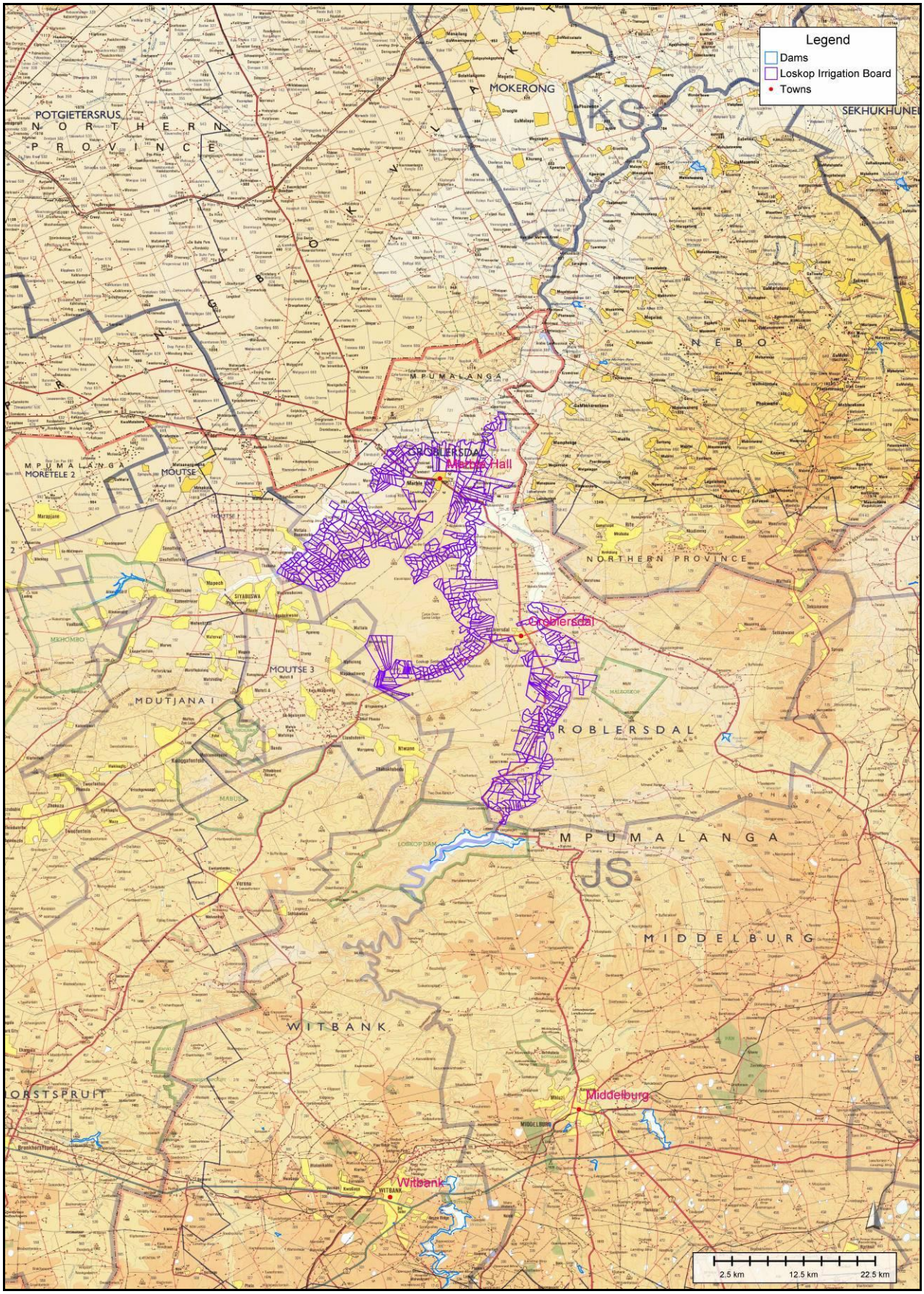


Figure 2-1 Location map of Loskop Irrigation Scheme

2.2 History of the Loskop Irrigation scheme

The first farms in the Olifants River Valley were demarcated in 1886 and the farmers cultivated wheat under dry-land conditions. Around 1925, after the successes of the small irrigation schemes, the Hereford Irrigation Board was founded to supply irrigation water to an area of about 2 140ha which was situated a few kilometres downstream of the present Loskop Dam. The early success of this scheme gave rise to a petition which resulted in studies of the Hereford Scheme, as well as in a soil survey and a topographical survey of the dam basin. This paved the way for the commencement of the construction of the Loskop dam in 1934 as well as the establishment of the Loskop Irrigation Scheme.

The dam was completed in 1938 and the wall was raised in 1979. The capacity of the raised dam is 362 million m^3. The dam has been built to accommodate a design flood of 2 886 m^3/s (1:200 year flood). The dam was initially built to provide for the irrigation needs of farmers in the Olifants, Moses and Elands River valleys. Development in the Witbank-Middelburg area necessitated the raising of the dam wall so that the portion of the assured yield which had in the meantime become affected as a result of the construction of upstream dams such as the Rondebosch, Witbank and Doornpoort Dams on the Highveld, could be restored. Furthermore, water from the dam supplies Loskop Irrigation Board, the Hereford Irrigation Board, the Olifants River Irrigation Board as well as the Groblersdal and Marble Hall Municipalities.

Loskop Dam Jan 1977, Department of Water Affairs and Forestry

Figure 2-2: Raising of Loskop Dam wall

The scheme was transferred to the Loskop Irrigation Board on 1 April 1992 with 4 Board Members appointed by the Minister of Water Affairs and 4 elected members from the irrigators on the Scheme. Currently all Board Members are elected by the irrigators.

The instruction to the Board was to distribute water and to maintain the irrigation canals, excluding the dam, and these activities have to be financed with the revenue received by the Board.

The Irrigation Board has a total scheduled area of 16 135 hectares, at a scheduled quota of 7 700 m^3/ha/a which translates to a total allocation of 124.2 million m^3/a. There are approximately 656 properties within the scheme and the majority have an average size of 25,7ha. A further 45 consumers are also supplied to by the Board which include all industrial consumers (27) and also private users (18).

The Scheme consists of a network of concrete lined canals and 7 balancing dams. The total length of the canal system is ±495 km and consists of 2 main canals, a left bank canal of 96km and right bank canal of 60 km. The rest of the network is made up of branch canals. A network of cemented and earthen drains is distributed throughout the Scheme.

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). The Loskop Irrigation Board has submitted an application for transformation but has not been transformed yet.

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 Board therefore functions under the rules and regulations of the previous Water Act until the Board is transformed and compulsory licensing is required.

The Irrigation Board has a total scheduled area of 16 135 hectares, at a scheduled quota of 7 700 m^3/ha/a which translates to a total allocation of 124.2 million m^3/a.

2.4 Irrigated areas and types of crops

The typical crop mix found within the area of operation of the Loskop IB Scheme is presented in **Table 2.1.**

Table 2-1: Irrigated crops in Loskop Irrigation Scheme

Crops	Hectares	%		Crops	Hectares	%
Wheat (winter)	9 000	24.2		Groundnuts	3 000	8.1
Cotton	6 000	16.1		Soy bean	3 000	8.1
Tobacco	5 000	13.4		Peas	2 000	5.4
Maize	5 000	13.4		Table Grapes	250	
Citrus	4 000	10.7				

The latest crop survey undertaken by the Irrigation Board was in June 2011 and the results (grouped per ward) are presented in **Table 2-2.**

Table 2-2: Crop mix for June 2011

Crop	Ward								Crop total (ha)	% of total crop area
	E2	W2	W3 & 5	W4	W7	W8	W6	W10		
Oranges	386	469	64.9	425	656.02	1072	590	1335.7	**4 998**	22.66%
Vegetables	0	40	65	37	337	88	0	0	**567**	2.57%
Peas	163	0	255	241	31	14	0	0	**704**	3.19%
Wheat	834	1644	812	545	833.5	1033	2105	2725	**10 531**	47.75%
Maize	0	1297	0	368	431	21	0	0	**2 117**	9.60%
Green feed	0	0	81	55	23	73	0	0	**232**	1.05%
Beans	0	0	0	0	270.5	393	0	0	**663**	3.01%
Cotton	0	0	0	0	412	220	0	0	**632**	2.87%
Potatoes	15	0	482	20	80	133	0	0	**730**	3.31%
Sweet potatoes	0	0	0	0	0	65	0	0	**65**	0.29%
Grapes	120	0	69	69	131	0	0	219	**608**	2.76%
Figs	0	0	8	0	0	0	0	0	**8**	0.04%
Lemons	18.8	0	20	0	0	0	0	0	**38**	0.18%
Macadamia	3	0	0	3	0	0	0	0	**6**	0.03%
Pecan	0	0	0	0.5	0	0	0	0	**0.5**	0.00%
Tobacco	0	0	0	63	91	0	0	0	**154**	0.70%
Ward Total	**1 539.8**	**3 450.0**	**1 856.9**	**1 826.5**	**3 296.0**	**3 112.0**	**2 695.0**	**4 279.7**	**22 056**	
Percentages	7.0%	15.6%	8.4%	8.3%	14.9%	14.1%	12.2%	19.4%		

A graphical representation of the crops under irrigation during the 2011 survey is shown in Figure 2-3 and the total irrigated crop area within each ward is shown in Figure 2-4.

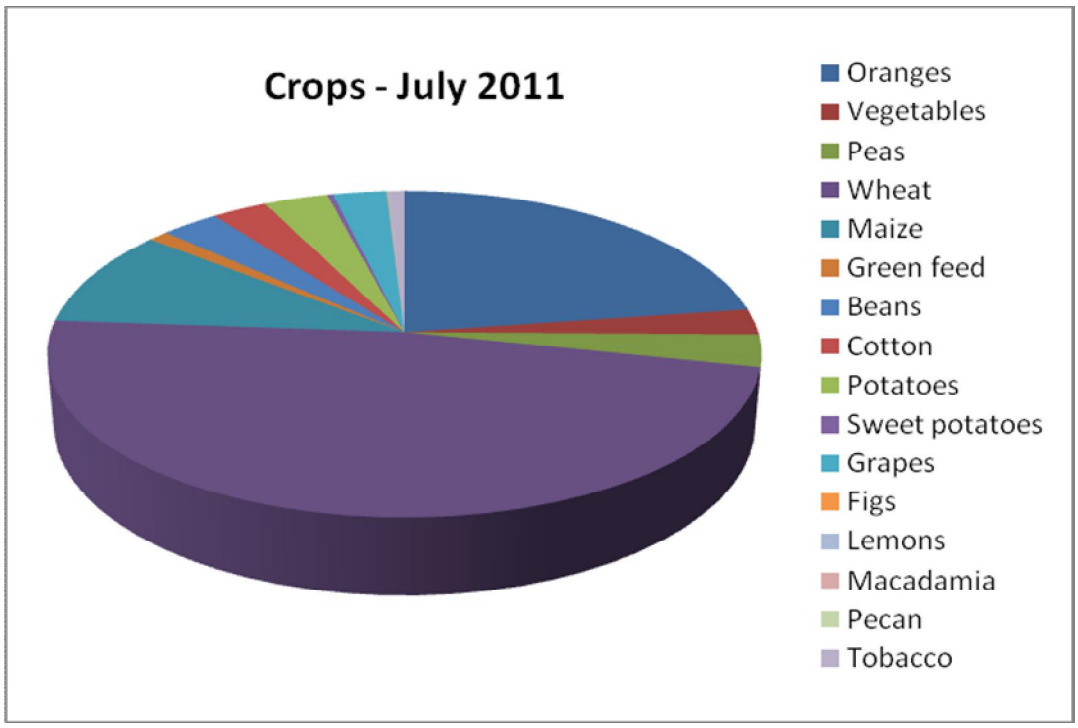


Figure 2-3: Crops under irrigation during 2011

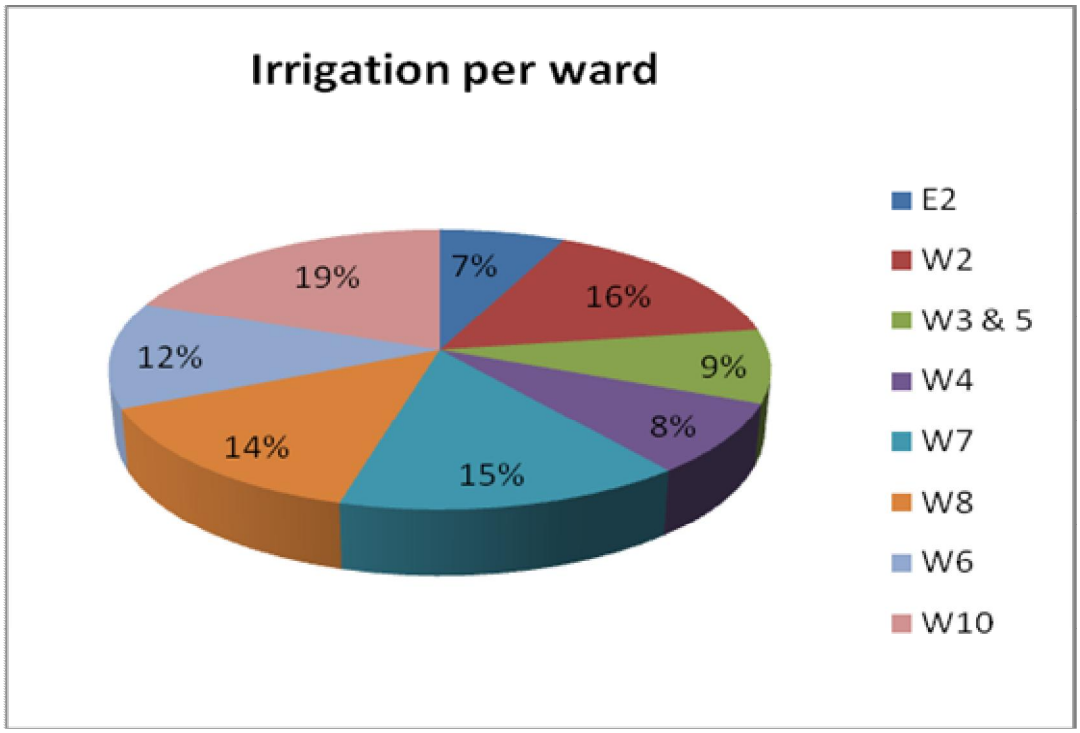


Figure 2-4: Irrigated crop area per ward during 2011

The periods during which farmers irrigate the various crops are shown in **Table 2-3**.

Table 2-3: Irrigation periods

Crop	Irrigation Season
Tobacco	October–March
Cotton	October–April
Wheat (winter)	May–early October
Soya bean	November–April
Groundnuts	October–March
Peas	May–early August
Maize	August–February
Citrus	12 months, peaks in September/October and December to February
Table grapes	12 months

2.5 Historic water use

The most recent seven water years (2004/5 to 2010/11) demonstrate a range of water use in the Loskop Irrigation Scheme. Irrigation agriculture on the left bank has ranged from 79.45 million m^3/a in 2004/05 up to 108.34 million m^3/a in 2006/07 with a seven-year average of 91.41 million m^3/a.

Irrigation agriculture on the right bank has ranged from 9.7 million m^3/a in 2010/11 to 13.97 million m^3/a in 2006/07 with a seven-year average of 10.9 million m^3/a. Industry on the left bank was at its least in 2007/08 at 1.64 m^3/a and peaked in 2009/10 at 18.38 million m^3/a.

Industry on the right bank was at its least in 2004/05 at 0.08 million m^3/a and also peaked in 2009/10 at 1.43 million m^3/a. Domestic water use however remained more or less constant with averages of 0.27 million m^3/a and 0.08 million m^3/a for the left and right banks respectively. No domestic uses were recorded from 2007 to 2011. Water provided to other institutions such as the Hereford Irrigation Scheme and the community of Aquaville has also been included in these figures.

Table 2-4: Historic water use levels (million m^3/a) for Loskop Irrigation Board

Canal section	Water use sector	Water year							Average
		2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	
Left	Irrigation	79.45	86.59	108.34	92.73	94.25	92.11	86.42	91.41
	Industry	7.20	3.90	1.76	1.64	3.22	18.38	11.50	6.80
	Domestic	0.66	0.60	0.65	0.00	0.00	0.00	0.00	0.27
Total: Left bank		**87.32**	**91.09**	**110.75**	**94.37**	**97.47**	**110.49**	**97.93**	**98.49**
Right	Irrigation	9.76	9.75	13.97	9.86	11.47	11.77	9.70	10.90
	Industry	0.08	0.10	0.14	0.15	0.42	1.43	1.10	0.49
	Domestic	0.19	0.17	0.19	0.00	0.00	0.00	0.00	0.08
Total: Right bank		**10.04**	**10.02**	**14.30**	**10.01**	**11.88**	**13.20**	**10.80**	**11.46**
Left & Right	Irrigation	89.21	96.35	122.31	102.59	105.72	103.88	96.12	102.31
	Industry	7.28	4.00	1.90	1.79	3.63	19.81	12.60	7.29
	Domestic	0.86	0.77	0.84	0.00	0.00	0.00	0.00	0.35
Grand Total		**97.35**	**101.12**	**125.05**	**104.38**	**109.35**	**123.69**	**108.72**	**109.95**

It was calculated in the water budget that the average total water diverted (released) into the Loskop Irrigation Scheme during the same seven year period was 148.2 million m^3/a, with the range being 129.86 million m^3/a in 2005/06 up to 160.59 million m^3/a in 2006/07.

3 INVENTORY OF THE WATER RESOURCES INFRASTRUCTURE AND OVERVIEW

The Loskop Irrigation Scheme comprises of two main irrigation canals, a left and a right bank canal which originates at the Loskop Dam wall. The canal distribution system includes seven balancing dams and secondary canals which deliver water to the irrigators at their farm turnouts through a number of sluice gates and parshalls.

3.1 Loskop Dam

Loskop Dam was completed in 1938 and the wall was raised in 1979. The full supply capacity of the raised dam is 362 million m^3 and can accommodate a design flood of 2 886 m^3/s. The dam was initially built to provide for the irrigation needs of farmers in the Olifants, Moses and Elands River valleys. The Loskop Dam is operated and managed by the DWA based in Groblersdal and it is the Department's responsibility to determine the annual water quota based on the volume of water in the dam. This total annual quota for the water year, which runs from May to the end of April, cannot exceed the total allowable allocation, but can be set at a lower level than this in the case of extreme weather conditions, such as droughts.

Water is also released from the Loskop Dam into the river to meet other water requirements downstream such as the Hereford Irrigation Board, the Olifants River Irrigation Board as well as the Groblersdal and Marble Hall Municipalities.

3.2 Hereford Irrigation Scheme

The Hereford Irrigation Scheme was established in 1926 and lies on the left bank of the Olifants River approximately 16 km downstream of the Loskop Dam. Since its inception, the scheme has been running as a private irrigation scheme. The scheme is supplied from the Miessner weir with water released from the right bank outlet works of the Loskop Dam. From the weir water is diverted through the irrigation canal which was constructed in 1926. This canal has now been relined to a concrete canal which has reduced the water losses significantly.

With the construction of the Loskop Dam, the normal flow of the Olifants River was reduced. In compensation for the reduction in normal flow, the Hereford IB was allocated 26.8 million m^3/a of water from the Loskop Dam with the river losses taken up by the DWA.

Photo 3-1: View of the Hereford outlet works at the Loskop Dam wall

3.3 Irrigation conveyance infrastructure

Figure 3.1 below provides the conveyance and distribution infrastructure of the Loskop Irrigation Scheme. Water is released from the Loskop Dam into the two main canals being the right bank and left bank canals. The right bank canal is a narrow trapezoidal structure with a length of 60 km while the left bank canal is wide trapezoidal structure and about 96 km in length. The scheme is divided into eight water wards. One on the left bank canal (E2) and seven on the right bank canal (W2, W3+W5, W4, W6, W7, W8 and W10). Each ward has a ward manager who is responsible for the water distribution management of the specific ward. The right bank water distribution system comprises of secondary canal systems, three active balancing dams and six siphons. The left bank distribution system consists of secondary canals, four balancing dams and one siphon. Water is delivered to the farmers through pressure regulated sluices which are set on a daily basis. The dam setting is normally changed on a 24 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 length of the canal system is some 495 km. As illustrated in Figure 3.1 there are approximately 339 km of secondary and branch canals in the canal system which distributes the water to approximately 600 sluices. The entire distribution canal infrastructure is concrete

lined and fifty percent of the branch canals are piped. A map indicating the various wards and scheme layout is included in **Annexure A**.

3.3.1 Left bank irrigation canal

The canal on the left bank comprises a 96 km long, wide trapezoidal concrete lined canal. The maximum design capacity of the canal is 10.2 m^3/s (322 million m^3/a) at the head works but due to the decrease in slope lower down, the canal structure downstream will flood at this flow rate. Therefore the maximum hydraulic capacity at which the left bank canal is operated is 8.2 m^3/s. There are some 543 sluice gates on the Left bank canal and various branch canals, serving 14 305 ha along the western side of the Olifants River (see Figure 3.1). Approximately 90 % of the conveyance structure in ward 4 is piped. There is also a large siphon on the left bank of 2.4 km in length and almost 2 m in diameter.

3.3.1 Right bank irrigation canal

The canal on the right bank comprises a 60 km long, narrow trapezoidal concrete lined structure. Even though the maximum design capacity of the canal is 1.7 m^3/s (53.6 million m^3/a) at the head works, the hydraulic capacity at which the right bank canal is operated is 1.3 m^3/s due to a decrease in slope lower down. There are 56 sluice gates and 15 water meters on the right bank canal serving about 1 984 ha along the eastern side of the Olifants River by means of pipes as well as branch canals (see Figure 3-1). There are six siphons on the right bank section.

