water affairs

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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

LOWER OLIFANTS RIVER WUA WATER MANAGEMENT PLAN

Final Report

December 2012

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	Lower Olifants River WUA - Water Management Plan
Authors	Toriso Tlou, Pr. Eng Francois Joubert

Revision	Date	Report Status
Draft 1	19/03/2012	First draft for comment
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Director: Water Use Efficiency

WMP accepted by LORWUA

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Chief Executive Officer: J Matthee

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Accepted on behalf of LORWUA

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Chairman: LORWUA

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EXECUTIVE SUMMARY

The Lower Olifants Water User Association is situated in the Vredendal/Koekenaap area and Figure 2.1 provides a locality map. The Association is located within the Olifants-Doorn WMA. The major river in the WMA is the Olifants River, which rises in the Agter Witzenberg Mountains to the north of Ceres, with the Doring River as its major tributary.

The scheme consists of the Clanwilliam Dam (122 million m³) on the Olifants River, with the Bulshoek Dam (5.2million m³) lower downstream, approximately 260 km main canals and 40 km of smaller branch canals. The main canal starts at Bulshoek Dam and runs along the left bank of the Olifants River until it splits in two with a raised siphon over the Olifants River to the right bank, close to Klawer. From the split, there is a canal on both banks of the Olifants River up to Ebenhaezer and Olifants River Nedersetting areas respectively. At the end of the canals there are various balance dams to manage the water optimally and to limit wasted water to the minimum.

The length of the left bank canal is approximately 125.5 km while the right bank canal has a length of 111.8 km. The scheme is divided into nine wards with four wards on the left bank canal and five wards on the right bank canal. Each water ward has a ward manager who is responsible for the water distribution management of the specific ward. The canal infrastructure comprises of secondary canal systems, sluices, long weirs, siphons, side spillways, tunnels and pipes. Water is delivered to the farmers through sluices which are set on a daily basis. The standard sluice in the canal system comprises of a 300mm by 300mm plate covering a 300 mm diameter pipe mouth or orifice. The sluice gates are fitted with long handles and locked in place to allow flow through the partly opened orifice.

The dam setting is changed on a six 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 WUA has a total scheduled area of 10 007 hectares, at a scheduled quota of 12 200 m3/ha/a which translates to a total allocation of 122.09 million m3/a. The various categories of water users and the annual allocation are shown in the following table.

Water Use category	***Annual allocation m³***
Commercial Farmers (9 510 ha)	*116 022 000*
Ebenhaezer Small Farmers (257 ha)	*3 135 400*
Emerging Farmers (240 ha)	*2 928 000*
Matzikama Municipality (7 towns)	*8 351 000*
Industries	*3 200 000*
TOTAL	***133 636 400***

The capacity of the canal is such that the WUA can only supply between 60% and 70% of the water during peak seasons.

Economic activity is based on commercial irrigated agriculture, and approximately 90 per cent (8 176 hectares) of the water is used for the irrigation of wine grapes, table grapes,

tomatoes, citrus, deciduous fruit, and vegetables. Some 88% of the total area under irrigation is planted with permanent crops.

Water balance assessment

Using the information obtained from the Water Use Efficiency Accounting Reports (WUEARs) for Oct 2008 to Aug 2012, previous studies and consultation with the management of the WUA, a water budget for the LORWUA was prepared. 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 Water Administration System (WAS).

The average water losses have been 24.6% (13.1% unavoidable and 11.5% avoidable) of the released water from the dam into the canal system. This translated to an average of approximately 34.97 million m^3/a water losses in the LORWUA area. In terms of volume, approximately 16.3 million m^3/a are avoidable losses.

Existing water conservation measures

The LORWUA has been implementing various measures to improve the management of delivery to the irrigators. These measures include (a) annual maintenance of the irrigation canals to reduce avoidable water losses, (b) installation and maintenance of an extensive telemetric flow measurement system to monitor and audit the water delivery,(c) commissioning and financing of a detailed canal condition assessment, (d) installation of flow measurements at the critical diversion points to measure how much water is diverted at different points of the irrigation scheme, (e) continuous maintenance and repair work to the structure and canals including a professional diving team to undertake repairs on the system not normally accessible, (f) automated releases from Bulshoek Dam where a specific discharge rate is set and that rate then remains constant, (g) introduction of WAS-Client for use by farmers which allows them to capture and keep record of their weekly water orders - WAS-Client can also be used to capture water orders and to upload such orders to the WAS database, (h) keeping algae under control by dosing on a regular basis of once every two months of more of the when required.

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 LORWUA canal system. The analysis indicated that the unavoidable water losses due to evaporation losses and seepage is 18.65 million m^3/a, which translates to 13.1% of the total volume of water diverted into the LORWUA canal system.

A Water Research Commission (WRC) study conducted in 2010 provided guidelines of 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 14.2 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 23.1% of the total releases into the canal system or 32.9 million m^3/a.*

<u>Water management issues</u>

The water budget analysis discussed in the previous chapter has helped to identify several key water management issues. The water budget analysis showed that on an annual basis, there is not sufficient water to meet the LORWUA's irrigation demands. It also highlighted that irrigators are currently not utilising their full water allocation due to the capacity of the canal. In addition to the water budget analysis, discussions were held with the management and other parties who are knowledgeable about the WUA. This was done to determine the key issues the scheme is facing. The main water management issues identified include the following;

a) *The LORWUA have adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. However, the accuracy and reliability of the rated sluice gates and flumes is very low. With the LORWUA normally operating 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. Therefore there is scope for under-accounting of the water diverted and delivered to the irrigators.*

b) *There is a telemetry system where water is released from Bulshoek Dam into the main canal and there are telemetry systems at the beginning and end of each section. The readings of the telemetry systems are however not automatically imported on the WAS system The compatibility between the existing telemetry system and WAS should be addressed together with the automatic importation of telemetry data into WAS.*

c) *It is currently difficult to disaggregate the losses as 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 leakage, spills and over delivery to users have not been disaggregated. 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.*

d) *The WAS water release module is currently not being utilised due to inaccurate lag times.*

e) *Presently there is limited scheme balancing capacity and the goal is to investigate the possibility of creating additional storage capacity (Koekenaap) which will assist in operating the system as effectively as possible.*

f) *During the condition assessment of the existing canal infrastructure the consultants also evaluated the procedures undertaken by the WUA when maintenance is conducted and some procedures were found to be inadequate. While most of the recommendations have already been implemented the present modus operandi when maintenance and repairs are undertaken should be investigated and improved where possible.*

Water Management Plan

Water saving targets

The set targets for the LORWUA are illustrated in the table below.

Description	System inflow (x $10^6 m^3$)	Present situation - Losses				Acceptable water losses		Target water saving	
		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		18.2		18.2	12.8%	18.2	12.8%	0.0	0.0%
Evaporation		0.448		0.448	0.3%	0.4	0.3%	0.0	0.0%
Filling losses Leakages Spills Over delivery Canal end returns		0	16.321	16.321	11.4%	14.2	10.0%	2.1	1.4%
Other		0	0	0	0.0%	0.0	0.0%	0.0	0.0%
Total	**142.35**	**18.648**	**16.321**	**34.969**	**24.6%**	**32.9**	**23.1%**	**2.1**	**1.5%**
% of total volume released into system		**13.1%**	**11.5%**	**24.6%**					

Based on the projected water saving targets, the LORWUA can achieve a 1.5% reduction in irrigation water losses relative to the 2012 levels in a relative short period (3 years and less).

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans and by revising the maintenance regime and algae control is some 2.1 million m^3/a.

For the long term a further 4.2 million m^3/a saving is envisaged by refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.

The priority water management measures to improve irrigation water use efficiency on the LORWUA include the following:

(i) *Incorporating the existing telemetry system with WAS*

(ii) *Expand WUEAR*

(iii) *Fully implement the Release Module of WAS*

(iv) *Ponding tests to establish canal seepage*

(v) *Revise maintenance procedures and actions during refurbishment periods*

(vi) Develop and implement a comprehensive Management Information System

(vii) *Investigate and implement incentive based pricing*

(viii) *Expand area of operation*

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 LORWUA.

The intention of the Water Management Plan not to burden the WUA 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 WUA 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 WUA 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 WUA 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. The identified measures for implementation should reduce the water losses from the current 24.6% to 20% of the total inflow into the irrigation scheme.

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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 Efficiency Accounting Report

GLOSSARY OF TERMS

Application efficiency	The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent.
Applied water:	Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries
Conduit:	Any open or closed channel intended for the conveyance of water.
Conservation:	Increasing the efficiency of energy use, water use, production, or distribution.
Consumptive use (evapo-transpiration)	Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called: Crop requirement, crop irrigation requirement, and consumptive use requirement.
Conveyance loss:	Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation and transpiration by plants growing in or near the channel.
Conveyance system efficiency:	The ratio of the volume of water delivered to irrigators in proportion to the volume of water introduced into the conveyance system.
Cropping pattern:	The acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops, 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 (trickle) irrigation: An irrigation method in which water is delivered to, or near, each plant in small-diameter plastic tubing. The water is then discharged at a rate less than the soil infiltration capacity through pores, perforations, or small emitters on the tubing. The tubing may be laid on the soil surface, be shallowly buried, or be supported above the surface (as on grape trellises).

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

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

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

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

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

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

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

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

Telemetry: Involving a wireless means of data transfer

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

1 INTRODUCTION

1.1 Background

Irrigation agriculture is the biggest water user in the South Africa using approximately 62% of the current water use nationally. With the increasing competition between existing user sectors, the available water cannot meet the demand under current water use practices and operating conditions in all water use 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 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.

1.2 Study Objectives

The primary objective of the study is the development and implementation of irrigation WMP for the LORWUA to improve water use efficiency. In order to achieve this objective, the development and implementation of the WMP to improve water use efficiency, the following aspects have to be considered:

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

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

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

1.3 Structure of this report

This report has been structured to first provide a perspective of the LORWUA 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 approach and methods used to determine the irrigation water budget and identify and evaluate water management issues with a view to developing a water management plan for LORWUA. This chapter also describes the assumptions and limitations to the available information.

Chapter 3 describes the catchment characteristics of the Olifants River catchment in which the LORWUA is situated. The chapter describes the history of the LORWUA, the scheduled quota and also describes the catchment and the current land-use practices in the catchment.

Chapter 4 describes the overview of irrigation in the LORWUA. The chapter also describes the background to the scheme, the institutional arrangements of the irrigation system, its infrastructure, the current operating rules, the cropping systems as well as the irrigation systems. It then describes the standards that can be adopted as appropriate for benchmarking of irrigation water use and management practices. The chapter then discusses the current water use situation by the irrigation sector including the sources of water supply for the climatic zones and irrigation systems used in the LORWUA.

Chapter 5 describes the water balance assessment as conducted based on the water use and compared with expected irrigation efficiency levels for the different irrigation systems. This chapter also provides the performance benchmarking of the irrigation sector when compared with the expected standards.

Chapter 6 of this report describes the existing water conservation and demand management measures that the irrigation sector is currently undertaking. These include irrigation rescheduling, high technology irrigation systems, etc. of water from the recovery dams as well as the current pricing for irrigation water use.

Chapter 7 then discusses areas of potential improvement in water use efficiency and the constraints that the irrigation sector faces. This is the strategic WC/WDM business plan for irrigation agriculture. The chapter also provides an estimate of the capital investment required to implement the strategy. It also provides the performance indicators for monitoring and controlling the implementation of the measures.

Chapter 8 provides a conclusion and recommendation for the irrigation sector.

2 CHARACTERISTICS OF THE OLIFANTS RIVER CATCHMENT

2.1 Overview

The Lower Olifants Water User Association is situated in the Vredendal/Koekenaap area and **Figure 2.1** provides a locality map. The Association is located within the Olifants-Doorn WMA. The major river in the WMA is the Olifants River, which rises in the Agter Witzenberg Mountains to the north of Ceres, with the Doring River as its major tributary. The mainstream of the river is some 250 km long, initially flowing through a steep narrow valley, but eventually widening and flattening into a wide floodplain downstream of Klawer. Most of the smaller streams of the Olifants River do not flow during summer but the main river is perennial, although summer flow is low. The flow in the Doring River is highly variable and seasonal, with the flow in the river ceasing for several days to several months each year. The catchment area upstream of the Clanwilliam Dam consists of natural mountain streams and rivers. The Jan Dissels River flows into the Olifants River below the Clanwilliam Dam, but upstream of the Bulshoek Weir.

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2.1.1 Climate and rainfall distribution

The Olifants/Doring Rivers water management area is situated along the west coast of South Africa, beside the cold Benguela sea current. The catchment is characterized by a Mediterranean climate with winter rainfall from May to the end of August. The summer months, November to February, are very warm and dry. The climate variation is extreme with summer temperatures reaching 45 °C in the Vredendal area and snowfall until mid-September in the Cederberg area. Rainfall varies from over 1 000 millimetres per year in the Cederberg mountains to less than 100 millimetres per year in the coastal areas.

2.1.2 Geology and soils of the catchment

The Upper Olifants River (E10A-G) rises in the Cederberg Mountains at the southern edge of the WMA and provides the most significant contribution to available water in the WMA. The Upper Olifants has a catchment of 2 888 km^2 which drains to the Clanwilliam Dam. The area is dominated by the Table Mountain Group which forms the high ridges of the Cederberg. TMG fractured-rock aquifers provide an important base flow contribution to surface water drainage.
The Lower Olifants River flows from Clanwilliam Dam for 24 km to the Bulshoek Weir, below which the Doring River (E33F-H) joins it and together they flow to the sea at the Olifants Estuary. The Lower Olifants has a catchment area of 8 216 km^2. The E33F-H catchments are underlain mainly by low-grade metamorphic schists, limestone and marbles of the Nama and Gariep Groups, locally overlain by aeolian, shallow-marine and alluvial terrace deposits. The E10J-K catchments are underlain by gently folded and faulted TMG units, with localized outcrops of lower Bokkeveld Group around Clanwilliam.

