



**water affairs**

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Water Affairs  
REPUBLIC OF SOUTH AFRICA



**CONTRACT NO. WP 10276**

**Development and Implementation of Irrigation  
Water Management Plans to Improve  
Water Use Efficiency in the Agricultural Sector  
LOWER SUNDAYS RIVER IRRIGATION SCHEME WATER  
MANAGEMENT PLAN**

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**FINAL REPORT**

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# water affairs

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**DIRECTORATE: WATER USE EFFICIENCY**

**CONTRACT NO. WP 10276**

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

**LOWER SUNDAYS RIVER IRRIGATION SCHEME WATER  
MANAGEMENT PLAN**

**FINAL**

**MARCH 2013**

Prepared by

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## EXECUTIVE SUMMARY

### Background

The Department of Water Affairs (DWA) through the Directorate: Water Use Efficiency commissioned a study to develop pilot Water Management Plans (WMPs) for fourteen (14) selected irrigation schemes as part of its assistance to the agriculture sector as well as to initiate a process whereby all irrigation schemes develop their own WMPs for implementation as required by the National Water Act (36 of 1998).

The study was informed by the fact that no progress had been made by the agricultural sector with respect to the development and implementation of WMPs for that sector. However because there were no guidelines and templates provided by the DWA, this was provided as the reason for a lack of progress by some of the irrigation schemes. Furthermore the study was initiated to address the increasing water scarcity<sup>1</sup> in a number of Water Management Areas (WMAs).

One of the approaches in addressing the increasing water scarcity and competition for water is to ensure that existing water users utilise their existing water entitlement efficiently.

### Project Objectives and approach taken

The primary objective of the study is the development and implementation of irrigation WMPs for 14 irrigation schemes to improve water use efficiency in the agricultural sector. However the focus of the study was at the irrigation scheme level with minimal work conducted to determine on-farm irrigation water use efficiency levels.

In order to achieve this objective, the following tasks have to be undertaken:

- Compilation of a situation assessment of the current water use and irrigation water use practices in the fourteen irrigation schemes;
- Determination of the irrigation water balance assessment and establishing water use baseline for each irrigation scheme;
- Determination of the irrigation water management issues based on the situation assessment and water balance assessments prepared for each irrigation scheme;

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<sup>1</sup> Water scarcity – this is an imbalance of supply and requirement under prevailing institutional arrangements indicating an excess of water requirements over available water at the required assurance of supply, especially if the remaining supply options are difficult or costly to tap. The current utilisation as a percentage of total available resources at the required assurance of supply can illustrate the scale of the problem and the latitude for policymakers

- Identification of opportunities to improve water use efficiency in the agricultural sector;
- Benchmarking of irrigation water use efficiency and setting irrigation water use efficiency targets for each scheme;
- Preparation of an irrigation water management plan for each irrigation scheme;
- Capacity building of the Government Water Schemes (GWS's), Irrigation Boards (IB's) and Water User Associations (WUAs) to implement the identified opportunities to improve irrigation water use efficiency.

### **Overview of the Lower Sundays River Irrigation Scheme**

Planning of the Darlington Dam to supply the Lower Sundays River Irrigation Scheme commenced in 1917 and the dam construction was completed during 1922 and filled for the first time in 1928. The storage capacity of Darlington Dam when it was built was 187 million m<sup>3</sup>. The dam could not meet the increasing irrigation demands. The Orange to Fish River transfer scheme was then developed to supplement irrigation agriculture in both the Fish as well as the Sundays through the transfer scheme.

**Figure 1** below provides a schematic layout of the Lower Sundays River Irrigation Scheme.

#### *Schedule of rateable area*

The Lower Sundays River Irrigation Scheme has a total schedule of rateable area of 17 292.7 hectares, which is supplied from Darlington Dam with water diverted at the Korhaans weir. The Lower Sundays River Irrigation Scheme has a total scheduled quota of 156 million m<sup>3</sup>/a, at 9 000 m<sup>3</sup> per ha per annum scheduled allocation.

The main types of crops irrigated in the Lower Sundays River Irrigation Scheme are citrus and Lucerne which comprise approximately 62% and 21% of the irrigated area in the irrigation scheme area.