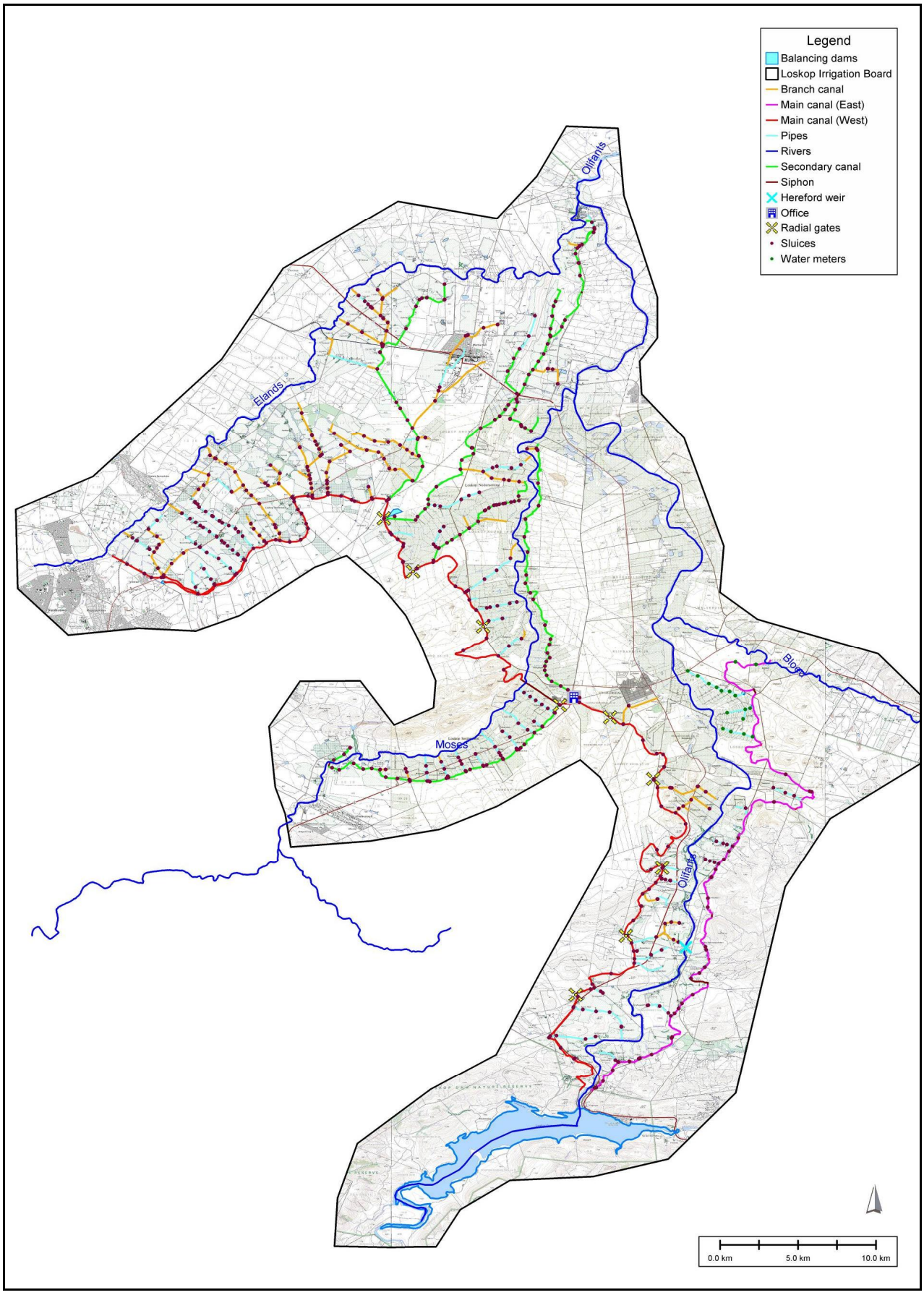


Figure 3-1: Loskop Irrigation Board Infrastructure

3.4 Irrigation storage and regulation system

A large scheme balancing dam is situated in ward six on the Left Bank canal. This balancing dam covers an area of 18 hectares and has a maximum capacity of 499 000 m³ at a depth of 4 m. The dam (W6) provides irrigation water for wards 7 and 8 as well as the municipality (as an additional source and during periods of water shortage). Three scheme balancing dams are located on the right bank canal. Table 3-1 provides basic information for these dams. The balancing dams decrease the pressure in the canal system and ensure that the canal system is full so that multiple abstractions can be made simultaneously.

Table 3-1 Scheme balancing dams

Dam reference	Maximum depth (m)	Full capacity (m³)	Number of outlets
A	4	28 185	4
B	4.6	50 235	5
C	6.3	63 796	7
W6	4	449 000	2
W10	1.7	10 000	-
Mtombo	3.2	51 281	2
W8	2	18 417	-

3.5 Flow Measurement and telemetry system

3.5.1 Measurement of flow into and out of the Scheme

The first measurement takes place at the Loskop Dam wall where a telemetry system is used to measure the total volume of water released into the two main canals of the Loskop IB. A Base System is located at the Loskop Irrigation Board Office (4 km from Groblersdal) and consists of a base computer, which holds the central database to store and convert all of the data received from the Remote Telemetry Unit together with an antenna to receive from and transmit data to the remote telemetry system. It is seen as too expensive at this point in time to install more telemetry systems in other parts of the scheme.

The Loskop Irrigation Board measures the weekly volume of water delivered to the water users using pressure regulating sluice gates (inlet) and parshall flumes (outlet), ranging from two to six feet. 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 17 m³/hour, 34 m³/hour, 51 m³/hour, 68 m³/hour, 102 m³/hour, 151 m³/hour, and 200 m³/hour.

The quantity of water that was actually delivered to farmers can be monitored by comparing the volume of water ordered per ward. The percentage of water lost can then be calculated and the scheme administrators will also know if any farmer has taken more than his or her allocation.

Photo 3-2: Telemetry system at the left outlet of Loskop Dam

Return flows are determined by measuring the return flow at each ward twice a day. Each ward manager then sends the average loss per day to the scheme manager who includes the values in the weekly flow records. Measurements of canal end return flows are also included in the water budget.

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

It was not possible to undertake a comprehensive condition assessment of the irrigation canals of the Loskop Irrigation Board but a visit to the scheme did take place during a dry period and some of the canals were inspected. A list of criteria for undertaking canal condition assessment was developed for use later during the implementation phase. The Canal Condition Evaluation component of RAT includes visual rating methodologies on:

- the general condition of the canal
- conditions which indicate seepage or structural problems

Seven (7) factors are used in this procedure which may be grouped as follows:

- general condition of the canals
- presence of cracks (hairline, pencil-size, and large)
- amount of patchwork
- vegetation in canal and along embankment

Tables 4.1 – 4.5 provide details on the 7 rating factors and definition of numerical values used that are recommended to be used during the dry periods.

Table 4-1: General Condition rating

Rating	Definition
1	Excellent – no visible cracks or vegetation
2	Good – having cracks greater than 3.0 m apart and some weeds
3	Fair – cracks 1.5-3.0 m apart, with moderate vegetation in canal and drainage ditch
4	Poor – cracks 1.0-1.5 m apart, with dense vegetation in canal and drainage ditch
5	Serious Problems – visible large cracks less than 1.0m apart with lush vegetation

Table 4-2: Criteria for hairline, pencil size and large cracks

Rating	Definition
1	None to Sparse
2	Greater than 3.0 m apart
3	1.5 – 3.0 m apart
4	1.0 – 1.5 apart
5	Less than 1.0 m apart

Table 4-3: Noticeable amounts of maintenance and repair (patchwork)

Rating	Definition
1	None to Sparse
2	A few areas
3	Sparse
4	Moderate
5	Severe

Table 4-4: Vegetation growing in canal lining

Rating	Definition
0	None
1	Sparse
2	Moderate
3	Dense

Table 4-5: Vegetation in drainage canals and along the outer embankment of the levee

Rating	Definition
1	Normal; rain-fed weeds only
2	Canal fed grass or small weeds only
3	Moderate; bushes & some small to no trees with no water near levee or drain
4	Dense; more bushes & larger trees, little or no standing water, little or no aquatic vegetation
5	Dense and lush; bushes, trees, lots of aquatic vegetation with standing water

4.3 Results and analysis of preliminary assessment

4.3.1 Condition evaluation of the head works

During the site visit of 27 June 2011 the head works were inspected and the condition of the structure found to be good.

4.3.2 Condition evaluation of main canal sections

Although no formal condition assessment was carried out on the main canal section of the Loskop Irrigation Scheme, various observations were made and discussions were held with the scheme management during the site visit. The canal structure is old and therefore the concrete is deteriorating at a few locations. Some canal sections have shifted from their original positions due to age and soil conditions, resulting in cracks and possible leakages. These sections are attended to by the IB during the maintenance weeks when the canal is relined with concrete, new sections installed and shifting sections stabilised. (See photos below).

Figure 4-1 Deteriorating canal structure (left bank)

Figure 4-2 Restoration of canal sections on the left bank

Figure 4-3 Canal stabilisation on the left bank

Figure 4-4 Canal failure and refurbishment (right bank)

4.3.3 Condition evaluation of the secondary and branch canals

Similar conditions were observed on the secondary canals as on the main canals and the same methods of maintenance and refurbishment are applied. Almost 50 % of the branch canals are however piped and no observations or complaints from the IB in terms of the condition of these structures were made.

4.3.4 Condition evaluation of the siphons

During the site visit it was observed that a lot of debris and algae accumulate at the siphon entrances. Fortunately the IB has made provision for this by installing screens at the entrances of the siphons preventing the debris from entering the siphon and causing blockages. The screens are cleaned regularly to prevent blockage in the canal structure.

Figure 4-5 Entrance of siphon with screen

5 SCHEME OPERATIONS AND OPERATING PROCEDURES

5.1 General scheme operation

The Loskop Irrigation Board employs 56 full time employees (technicians and managers numbering 16 and 51 unskilled labourers) that oversees the day-to-day management of the Loskop Irrigation Scheme. The Loskop Dam is operated and managed by the DWA based in Groblersdal and it is the Department's responsibility to determine the annual water quota based on the quantity of water in the dam. This total annual quota for the water year, which runs from May to April, cannot exceed the total allowable irrigation entitlement (of 124 Million m^3/a), but can be set at a lower level than this in the case of water shortages, such as droughts. Every irrigation farmer submits a request to the scheme administrators every Thursday for the water requirement of the following week. It is the responsibility of the scheme administrators to add up all the irrigation requests and submit a request to the Department of Water Affairs who then release the total required volume of water into the canal from the Sunday evening. The scheme employees then open each farmer's sluice gate to the appropriate height based on their requested water quantity.

The Loskop Irrigation Board consists of eight members, one chosen from each of the eight sub-districts (wards) that constitute the Loskop Irrigation Area. The members of the irrigation scheme elect the Board members every three years. The number of votes that any one farmer is allocated is dependent on the number of hectares that he or she owns. Each farmer is allocated 1 vote for every 6 hectares up to a maximum of 10 votes per person. The Board is in turn accountable to the members who elected them and are required to meet with the members at least once a year at an annual general meeting (AGM). The function of this meeting is to report back to the scheme members and for the members to raise issues with the Board. The Irrigation Board, particularly the Chairman of the Board, is however approachable by the members' and, therefore, if there are pressing issues that a farmer, or group of farmers wish to discuss, they are not required to wait until the AGM. In addition to the AGM, the Board is required to meet with and report to the local Department of Water Affairs in Groblersdal once a month. The purpose of these meetings is to discuss management and operational issues and to ensure the efficient operation of the irrigation scheme.

Although the scheme was privatized in 1992, *de jure* authority over the scheme still rests with DWA. Although DWA has these *de jure* rights to intervene in the management of the scheme, to date no intervention has taken place and, according to the CEO of the Loskop Irrigation Board, intervention is unlikely to take place. No other government department or nongovernmental organization exerts any influence over the management of the scheme, nor do they have any *de jure* rights to do so.

According to the National Water Act (Act No. 36 of 1998), an ecological reserve is required to be set aside for the sustainable maintenance of ecosystems along a particular water course. Progress has been made along the Olifants River with regard to the calculation of the reserve but this has not yet made an impact on the Loskop Irrigation Scheme. The

calculation of the ecological reserve is the function of the DWA, who will then be required to inform the Board of any changes to their entitlements as a result of the reserve.

5.2 Water ordering and delivery procedures

In order to ensure that the irrigators receive their scheduled quota as and when required, the Loskop IB operates the irrigation scheme 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 600 abstraction points along the canal systems. The procedures followed by the irrigators in ordering their water requirements are as follows:

(1) Each irrigator determines how much water they need to order based on their irrigation scheduling as well as their scheduled quota.
(2) The irrigators submit their requests to the Loskop IB by the close of business on a Thursday for their total water requirements to be delivered the following week. Irrigators must specify their needs clearly on the request form and the IB will endeavour to supply the water as requested.
(3) The management at the Loskop IB then reconcile the total requested volume for the week and then calculates how much water should be supplied to each of the different sections of canal systems based on the request.
(4) In the event that the requested volume exceeds the maximum hydraulic capacity of the canal systems, the requested volumes will be reduced proportionally to the determined hydraulic capacity of the canal infrastructure, taking into account estimated water losses.
(5) In order to reduce the water losses, the Loskop IB also determines the minimum volume of water that can be delivered in each canal system without significant water losses. If the requests amount to less than the minimum threshold for release, the irrigators in that particular section will not receive their requests.

The management is responsible for ensuring that water is efficiently and effectively delivered to the appropriate farmers. A number of employees are involved with processing the water requirements and requesting the correct quantity of water from the DWA in Groblersdal. Others are responsible for administrating the billing and fee collection and monitoring the quantity of water that is conveyed along the irrigation canal. A record of the total volume of water supplied to each individual farmer is kept and a farmer is not permitted to exceed his or her annual water allocation. Monitoring the water levels in the balancing dams and measuring the quantity of water returned to the Olifants River are also the responsibility of the irrigation scheme employees.

The workers who are employed by the scheme perform day-to-day maintenance and upkeep of the canals and carry out any small construction work. The water control aide(s) are responsible for setting the various sluice gates to the required level (which is determined by the farmer’s request for water) for each irrigation farmer.

The water is supplied to the users through sluice gates or measured by parshall flumes, which are adjusted according to the water level (i.e. pressure) in the canal system.

5.3 Water trading - Temporary water transfers

There are periods when irrigators exhaust their scheduled quota before the start of the new water year and they may then 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.

The irrigators then approach the Loskop IB to facilitate the temporary transfer based on whether there is sufficient hydraulic capacity in the irrigation canal system to accommodate the transfer to the temporary user(s). Currently the IB is not involved in any of the negotiations as the water use entitlements are held by the individual water user.

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 Loskop Dam are high, irrigation farmers are not required to meet many of these costs and are also not required to meet any capital costs. The Loskop IB incurs a number of expenses relating to the maintenance and refurbishment of the canal systems and the administration of the scheme. The costs of the Loskop Irrigation Scheme for the 1999/00 and 2010/11 financial years are presented in Table 5-1.

Table 5-1: Scheme costs

Cost item	1999/2000	2010/2011
Regular repair and replacement costs	800 000	1 828 571
Administration costs	700 000	1 600 000
Maintenance costs (including labour and materials)	8 026 000	18 345 143
Running costs (associated with diverting water and opening sluice gates)	1 500 000	3 428 571
Current investment project	2 300 000	
Total	**13 326 000**	**25 202 286**

Based on the above costs, the DWA charged the Loskop Irrigation Scheme 2c/m³ for irrigation water in 1999/2000. This cost was then passed on to the irrigators and a further 5c/ m³ was added by the Loskop Irrigation Scheme to cover its costs. The total cost for irrigation on the Loskop Irrigation Scheme was therefore 7c/m³. Ten years have lapsed since then and the tariff payable by the irrigators for water today is 16c/m³. With the scheduled allocation of 124 million m^3/a, the Loskop Irrigation Board pays approximately R 20 million per year or each irrigator pays an estimated R 1 229 per hectare per year.

6 LOSKOP IRRIGATION SCHEME 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 Loskop Dam wall where water is released from the dam into the two main irrigation canals. Weekly records of the inflows into the main canals at the Loskop Dam wall were evaluated. The records were aggregated into monthly records. Monthly records from the 2004/05 water year to 2010/11 water year were generated and are presented in **Table 6-1**.

Records on storage releases from the balancing dams were also included.

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 (or rather administered) through the variable water pressure at different adjustable sluice gates. The sluices are adjusted by hand in increments.

The monthly data on releases at the individual delivery points were aggregated to provide records of consumptive use by the irrigators.

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.

Committed 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.

Outflows are determined by measuring the outflow at each ward twice a day. Each ward manager then sends the average loss per day to the scheme manager who includes the values in the weekly flow records. Measurements of canal end returns are also included in the water budget. No direct measurements of water in terms of evaporation are currently performed in the system.

6.5 Overall scheme water balance

Using the information obtained from the WUEARs, previous studies and consultation with the management of the Irrigation Board (IB), the water budget for the Loskop IB was prepared and is provided in **Table 6-1**.

The water balance is based on information from the Water Administration System (WAS) which each ward manager runs in his/her own water ward. Water orders are captured by each ward manager in the WAS program. 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 Loskop Irrigation Scheme were provided on a weekly basis.

The outflows consist of all the ways that water is consumed within 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. The volume of water that is requested by the irrigators in the Loskop IB area varies from year to year, as does the cropping pattern for each year. For the past seven water years the irrigation water applied for has ranged from 89 million m^3/a in 2004/05 to 122 million m^3/a in 2006/07. Over the past four years, irrigators have been requesting on average 95% of the total scheduled quota of 124 million m^3/a.

An analysis of the percentage of inflow to the water allocation indicates that since 2004/05 water year, on average 15% more water has been released from the Loskop Dam than the water allocation of 124 million m^3/a. It should be kept in mind though that the released water has been diverted to other users outside the scheme and includes provision for operational spills.

Table 6-1: Water budget

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
May-04	4,723,096	542,346	5,265,442	264,919	162,182	3,243,308	421,111	3,664,419	70,564	576	71,140	1,409,224	120,659	1,427,146	**27.64%**	1,479,788	31.33%	121,235	22.35%	1498286
June-04	8,107,995	729,488	8,837,483	58,090	100,442	6,087,840	621,851	6,709,691	134,150	772	134,922	1,886,005	106,865	2,035,222	**22.92%**	2,020,155	24.92%	107,637	14.76%	2,170,144
July-04	8,158,323	944,094	9,102,417	263,287	81,448	5,892,112	847,398	6,739,510	130,710	1,344	132,054	2,135,501	95,352	2,049,014	**22.97%**	2,266,211	27.78%	96,696	10.24%	2,181,068
Aug-04	11,133,890	1,349,512	12,483,402	56,276	462,642	8,332,038	1,188,877	9,520,915	170,748	960	171,708	2,631,104	159,675	3,197,145	**24.80%**	2,801,852	25.17%	160,635	11.90%	3,368,853
Sep-04	20,730,144	1,942,701	22,672,845	262,652	106,708	16,138,578	1,660,091	17,798,669	236,472	1,896	238,368	4,355,094	280,714	4,479,864	**19.90%**	4,591,566	22.15%	282,610	14.55%	4,718,232
Oct-04	13,164,325	1,060,242	14,224,567	223,215	56,575	10,264,505	921,642	11,186,147	162,647	1,152	163,799	2,737,173	137,448	2,707,981	**19.26%**	2,899,820	22.03%	138,600	13.07%	2,871,780
Nov-04	12,167,373	1,030,217	13,197,590	97,557	60,600	9,267,317	891,546	10,158,863	126,240	1,968	128,208	2,773,816	136,703	2,873,562	**21.83%**	2,900,056	23.83%	138,671	13.46%	3,001,770
Dec-04	6,461,602	551,809	7,013,411	44,461	103,163	4,722,878	472,225	5,195,103	102,828	1,536	104,364	1,635,896	78,048	1,772,646	**25.07%**	1,738,724	26.91%	79,584	14.42%	1,877,010
Jan-05	10,253,005	1,271,371	11,524,376	52,127	102,225	7,708,124	983,103	8,691,227	140,856	3,240	144,096	2,404,025	285,028	2,739,151	**23.67%**	2,544,881	24.82%	288,268	22.67%	2,883,247
Feb-05	11,552,005	1,368,401	12,920,406	148,427	99,300	8,524,664	1,033,299	9,557,963	153,228	2,328	155,556	2,874,113	332,774	3,157,760	**24.53%**	3,027,341	26.21%	335,102	24.49%	3,313,316
March-05	9,722,581	1,045,324	10,767,905	184,787	103,871	7,698,667	895,155	8,593,822	139,588	2,664	142,252	1,884,326	147,505	1,950,915	**18.26%**	2,023,914	20.82%	150,169	14.37%	2,093,167
Apr-05	4,978,907	718,779	5,697,686	145,404	40,995	3,872,133	627,841	4,499,974	78,363	912	79,275	1,028,411	90,026	1,014,028	**18.13%**	1,106,774	22.23%	90,938	12.65%	1,093,303
2004/2005	**121,153,246**	**12,554,284**	**133,707,530**	**1,801,202**	**1,480,151**	**91,752,164**	**10,564,139**	**102,316,303**	**1,646,394**	**19,348**	**1,665,742**	**27,754,688**	**1,970,797**	**29,404,434**	**22.04%**	**121,153,246**	**12,554,284**	**133,707,530**	**1,801,202**	**1,480,151**
May-05	6,252,119	749,082	7,001,201	11,151	100,304	4,738,016	618,385	5,356,401	119,328	552	119,880	1,394,775	130,145	1,614,073	**22.76%**	1,514,103	24.22%	130,697	17.45%	1,733,953
June-05	11,837,219	1,201,948	13,039,167	50,400	100,347	9,338,521	1,001,139	10,339,660	162,291	1,992	164,283	2,336,407	198,817	2,585,171	**19.75%**	2,498,698	21.11%	200,809	16.71%	2,749,454
July-05	11,052,418	1,023,024	12,075,442	55,089	173,667	8,911,381	886,976	9,798,357	130,954	1,392	132,346	2,010,083	134,656	2,263,317	**18.56%**	2,141,037	19.37%	136,048	13.30%	2,395,663
Aug-05	17,971,074	1,815,292	19,786,366	72,885	155,091	14,073,624	1,515,026	15,588,650	202,618	1,872	204,490	3,694,832	298,394	4,075,432	**20.51%**	3,897,450	21.69%	300,266	16.54%	4,279,922
Sep-05	17,904,087	1,671,749	19,575,836	254,490	28,830	13,956,071	1,464,447	15,420,518	185,624	1,728	187,352	3,762,392	205,574	3,742,306	**19.34%**	3,948,016	22.05%	207,302	12.40%	3,929,658
Oct-05	13,139,072	1,271,883	14,410,955	39,449	64,363	10,201,653	1,061,293	11,262,946	154,848	1,800	156,648	2,782,571	208,790	3,016,275	**20.89%**	2,937,419	22.36%	210,590	16.56%	3,172,923
Nov-05	10,619,347	866,225	11,485,572	297,134	198,690	7,689,044	816,057	8,505,101	122,160	2,040	124,200	2,808,143	48,128	2,757,827	**24.22%**	2,930,303	27.59%	50,168	5.79%	2,882,027
Dec-05	10,067,538	899,080	10,966,618	102,410	144,605	7,436,663	740,341	8,177,004	123,264	1,416	124,680	2,507,611	157,323	2,707,129	**24.59%**	2,630,875	26.13%	158,739	17.66%	2,831,809
Jan-06	5,443,314	630,011	6,073,325	279,514	126,046	3,750,656	501,767	4,252,423	69,300	1,208	70,508	1,623,358	127,036	1,596,926	**26.98%**	1,692,658	31.10%	128,244	20.36%	1,667,434
Feb-06	4,439,318	611,207	5,050,525	62,034	467,185	3,482,812	477,290	3,960,102	55,392	1,230	56,622	901,114	132,687	1,438,952	**26.38%**	956,506	21.55%	133,917	21.91%	1,495,574
March	3,650,309	574,843	4,225,152	79,346	133,913	2,947,628	418,885	3,366,513	62,184	1,008	63,192	640,497	154,950	850,014	**19.86%**	702,681	19.25%	155,958	27.13%	913,206
Apr-06	5,534,296	630,584	6,164,880	18,795	101,751	4,567,006	520,650	5,087,656	68,640	886	69,526	898,650	109,048	1,090,654	**17.46%**	967,290	17.48%	109,934	17.43%	1,160,180
2005/2006	**117,910,111**	**11,944,928**	**129,855,039**	**1,322,697**	**1,794,792**	**91,093,075**	**10,022,256**	**101,115,331**	**1,456,603**	**17,124**	**1,473,727**	**25,360,433**	**1,905,548**	**27,738,076**	**21.28%**	**117,910,111**	**11,944,928**	**129,855,039**	**1,322,697**	**1,794,792**
May-06	6,134,005	866,335	7,000,340	77,932	82,463	4,603,988	604,419	5,208,407	26,684	2,170	28,854	1,503,333	259,746	1,767,610	**25.23%**	1,530,017	24.94%	261,916	30.23%	1,796,464
June-06	8,092,636	1,409,360	9,501,996	146,441	111,180	6,352,611	1,007,168	7,359,779	26,298	2,272	28,570	1,713,727	399,920	2,078,386	**21.95%**	1,740,025	21.50%	402,192	28.54%	2,106,956
July-06	8,282,107	1,002,265	9,284,372	157,507	86,235	7,308,276	838,559	8,146,835	109,946	1,392	111,338	863,885	162,314	954,927	**10.36%**	973,831	11.76%	163,706	16.33%	1,066,265
Aug-06	13,841,859	1,609,077	15,450,936	91,971	299,277	11,180,059	1,341,017	12,521,076	166,227	2,376	168,603	2,495,573	265,684	2,968,563	**18.96%**	2,661,800	19.23%	268,060	16.66%	3,137,166

