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

KAKAMAS WATER USER ASSOCIATION

WATER MANAGEMENT PLAN

FINAL REPORT

March 2013

Prepared by

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Contract Title:	Development and Implementation of Water Management Plans to improve water use efficiency in the agricultural sector
Report Title	Kakamas Water User Association - Water Management Plan
Authors	Toriso Tlou, Pr. Eng; Francois Joubert

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Draft 1	23/03/2012	First draft for comment
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Consultants: Tlou Consulting (Pty) Ltd in association with Schoeman and Vennote

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Chairman: Kakamas WUA

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EXECUTIVE SUMMARY

The small town of Kakamas was developed and maintained by a couple of very poor stock farmers at the end of the 19th century. In 1897 the Dutch Reformed Church started a "colony" on the farms Soetap and Kakamas on the banks of the Orange River for white people who got impoverished as a result of the drought. Kakamas became a proper settlement in 1898 under the auspices of the Dutch Reformed Church and soon developed into an agricultural centre.

The scheme was taken over by the Department of Water Affairs in 1964.

Irrigation development in the Lower Orange WMA was stimulated by the construction of several dams. Great expansions of irrigation were made possible along the Orange River by the construction of Gariep and Vanderkloof dams in the Upper Orange WMA during the 1970's.

Problems were experienced creating sufficient flow in the main irrigation canals, particularly the canal on the South Bank of the Orange River and in 1993 the Neusberg Weir was completed. Neusberg Weir alleviated the supply problems previously experienced with the main irrigation canals and also increased the capacities of the main supply canals from approximately 3 m^3/s *to 7.5* m^3/s *and 6.8* m^3/s *for the north bank and south bank canals respectively.*

The Kakamas WUA with it offices in the town of Kakamas is situated 80 kilometres downstream of Upington in Lower Orange WMA. The area of operation stretches on both sides of the Orange River from Neusberg Weir in the east to just downstream of the Augrabies Waterfall in the west.

The Kakamas WUA was established with the purpose of taking over the operations and maintenance of the Kakamas Government Water Scheme. It was established in terms of Section 98 (6) of the National Water Act, 1998 by Proclamation No.516 in Government Gazette No. 22357 dated 15 June 2001 after approval of its constitution by the Minister. Certain powers and duties in terms of the National Water Act have also been delegated to the Association to enable us to perform the operation and maintenance functions of the scheme.

The Lower Orange WMA is the lowest WMA in the Orange/Vaal River Basin and as such is affected by upstream activities, both in terms of the Upper Orange and the Vaal System. The topography of the area is flat with large pans or endoreic areas that do not contribute runoff to the Orange River system. The two major storage dams Gariep and Vanderkloof, which supply all the irrigation, urban, and mining requirements along the Lower Orange River are located in the Upper Orange WMA and are of critical importance to the Lower Orange WMA and shortages in the Upper Orange WMA directly impacts on the Lower Orange WMA.

The total area under irrigation is 10 485.1 ha. The scheme consists of a lined canal on both sides of the Orange River which more or less track the river course. While some farmers pump directly from the rivers the majority are supplied from these canals. The WUA also supplies water for industrial and municipal use.

Originally designed as a flood irrigation scheme, 90% of the area is still irrigated by flood irrigation and the remaining 10% is irrigated with micro and drip irrigation systems. The canal users are measured using calibrated sluices while the users which abstract directly from the river are not metered.

The entire Kakamas WUA infrastructure was rehabilitated between 1983 and 1998 at a cost of R270 million and the condition of the infrastructure is very good.

The operating philosophy is that the WUA has created just another channel of the river and water flows through the canals with similar or less losses as would be the case if the water had stayed in the river.

A summary of the infrastructure is provided in the table below.

Type of structure	***Total***
Main canals (km)	*75.4*
Secondary canals/pipelines (km)	*68.9*
Storm water and subsurface drainage canals (km)	*44.0*
Sub surface pipe drains (km)	*23.0*
Tunnels	*2*
Aqueducts	*4*
Siphons	*40*
Flow measuring structures	*12*
Bulk water diversion structures	*8*
Property sluices	*500*
Reject structures	*32*

The main crops that are under irrigation include grapes (approximately 9 548 ha), and other crops such as lucerne, maize, cotton, wheat, peas and pecan nuts (approximately 1 061 ha).

The towns of Kakamas, Marchand and Augrabies as well as the settlements of Lutzburg, Cillie and Aiheit form part of the Kai !Garip Municipality and abstract water within the borders of the WUA either through direct withdrawal from the Orange River by means of their own waterworks or from the canals or through a combination of both.

The Kai !Garip Municipality is the Service Provider in terms of the Water Services Act throughout the whole area of operation of the Kakamas Water User Association and water is supplied to them in bulk. Details of each group of water users are shown in the table below.

Group	***Annual quota (m³)***
Agricultural - Irrigation	*159 139 500*
Industrial users	*30 000*
Domestic users	*1 618 500*
Municipal users	*1 698 050*
Total	***162 486 050***

Water balance assessment

Using the information obtained from the Water Use Efficiency Accounting Reports (WUEARs), previous studies and consultation with the management of the WUA, a water budget for the Kakamas WUA was prepared.

The average water losses have been 25.9% (8.3% unavoidable and 17.6% avoidable) of the released water from the dam into the canal system. This translated to an average of approximately 94.9 million m^3/a water losses in the Kakamas WUA area of operation. In terms of volume, approximately 64.5 million m^3/a are avoidable losses.

Existing water conservation measures

The Kakamas WUA has been implementing various measures to improve the management of delivery to the irrigators and to minimise losses. These measures include annual maintenance of the irrigation canals to reduce avoidable water losses, as well as having programs to address problems with midgets and the promotion of laser levelling.

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 Kakamas WUA canal system. The analysis indicated that the unavoidable water losses due to evaporation losses and seepage is 30.38 million m^3/a, which translates to 8.3% of the total volume of water diverted into the Kakamas WUA 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 36.6 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 18.3% of the total releases into the canal system or 66.978 million m^3/a.

Water management issues

The water budget analysis together with discussions held with the Kakamas WUA has helped to identify several key water management issues. There is however insufficient data *to clearly determine where and how losses are occurring. Currently there are no records as to how much water spills occur due to operational issues or how much water is returned to the river through the reject structures or at the canal end points.*

The most noticeable aspect that was noticed during the consultations with the WUA is the sense of awareness of the management of the importance of efficient irrigation water management and conservation, and the interest shown to learn as much as possible. The main water management issues identified include the following;

a) *The Kakamas WUA appears to have adequate flow measurement structures in place to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into the major sections. These include weirs and parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers. However, there is no measurement of water returning back to the river through reject structures or canal end points. Without these measurements it is impossible to conduct an accurate water budget.*

b) *There is measurement taking place within the scheme linked to a telemetry system where water is released from the weirs into the main canal and there are also other measurements (not telemetric) taken where water is diverted into sub sections of the scheme. WAS is not utilised on the scheme and the flow measurements are only available in spreadsheet format. The problem is not so much with the current system in operation in on the scheme but with continuity. WAS is a standardised program in use on various schemes throughout the country with many trained operators handling the system. This reduces the risk of an in-house developed program and temporary personnel could assist with the upkeep of the system should the regular operator(s) leave of fall ill.*

c) *It is currently difficult to disaggregate the losses as there is no differentiation in the water balance assessment between the losses. 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) *In the Kakamas WUA, 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 also difficult to borrow against the assets as they are owned by government.*

<u>Water saving targets</u>

The set targets for the Kakamas WUA are illustrated in the table below.

Description	System inflow ($x\ 10^6 m^3$)	Present situation - Losses				Acceptable water losses		Target water savings	
		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		*29.280*		*29.280*	8.00%	29.3	8.00%	0	0.00%
Evaporation		*1.098*		*1.098*	0.30%	1.098	0.30%	0	0.00%
Filling losses									
Leakages									
Spills									
Over delivery			*64.489*	*64.489*	17.62%	36.6	10.00%	27.889	7.62%
Canal end returns									
Other									
Total	***366***	***30.378***	***64.489***	***94.867***	***25.92%***	***66.978***	***18.30%***	***27.889***	***7.62%***
% of total volume released into system		***8.30%***	***17.62%***	***25.92%***					

Based on the projected water saving targets, the Kakamas WUA can achieve a 2 % reduction in irrigation water losses relative to the 2011 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 is some 6 million m^3/a.

For the long term a further 21.889 million m^3/a saving is envisaged by optimising the operations. The long term target is to reduce the water losses to approximately 18.3% of the total diversion.

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

(1) Identify "obsolete" return structures in order to minimise measurement.

(2) Devise methods to protect measuring equipment.

(3) Installing measurement devices to improve management of the water delivery system and undertake water budgets based on measured data.

(4) Revise and improve current maintenance procedures and actions.

(5) Incorporate all relevant data in a custom Management Information System.

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 Kakamas WUA.

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 25.9% to 18.3% of the total inflow into the irrigation scheme.

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ABBREVIATIONS

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

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 channel-like device, based on the principle of critical flow, used to measure the flow of water in open conduits. Formerly termed the Improved Venturi Flume.
Percolation:	Downward movement of water through the soil profile or other porous media.

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

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

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

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

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

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

Telemetry Involving a wireless means of data transfer

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

1 INTRODUCTION

1.1 Background

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

Following on the meetings with DWA Directorate: Water Use Efficiency and the DWA Regional Office this report provides an overview of the water allocation and use situation of the Kakamas WUA and related institutional arrangements.

1.2 Study Objectives

The primary objective of the study is the development and implementation of an Irrigation Water Management Plan for the Kakamas WUA to improve water use efficiency in the scheme. In order to achieve this objective, the following aspects were considered:

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

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

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

1.3 Structure of the report

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

Chapter 2 describes the catchment characteristics of the Lower Orange River catchment in which the Kakamas WUA is situated. The chapter describes the history of the Kakamas WUA, the scheduled quotas and current land-use practices in the catchment.

Chapter 3 provides an overview of water distribution infrastructure found in the Kakamas WUA. The chapter also describes the measurement of flow into and out of the Scheme.

Chapter 4 provides a condition assessment of the infrastructure of the Kakamas WUA.

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

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

Chapter 7 of this report describes the existing water conservation and demand management measures that have already being implemented by the WUA.

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

Chapter 9 provides the Water Management Plan for the Kakamas WUA.

Chapter 10 includes the conclusion and recommendation for the Kakamas WUA.

2 CHARACTERISTICS OF ORANGE RIVER CATCHMENT

2.1 Overview

The Kakamas Water User Association with it offices in the town of Kakamas is situated 80 kilometres downstream of Upington in Lower Orange WMA. The area of operation stretches on both sides of the Orange River from Neusberg Weir in the east to just downstream of the Augrabies Waterfall in the west. **Figure 2.1** presents the locality map of the Kakamas Irrigation Scheme.