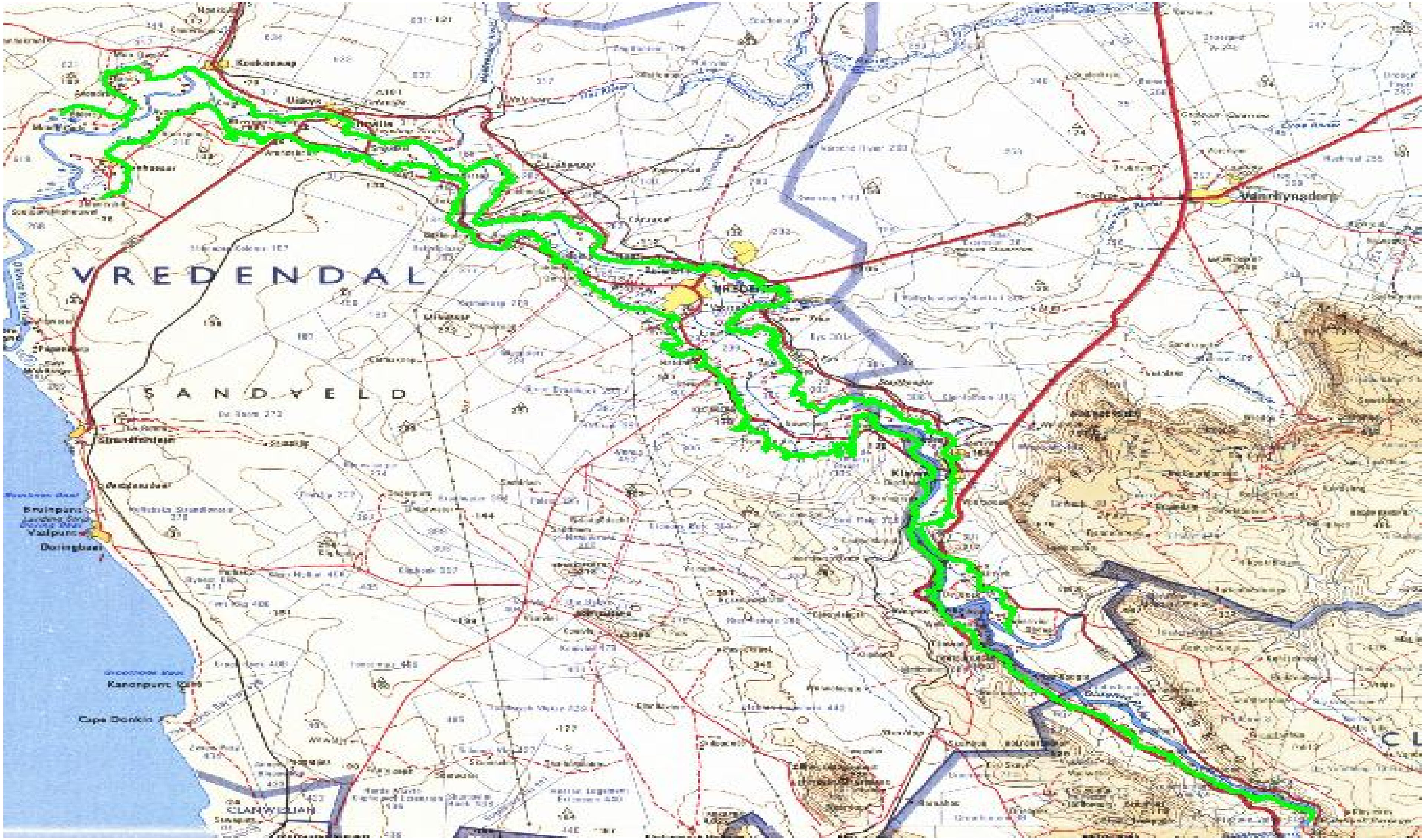


Figure 2-1 Location map of Lower Olifants WUA

2.2 History of the Lower Olifants WUA

The possibility to take water from the Olifants River for irrigation purposes was mentioned as far back as 1832 by Pastor Leipoldt during the construction of the mission at Ebenhaeser. Following various submissions and studies which led to nothing, local farmers took the initiative by installing a series of steam driven pumps, wind pumps and bucket bumps. By 1886 there were already three 6-horsepower pumps in use. Unfortunately due continues breakages of the pumps and the costs associated with the levelling of the fields, the enthusiasm began to dwindle.

In 1907 the Member of Parliament for Clanwilliam (Mr. DJA van Zyl) insisted that a previous proposal by a Mr. Gamble be implemented. After discussions it was decided that the then Director of Irrigation, Mr. CF Canthack should visit the area for final investigations. His report was submitted in 1909. Following the proclamation of the Olifants Irrigation District in 1911 an amount of 155 000 pounds was approved by Parliament and construction began in 1913.

Due to the first World War and the Flue of October 1918, progress was very slow. The construction of the wall (Bulshoek weir) and canal system was undertaken simultaneously and in 1920 the construction of the left bank canal down to the farm Bakleiplaas was completed. On 31 March 1920 the sluices were put into operation and the whole scheme was completed in 1924 at a cost of 601 568 pounds.

The Bulshoek Dam had an initial capacity of 6.55 million m^3 and some 8 500 hectares were included in the scheme and serviced by system of unlined canals extending down the Olifants Valley.

It was soon found that the Olifants River could not supply the scheduled irrigation area with sufficient water during the critical summer months. In 1935 the Clanwilliam Dam with a capacity of 69.86 million m^3, was built in the Olifants River, some 2 km from the town of Clanwilliam, to augment supplies to the area serviced by the Bulshoek Dam, which by then had increased to 9 114 hectares. The canals below Bulshoek were also improved (in some cases lined) to reduce losses.

In spite of the additional storage, periodic shortages were still experienced and in 1962 it was decided to raise the Clanwilliam Dam by 6.1 m, thereby increasing the capacity of the dam to 128 million m^3.

After the late 1960s, the Vredendal GWS managed the irrigation scheme. An advisory committee from the DWA was appointed to facilitate the transformation process towards a WUA and in 2000, the Lower Olifants River Water User Association became the first WUA to be formally established in South Africa. The constitution of the LORWUA was approved on 6 January 2000 by the Minister of the Department of Water Affairs and Forestry.

2.3 Water use permits / licenses and contracts

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

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

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

The categories of water users and the annual allocation are shown in Table 2-1.

Table 2-1: LORWUA - Water allocations

Water Use category	Annual allocation m^3
Commercial Farmers (9 510 ha)	116 022 000
Ebenhaezer Small Farmers (257 ha)	3 135 400
Emerging Farmers (240 ha)	2 928 000
Matzikama Municipality (7 towns)	8 351 000
Industries	3 200 000
TOTAL	**133 636 400**

The WUA has a total scheduled area of 10 007 hectares, at a scheduled quota of 12 200 m^3/ha/a which translates to a total allocation of 122.09 million m^3/a.

2.4 Irrigated areas and types of crops

Economic activity is based on commercial irrigated agriculture, and approximately 90 per cent (8 176 hectares) of the total water use goes for the irrigation of wine grapes, table grapes, tomatoes, citrus, deciduous fruit, and vegetables. The typical crop mix across the LORWUA is indicated in Table 2-2 below.

Table 2-2: Typical irrigated areas in LORWUA

Crop Classification	Crop type	Extent (ha)	Total (ha)	% of total
Permanent crops	Vineyards - Export	653	9 835	88
	Vineyards - Wine	7 892		
	Vineyards - Raisons	763		
	Lucerne	289		
	Other	238		
Cash crops	Tomatoes - Tunnels	40	1 349	12
	Tomatoes - Factory	369		
	Tomatoes - Market	183		
	Vegetables - Under netting	80		
	Vegetables - Open	677		
Total		***11 184***	***11 184***	***100***

Figure 2-2 illustrates the composition of the crops irrigated within the area of operation of the LORWUA.

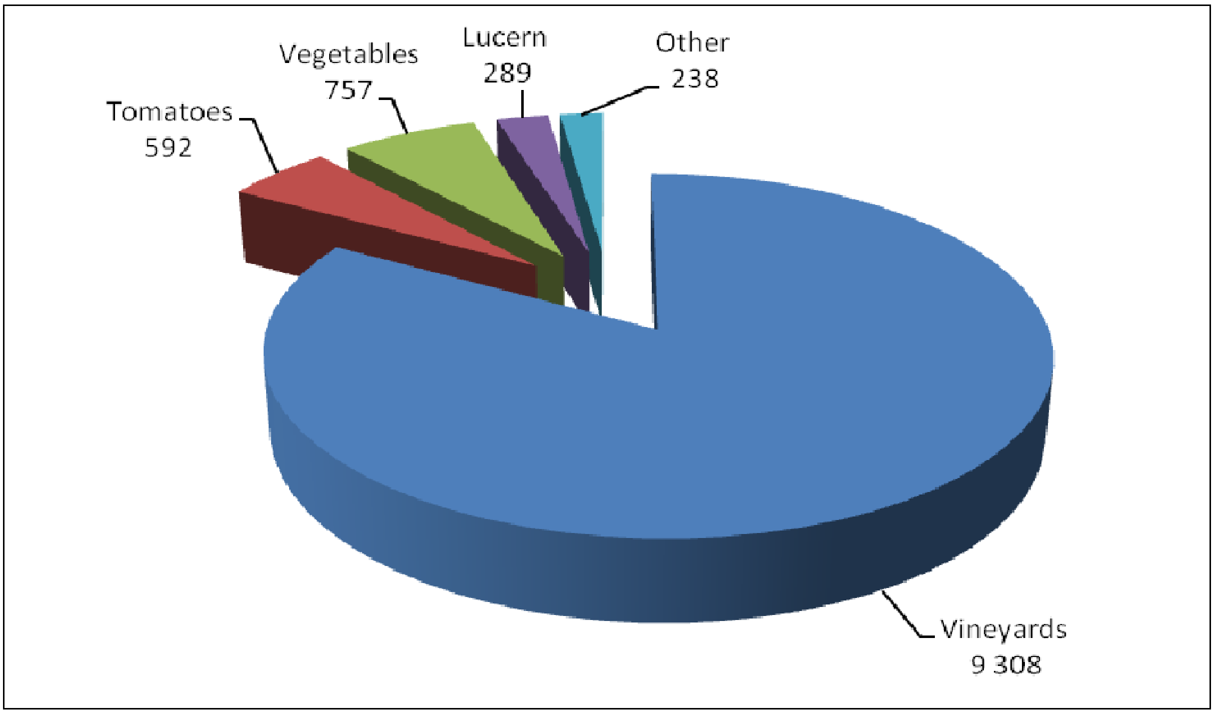


Figure 2-2: Crops under irrigation

2.5 Historic water use

The most recent three water years (2008/9 to 2010/11) demonstrate a range of water use in the LORWUA. Irrigation agriculture ranged from 91.9 million m^3/a in 2008/09 up to 100.1 million m^3/a in 2010/11 with a three-year average of 95.58 million m^3/a.

Industry was at its least in 2011/12 at 9.72 million m^3/a and peaked in 2009/10 at 10.28 million m^3/a. Domestic water use however remained more or less constant with an average of 1.87 million m^3/a

Table 2-3: Historic water use levels (m^3/a) for LORWUA

Water use sector	2008/2009	2009/2010	2010/2011	Average (m^3/a)	% of total requested
Agriculture	91 947 708	100 154 540	94 624 706	95 575 651	89.0
Industrial	9 757 179	10 275 949	9 721 136	9 918 088	9.2
Domestic	1 941 927	1 962 012	1 706 545	1 870 161	1.7
Total	*103 646 814*	*112 392 501*	*106 052 387*	*107 363 901*	*100*
% of irrigation quota used	81.8	89.1	84.2	85.0	

It was calculated in the water budget that the average total water diverted (released) into the LORWUA during the same three year period was 142 million m^3/a, with the range being 137.89 million m^3/a in 2010/11 up to 149.06 million m^3/a in 2009/10.

3 INVENTORY OF THE WATER RESOURCES INFRASTRUCTURE AND OVERVIEW

The LORWUA Scheme comprises of two main irrigation canal infrastructures, a left and a right bank. Initially the canal follows the left bank of the Olifants River from the Bulshoek Dam to where the Doring River joins the Olifants River. From there the canal splits into the left bank canal (southern side) and the right bank canal (northern side). Both canals follow the banks of the Olifants River and cross the tributaries with siphons.

3.1 Bulshoek Dam

The construction of the Bulshoek Dam and canal system was undertaken simultaneously and in 1920 the construction of the left bank canal down to the farm Bakleiplaas was completed. On 31 March 1920 the sluices of Bulshoek Dam were put into operation and the whole scheme was completed in 1924 at a cost of 601 568 pounds. The Bulshoek Dam had an initial capacity of 6.55 million m^3 and some 8 500 hectares were included in the scheme and serviced by system of unlined canals extending down the Olifants Valley.

Photo 3-1: Bulshoek Dam wall

3.2 Clanwilliam Dam

The Clanwilliam Dam in the Olifants River is situated some 3 km from Clanwilliam. As irrigation development progressed along the Olifants River lower down, the water-supply obtained from the Bulshoek Dam, 24 km below Clanwilliam, became inadequate, and the Clanwilliam Dam was built by the Department of Water Affairs during 1932-35 at a cost of £211,000 to augment the supply. It is a concrete overspill structure 38 metres above foundation level with a capacity of 69.86 million m^3 and a surface area of 786 hectares at full supply lever.

Picture 3-1: Clanwilliam Dam: June 1936 (DWA)

In spite of the additional storage and canal improvements, periodic shortages were still experienced and in 1962 is was decided to raise the Clanwilliam Dam by 6.1 metres. During the raising of the dam which took place between 1964 and 1966 the overspill crest was raised by 3.05 metres and 13 crest gates with a height of 3.05 meters were installed. This increased the design capacity of the dam to 128 million m^3.