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
Sep-06	16,963,689	2,042,288	19,005,977	182,374	278,346	13,457,684	1,722,986	15,180,670	172,894	5,064	177,958	3,333,111	314,238	3,743,321	**19.60%**	3,506,005	20.67%	319,302	15.63%	3,921,279
Oct-06	18,055,296	2,240,695	20,295,991	108,133	195,900	14,161,074	1,874,904	16,035,978	180,672	4,728	185,400	3,713,550	361,063	4,162,380	**20.42%**	3,894,222	21.57%	365,791	16.32%	4,347,780
Nov-06	6,482,197	699,075	7,181,272	242,966	657,273	5,192,486	641,567	5,834,053	87,360	792	88,152	1,202,351	56,716	1,673,374	**22.03%**	1,289,711	19.90%	57,508	8.23%	1,761,526
Dec-06	11,868,577	1,278,986	13,147,563	286,232	48,290	9,675,380	1,122,216	10,797,596	151,800	2,976	154,776	2,041,397	153,794	1,957,249	**15.16%**	2,193,197	18.48%	156,770	12.26%	2,112,025
Jan-06	14,879,033	1,364,238	16,243,271	277,159	71,157	11,272,267	1,271,027	12,543,294	152,808	2,304	155,112	3,453,958	90,907	3,338,863	**20.82%**	3,606,766	24.24%	93,211	6.83%	3,493,975
Feb-07	15,779,986	1,814,024	17,594,010	262,048	273,230	11,640,764	1,501,229	13,141,993	144,044	1,630	145,674	3,995,178	311,165	4,317,525	**24.52%**	4,139,222	26.23%	312,795	17.24%	4,463,199
March-06	14,658,890	1,361,120	16,020,010	71,801	198,567	10,729,700	1,121,971	11,851,671	140,232	1,608	141,840	3,788,958	237,541	4,153,265	**25.72%**	3,929,190	26.80%	239,149	17.57%	4,295,105
Apr-06	8,510,840	1,357,458	9,868,298	152,448	67,928	5,176,893	1,249,031	6,425,924	67,776	1,344	69,120	3,266,171	107,083	3,288,734	**33.61%**	3,333,947	39.17%	108,427	7.99%	3,357,854
2006/2007	**143,549,115**	**17,044,921**	**160,594,036**	**2,057,012**	**2,369,846**	**110,751,182**	**14,296,094**	**125,047,276**	**1,426,741**	**28,656**	**1,455,397**	**31,371,192**	**2,720,171**	**34,404,197**	21.38%	**143,549,115**	**17,044,921**	**160,594,036**	**2,057,012**	**2,369,846**
May-07	10,391,065	1,233,649	11,624,714	183,432	305,891	8,104,284	994,189	9,098,473	118,116	1,368	119,484	2,168,665	238,092	2,529,216	**21.53%**	2,286,781	22.01%	239,460	19.41%	2,648,700
June-07	9,229,044	742,559	9,971,603	63,185	377,320	7,043,878	579,585	7,623,463	99,434	2,670	102,104	2,085,732	160,304	2,560,171	**24.89%**	2,185,166	23.68%	162,974	21.95%	2,662,275
July-07	10,009,990	1,192,706	11,202,696	268,016	162,805	7,542,686	992,597	8,535,283	90,603	3,048	93,651	2,376,701	197,061	2,468,551	**22.24%**	2,467,304	24.65%	200,109	16.78%	2,562,202
Aug-07	14,858,508	1,301,459	16,159,967	212,291	422,650	11,149,879	1,156,885	12,306,764	121,806	3,442	125,248	3,586,823	141,132	3,938,314	**24.06%**	3,708,629	24.96%	144,574	11.11%	4,063,562
Sep-07	18,190,307	1,916,952	20,107,259	44,449	138,323	14,166,733	1,576,378	15,743,111	168,672	3,524	172,196	3,854,902	337,050	4,285,826	**21.22%**	4,023,574	22.12%	340,574	17.77%	4,458,022
Oct-07	9,251,051	823,603	10,074,654	80,399	795,968	6,925,315	817,179	7,742,494	91,718	3,924	95,642	2,234,018	2,500	2,952,087	**27.36%**	2,325,736	25.14%	6,424	0.78%	3,047,729
Nov-07	7,810,433	879,021	8,689,454	136,872	182,268	6,051,815	778,315	6,830,130	92,546	3,240	95,786	1,666,072	97,466	1,808,934	**20.71%**	1,758,618	22.52%	100,706	11.46%	1,904,720
Dec-07	7,978,773	852,694	8,831,467	179,011	135,460	6,472,934	692,917	7,165,851	93,088	3,390	96,478	1,412,751	156,387	1,525,587	**17.36%**	1,505,839	18.87%	159,777	18.74%	1,622,065
Jan-08	7,137,525	757,282	7,894,807	215,722	245,054	5,100,964	589,675	5,690,639	76,984	3,717	80,701	1,959,577	163,890	2,152,799	**27.17%**	2,036,561	28.53%	167,607	22.13%	2,233,500
Feb-08	11,423,447	864,706	12,288,153	201,798	180,536	8,296,205	835,721	9,131,926	99,866	3,264	103,130	3,027,376	25,721	3,031,835	**24.72%**	3,127,242	27.38%	28,985	3.35%	3,134,965
March-08	8,547,161	674,791	9,221,952	42,918	39,168	6,552,420	570,197	7,122,617	72,793	1,920	74,713	1,921,948	102,674	2,020,872	**21.92%**	1,994,741	23.34%	104,594	15.50%	2,095,585
Apr-08	9,242,566	766,693	10,009,259	0	232,416	6,965,092	627,070	7,592,162	78,673	6,912	85,585	2,198,801	132,711	2,563,928	**25.03%**	2,277,474	24.64%	139,623	18.21%	2,649,513
2007/2008	**124,069,870**	**12,006,115**	**136,075,985**	**1,628,093**	**3,217,859**	**94,372,205**	**10,210,708**	**104,582,913**	**1,204,299**	**40,419**	**1,244,718**	**28,493,366**	**1,754,988**	**31,838,120**	23.13%	**124,069,870**	**12,006,115**	**136,075,985**	**1,628,093**	**3,217,859**
May-08	6,543,171	621,912	7,165,083	116,671	45,558	5,135,221	552,363	5,687,584	66,748	1,464	68,212	1,341,202	68,085	1,338,174	**18.86%**	1,407,950	21.52%	69,549	11.18%	1,406,386
June-08	9,888,494	839,123	10,727,617	127,407	94,940	7,611,616	701,973	8,313,589	87,170	1,480	88,650	2,189,708	135,670	2,292,911	**21.44%**	2,276,878	23.03%	137,150	16.34%	2,381,561
July-08	11,540,712	1,341,243	12,881,955	376,471	354,750	8,915,176	1,150,579	10,065,755	96,391	1,560	97,951	2,529,145	189,104	2,696,528	**20.97%**	2,625,536	22.75%	190,664	14.22%	2,794,479
Aug-08	16,979,738	1,666,400	18,646,138	171,710	158,792	13,283,224	1,429,269	14,712,493	165,828	1,440	167,268	3,530,686	235,691	3,753,459	**20.14%**	3,696,514	21.77%	237,131	14.23%	3,920,727
Sep-08	24,124,434	2,875,390	26,999,824	331,381	379,686	18,938,792	2,529,957	21,468,749	201,353	5,944	207,297	4,984,289	339,489	5,372,083	**19.86%**	5,185,642	21.50%	345,433	12.01%	5,579,380
Oct-08	12,503,444	1,524,596	14,028,040	83,395	130,207	9,883,048	1,251,765	11,134,813	115,854	6,660	122,514	2,504,542	266,171	2,817,525	**20.02%**	2,620,396	20.96%	272,831	17.90%	2,940,039
Nov-08	4,158,991	414,490	4,573,481	161,085	9,873	3,000,832	331,927	3,332,759	52,584	3,978	56,562	1,105,575	78,585	1,032,948	**23.36%**	1,158,159	27.85%	82,563	19.92%	1,089,510
Dec-08	12,101,388	1,026,550	13,127,938	79,019	162,266	8,424,344	794,090	9,218,434	115,195	6,273	121,468	3,561,849	226,187	3,871,283	**29.30%**	3,677,044	30.39%	232,460	22.64%	3,992,751
Jan-09	6,790,562	706,224	7,496,786	84,786	73,955	4,986,136	494,891	5,481,027	68,472	4,452	72,924	1,735,954	206,881	1,932,004	**25.81%**	1,804,426	26.57%	211,333	29.92%	2,004,928
Feb-09	5,765,641	965,591	6,731,232	45,733	103,402	4,500,152	820,981	5,321,133	63,856	4,440	68,296	1,201,633	140,170	1,399,472	**20.61%**	1,265,489	21.95%	144,610	14.98%	1,467,768

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
March-09	7,945,300	721,206	8,666,506	152,379	191,813	6,045,544	686,356	6,731,900	81,120	0	81,120	1,818,636	34,850	1,892,920	**21.74%**	1,899,756	23.91%	34,850	4.83%	1,974,040
Apr-09	8,505,152	1,182,119	9,687,271	261,292	147,500	6,742,992	1,140,381	7,883,373	62,328	4,530	66,858	1,699,832	37,208	1,623,248	**16.96%**	1,762,160	20.72%	41,738	3.53%	1,690,106
2008/2009	**126,847,027**	**13,884,844**	**140,731,871**	**1,991,329**	**1,852,742**	**97,467,077**	**11,884,532**	**109,351,609**	**1,176,899**	**42,221**	**1,219,120**	**28,203,051**	**1,958,091**	**30,022,555**	**21.35%**	**126,847,027**	**13,884,844**	**140,731,871**	**1,991,329**	**1,852,742**
May-09	8,038,486	790,266	8,828,752	171,140	127,149	6,334,384	674,936	7,009,320	73,107	1,560	74,667	1,630,995	113,770	1,700,774	**19.36%**	1,704,102	21.20%	115,330	14.59%	1,775,441
June-09	7,779,343	797,152	8,576,495	100,988	110,659	6,094,344	724,843	6,819,187	70,564	1,080	71,644	1,614,435	71,229	1,695,335	**19.74%**	1,684,999	21.66%	72,309	9.07%	1,766,979
July-09	11,513,918	1,365,482	12,879,400	108,748	163,192	8,984,808	1,235,545	10,220,353	100,054	2,616	102,670	2,429,056	127,321	2,610,821	**20.19%**	2,529,110	21.97%	129,937	9.52%	2,713,491
Aug-09	15,529,636	1,438,221	16,967,857	291,825	183,544	12,383,272	1,423,681	13,806,953	123,600	2,952	126,552	3,022,764	11,588	2,926,071	**17.36%**	3,146,364	20.26%	14,540	1.01%	3,052,623
Sep-09	23,282,288	2,511,338	25,793,626	42,016	128,250	18,701,412	2,224,731	20,926,143	188,136	4,488	192,624	4,392,740	282,119	4,761,093	**18.40%**	4,580,876	19.68%	286,607	11.41%	4,953,717
Oct-09	12,031,447	1,556,781	13,588,228	68,228	106,893	9,318,361	1,293,697	10,612,058	98,064	1,824	99,888	2,615,022	261,260	2,914,947	**21.39%**	2,713,086	22.55%	263,084	16.90%	3,014,835
Nov-09	5,609,557	768,804	6,378,361	138,747	81,346	4,520,747	716,082	5,236,829	56,572	1,200	57,772	1,032,238	51,522	1,026,359	**16.24%**	1,088,810	19.41%	52,722	6.86%	1,084,131
Dec-09	9,712,209	1,869,816	11,582,025	326,237	5,315	8,197,166	1,212,311	9,409,477	78,974	1,584	80,558	1,436,069	655,921	1,771,068	**15.73%**	1,515,043	15.60%	657,505	35.16%	1,851,626
Jan-10	10,430,357	1,078,552	11,508,909	187,125	123,165	8,438,046	861,625	9,299,671	80,280	1,440	81,720	1,912,031	215,487	2,063,558	**18.03%**	1,992,311	19.10%	216,927	20.11%	2,145,278
Feb-10	15,044,524	1,091,279	16,135,803	0	79,243	11,801,356	995,697	12,797,053	98,170	960	99,130	3,144,998	94,622	3,318,863	**20.47%**	3,243,168	21.56%	95,582	8.76%	3,417,993
March-10	20,207,597	1,683,795	21,891,392	168,385	248,386	15,553,332	1,417,923	16,971,255	150,936	840	151,776	4,503,329	265,032	4,848,362	**22.07%**	4,654,265	23.03%	265,872	15.79%	5,000,138
Apr-10	1,380,672	455,620	1,836,292	130,339	1,227	166,160	418,364	584,524	1,260	240	1,500	1,213,252	37,016	1,121,156	**65.67%**	1,214,512	87.97%	37,256	8.18%	1,122,656
2009/2010	**140,560,034**	**15,407,106**	**155,967,140**	**1,733,778**	**1,358,369**	**110,493,388**	**13,199,435**	**123,692,823**	**1,119,717**	**20,784**	**1,140,501**	**28,946,929**	**2,186,887**	**30,758,407**	**19.77%**	**140,560,034**	**15,407,106**	**155,967,140**	**1,733,778**	**1,358,369**
May-10	7,302,597	567,783	7,870,380	333,140	900	6,071,952	549,572	6,621,524	60,934	840	61,774	1,169,711	17,371	854,842	**11.34%**	1,230,645	16.85%	18,211	3.21%	916,616
June-10	10,460,577	796,045	11,256,622	43,342	24,276	8,903,729	708,651	9,612,380	83,000	720	83,720	1,473,848	86,674	1,541,456	**13.72%**	1,556,848	14.88%	87,394	10.98%	1,625,176
July-10	7,132,966	877,660	8,010,626	29,075	22,357	5,468,979	826,944	6,295,923	54,092	720	54,812	1,609,895	49,996	1,653,173	**20.65%**	1,663,987	23.33%	50,716	5.78%	1,707,985
Aug-10	13,982,613	1,251,899	15,234,512	102,539	419,960	10,829,511	1,156,483	11,985,994	103,896	1,320	105,216	3,049,206	94,096	3,460,723	**22.25%**	3,153,102	22.55%	95,416	7.62%	3,565,939
Sep-10	22,272,421	2,440,406	24,712,827	131,043	60,067	17,925,857	2,085,126	20,010,983	159,908	3,144	163,052	4,186,656	352,136	4,467,816	**18.13%**	4,346,564	19.52%	355,280	14.56%	4,630,868
Oct-10	16,255,196	1,847,711	18,102,907	108,545	165,783	13,369,696	1,522,096	14,891,792	121,438	2,064	123,502	2,764,062	323,551	3,144,851	**17.32%**	2,885,500	17.75%	325,615	17.62%	3,268,353
Nov-10	7,132,790	738,692	7,871,482	89,145	48,972	5,714,824	625,058	6,339,882	63,435	1,656	65,091	1,354,531	111,978	1,426,336	**18.21%**	1,417,966	19.88%	113,634	15.38%	1,491,427
Dec-10	5,704,106	606,463	6,310,569	84,752	183,752	3,862,360	531,987	4,394,347	41,936	1,656	43,592	1,799,810	72,820	1,971,630	**30.76%**	1,841,746	32.29%	74,476	12.28%	2,015,222
Jan-11	2,330,143	406,554	2,736,697	51,634	17,418	2,005,908	341,124	2,347,032	25,657	1,296	26,953	298,578	64,134	328,496	**12.16%**	324,235	13.91%	65,430	16.09%	355,449
Feb-11	13,301,868	1,401,226	14,703,094	95,475	68,297	10,573,696	1,211,965	11,785,661	96,646	1,464	98,110	2,631,526	187,797	2,792,145	**19.03%**	2,728,172	20.51%	189,261	13.51%	2,890,255
March-11	18,602,975	1,396,276	19,999,251	165,768	125,789	14,299,748	1,257,372	15,557,120	123,370	2,232	125,602	4,179,857	136,672	4,276,550	**21.43%**	4,303,227	23.13%	138,904	9.95%	4,402,152
Apr-11	4,022,370	421,175	4,443,545	52,950	87,376	3,336,208	357,790	3,693,998	26,616	1,648	28,264	659,546	61,737	755,709	**16.88%**	686,162	17.06%	63,385	15.05%	783,973
2010/2011	**128,500,622**	**12,751,890**	**141,252,512**	**1,287,408**	**1,224,947**	**102,362,468**	**11,174,168**	**113,536,636**	**960,928**	**18,760**	**979,688**	**25,177,226**	**1,558,962**	**26,673,727**	**18.93%**	**128,500,622**	**12,751,890**	**141,252,512**	**1,287,408**	**1,224,947**

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 determinations, inaccurate water measuring structures and other restricting factors such as aquatic weed 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.

An irrigation water budget was developed for the Loskop Irrigation Scheme. The water budget was based on information obtained from the Water Administration System (WAS) which each ward manager runs in his/her own water ward.

Fortunately the Loskop IB installed a weather station at their office some time ago. The evaporation measured at this station was used in the determination of the evaporation losses for the seven year period. Rainfall has not been included as inflow in this water budget.

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

The water budget is an important tool for analysing the water management issues provided adequate and reliable data was available. At a scheme level there was sufficient data to determine a water budget based on the WAS.

6.6.2 Gross Water losses

The total monthly losses summarised by main canals for the period May 2004 to Apr 2011 are shown in Table 6-2. The values in this table reflect the total losses and include seepage, evaporation, leakage and operational losses (including tail 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 two main canals.

Table 6-2: Loskop IB - Historical monthly losses

Month	Left Bank		Right Bank	
	Volume (10^3m^3)	% of inflow	Volume (10^3m^3)	% of inflow
May-04	1 480	31.33%	121	22.35%
June-04	2 020	24.92%	108	14.76%
July-04	2 266	27.78%	97	10.24%
Aug-04	2 802	25.17%	161	11.90%
Sep-04	4 592	22.15%	283	14.55%
Oct-04	2 900	22.03%	139	13.07%
Nov-04	2 900	23.83%	139	13.46%
Dec-04	1 739	26.91%	80	14.42%
Jan-05	2 545	24.82%	288	22.67%
Feb-05	3 027	26.21%	335	24.49%
Mar-05	2 024	20.82%	150	14.37%
Apr-05	1 107	22.23%	91	12.65%
May-05	1 514	24.22%	131	17.45%
June-05	2 499	21.11%	201	16.71%
July-05	2 141	19.37%	136	13.30%
Aug-05	3 897	21.69%	300	16.54%
Sep-05	3 948	22.05%	207	12.40%
Oct-05	2 937	22.36%	211	16.56%
Nov-05	2 930	27.59%	50	5.79%
Dec-05	2 631	26.13%	159	17.66%
Jan-06	1 693	31.10%	128	20.36%
Feb-06	957	21.55%	134	21.91%
Mar-06	703	19.25%	156	27.13%
Apr-06	967	17.48%	110	17.43%
May-06	1 530	24.94%	262	30.23%
June-06	1 740	21.50%	402	28.54%
July-06	974	11.76%	164	16.33%
Aug-06	2 662	19.23%	268	16.66%
Sep-06	3 506	20.67%	319	15.63%
Oct-06	3 894	21.57%	366	16.32%
Nov-06	1 290	19.90%	58	8.23%
Dec-06	2 193	18.48%	157	12.26%
Jan-07	3 607	24.24%	93	6.83%
Feb-07	4 139	26.23%	313	17.24%
Mar-07	3 929	26.80%	239	17.57%
Apr-07	3 334	39.17%	108	7.99%
May-07	2 287	22.01%	239	19.41%
June-07	2 185	23.68%	163	21.95%
July-07	2 467	24.65%	200	16.78%
Aug-07	3 709	24.96%	145	11.11%
Sep-07	4 024	22.12%	341	17.77%

Month	Left Bank		Right Bank	
	Volume (10^3m^3)	% of inflow	Volume (10^3m^3)	% of inflow
Oct-07	2 326	25.14%	6	0.78%
Nov-07	1 759	22.52%	101	11.46%
Dec-07	1 506	18.87%	160	18.74%
Jan-08	2 037	28.53%	168	22.13%
Feb-08	3 127	27.38%	29	3.35%
Mar-08	1 995	23.34%	105	15.50%
Apr-08	2 277	24.64%	140	18.21%
May-08	1 408	21.52%	70	11.18%
June-08	2 277	23.03%	137	16.34%
July-08	2 626	22.75%	191	14.22%
Aug-08	3 697	21.77%	237	14.23%
Sep-08	5 186	21.50%	345	12.01%
Oct-08	2 620	20.96%	273	17.90%
Nov-08	1 158	27.85%	83	19.92%
Dec-08	3 677	30.39%	232	22.64%
Jan-09	1 804	26.57%	211	29.92%
Feb-09	1 265	21.95%	145	14.98%
Mar-09	1 900	23.91%	35	4.83%
Apr-09	1 762	20.72%	42	3.53%
May-09	1 704	21.20%	115	14.59%
June-09	1 685	21.66%	72	9.07%
July-09	2 529	21.97%	130	9.52%
Aug-09	3 146	20.26%	15	1.01%
Sep-09	4 581	19.68%	287	11.41%
Oct-09	2 713	22.55%	263	16.90%
Nov-09	1 089	19.41%	53	6.86%
Dec-09	1 515	15.60%	658	35.16%
Jan-10	1 992	19.10%	217	20.11%
Feb-10	3 243	21.56%	96	8.76%
Mar-10	4 654	23.03%	266	15.79%
Apr-10	1 215	87.97%	37	8.18%
May-10	1 231	16.85%	18	3.21%
June-10	1 557	14.88%	87	10.98%
July-10	1 664	23.33%	51	5.78%
Aug-10	3 153	22.55%	95	7.62%
Sep-10	4 347	19.52%	355	14.56%
Oct-10	2 886	17.75%	326	17.62%
Nov-10	1 418	19.88%	114	15.38%
Dec-10	1 842	32.29%	74	12.28%
Jan-11	324	13.91%	65	16.09%
Feb-11	2 728	20.51%	189	13.51%
Mar-11	4 303	23.13%	139	9.95%

Month	Left Bank		Right Bank	
	Volume (10^3m^3)	% of inflow	Volume (10^3m^3)	% of inflow
Apr-11	686	17.06%	63	15.05%

A graphic representation of the total monthly losses for the two main canals is shown in Figure 6-1.