The Orange River is South Africa's major river. Its length from the Drakensberg in Lesotho to the mouth at the West Coast at Alexander Bay is approximately 2 300 km. Where it rises in the eastern highlands of Lesotho, the river is known as the Senqu River. The Orange River forms the borders between several South African provinces as well as the border between Namibia (southern boundary) and South Africa. The Orange River flows through the semi-desert/desert area along the southern border of Namibia. The estimated annual sediment load is approximately 120 million tons, 6 times more than any other river in South Africa. The Department of Water Affairs divided the Orange River catchment in two water management areas namely the Upper Orange and the Lower Orange Water Management Areas.

The Lower Orange WMA is the lowest WMA in the Orange/Vaal River Basin and as such is affected by upstream activities, both in terms of the Upper Orange and the Vaal System. The topography of the area is flat with large pans or endoreic areas that do not contribute runoff to the Orange River system.

The Orange River, which forms a green belt in an otherwise arid landscape, also forms the border between South Africa and Namibia over about 550 km to the west of 20 degrees longitude. The Vaal River, the main tributary to the Orange River, has its confluence with the Orange River about 13 km west of Douglas. Other tributaries are the Ongers and Hartebeest Rivers from the south, and the Molopo River and Fish River (Namibia) from the north.

The two major storage dams Gariep and Vanderkloof, which supply all the irrigation, urban, and mining requirements along the Lower Orange River are located in the Upper Orange WMA and are of critical importance to the Lower Orange WMA and shortages in the Upper Orange WMA directly impacts on the Lower Orange WMA.

2.1.1 Climate and rainfall distribution

The area comprising the Lower Orange WMA is largely arid and experiences a harsh climate. It has the lowest mean annual rainfall in the country, varying from 400mm in the east to 50 mm per annum on the west coast. Potential evaporation can reach 3 000 mm per annum.

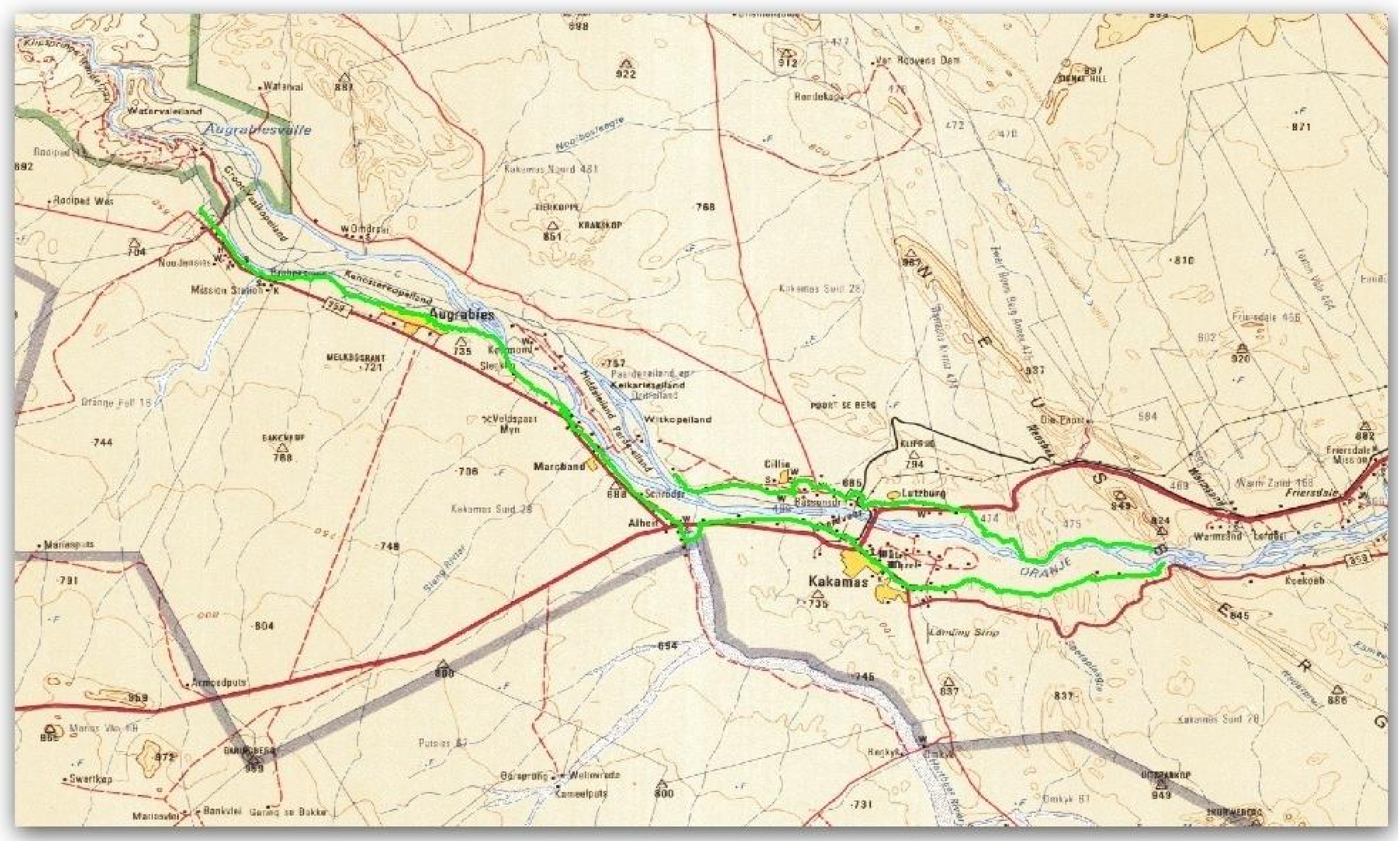

Figure 2-1: Location Map of Kakamas Irrigation Scheme

2.1.2 Geology and soils of the catchment

The topography of the Lower Orange WMA is such that it is largely flat, with large pans or endoreic areas that do not contribute significant runoff to the Orange River system. Water users situated outside the reach of the Orange River therefore rely heavily on groundwater supplies. In the western side of the WMA, the rocky and barren Richtersveld Mountains are found while the northern area is covered by Kalahari sands. A complex geology exists south and westwards of the Orange River, with a variety of rich mineral deposits and shallow, rocky soils. The area in and around the Lower Orange WMA is typically characterised by four desert systems, three of which drain into the Orange (UNDP, 2007): the Succulent Karoo, Nama Karoo (receiving mainly summer rainfall and comprising numerous vegetation types) and the Southern Kalahari (consisting of a deep layer of windblown sand with little run-off from rainfall). The Namib Desert system which does not drain into the Orange River Basin, is the driest of the four, forming a narrow strip along the Atlantic coast (GDC, 2009).

2.2 History of the Kakamas Irrigation scheme

The small town of Kakamas was developed and maintained by a couple of very poor stock farmers at the end of the 19th century. In 1897 the Dutch Reformed Church started a “colony” on the farms Soetap and Kakamas on the banks of the Orange River for white people who got impoverished as a result of the drought. Kakamas became a proper settlement in 1898 under the auspices of the Dutch Reformed Church and soon developed into an agricultural centre.

Ignoring the criticism of qualified engineers about their building methods the farmers constructed the water canals by hand. Some of these are still used to supply the town and surrounding area with water for irrigation. For their efforts they were each awarded the right to one of the irrigation plots. The men worked extremely hard even taking the yoke themselves, rather than wasting precious time in launching a time consuming search for oxen and donkeys grazing somewhere in the field.

The dry piling of the stone along rocky slopes can still be seen today. By dry piling instead of excavating through rock, the farmers were able to cut the overall costs of the canals considerably.

The ingenuity of the workers under the leadership of Japie Lutz is demonstrated in the workmanship at the water tunnels in the northern canal.

The scheme was taken over by the Department of Water Affairs in 1964.

Irrigation development in the Lower Orange WMA was stimulated by the construction of several dams. Great expansions of irrigation were made possible along the Orange River by the construction of Gariep and Vanderkloof dams in the Upper Orange WMA during the 1970’s.

Problems were experienced creating sufficient flow in the main irrigation canals, particularly the canal on the South Bank of the Orange River and in 1993 the Neusberg Weir was completed. Neusberg Weir alleviated the supply problems previously experienced with the main irrigation canals and also increased the capacities of the main supply canals from approximately 3 m^3/s to 7.5 m^3/s and 6.8 m^3/s for the north bank and south bank canals respectively.

The Kakamas WUA was established with the purpose of taking over the operations and maintenance of the Kakamas Government Water Scheme. It was established in terms of Section 98 (6) of the National Water Act after approval of its constitution by the Minister through proclamation no. 516 in Government Gazette no. 22357 dated 15 June 2001.

The total area under irrigation is 10 485.1 ha. The scheme consists of a lined canal on both sides of the Orange River which more or less track the river course. While some farmers pump directly from the rivers the majority are supplied from these canals. The WUA also supplies water for industrial and municipal use.

Originally designed as a flood irrigation scheme, 90% of the area is still irrigated by flood irrigation and the remaining 10% is irrigated with micro and drip irrigation systems. The canal users are measured using calibrated sluices while the users which abstract directly from the river are not metered. The main crops grown are grapes, lucerne and maize, with other crops such as cotton, wheat, peas and pecan nuts making up the balance. Water shortages are rare and users are billed on a m^3/ha/a basis with the allocation being 15 000 m^3/ha/a.

The entire Kakamas GWS infrastructure was rehabilitated between 1983 and 1993 and this scheme is in the best condition of all the schemes included the study. The operating philosophy is that the *WUA* has created just another channel of the river and water flows through the canals with similar or less losses as would be the case if the water had stayed in the river.

The announcement of the formation of the *water user association* was made on 15 June 2001 as per Government notice No. 516. The Minister of Water Affairs signed final approval in March 2003 and *WUA* took over the maintenance of all infrastructures from the Department of Water Affairs. The ownership of the infrastructure remains vested in the Department of Water Affairs.

2.3 Water use permits / licenses and contracts

The authorisation for the water use, within the Kakamas WUA'S area of jurisdiction, lies in the Schedule of Rateable Areas for 10 485.1 ha, drawn up in terms of section 88 of the 1956 Water Act. This Schedule is included as an Annexure to the Constitution of the Kakamas WUA and was declared as Existing Lawful Water Use under section 33 of the National Water Act, 1998.