Picture 3-2 : Clanwilliam Dam : Present

The mass gravity concrete structure is 43 m high and the maximum discharge capacity of the two bottom outlet pipes is approximately 10 m^3/s

3.3 Irrigation conveyance infrastructure

Currently, the scheme consists of the Clanwilliam Dam (122 million m^3) on the Olifants River, with the Bulshoek Dam (5.2million m^3) lower downstream, approximately 260 km main canal and 40 km of smaller branch canals. The main canal starts at Bulshoek Dam and runs along the left bank of the Olifants River until it splits in two with a raised siphon over the Olifants River to the right bank, close to Klawer. From the split, there is a canal on both banks of the Olifants River up to Ebenhaezer and Olifants River settlement areas respectively. At the end of the canals there are various balance dams to manage the water optimally and to keep wasted water to the minimum.

Figure 3.1 below provides the conveyance and distribution infrastructure of the LORWUA. Water is released from the Bulshoek Dam into the left bank canal which follows the Olifants River to where the Doring River joins the Olifants River. The canal splits into the left bank canal and right bank canal. Both canals follow the banks of the Olifants River and cross the various tributaries of the Olifants River with siphons.

The length of the left bank canal is approximately 125.5 km while the right bank canal has a length of 111.8 km. The scheme is divided into nine sections with four sections on the left bank canal and five sections on the right bank canal. Each water ward has a ward manager who is responsible for the water distribution management of the specific ward. The canal infrastructure comprises of secondary canal systems, sluices, long weirs, siphons, side spillways, tunnels and pipes. Water is delivered to the farmers through sluices which are set on a daily basis. The standard sluice in the canal system comprises of a 300mm by 300mm plate covering a 300 mm diameter pipe mouth or orifice. The sluice gates are fitted with long handles and locked in place to allow flow through the partly opened orifice.

The dam setting is changed on a six 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 different canal sections within the distribution network are presented in Table 3-1.

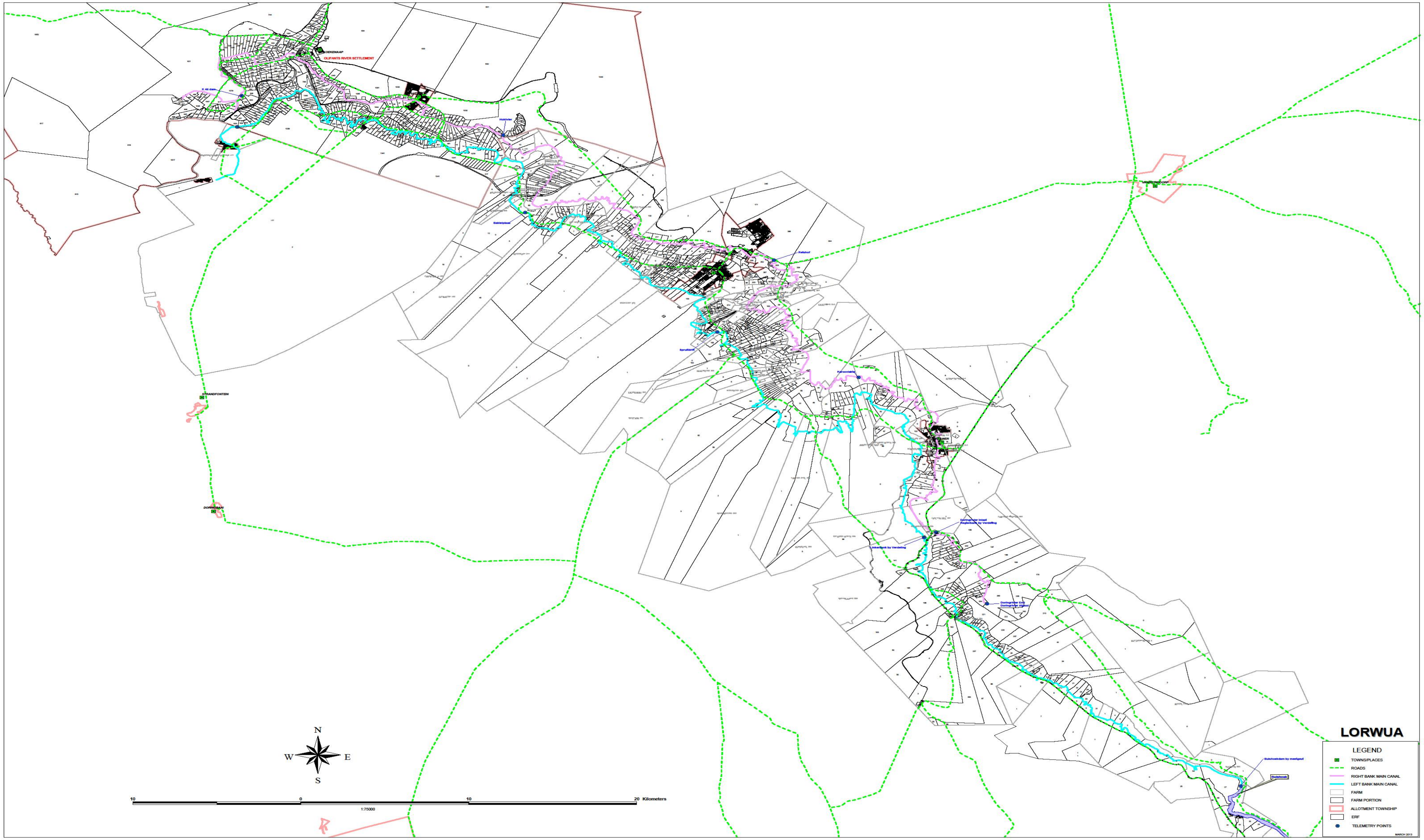
Table 3-1: Canal sections

River Bank	Location	Section name	From sluice	To sluice	Approximate length (km)
Left	From Bulshoek to division	Trawal	M0	M24	32.6
	From division to Ebenhaeser	Naauwkoes	L25	L63	38
		Vredendal	L64	L119	22.5
		Sandkraal	L111	L151	32.4
Right	From division to Koekenaap	Klawer	R 0	R 16	18.3
		Karoovlakte	R 17	R 47	23
		Retshof	R 48	R 85	31.1
		Koekenaap	K0	K46	30.7
	From division to end of Doring River canal	Doring River	DO	D15	8.7

A map indicating the various canal sections and scheme layout is included in **Annexure A**.

Due to limited construction methods (early 1900's) and compaction of the underlying soils, the longitudinal slope is not constant and various low points are formed in the canals. These low points accumulate sediment and do not drain properly, leaving standing water of up to 400 mm deep at certain sections.

Figure 3-1: LORWUA Infrastructure



3.4 Irrigation storage and regulation system

Three scheme balancing dams are located on the Left and Right bank canal respectively. Table 3-2 provides basic information for these dams. The balancing dams decrease the pressure on the canal system and allows for shorter delivery periods to water users. They also intercept any surplus water in the system and act as backups to fill up any shortages.

Table 3-2 Scheme balancing dams

Dam	Location	Full capacity (m^3)
L140 - Sandkraal	Left bank	4 500
L 143 - Sandkraal	Left bank	9 000
Ebenhaeser dam - Sandkraal	Left bank	136 334
K 25 - Koekenaap	Right bank	2 400
K 35 - Koekenaap	Right bank	2 400
K 46 - Koekenaap	Right bank	2 400

3.5 Flow Measurement and telemetry system

3.5.1 Measurement of flow into and out of the Scheme

Measurements of flow within the scheme are done through various structures and flow measurement stations in the canal system. The following structures are utilised:

Broad crested weirs

Parshall flumes

Parshall flumes are the most common method used in the canal system. It is well defined and has limited flow measurement errors if built properly

Cipoletti weirs

Mainly are used for silt collection near the crest, these weirs are not as accurate as Parshall flumes and errors can be as high as 10%. They also tend to cause large head losses and are inaccurate when submerged.

Short crested weirs

Some of the long weirs in the canal system are also utilised as measurement structures and the height vs. flow curves and tables for these structures vary according to the in-situ calibration of the structure

Sharp crested weirs

The V-notch and rectangular notch are used for flow measurement of the discharge of water to the various users. These sharp crested weirs are widely used and have good accuracy. It is however important to ensure that all sharp-crested weirs are sufficiently aerated.

Table 3-3 summarises the existing flow measurement structures.

Table 3-3: Existing flow measurement structures

Name	Type of structure
Bulshoek	Parshall flume
Left Bank	Crump weir
Naauwkoes	Side weir
Vredendal	Side weir
Sandkraal	Crump weir
Right bank	Measure plate
Karoovlakte	Side weir
Retshof	Side weir
Koekenaap	Side weir
Holrivier	Measure plate
Trench K	Parshall flume
Doringrivier	Measure plate

The Parshall flumes in the canal system are well defined and following the study by Element it was established that the existing flow measurement tables compares very well with the theoretical formula for the different flumes.

The first measurement takes place at the Bulshoek Dam where a telemetry system is used to measure the total volume of water released into the LORWUA. A Base System is located at the offices of the LORWUA in Vredendal and consists of a base computer, which holds the central database to store and convert all of the data received from the Remote Telemetry Units together with an antenna to receive from and transmit data to the remote telemetry systems.

The total flow of water is also measured through the use of telemetry systems at the beginning of each canal section/ward. A schematic layout of the telemetry system is presented in Figure 3-2.

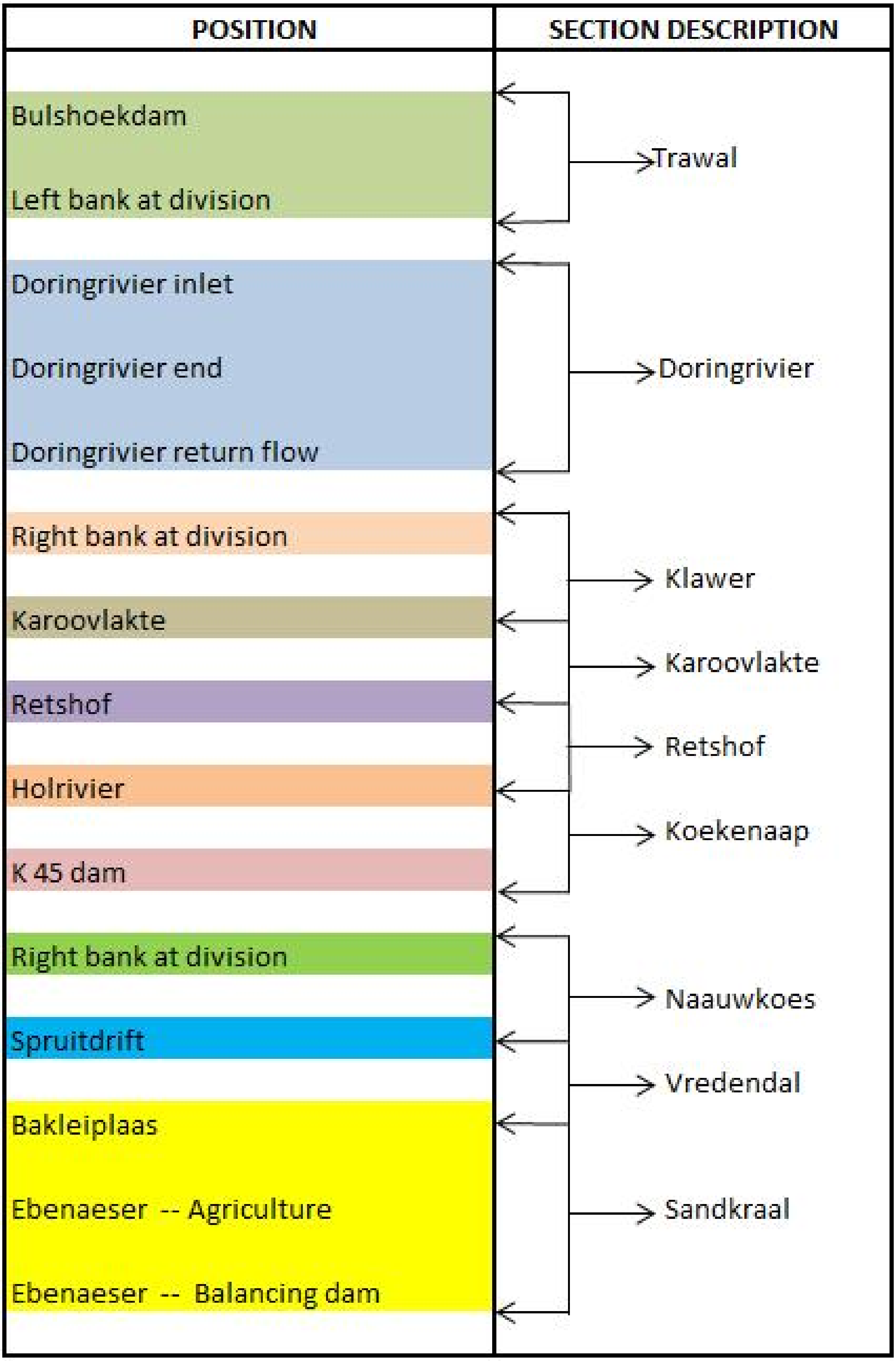


Figure 3-2: Telemetry system

Photo 3-2: Sharp-crested measurement structure for Koekenaap section

4 INFRASTRUCTURE CONDITION ASSESSMENT

4.1 Overview

During 2003 a complete canal survey was undertaken by Element Consulting Engineers following their appointment by LORWUA. The survey was undertaken between 23/09/2003 and 03/10/2003. The canal was drained during this maintenance period. The survey of the smaller trenches was done at a later stage (06/02/2004 to 08/02/2004), while they were in operation.

The following section provides the results of the infrastructure condition assessment.