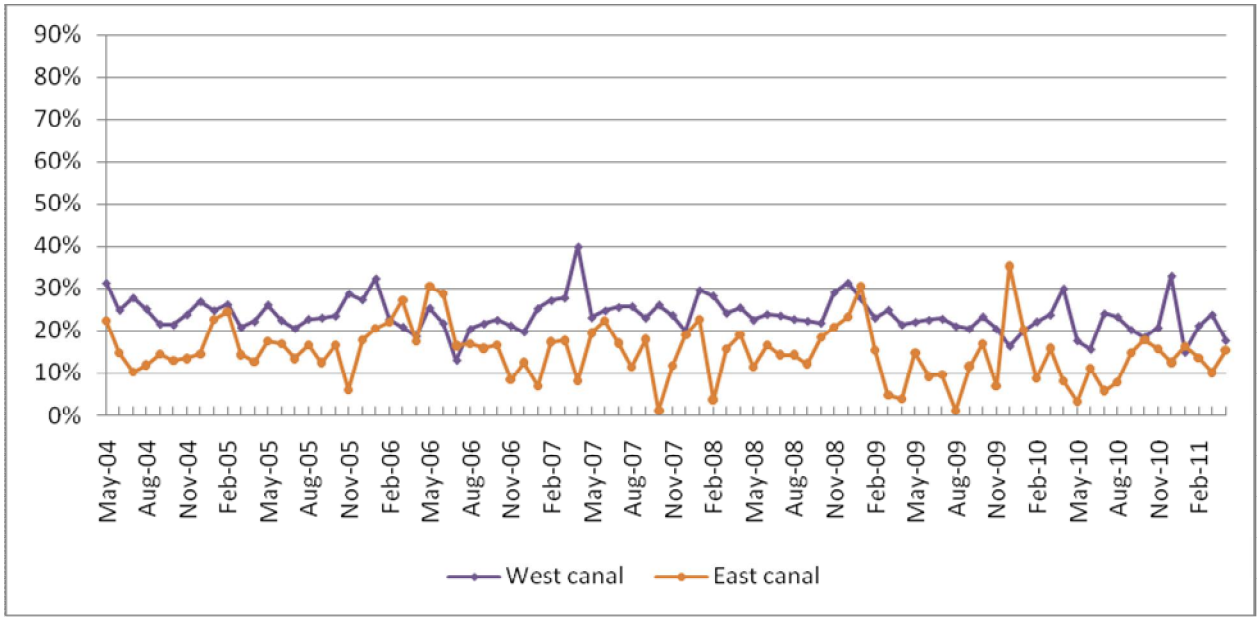


Figure 6-1: Loskop IB - Historical canal losses

From the data presented in Table 6-2 and Figure 6-1 it is clear that the total losses on the left bank (West) canal are roughly 8.7% more than the losses on the right bank (East) canal. This can be attributed to the fact that the West canal serves a much larger area and is therefore a bigger conveyance system than the East canal. The ground formation of the right bank canal has much less turf than that of the left bank canal where the canal structure is more likely to fail or crack due to soil movement.

The **average** water losses have been 21% of the released water from the dam into the canal system. This translated to an **average** of approximately 31.2 million m^3/a water losses in the Loskop Irrigation Scheme area. This volume includes water losses that are difficult to measure including the unavoidable water losses as well as some of the avoidable losses. On average the return flow (canal tail ends) over seven years was 1% of the water released into the canal system.

Figure 6.3 indicates the comparison between the supply and demand from May 2004 to February 2011.

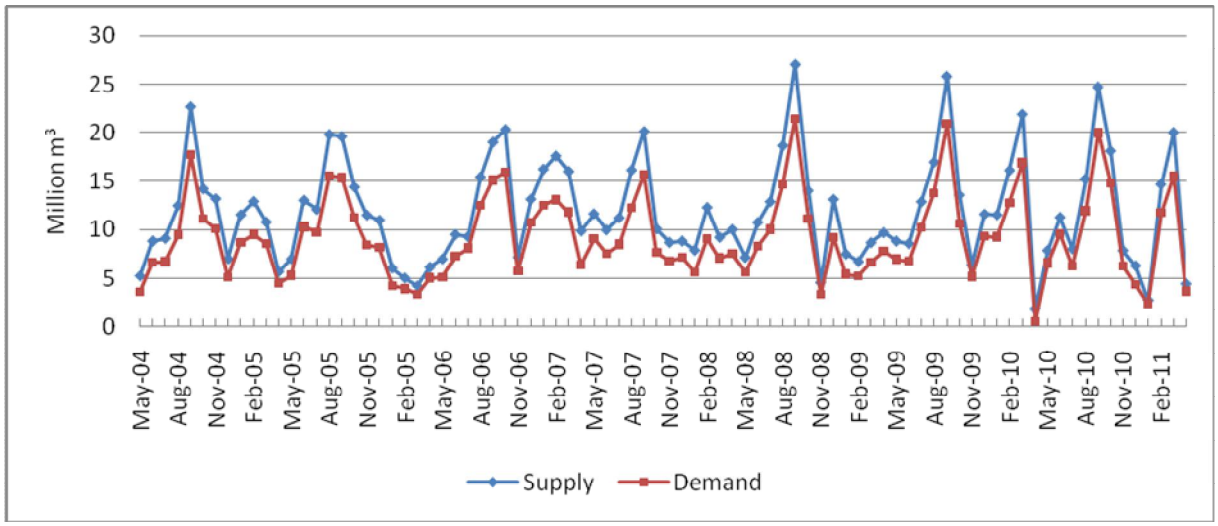


Figure 6.3: Comparison of deliveries and the demands

6.6.3 Conveyance losses

Conveyance losses within a canal system can be defined as the difference between the inflow into the scheme and the water delivered to the farm boundaries. 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 losses 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 Loskop Irrigation Scheme 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 000m^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, quantity of sediment, etc.

For the Loskop Irrigation Scheme, eleven sections were chosen on the left bank to determine seepage losses. Ten sections were taken between the radial gates with varying distances and flow depths at 8.2 m^3/s and one section was taken along the siphon. The wetted perimeter for each section was determined and multiplied with the section length as well as the 1.9 l/s per 1 000 m^2 to get the total seepage loss per section. All the sections were then added. No longitudinal sections, cross sections or dimensions were available for the right bank canal. The seepage loss in the left bank canal was calculated as 11.48 % of the inflow and the same percentage was used for the right bank canal.

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). The evaporation records gathered from the weather station were used to determine the percentage evaporation loss of the total inflow into the West canal. The same eleven sections on the left bank used for estimating the seepage loss were used for estimating the evaporation loss as well. The surface area of each section at a flow rate of 8.2 m^3/s was multiplied by the annual evaporation and all the sections were added. The evaporation loss expressed as a percentage of total inflow was 0.34 % for the left and right banks canals. This corresponds with the theoretical value of 0.3% of Reid, Davidson and Kotze.

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 measurements. These losses are estimated to fluctuate between 9% and 17% (Reid, Davidson and Kotze, 1986).

6.6.3.4 Leaks and Spills:

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 the Board aims to operate the system within a range of 35% to 85% of the design capacity, the water demand during peak periods, sediment and aquatic weed growth necessitates periodic operation of the system at peak capacity, resulting in higher leakages.

6.6.3.5 Aquatic weeds:

Aquatic weeds (water grass and algae growth) in irrigation canal systems are 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 Loskop IB. The figures are based on the averages over the seven water years (2004 to 2011). It is important to note that not all of the categories included in the table are shown on the WUEARs. Some of the values are estimations and are based on information obtained during discussions held with the management of the Board.

Table 6-3: Loskop IB - Breakdown of water losses

Description	Unavoidable losses (m^3*10^6)	Avoidable losses (m^3*10^6)	Total losses (m^3*10^6)	% of total losses
Seepages	17.049		17.049	54.66%
Evaporation	0.449		0.449	1.43%
Filling losses		12.383	12.383	39.70%
Leakages				
Spills				
Operational Losses				
Over delivery to users				
Canal end returns		1.311	1.311	4.20%
Other				
Total	**17.498**	**13.694**	**31.193**	**100%**
% of total losses	**56%**	**44%**	**100%**	
% of total volume released into system	**12%**	**9%**	**21%**	

From the data presented in Table 6-3 it is evident that the total losses on the scheme amount to 21%. Of the total losses occurring on the scheme, 12% can be classified as unavoidable losses while 9% or approximately 13.7 million cubic metres are avoidable losses. The bulk of the avoidable losses (12.4 million cubic metres) are made up of operational losses. It is interesting to note that the unavoidable losses are more than the avoidable losses. This can be attributed to the fact that almost 80 % of the branch canals in the whole scheme are piped, reducing operational losses. Start-up and shut-down losses have also been eliminated since the IB started operating the scheme over weekends during periods of high demand.

6.6.4 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the estimated avoidable water losses from 2004/5 to 2010/11 water years have been 85 million m^3. This quantity 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.
- *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.

Sufficient data was available to determine the avoidable losses since measurements of the flows at the canal end point of each ward, as presented in Table 6-4, were taken.

Table 6-4 Tail water per ward

Year	WARD							
	E2	**W2**	**W3+W5**	**W4**	**W6**	**W7**	**W8**	**W10**
2004/2005	19 348	79 650	119 854	366 432	228 048	190 199	392 888	269 323
2005/2006	17 124	103 584	129 636	352 536	107 752	188 596	366 515	207 984
2006/2007	28 656	189 995	172 618	344 814	115 183	185 237	247 254	171 640
2007/2008	40 419	153 292	171 767	234 500	123 449	183 377	186 628	151 286
2008/2009	42 221	162 020	217 180	182 400	121 593	164 915	185 294	143 497
2009/2010	20 784	195 936	212 592	152 112	104 871	173 136	150 988	130 082
2010/2011	18 760	183 472	158 029	121 608	117 070	147 485	120 518	112 746

7 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

7.1 Overview

The Loskop Irrigation Board 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 Detailed flow metering/measurement

The Loskop IB 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 sufficient to ensure that detailed water budgets can be conducted at scheme level as well as at sub-scheme level. Measurements of flows at the canal end point of each ward are taken daily making it possible to calculate the avoidable losses. The Board recently acquired an OTT ADC (Acoustic Digital Current Meter) to assist in the measurement and calculation of flow volumes and losses.

The problem currently is that no other telemetry system, except for the one at the dam release point, is installed and therefore manual reading of weekly and monthly records are being undertaken.

7.3 Efficient operation and maintenance of the canal infrastructure

Although the ownership of the canal infrastructure at the Loskop Irrigation Board is with the Department of Water Affairs there is an agreement that the IB is responsible for the operation and maintenance of the canal infrastructure.

The Loskop IB has an annual O&M budget which amounts to some R20 million per year. This is financed from the scheme charges which currently stands at R1 230 per ha/a.

Continuous maintenance and repair work to the structure and canals have to be done. For this purpose there is a maintenance division that is tasked with construction and maintenance. The following are inter alia undertaken by the division:

- Replacement of canal sections due to the changing ground formations,
- Relining of existing canals which no longer meet the set standards,
- Replacement of structures that no longer provide water accurately due to erosion and wear,
- Maintenance of flow banks that protect the canal system from flood water

During the scheduled dry weeks which occur more or less four times a year, canal sections are refurbished where necessary. Joints are sealed with Jaco Flex when required. The surface areas of the canal sections are cleaned with a high pressure water spray in order to clean the surface. The original and clean canal section is then sprayed with an epoxy mix.

This process lengthens the life span of the canal structure and improves the flow speed through the canal system (See Figure 7-1). In areas where canal sections are expected to fail soon, the sections are connected to one another with wire and/or to an iron pole planted at an angle about half a meter from the side of the canal. This method is a temporary solution until the next dry week when outstanding maintenance to the canal structure can be undertaken.

All refurbishment and maintenance is financed by the Irrigation Board who operates within the available budget as financed by the water users. No subsidy is received from DWA.

The irrigation water budget at the scheme level for the Loskop Irrigation Scheme indicated that the scheme "water losses", was averaging approximately 31.19 million m^3/a. These losses include tail water, avoidable losses such as leakage and unavoidable water losses which include evaporation losses due to the exposed canal surface area and seepage losses. This volume could have been significantly more hadn't it been for the Irrigation Board's maintenance division and planning.

Figure 7-1: Epoxy application

Figure 7-2: "Smooth and Patch" of canal section

Figure 7-3: Temporary measures to stabilise canal

7.4 Successful action against aquatic weeds

Algae have become a serious problem amongst irrigation schemes and Loskop Irrigation Scheme is no exception. Time and again the canal structure has flooded due to algae taking up additional volume and increasing the water level or influencing the flow. Fortunately the Loskop Irrigation Scheme has a number of radial gates along the canal structure which greatly assists in the dosage process (with copper sulphate) against the algae. The radial gates are opened slightly to allow a flow of 15 to 20 cusecs, in which the copper sulphate is then dosed from gate to gate. The Irrigation Board strives to keep the algae under control by dosing on a regular basis of once every two months. Sometimes the dosage is diluted and applied more often to prevent the algae from rising and causing the canals to overflow. The Loskop Irrigation Board has spent approximately a million rand on the dosage against algae since 2007.

Figure 7-4: Algae growth in the canal system and radial gate

7.5 Good balancing system

A large scheme balancing dam is situated in ward six on the left bank canal. This balancing dam covers an area of 18 hectares and has a maximum capacity of 499 000 m³ at a depth of 4 m. The dam (W6) provides irrigation water for wards 7 and 8 as well as the municipality (as an additional source and during periods of water shortage). Three scheme balancing dams, A, B and C are located on the right bank canal. The balancing dams decrease the pressure on the canal system and provide some water during the dry weeks.

Furthermore many farm dams exist within the scheme and some have capacities large enough to store water for two consecutive dry weeks and enhance water conservation. The

Irrigation Board has a programme whereby farmers can borrow money to seal or line these farm dams and repay the loan over five years. Almost sixty percent of the farm dams in the irrigation scheme are sealed. According to the Board a lot of water is saved through this method.

There are a number of farm dams at the canal end points especially the branch canals into which some of the return water flows. The board together with the farmers are planning to erect more of these dams mainly where sluices at the end points run dry. Measuring devices will be installed whereby the inflow into the dam can be subtracted from the quota.

Figure 7-5 Balancing dam on the right bank

7.6 Minimising losses

During periods of high demand the Irrigation Board operates the scheme over weekends as well. Although this resulted in additional costs in terms of labour, there has been a decrease in operational losses caused by the start-up and shut-down of the system (filling losses). The additional costs for operating the scheme over weekends adds up to R 2 480 per weekend. Furthermore almost 50 % of all the branch canals in the scheme have been piped, decreasing avoidable losses such as leakages and spills as well as unavoidable losses such as evaporation.

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 Loskop Irrigation Scheme's irrigation demands. It also highlighted that irrigators are currently utilising their full water allocation.

In addition to the water budget analysis, discussions were held with the management and other people who are knowledgeable about the Loskop Irrigation Scheme. This was done to determine the key issues the scheme is facing. Table 8-1below provides the key issues identified and these are discussed in more detail in the following sections of this chapter.

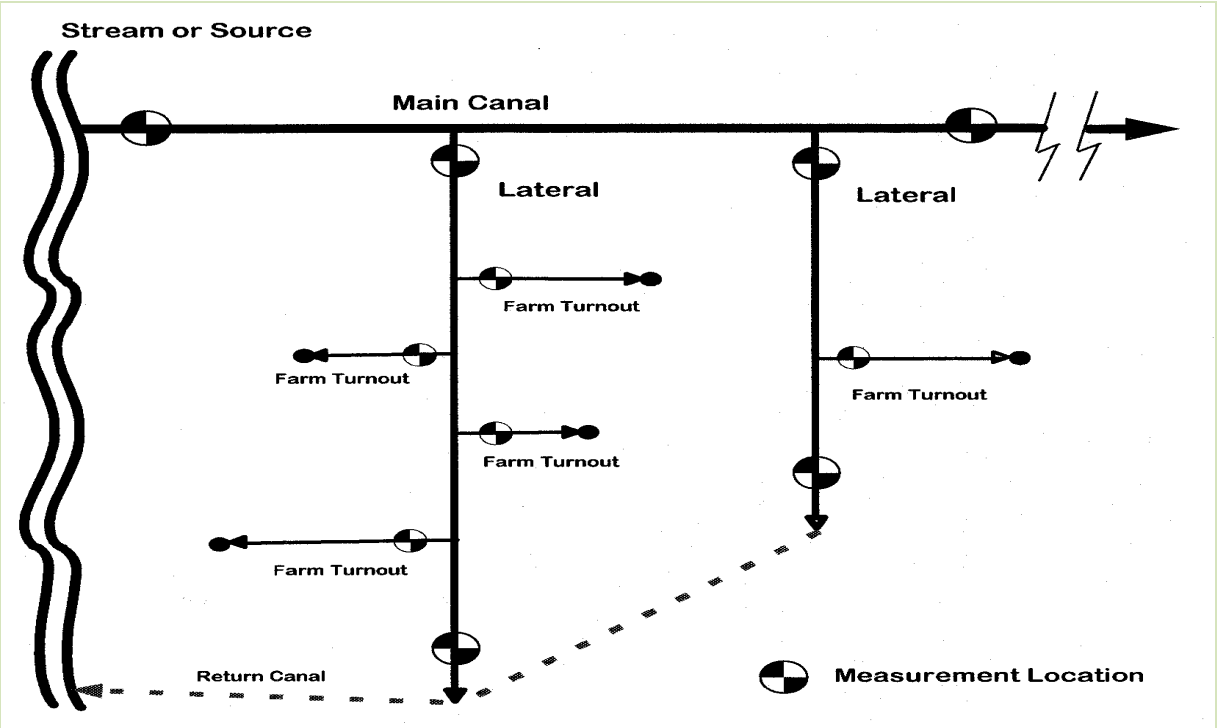
8.2 Flow measurements and water accounting

8.2.1 Adequacy of flow data

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. The figure 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 IB about the quantity, timing, and location of water use and therefore enables the IB to conduct a water budget not only at scheme level but also for sub-schemes within the irrigation scheme.

As illustrated in the figure below, it would be ideal to have electronic 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 3-1, the Loskop Irrigation Scheme has adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. The IB makes regular measurements of flows into all the measurement points. These include parshall flumes on the canals and flumes and rated sluice gates on the laterals to the individual farmers as well as v-notches at the canal end points.



Source: Bureau of Reclamation

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

8.2.2 Telemetry systems and compatibility with WAS

DWA has two telemetry systems at the outlet from the dam into each canal but it does not always correspond with the water that is requested by the scheme and therefore the board has their own telemetry system. The Loskop Irrigation Scheme has Android Telemetry Systems installed only at the Loskop Dam wall. There is a telemetry system at each bank where water is released into the two main canals. The readings, flows and levels are however manually captured on the WAS system.

Management Goal 1

The objective to address the above irrigation water management issue is to ensure that the following is achieved by the Loskop IB:

(i) Continuation of regular measurement of flows into all primary and branch canals, as well as measurement at the tail ends of the canal system

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

(iii) The flows and levels are intended to be sent by telemetry system to the Loskop IB offices for direct input into the WAS programme.

8.2.3 Irrigation water budget is not conducted in detail

It is currently difficult to disaggregate the losses. There is no differentiation in the water balance assessment between the losses. Although there is not much tail water, the remaining avoidable losses such as leakages have not been disaggregated. Although an extensive measurement system is in place, the data is not captured electronically in the WUEAR. 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 Loskop IB are included in determining water budgets and calculating water losses at scheme as well as ward/sub-scheme level. This will enable the IB to undertake comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified. Ponding testes could also be undertaken to verify the theoretical calculations of the seepage losses on the canal system.

8.3 Operational water management issues

8.3.1 The installed WAS is currently not being fully utilised

The Water Administration System (WAS) was developed by Dr. Nico Benade (with funding mainly from the WRC & DWA) as a tool to be used by Irrigation Boards/Schemes to optimize their irrigation water management and minimize management-related distribution losses in irrigation canal systems. WAS consists of seven modules integrated into a single program and these modules can be implemented partially or as a whole.