In terms of the National Water Act (Act 36 of 1998), the irrigation boards were required to be transformed into Water User Associations (WUA). The Kakamas Irrigation Board was then transformed into a WUA in 2001. The scheme has a total scheduled area of 10 609 hectares, at a scheduled quota of 15 000 m^3/ha/a.

In the Constitution of the Kakamas Water User Association two categories of water users are identified namely *Category* A which represent the local authority in the area communities on both sides of the river in the Kenhardt and Gordonia districts respectively, emerging farmers, industrial users, domestic users and environmental and recreation users. *Category B* represents water users in the agricultural sector with withdrawals either from waterworks on the scheme or directly from the Orange River.

The towns of Kakamas, Marchand and Augrabies as well as the settlements of Lutzburg, Cillie and Aiheit form part of the Kai !Garip Municipality and abstract water within the borders of the WUA either through direct withdrawal from the Orange River by means of their own waterworks or from the canals or through a combination of both. The Kai !Garip Municipality is the Service Provider in terms of the Water Services Act throughout the whole area of operation of the Kakamas Water User Association and water is supplied to them in bulk. Details of each group of water users are shown in Table 2-1 .

Table 2-1: Kakamas Water User Association water use entitlements

Group	Annual quota (m^3)
Agricultural - Irrigation	159 139 500
Industrial users	30 000
Domestic users	1 618 500
Municipal users	1 698 050
Total	**162 486 050**

2.4 Irrigated areas and types of crops

The typical crop mix across the Kakamas WUA is shown in **Table 2.2** below. The main crops that are under irrigation include grapes and other crops such as lucerne, maize, cotton, wheat, peas and pecan nuts.

Table 2-2: Crops irrigated within the area of operation of the Kakamas WUA

Crops	Hectares	%
Grapes	9 548	90%
Other	1 061	10%
Totals	**10 609**	**100%**

2.5 Historic water use

The water use for the period between Jan 2008 and Jul 2010 demonstrate a range of water use in the Kakamas WUA. Monthly irrigation agriculture has ranged between 18.6 million m^3/month in December 2008 and 3.8 million m^3/month in June 2008, with an average of 12.091 million m^3/month. The total average other requirements for the same period is 0.33 million m^3/month

Table 2-3: Historic water use levels for the Kakamas WUA

Month	Irrigation ($\times 10^3$ m^3)	Other users ($\times 10^3$ m^3)				Total
		Domestic	Industrial	Municipality	State Dept.	
Jan. 2008	16 924.3	204.8	0.6	128.6	5.4	17 263.7
Feb. 2008	14 109.1	187.7	0.6	128.6	5.4	14 431.4
Mar. 2008	18 357.5	204.8	0.6	48.8	5.4	18 617.1
Apr. 2008	9 192.7	93.1	0.6	48.8	5.4	9 340.6
May 2008	6 310.0	74.5	0.6	48.8	5.4	6 439.3
Jun. 2008	3 723.1	37.3	0.6	48.8	5.4	3 815.2
Jul. 2008	4 902.0	74.6	0.6	48.8	5.4	5 031.4
Sep. 2008	11 539.8	149.5	7.9	145.9	5.4	11 848.5
Nov. 2008	15 158.8	224.4	8.3	208.8	0.0	15 600.3
Dec. 2008	18 125.3	224.4	8.3	261.5	0.0	18 619.5
Jan. 2009	15 668.2	224.4	7.9	261.5	0.0	16 162.0
Feb. 2009	17 051.1	205.6	7.9	235.5	0.0	17 500.1
Mar. 2009	12 736.6	205.6	7.9	235.5	0.0	13 185.6
Jan. 2010	16 098.8	224.3	7.9	262.5	0.0	16 593.5
Feb. 2010	16 517.1	205.5	7.9	262.5	0.0	16 993.0
Mar. 2010	13 942.8	205.5	7.9	264.3	0.0	14 420.5
Apr. 2010	7 910.4	93.4	7.9	232.6	0.0	8 244.3
May 2010	4 811.7	74.6	7.9	235.5	0.0	5 129.7
Jun. 2010	5 031.7	37.3	7.9	130.4	0.0	5 207.3
Jul. 2010	7 148.6	74.6	7.9	154.7	0.0	7 385.8
Monthly Average	**11 763.0**	**151.3**	**5.4**	**169.6**	**2.2**	**12 091.4**

3 INVENTORY OF THE EXISTING WATER INFRASTRUCTURE

3.1 Overview

The Kakamas Irrigation Scheme comprises two weirs, primary irrigation conveyance infrastructure which diverts water from the Orange River into the scheme and a canal distribution system which delivers the water ordered to the irrigators at their farm turnouts through a number of sluice gates.

3.2 Neusberg and Marchand weirs

The Neusberg Weir, planned as far back as 1897 by the British Colonial Officers of the time, was completed in 1993. The weir is 995m long with an average height of 5m and was both designed and constructed by DWAF. The weir is located approximately 12km upstream of Kakamas and forms a small reservoir in the Orange River with storage of almost 2 million m^3.

The Neusberg Weir (Figure 3-1) was constructed using Roller Compacted Concrete (RCC) and is made up of three notches separated by four director walls. The director walls extend 10m upstream and are designed to provide more accurate flow measurements. There are two notches for the low to medium flows located on the left and right banks. The 330m long low notch on the left bank is 250 mm lower than the 250m long notch on the right bank. The central notch is the high flow notch and is 1 600mm higher than the left bank notch. The notches are designed to provide flows of reasonable accuracy over a wide flow range. The lowest notch on the left bank will measure flows up to 140 m^3/s before the right notch comes into effect. The central notch only comes into effect at flows in excess of 1 870 m^3/s and the combined spillway is designed to provide reasonable estimates of high flood flows up to 11 800 m^3/s which represents the 1 in 50 year flood.

Figure 3-1: Neusberg Weir

A small fish way was included in the flow director wall at the left low flow notch to provide access for fish moving upstream. This is the first time that the so-called vertical slot concept has been used for a fish way in South Africa. It consists of a 2m wide by 2.5m deep rectangular channel in which pre-cast concrete baffle walls were provided at 3m intervals. By careful placing of the baffle walls, resting pools were created for the fish moving upstream against the strong currents.

An aerial view of the Marchand Weir is shown in Figure 3-2. The diversion into the Marchand Canal on the left bank is clearly visible.

Figure 3-2: Marchand Weir

3.3 Irrigation conveyance infrastructure

The scheme consist of the Neusberg and Marchand Weirs in the Orange River, 75,4km concrete main canals, 68,9 km concrete secondary canals, 44km open storm water and subsurface drainage canals and 23km of subsurface pipe drains. Bulk water is supplied within the borders of the association through the canal systems for irrigation, towns, settlements, industries and domestic and stock watering purposes. A breakdown of the main infrastructure found within the various sections of the Kakamas WUA is presented in Table 3-1 .

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Table 3-1: Conveyance infrastructure

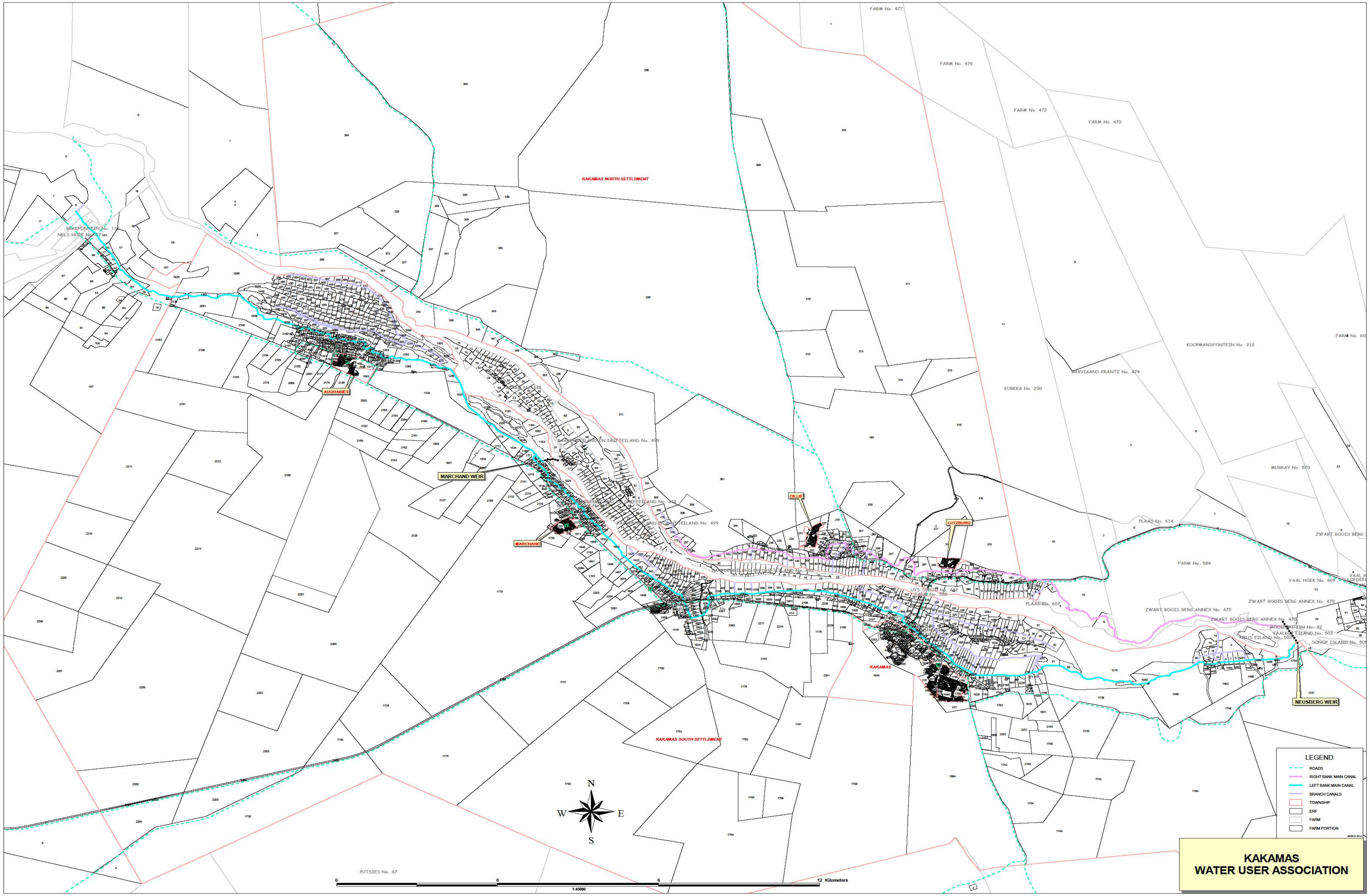
Description	Canal No.	Name	Length (m)
KAKAMAS NORTH			
Canals	1	North Main canal	18 275
	2	Schroder branch canal	1 240
	3	North Main canal	7 439
	4	Drift Eiland canal	3 379
	5	Cilliers branch canal	2 513
	Combined length		*32 846*
Open drains	1	Janneman Threon	934
	2	Lutzburg	1 380
	3	Branch drain 1 Lutzburg	280
	4	Branch drain 2 Lutzburg	780
	5	Van der Westhuizen	875
	6	Scheepers	1 169
	7	Koortzen Rykheer	1 340
	8	Spangenberg	550
	9	JJJ Coetzee	535
	Combined length		*7 842*
KAKAMAS SOUTH			
Canals	1	South Main canal	9 245
	2	Neus branch canal No.1	382
	3	Neus branch canal No.2	1 462
	4	Neus branch canal No.3	253
	5	Bosvoor	761
	6	Middelvoor	2 736
	7	Noordrant West	982
	8	Noordrant East	300
	9	Middelvoor	1 014
	10	Binnevoor	4 061
	11	Onderbos	2 832
	12	Sandheuwel	3 023
	13	South Main canal	6 411
	14	South Main canal	6 230
	15	Altheit Island canal	3 363
	16	Altheit main canal	5 794
	17	Speen canal	886