4.2 Canal Condition Evaluation

During the investigation the following typical defects were identified:

- Rough surface finish to wall and floor areas
- Exposed aggregate on the walls and floor areas
- Panels of the canal that sagged or bulged due to movement of the supporting soil
- Patch and repair work that were previously done, which became loose from the canal
- Defects at wall and floor joint
- Unstable embankments on the side of the canal
- Vegetation growth that undermine the structural capacity of the canal

4.3 Descriptions of defects

4.3.1 Defects to concrete surfaces

During the investigation the following typical defects to the canal floor and walls were found:

- About 80% of the total surface areas were found to have a rough finishing texture.
- About 50% of the rough surface indicated exposed aggregate and at some areas a 100% exposure was noted.
- About 5% of the walls were cast uneven.
- At some areas the wall panels were either slightly pushed into the canal due to vegetation and tree roots behind the panels or sagged down into the eroded backfilling due to excessive surface and ground water.
- About 50% of the plasterwork on the walls was loose and in a bad condition.
- About 50% of all the previous patchwork became loose.
- A few areas of newly applied patchwork were also found.

- At some sections the top part (300mm) of the previously extended walls broke away due to vegetation behind the walls.
- Some of the floor areas could not be investigated properly due to water and mud covering the floor.
- Structural cracks in the walls and floor slabs were noted at various areas as well as minor crack patterns in the plasterwork of the walls.

4.3.2 Defects to expansion joints

The following structural defects at expansion joints in the wall and floor were noted:

- Damaged or disintegrated sealant in the joints causing seepage of ground water to enter the empty canal, or leakage of canal water to the backfill material behind the walls causing erosion.
- Where joints were repaired previously, the surface preparation was not done properly leading to patchwork becoming loose after a while.
- About 80% of the patchwork applied to the wall joints were never cut through at the joint positions thus the reason for the cracks occurring at the joints.

4.3.3 Backfilling behind canal walls and under canal floors

At various places along the canal erosion of the backfill behind the walls and under the floors was found. This indicates that when the canal is empty groundwater seeps through the defect joint and when the canal is used the canal water leaks out at the joints causing erosion to the backfill material.

Another possible reason for the erosion of the backfill material could be insufficient or poor compaction of the fill material during the construction of the canal.

4.3.4 Vegetation and embankments next to the canal

On certain sections of the canal unstable embankments next to the canal exists. This causes soil and rocks to fall into the canal, damaging and obscuring it. On other sections vegetation and trees grow on the embankment next to the canal. The roots of the vegetation and trees grow into the canal at the defected joints. This leads to cracking and spalling of the walls.

4.3.5 Defects in tunnels

The following structural defects in the tunnels were found:

- Exposed aggregate on 80% to 100% of the wall and floor areas of the tunnels occurred.
- The roof of the tunnel between stake value 21 366 and stake value 21 573 of the Retshof canal section had collapsed previously but the canal was cleared from the collapsed material.

4.3.6 Defects at siphons

The following table shows the general characteristics of the siphons investigated:

Table 4-1: Siphons in LORWUA Canal System

SIPHON	SECTION	SLUICE	DESCRIPTION	APPR SV	LENGTH	DIA
Left	Naauwkoes	L25A	Flat siphon	1600	63.3	1.3(h)x1.6(w)
Left	Naauwkoes	L44	Kanaalwaghuis	23500	68.7	1.8
Left	Naauwkoes	L47	Ouplaas	28000	250.7	1.2
Left	Vredendal	L109	Bakleiplaas	21400	143.6	1.2
Left	Sandkraal	L129	A Swartz	14000	168	1
Left	Sandkraal	L131	C Visser	15100	126.6	?
Left	Sandkraal	L140B	Bloukrans	24200	371.3	1
Right	Split	R 1	Verdeling	0	681	1.7
Right	Klawer	R 11	C Ryk	11700	323.8	1.6
Right	Karoovlakte	R 44	Kleinrivier	20100	1068.5	1.6
Right	Koekenaap	KO trench	Holrivier	100	390.7	1.4
Right	Koekenaap	K21	Hoekklip	18250	681.3	1.05
Doring	Split	0	Verdeling	0	675.2	Small
Doring	Doring River		Glypan	1100	131.9	0.8
Doring	Doring River		Eureka	3750	126	0.8
Doring	Doring River		Hetsluis 1	4200	132.4	0.8to2x0.4
Doring	Doring River		Hetsluis 2	4700	133.1	1x0.6+1x0.5
Doring	Doring River		End of Doring	8000	677.8	0.47

Since the siphons are approximately 80 years old and the scour valves, if installed, do not function properly, access to siphons were not always possible. Hence assessments on the condition of the siphons had to be made by means of a visual inspection at the ends, as well as other symptoms, such as leaking, cracks, etc.

In some cases, no access was available and therefore no assessment was possible. The following table shows the general characteristics of the siphons investigated.

Table 4-2: Condition assessment of siphons

Description	Condition
Flat Siphon	• The Flat Siphon has a comprehensive longitudinal crack, resulting in severe leaking and requires repair. • The aggregate is partly exposed at the outlet and requires repair. • The scour is not functional and requires repair.
Kanaalwag-Huis Siphon	• Shows little sign of leakage. • Exposed aggregate at inlet requires repair. • Scour is not functional and requires attention.
Ouplaas Siphon	• Rehabilitated in 2006.
Bakleiplaas Siphon	• Siphon is generally in a reasonable condition. • Exposed aggregate at inlet requires upgrading.
A Swarts Siphon	• Scour valve and pipe requires attention. • Cracks in existing fibreglass lining results in extensive leaking (see vegetation on photographs).
C Visser Siphon	• Siphon is in reasonable condition. • Scour requires proper routing away from siphon.
Bloukrans Siphon	• Siphon is generally in good condition. • Scour requires attention.
Olifantsriver Siphon	• Rehabilitated in 2008.
Klawer: C Ryk Siphon	• Siphon shows no visible leakage. • Scour requires attention.
Klein River Siphon	• This siphon has been rehabilitated in 2001 and is in good condition.
Hol River Siphon	• Rehabilitated in 2004.
Hoekklip Siphon	• Siphon shows visible leakage at previous repairs; requires upgrading. • Exposed aggregate at outlet requires upgrading.

4.3.7 Critical sections of the canal network

LORWUA identified certain sections of the canal as critical sections. Maintenance of these sections is prioritised because of the associated risk involved should a failure in the canal occur. Due to the topography of the area, these sections of canal are situated on embankments and should a section of canal fails, the embankment and adjacent orchards would be subjected to flooding and erosion. Table 4-3 indicates the critical sections of the canal.

Table 4-3: Critical canal sections

SECTION	APPROXIMATE STAKE VALUE OF CRITICAL SECTION	LENGHT OF CRITICAL SECTION (m)
Trawal	0 – 3 000 27 500 – 32 500	3000 5000
Klawer	0 – 3 000 15 400 – 18 000	3000 2600
Naauwkoes	4 000 – 4 300 7 500 – 8 800 11 000 – 15 000	300 1300 4000
Karoovlakte	8 750 – 12 250 16 500 – 17 750	3500 1250
Retshof	1 000 – 3 000 6 000 – 9 500 18 000 – 31 000	2000 3500 13000
Vredendal	15 500 – 16 600 21 000 – 22 400	1100 1400
Sandkraal	800 – 1 100 1 500 – 3 000 4 500 – 5 500 12 000 – 19 500 22 500 – 26 500 27 600 – 28 500	300 1500 1000 7500 4000 900
Koekenaap	9 000 – 11 200 12 500 – 16 000	2200 3500

5 SCHEME OPERATIONS AND OPERATING PROCEDURES

5.1 General scheme options

The LORWUA employs full time employees and oversees the day-to-day management of the Scheme. The Clanwilliam Dam is operated and managed by the DWA and it is the Department's responsibility to determine the annual water quota based on the amount of water in the dam. This total annual quota for the water year, which runs from October to September, 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 extreme weather conditions, such as droughts.

The capacity of the canal is also not sufficient and the WUA can only supply between 60% and 70% of the water during peak seasons.

Every irrigation farmer submits a request to the scheme administrators every Wednesday for the water requirement of the following week. It is the responsibility of the ward managers to add up all the irrigation requests and then submit a request to the Department of Water Affairs who then release the total required amount of water from the Bulshoek Dam into the canal system. The ward managers then open each farmer's sluice gate to the appropriate height according to the request for water.

The LORWUA Board consists of 16 members and the current profile of the membership of the Lower Olifants River Water User Association is as follows:

- **Commercial farmers:** use water for irrigation, livestock and their own domestic use. (eight representatives)
- **Emerging farmers** – use water for irrigation and livestock. Lack of financial support, land closer to water and water rights. (one representative)
- **Ebenhaezer Small Farmers** – This community is situated at bottom part of the canal and consists of 153 small farmers with 257 ha water. (One representative + one secundi)
- **Industries –** There are two major industries. Namakwa Sands extracting minerals from sands dunes on the West Coast that uses mainly sea water on site. The WUA supply untreated water mainly on their big plants. Cape Lime, near the town Vredendal, uses water from the system. Other includes six wine cellars. (two representatives)
- **Municipalities –** Bulk water is supplied to 8 towns namely: Klawer, Vredendal, Vanrhynsdorp, Lutzville, Koekenaap, Strandfontein, Doringbaai and Papendorp. All fall under the Matzikama Municipality. (two representatives)
- **Individual water users –** This group includes farm workers (two representatives)

The Board is accountable to the members who elect 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 WUA members and for the members to raise issues with the

Board. The WUA, the Chairman of the Board and other councillors are however at the members' disposal at any time 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. The purpose of these meetings is to discuss management and operational issues and to ensure the efficient running of the WUA.

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. As yet little progress has been made along the Olifants River with regard to the calculation of the reserve and, therefore, this has not yet made an impact on the LORWUA. The calculation of the ecological reserve is the function of the DWA, who will then be required to inform the WUA of any changes to their abstraction rights 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 LORWUA 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 1 415 abstraction points along the canal systems.

Two water quotas are used in the LORWUA, namely, a yearly quota and a weekly quota. The weekly quota is equal to 325 m^3/ha/week for all irrigators. No irrigator is allowed to request more than the weekly quota and no substitution between weeks is allowed (i.e. an irrigator is not allowed to receive 250 m^3/ha one week and 400 m^3/ha the next week), because the canal capacity does not allow such substitutions.

The annual quota theoretically entitles all registered irrigation users in the LORWUA to up to 12 200 m^3/ha, however the actual annual quota is determined annually after the rain season during October/November and is approximately only 50% of the quota due to the capacity of the canal.

Lower Olifants River WUA uses a 6 hourly distribution and a "rolbeurt" (revolving turn) system which has been added to WAS. According to the “rolbeurt” system farmers are not allowed to order water with the same starting day every week. The starting day is rolled over to the next day in the following week. The reason for this is to put the maximum amount of water into the canal without exceeding the MAR and not to supply water on weekends to the same user over and over.

The total scheme is divided into 7 wards (Trawal, Klawer and Doring River are handled as one ward) with a water control officer responsible for each ward. The water orders are captured every Thursday in WAS by the various water control officers. The 6 hourly distribution sheet is then generated which is used to determine the release and settings for a number of control points at the start of each section/ward.

LORWUA call their 6 hourly distribution sheet a "bokvel" which is compiled every week once all the water orders for the following week have been received. The "bokvel" is a giant spreadsheet with the different off-takes and delivery points in each row. Each column represents 6 hours of a specific week. The columns are then added up to get the totals for all the delivery points in the canal network. The 6 hourly totals of each delivery point are then checked to see if it exceeds the maximum abstraction right at that point in the canal. If it does the ward manager will "move" the water of certain abstractions 6 hours to the left or to the right until the maximum abstraction right is ok.

5.3 Water trading - Temporary water transfers

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

- The current rules of the LORWUA regarding the temporary transfer of water are as follows:
- No water can be permanantly transferred between the left and right bank canals
- Only when an irrigator has exhausted the allocated water at a specific sluice can water be transferred
- No water will be transferred down-stream during periods of high demand
- Irrigation water will only be transferred if the allocated water of that specific sluice has been exhausted
- Water will only be transferred from the area above Bulshoek dam if it can be proved that that water is redundant and that there is sufficient capacity in the canal to accommodate the requested transfer with the permission of the Clanwilliam WUA
- No additional MAR will be created with transferred water
- Transfer of water between two sluices can only happen if both are in the same immediate vicinity
- Transfer can only take place if it is requested on the required form

5.4 Water pricing structure

5.4.1 Setting of the irrigation pricing

The LORWUA incurs a number of expenses relating to the maintenance and refurbishment of the canal systems and the administration of the scheme. The present cost of water for the various users is given in Table 5-1.

Table 5-1: Water tariffs

Water use sector	Tariff
Agricultural water	R 2 658.47/ha/a
Domestic water – “waterkas”	R 257.00/kas/month
Domestic water (Pensioners) – “waterkas”	R 62.00/kas/month
Industrial use	R 0.7644/m^3
EKB	R 196.35/ha/a

6 LORWUA 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 Bulshoek Dam where water is released from the dam into the irrigation canal. Weekly records of the inflows into the main canal at the Bulshoek Dam wall were evaluated. The records were aggregated into monthly records. Monthly records from 2008/09 water year to 2010/11 water year were generated as illustrated in Table 6-1 below.

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 different sluice gates. Due to the pressure variance in the canal system there is a margin of error in the volume of water delivered to the water user and water users are requested to accept a margin of error of 10%. The monthly data on releases at the individual sluices and parshalls were aggregated to provide records of consumptive use by the irrigators.

Records of weekly deliveries to other water users especially in the industrial sector were included in the consumptive use.

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 either committed or non-committed outflow.

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

Uncommitted outflow is regarded as a water loss and 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 WUA, the water budget for the LORWUA 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 LORWUA were provided on a weekly basis.