The seven modules are the:

(i) Administration module
(ii) Water order module
(iii) Water accounts module
(iv) Water release module
(v) Measured data module
(vi) Crop water use module, and
(vii) Report module

The Water Release module for example links with the water administration and order modules and can be used to:

- Minimize distribution losses on canal networks
- Calculate water releases for the main canal(s) and all their branches allowing for lag times and water losses such as seepage and evaporation; and
- Determine operational procedures for a dam with varying downstream inflows and outflows in a river allowing for lag times and water losses such as seepage, evaporation and transpiration.

However, at present the WAS Water Release and Report modules are not used in the Loskop Irrigation Scheme.

Management Goal 3

The management objective to address the above issue, is to investigate the implementation of the other modules of the WAS programme, particularly the water order and water release modules. This could be undertaken within 2 years from the completion of this Water Management Plan (WMP).

Furthermore, the measured data module should be linked to the telemetry system to enable direct reading of the measured data into the WAS programme. This can be used to undertake automatic reporting on water losses, not only at scheme level, but also at sub-scheme levels.

8.3.2 Available datasets not integrated into a Management Information System

The Loskop IB has gathered and generated their own detailed datasets, ranging from individual sluice detail to water user address information. 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.

Management Goal 4

The development of a spatially linked Management Information System that integrates all the relevant and available datasets.

8.4 Infrastructure related issues

In order to properly develop the Loskop IB water management plan, it is essential that an assessment of the overall condition of the facilities to identify potential issues be carried out. As indicated in Chapter 4, a condition assessment together with discussions with the Loskop IB was undertaken. That included the operation and maintenance system as well as the conveyance and distribution system. No assessment of the on-farm delivery systems was conducted.

8.4.1 Maintenance procedures

A detailed condition assessment of the existing canal infrastructure has not been undertaken but there are sections in the structure requiring attention. Seepage and canal losses may be taking place on these sections or at the joints between the different canal sections. The IB 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.

At present only four weeks per year are set aside for maintenance and refurbishment of the canal structures. The security of supply of water to the diverse irrigators does not allow for more dry weeks. The IB is aiming to build more farm dams in close cooperation with the

irrigators especially at the canal ends. This will enable storage of water over longer periods for irrigation purposes. There are also a few radial gates on the left bank which are used during the dosage process against algae. If managed well, these radial gates can be used, together with the balancing dams, for sectional restoration of the canal structure.

The present modus operandi when maintenance and repairs are undertaken should also be investigated and improved where possible.

Management Goal 5

Although the Loskop IB has a good balancing system in place to ensure security of water supply during dry periods, more balancing dams and use of radial gates may allow for more refurbishment periods additional to dry weeks. The IB can conduct a refurbishment programme whereby they make optimal use of the already installed radial gates and balancing dams. Revision of the current actions taken when canals are maintained and/or repaired should be investigated and improved where possible.

8.4.2 Ownership of irrigation infrastructure

The IB has two main elements that dictate operations – water and infrastructure . The ownership of irrigation infrastructure can prove to be one of the main barriers to improvement in irrigation efficiency if it is not well managed. More specifically, it is the management of the infrastructure, more than the ownership of the irrigation infrastructure that can create problems with the ensuring the quality of the infrastructure is maintained.

In the Loskop Irrigation Scheme, the DWA still owns the irrigation infrastructure including the main, primary and branch canals. However, the IB operates the irrigation infrastructure as an agent of the DWA and undertakes the normal maintenance of the irrigation infrastructure.

The problems will most likely arise, when the major infrastructure needs replacement/total refurbishment. It is unlikely that the IB has the financial capacity to undertake the refurbishment of the assets which are owned by government. It is also difficult to borrow against the assets as they are owned by government. Therefore the responsibility for replacement of major assets lies with government, whose priorities may be different to those of the IBs.

Management Goal 6

The broad objective to address this issue around ownership of the irrigation infrastructure is to ensure that the levels of responsibility between the DWA and the WUA are further refined than the existing agreement. This is assuming that the DWA does not want to transfer the infrastructure to the WUA in the short to medium term.

8.5 Institutional Water Management Issues

8.5.1 Updating and implementation of the Water Management Plan.

The Scheme Manager will be responsible for the annual updating and implementation of the Water Management Plan (WMP) for the scheme.

- The roles and responsibilities of the applicable 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 status of water losses, water saving targets, goals and objectives as well as the actions taken to reduce water losses
- 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 7

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.

8.5.2 Institution of a Water User Association

The available water for irrigation in the Loskop area has a declining tendency and the Loskop Irrigation Board is concerned since the supply of the whole system in normal years is already exceeded. The whole water resource cannot be managed if it is not measured accurately and paid for.

Management Goal 8

A Water User Association where all users of the river system will be represented in order to control and distribute the available water and act against users who are using water unlawfully.

8.6 Pollution

8.6.1 Water pollution upstream of the Loskop Dam

The Board is extremely concerned about the pollution upstream of Loskop Dam. Although the Department of Water Affairs has already employed countermeasures to minimise pollution, it is the Board's opinion that action against transgressors is not sufficiently enforced and strict enough.

Management Goal 9

Revise countermeasures and apply stricter rules and regulations regarding pollution. Take action against polluters.

8.7 Alien vegetation

8.7.1 Intruding vegetation downstream of Loskop Dam

Besides the indigenous vegetation taking over in the river system and resulting in losses, the Board is concerned about the alien trees that are intruding (especially in the river below Loskop Dam). The eradication of such plants is however outside the jurisdiction of the Board.

Management Goal 10

Ensure and foster a close working relationship between the Loskop Irrigation Board and the manager of the Working for Water program and provide information on areas of infestation.

8.8 Aquatic weeds

Algae are an ever growing concern and if not controlled can cause serious problems. The canal structure is under a lot of stress when the banks are flooded due to the effect the algae have on the water level. Algae can cause blockages in the system (from the main canal to the irrigation system) and contribute to operational losses. Algae growth is currently treated by copper sulphate dosage on a regular basis.

There is however an alternative product available for the treatment of algae. MAHNACIDE H Herbicide (a product of Baker Hughes Inc.) is a water soluble herbicide for the control of submerged aquatic weeds and algae in irrigation canals and irrigation reservoirs. The active ingredient, Acrolein, is a general cell toxicant which reacts with sulfhydryl groups in proteins. All typical submersed aquatic weed species and algae appear to be susceptible.

Management Goal 11

Investigate the possibility to use MAGNACIDE-H Herbicide against the control of aquatic weeds.

Table 8-1: Loskop Irrigation Scheme: Identified water management issues

Item No.	Issue description	Comments
1	The flow measurements taking place on the diversion points within the Loskop Irrigation Scheme are being manually read due to the absence of a telemetry system. Errors can easily be made this way.	Link the telemetry system at the Loskop dam with the WAS. Install more telemetry stations.
2	WAS is not fully utilised	Eliminate problems through professional advice & training. Generate WUEARs through WAS.
3	Irrigation water budget and balance assessment. Disaggregate losses.	Include rainfall and evaporation records in the water balance. Break down losses. Utilise WAS.
4	Sections 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 to make provision for water when there is no water in the canal.	More balancing dams and use of radial gates may allow for more refurbishment periods additional to dry weeks. Investigate and revise current maintenance procedures.
5	DWA still owns the irrigation infrastructure but the IB operates it as an agent of the DWA and undertakes the normal maintenance thereof. It is unlikely that the IB has the financial capacity to undertake the refurbishment of the assets which are owned by government. Therefore the responsibility for replacement of major assets lies with government.	Responsibility between the DWA and the Loskop IB should be further refined. Service level agreement.
6	The available water for in the Loskop area is declining. The Board is concerned since the	A Water User Association where all

Item No.	Issue description	Comments
	supply of the whole system in normal years is already exceeded.	users of the river system will be represented in order to control and distribute the available water.
7	Very concerned about the pollution upstream of Loskop Dam. Although the Department of Water Affairs has already employed countermeasures to minimise pollution, it is the Board's opinion that there is still not being acted strictly enough.	Revise countermeasures and apply stricter rules and regulations regarding pollution. Institution of a WUA.
8	Besides the indigenous vegetation intruding the river system and resulting losses, the Board is concerned about the alien trees, especially in the river below Loskop Dam. The eradication of such plants is however outside the jurisdiction of the Board.	Assistance in development of an eradication programme by WfW.
9	Algae growth is a common phenomenon and expensive to control.	Investigate the use of MAGNACIDE-H Herbicide or alternative methods to control aquatic weeds.
10	Updating and implementation of the Water Management Plan.	Implementation, monitoring, reviewing and updating of the 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 LOSKOP IRRIGATION BOARD WATER MANAGEMEN PLAN

A comprehensive Water Management Plan for the Loskop IB is included in **Annexure B** and this section will only address the pertinent matters included in the plan.

9.1 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 Loskop IB.

A Water Research Commission (WRC) study (Report TT465/10) 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 14.85 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 Loskop IB were determined to be 12.0% of the total releases into the canal system. This water is additional to the irrigation water use required at the farms 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 is 22.0% of the total releases into the canal system.

Table 9-1: Target water losses in the Loskop IB

Description	System inflow ($x 10^6 m^3$)	Present situation - Losses				Acceptable water losses		Water savings targets	
		Unavoidable losses ($x 10^6 m^3$)	Avoidable losses ($x 10^6 m^3$)	Total Losses ($x 10^6 m^3$)	% of total volume released	Annual volume ($x 10^6 m^3$)	% of total volume released	Annual volume ($x 10^6 m^3$)	% of total volume released
Seepages		*17.049*		*17.049*	11.48%	17.0	11.48%	0	0.00%
Evaporation		*0.449*		*0.449*	0.30%	0.449	0.30%	0	0.00%
Filling losses									
Leakages			*12.383*	*12.383*	8.08%				
Spills						14.85	10.00%	-1.156	-0.78%
Over delivery									
Canal end returns			*1.311*	*1.311*	0.88%				
Other			*0.000*	*0.000*	0.00%	0	0.00%	0	0.00%
Total	***148.5***	***17.498***	***13.694***	***31.192***	***20.75%***	***32.348***	***21.78%***	***-1.156***	***-0.78%***
% of total volume released into system		***11.78%***	***9.22%***	***20.75%***					

Based on the projected water saving targets, the Loskop IB is already within the acceptable range in term of losses. This however does not mean that further improvements are not possible. The short-term aim is therefore to maintain the losses within the acceptable range.

10 IMPLEMENTATION PLAN

The evaluation of the potential measures for implementation in the Loskop IB area of operation 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 priorities for implementation are as follows:

(i) Linking the existing telemetry system with WAS (water released into the two main canals).
(ii) Expand WUEAR to enable water budget analysis at both scheme and sub-scheme level.
(iii) Investigate full implementation the Release and Report Modules of WAS.
(iv) Review current maintenance procedures.
(v) Address pollution problems.
(vi) Formalise Service Level Agreement.
(vii) Develop and implement a comprehensive Management Information System.
(viii) Implement incentive based pricing.

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

Table 10-1: Loskop IB action plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	- Conduct seepage loss measurements in representative canal and pipeline segments though ponding tests where possible. Extrapolate results from tested segments to similar segments and revise water budget. - Undertake sub-scheme water budgets - Prioritise areas of significant water losses	Apr '13 – Feb '14 Apr '13 – Feb '15 Apr '13 – Feb '15	Loskop IB
2	Further reduce leakage losses in irrigation canal infrastructure	- Formalise Service Level Agreement	Apr '13 – Feb '15	Loskop IB/DWA
3	Increase operational efficiency	- Link telemetry system with WAS - Implement release module of WAS - Generate WUEARs through WAS - Incorporate data in a custom Water Management System	Apr '13 – Feb '15 Apr '13 – Feb '15 Apr '13 – Feb '15 Apr '13 – Feb '15	Loskop IB
4	Address pollution	- Engage with relevant stakeholders to resolve crisis. Investigate and implement methods to resolve problem. Escalate matter if	Apr '13 – Feb '18	Loskop IB/DWA

Priority	Goal	Action Plan	Timeline	Responsible Authority
		necessary.		
5	In 5 years, implement incentive pricing structure for the IB if viable	- Review current irrigation water pricing strategy - Engage with irrigators on incentive pricing structure - Update water pricing strategy - Implement water billing based on incentive pricing rate	Apr '13 – Feb '18	DWA/ HBPIB

11 CONCLUSIONS AND RECOMMENDATIONS

The Loskop Irrigation Board has an allocation of some 124 million cubic metres of water per annum from the Loskop Dam but this allocation excludes losses. The Board only paid for 124 million m^3 although it received much more than that and it is here where the main challenge lies. Although it can be expected that the DWA will allow for a certain percentage losses, this percentage is presently unknown and if the Board is charged for system losses it will substantially reduce their income.

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 IB each year.

The Goals for the WMP have been set and the IB believes that the targets and objectives set in the WMP are achievable through proper oversight by the CEO 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 Loskop IB is already within the acceptable target (21.8%) with present losses in the order of 20.8%.

This however does not mean that the Scheme is operated as efficiently as possible but the incremental costs associated with reducing the losses substantially, is prohibitively expensive.

The Loskop IB has identified various measures to improve the efficiency and effectiveness and a revision of the plan within a year will show whether these measures had a marked effect on losses.

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ANNEXURE A

MAPS

ANNEXURE B

WATER MANAGEMENT PLAN OF THE LOSKOP IRRIGATION BOARD

SUMMARISED WATER MANAGEMENT PLAN FOR THE LOSKOP IRRIGATION BOARD APRIL 2013 TO MARCH 2014

March 2013

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1 BACKGROUND

The first farms in the Olifants River Valley were demarcated in 1886 and the farmers cultivated wheat under dry-land conditions. Around 1925, after the successes of the small irrigation schemes, the Hereford Irrigation Board was founded to supply irrigation water to an area of about 2 140ha which was situated a few kilometres downstream of the present Loskop Dam. The early success of this scheme gave rise to a petition which resulted in studies of the Hereford Scheme, as well as in a soil survey and a topographical survey of the dam basin. This paved the way for the commencement of the construction of the Loskop dam in 1934 as well as the establishment of the Loskop Irrigation Scheme.

The dam was completed in 1938 and the wall was raised in 1979. The capacity of the raised dam is 362 million m^3. The dam has been built to accommodate a design flood of 2 886 m^3/s (1:200 year flood). The dam was initially built to provide for the irrigation needs of farmers in the Olifants, Moses and Elands River valleys. Development in the Witbank-Middelburg area necessitated the raising of the dam wall so that the portion of the assured yield which had in the meantime become affected as a result of the construction of upstream dams such as the Rondebosch, Witbank and Doornpoort Dams on the Highveld, could be restored. Furthermore, water from the dam supplies Loskop Irrigation Board, the Hereford Irrigation Board, the Olifants River Irrigation Board as well as the Groblersdal and Marble Hall Municipalities.

The scheme was transferred to the Loskop Irrigation Board on 1 April 1992 with 4 Board Members appointed by the Minister of Water Affairs and 4 elected members from irrigators on the Scheme. Currently all Board Members are elected by the irrigators.

The instruction to the Board was to distribute water and to maintain the irrigation canals, excluding the dam, and these activities have to be financed with the revenue received by the Board.

The Irrigation Board has a total scheduled area of 16 135 hectares, at a scheduled quota of 7 700 m^3/ha/a which translates to a total allocation of 124.2 million m^3/a. There are approximately 656 properties within the scheme and the majority have an average size of 25,7ha. A further 45 consumers are also supplied to by the Board which include all industrial consumers (27) and also private users (18).

The Scheme consists of a network of concrete lined canals and 7 balancing dams. The total length of the canal system is ±495 km and consists of 2 main canals, a left bank canal of 96km and right bank canal of 60 km. The rest of the network is made up of branch canals. A network of cemented and earthen drains is distributed throughout the Scheme.

The typical crop mix found within the area of operation of the Loskop IB Scheme is presented in Table 1-1**.**

Table 1-1: Irrigated crops in Loskop Irrigation Scheme

Crops	Hectares	%		Crops	Hectares	%
Wheat (winter)	9 000	24.2		Groundnuts	3 000	8.1
Cotton	6 000	16.1		Soy bean	3 000	8.1
Tobacco	5 000	13.4		Peas	2 000	5.4
Maize	5 000	13.4		Table Grapes	250	
Citrus	4 000	10.7				

The latest crop survey undertaken by the Irrigation Board was in June 2011 and the results (grouped per ward) are presented in Table 1-2**.**

Table 1-2: Crop mix for June 2011

Crop	Ward								Crop total (ha)	% of total crop area
	E2	W2	W3 & 5	W4	W7	W8	W6	W10		
Oranges	386	469	64.9	425	656.02	1072	590	1335.7	**4 998**	22.66%
Vegetables	0	40	65	37	337	88	0	0	**567**	2.57%
Peas	163	0	255	241	31	14	0	0	**704**	3.19%
Wheat	834	1644	812	545	833.5	1033	2105	2725	**10 531**	47.75%
Maize	0	1297	0	368	431	21	0	0	**2 117**	9.60%
Green feed	0	0	81	55	23	73	0	0	**232**	1.05%
Beans	0	0	0	0	270.5	393	0	0	**663**	3.01%
Cotton	0	0	0	0	412	220	0	0	**632**	2.87%
Potatoes	15	0	482	20	80	133	0	0	**730**	3.31%
Sweet potatoes	0	0	0	0	0	65	0	0	**65**	0.29%
Grapes	120	0	69	69	131	0	0	219	**608**	2.76%
Figs	0	0	8	0	0	0	0	0	**8**	0.04%
Lemons	18.8	0	20	0	0	0	0	0	**38**	0.18%
Macadamia	3	0	0	3	0	0	0	0	**6**	0.03%
Pecan	0	0	0	0.5	0	0	0	0	**0.5**	0.00%
Tobacco	0	0	0	63	91	0	0	0	**154**	0.70%
Ward Total	**1 539.8**	**3 450.0**	**1 856.9**	**1 826.5**	**3 296.0**	**3 112.0**	**2 695.0**	**4 279.7**	**22 056**	
Percentages	7.0%	15.6%	8.4%	8.3%	14.9%	14.1%	12.2%	19.4%		

A graphical representation of the crops under irrigation during the 2011 survey is shown in and the total irrigated crop area within each ward is shown in Figure 2-4.

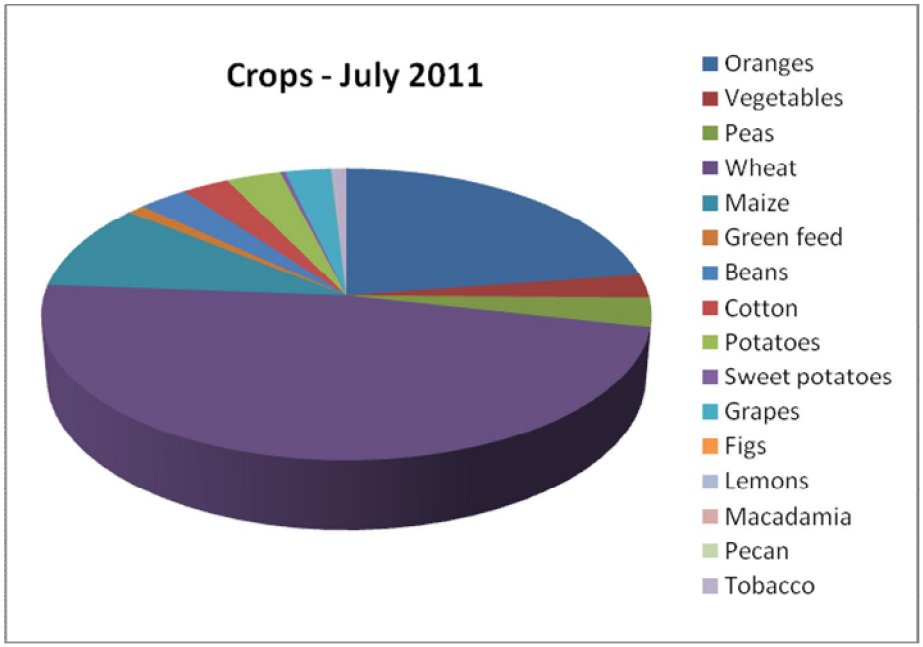


Figure 1-1: Crops under irrigation during 2011

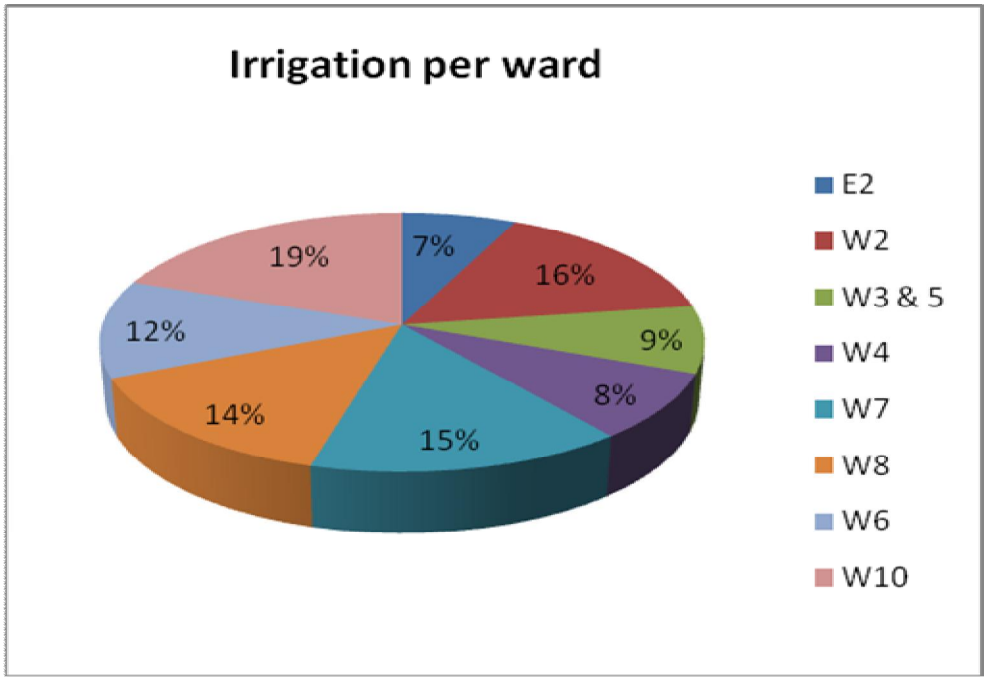


Figure 1-2: Irrigated crop area per ward during 2011

The most recent seven water years (2004/5 to 2010/11) demonstrate a range of water use in the Loskop Irrigation Scheme. Irrigation agriculture on the left bank has ranged from 79.45 million m^3/a in 2004/05 up to 108.34 million m^3/a in 2006/07 with a seven-year average of 91.41 million m^3/a.