#### *Conveyance and delivery infrastructure*

Water to the water users in the Lower Sundays River Irrigation Scheme is delivered through a system of canal infrastructure.

There are four management zones supplied from the main canal. There is approximately 316 km of canal infrastructure both on the left bank and right bank of the Sundays River. Furthermore the scheme has a balancing dam to provide balancing capacity initially to downstream users but lately for domestic water supply to Nelson Mandela Metropolitan Municipality.

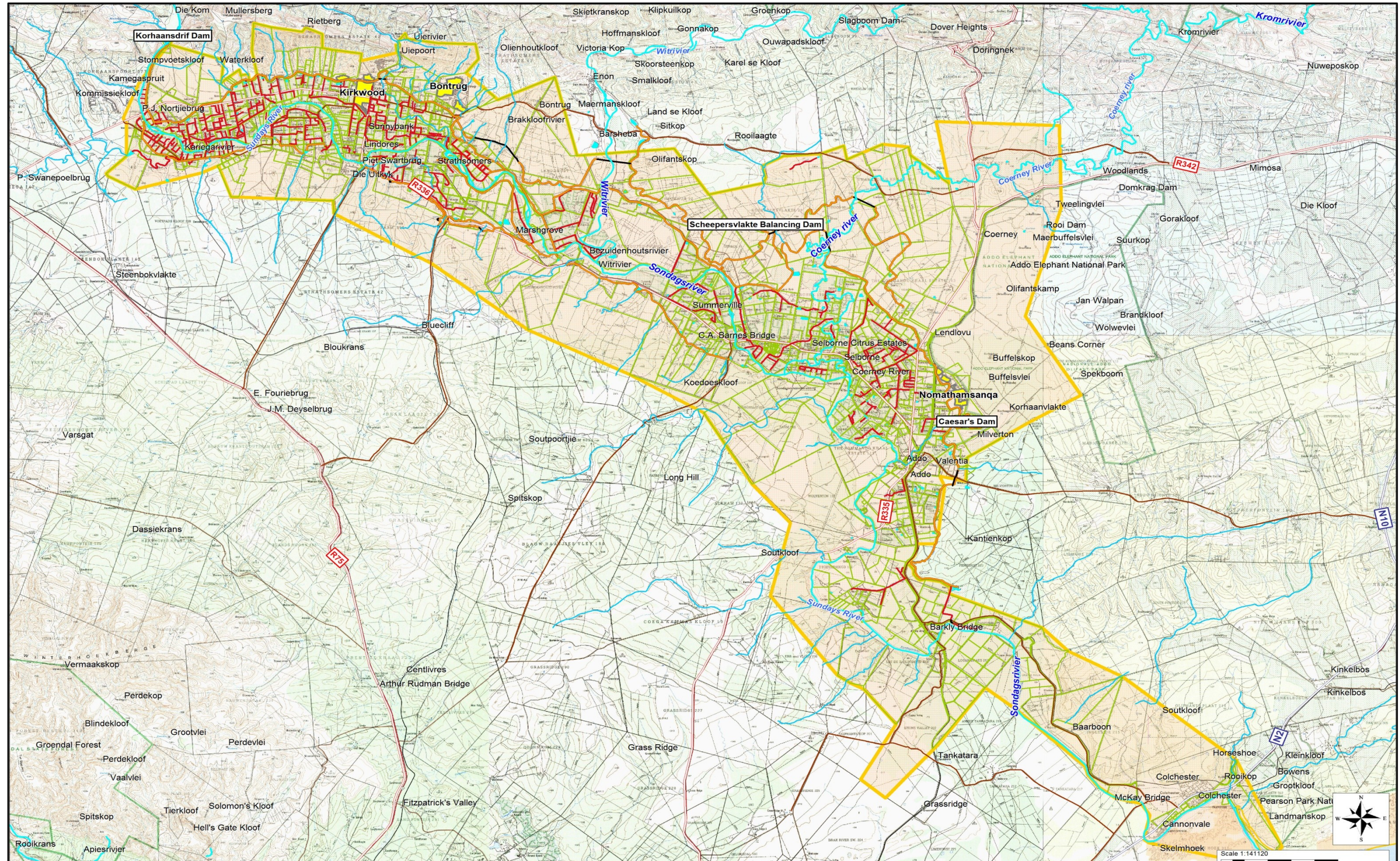


Figure 1: Layout of the Lower Sundays River Irrigation Scheme

The total length of the canal infrastructure excluding drainage canals is approximately 316 km with all the canals concrete lined. There is approximately 10.9 km of canal siphons in the Lower Sundays River irrigation scheme including the 10 km pipeline which supplies the NMMM water treatment works on the right bank.