The outflows consist of all the ways that water is removed from 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 LORWUA area varies from year to year. Although the cropping pattern remains similar, users will plant more cash crops in a good year when the quota is higher.

Table 6-1: Water budget

Month	Releases from dam (m3)	Total demand (m3)	Total loss	
			(m3)	%
Oct-08	8 055 214	6 393 027	1 662 187	20.6
Nov-08	13 113 612	10 338 933	2 774 679	21.2
Dec-08	16 316 094	12 158 030	4 158 064	25.5
Jan-09	16 690 194	12 200 079	4 490 115	26.9
Feb-09	17 283 960	12 483 780	4 800 180	27.8
Mar-09	20 887 938	13 214 016	7 673 922	36.7
Apr-09	13 680 426	9 547 133	4 133 293	30.2
May-09	8 573 448	6 473 075	2 100 373	24.5
Jun-09	4 316 592	3 490 033	826 559	19.1
Jul-09	4 115 888	3 662 397	453 491	11.0
Aug-09	6 597 649	5 545 377	1 052 272	15.9
Sep-09	10 410 810	8 140 934	2 269 876	21.8
Oct-09	9 943 458	8 022 011	1 921 447	19.3
Nov-09	17 504 220	12 418 550	5 085 670	29.1
Dec-09	16 890 390	12 320 747	4 569 643	27.1
Jan-10	21 245 712	15 886 780	5 358 932	25.2
Feb-10	17 267 580	12 593 381	4 674 199	27.1
Mar-10	15 151 404	10 692 949	4 458 455	29.4
Apr-10	14 027 578	10 715 985	3 311 593	23.6
May-10	5 670 474	4 872 070	798 404	14.1
Jun-10	3 365 190	2 650 899	714 291	21.2
Jul-10	7 269 774	4 845 307	2 424 467	33.3
Sep-10	14 534 726	11 524 750	3 009 976	20.7
Oct-10	10 407 120	7 896 802	2 510 318	24.1
Nov-10	13 641 522	10 632 325	3 009 197	22.1
Dec-10	11 686 338	8 592 873	3 093 465	26.5
Jan-11	20 364 234	16 315 606	4 048 628	19.9
Feb-11	16 225 002	12 225 388	3 999 614	24.7
Mar-11	15 415 746	11 789 562	3 626 184	23.5
Apr-11	13 392 468	10 529 474	2 862 994	21.4
May-11	3 364 422	2 226 635	1 137 787	33.8
Jun-11	5 957 640	4 098 424	1 859 216	31.2
Jul-11	5 744 146	3 903 724	1 840 422	32.0
Aug-11	6 575 995	5 436 395	1 139 600	17.3
Sep-11	15 123 750	12 405 179	2 718 571	18.0
Oct-11	8 345 000	10 622 000	2 277 000	21.0
Nov-11	10 447 000	12 654 000	2 207 000	17.0
Dec-11	12 206 000	16 511 000	4 305 000	26.0
Jan-12	15 658 000	21 491 000	5 832 000	27.0
Feb-12	12 556 000	16 554 000	3 998 000	24.0
Mar-12	11 122 000	14 473 000	3 351 000	23.0
Apr-12	11 130 000	13 453 000	2 323 000	17.0
May-12	1 903 000	2 820 000	918 000	32.0
Jun-12	2 662 000	3 771 000	1 108 000	29.0
Aug-12	2 856 000	4 389 000	1 532 000	34.0

6.6 Losses

6.6.1 Overview

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

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

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

An irrigation water budget was developed for the LORWUA. The water budget was 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 LORWUA were provided on a weekly basis.

Rainfall has not been included as inflow in this water budget.

The outflows consist of all the ways that water is removed from 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 Oct 2008 to Sep 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 end of canal outflows). It therefore reflects the difference between the volume that was ordered by the water users and the volume of water released into the inlet of the main canal.

Table 6-2: LORWUA - Historical monthly losses

Month	Total losses (m^3)	% of volume released
Oct-08	1 662 187	20.6
Nov-08	2 774 679	21.2
Dec-08	4 158 064	25.5
Jan-09	4 490 115	26.9
Feb-09	4 800 180	27.8
Mar-09	7 673 922	36.7
Apr-09	4 133 293	30.2
May-09	2 100 373	24.5
Jun-09	826 559	19.1
Aug-09	1 052 272	15.9
Sep-09	2 269 876	21.8
Oct-09	1 921 447	19.3
Nov-09	5 085 670	29.1
Dec-09	4 569 643	27.1
Jan-10	5 358 932	25.2
Feb-10	4 674 199	27.1
Mar-10	4 458 455	29.4
Apr-10	3 311 593	23.6
May-10	798 404	14.1
Jun-10	714 291	21.2
Jul-10	2 424 467	33.3
Sep-10	3 009 976	20.7
Oct-10	2 510 318	24.1
Nov-10	3 009 197	22.1
Dec-10	3 093 465	26.5
Jan-11	4 048 628	19.9
Feb-11	3 999 614	24.7
Mar-11	3 626 184	23.5
Apr-11	2 862 994	21.4
May-11	1 137 787	33.8
Jun-11	1 859 216	31.2
Jul-11	1 840 422	32.0
Aug-11	1 139 600	17.3
Sep-11	2 718 571	21.0
Oct-11	2 277 000	21.0
Nov-11	2 207 000	17.0
Dec-11	4 305 000	26.0
Jan-12	5 832 000	27.0
Feb-12	3 998 000	24.0
Mar-12	3 351 000	23.0
Apr-12	2 323 000	17.0
May-12	918 000	32.0
Jun-12	1 108 000	29.0
Aug-12	1 532 000	34.0

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

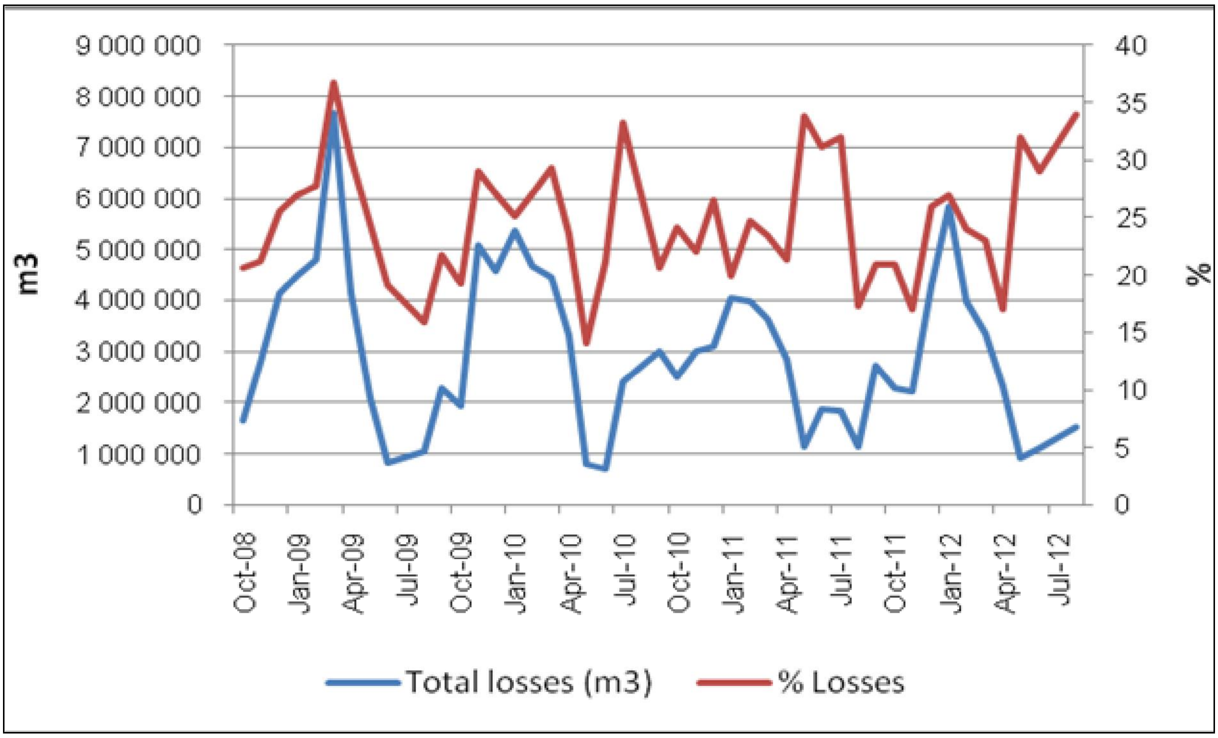


Figure 6-1: LORWUA - Historical canal losses

The **average** water losses have been 24.7% of the released water from the dam into the canal system. This translated to an **average** of approximately 34.97 million m^3/a water losses in the LORWUA area. This volume mainly refers to the water losses that are difficult to measure including the unavoidable water losses as well as some of the avoidable losses. These include canal evaporation losses, seepage in the primary canals and distribution canals, percolation, leakage and start-up and shut-down losses, sudden drop in demand (rainfall). Most of the tail water is captured in balancing dams for redistribution and return flows are therefore shown as 0%. The tail water of the Doring River Canal is not measured.

Figure 6-2 indicates the monthly comparison between the supply and demand from October 2008 to August 2012.

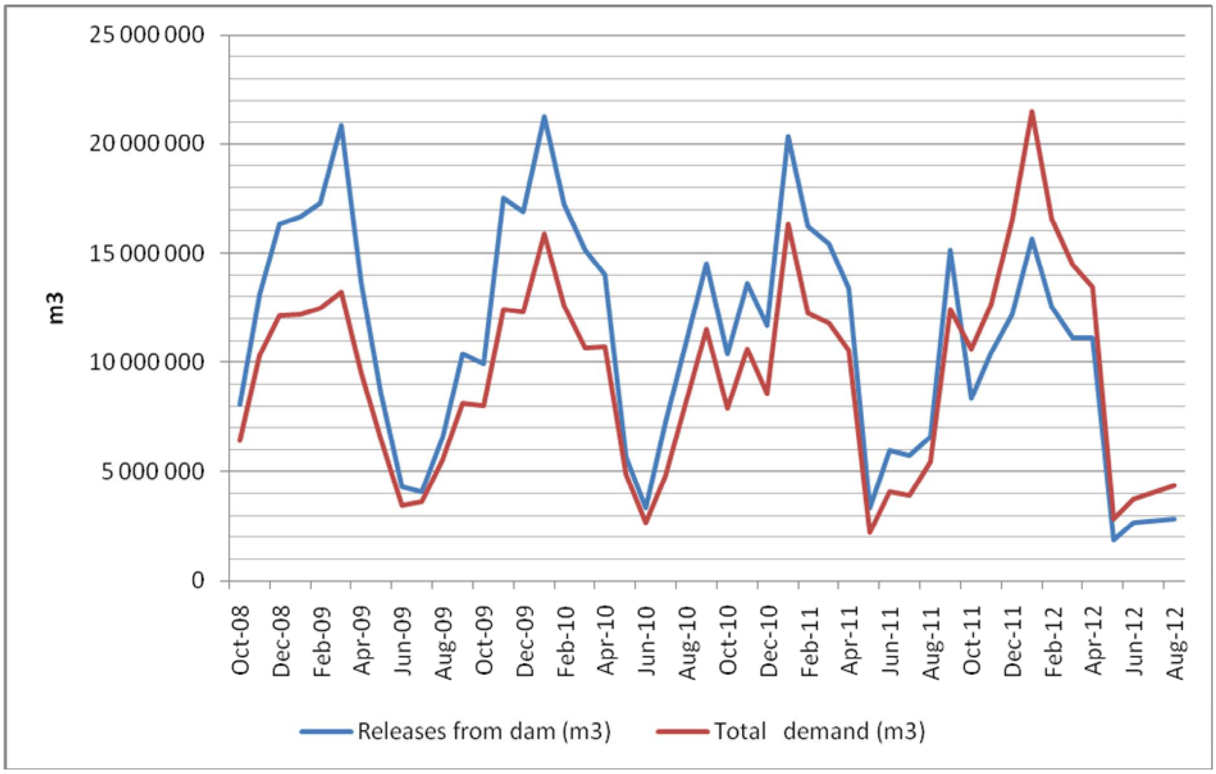


Figure 6-2: Monthly releases vs demand

6.6.3 Conveyance losses

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

Unavoidable losses

Unavoidable losses takes place on a continual basis and the bulk of unavoidable losses are made up of seepage losses, evaporation losses and also filling losses after dry periods.

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 the LORWUA 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, amount of sediment, etc.

For the LORWUA, ten hydraulic sections were chosen to determine the seepage losses and the detail of these sections is provided in Table 6-3.

Table 6-3: Detail of hydraulic sections

Hydraulic section	Length (m)	Wetted perimeter (m)
Trawal	32 632	8.55
Naauwkoes	33 011	7.02
Naauwkoes - Vredendal	11 888	5.4
Vredendal - Sandkraal	21 400	4.56
Sandkraal	26 570	3.66
Klawer - Karoovlakte	29 826	4.91
Karoovlakte - Retshof	12 398	6.68
Retshof	30 592	4.82
Koekenaap - 1	14 907	4.24
Koekenaap - 2	15 229	3.81
Doringrivier	8 657	2.38

The seepage losses on the LORWUA canal system represents 13 % of the total volume released into the system.

6.6.3.2 Evaporation losses

Evaporation data was used to estimate the average monthly evaporation as part of the water balance for the different canal sections. For the purposes of the water balance it was assumed that the evaporation is 6.2 mm/day for the exposed water surface area in the canal. This represents 1.0% of the total flow in the canal system.

6.6.3.3 Operational wastage:

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

6.6.3.4 Leaks and Spills:

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.

Figure 6-3: Canal break

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 WUA aims to operate the system within a range of 35% to 85% of the design capacity, the water demand during peak periods, sediment and weed/algae growth necessitates periodic operation of the system at 110% of the design capacity, resulting in high leakages and spills.