Description	Canal No.	Name	Length (m)
	18	Marchand canal	2 350
	19	Reject - Bosvoor	260
	20	Reject - Altheit	230
	Combined length		*52 575*
Open drains	1	Neusdrein	2 140
	2	Bosvoorhoof	5 237
	3	Kakamas East	4 289
	4	O'Connel	954
	5	Johan van Rensburg	750
	6	Drienus van Zyl	745
	7	Reject - Drienus van Zyl	650
	8	MG Mans	635
	9	Standerd Bank	600
	10	Hoërskool	360
	11	Steenkamp	1 065
	12	Truter	495
	13	Barnard	495
	14	Bezuidenhout	320
	15	Johan van Zyl1 (s\o)	340
	16	Johan van Zyl2	270
	17	Frikkie van Shalkwyk	485
	18	Zaaiman	500
	Combined length		*20 328*
Pipe drains	1	Neus	934
	2	Kakamas East	1 660
	3	Bennie Koortzen East	450
	4	Bennie Koortzen West	440
	5	Vrekwerk	680
	6	Lappies	480
	7	Jan v\d Westhuizen	830
	Combined length		*5 474*
PAARDEN ISLAND			
Canals	1	Paarden Island main canal	5 914
	2	Witkop Island branch canal	2 286
	3	Witkop Island branch canal	1 464
	4	Paarden Island main canal	5 326

Description	Canal No.	Name	Length (m)
	5	Seweman branch canal	1 235
	6	Skoolkop canal	638
	7	Drieman branch canal	644
	8	Reject - Eli se val	131
	Combined length		*17 638*
Pipe drains	1	Pipe drain 1	2 021
	2	Pipe drain 2	3 200
	3	Pipe drain 3	1 575
	4	Pipe drain 4	2 806
	5	Pipe drain 5	925
	Combined length		*10 527*
MARCHAND			
Canals	1	Alheit Island canal	3 363
	2	Alheit Main canal	5 794
	3	Speen canal	886
	4	Marchand canal	2 350
	Combined length		*12 393*
Open drains	1	Alheit	1 719
	2	Augrabies Inkeer	140
	Combined length		*1 859*
AUGRABIES\NOUDONZEES			
Canals	1	Augrabies Main canal	500
	2	Augrabies Main canal	4 619
	3	Augrabies Main canal	281
	4	Renosterkop Main canal	3 320
	5	A - canal	4 807
	6	Oumens Eiland canal	1 490
	7	B - canal	4 366
	8	C - canal	3 831
	9	D - canal	3 626
	10	Augrabies Main canal	3 000
	11	Noudonzees canal	8 200
	12	Klein Kanaaltjie	400
	13	Reject - B en C canals	624
	Combined length		*39 064*
Open drains	1	Barbees	192

Description	Canal No.	Name	Length (m)
	2	F.Nel\B du Plessis	705
	3	P.Visser	425
	Combined length		*1 322*
Pipe drains	1	Pipe drain 1	4 698
	2	Pipe drain 2	4 077
	3	Pipe drain 3	3 416
	4	Pipe drain Noudonzees 1	176
	5	Pipe drain Noudonzees 2	211
	Combined length		*12 577*

Figure 3-3: Kakamas Irrigation Scheme Infrastructure



3.4 Irrigation storage and regulation system

There are no balancing dams in the area of operation and the lack of storage capacity, i.e. balancing dams within the canal system, makes it difficult to manage the water releases since shortfalls cannot be supplemented within a short time frame. The canal system was designed to meet its water demand within a 120 (Mon – Sat morning) hour week, but with mostly labour intensive flood irrigation taking place in the scheme, the water abstraction is peaking during day time.

3.5 Flow Measurement and telemetry system

3.5.1 Measurement of flow into and out of the Scheme

The first measurement takes place at the Neusberg Weir. The total flow of water can also be measured at the following diversions: Bosvoor, Stasie, Alheit, Marchand, Schroder, Rooidraai, Drift, Cillie and Paarden Eiland (Augrabies).

Figure 3-4: Diversion

3.5.2 Measurement at user outlets

The Kakamas Water User Association (WUA) measures the weekly volume of water delivered to the water users using calibrated measuring structures. Users abstracting directly from the Orange River are required to meter their water use through in-line water meters. A typical user outlet located on the Northern canal is shown in Figure 3-5.

Figure 3-5: User outlet on Northern canal

Reject structures serves to get rid of excess water in canal system and also allows scouring sedimentation out of the canal at these points. The reject water is passed into drainage canals. Various reject structures are situated along the scheme and there is no measurement of water returning back to the river through reject structures or canal end points.

Pictures of a typical reject structure (and one with measuring point) are provided in Figure 3-6 and Figure 3-7.

Figure 3-6: Reject structure

Figure 3-7: Measuring point at reject structure

3.6 Infrastructure summary

A description of the various structures found within the area of operation of the Kakamas WUA is provided in Table 3-2.

Table 3-2: Description of infrastructure within the KWUA

Type of structure	Description
Secondary canals / pipelines	Includes small secondary canals and pipelines that convey water from the Main Canal to irrigation properties not adjacent to the canal.
Aqueducts	Elevated canal structures constructed to convey water over dry water courses, supported on tie beams.
Siphons	Underground pipes constructed to convey water underneath dry water courses, preventing damage to the canal structure
Flow measuring structures	Permanent structures constructed to measure the volume of water that passes the measuring point, (parshalls, sharp crested weirs,
Bulk water sluices	Sluices situated in the waterway, used to control the flow of water downstream of the control point.
Property sluices	Water from off takes that are serving the irrigation properties is controlled by sluices and the volume of water is measured by a parshall.
Reject structures	Water diversion structures that are used to divert excess water back to the river, i.e. water that is more than the maximum flow capacity of the downstream section of the canal.

An inventory of the canal infrastructure, summarised by section in presented in Table 3-3.

Table 3-3: Infrastructure summary

Type of structure	Total
Secondary canals/pipelines (km)	68.9
Storm water and subsurface drainage canals (km)	44.0
Sub surface pipe drains (km)	23.0
Tunnels	2
Aqueducts	4
Siphons	40
Flow measuring structures	12
Bulk water diversion structures	8
Property sluices	500
Reject structures	32

4 INFRASTRUCTURE CONDITION ASSESSMENT

4.1 Overview

The entire Kakamas WUA infrastructure was rehabilitated between 1983 and 1998 at a cost of R270 million and the condition of the infrastructure is very good. A detailed condition assessment was therefore not undertaken. Figure 4-1 and Figure 4-2 provide a view of the canal system, showing the excellent condition of the canal.

Figure 4-1: Siphon and canal condition

Figure 4-2: Condition of main canal

5 SCHEME OPERATIONS AND OPERATING PROCEDURES

5.1 General

The Kakamas WUA employs 18 full time employees that oversees the day-to-day management of the scheme. Elected or nominated delegates represent the users in the different sectors from each interest group as prescribed by the Constitution of the Kakamas Water User Association. The Management Committee for the Kakamas Water User Association comprises 15 members. The Management Committee is constituted as follows:

- Eight persons representing irrigation in the 8 Sub-areas
- One person representing emerging farmers
- One person representing domestic users
- One person representing the local authority
- Two persons representing the communities/farm workers
- One person representing industry
- One person representing environmental and recreation users

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, particularly the Chairman of the Board, is 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 Orange River with regard to the calculation of the reserve and, therefore, this has not yet made an impact on the Kakamas WUA. 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

The supply at the main canal is from the Neusberg Weir and is set by the WUA. If the canal level increases a spillway sluice gate can be used at the divert structure of the canal to get rid of excess water. The opposite applies if the canal level decreases, the sluice gate can be turned smaller to increase the canal level. The maximum flow at the start of the canal is 7.45 m^3/s.

Every irrigation farmer submits a request to the scheme administrators before 14:00 every Thursday for the water requirement of the following week. The total scheme is divided into a number of water wards ("bereike") with a water control officer responsible for each ward. The water orders are captured and a distribution sheet is then generated which is used to determine the releases and settings for a number of control points at the start of each section/ward.

Sluices on the Southern canal are locked during the evening and set by the water control officers the following morning.

Water users on the Northern canal opens and closes the sluice gates themselves and are monitored by the water control officers to check whether they are sticking to their orders. If transgressors are found, their sluice gates are locked

During weekends the level of the canal is lowered and there are users who only abstract water during weekends at night.

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 Kakamas WUA regarding the temporary transfer of water are as follows:

- 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
- No additional MAR will be created with transferred water
- Transfer can only take place if it is requested on the required form

Permanent transfer of water use entitlements are however problematic and is presently hampering development as water users are not prepared to undertake the huge capital outlay required to establish new fields without a permanent transfer and accompanying water use entitlement.

5.4 Water pricing structure

5.4.1 Setting of the irrigation pricing

The Kakamas WUA 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 (2012/13)

Water use sector	Tariff
Agricultural water – From canal (R/ha)	R 1 252.00
Agricultural water – From river	R 601.00
Industrial water – From canal (c/m^3)	50.9
Industrial use – From river (c/m^3)	24.81

6 KAKAMAS WUA WATER BUDGET

6.1 Introduction

The purpose of a water balance is to summarise the inflows, consumption and outflows from the area of operation of the WUA. 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 Neusberg Weir where water is released into the irrigation canals.