The condition of the canals was found to be generally fair to poor in some sections.

Besides the canal infrastructure there are sluice gates and Parshall Flumes and various other types of measuring structures including cipoletti weirs, krumps etc. to measure the volume of water taken by each water user in the canal. There are approximately 932 sluice gates at the farm turnouts through which irrigation water is delivered to the farmers.

#### *Irrigation storage and regulation*

There is a balancing dam in the Lower Sundays River Irrigation Scheme, known as the Scheepersvlakte Dam. The dam provides the balancing and regulation of flow to downstream water users of the Lower Sundays River WUA. This balancing dam has the effect of reducing the time it takes to deliver water to downstream water users while balancing any irrigation spills from upstream water users and collects and stores the water for supply to the Nelson Mandel Bay Municipality.

The storage capacity of Scheepersvlakte balancing dam is provided as 0.8 million m<sup>3</sup>. However there are no flow measurements immediately downstream of the balancing dam on the gravity pipeline to measure the flow to NMMM water treatment plants. There is however a flow meter at the treatment works which provides daily inflows into the plant. Although there is daily consumption available this was not being analysed to provide the weekly consumption of the NMMM water treatment works.

#### **Findings of the situation assessments**

A situation assessment of the Lower Sundays River Government Scheme was conducted to determine the water management issues affecting the effective and efficient use of the available water to the scheme. The assessment was not conducted at sub-scheme level, because there was no information available on the weekly inflows and irrigation applications to each of the branch canals in the scheme area. This has now changed and information is available for further analysis and improvement to the better control of the system.

#### *Best Management Practice - Expected water losses*

An evaluation of the expected water losses based on the existing canal infrastructure and assuming the infrastructure is maintained was conducted for the Lower Sundays River canal

system. The analysis indicated that the unavoidable water losses due to evaporation and seepage based on the expected hydraulic conductivity of lined canals were 0.38 million m<sup>3</sup>/a and 12.49 million m<sup>3</sup>/a respectively, making a total of 12.87 million m<sup>3</sup>/a of the unavoidable water losses. This translates into 12% of the total volume of water diverted into the Lower Sundays River canal system.

There are expected to be operational inefficiencies due to the canal filling required after the maintenance done during the winter months and extended weekends; the metering errors even after calibration as well as problems in matching supplies and demands when applicants make changes to their requirements during the week. This could not be determined because the figures indicate a negative percentage which is unrealistic.

#### *Water balance assessment*

A water balance assessment that was conducted for the Lower Sundays River WUA irrigation scheme indicated that the more water was being used in the scheme than was diverted at the Korhaans weir. The average water losses based on the 2012 weekly records was determined to be -0.39% of the total water diverted into the Lower Sundays River irrigation scheme. This is not possible to divert less water than the actual water use.