Figure 6-4: Flooding of canal

6.6.3.5 Aquatic weeds and algae:

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

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

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

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

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

(v) Water logging of long-weirs occurs.

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

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

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

Table 6-4 provides a summary of the various losses on the canal distribution network of the LORWUA. The figures are based on the averages over the three water years (2008 to 2011). It is important to note that not all of the categories included in the table are shown on the WUEAR. Some of the values are estimations and are based on information obtained during discussions held with the management of the WUA.

Table 6-4: LORWUA - 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	18.2		18.200	52.0
Evaporation	0.448		0.448	1.3
Filling losses		16.321	16.321	46.7
Leakages				
Spills				
Over delivery to users				
Canal end returns			0	0.0
Other			0	0.0
Total	**18.648**	**16.321**	**34.969**	**100.0**
% of Total losses	**53.3**	**46.7**	**100.0**	
% of total released into system	**13.1**	**11.5**	**24.6**	

From the data presented in **Table 6-4** it is evident that the total losses on the scheme amount to 24.6% (*13.1% unavoidable and 11.5% avoidable*). In terms of total losses occurring on the scheme, 53.3% can be classified as unavoidable losses while 46.7% or approximately 16.3 million cubic metres are avoidable losses.

6.6.4 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the average annual avoidable water losses from 2008/9 to 2010/11 water years have been 16.3 million m^3. This volume may be due to a number of factors.

- *Water measurement errors*: With the current method of manual reading of the depth of flows by the WCOs, there is a likelihood of measurement errors due to human error. The implementation of telemetry systems may reduce the avoidable losses.

- *Scheduling of deliveries.* The other reason could be that, although there is weekly scheduling of deliveries and water is delivered only when needed, it is a very complicated process of trying to match the deliveries with the water applications. This happens particularly when the irrigators change their requests and there may be a time lag in adjusting the volume required not only at the sluice but through the canal system.

- *Volume of water ordered*: There is potential for significant water losses to take place if the volume of water ordered is very small compared to the minimum amount to reduce water losses.

- *Leakage in the canal structure*: Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network due to its age and the difficult terrain it traverses.

7 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

7.1 Overview

The LORWUA has been implementing various 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 an extensive telemetric flow measurement system in place to monitor and audit the water delivery. These existing water management measures are discussed in more detail below.

7.2 Canal condition assessment

LORWUA appointed Element Consulting Engineers to undertake an investigation into the rehabilitation of the canal system downstream of Bulshoek Dam. The project entailed a survey of the canal system and focussed on three aspects of the canal system. Firstly the hydraulic components of the system were investigated, secondly a visual inspection and structural investigation of the canal was undertaken to determine the short and long term rehabilitation requirements of the canal and thirdly, an economical investigation was done to evaluate the different rehabilitation scenarios in terms of their net present values.

LORWUA funded the study.

7.3 Flow metering/measurement

LORWUA 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 although they are not presently used for the generation of such budgets. Measurements of flows at the canal end point on the Doring River are not taken (although not presently measured, this is a small volume) and all other canals end in balancing dams. This makes it possible calculate the avoidable losses.

There are 15 telemetry stations with real time measurement on the system and manual reading of weekly and monthly records is not necessary.

7.4 Operation and maintenance of the canal infrastructure

Although the ownership of the canal infrastructure at the LORWUA is with the Department of Water Affairs (DWA) there is an agreement that the WUA is responsible for the operation and maintenance of the canal infrastructure while the refurbishment should be financed by DWA.

The LORWUA has an annual O&M budget which amounts to some R9.46 million per year. This is *inter alia* financed from the scheme charges which currently is R2 658.47 per ha/a for the 9 510 scheduled hectares.

Continuous maintenance and repair work to the structure and canals have to be done. For this purpose there is currently a maintenance division that is tasked with construction and maintenance. To explain, the following:

- Replacement of canal sections due to the changing ground formations,
- Relining of existing canals which no longer meet the set requirements due to erosion,

- Replacement of structures that no longer provide water accurately due to erosion and wear,
- Maintenance of flow banks that protects the canal system from flood water,
- A professional diving team to undertake repairs on the system not normally accessible (see picture).

During the scheduled dry weeks, which occur more or less seven times a year, canal sections are refurbished where necessary. Joints are sealed with Jaco Flex every ten years. The surface area of the canal sections are cleaned with a high pressure water spray in order to remove any rough textures or aggregates. The original and clean canal section is then plastered with mortar. This process lengthens the life span of the canal structure by an additional ten years.

All refurbishment and maintenance is financed by the WUA 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 LORWUA indicates that the scheme "water losses", was averaging approximately 34.97 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 WUA's maintenance division and dive team.

A breakdown of the major maintenance-related expenditure (on the canal system) for the previous five years is shown in Table 7-1.

Table 7-1: Canal maintenance expenditure

Description	Financial year					5-year total
	2008 - 09	2009 - 10	2010 - 11	2011 - 12	2012 -13	
Dosing for water grass	70 000	90 000	97 000	118 000	186 000	561 000
Telemetry system	36 000	68 000	89 000	569 000	450 000	1 212 000
General maintenance of canals	1 425 552	711 000	651 000	1 631 000	1 591 000	6 009 552
Cleaning of canals	495 000	580 000	647 000	600 000	600 000	2 922 000
Re-coating of canals (Plaster)	35 000	1 376 820	11 180 424	4 334 130	5 800 000	22 726 374
Sealing of canal joints	1 174 385	754 750	-------	-------	-------	1 929 135
Use of divers to seal leaks	554 003	615 558	683 953	759 948	835 943	3 449 405
Canal breaks	-------	2 500 722	2 284 372	1 795 255	-------	6 580 349
TOTAL	**3 789 940**	**6 696 850**	**15 632 749**	**9 807 333**	**9 462 943**	**45 389 815**
Capital works (from reserve fund)	2 627 797	3 237 601	11 011 576	2 164 114	2 141 255	21 182 343
Total operating expenses	20 695 727	26 038 061	31 578 717	28 565 932	30 913 508	137 791 945

Figure 7-1: Diver preparing to undertake maintenance in closed canal

Figure 7-2: Major canal failure

Figure 7-3: "Pump garden" to pump water across broken canal section

Figure 7-4: Lutzville canal break

Figure 7-5: Lutzville canal break - reparation in progress

7.5 Automated Releases from Bulshoek Dam

The sluice gates at the Bulshoek Dam were replaced with automatic sluices in 2011. Through the use of the Scada program the releases from Bulshoek Dam and the division at the Doring River canal are now automated and much more accurate than before. A specific discharge rate is set and that rate then remains constant. This automation ensures that the flow in the canal system is as even as possible.

7.6 Full implementation of WAS

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

7.7 Algae and alien plants

Fortunately algae are not yet such a major problem as is the case with some other irrigation schemes. If a problem does occur, it is immediately dosed. The WUA 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 LORWUA has budgeted R 186 000.00 for the dosage against algae for the 2012/2013 financial year.

7.8 Balancing system

There are three scheme balancing dams on each of the left and right bank canals. The balancing system is however limited and this is mainly due to the absence of suitable dam sites. Koekenaap will especially benefit from additional storage.

There are however farm dams within the scheme and some have capacities large enough to store water for two consecutive dry weeks and enhance water conservation. Following the drought of 2003-2004 water losses from these dams became a big issue and basically forced the farmers to take a closer look at on-farm efficiency and losses. As a result, 70% of the farm dams have been lined by the water users. Scientific farming practices are also widely applied and only some 10% of the area is still irrigated by means of flood irrigation systems.

Figure 7-6 Balancing dam - Koekenaap

Figure 7-7: Balancing dam – “Die Palms”

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 showed that on an annual basis, there is not sufficient water to meet the LORWUA's irrigation demands. It also highlighted that irrigators are currently not utilising their full water allocation due to the capacity of the canal.

In addition to the water budget analysis, some limited discussions were held with the management and other people who are knowledgeable about the WUA. This was done to determine the key issues the scheme is facing. Table 8-1 provides the key issues identified as included in the WMP (**Annexure B**) and the following section is an excerpt from the WMP.

8.2 Flow measurements and water accounting

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. Figure 8-1 below, provides the extent of flow measurement that is ideal for conducting an irrigation scheme water budget. The availability of flow measurements helps inform both the water user and the WUA about the quantity, timing, and location of water use and therefore enables the WUA to conduct a water budget not only at scheme level but also at sub-scheme level.

As illustrated in Figure 8-1 below, it would be ideal to have flow measurements at the inlet to the primary canals as well as at the tail water ends. This would assist in determining the water losses in each section of the canal system, as well as the operational spills if there are any.

As indicated in previous sections, the LORWUA have adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into all the measurement points. These include weirs and parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers as well as measuring structures at the canal end points.

However, the accuracy and reliability of the rated sluice gates and flumes is very low. With the LORWUA normally operating 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. Therefore there is scope for under-accounting of the water diverted and delivered to the irrigators.

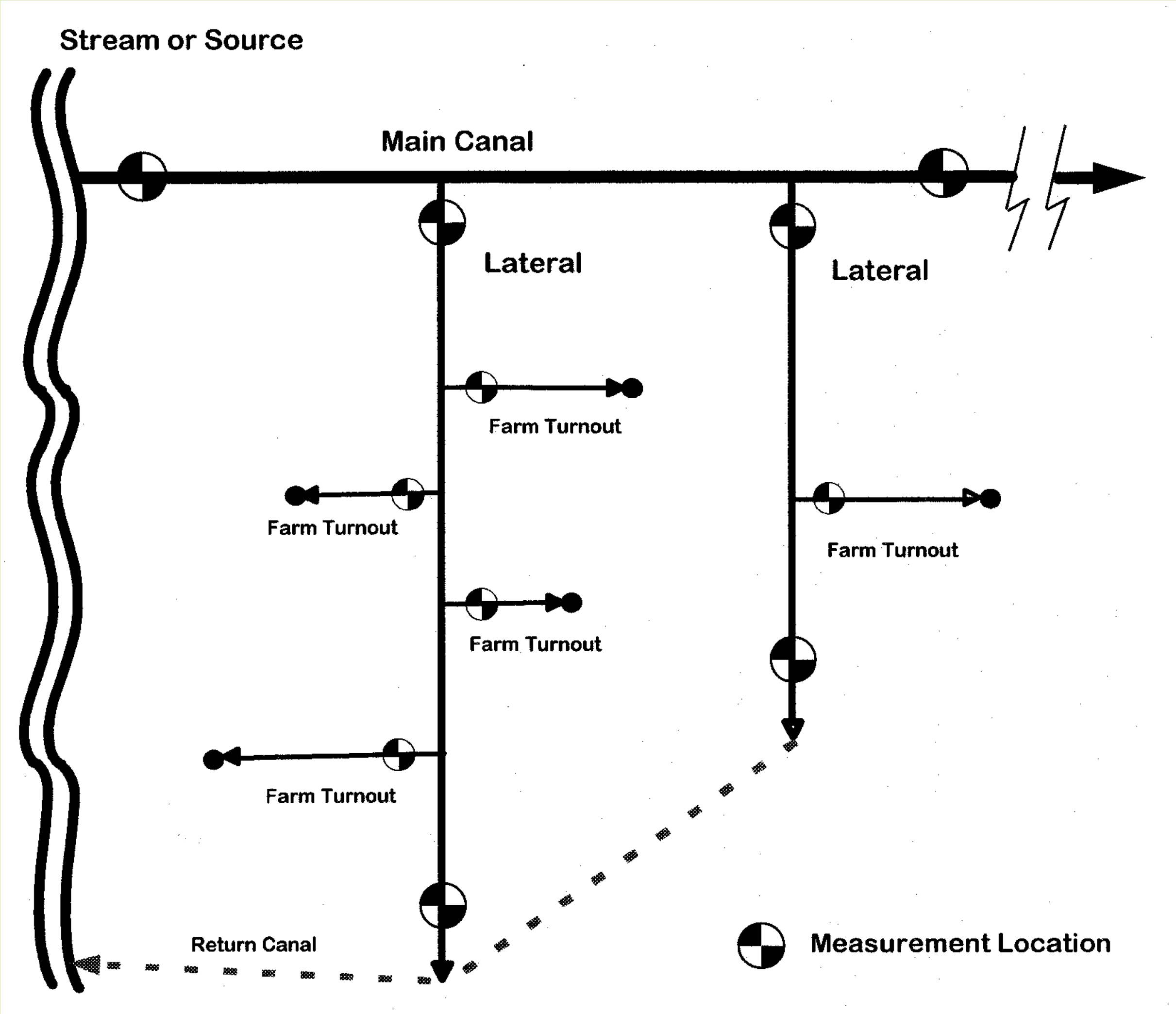


Figure 8-1: Irrigation Scheme with ideal water measurement system

Source: Bureau of Reclamation

8.2.1 Telemetry systems and compatibility with WAS

There is a telemetry system where water is released from Bulshoek Dam into the main canal and there are telemetry systems at the beginning and end of each section. The readings of the telemetry systems are however not automatically imported 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 LORWUA:

(i) Continuation of regular measurement of flows into and in the canal system 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 compatibility between the existing telemetry system and WAS should be addressed together with the automatic importation of telemetry data into WAS. The flows and levels are intended to be sent by telemetry system to the LORWUA offices for direct input into the WAS programme. This information can then be used to adjust flow rates of water in real-time and to determine water losses at scheme level and also at ward/sub-scheme levels.

8.2.2 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 leakage, spills and over delivery to users have not been disaggregated. Although an excellent real time telemetric monitoring system is in place, the data is used for monitoring purposes only and the data is not incorporated into the WAS system automatically. Currently it is not possible to easily conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention. The accuracy of the seepage losses remains questionable and it is proposed that ponding tests be done to verify the accuracy of the theoretical calculations.