Irrigation agriculture on the right bank has ranged from 9.7 million m^3/a in 2010/11 to 13.97 million m^3/a in 2006/07 with a seven-year average of 10.9 million m^3/a. Industry on the left bank was at its least in 2007/08 at 1.64 m^3/a and peaked in 2009/10 at 18.38 million m^3/a.

Industry on the right bank was at its least in 2004/05 at 0.08 million m^3/a and also peaked in 2009/10 at 1.43 million m^3/a. Domestic water use however remained more or less constant with averages of 0.27 million m^3/a and 0.08 million m^3/a for the left and right banks respectively. No domestic uses were recorded from 2007 to 2011. Water provided to other institutions such as the Hereford Irrigation Scheme and the community of Aquaville has also been included in these figures.

Table 1-3: Historic water use levels (million m^3/a) for Loskop Irrigation Board

Canal section	Water use sector	Water year							Average
		2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011	
Left	Irrigation	79.45	86.59	108.34	92.73	94.25	92.11	86.42	91.41
	Industry	7.20	3.90	1.76	1.64	3.22	18.38	11.50	6.80
	Domestic	0.66	0.60	0.65	0.00	0.00	0.00	0.00	0.27
Total: Left bank		**87.32**	**91.09**	**110.75**	**94.37**	**97.47**	**110.49**	**97.93**	**98.49**
Right	Irrigation	9.76	9.75	13.97	9.86	11.47	11.77	9.70	10.90
	Industry	0.08	0.10	0.14	0.15	0.42	1.43	1.10	0.49
	Domestic	0.19	0.17	0.19	0.00	0.00	0.00	0.00	0.08
Total: Right bank		**10.04**	**10.02**	**14.30**	**10.01**	**11.88**	**13.20**	**10.80**	**11.46**
Left & Right	Irrigation	89.21	96.35	122.31	102.59	105.72	103.88	96.12	102.31
	Industry	7.28	4.00	1.90	1.79	3.63	19.81	12.60	7.29
	Domestic	0.86	0.77	0.84	0.00	0.00	0.00	0.00	0.35
Grand Total		**97.35**	**101.12**	**125.05**	**104.38**	**109.35**	**123.69**	**108.72**	**109.95**

It was calculated in the water budget that the average total water diverted (released) into the Loskop Irrigation Scheme during the same seven year period was 148.2 million m^3/a, with the range being 129.86 million m^3/a in 2005/06 up to 160.59 million m^3/a in 2006/07.

2 LEGAL PROVISION FOR DEVELOPING AND IMPLEMENTING THE LOSKOP IB WATER MANAGEMENT PLAN

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:

(i) Prevent water from any water resource being wasted;
(ii) Exercise general supervision over water resources
(iii) Regulate the flow of water course
(iv) Investigate and record quantities of water.
(v) *Supervise and regulate the distribution and use of water from a water resource.*

The Business Plan for the Loskop IB 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 Loskop IB has developed a WMP in terms of the provisions of the NWA to enable it to manage the irrigation water in the scheme effectively and efficiently.

3 LOSKOP IRRIGATION SCHEME WATER BALANCE

3.1 Introduction

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

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

3.2 Overall scheme water balance

Using the information obtained from the WUEARs, previous studies and consultation with the management of the Irrigation Board (IB), the water budget for the Loskop IB was prepared and is provided in Table 3-1.

The water balance is based on information from the Water Administration System (WAS) which each ward manager runs in his/her own water ward. Water orders are captured by each ward manager in the WAS program. 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 Loskop Irrigation Scheme were provided on a weekly 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. The volume of water that is requested by the irrigators in the Loskop IB area varies from year to year, as does the cropping pattern for each year. For the past seven water years the irrigation water applied for has ranged from 89 million m^3/a in 2004/05 to 122 million m^3/a in 2006/07. Over the past four years, irrigators have been requesting on average 95% of the total scheduled quota of 124 million m^3/a.

An analysis of the percentage of inflow to the water allocation indicates that since 2004/05 water year, on average 15% more water has been released from the Loskop Dam than the water allocation of 124 million m^3/a. It should be kept in mind though that the released water has been diverted to other users outside the scheme and includes provision for operational spills.

Table 3-1: Water budget

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
May-04	4,723,096	542,346	5,265,442	264,919	162,182	3,243,308	421,111	3,664,419	70,564	576	71,140	1,409,224	120,659	1,427,146	**27.64%**	1,479,788	31.33%	121,235	22.35%	1498286
June-04	8,107,995	729,488	8,837,483	58,090	100,442	6,087,840	621,851	6,709,691	134,150	772	134,922	1,886,005	106,865	2,035,222	**22.92%**	2,020,155	24.92%	107,637	14.76%	2,170,144
July-04	8,158,323	944,094	9,102,417	263,287	81,448	5,892,112	847,398	6,739,510	130,710	1,344	132,054	2,135,501	95,352	2,049,014	**22.97%**	2,266,211	27.78%	96,696	10.24%	2,181,068
Aug-04	11,133,890	1,349,512	12,483,402	56,276	462,642	8,332,038	1,188,877	9,520,915	170,748	960	171,708	2,631,104	159,675	3,197,145	**24.80%**	2,801,852	25.17%	160,635	11.90%	3,368,853
Sep-04	20,730,144	1,942,701	22,672,845	262,652	106,708	16,138,578	1,660,091	17,798,669	236,472	1,896	238,368	4,355,094	280,714	4,479,864	**19.90%**	4,591,566	22.15%	282,610	14.55%	4,718,232
Oct-04	13,164,325	1,060,242	14,224,567	223,215	56,575	10,264,505	921,642	11,186,147	162,647	1,152	163,799	2,737,173	137,448	2,707,981	**19.26%**	2,899,820	22.03%	138,600	13.07%	2,871,780
Nov-04	12,167,373	1,030,217	13,197,590	97,557	60,600	9,267,317	891,546	10,158,863	126,240	1,968	128,208	2,773,816	136,703	2,873,562	**21.83%**	2,900,056	23.83%	138,671	13.46%	3,001,770
Dec-04	6,461,602	551,809	7,013,411	44,461	103,163	4,722,878	472,225	5,195,103	102,828	1,536	104,364	1,635,896	78,048	1,772,646	**25.07%**	1,738,724	26.91%	79,584	14.42%	1,877,010
Jan-05	10,253,005	1,271,371	11,524,376	52,127	102,225	7,708,124	983,103	8,691,227	140,856	3,240	144,096	2,404,025	285,028	2,739,151	**23.67%**	2,544,881	24.82%	288,268	22.67%	2,883,247
Feb-05	11,552,005	1,368,401	12,920,406	148,427	99,300	8,524,664	1,033,299	9,557,963	153,228	2,328	155,556	2,874,113	332,774	3,157,760	**24.53%**	3,027,341	26.21%	335,102	24.49%	3,313,316
March-05	9,722,581	1,045,324	10,767,905	184,787	103,871	7,698,667	895,155	8,593,822	139,588	2,664	142,252	1,884,326	147,505	1,950,915	**18.26%**	2,023,914	20.82%	150,169	14.37%	2,093,167
Apr-05	4,978,907	718,779	5,697,686	145,404	40,995	3,872,133	627,841	4,499,974	78,363	912	79,275	1,028,411	90,026	1,014,028	**18.13%**	1,106,774	22.23%	90,938	12.65%	1,093,303
2004/2005	**121,153,246**	**12,554,284**	**133,707,530**	**1,801,202**	**1,480,151**	**91,752,164**	**10,564,139**	**102,316,303**	**1,646,394**	**19,348**	**1,665,742**	**27,754,688**	**1,970,797**	**29,404,434**	**22.04%**	**121,153,246**	**12,554,284**	**133,707,530**	**1,801,202**	**1,480,151**
May-05	6,252,119	749,082	7,001,201	11,151	100,304	4,738,016	618,385	5,356,401	119,328	552	119,880	1,394,775	130,145	1,614,073	**22.76%**	1,514,103	24.22%	130,697	17.45%	1,733,953
June-05	11,837,219	1,201,948	13,039,167	50,400	100,347	9,338,521	1,001,139	10,339,660	162,291	1,992	164,283	2,336,407	198,817	2,585,171	**19.75%**	2,498,698	21.11%	200,809	16.71%	2,749,454
July-05	11,052,418	1,023,024	12,075,442	55,089	173,667	8,911,381	886,976	9,798,357	130,954	1,392	132,346	2,010,083	134,656	2,263,317	**18.56%**	2,141,037	19.37%	136,048	13.30%	2,395,663
Aug-05	17,971,074	1,815,292	19,786,366	72,885	155,091	14,073,624	1,515,026	15,588,650	202,618	1,872	204,490	3,694,832	298,394	4,075,432	**20.51%**	3,897,450	21.69%	300,266	16.54%	4,279,922
Sep-05	17,904,087	1,671,749	19,575,836	254,490	28,830	13,956,071	1,464,447	15,420,518	185,624	1,728	187,352	3,762,392	205,574	3,742,306	**19.34%**	3,948,016	22.05%	207,302	12.40%	3,929,658
Oct-05	13,139,072	1,271,883	14,410,955	39,449	64,363	10,201,653	1,061,293	11,262,946	154,848	1,800	156,648	2,782,571	208,790	3,016,275	**20.89%**	2,937,419	22.36%	210,590	16.56%	3,172,923
Nov-05	10,619,347	866,225	11,485,572	297,134	198,690	7,689,044	816,057	8,505,101	122,160	2,040	124,200	2,808,143	48,128	2,757,827	**24.22%**	2,930,303	27.59%	50,168	5.79%	2,882,027
Dec-05	10,067,538	899,080	10,966,618	102,410	144,605	7,436,663	740,341	8,177,004	123,264	1,416	124,680	2,507,611	157,323	2,707,129	**24.59%**	2,630,875	26.13%	158,739	17.66%	2,831,809
Jan-06	5,443,314	630,011	6,073,325	279,514	126,046	3,750,656	501,767	4,252,423	69,300	1,208	70,508	1,623,358	127,036	1,596,926	**26.98%**	1,692,658	31.10%	128,244	20.36%	1,667,434
Feb-06	4,439,318	611,207	5,050,525	62,034	467,185	3,482,812	477,290	3,960,102	55,392	1,230	56,622	901,114	132,687	1,438,952	**26.38%**	956,506	21.55%	133,917	21.91%	1,495,574
March	3,650,309	574,843	4,225,152	79,346	133,913	2,947,628	418,885	3,366,513	62,184	1,008	63,192	640,497	154,950	850,014	**19.86%**	702,681	19.25%	155,958	27.13%	913,206
Apr-06	5,534,296	630,584	6,164,880	18,795	101,751	4,567,006	520,650	5,087,656	68,640	886	69,526	898,650	109,048	1,090,654	**17.46%**	967,290	17.48%	109,934	17.43%	1,160,180
2005/2006	**117,910,111**	**11,944,928**	**129,855,039**	**1,322,697**	**1,794,792**	**91,093,075**	**10,022,256**	**101,115,331**	**1,456,603**	**17,124**	**1,473,727**	**25,360,433**	**1,905,548**	**27,738,076**	**21.28%**	**117,910,111**	**11,944,928**	**129,855,039**	**1,322,697**	**1,794,792**
May-06	6,134,005	866,335	7,000,340	77,932	82,463	4,603,988	604,419	5,208,407	26,684	2,170	28,854	1,503,333	259,746	1,767,610	**25.23%**	1,530,017	24.94%	261,916	30.23%	1,796,464
June-06	8,092,636	1,409,360	9,501,996	146,441	111,180	6,352,611	1,007,168	7,359,779	26,298	2,272	28,570	1,713,727	399,920	2,078,386	**21.95%**	1,740,025	21.50%	402,192	28.54%	2,106,956
July-06	8,282,107	1,002,265	9,284,372	157,507	86,235	7,308,276	838,559	8,146,835	109,946	1,392	111,338	863,885	162,314	954,927	**10.36%**	973,831	11.76%	163,706	16.33%	1,066,265
Aug-06	13,841,859	1,609,077	15,450,936	91,971	299,277	11,180,059	1,341,017	12,521,076	166,227	2,376	168,603	2,495,573	265,684	2,968,563	**18.96%**	2,661,800	19.23%	268,060	16.66%	3,137,166

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
Sep-06	16,963,689	2,042,288	19,005,977	182,374	278,346	13,457,684	1,722,986	15,180,670	172,894	5,064	177,958	3,333,111	314,238	3,743,321	**19.60%**	3,506,005	20.67%	319,302	15.63%	3,921,279
Oct-06	18,055,296	2,240,695	20,295,991	108,133	195,900	14,161,074	1,874,904	16,035,978	180,672	4,728	185,400	3,713,550	361,063	4,162,380	**20.42%**	3,894,222	21.57%	365,791	16.32%	4,347,780
Nov-06	6,482,197	699,075	7,181,272	242,966	657,273	5,192,486	641,567	5,834,053	87,360	792	88,152	1,202,351	56,716	1,673,374	**22.03%**	1,289,711	19.90%	57,508	8.23%	1,761,526
Dec-06	11,868,577	1,278,986	13,147,563	286,232	48,290	9,675,380	1,122,216	10,797,596	151,800	2,976	154,776	2,041,397	153,794	1,957,249	**15.16%**	2,193,197	18.48%	156,770	12.26%	2,112,025
Jan-06	14,879,033	1,364,238	16,243,271	277,159	71,157	11,272,267	1,271,027	12,543,294	152,808	2,304	155,112	3,453,958	90,907	3,338,863	**20.82%**	3,606,766	24.24%	93,211	6.83%	3,493,975
Feb-07	15,779,986	1,814,024	17,594,010	262,048	273,230	11,640,764	1,501,229	13,141,993	144,044	1,630	145,674	3,995,178	311,165	4,317,525	**24.52%**	4,139,222	26.23%	312,795	17.24%	4,463,199
March-06	14,658,890	1,361,120	16,020,010	71,801	198,567	10,729,700	1,121,971	11,851,671	140,232	1,608	141,840	3,788,958	237,541	4,153,265	**25.72%**	3,929,190	26.80%	239,149	17.57%	4,295,105
Apr-06	8,510,840	1,357,458	9,868,298	152,448	67,928	5,176,893	1,249,031	6,425,924	67,776	1,344	69,120	3,266,171	107,083	3,288,734	**33.61%**	3,333,947	39.17%	108,427	7.99%	3,357,854
2006/2007	**143,549,115**	**17,044,921**	**160,594,036**	**2,057,012**	**2,369,846**	**110,751,182**	**14,296,094**	**125,047,276**	**1,426,741**	**28,656**	**1,455,397**	**31,371,192**	**2,720,171**	**34,404,197**	**21.38%**	**143,549,115**	**17,044,921**	**160,594,036**	**2,057,012**	**2,369,846**
May-07	10,391,065	1,233,649	11,624,714	183,432	305,891	8,104,284	994,189	9,098,473	118,116	1,368	119,484	2,168,665	238,092	2,529,216	**21.53%**	2,286,781	22.01%	239,460	19.41%	2,648,700
June-07	9,229,044	742,559	9,971,603	63,185	377,320	7,043,878	579,585	7,623,463	99,434	2,670	102,104	2,085,732	160,304	2,560,171	**24.89%**	2,185,166	23.68%	162,974	21.95%	2,662,275
July-07	10,009,990	1,192,706	11,202,696	268,016	162,805	7,542,686	992,597	8,535,283	90,603	3,048	93,651	2,376,701	197,061	2,468,551	**22.24%**	2,467,304	24.65%	200,109	16.78%	2,562,202
Aug-07	14,858,508	1,301,459	16,159,967	212,291	422,650	11,149,879	1,156,885	12,306,764	121,806	3,442	125,248	3,586,823	141,132	3,938,314	**24.06%**	3,708,629	24.96%	144,574	11.11%	4,063,562
Sep-07	18,190,307	1,916,952	20,107,259	44,449	138,323	14,166,733	1,576,378	15,743,111	168,672	3,524	172,196	3,854,902	337,050	4,285,826	**21.22%**	4,023,574	22.12%	340,574	17.77%	4,458,022
Oct-07	9,251,051	823,603	10,074,654	80,399	795,968	6,925,315	817,179	7,742,494	91,718	3,924	95,642	2,234,018	2,500	2,952,087	**27.36%**	2,325,736	25.14%	6,424	0.78%	3,047,729
Nov-07	7,810,433	879,021	8,689,454	136,872	182,268	6,051,815	778,315	6,830,130	92,546	3,240	95,786	1,666,072	97,466	1,808,934	**20.71%**	1,758,618	22.52%	100,706	11.46%	1,904,720
Dec-07	7,978,773	852,694	8,831,467	179,011	135,460	6,472,934	692,917	7,165,851	93,088	3,390	96,478	1,412,751	156,387	1,525,587	**17.36%**	1,505,839	18.87%	159,777	18.74%	1,622,065
Jan-08	7,137,525	757,282	7,894,807	215,722	245,054	5,100,964	589,675	5,690,639	76,984	3,717	80,701	1,959,577	163,890	2,152,799	**27.17%**	2,036,561	28.53%	167,607	22.13%	2,233,500
Feb-08	11,423,447	864,706	12,288,153	201,798	180,536	8,296,205	835,721	9,131,926	99,866	3,264	103,130	3,027,376	25,721	3,031,835	**24.72%**	3,127,242	27.38%	28,985	3.35%	3,134,965
March-08	8,547,161	674,791	9,221,952	42,918	39,168	6,552,420	570,197	7,122,617	72,793	1,920	74,713	1,921,948	102,674	2,020,872	**21.92%**	1,994,741	23.34%	104,594	15.50%	2,095,585
Apr-08	9,242,566	766,693	10,009,259	0	232,416	6,965,092	627,070	7,592,162	78,673	6,912	85,585	2,198,801	132,711	2,563,928	**25.03%**	2,277,474	24.64%	139,623	18.21%	2,649,513
2007/2008	**124,069,870**	**12,006,115**	**136,075,985**	**1,628,093**	**3,217,859**	**94,372,205**	**10,210,708**	**104,582,913**	**1,204,299**	**40,419**	**1,244,718**	**28,493,366**	**1,754,988**	**31,838,120**	**23.13%**	**124,069,870**	**12,006,115**	**136,075,985**	**1,628,093**	**3,217,859**
May-08	6,543,171	621,912	7,165,083	116,671	45,558	5,135,221	552,363	5,687,584	66,748	1,464	68,212	1,341,202	68,085	1,338,174	**18.86%**	1,407,950	21.52%	69,549	11.18%	1,406,386
June-08	9,888,494	839,123	10,727,617	127,407	94,940	7,611,616	701,973	8,313,589	87,170	1,480	88,650	2,189,708	135,670	2,292,911	**21.44%**	2,276,878	23.03%	137,150	16.34%	2,381,561
July-08	11,540,712	1,341,243	12,881,955	376,471	354,750	8,915,176	1,150,579	10,065,755	96,391	1,560	97,951	2,529,145	189,104	2,696,528	**20.97%**	2,625,536	22.75%	190,664	14.22%	2,794,479
Aug-08	16,979,738	1,666,400	18,646,138	171,710	158,792	13,283,224	1,429,269	14,712,493	165,828	1,440	167,268	3,530,686	235,691	3,753,459	**20.14%**	3,696,514	21.77%	237,131	14.23%	3,920,727
Sep-08	24,124,434	2,875,390	26,999,824	331,381	379,686	18,938,792	2,529,957	21,468,749	201,353	5,944	207,297	4,984,289	339,489	5,372,083	**19.86%**	5,185,642	21.50%	345,433	12.01%	5,579,380
Oct-08	12,503,444	1,524,596	14,028,040	83,395	130,207	9,883,048	1,251,765	11,134,813	115,854	6,660	122,514	2,504,542	266,171	2,817,525	**20.02%**	2,620,396	20.96%	272,831	17.90%	2,940,039
Nov-08	4,158,991	414,490	4,573,481	161,085	9,873	3,000,832	331,927	3,332,759	52,584	3,978	56,562	1,105,575	78,585	1,032,948	**23.36%**	1,158,159	27.85%	82,563	19.92%	1,089,510
Dec-08	12,101,388	1,026,550	13,127,938	79,019	162,266	8,424,344	794,090	9,218,434	115,195	6,273	121,468	3,561,849	226,187	3,871,283	**29.30%**	3,677,044	30.39%	232,460	22.64%	3,992,751
Jan-09	6,790,562	706,224	7,496,786	84,786	73,955	4,986,136	494,891	5,481,027	68,472	4,452	72,924	1,735,954	206,881	1,932,004	**25.81%**	1,804,426	26.57%	211,333	29.92%	2,004,928
Feb-09	5,765,641	965,591	6,731,232	45,733	103,402	4,500,152	820,981	5,321,133	63,856	4,440	68,296	1,201,633	140,170	1,399,472	**20.61%**	1,265,489	21.95%	144,610	14.98%	1,467,768