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 through the parshalls. The monthly data on releases at the individual sluices 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 ether committed or non-committed outflow. Committed outflow is that part of the outflow that is committed to other uses or users. Uncommitted outflow is outflow that is available for other or downstream use. Uncommitted outflow can occur as a result of a lack of storage or operational measures. There are numerous reject points on the Kakamas scheme that discharges water back to the river but none of these points are measured, making it impossible to determine the outflows.

6.5 Overall scheme water balance

The water balance is based on information obtained from the WUA which is held in a custom database. The Water Administration System (WAS) is not used on the Kakamas WUA. The records of inflows which consist of all the sources of water supply to the Kakamas WUA were provided on a monthly basis.

The outflows consist of all the ways that water is consumed 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.

Currently there is no accurate data available on the exact volume of water loss on the canal system. An estimated figure of 25% is used by the Kakamas WUA in submitting their monthly water loss reports to DWA.

The actual water releases for the period 1 July 2007 to 30 June 2008 are shown in Table 6-1.

Table 6-1: Actual releases

Month	Total volume released (m3)
Jul-07	21 163 544
Aug-07	37 190 650
Sep-07	36 575 866
Oct-07	37 558 474
Nov-07	35 991 636
Dec-07	35 926 806
Jan-08	36 192 504
Feb-08	31 609 692
Mar-08	34 626 109
Apr-08	19 532 578
May-08	21 192 976
Jun-08	18 439 163
Total	**366 000 000**

6.6 Losses

6.6.1 Overview

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

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

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

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

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

Avoidable losses

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

6.6.2.1 Evaporation losses

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

For the Kakamas WUA the estimated value of the evaporation loss as a percentage of the total inflow into the scheme was calculated as 1 098 000 m ^{3} per annum.

6.6.2.2 Seepage losses:

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

Other factors that have an effect on seepage losses are *inter alia*, Soil characteristics, water depth in the canal, flow speed, soil capillary tension, quantity of sediment, etc.

Given the excellent condition and age of the canal infrastructure the seepage loss on the Kakamas Irrigation Scheme as a percentage of the total input volume was the estimated to be 8 %. This translates to a volume of 29.28 million m^3 per annum.

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

6.6.2.4 Leaks and Spills:

Leaks normally occur on broken sections of the canals and on the top sections of the canal body and can be as a result of maintenance problems and the general deterioration of the canal network due to its age. The determination of the volume of water that is lost as a result of leakages and spills is very difficult to calculate and can only really be determined through accurate measuring. An important factor that has a marked effect on leakages is 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.

The distribution network of the Kakamas WUA is new and in excellent condition and the average operational losses and leakages for the WUA was estimated at 17.6 % of the inflow.

6.6.2.5 Aquatic weeds

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

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

(ii) Overestimation of the quantity 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) Aquatic weed fragments occlude irrigation systems and filters at water purification plants.

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

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

The total outflow from the canal system was calculated using the formula below.

Total outflow = (Volume released – Registered water use) / Volume released

= (366 000 000 – 162 000 000) / 366 000 000

= 55.7%

Of the total volume released into the canal system, 30% (29.78%) can be classified as committed outflow for downstream users. Although there is no accurate information available on the volume of water that is diverted back to the river at various reject structures, the percentage of operational losses in the canal system was estimated at approximately 25.92%. Table 6-2 provides a summary of the various losses on the canal distribution network of the Kakamas WUA. It is important to note that a further breakdown of the losses was not possible.

Table 6-2: Kakamas WUA - Breakdown of water losses

Description	*System inflow (x 106m3)*	*Present situation – Losses*			
		Unavoidable Losses (x 10^6m^3)	*Avoidable Losses (x 10^6m^3)*	*Total Losses (x 10^6m^3)*	% of total volume released
Seepages		*29.280*		*29.280*	7.99%
Evaporation		*1.098*		*1.098*	0.29%
Filling losses					
Leakages					
Spills		*0*	*64.489*	*64.489*	17.62%
Over delivery					
Canal end returns					
Other					
Total	***366.0***	***30.378***	***64.489***	***94.867***	***25.92%***
% of total volume released into system		***8.28%***	***17.62%***	***25.92%***	

From the data presented Table 6-2 it is evident that the total losses on the scheme amount to 25.9%. Of the total losses occurring on the scheme 30.378 million m^3 can be classified as unavoidable losses.

6.6.3 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the average estimated avoidable water losses have been 64.489 million m^3. This quantity can be attributed to a number of factors.

- *Measuring 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.* 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.
- *Over delivery*: There is potential for significant "water losses" to take place if the sluice settings to individual users and direct abstractions from the river are not monitored on a continuous to ensure that they are indeed correct.
- *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/or deterioration of the canal network.

7 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

7.1 Overview

The Kakamas WUA 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 programs to address problems with midgets. These existing water management measures are discussed in more detail below.

7.2 Operation and maintenance of the canal infrastructure

Although the ownership of the canal infrastructure at the Kakamas WUA 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.

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. A detailed maintenance regime and civil maintenance guidelines were developed and included in the cooperation agreement. The following items are *inter alia* included in the guidelines:

- The structure (or part thereof),
- Items to be checked,
- Corrective steps to be taken, and
- Proposed inspection frequency.

During the scheduled dry weeks, which occurs three times a year(2 weeks at a time), canal sections are maintained where necessary and includes the following;

- Sealing of joints,
- Reparation / replacement of structures that no longer provide water accurately due to erosion and wear,
- Maintenance of storm water structures that protects the canal system from flood water.

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.

7.3 Promotion of laser levelling

Originally designed as a flood irrigation scheme, 70% of the area is still irrigated by flood irrigation and the remaining 30% being irrigated with micro and drip irrigation. The active promotion of laser levelling of flood irrigation areas is resulting in an increase in laser levelling with 95% of the flood irrigated area already laser levelled.

This procedure, which takes place when an old vineyard is replaced, significantly improves the efficiency of flood irrigation by eliminating uneven distribution, ponding and related water-logging and over-irrigation.

8 WATER MANAGEMENT ISSUES AND GOALS

8.1 Overview the management issues

The water budget analysis discussed in the previous chapter together with discussions held with Kakamas WUA, has helped to identify several key water management issues. There is however insufficient data to clearly determine where and how losses are occurring. Currently there are no records as to how much water spills occur due to operational issues or how much water is returned to the river through the reject structures or at the canal end points.

The most noticeable aspect that was noticed during the consultations with the WUA is the sense of awareness of the management of the importance of efficient irrigation water management and conservation, and the interest shown to learn as much as possible. In addition to the water budget analysis, some limited discussions were held with the management and other people who are knowledgeable about the Kakamas Irrigation Scheme. This was done to determine the key issues the scheme is facing. **Table 8.1** below provides the key issues identified and these are discussed in more detail in the following sections of this chapter.

8.2 Flow measurement data and assessments

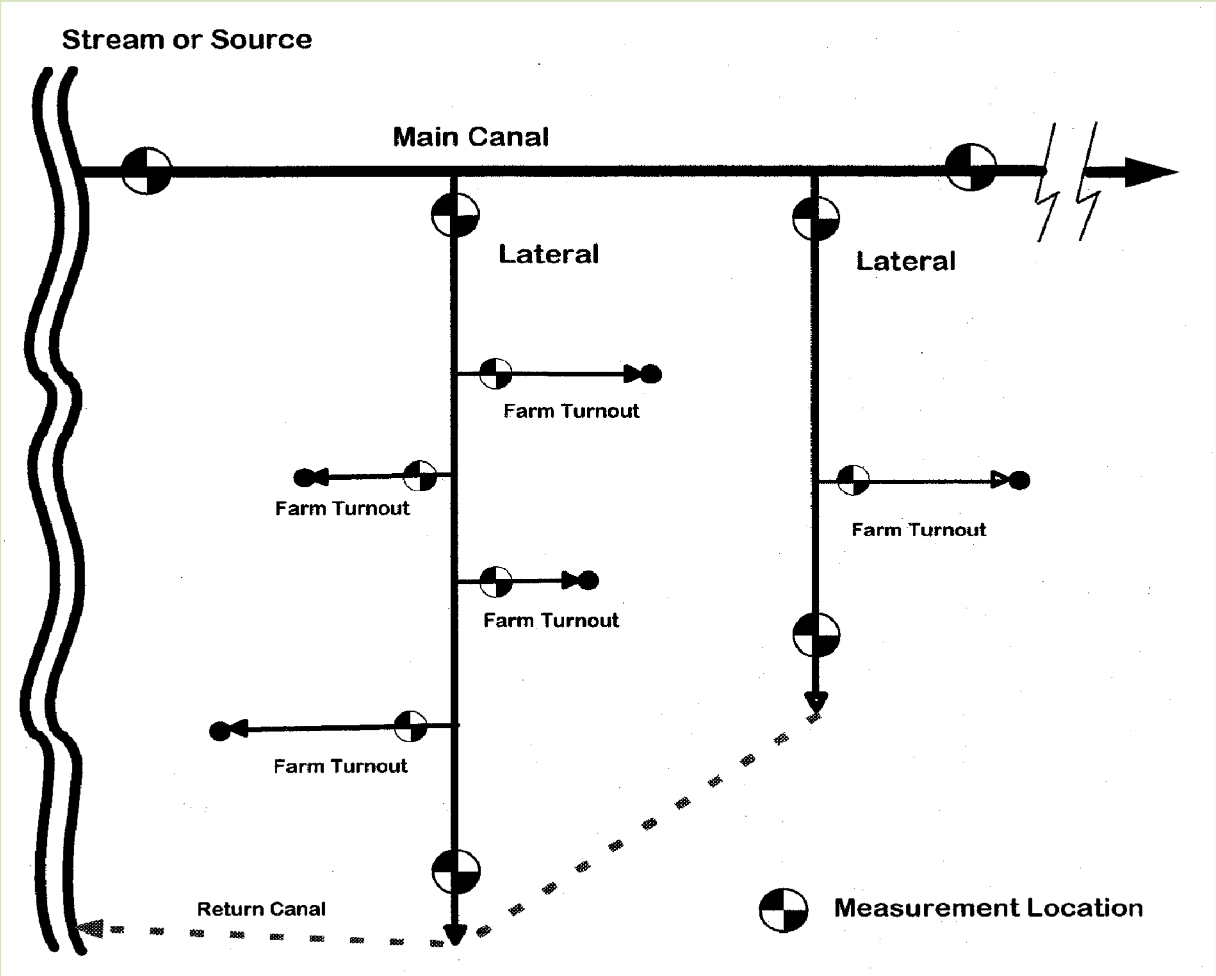
8.2.1 Adequacy of flow data

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. Figure 8-1 below, provides the extent of flow measurement that is ideal for conducting an irrigation scheme water budget. The availability of flow measurements helps inform both the water user and the 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 for sub-schemes within the irrigation scheme.