Management Goal 2

The goal to address the above issue is to ensure that all the flow measurements in the LORWUA are included in determining water budgets and calculating water losses at scheme as well as ward/sub-scheme level. This will enable the WUA 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 should 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 WAS release module is currently not being 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:

(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.

At present, releases of the WAS Water Release model is not as accurate as it should be due to inaccurate lag times.

Management Goal 3

The management objective to address the above issue, is to ensure that all the modules of the WAS programme, particularly the water release modules, are implemented fully and that weekly and monthly reports from the modules are generated. This could be undertaken within 1 year from the completion of this Water Management Plan (WMP).

8.3.2 Available datasets not integrated into a Management Information System

The LORWUA has commissioned various studies in the past and have gathered and generated their own detailed datasets, ranging from individual sluice detail to water user address information. All these datasets are in standalone databases of 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 water management plan, it was essential that an assessment of the overall condition of the facilities to identify potential issues was carried out. As indicated in Chapter 4, a detailed condition assessment was undertaken by the LORWUA. This included the operation and maintenance system as well as the conveyance and distribution system. No detailed assessment of the on-farm delivery systems was however conducted.

8.4.1 Limited scheme balancing capacity

Balancing dams decrease the pressure on the canal system and allows for shorter delivery periods to water users. They also intercept any surplus water in the system and act as backups to supplement supply should shortages arise (canal breaks, etc.). The LORWUA only has the benefit of six balancing dams on the scheme, with minimal storage capacity.

Management Goal 5

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

8.4.2 Maintenance procedures

During the condition assessment of the existing canal infrastructure the consultants also evaluated the present procedures undertaken by the WUA when maintenance is conducted. When maintenance is conducted on the canal joints for example it was noted that the joints were plastered, therefore providing no room for expansion or contraction. This means that the seal is only performing for a short while before it cracks and starts to leak again. The present modus operandi when maintenance and repairs are undertaken should be investigated and improved where possible.

Management Goal 6

Revision of the current actions taken when canals are maintained and/or repaired should be investigated and improved where possible.

8.4.3 Ownership of irrigation infrastructure

The irrigation boards and Water User Associations have two main elements that dictate their 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 LORWUA, the Department of Water Affairs (DWA) still owns the irrigation infrastructure including the main and branch canals. However, the WUA operates the irrigation infrastructure as an agent of the DWA and undertakes the normal maintenance of the irrigation infrastructure.

Problems will most likely arise when the major infrastructure needs replacement/total refurbishment. It is unlikely that the WUA 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 WUA.

Management Goal 7

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 LORWUA area of operation

There are currently water users abstracting water from the Olifants River between the Bulshoek and Clanwilliam dams. These users are presently not included in the LORWUA although they abstract water from the same source (Olifants River above and below

Bulshoek dam). The possibility to have various sub-groups and sub-areas in one WUA, each with different water pricing structures could allow the inclusion of the abovementioned users and ensure that the whole source is managed.

Management Goal 8

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

8.5.2 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 9

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

Table 8-1: LORWUA: Identified water management issues

Item No.	Issue description	Comments
1	The telemetric flow measurements taking place on the various diversion points within the LORWUA are not automatically imported on the WAS system.	Link the telemetry system with the WAS.
2	Irrigation water budget not conducted in detail. Data from the real time telemetric monitoring system is used for monitoring purposes only and the data is not incorporated into the WAS system automatically.	Break down losses per sub-scheme. Measure return flows of Doring River canal.
3	Release module of WAS is not fully operational.	Implement Release Module of WAS.
4	Available datasets not integrated into a Management Information System. Having all this data in one integrated system will be a huge benefit and should enable quicker and better informed decision making.	Develop and implement a Management Information System.
5	Limited scheme balancing capacity.	Constructing additional storage capacity (balancing dams) which will assist in operating the system as effectively as possible.
6	Maintenance procedures	Revision of the current actions taken when canals are maintained should be investigated and improved where possible.
7	Ownership of irrigation infrastructure	Responsibility between the DWA and the

Item No.	Issue description	Comments
		LORWUA should be further refined.
8	LORWUA area of operation	Water User Association where all users of the river system below Clanwilliam Dam are represented.
9	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 LORWUA WATER MANAGEMENT PLAN

The comprehensive LORWUA Water Management Plan is included in **Annexure B** and this section will 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 LORWUA.

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

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 14.2 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 LORWUA were determined to be 13.1% of the total releases into the canal system. This water is additional to the irrigation water use required at the farm edge.

As illustrated in Table 9-1 below, the expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses will be 23.1% of the total releases into the canal system.

Table 9-1: Target water losses in the LORWUA

Description	*System inflow (x $10^6 m^3$)*	*Present situation - Losses*				Acceptable water losses		Target water saving	
		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		*18.2*		*18.2*	12.8%	18.2	12.8%	0.0	0.0%
Evaporation		*0.448*		*0.448*	0.3%	0.4	0.3%	0.0	0.0%
Filling losses		*0*	*16.321*	*16.321*	11.4%	14.2	10.0%	2.1	1.4%
Leakages									
Spills									
Over delivery									
Canal end returns									
Other		*0*	*0*	*0*	0.0%	0.0	0.0%	0.0	0.0%
Total	***142.35***	***18.648***	***16.321***	***34.969***	**24.6%**	**32.9**	**23.1%**	**2.1**	**1.5%**
% of total volume released into system		***13.1%***	***11.5%***	***24.6%***					

Based on the projected water saving targets, the LORWUA can achieve a 1.5% reduction in irrigation water losses relative to the 2012 levels in a relative short period (3 years and less).

9.1.1 Short term water saving targets

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans and by revising the maintenance regime and algae control is some 2.1 million m^3/a.

9.1.2 Long term water saving targets

For the long term a further 4.2 million m^3/a saving envisaged by refurbishment of the canal infrastructure. The long term target is to reduce the water losses to approximately 20% of the total diversion.

9.2 Implementation Plan

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

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

(ix) *Incorporating the existing telemetry system with WAS*
(x) *Expand WUEAR*
(xi) *Fully implement the Release Module of WAS*
(xii) *Ponding tests to establish canal seepage*
(xiii) *Revise maintenance procedures and actions during refurbishment periods*
(xiv) Develop and implement a comprehensive Management Information System
(xv) *Incentive based pricing*
(xvi) Expand area of operation

The action plan for implementation is presented in Table 9-2 .

Table 9-2: LORWUA Action Plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	(i) Start measurement of Doring River Canal return flows. (ii) Conduct seepage loss measurements in representative canal and pipeline segments though ponding tests. Extrapolate results from tested segments to similar segments and revise water budget. (iii) Undertake sub-scheme water budgets (iv) Prioritise areas of significant water losses	Mar ’13 – Feb ‘14 Mar ’13 – Feb ‘14 Mar ’13 – Feb ‘15 Mar ’13 – Feb ‘14	LORWUA
2	Reduce seepage losses in irrigation canal infrastructure within 5 years	(i) Revise and improve current maintenance procedures	Mar ’13 – Feb ‘14	LORWUA
3	Increase operational efficiency	(i) Link telemetry system with WAS (ii) Implement release module of WAS (iii) Undertake study to identify possible additional balancing capacity in the Koekenaap area. (iv) Incorporate data in a custom Water Management System	Mar ’13 – Feb ‘15 Mar ’13 – Feb ‘15 Mar ’13 – Feb ‘15 Mar ’13 – Feb ‘15	LORWUA
4	In 3 years,	(i) Review current irrigation water pricing strategy		DWA/LORWUA

Priority	Goal	Action Plan	Timeline	Responsible Authority
	implement incentive pricing structure for the WMA if viable	(ii) Engage with irrigators on incentive pricing structure (iii) Update water pricing strategy (iv) Implement water billing based on incentive pricing rate	Mar ’13 – Feb ‘16	
5	In 5 years expand area of operation of the LORWUA	(i) Engage with other stakeholders to increase the area of operation of the WUA to include all water users below the Clanwilliam Dam.	Mar ’13 – Feb ‘18	DWA/LORWUA

10 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 LORWUA.

The intention of the Water Management Plan not to burden the WUA 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 WUA 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 WUA 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 WUA 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. The identified measures for implementation should reduce the water losses from the current 24.6% to 20% of the total inflow into the irrigation scheme.

11 REFERENCE

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ANNEXURE A

MAPS

ANNEXURE B

WATER MANAGEMENT PLAN : LOWER OLIFANTS RIVER WATER USER ASSOCIATION

Lower Olifants River
Water User Association

WATER MANAGEMENT PLAN FOR THE
LOWER OLIFANTS RIVER WATER USER ASSOCIATION
APRIL 2013 TO MARCH 2014

January 2013

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TABLE OF CONTENTS

1 BACKGROUND

The Lower Olifants Water User Association is situated in the Vredendal/Koekenaap area and Figure 2.1 provides a locality map. The Association is located within the Olifants-Doorn WMA. The major river in the WMA is the Olifants River, which rises in the Agter Witzenberg Mountains to the north of Ceres, with the Doring River as its major tributary.

The scheme consists of the Clanwilliam Dam (122 million m^3) on the Olifants River, with the Bulshoek Dam (5.2million m^3) lower downstream, approximately 260 km main canals and 40 km of smaller branch canals. The main canal starts at Bulshoek Dam and runs along the left bank of the Olifants River until it splits in two with a raised siphon over the Olifants River to the right bank, close to Klawer. From the split, there is a canal on both banks of the Olifants River up to Ebenhaezer and Olifants River Settlement areas respectively. At the end of the canals there are various balancing dams to manage the water optimally and to limit wasted water to the minimum.

The length of the left bank canal is approximately 125.5 km while the right bank canal has a length of 111.8 km. The scheme is divided into nine wards with four wards on the left bank canal and five wards on the right bank canal. Each water ward has a ward manager who is responsible for the water distribution management of the specific ward. The canal infrastructure comprises of secondary canal systems, sluices, long weirs, siphons, side spillways, tunnels and pipes. Water is delivered to the farmers through sluices which are set on a daily basis. The standard sluice in the canal system comprises of a 300mm by 300mm plate covering a 300 mm diameter pipe mouth or orifice. The sluice gates are fitted with long handles and locked in place to allow flow through the partly opened orifice.

The dam setting is changed on a six 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 WUA has a total scheduled area of 10 007 hectares, at a scheduled quota of 12 200 m3/ha/a which translates to a total allocation of 122.09 million m3/a. The various categories of water users and the annual allocation are shown in the following table.

Water Use category	Annual allocation m^3
Commercial Farmers (9 510 ha)	116 022 000
Ebenhaezer Small Farmers (257 ha)	3 135 400
Emerging Farmers (240 ha)	2 928 000
Matzikama Municipality (7 towns)	8 351 000
Industries	3 200 000
TOTAL	**133 636 400**

The capacity of the canal is such that the WUA can only supply between 60% and 70% of the water during peak seasons.

Economic activity is based on commercial irrigated agriculture, and approximately 90 per cent (8 176 hectares) of the water is used for the irrigation of wine grapes, table grapes, tomatoes, citrus, deciduous fruit, and vegetables. Some 88% of the total area under irrigation is planted with permanent crops.

2 LEGAL PROVISION FOR DEVELOPING AND IMPLEMENTING THE LORWUA 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 LORWUA 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 LORWUA has developed a draft WMP in terms of the provisions of the NWA to enable it to manage the irrigation water in the scheme effectively and efficiently.

3 LORWUA 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 LORWUA. 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.

3.2 Losses

3.2.1 Overview

An irrigation water budget was developed by the LORWUA. The water budget was based on information obtained from the Water Administration System (WAS).

3.2.2 Gross Water losses

The total monthly losses for the period Oct 2008 to Sep 2011 were calculated and reflect the total losses and include seepage, evaporation, leakage and operational losses (including end of canal outflows). It therefore reflects the difference between the volume that was ordered by the water users and the volume of water released into the inlet of the main canal.

The **average** water losses have been 24.7% of the released water from the dam into the canal system. This translated to an **average** of approximately 34.97 million m^3/a water losses in the LORWUA area. This volume mainly refers to the water losses that are difficult to measure including the unavoidable water losses as well as some of the avoidable losses. These include canal evaporation losses, seepage in the primary canals and distribution canals, percolation, leakage and start-up and shut-down losses, sudden drop in demand (rainfall). Most of the tail water is captured in balancing dams for redistribution and return flows are therefore shown as 0%. The tail water of the Doorn River Canal is not measured.

3.2.3 Conveyance losses

Conveyance losses within a canal system can be defined as the difference between the water released at the canal inlets and the water delivered to the farm boundary.

The main losses occurring within the LORWUA served by canal distribution networks include the following;

3.2.3.1 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, amount of sediment, etc.

The seepage losses on the LORWUA canal system represents 13 % of the total volume released into the system.

3.2.3.2 Evaporation losses

Evaporation data was used to estimate the average monthly evaporation as part of the water balance for the different canal sections. For the purposes of the water balance it was assumed that the evaporation is 6.2 mm/day for the exposed water surface area in the canal. This represents 1.0% of the total flow in the canal system.

3.2.3.3 Operational wastage:

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

3.2.3.4 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 WUA aims to operate the system within a range of 35% to 85% of the design capacity, the water demand during peak periods, sediment and weed/algae growth necessitates periodic operation of the system at 110% of the design capacity, resulting in high leakages and spills.

3.2.3.5 Aquatic weeds and algae:

Aquatic weed and algae growth in irrigation canal systems is fast becoming one of the major operational headaches in scheme management, especially on those schemes where water is becoming progressively eutrophic.

Table 3-1 provides a summary of the various losses on the canal distribution network of the LORWUA. The figures are based on the averages over the three water years (2008 to 2011). It is important to note that not all of the categories included in the table are shown on the

WUEAR. Some of the values are estimations and are based on local knowledge of the system.