Year	Releases from dam			Balancing dams		Demand			Canal end points			Losses (excluding canal end points)				Monthly Gross Losses				
	L/B	R/B	Total	Gain	Loss	L/B	R/B	Total	L/B	R/B	Total	L/B	R/B	Total	%	L/B	% of supply	R/B	% of supply	Total
March-09	7,945,300	721,206	8,666,506	152,379	191,813	6,045,544	686,356	6,731,900	81,120	0	81,120	1,818,636	34,850	1,892,920	**21.74%**	1,899,756	23.91%	34,850	4.83%	1,974,040
Apr-09	8,505,152	1,182,119	9,687,271	261,292	147,500	6,742,992	1,140,381	7,883,373	62,328	4,530	66,858	1,699,832	37,208	1,623,248	**16.96%**	1,762,160	20.72%	41,738	3.53%	1,690,106
2008/2009	**126,847,027**	**13,884,844**	**140,731,871**	**1,991,329**	**1,852,742**	**97,467,077**	**11,884,532**	**109,351,609**	**1,176,899**	**42,221**	**1,219,120**	**28,203,051**	**1,958,091**	**30,022,555**	**21.35%**	**126,847,027**	**13,884,844**	**140,731,871**	**1,991,329**	**1,852,742**
May-09	8,038,486	790,266	8,828,752	171,140	127,149	6,334,384	674,936	7,009,320	73,107	1,560	74,667	1,630,995	113,770	1,700,774	**19.36%**	1,704,102	21.20%	115,330	14.59%	1,775,441
June-09	7,779,343	797,152	8,576,495	100,988	110,659	6,094,344	724,843	6,819,187	70,564	1,080	71,644	1,614,435	71,229	1,695,335	**19.74%**	1,684,999	21.66%	72,309	9.07%	1,766,979
July-09	11,513,918	1,365,482	12,879,400	108,748	163,192	8,984,808	1,235,545	10,220,353	100,054	2,616	102,670	2,429,056	127,321	2,610,821	**20.19%**	2,529,110	21.97%	129,937	9.52%	2,713,491
Aug-09	15,529,636	1,438,221	16,967,857	291,825	183,544	12,383,272	1,423,681	13,806,953	123,600	2,952	126,552	3,022,764	11,588	2,926,071	**17.36%**	3,146,364	20.26%	14,540	1.01%	3,052,623
Sep-09	23,282,288	2,511,338	25,793,626	42,016	128,250	18,701,412	2,224,731	20,926,143	188,136	4,488	192,624	4,392,740	282,119	4,761,093	**18.40%**	4,580,876	19.68%	286,607	11.41%	4,953,717
Oct-09	12,031,447	1,556,781	13,588,228	68,228	106,893	9,318,361	1,293,697	10,612,058	98,064	1,824	99,888	2,615,022	261,260	2,914,947	**21.39%**	2,713,086	22.55%	263,084	16.90%	3,014,835
Nov-09	5,609,557	768,804	6,378,361	138,747	81,346	4,520,747	716,082	5,236,829	56,572	1,200	57,772	1,032,238	51,522	1,026,359	**16.24%**	1,088,810	19.41%	52,722	6.86%	1,084,131
Dec-09	9,712,209	1,869,816	11,582,025	326,237	5,315	8,197,166	1,212,311	9,409,477	78,974	1,584	80,558	1,436,069	655,921	1,771,068	**15.73%**	1,515,043	15.60%	657,505	35.16%	1,851,626
Jan-10	10,430,357	1,078,552	11,508,909	187,125	123,165	8,438,046	861,625	9,299,671	80,280	1,440	81,720	1,912,031	215,487	2,063,558	**18.03%**	1,992,311	19.10%	216,927	20.11%	2,145,278
Feb-10	15,044,524	1,091,279	16,135,803	0	79,243	11,801,356	995,697	12,797,053	98,170	960	99,130	3,144,998	94,622	3,318,863	**20.47%**	3,243,168	21.56%	95,582	8.76%	3,417,993
March-10	20,207,597	1,683,795	21,891,392	168,385	248,386	15,553,332	1,417,923	16,971,255	150,936	840	151,776	4,503,329	265,032	4,848,362	**22.07%**	4,654,265	23.03%	265,872	15.79%	5,000,138
Apr-10	1,380,672	455,620	1,836,292	130,339	1,227	166,160	418,364	584,524	1,260	240	1,500	1,213,252	37,016	1,121,156	**65.67%**	1,214,512	87.97%	37,256	8.18%	1,122,656
2009/2010	**140,560,034**	**15,407,106**	**155,967,140**	**1,733,778**	**1,358,369**	**110,493,388**	**13,199,435**	**123,692,823**	**1,119,717**	**20,784**	**1,140,501**	**28,946,929**	**2,186,887**	**30,758,407**	**19.77%**	**140,560,034**	**15,407,106**	**155,967,140**	**1,733,778**	**1,358,369**
May-10	7,302,597	567,783	7,870,380	333,140	900	6,071,952	549,572	6,621,524	60,934	840	61,774	1,169,711	17,371	854,842	**11.34%**	1,230,645	16.85%	18,211	3.21%	916,616
June-10	10,460,577	796,045	11,256,622	43,342	24,276	8,903,729	708,651	9,612,380	83,000	720	83,720	1,473,848	86,674	1,541,456	**13.72%**	1,556,848	14.88%	87,394	10.98%	1,625,176
July-10	7,132,966	877,660	8,010,626	29,075	22,357	5,468,979	826,944	6,295,923	54,092	720	54,812	1,609,895	49,996	1,653,173	**20.65%**	1,663,987	23.33%	50,716	5.78%	1,707,985
Aug-10	13,982,613	1,251,899	15,234,512	102,539	419,960	10,829,511	1,156,483	11,985,994	103,896	1,320	105,216	3,049,206	94,096	3,460,723	**22.25%**	3,153,102	22.55%	95,416	7.62%	3,565,939
Sep-10	22,272,421	2,440,406	24,712,827	131,043	60,067	17,925,857	2,085,126	20,010,983	159,908	3,144	163,052	4,186,656	352,136	4,467,816	**18.13%**	4,346,564	19.52%	355,280	14.56%	4,630,868
Oct-10	16,255,196	1,847,711	18,102,907	108,545	165,783	13,369,696	1,522,096	14,891,792	121,438	2,064	123,502	2,764,062	323,551	3,144,851	**17.32%**	2,885,500	17.75%	325,615	17.62%	3,268,353
Nov-10	7,132,790	738,692	7,871,482	89,145	48,972	5,714,824	625,058	6,339,882	63,435	1,656	65,091	1,354,531	111,978	1,426,336	**18.21%**	1,417,966	19.88%	113,634	15.38%	1,491,427
Dec-10	5,704,106	606,463	6,310,569	84,752	183,752	3,862,360	531,987	4,394,347	41,936	1,656	43,592	1,799,810	72,820	1,971,630	**30.76%**	1,841,746	32.29%	74,476	12.28%	2,015,222
Jan-11	2,330,143	406,554	2,736,697	51,634	17,418	2,005,908	341,124	2,347,032	25,657	1,296	26,953	298,578	64,134	328,496	**12.16%**	324,235	13.91%	65,430	16.09%	355,449
Feb-11	13,301,868	1,401,226	14,703,094	95,475	68,297	10,573,696	1,211,965	11,785,661	96,646	1,464	98,110	2,631,526	187,797	2,792,145	**19.03%**	2,728,172	20.51%	189,261	13.51%	2,890,255
March-11	18,602,975	1,396,276	19,999,251	165,768	125,789	14,299,748	1,257,372	15,557,120	123,370	2,232	125,602	4,179,857	136,672	4,276,550	**21.43%**	4,303,227	23.13%	138,904	9.95%	4,402,152
Apr-11	4,022,370	421,175	4,443,545	52,950	87,376	3,336,208	357,790	3,693,998	26,616	1,648	28,264	659,546	61,737	755,709	**16.88%**	686,162	17.06%	63,385	15.05%	783,973
2010/2011	**128,500,622**	**12,751,890**	**141,252,512**	**1,287,408**	**1,224,947**	**102,362,468**	**11,174,168**	**113,536,636**	**960,928**	**18,760**	**979,688**	**25,177,226**	**1,558,962**	**26,673,727**	**18.93%**	**128,500,622**	**12,751,890**	**141,252,512**	**1,287,408**	**1,224,947**

3.3 Losses

3.3.1 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 determinations, inaccurate water measuring structures and other restricting factors such as aquatic weed 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.

An irrigation water budget was developed for the Loskop Irrigation Scheme. The water budget was based on information obtained from the Water Administration System (WAS) which each ward manager runs in his/her own water ward.

Fortunately the Loskop IB installed a weather station at their office some time ago. The evaporation measured at this station was used in the determination of the evaporation losses for the seven year period. Rainfall has not been included as inflow in this water budget.

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.

The water budget is an important tool for analysing the water management issues provided adequate and reliable data was available. At a scheme level there was sufficient data to determine a water budget based on the WAS.

3.3.2 Gross Water losses

The total monthly losses summarised by main canals for the period May 2004 to Apr 2011 are shown in Table 3-2. The values in this table reflect the total losses and include seepage, evaporation, leakage and operational losses (including tail 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 two main canals.

Table 3-2: Loskop IB - Historical monthly losses

Month	Left Bank		Right Bank	
	Volume (10^3m^3)	% of inflow	Volume (10^3m^3)	% of inflow
May-04	1 480	31.33%	121	22.35%
June-04	2 020	24.92%	108	14.76%
July-04	2 266	27.78%	97	10.24%
Aug-04	2 802	25.17%	161	11.90%
Sep-04	4 592	22.15%	283	14.55%
Oct-04	2 900	22.03%	139	13.07%
Nov-04	2 900	23.83%	139	13.46%
Dec-04	1 739	26.91%	80	14.42%
Jan-05	2 545	24.82%	288	22.67%
Feb-05	3 027	26.21%	335	24.49%
Mar-05	2 024	20.82%	150	14.37%
Apr-05	1 107	22.23%	91	12.65%
May-05	1 514	24.22%	131	17.45%
June-05	2 499	21.11%	201	16.71%
July-05	2 141	19.37%	136	13.30%
Aug-05	3 897	21.69%	300	16.54%
Sep-05	3 948	22.05%	207	12.40%
Oct-05	2 937	22.36%	211	16.56%
Nov-05	2 930	27.59%	50	5.79%
Dec-05	2 631	26.13%	159	17.66%
Jan-06	1 693	31.10%	128	20.36%
Feb-06	957	21.55%	134	21.91%
Mar-06	703	19.25%	156	27.13%
Apr-06	967	17.48%	110	17.43%
May-06	1 530	24.94%	262	30.23%
June-06	1 740	21.50%	402	28.54%
July-06	974	11.76%	164	16.33%
Aug-06	2 662	19.23%	268	16.66%
Sep-06	3 506	20.67%	319	15.63%
Oct-06	3 894	21.57%	366	16.32%
Nov-06	1 290	19.90%	58	8.23%
Dec-06	2 193	18.48%	157	12.26%
Jan-07	3 607	24.24%	93	6.83%
Feb-07	4 139	26.23%	313	17.24%
Mar-07	3 929	26.80%	239	17.57%
Apr-07	3 334	39.17%	108	7.99%
May-07	2 287	22.01%	239	19.41%
June-07	2 185	23.68%	163	21.95%
July-07	2 467	24.65%	200	16.78%
Aug-07	3 709	24.96%	145	11.11%
Sep-07	4 024	22.12%	341	17.77%

Month	Left Bank		Right Bank	
	Volume (10^3m^3)	% of inflow	Volume (10^3m^3)	% of inflow
Oct-07	2 326	25.14%	6	0.78%
Nov-07	1 759	22.52%	101	11.46%
Dec-07	1 506	18.87%	160	18.74%
Jan-08	2 037	28.53%	168	22.13%
Feb-08	3 127	27.38%	29	3.35%
Mar-08	1 995	23.34%	105	15.50%
Apr-08	2 277	24.64%	140	18.21%
May-08	1 408	21.52%	70	11.18%
June-08	2 277	23.03%	137	16.34%
July-08	2 626	22.75%	191	14.22%
Aug-08	3 697	21.77%	237	14.23%
Sep-08	5 186	21.50%	345	12.01%
Oct-08	2 620	20.96%	273	17.90%
Nov-08	1 158	27.85%	83	19.92%
Dec-08	3 677	30.39%	232	22.64%
Jan-09	1 804	26.57%	211	29.92%
Feb-09	1 265	21.95%	145	14.98%
Mar-09	1 900	23.91%	35	4.83%
Apr-09	1 762	20.72%	42	3.53%
May-09	1 704	21.20%	115	14.59%
June-09	1 685	21.66%	72	9.07%
July-09	2 529	21.97%	130	9.52%
Aug-09	3 146	20.26%	15	1.01%
Sep-09	4 581	19.68%	287	11.41%
Oct-09	2 713	22.55%	263	16.90%
Nov-09	1 089	19.41%	53	6.86%
Dec-09	1 515	15.60%	658	35.16%
Jan-10	1 992	19.10%	217	20.11%
Feb-10	3 243	21.56%	96	8.76%
Mar-10	4 654	23.03%	266	15.79%
Apr-10	1 215	87.97%	37	8.18%
May-10	1 231	16.85%	18	3.21%
June-10	1 557	14.88%	87	10.98%
July-10	1 664	23.33%	51	5.78%
Aug-10	3 153	22.55%	95	7.62%
Sep-10	4 347	19.52%	355	14.56%
Oct-10	2 886	17.75%	326	17.62%
Nov-10	1 418	19.88%	114	15.38%
Dec-10	1 842	32.29%	74	12.28%
Jan-11	324	13.91%	65	16.09%
Feb-11	2 728	20.51%	189	13.51%
Mar-11	4 303	23.13%	139	9.95%

A graphic representation of the total monthly losses for the two main canals is shown in Figure 3-1.

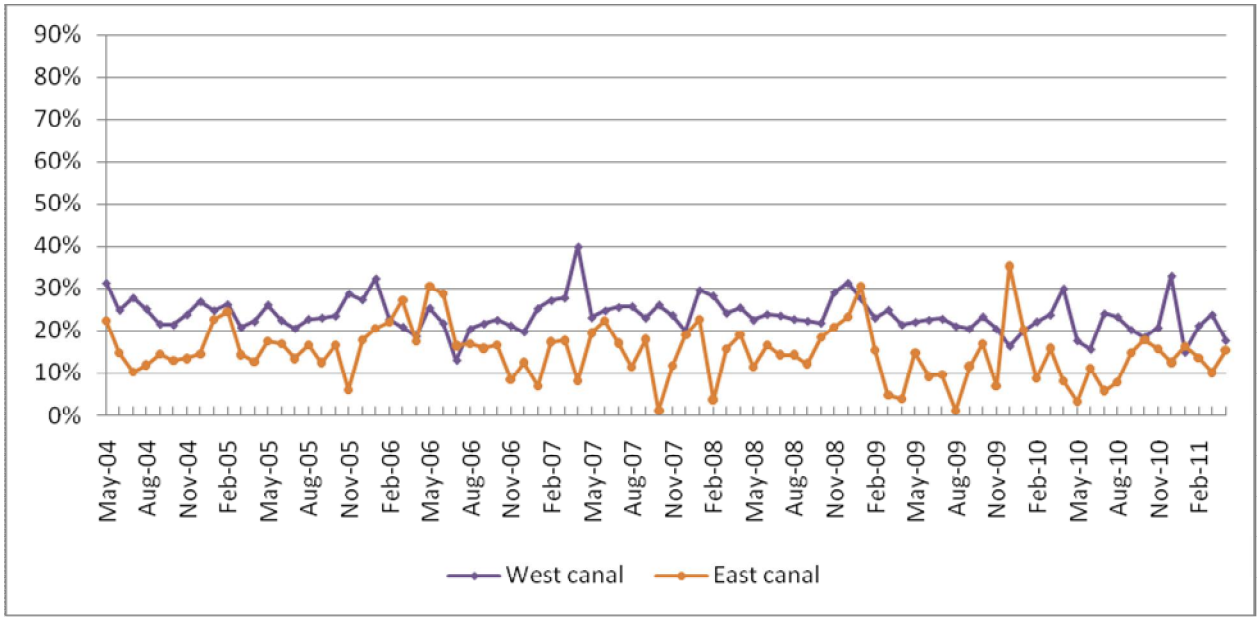


Figure 3-1: Loskop IB - Historical canal losses

From the data presented in Figure 3-1 and Table 3-2 it is clear that the total losses on the left bank (West) canal are roughly 8.7% more than the losses on the right bank (East) canal. This can be attributed to the fact that the West canal serves a much larger area and is therefore a bigger conveyance system than the East canal. The ground formation of the right bank canal has much less turf than that of the left bank canal where the canal structure is more likely to fail or crack due to soil movement.

The **average** water losses have been 21% of the released water from the dam into the canal system. This translated to an **average** of approximately 31.2 million m^3/a water losses in the Loskop Irrigation Scheme area. This volume includes water losses that are difficult to measure including the unavoidable water losses as well as some of the avoidable losses. The return flow (canal tail ends) on average over seven years was 1% of the water released into the canal system.

Figure 3-1 provides comparison between the supply and demand from May 2004 to February 2011.

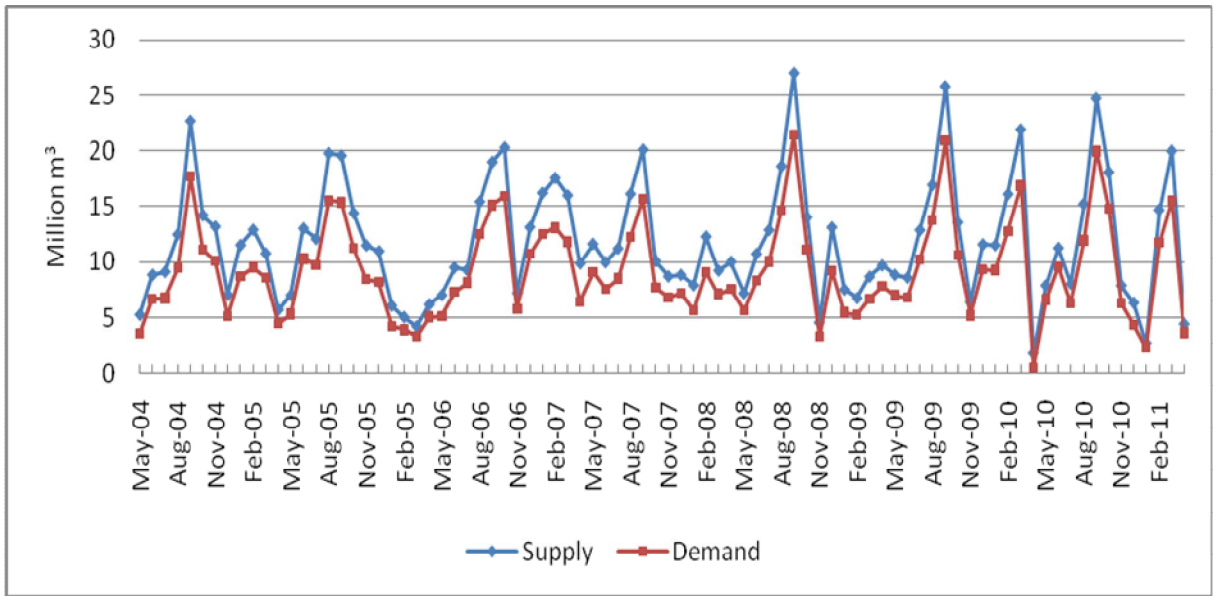


Figure 3-2: Comparison of deliveries and the demands

3.3.3 Conveyance losses

Conveyance losses within a canal system can be defined as the difference between the inflow into the scheme and the water delivered to the farm boundaries. 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 losses and evaporation losses.

Avoidable losses

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

The main losses occurring within Loskop Irrigation Scheme served by canal distribution networks include the following;

3.3.3.1 Seepage losses:

Seepage losses from concrete lined, half lined and earth canals are normally expressed in l/s per 1 000m^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, quantity of sediment, etc.

For the Loskop Irrigation Scheme, eleven sections were chosen on the left bank to determine seepage losses. Ten sections were taken between the radial gates with varying distances and flow depths at 8.2 m^3/s and one section was taken along the siphon. The wetted perimeter for each section was determined and multiplied with the section length as well as the 1.9 l/s per 1 000 m^2 to get the total seepage loss per section. All the sections were then added. No longitudinal sections, cross sections or dimensions were available for the right bank canal. The seepage loss in the left bank canal was calculated as 11.48 % of the inflow and the same percentage was used for the right bank canal.

3.3.3.2 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). The evaporation records gathered from the weather station were used to determine the percentage evaporation loss of the total inflow into the West canal. The same eleven sections on the left bank used for estimating the seepage loss were used for estimating the evaporation loss as well. The surface area of each section at a flow rate of 8.2 m^3/s was multiplied by the annual evaporation and all the sections were added. The evaporation loss expressed as a percentage of total inflow was 0.34 % for the left and right banks canals. This corresponds with the theoretical value of 0.3% of Reid, Davidson and Kotze.

3.3.3.3 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 measurements. These losses are estimated to fluctuate between 9% and 17% (Reid, Davidson and Kotze, 1986).

3.3.3.4 Leaks and Spills:

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 the Board aims to operate the system within a range of 35% to 85% of the design capacity, the water demand during peak periods, sediment and aquatic weed growth necessitates periodic operation of the system at peak capacity, resulting in higher leakages.

3.3.3.5 Aquatic weeds:

Aquatic weeds (water grass and algae growth) in irrigation canal systems are 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 3-3 provides a summary of the various losses on the canal distribution network of the Loskop IB. The figures are based on the averages over the seven water years (2004 to 2011). It is important to note that not all of the categories included in the table are shown on the WUEARs. Some of the values are estimations and are based on information obtained during discussions held with the management of the Board.

Table 3-3: Loskop IB - Breakdown of water losses

Description	Unavoidable losses (m^3*10^6)	Avoidable losses (m^3*10^6)	Total losses (m^3*10^6)	% of total losses
Seepages	17.049		17.049	54.66%
Evaporation	0.449		0.449	1.43%
Filling losses		12.383	12.383	39.70%
Leakages				
Spills				
Operational Losses				
Over delivery to users				
Canal end returns		1.311	1.311	4.20%
Other				
Total	**17.498**	**13.694**	**31.193**	**100%**
% of total losses	**56%**	**44%**	**100%**	
% of total volume released into system	**12%**	**9%**	**21%**	

From the data presented in Table 3-3 it is evident that the total losses on the scheme amount to 21%. Of the total losses occurring on the scheme, 12% can be classified as unavoidable losses while 9% or approximately 13.7 million cubic metres are avoidable losses. The bulk of the avoidable losses (12.4 million cubic metres) are made up of operational losses. It is interesting to note that the unavoidable losses are more than the avoidable losses. This can be attributed to the fact that almost 80 % of the branch canals in the whole scheme are piped, reducing operational losses. Start-up and shut-down losses have also been eliminated since the IB stared operating the scheme over weekends (June 2011).

3.3.4 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the estimated avoidable water losses from 2004/5 to 2010/11 water years have been 85 million m^3. This quantity 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.
- *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.

Sufficient data was available to determine the avoidable losses since measurements of the flows at the canal end point of each ward, as presented in Table 6, were taken.

Table 3-4 Tail water per ward

Year	WARD							
	E2	**W2**	**W3+W5**	**W4**	**W6**	**W7**	**W8**	**W10**
2004/2005	19 348	79 650	119 854	366 432	228 048	190 199	392 888	269 323
2005/2006	17 124	103 584	129 636	352 536	107 752	188 596	366 515	207 984
2006/2007	28 656	189 995	172 618	344 814	115 183	185 237	247 254	171 640
2007/2008	40 419	153 292	171 767	234 500	123 449	183 377	186 628	151 286
2008/2009	42 221	162 020	217 180	182 400	121 593	164 915	185 294	143 497
2009/2010	20 784	195 936	212 592	152 112	104 871	173 136	150 988	130 082
2010/2011	18 760	183 472	158 029	121 608	117 070	147 485	120 518	112 746

4 WATER MANAGEMENT ISSUES AND GOALS

4.1 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 Loskop Irrigation Scheme's irrigation demands. It also highlighted that irrigators are currently utilising their full water allocation.