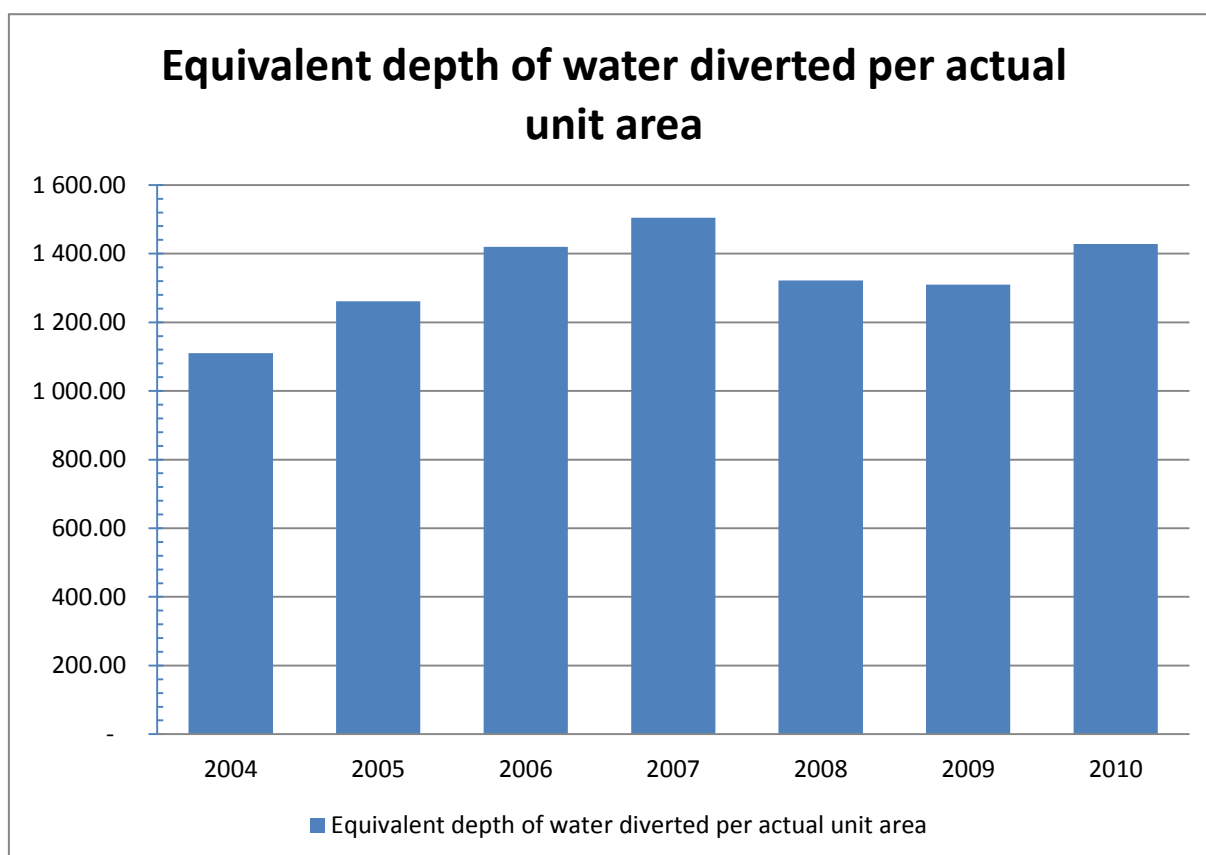
#### *Equivalent depth of water diverted per actual unit area irrigated*

In order to determine the extent of conveyance water use efficiency in the Lower Sundays River Irrigation Scheme, a performance indicator (PI) was developed based on the actual irrigation water and the water diverted into the scheme. The PI known as the equivalent depth of water diverted per actual unit area irrigated was determined.

In the Lower Sundays River Government Scheme, the trend line indicates the equivalent depth has been increasing from 1 321 mm per m<sup>2</sup> of irrigated area in 2008 to 1 427 mm per m<sup>2</sup> of irrigated area in the 2010 water year (see **Figure 2** below). This increase could be an indication that the conveyance efficiency of the Lower Sundays River Government Water Scheme has been declining over the period after 2008. However, there were insufficient annual records to determine whether the decline in the equivalent depth would continue or not.

Because the equivalent depth indicator was determined at scheme level, it is likely that in some branch canals, the equivalent depth is declining while in other it is increasing, which would be an indication that the water losses are much higher in other sub-schemes.

Any improvements, for example, in on-farm water use efficiency may likely be offset with the increase in water losses. This conclusion has however only been reached with very limited data as no other historical data was available and will need to be verified in time.



**Figure 2: Irrigation water diversion expressed as an equivalent depth of water diverted per actual unit area irrigated for the Lower Sundays River WUA canals**

### *Water Management Issues*

A number of water management issues affecting the effective and efficient use of water in the Lower Sundays River Irrigation Scheme were identified based on the water balance assessment, discussions with scheme managers and some field work that was conducted. The main water management issues identified include the following:

- (i) A comparison of the weekly diversions at the Korhaans weir with the actual water use indicates that in some weeks more water is recorded as used compared to the amount diverted. This is not possible if the seepage, evaporation and operational losses are taken into consideration. The Lower Sundays River WUA must investigate

as to the reasons why they are diverting less water than they are using. This should include the following:

- a. The accuracy of the existing measurements needs to be investigated in order to determine their accuracy;
  - b. On the assessment of the expected unavoidable losses of -0.39% this should be explained as to the reasons for the negative losses.
- (ii) A comprehensive water balance assessment cannot be conducted because the changes in the Scheepersvlakte balancing dam are not included in the assessment. Therefore the current water balance is not correct. Furthermore the measurements at the canal tail ends are not included. The structure of the water balance from the LSRWUA is structured not to include spills or have no spills at the tail ends. After discussion with the WUA, this information was still not included.
- (iii) The water administration system to manage water use is not being fully utilised for sub-scheme water budgets.
- (iv) The LSRWUA has not been submitting water use efficiency and accounting reports to the DWA.

## **Water Management Plan for the Lower Sundays River Irrigation Scheme**

### *Establishment of water saving targets at sub-scheme level*

The implementation of a Water Management Plan for the Lower Sundays River Irrigation Scheme to reduce water losses will imply reducing the water diverted per unit of the land area irrigated in the scheme. As is expected, this will not affect the yields of the crops being irrigated in the scheme area.

Therefore reducing the water diverted per unit of land area would mean an increase in productivity per unit of water which would be a clear indication of progress towards greater efficiency for the Lower Sundays River Irrigation Scheme assuming the scheduled quota of 9 000 m<sup>3</sup>/ha/a remains constant.

A lack of accurate information to determine the extent of water losses in the Lower Sundays River Water User Association scheme area has made it difficult to establish water loss targets and therefore the potential water saving targets. As indicated it is unrealistic to divert less water than is utilised by the irrigators as well as the NMMM and other users. The focus of this water management plan is for the LSRWUA to review and evaluate the current water measurements records with a view to determining their accuracy.

### *Identified water management measures to improve water use efficiency in the Lower Sundays River Irrigation Scheme*

The priority water management measures to improve irrigation water use efficiency on the Lower Sundays River Irrigation Scheme include the following:

1. Checking the current water measurements to determine why less water is diverted compared to the actual water use and the expected unavoidable seepage and evaporation losses.
2. Based on the justification of water measurements, prepare water balance assessment for the different sub-schemes to determine the gross water losses and the avoidable water losses to be reduce. The water balance assessment must include the weekly water measurements at the Korhaans weir, the changes in the volume of water stored in the Scheepersvlakte balancing dam,
3. Set the acceptable water losses once the water balance assessment has been updated taking into account the unavoidable water losses as determined for the scheme.
4. Preparation of more detailed water balance assessments for the Lower Sundays River Irrigation Scheme, as well as the sub-schemes to enable prioritisation of intervention on the sub-schemes where the conveyance efficiency levels are found to be very low.
5. Implementation of all modules of the WAS programme to enable irrigation monitoring and control of water use to reduce operational losses such as canal tail ends spills to be carried out as well as undertake water balance assessment at scheme as well as sub-scheme level,

### **Conclusions and Recommendations**

Although the unavoidable water losses have been determined, it is not possible at this stage to determine the avoidable water losses in the Lower Sundays River Irrigation Scheme. This is because more water is being used than is currently being diverted at the Korhaans weir, which is not possible.

The WMP for Lower Sundays River Water User Association is therefore to undertake the following:

- (i) *Accuracy of scheme water measurements* - The WUA must investigate the reasons why the 50% of the weekly records indicate that less water is diverted than is used in the scheme. This will include evaluating the accuracy of the water measurements in the scheme; incorporating the Scheepersvlakte balancing dam into the water balance; incorporating the water measurements if any at the canal tail ends.

- (ii) *Water balance assessment at sub-scheme level* – According to discussions with the WUA there is sufficient information to conduct water balance assessments at sub-scheme level. The WUA must undertake water balance assessments for the four canals, namely the Kirkwood primary canal (this will enable DWA to assess the need for refurbishment where losses are found to be very high); the Wesbank secondary canal; the Mistkraal secondary canal; and the Tregerone/Selbourne secondary canal.
- (iii) *Ensure existing telemetry system is fully operational* – The WUA should engage with the contractor responsible for the installation of the telemetry to ensure that all contractual issues are resolved to enable full utilisation of the telemetry system.
- (i) *Full implementation of WAS programme* - This measure is aligned to the above measures and is considered to be important for implementation in the short term. The WUA must ensure that the WAS programme or a similar system which is compatible with the existing telemetry system is fully operational in order to generate water use efficiency accounting reports.
- (ii) *Monthly reporting of water use efficiency* – The WUA must ensure that they submit monthly water use efficiency reports to the DWA in the format and standard prescribed by the Department and as discussed in this plan.
- (iii) *Incentive based pricing* - This measure is considered a national issue which does not only affect the Lower Sundays River irrigation scheme. It is dependent on whether the irrigators would require changes to the current water pricing which are area based and the implications to revenue management by the irrigation scheme which may not be stable.