Table 3-1: LORWUA - 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	18.2		18.200	52.0
Evaporation	0.448		0.448	1.3
Filling losses		16.321	16.321	46.7
Leakages				
Spills				
Over delivery to users				
Canal end returns			0	0.0
Other			0	0.0
Total	**18.648**	**16.321**	**34.969**	**100.0**
% of Total losses	**53.3**	**46.7**	**100.0**	
% of total released into system	**13.1**	**11.5**	**24.6**	

From the data presented in Table 3-1 it is evident that the total losses on the scheme amount to 24.6% (*13.1% unavoidable and 11.5% avoidable*). In terms of total losses occurring on the scheme, 53.3% can be classified as unavoidable losses while 46.7% or approximately 16.3 million cubic metres are avoidable losses.

3.2.4 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the average annual avoidable water losses from 2008/9 to 2010/11 water years have been 16.3 million m^3. This volume can be attributed to a number of factors.

- *Water measurement errors*: With the current method of manual reading of the depth of flows by the WCOs, there is a likelihood of measurement errors due to human error. The implementation of telemetry systems may reduce the avoidable losses.

- *Scheduling of deliveries.* The other reason could be that, although there is weekly scheduling of deliveries and water is delivered only when needed, it is a very complicated process of trying to match the deliveries with the water applications. This happens particularly when the irrigators change their requests and there may be a time lag in adjusting the volume required not only at the sluice but through the canal system.

- *Volume of water ordered*: There is potential for significant water losses to take place if the volume of water ordered is very small compared to the minimum amount to reduce water losses.

- *Leakage in the canal structure*: Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network due to its age and the difficult terrain it traverses.

4 WATER MANAGEMENT ISSUES AND GOALS

The water budget analysis discussed in the previous chapter has helped to identify several key water management issues. The water budget analysis showed that on an annual basis, there is not sufficient water to meet the LORWUA's irrigation demands. It also highlighted that irrigators are currently not utilising their full water allocation due to the capacity of the canal.

The following water management issues and goals were identified by the WUA.

4.1 Flow measurements and water accounting

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. The availability of flow measurements helps inform both the water user and the WUA about the quantity, timing, and location of water use and therefore enables the WUA to conduct a water budget not only at scheme level but also at sub-scheme level.

The LORWUA have adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into all the measurement points. These include weirs and parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers as well as measuring structures at the canal end points.

However, the accuracy and reliability of the rated sluice gates and flumes is very low. With the LORWUA normally operating 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. Therefore there is scope for under-accounting of the water diverted and delivered to the irrigators.

4.1.1 Telemetry systems and compatibility with WAS

There is a telemetry system where water is released from Bulshoek Dam into the main canal and there are telemetry systems at the beginning and end of each section. The readings of the telemetry systems are however not automatically imported on the WAS system.

<u>Management Goal 1</u>

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

(iv) Continuation of regular measurement of flows into and in the canal system 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) The compatibility between the existing telemetry system and WAS should be addressed together with the automatic importation of telemetry data into WAS. The flows and levels are intended to be sent by telemetry system to the LORWUA offices for direct input into the WAS programme. This information can then be used to adjust flow rates of water in real-time and to determine water losses at scheme level and also at ward/sub-scheme levels.

4.1.2 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 leakage, spills and over delivery to users have not been disaggregated. Although an excellent real time telemetric monitoring system is in place, the data is used for monitoring purposes only and the data is not incorporated into the WAS system automatically. Currently it is not possible to easily conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention. The accuracy of the seepage losses remains questionable and the WUA will conduct ponding tests to verify the accuracy of the theoretical calculations.

<u>Management Goal 2</u>

The goal to address the above issue is to ensure that all the flow measurements in the LORWUA are included in determining water budgets and calculating water losses at scheme as well as ward/sub-scheme level. This will enable the WUA 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 will also be undertaken to verify the theoretical calculations of the seepage losses on the canal system.

4.2 Operational water management issues

4.2.1 The WAS release module is currently not being utilised

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.

At present, releases of the WAS Water Release model is not as accurate as it should be due to inaccurate lag times.

<u>Management Goal 3</u>

The management objective to address the above issue, is to ensure that all the modules of the WAS programme, particularly the water release modules, are implemented fully and that weekly and monthly reports from the modules are generated.

4.2.2 Available datasets not integrated into a Management Information System

The LORWUA has commissioned various studies in the past and have gathered and generated detailed datasets, ranging from individual sluice detail to water user address information. All these datasets are in standalone databases of 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.

4.3 Infrastructure related issues

In order to properly develop the water management plan, it was essential that an assessment of the overall condition of the facilities to identify potential issues was carried out. A detailed condition assessment was undertaken by the LORWUA. This included the operation and maintenance system as well as the conveyance and distribution system. No detailed assessment of the on-farm delivery systems was however conducted.

4.3.1 Limited scheme balancing capacity

Balancing dams decrease the pressure on the canal system and allows for shorter delivery periods to water users. They also intercept any surplus water in the system and act as backups to supplement supply should shortages arise (canal breaks, etc.). The LORWUA only has the benefit of six balancing dams on the scheme, with minimal storage capacity.

Management Goal 5

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

4.3.2 Maintenance procedures

During the condition assessment of the existing canal infrastructure the consultants also evaluated the present procedures undertaken by the WUA when maintenance is conducted. When maintenance is conducted on the canal joints for example it was noted that the joints were plastered, therefore providing no room for expansion or contraction. This means that the seal is only performing for a short while before it cracks and starts to leak again. The present modus operandi when maintenance and repairs are undertaken should be investigated and improved where possible.

Management Goal 6

Revision of the current actions taken when canals are maintained and/or repaired should be investigated and improved where possible.

4.3.3 Ownership of irrigation infrastructure

The irrigation boards and Water User Associations have two main elements that dictate their 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 LORWUA, the Department of Water Affairs (DWA) still owns the irrigation infrastructure including the main and branch canals. However, the WUA operates the irrigation infrastructure as an agent of the DWA and undertakes the normal maintenance of the irrigation infrastructure.

Problems will most likely arise when the major infrastructure needs replacement/total refurbishment. It is unlikely that the WUA 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 WUA.

Management Goal 7

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.

4.4 Institutional Water Management Issues

4.4.1 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

Management Goal 8

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

4.4.2 LORWUA area of operation

There are currently water users abstracting water from the Olifants River between the Bulshoek and Clanwilliam dams. These users are presently not included in the LORWUA although they abstract water from the same source (Olifants River above and below Bulshoek dam). The possibility to have various sub-groups and sub-areas in one WUA, each with different water pricing structures could allow the inclusion of the abovementioned users and ensure that the whole source is managed.

Management Goal 9

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

5 ESTABLISHING WATER SAVINGS TARGETS

5.1 Acceptable water losses

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

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 2.59 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 savings and the target water losses of each of the two canal systems.

5.2 Water savings targets

The unavoidable water losses in the LORWUA were determined to be 13.1% of the total releases into the canal system. This water is additional to the irrigation water use required at the farm edge.

Furthermore there are operational challenges in operating the scheme including trying to match the delivery to the irrigation applications. Based on the WRC study the attainable range of operational losses which are not likely to the recovered through water management intervention measures is 10% of the total releases into the system. below provides the water loss target for the LORWUA. As illustrated in below, the expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses will be 23.1% of the total releases into the canal system.

Table 5-1: Target water losses in the LORWUA canal system

Description	***System inflow*** *(x 10^6m^3)*	***Present situation - Losses***				**Acceptable water losses**		**Target water saving**	
		Unavoidable losses *(x 10^6m^3)*	***Avoidable losses*** *(x 10^6m^3)*	***Total Losses*** *(x 10^6m^3)*	**% of total volume released**	**Annual volume** (x 10^6m^3)	**% of total volume released**	**Annual volume** (x 10^6m^3)	**% of total volume released**
Seepages		*18.2*		*18.2*	12.8%	18.2	12.8%	0.0	0.0%
Evaporation		*0.448*		*0.448*	0.3%	0.4	0.3%	0.0	0.0%
Filling losses		*0*	*16.321*	*16.321*	11.4%	14.2	10.0%	2.1	1.4%
Leakages									
Spills									
Over delivery									
Canal end returns									
Other		*0*	*0*	*0*	0.0%	0.0	0.0%	0.0	0.0%
Total	***142.35***	***18.648***	***16.321***	***34.969***	**24.6%**	**32.9**	**23.1%**	**2.1**	**1.5%**
% of total volume released into system		***13.1%***	***11.5%***	***24.6%***					

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 irrigation water use efficiency in the LORWUA.

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

(1) Flow measurement and telemetry infrastructure
  a. Link the telemetry system with the WAS.
  b. Fully implement the Release Module of WAS.
  c. Measure return flows on Doring River canal.
  d. Expand the water accounting report to distinguish between left, right and Doring River canals within the WUA.
  e. Undertake ponding tests to determine seepage as accurately as possible.

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

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

(4) Operation and management related
  a. Incorporate all relevant data in a custom Management Information System.
  b. Assess the possibility to implement incentive based water pricing.

(5) Institution related
  a. Review the possibility to expand the area of operation of the LORWUA.

6.2 Flow measurement and telemetry infrastructure

6.2.1 Check compatibility of telemetry system with WAS

The LORWUA should review the current telemetry system to ensure that flow measurements can be read in real time into the Water Administration System (WAS). The LORWUA already has an excellent telemetry system in place and will only require a specialist telemetry expert to update the existing software to ensure compatibility with the WAS so that all flow records can be read directly into the WAS programme.

6.2.2 Fully implement Release Module of WAS

The population of the required scheme and various canal parameters have already been undertaken by the WUA and the Release Module of WAS should have been implemented. There are however some problems with the calculation of the lag times 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 total scheme and no individual reporting is done for the two main canals or 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 should be discussed with NB Systems to indentify the actions that must be incorporated to allow reporting at sub-scheme level.

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.

6.2.5 Measure return flows of Doring River Canal

The Doring River Canal is the only canal that does not end in a balancing dam. Presently the return-flows at the canal end point are no measured or included in the WUEAR. The return flows are not high and it is not necessary to install a telemetric unit at the end point and an Orpheus Mini Meter is proposed. If these return-flows are available, water balances can be undertaken for each of the three canal sections (Left, Right and Doring River).

6.3 Canal maintenance and refurbishment

6.3.1 Investigate present modus operandi during maintenance periods

The WUA is at present undertaking maintenance and also implemented unique ways to deal with identified problems in the system (professional divers). The fact that maintenance is undertaken does however not mean that the right things are done right. The present modus operandi when maintenance and repairs are undertaken will therefore be investigated and improved where possible.

6.3.2 Investigate the use of MAHNACIDE H against algae growth

Algae are a growing concern in the LORWUA irrigation canal structure and the WUA may consider alternatives in resolving the problem. The presence of algae 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. Algae growth is currently treated by copper sulphate and sulphuric acid dosages 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.

Since the growth of aquatic weeds is a common phenomenon in many irrigation schemes, the option that the treatment thereof should become a priority of DWA should be considered. MAGNACIDE H Herbicide is an effective new product but most probably outside the financial reach of the WUA and the WUA will enter into formal negotiations regarding the possible subsidisation of the use of MAGNACIDE H.

6.4 Infrastructure relates issues

6.4.1 Investigate possible additional balancing capacity

The LORWUA has a limited balancing system in place which limits the security of water supply during shortages or major canal failures. The WUA will investigate the possibility of creating additional storage capacity at Koekenaap which will assist in operating the system as effectively as possible.

6.5 Institutional issues

6.5.1 Investigate possible expansion of the area of operation of the LORWUA

There are currently water users abstracting water from the Olifants River between the Bulshoek and Clanwilliam dams. These users are presently not included in the LORWUA although they abstract water from the same source (Olifants River above and below Bulshoek dam). The LORWUA will engage with other water users to establish the willingness of these users to be incorporated into the present WUA.

6.6 Financial

6.6.1 Investigate possibility of incentive based water pricing

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

In order to encourage irrigators to use water efficiently, incremental water pricing may considered, based on the optimal crop water requirements. The implementation of incentive water pricing in irrigation agriculture, requires that comprehensive regulatory and operational criteria to be met before considering the economic criteria for incentive based pricing of irrigation water. The LORWUA 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 LORWUA area to improve water use efficiency and reduce water losses indicates that all the measures are economically justified for implementation based on the unit cost of water saved.

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

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

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

Table 7-1: LORWUA action plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	(i) Start measurement of Doring River Canal return flows. (ii) Conduct seepage loss measurements in representative canal and pipeline segments though ponding tests. Extrapolate results from tested segments to similar segments and revise water budget. (iii) Undertake sub-scheme water budgets (iv) Prioritise areas of significant water losses	Mar '13 – Feb '14 Mar '13 – Feb '14 Mar '13 – Feb '15 Mar '13 – Feb '14	LORWUA
2	Reduce seepage losses in irrigation canal infrastructure within 5 years	(i) Revise and improve current maintenance procedures	Mar '13 – Feb '14	LORWUA
3	Increase operational efficiency	(i) Link telemetry system with WAS (ii) Implement release module of WAS (iii) Undertake study to identify possible additional balancing capacity in the Koekenaap area. (iv) Incorporate data in a custom Water Management System	Mar '13 – Feb '15 Mar '13 – Feb '15 Mar '13 – Feb '15 Mar '13 – Feb '15	LORWUA

Priority	Goal	Action Plan	Timeline	Responsible Authority
4	In 3 years, implement incentive pricing structure for the WMA if viable	(i) Review current irrigation water pricing strategy (ii) Engage with irrigators on incentive pricing structure (iii) Update water pricing strategy (iv) Implement water billing based on incentive pricing rate	Mar '13 – Feb '16	DWA/ LORWUA
5	In 5 years expand area of operation of the LORWUA	(i) Engage with other stakeholders to increase the area of operation of the WUA to include all water users below the Clanwilliam Dam.	Mar '13 – Feb '18	DWA/ LORWUA