As illustrated in Figure 8-1 below, it would be ideal to have flow measurements at the inlet to the primary canals as well as at the tail water ends and reject points. 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.

The Kakamas WUA appears to have adequate flow measurement structures in place to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into the major sections. These include weirs and parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers.

However, there is no measurement of water returning back to the river through reject structures or canal end points. Without these measurements it is impossible to conduct an accurate water budget.



Source: Bureau of Reclamation

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

There is measurement taking place within the scheme where water is released from the weirs into the main canal and there are also other measurements (not telemetric) taken where water is diverted into sub sections of the scheme. WAS is not utilised on the scheme and the flow measurements are only available in spreadsheet format.

Most of the reject points have measurement structures in place but they are not equipped with measuring devices. To complicate the matter, not all of the reject structures are used on a continuous basis and are only used when the system is drained for maintenance or when flood situations are experienced.

Management Goal 1

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

(i) Identification of reject structures that are rarely used.
(ii) Assess condition of measuring structures at reject points that are regularly used.
(iii) Calibrate those structures that are used on a regular basis.
(iv) Prepare a budget to equip the identified reject structures with measuring structures and devices within one year.
(v) Undertake the installation of measuring equipment on the identified reject structures and current measuring points on a "ward basis" and progress downstream on the main canal.

8.2.2 Irrigation water budget is not conducted in detail

It is currently impossible to calculate or measure any losses and it is therefore impossible to accurately calculate avoidable losses such as leakage, spills and over delivery to users. Currently it is not possible to conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention.

Management Goal 2

The goal to address the above issue is to ensure that all the current flow measurements in the Kakamas WUA are included in determining water budgets and calculating water losses within 1 year at scheme as well as section 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.

8.3 Operational water management issues

8.3.1 WAS not implemented

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.

However, WAS is not implemented at all on the scheme. The problem is not so much with the current system in operation in on the scheme but with continuity. WAS is a standardised program in use on various schemes throughout the country with many trained operators handling the system. This reduces the risk of an in-house developed program and temporary personnel could assist with the upkeep of the system should the regular operator(s) leave of fall ill.

The whole WAS system does not have to be implemented at once and a phased approach is normally followed. This lessens the burden on the WUA and allows time to get all the necessary information and data in place before a module is implemented.

Management Goal 3

The management objective to address the above issue, is to undertake a feasibility study for the phased implementation of the WAS program. This could be undertaken within 12 months from the completion of this Water Management Plan (WMP).

8.3.2 Available datasets not integrated into a Management Information System

The Kakamas WUA has gathered and generated detailed datasets, ranging from individual sluice detail to water user address information. All these datasets are in standalone databases or spreadsheets and very little thereof are spatially linked. Having all this data in one integrated Management Information System will be a huge benefit and should enable quicker and better informed decision making.

Management Goal 4

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

8.4 Infrastructure related issues

8.4.1 Canal maintenance

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

Management Goal 5

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

8.4.2 Ownership of irrigation infrastructure

The 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 Kakamas WUA, 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 6

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

8.5 Institutional Water Management Issues

8.5.1 Updating and implementation of the Water Management Plan

The CEO of the Kakamas WUA will amongst others, be responsible for the annual updating and implementation of the Water Management Plan (WMP) for the scheme. The roles and responsibilities of the CEO for the updating and implementation of the WMP will be the following:

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

Management Goal 7

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

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

Item No.	Issue description	Comments
1	No flow measurements at reject points are taking place and no water accurate budget can be compiled.	Identification of operational reject points and the installation of measuring equipment.
2	Irrigation water budget cannot be conducted in detail. Data from the monitoring system and other measurements is used for monitoring purposes only and it is impossible to disaggregate the losses.	Break down losses.
3	WAS is not utilised on scheme.	Investigate the use and implementation 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.	
5	Maintenance plan and procedures	Revision of the current actions taken when canals are maintained should be investigated and improved where possible.
6	Ownership of irrigation infrastructure	Responsibility between the DWA and the Kakamas WUA should be further refined.

9 KAKAMAS WATER MANAGEMENT PLAN

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

9.1 Setting of water savings targets

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

A Water Research Commission (WRC) study (Report TT465/10) which was conducted in 2010, has provided guidelines of the desired range of operational losses due to metering errors, canal filling losses after each dry period that have to be included in order to determine the BMP for operational and distribution efficiency (Reinders 2010). This is additional to the unavoidable losses determined in the previous sections. This desired range is expressed as a percentage of inflow into the irrigation scheme. The desired range for operational losses (i.e. metering errors, canal fillings, etc.) is 10% of the inflow into the irrigation scheme.

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 36.6 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 Kakamas WUA were determined to be 8.3% 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 is 18.28% of the total releases into the canal system.

Table 9-1: Target water losses in the Kakamas WUA

<table>
<tr><th rowspan="2">Description</th><th rowspan="2">System inflow (x $10^6 m^3$)</th><th colspan="4">Present situation - Losses</th><th colspan="2">Acceptable water losses</th><th colspan="2">Target water savings</th></tr>
<tr><th>Unavoidable Losses (x $10^6 m^3$)</th><th>Avoidable Losses (x $10^6 m^3$)</th><th>Total Losses (x $10^6 m^3$)</th><th>% of total volume released</th><th>Annual volume (x $10^6 m^3$)</th><th>% of total volume released</th><th>Annual volume (x $10^6 m^3$)</th><th>% of total volume released</th></tr>
<tr><td>Seepages</td><td rowspan="9"></td><td>29.280</td><td></td><td>29.280</td><td>8.00%</td><td>29.3</td><td>8.00%</td><td>0</td><td>0.00%</td></tr>
<tr><td>Evaporation</td><td>1.098</td><td></td><td>1.098</td><td>0.30%</td><td>1.098</td><td>0.30%</td><td>0</td><td>0.00%</td></tr>
<tr><td>Filling losses</td><td rowspan="6"></td><td rowspan="6">64.489</td><td rowspan="6">64.489</td><td rowspan="6">17.62%</td><td rowspan="6">36.6</td><td rowspan="6">10.00%</td><td rowspan="6">27.889</td><td rowspan="6">7.62%</td></tr>
<tr><td>Leakages</td></tr>
<tr><td>Spills</td></tr>
<tr><td>Over delivery</td></tr>
<tr><td>Canal end returns</td></tr>
<tr><td>Other</td></tr>
<tr><td>Total</td><td>30.378</td><td>64.489</td><td>94.867</td><td>25.92%</td><td>66.978</td><td>18.30%</td><td>27.889</td><td>7.62%</td></tr>
<tr><td>% of total volume released into system</td><td></td><td>8.30%</td><td>17.62%</td><td>25.92%</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Based on the projected water saving targets, the Kakamas WUA can achieve a 2 % reduction in irrigation water losses relative to the 2011 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 is some 6 million m^3/a.

9.1.2 Long term water saving targets

For the long term a further 21.889 million m^3/a saving is envisaged by optimising the operations. The long term target is to reduce the water losses to 18.3% of the total diversion.

9.2 Implementation Plan

An evaluation of the potential measures for implementation in the Kakamas WUA 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:

(1) Identify "obsolete" return structures in order to minimise measurement.

(2) Devise methods to protect measuring equipment.

(3) Installing measurement devices to improve management of the water delivery system and undertake water budgets based on measured data.

(4) Revise and improve current maintenance procedures and actions.

(5) Incorporate all relevant data in a custom Management Information System.

Table 9-2: Kakamas Water User Association: Water Management Measures and Action Plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	(i) Identify "obsolete" return structures in order to minimise measurement points. (ii) Devise methods to protect measuring equipment. (iii) Installing measurement devices to improve management of the water delivery system and undertake water budgets based on measured data. (iv) Undertake sub-scheme water budgets. (v) Prioritise areas/sections with significant water losses.	Apr '13 – Mar '14 Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15 Apr '13 – Mar '14	KWUA
2	Increase operational efficiency	(i) Investigate implementation of WAS (ii) Measurement of direct abstractions from river. (iii) Incorporate data in a custom Water Management System	Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15	KWUA
3	Reduce losses in irrigation canal infrastructure	(i) Revise and improve current maintenance procedures	Apr '13 – Mar '18	KWUA

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 Kakamas WUA.

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

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans is some 6 million m^3/a. For the long term a further 21.8 million m^3/a saving is envisaged by optimising the operations. The long term target is to reduce the water losses to 18.3% of the total diversion.

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ANNEXURE A

COST ANALYSIS

Item	Description	Total
MEASURE RETURN FLOWS		
Measuring equipment	Installing measuring equipment (preferably telemetry) at 12 of the identified reject points.	
Installation period		24 Months
Productive period		20 Years
Initial Capital Investment Costs	Software	R 150 000
	Telemetry infrastructure	R 840 000
	Total	**R 990 000**
Annual O&M Expenses		R 60 000
Reduction in losses	Million m^3/a	6.0
Cost per m^3 (3 years)		**R 0.065**

ANNEXURE B

WATER MANAGEMENT PLAN : KAKAMAS WATER USER ASSOCIATION

SUMMARISED WATER MANAGEMENT PLAN FOR THE KAKAMAS IRRIGATION BOARD

APRIL 2013 TO MARCH 2014

MARCH 2013

Submitted by:

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1 BACKGROUND

The small town of Kakamas was developed and maintained by a couple of very poor stock farmers at the end of the 19th century. In 1897 the Dutch Reformed Church started a “colony” on the farms Soetap and Kakamas on the banks of the Orange River for white people who got impoverished as a result of the drought. Kakamas became a proper settlement in 1898 under the auspices of the Dutch Reformed Church and soon developed into an agricultural centre.

The scheme was taken over by the Department of Water Affairs in 1964.

Irrigation development in the Lower Orange WMA was stimulated by the construction of several dams. Great expansions of irrigation were made possible along the Orange River by the construction of Gariep and Vanderkloof dams in the Upper Orange WMA during the 1970’s.

Problems were experienced creating sufficient flow in the main irrigation canals, particularly the canal on the South Bank of the Orange River and in 1993 the Neusberg Weir was completed. Neusberg Weir alleviated the supply problems previously experienced with the main irrigation canals and also increased the capacities of the main supply canals from approximately 3 m^3/s to 7.5 m^3/s and 6.8 m^3/s for the north bank and south bank canals respectively.

The Kakamas WUA with it offices in the town of Kakamas is situated 80 kilometres downstream of Upington in Lower Orange WMA. The area of operation stretches on both sides of the Orange River from Neusberg Weir in the east to just downstream of the Augrabies Waterfall in the west.