In addition to the water budget analysis, discussions were held with the management and other people who are knowledgeable about the Loskop Irrigation Scheme. 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.

4.2 Flow measurements and water accounting

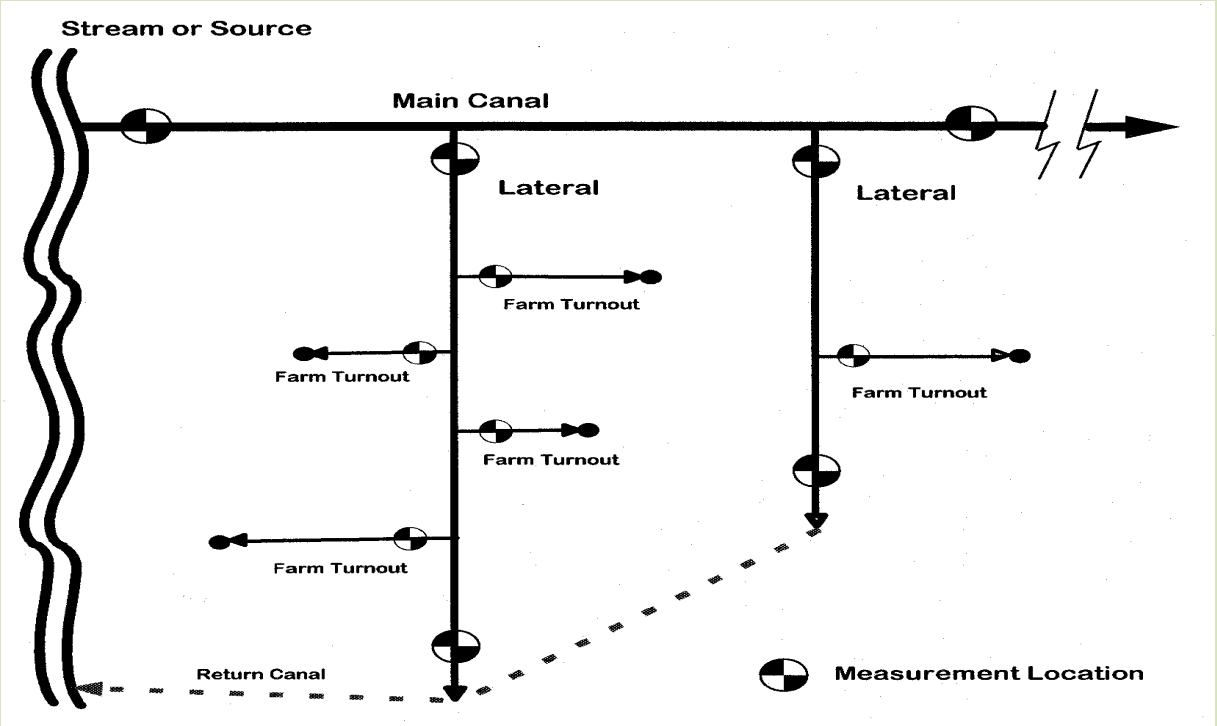
4.2.1 Adequacy of flow data

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. The figure 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 IB about the quantity, timing, and location of water use and therefore enables the IB to conduct a water budget not only at scheme level but also for sub-schemes within the irrigation scheme.

As illustrated in the figure below, it would be ideal to have electronic 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 4.1, the Loskop Irrigation Scheme has adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. The IB makes regular measurements of flows into all the measurement points. These include parshall flumes on the canals and flumes and rated sluice gates on the laterals to the individual farmers as well as v-notches at the canal end points.

However, the accuracy and reliability of the rated sluice gates and flumes is very low. With the Loskop Irrigation Scheme operating continuously and normally at high flows, devices such as sharp-crested weirs, short-throated flumes, rated sluice gates or submerged orifices do not operate well in high flow situations. There is therefore a possibility of un-accounting of the water diverted and delivered to the irrigators.



Source: Bureau of Reclamation

Figure 4-1: Irrigation Scheme with ideal water measurement system

4.2.2 Telemetry systems and compatibility with WAS

DWA has two telemetry systems at the outlet from the dam into each canal but it does not always correspond with the water that is requested by the scheme and therefore the board has their own telemetry system. The Loskop Irrigation Scheme has Android Telemetry Systems installed only at the Loskop Dam wall. There is a telemetry system at each bank where water is released into the two main canals. However the data from the telemetry system is not automatically imported into the Water Administration System (WAS) On the rest of the scheme there are no other telemetry systems installed and flows and levels are therefore manually captured on the WAS system.

Management Goal 1

The objective to address the above irrigation water management issue is to ensure that the following is achieved by the Loskop IB:

(iv) Continuation of regular measurement of flows into all primary and branch canals, as well as measurement at the tail ends of the canal system

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

(vi) More telemetry systems can be permanently installed to measure/monitor deliveries to the different canal sections as well as to monitor any operational spills or tail water

that is not used in the scheme. The flows and levels are intended to be sent by telemetry system to the Loskop IB offices for direct input into the WAS programme.

4.2.3 Irrigation water budget is not conducted in detail

It is currently difficult to disaggregate the losses. There is no differentiation in the water balance assessment between the losses. Although there is not much tail water, the remaining avoidable losses such as leakages have not been disaggregated. Although an extensive measurement system is in place, the data is not captured electronically in the WUEAR. 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 Loskop IB are included in determining water budgets and calculating water losses at scheme as well as ward/sub-scheme level. This will enable the IB to undertake comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified. Ponding testes could also be undertaken to verify the theoretical calculations of the seepage losses on the canal system.

4.3 Operational water management issues

4.3.1 The installed WAS is currently not being fully utilised

The Water Administration System (WAS) was developed by Dr. Nico Benade (with funding mainly from the WRC and DWA) as a tool to be used by Irrigation Boards/Schemes to optimize their irrigation water management and minimize management-related distribution losses in irrigation canal systems. WAS consists of seven modules integrated into a single program and these modules can be implemented partially or as a whole.

The seven modules are the:

(viii) Administration module

(ix) Water order module

(x) Water accounts module

(xi) Water release module

(xii) Measured data module

(xiii) Crop water use module, and

(xiv) Report module

The Water Release module for example links with the water administration and order modules and can be used to:

- Minimize distribution losses on canal networks

- Calculate water releases for the main canal(s) and all their branches allowing for lag times and water losses such as seepage and evaporation; and
- Determine operational procedures for a dam with varying downstream inflows and outflows in a river allowing for lag times and water losses such as seepage, evaporation and transpiration.

However, at present the WAS Water Release and Report modules are not used in the Loskop Irrigation Scheme.

Management Goal 3

The management objective to address the above issue is to investigate the implementation of other modules of the WAS programme, particularly the water order, water release and report modules. This could be undertaken within 2 years from the completion of this Water Management Plan (WMP).

Furthermore, the measured data module should be linked to the telemetry system to enable direct reading of the measured data into the WAS programme. This can be used to undertake automatic reporting on water losses, not only at scheme level, but also at sub-scheme levels.

4.3.2 Available datasets not integrated into a Management Information System

The Loskop IB has gathered and generated their own detailed datasets, ranging from individual sluice detail to water user address information. 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.

Management Goal 4

The development of a spatially linked Management Information System that integrates all the relevant and available datasets.

4.4 Infrastructure related issues

In order to properly develop the Loskop IB water management plan, it is essential that an assessment of the overall condition of the facilities to identify potential issues be carried out. As indicated in Chapter 4, a condition assessment together with discussions with the Loskop IB was undertaken. That included the operation and maintenance system as well as the conveyance and distribution system. No assessment of the on-farm delivery systems was conducted.

4.4.1 Maintenance procedures

A detailed condition assessment of the existing canal infrastructure has not been undertaken but there are sections in the structure requiring attention. Seepage and canal losses may be

taking place on these sections or at the joints between the different canal sections. The IB 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.

At present only four weeks per year are set aside for maintenance and refurbishment of the canal structures. The security of supply of water to the diverse irrigators does not allow for more dry weeks. The IB is aiming to build more farm dams in close cooperation with the irrigators especially at the canal ends. This will enable storage of water over longer periods for irrigation purposes. There are also a few radial gates on the left bank which are used during the dosage process against algae. If managed well, these radial gates can be used, together with the balancing dams, for sectional restoration of the canal structure.

The present modus operandi when maintenance and repairs are undertaken should also be investigated and improved where possible.

Management Goal 5

Although the Loskop IB has a good balancing system in place to ensure security of water supply during dry periods, more balancing dams and use of radial gates may allow for more refurbishment periods additional to dry weeks. The IB can conduct a refurbishment programme whereby they make optimal use of the already installed radial gates and balancing dams. Revision of the current actions taken when canals are maintained and/or repaired should be investigated and improved where possible.

4.4.2 Ownership of irrigation infrastructure

The IB has two main elements that dictate operations – water and infrastructure . The ownership of irrigation infrastructure can prove to be one of the main barriers to improvement in irrigation efficiency if it is not well managed. More specifically, it is the management of the infrastructure, more than the ownership of the irrigation infrastructure that can create problems with the ensuring the quality of the infrastructure is maintained.

In the Loskop Irrigation Scheme, the DWA still owns the irrigation infrastructure including the main, primary and branch canals. However, the IB operates the irrigation infrastructure as an agent of the DWA and undertakes the normal maintenance of the irrigation infrastructure.

The problems will most likely arise, when the major infrastructure needs replacement/total refurbishment. It is unlikely that the IB has the financial capacity to undertake the refurbishment of the assets which are owned by government. It is also difficult to borrow against the assets as they are owned by government. Therefore the responsibility for replacement of major assets lies with government, whose priorities may be different to those of the IBs.

Management Goal 6

The broad objective to address this issue around ownership of the irrigation infrastructure is to ensure that the levels of responsibility between the DWA and the WUA are further refined

than the existing agreement. This is assuming that the DWA does not want to transfer the infrastructure to the WUA in the short to medium term.

4.5 Institutional Water Management Issues

4.5.1 Updating and implementation of the Water Management Plan.

The Scheme Manager will be responsible for the annual updating and implementation of the Water Management Plan (WMP) for the scheme.

- The roles and responsibilities of the applicable 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 status of water losses, water saving targets, goals and objectives as well as the actions taken to reduce water losses
- 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 7

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.

4.5.2 Institution of a Water User Association

The available water for irrigation in the Loskop area has a declining tendency and the Loskop Irrigation Board is concerned since the supply of the whole system in normal years is already exceeded. The whole water resource cannot be managed if it is not measured accurately and paid for.

Management Goal 8

A Water User Association where all users of the river system will be represented in order to control and distribute the available water and act against users who are using water unlawfully.

4.6 Pollution

4.6.1 Water pollution upstream of the Loskop Dam

The Board is extremely concerned about the pollution upstream of Loskop Dam. Although the Department of Water Affairs has already employed countermeasures to minimise pollution, it is the Board's opinion that action against transgressors is not sufficiently enforced and strict enough.

Management Goal 9

Revise countermeasures and apply stricter rules and regulations regarding pollution. Take action against polluters.

4.7 Alien vegetation

4.7.1 Intruding vegetation downstream of Loskop Dam

Besides the indigenous vegetation taking over in the river system and resulting in losses, the Board is concerned about the alien trees that are intruding (especially in the river below Loskop Dam). The eradication of such plants is however outside the jurisdiction of the Board.

Management Goal 10

Ensure and foster a close working relationship between the Loskop Irrigation Board and the manager of the Working for Water program and provide information on areas of infestation.

4.8 Aquatic weeds

Algae are an ever growing concern and if not controlled can cause serious problems. The canal structure is under a lot of stress when the banks are flooded due to the effect the algae have on the water level. Algae can cause blockages in the system (from the main canal to the irrigation system) and contribute to operational losses. Algae growth is currently treated by copper sulphate dosage on a regular basis.

There is however an alternative product available for the treatment of algae. MAHNACIDE H Herbicide (a product of Baker Hughes Inc.) is a water soluble herbicide for the control of submerged aquatic weeds and algae in irrigation canals and irrigation reservoirs. The active ingredient, Acrolein, is a general cell toxicant which reacts with sulfhydryl groups in proteins. All typical submersed aquatic weed species and algae appear to be susceptible.

Management Goal 11

Investigate the possibility to use MAGNACIDE-H Herbicide against the control of aquatic weeds.

Table 4-1: Loskop Irrigation Scheme: Identified water management issues

Item No.	Issue description	Comments
1	Lack of telemetry systems. The flow measurements taking place on the diversion points within the Loskop Irrigation Scheme are being manually read due to the absence of a telemetry system. Errors can easily be made this way.	Link the telemetry system at the Loskop dam with the WAS. Install more telemetry stations.
2	WAS is not fully utilised	Eliminate problems through professional advice & training. Generate WUEARs through WAS.
3	Irrigation water budget and balance assessment. Disaggregate losses.	Include rainfall and evaporation records in the water balance. Break down losses. Utilise WAS.
4	Sections of the canal structure are in a poor condition resulting in leakages which contribute to the avoidable losses. These areas can only receive attention during well planned dry weeks when farmers have to made provision for additional water when there is no water in the canal.	More balancing dams and use of radial gates may allow for more refurbishment periods additional to dry weeks. Investigate and revise current maintenance procedures.
5	DWA still owns the irrigation infrastructure but the IB operates it as an agent of the DWA and undertakes the normal maintenance thereof. It is unlikely that the IB has the financial capacity to undertake the refurbishment of the assets which are owned by government. Therefore the responsibility for replacement of major assets lies with government.	Responsibility between the DWA and the Loskop IB should be further refined. Service level agreement.
6	The available water for in the Loskop area is declining. The Board is concerned since the	A Water User Association where all

Item No.	Issue description	Comments
	supply of the whole system in normal years is already exceeded.	users of the river system will be represented in order to control and distribute the available water.
7	Very concerned about the pollution upstream of Loskop Dam. Although the Department of Water Affairs has already employed countermeasures to minimise pollution, it is the Board's opinion that there is still not being acted strictly enough.	Revise countermeasures and apply stricter rules and regulations regarding pollution. Institution of a WUA.
8	Besides the indigenous vegetation intruding the river system and resulting losses, the Board is concerned about the alien trees, especially in the river below Loskop Dam. The eradication of such plants is however outside the jurisdiction of the Board.	Assistance in development of an eradication programme by WfW.
9	Algae growth is a common phenomenon and expensive to control.	Investigate the use of MAGNACIDE-H Herbicide or alternative methods to control aquatic weeds.
10	Updating and implementation of the Water Management Plan.	Implementation, monitoring, reviewing and updating of the 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.

5 ESTABLISHING WATER SAVINGS TARGETS

5.1 Acceptable water losses

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 Loskop IB.

A Water Research Commission (WRC) study (Report TT465/10) 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 14.85 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.

5.2 Water savings targets

The unavoidable water losses in the Loskop IB were determined to be 12.0% 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 5-1 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 is 22.0% of the total releases into the canal system.

Table 5-1: Target water losses in the Loskop IB

Description	System inflow ($x 10^6 m^3$)	Present situation - Losses				Acceptable water losses		Water savings targets	
		Unavoidable losses ($x 10^6 m^3$)	Avoidable losses ($x 10^6 m^3$)	Total Losses ($x 10^6 m^3$)	% of total volume released	Annual volume ($x 10^6 m^3$)	% of total volume released	Annual volume ($x 10^6 m^3$)	% of total volume released
Seepages		*17.049*		*17.049*	11.48%	17.0	11.48%	0	0.00%
Evaporation		*0.449*		*0.449*	0.30%	0.449	0.30%	0	0.00%
Filling losses									
Leakages			*12.383*	*12.383*	8.08%				
Spills						14.85	10.00%	-1.156	-0.78%
Over delivery									
Canal end returns			*1.311*	*1.311*	0.88%				
Other			*0.000*	*0.000*	0.00%	0	0.00%	0	0.00%
Total	***148.5***	***17.498***	***13.694***	***31.192***	***20.75%***	***32.348***	***21.78%***	***-1.156***	***-0.78%***
% of total volume released into system		***11.78%***	***9.22%***	***20.75%***					

Based on the projected water saving targets, the Loskop IB is already within the acceptable range in term of losses. This however does not mean that further improvements are not possible. The short-term aim is therefore to maintain the losses within the acceptable range.

6 PRIORITISED WATER MANAGEMENT MEASURES

6.1 Overview

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 water management and irrigation water use efficiency in the Loskop IB.

The priority water management measures to improve irrigation water use efficiency in Loskop IB include the following:

(1) Flow measurement and telemetry infrastructure
   a. Link the telemetry system with the WAS.
   b. Investigate implementation of the Release and Report Modules of WAS.
   c. Expand the WUEAR to show sub-schemes and disaggregated losses.
   d. Undertake ponding tests to determine seepage as accurately as possible.

(2) Canal maintenance and refurbishment
   a. Service Level Agreement.
   b. Revision of maintenance procedures.
   c. Treatment of aquatic weeds.

(3) Operation and management related
   a. Address pollution.
   b. Incorporate all relevant data in a custom Management Information System.
   c. Investigate the possibility to implement incentive based water pricing.

6.2 Flow measurement and telemetry infrastructure

6.2.1 Check compatibility of telemetry system with WAS

The Loskop IB will review and expand the current telemetry system and investigate the possibility to link the system with WAS. If attainable it will allow for flow measurements or the releases into the system to be read in real time into the WAS.

6.2.2 Fully implement Release Module of WAS

The population of most of the required scheme and various canal parameters have been undertaken by the IB and the Release Module of WAS should have been implemented. There are however some problems with changing parameters (rapid aquatic weed growth) which hampers implementation of the module. The revision of the various parameters will be undertaken to pinpoint and address the problem to allow the module to be fully implemented. This module is essential from an operational point of view since the system is functioning close to full capacity during periods of high demand and correct releases should minimise operational losses due to spills.

6.2.3 Expand the WUEAR

Currently the Water Use Efficiency Accounting Report only provides the figures for the two main canals and no individual reporting is done on the various sections of the distribution network. By undertaking the report at a detailed level it would be possible to compile water balances for the individual sections which could assist in highlighting specific problem areas and allow for the prioritisation of interventions. This issue will be discussed with NB Systems to indentify the actions that must be incorporated to allow reporting at sub-scheme level. The WUEARs are also not generated through the use of WAS.

6.2.4 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.

6.3 Canal maintenance and refurbishment

6.3.1 Service level agreement

At present there is no service level agreement between the Loskop IB and the DWA regarding their roles and responsibilities. Assets are owned by DWA while the O&M is carried out by the Loskop IB. Without such an agreement, the lack of clarity may result in some of the issues such as refurbishment of the infrastructure not being carried out in time to reduce water losses from the canal infrastructure.

6.3.2 Treatment of aquatic weeds

Aquatic weeds are a problem in the Loskop IB. The presence of weeds in the canal can cause an increase in the water surface level resulting in higher water loss due to overtopping, higher leakages and over-delivery due to higher pressure at sluice gates. Algae therefore decrease the water delivery capacity and create the potential of erosion along the canal banks. Sandbars and berms can also be created by filtration of sediment or silt by aquatic vegetation.

The Irrigation Board strives to keep the algae under control by dosing with copper sulphate on a regular basis of once every two months. Sometimes the dosage is diluted and applied more often to prevent the algae from rising and causing the canals to overflow.

A new product, MAHNACIDE H Herbicide (a product of Baker Hughes Inc.) das also proved to be very effective against aquatic weeds. It is a water soluble herbicide for the control of submerged aquatic weeds and algae in irrigation canals and irrigation reservoirs. Although expensive, the use of this product will be investigated as an alternative or additional measure that could be implemented in the fight against aquatic weeds.

6.4 Operational and management related

6.4.1 Address pollution in catchment of Loskop Dam

Pollution has become an increasing problem in the Loskop Irrigation Scheme. Not only does it affect the water quality but also the canal structure. The catchment area of the Loskop Dam is subject to a lot of pollution and the poor water quality in the scheme therefore can mainly be attributed to the pollution taking place upstream of the Loskop Dam.

The Board will therefore again engage with the DWA to try and resolve this problem. Many of the crops produced are no subjected to quality tests and if this problem is not addressed as a matter of urgency, the whole irrigation business may be jeopardised.

6.4.2 Development of a Management Information System

The Loskop IB has commissioned various studies in the past and has their own 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 IB 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.

6.4.3 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 Loskop IB will investigate the possibility, costs and viability of incentive based water pricing.

7 IMPLEMENTATION PLAN

The evaluation of the potential measures for implementation in the Loskop IB area of operation 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 priorities for implementation are as follows:

(i) Linking the existing telemetry system with WAS (water released into the two main canals).
(ii) Expand WUEAR to enable water budget analysis at both scheme and sub-scheme level.
(iii) Fully implement the Release and Report Modules of WAS.
(iv) Review current maintenance procedures.
(v) Address pollution problems.
(vi) Formalise Service Level Agreement.
(vii) Develop and implement a comprehensive Management Information System.
(viii) Implement incentive based pricing.

The action plan for implementation is presented in Table 7-1.

Table 7-1: Loskop IB action plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	- Conduct seepage loss measurements in representative canal and pipeline segments though ponding tests where possible. Extrapolate results from tested segments to similar segments and revise water budget. - Undertake sub-scheme water budgets - Prioritise areas of significant water losses	Mar '13 – Feb '14 Mar '13 – Feb '15 Mar '13 – Feb '15	Loskop IB
2	Further reduce leakage losses in irrigation canal infrastructure	- Formalise Service Level Agreement	Mar '13 – Feb '15	Loskop IB/DWA
3	Increase operational efficiency	- Link telemetry system with WAS - Investigate implementation of release module of WAS - Generate WUEARs through the WAS - Incorporate data in a custom Water Management System	Mar '13 – Feb '15 Mar '13 – Feb '15 Mar '13 – Feb '15 Mar '13 – Feb '15	Loskop IB
4	Address pollution	- Engage with relevant stakeholders to resolve crisis. Investigate and implement methods to resolve problem. Escalate matter if	Mar '13 – Feb '18	Loskop IB/DWA

Priority	Goal	Action Plan	Timeline	Responsible Authority
		necessary.		
5	In 5 years, implement incentive pricing structure for the IB if viable	- Review current irrigation water pricing strategy - Engage with irrigators on incentive pricing structure - Update water pricing strategy - Implement water billing based on incentive pricing rate	Mar ’13 – Feb ‘18	DWA/ HBPIB