The Kakamas WUA was established with the purpose of taking over the operations and maintenance of the Kakamas Government Water Scheme. It was established in terms of Section 98 (6) of the National Water Act, 1998 by Proclamation No.516 in Government Gazette No. 22357 dated 15 June 2001 after approval of its constitution by the Minister. Certain powers and duties in terms of the National Water Act have also been delegated to the Association to enable us to perform the operation and maintenance functions of the scheme.

The Lower Orange WMA is the lowest WMA in the Orange/Vaal River Basin and as such is affected by upstream activities, both in terms of the Upper Orange and the Vaal System. The topography of the area is flat with large pans or endoreic areas that do not contribute runoff to the Orange River system. The two major storage dams Gariep and Vanderkloof, which supply all the irrigation, urban, and mining requirements along the Lower Orange River are located in the Upper Orange WMA and are of critical importance to the Lower Orange WMA and shortages in the Upper Orange WMA directly impacts on the Lower Orange WMA.

The total area under irrigation is 10 485.1 ha. The scheme consists of a lined canal on both sides of the Orange River which more or less track the river course. While some farmers pump directly from the rivers the majority are supplied from these canals. The WUA also supplies water for industrial and municipal use.

Originally designed as a flood irrigation scheme, 90% of the area is still irrigated by flood irrigation and the remaining 10% is irrigated with micro and drip irrigation systems. The canal users are measured using calibrated sluices while the users which abstract directly from the river are not metered.

The entire Kakamas WUA infrastructure was rehabilitated between 1983 and 1998 at a cost of R270 million and the condition of the infrastructure is very good.

The operating philosophy is that the WUA has created just another channel of the river and water flows through the canals with similar or less losses as would be the case if the water had stayed in the river.

A summary of the infrastructure is provided in the table below.

Table 1-1: Summary of infrastructure

Type of structure	Total
Main canals (km)	75.4
Secondary canals/pipelines (km)	68.9
Storm water and subsurface drainage canals (km)	44.0
Sub surface pipe drains (km)	23.0
Tunnels	2
Aqueducts	4
Siphons	40
Flow measuring structures	12
Bulk water diversion structures	8
Property sluices	500
Reject structures	32

The main crops that are under irrigation include grapes (approximately 9 548 ha), and other crops such as lucerne, maize, cotton, wheat, peas and pecan nuts (approximately 1 061 ha).

The towns of Kakamas, Marchand and Augrabies as well as the settlements of Lutzburg, Cillie and Aiheit form part of the Kai !Garip Municipality and abstract water within the borders of the WUA either through direct withdrawal from the Orange River by means of their own waterworks or from the canals or through a combination of both.

The Kai !Garip Municipality is the Service Provider in terms of the Water Services Act throughout the whole area of operation of the Kakamas Water User Association and water is supplied to them in bulk. Details of each group of water users are shown in Table 1.2.

Table 1.2 : Water user groups

Group	Annual quota (m^3)
Agricultural - Irrigation	159 139 500
Industrial users	30 000
Domestic users	1 618 500
Municipal users	1 698 050
Total	**162 486 050**

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

3 KAKAMAS WUA WATER BUDGET

3.1 Introduction

The purpose of a water balance is to summarise the inflows, consumption and outflows from the area of operation of the WUA. 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.

3.2 Inflows

The first measurement of water flow takes place at the Neusberg Weir where water is released into the irrigation canals.

3.3 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. 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.

3.4 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 and therefore available for other or downstream use. Uncommitted outflow can occur as a result of a lack of storage or operational measures. There are numerous reject points on the Kakamas scheme that discharges water back to the river but none of these points are measured, making it impossible to determine the outflows.

3.5 Overall scheme water balance

The water balance is based on information obtained from the WUA which is held in a custom database. The Water Administration System (WAS) is not used on the Kakamas WUA. The records of inflows which consist of all the sources of water supply to the Kakamas WUA were provided on a monthly basis.

The outflows consist of all the ways that water is consumed 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.

Currently there is no accurate data available on the exact volume of water loss on the canal system. An estimated figure of 25.9% is used by the Kakamas WUA in submitting their monthly water loss reports to DWA.

The actual water releases for the period 1 July 2007 to 30 June 2008 are shown in Table 3-1.

Table 3-1: Releases into scheme

Month	Total volume released (m3)
Jul-07	21 163 544
Aug-07	37 190 650
Sep-07	36 575 866
Oct-07	37 558 474
Nov-07	35 991 636
Dec-07	35 926 806
Jan-08	36 192 504
Feb-08	31 609 692
Mar-08	34 626 109
Apr-08	19 532 578
May-08	21 192 976
Jun-08	18 439 163
Total	**366 000 000**

3.6 Losses

3.6.1 Overview

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

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

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

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

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

Avoidable losses

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

3.6.2.1 Evaporation losses

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

For the Kakamas WUA the estimated value of the evaporation loss as a percentage of the total inflow into the scheme was calculated as 1 098 000 m^3 per annum.

3.6.2.2 Seepage losses:

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

Other factors that have an effect on seepage losses are *inter alia*, Soil characteristics, water depth in the canal, flow speed, soil capillary tension, quantity of sediment, etc.

Given the excellent condition and age of the canal infrastructure the seepage loss on the Kakamas Irrigation Scheme as a percentage of the total input volume was the estimated to be 8 %. This translates to a volume of 29.28 million m^3 per annum.

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

3.6.2.4 Leaks and Spills:

Leaks normally occur on broken sections of the canals and on the top sections of the canal body and can be as a result of maintenance problems and the general deterioration of the canal network due to its age. The determination of the volume of water that is lost as a result of leakages and spills is very difficult to calculate and can only really be determined through accurate measuring. An important factor that has a marked effect on leakages is 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.

The distribution network of the Kakamas WUA is new and in excellent condition and the average operational losses and leakages for the WUA was estimated at 17.6 % of the inflow.

3.6.2.5 Aquatic weeds

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

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

(ii) Overestimation of the quantity 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) Aquatic weed fragments occlude irrigation systems and filters at water purification plants.

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

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

The total outflow from the canal system was calculated using the formula below.

Total outflow = (Volume released – Registered water use) / Volume released

= (366 000 000 – 162 000 000) / 366 000 000

= 55.7%

Of the total volume released into the canal system, 30% (29.78%) can be classified as committed outflow for downstream users. Although there is no accurate information available on the volume of water that is diverted back to the river at various reject structures, the percentage of operational losses in the canal system was estimated at approximately 25.9%

Table 3-2 provides a summary of the various losses on the canal distribution network of the Kakamas WUA. It is important to note that a further breakdown of the losses was not possible.

Table 3-2: Kakamas WUA - Breakdown of water losses

Description	***System inflow*** *(x $10^6 m^3$)*	***Present situation - Losses***			
		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**
Seepages		*29.280*		*29.280*	7.99%
Evaporation		*1.098*		*1.098*	0.29%
Filling losses					
Leakages					
Spills					
Over delivery		*0*	*64.489*	*64.489*	17.62%
Canal end returns					
Other					
Total	***366.0***	***30.378***	***64.489***	***94.867***	***25.92%***
% of total volume released into system		***8.28%***	***17.62%***	***25.92%***	

From the data presented Table 3-2 it is evident that the total losses on the scheme amount to 25.9%. Of the total losses occurring on the scheme 30.38 million m^3 can be classified as unavoidable losses.

3.6.3 Avoidable water losses

Based on the above assessment and disaggregation of the gross water losses, the average estimated avoidable water losses have been 64.49 million m^3. This quantity can be attributed to a number of factors.

- *Measuring 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.* 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.
- *Over delivery*: There is potential for significant "water losses" to take place if the sluice settings to individual users and direct abstractions from the river are not monitored on a continuous to ensure that they are indeed correct.
- *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/or deterioration of the canal network.

4 WATER MANAGEMENT ISSUES AND GOALS

4.1 Overview the management issues

The water budget analysis discussed in the previous chapter together with discussions held with Kakamas WUA, has helped to identify several key water management issues. There is however insufficient data to clearly determine where and how losses are occurring. Currently there are no records as to how much water spills occur due to operational issues or how much water is returned to the river through the reject structures or at the canal end points.

The most noticeable aspect that was noticed during the consultations with the WUA is the sense of awareness of the management of the importance of efficient irrigation water management and conservation, and the interest shown to learn as much as possible. In addition to the water budget analysis, some limited discussions were held with the management and other people who are knowledgeable about the Kakamas Irrigation Scheme. This was done to determine the key issues the scheme is facing. **Table 4.1** below provides the key issues identified and these are discussed in more detail in the following sections of this chapter.

4.2 Flow measurement data and assessments

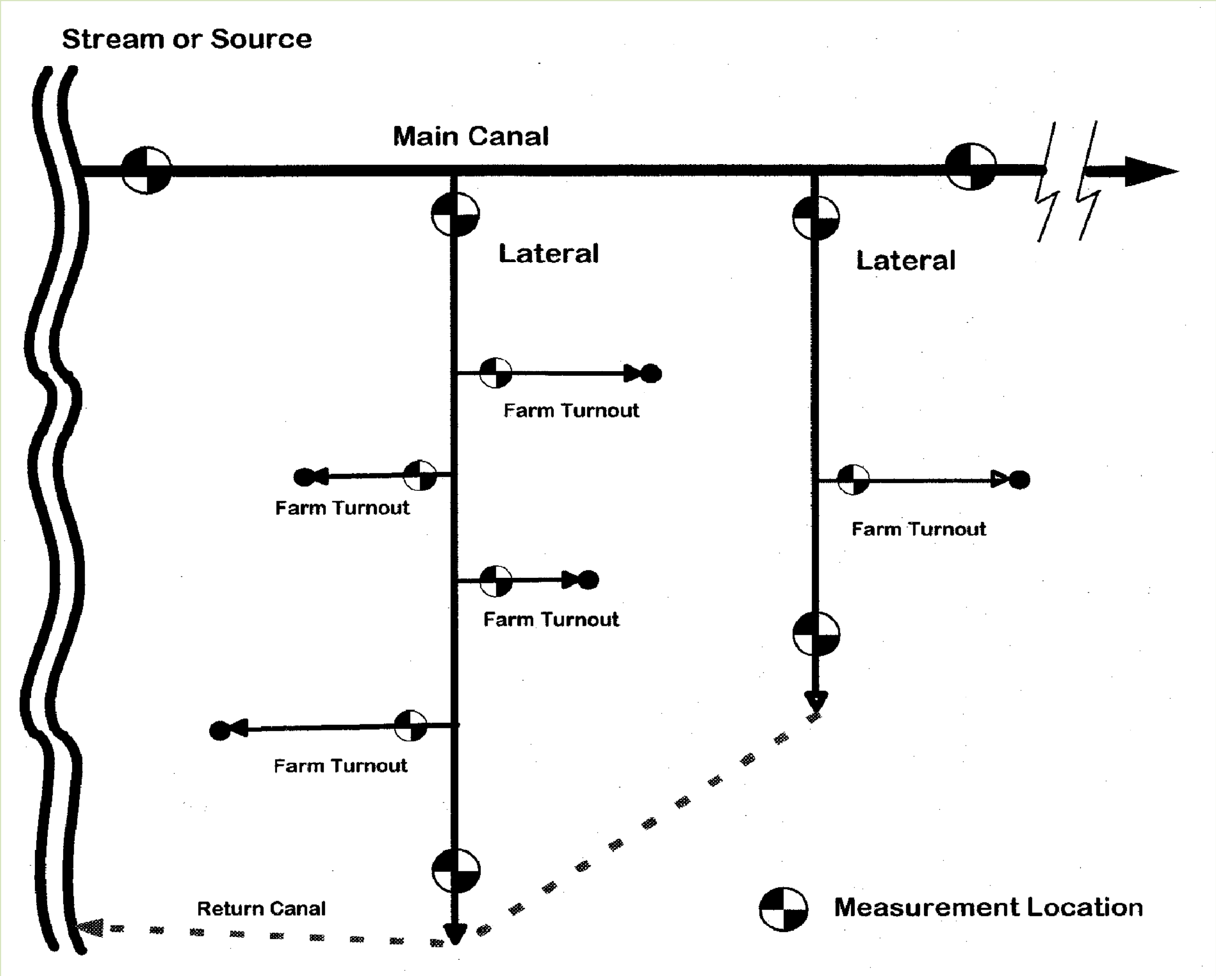
4.2.1 Adequacy of flow data

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. Figure 4-1 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 for sub-schemes within the irrigation scheme.

As illustrated in the figure it would be ideal to have flow measurements at the inlet to the primary canals as well as at the tail water ends and reject points. 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.

The Kakamas WUA appears to have adequate flow measurement structures in place to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into the major sections. These include weirs and parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers.

However, there is no measurement of water returning back to the river through reject structures or canal end points. Without these measurements it is impossible to conduct an accurate water budget.



Source: Bureau of Reclamation

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

There is measurement taking place within the where water is released from the weirs into the main canal and there are also other measurements (not telemetric) taken where water is diverted into sub sections of the scheme. WAS is not utilised on the scheme and the flow measurements are only available in spreadsheet format.

Most of the reject points have measurement structures in place but they are not equipped with measuring devices. To complicate the matter, not all of the reject structures are used on a continuous basis and are only used when the system is drained for maintenance or when flood situations are experienced.

Management Goal 1

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

(i) Identification of reject structures that are rarely used.
(ii) Assess condition of measuring structures at reject points that are regularly used.

(iii) Calibrate those structures that are used on a regular basis.

(iv) Prepare a budget to equip the identified reject structures with measuring structures and devices within one year.

(v) Undertake the installation of measuring equipment on the identified reject structures and current measuring points on a “ward basis” and progress downstream on the main canal.

4.2.2 Irrigation water budget is not conducted in detail

It is currently impossible to calculate or measure any losses and it is therefore impossible to accurately calculate avoidable losses such as leakage, spills and over delivery to users. Currently it is not possible to conduct water budgets for the various sections on the scheme. If this is undertaken it may highlight sections that require specific attention.

Management Goal 2

The goal to address the above issue is to ensure that all the current flow measurements in the Kakamas WUA are included in determining water budgets and calculating water losses within 1 year at scheme as well as section 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.

4.3 Operational water management issues

4.3.1 WAS not implemented

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.

However, WAS is not implemented at all on the scheme. The problem is not so much with the current system in operation in on the scheme but with continuity. WAS is a standardised program in use on various schemes throughout the country with many trained operators handling the system. This reduces the risk of an in-house developed program and temporary personnel could assist with the upkeep of the system should the regular operator(s) leave of fall ill.

The whole WAS system does not have to be implemented at once and a phased approach is normally followed. This lessens the burden on the WUA and allows time to get all the necessary information and data in place before a module is implemented.

Management Goal 3

The management objective to address the above issue, is to undertake a feasibility study for the phased implementation of the WAS program. This could be undertaken within 12 months from the completion of this Water Management Plan (WMP).

4.3.2 Available datasets not integrated into a Management Information System

The Kakamas WUA has gathered and generated detailed datasets, ranging from individual sluice detail to water user address information. All these datasets are in standalone databases or spreadsheets and very little thereof are spatially linked. Having all this data in one integrated Management Information System will be a huge benefit and should enable quicker and better informed decision making.

Management Goal 4

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

4.4 Infrastructure related issues

4.4.1 Canal maintenance

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

Management Goal 5

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

4.4.2 Ownership of irrigation infrastructure

The 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 Kakamas WUA, 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 6

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

4.5 Institutional Water Management Issues

4.5.1 Updating and implementation of the Water Management Plan

The CEO of the Kakamas WUA will amongst others, be responsible for the annual updating and implementation of the Water Management Plan (WMP) for the scheme. The roles and responsibilities of the CEO for the updating and implementation of the WMP will be the following:

- Take flow measurements and conduct a detailed water balance assessment on a monthly basis at scheme and sub-scheme level
- Compile Water Use Efficiency Accounting Reports and submit it on a monthly basis to the DWA Regional Office
- Develop improved water saving targets
- Do recommendations on observations regarding water conservation issues and report to the Chief Executive: SAAFWUA and DWA on ways to address the identified issues

- Develop activities that build on and complement other WC/WDM initiatives taking place at other water schemes
- Present water conservation information and training to irrigators and inform other scheme managers about success stories undertaken by the scheme
- Maintenance and modernisation of the irrigation infrastructure
- Liaise with DWA and other scheme managers to ensure consistent, efficient and effective deployment of water conservation messages, resources and services throughout the scheme
- Monitor the plan and schedule for implementing water conservation program components
- Report quarterly to DWA on the implementation status of the WMP regarding actions taken to reduce water losses and achievements towards achieving water saving targets, goals and objectives.
- Annually review and update of WMP with a water conservation program for the scheme with goals, objectives, action steps, measures, and timelines taking into consideration the latest measured data and the measures that have already been implemented.

Management Goal 7

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

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

Item No.	Issue description	Comments
1	No flow measurements at reject points are taking place and no water budget can be compiled.	Identification of operational reject points and the installation of measuring equipment.
2	Irrigation water budget cannot be conducted in detail. Data from the monitoring system and other measurements is used for monitoring purposes only and it is impossible to disaggregate the losses.	Break down losses.
3	WAS is not utilised on scheme.	Investigate the use and implementation 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.	Assimilate data and link spatially in a GIS.
5	Maintenance plan and procedures	Revision of the current actions taken when canals are maintained should be investigated and improved where possible.
6	Ownership of irrigation infrastructure	Responsibility between the DWA and the Kakamas WUA should be further refined.

5 ESTABLISHING WATER SAVINGS TARGETS

5.1 Acceptable water losses

A Water Research Commission (WRC) study (Report TT465/10) which was conducted in 2010, has provided guidelines of the desired range of operational losses due to metering errors, canal filling losses after each dry period that have to be included in order to determine the BMP for operational and distribution efficiency (Reinders 2010). This is additional to the unavoidable losses determined in the previous sections. This desired range is expressed as a percentage of inflow into the irrigation scheme. The desired range for operational losses (i.e. metering errors, canal fillings, etc.) is 10% of the inflow into the irrigation scheme.

Therefore on the basis of the WRC study a BMP for operational and distribution efficiency has been taken as 10% of the inflow into the scheme. This amounts to 36.6 million m^3/a based on the average inflow into the canals. This together with the unavoidable losses has been used in setting the water saving and water loss targets.

5.2 Water savings targets

The unavoidable water losses in the Kakamas WUA were determined to be 8.3% of the total releases into the canal system. This water is additional to the irrigation water use required at the farm edge.

As illustrated in Table 5-1 below, the expected average water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water due to problems of matching supply and delivery as well as metering errors and canal filling losses is 18.3% of the total releases into the canal system.

Table 5-1: Target water losses in the Kakamas WUA

Description	System inflow ($x 10^6 m^3$)	Present situation - Losses				Acceptable water losses		Target water savings	
		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		29.280		29.280	8.00%	29.3	8.00%	0	0.00%
Evaporation		1.098		1.098	0.30%	1.098	0.30%	0	0.00%
Filling losses Leakages Spills Over delivery Canal end returns Other			64.489	64.489	17.62%	36.6	10.00%	27.8892	7.62%
Total	**366**	**30.378**	**64.489**	**94.867**	**25.92%**	**66.978**	**18.30%**	**27.8892**	**7.62%**
% of volume released into system		**8.30%**	**17.62%**	**25.92%**					

Based on the projected water saving targets, the Kakamas WUA can achieve a 2 % reduction in irrigation water losses relative to the 2011 levels in a relative short period (3 years and less).

5.2.1 Short term water saving targets

For the short term which has been taken as 3 years, the total water savings that can be achieved through implementing the flow measurement and monitoring plans is some 6 million m^3/a.

5.2.2 Long term water saving targets

For the long term a further 15.7 million m^3/a saving is envisaged by optimising the operations. The long term target is to reduce the water losses to approximately 20% of the total diversion.

5.3 Implementation Plan

An evaluation of the potential measures for implementation in the Kakamas WUA 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:

(1) Identify "obsolete" return structures in order to minimise measurement.

(2) Devise methods to protect measuring equipment.

(3) Installing measurement devices to improve management of the water delivery system and undertake water budgets based on measured data.

(4) Revise and improve current maintenance procedures and actions.

(5) Incorporate all relevant data in a custom Management Information System.

Table 5-2: Kakamas Irrigation Scheme: Water Management Measures and action plan

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	Measurement and identification of losses	(i) Identify "obsolete" return structures in order to minimise measurement points. (ii) Devise methods to protect measuring equipment. (iii) Installing measurement devices to improve management of the water delivery system and undertake water budgets based on measured data. (iv) Undertake sub-scheme water budgets. (v) Prioritise areas/sections with significant water losses.	Apr '13 – Mar '14 Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15 Apr '13 – Mar '14	KWUA
2	Increase operational efficiency	(i) Investigate implementation of WAS (ii) Measurement of direct abstractions from river. (iii) Incorporate data in a custom Water Management System	Apr '13 – Mar '14 Apr '13 – Mar '15 Apr '13 – Mar '15	KWUA
3	Reduce losses in irrigation canal infrastructure	(ii) Revise and improve current maintenance procedures	Apr '13 – Mar '18	KWUA