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## ABBREVIATIONS

AIC	Average Incremental Cost
BMP	Best Management Practice
DWA	Department: Water Affairs
ET	Evapo-Transpiration
EWR	Environmental Water Requirements
GIS	Geographic Information System
GWS	Government Water Scheme
IB	Irrigation Board
LSRWUA	Lower Sundays River Water User Association
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MISD	Matching Irrigation Supply and Demand
NMMM	Nelson Mandela Metropolitan Municipality
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
WCD	Water Control Department

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WC/WDM	Water Conservation and Water Demand Management
WCO	Water Control Officer
WMA	Water Management Area
WMP	Water Management Plan
WUA	Water User Association
WUEAR	Water Use Efficiency Accounting Report

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## GLOSSARY OF TERMS

<b>Application efficiency</b>	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.
<b>Applied water:</b>	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
<b>Conduit:</b>	Any open or closed channel intended for the conveyance of water.
<b>Conservation:</b>	Increasing the efficiency of energy use, water use, production, or distribution.
<b>Consumptive use (evapo-transpiration)</b>	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.
<b>Conveyance loss:</b>	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.
<b>Conveyance system efficiency:</b>	The ratio of the volume of water delivered to irrigators in proportion to the volume of water introduced into the conveyance system.
<b>Cropping pattern:</b>	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.
<b>Crop water requirement:</b>	Crop consumptive use plus the water required to provide the leaching requirements.
<b>Crop irrigation</b>	Quantity of water, exclusive of effective precipitation, that is needed

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<b>requirement:</b>	for crop production.
<b>Crop root zone:</b>	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.
<b>Deep percolation:</b>	The movement of water by gravity downward through the soil profile beyond the root zone; this water is not used by plants.
<b>Demand scheduling:</b>	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.
<b>Distribution efficiency:</b>	Measure of the uniformity of irrigation water distribution over a field.
<b>Distribution loss:</b>	See conveyance loss.
<b>Distribution system:</b>	System of ditches, or conduits and their appurtenances, which conveys irrigation water from the main canal to the farm units.
<b>Diversion (water):</b>	Removal of water from its natural channels for human use.
<b>Diversion (structure):</b>	Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream.
<b>Drainage:</b>	Process of removing surface or subsurface water from a soil or area.
<b>Drainage system:</b>	Collection of surface and/or subsurface drains, together with structures and pumps, used to remove surface or groundwater.
<b>Drip (trickle) irrigation:</b>	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, and 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** The ratio of the volume of water used for consumptive use and

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<b>efficiency:</b>	leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).
<b>Operational losses:</b>	Losses at the tail ends, sluices not opened or closed on time or opened to big and spills
<b>Operational waste:</b>	Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.
<b>Pan evaporation:</b>	Evaporative water losses from a standardized pan. Pan evaporation is sometimes used to estimate crop evapo-transpiration and assist in irrigation scheduling.
<b>Parshall flume:</b>	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.
<b>Percolation:</b>	Downward movement of water through the soil profile or other porous media.
<b>Reservoir:</b>	Body of water, such as a natural or constructed lake, in which water is collected and stored for use.
<b>Return flow:</b>	That portion of the water diverted from a stream which finds its way back to the stream channel, either as surface or underground flow.
<b>Return-flow system:</b>	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.
<b>Run-off</b>	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.
<b>Request Form :</b>	A form on which an Irrigator requests the quantity of water he requires.
<b>Tail end water</b>	This is water at the endpoint of a canal

**Telemetry**

Involving a wireless means of data transfer

**Water Note**

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

## 1 INTRODUCTION

### 1.1 Background

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

The savings that can potentially be made from implementing WC/WDM measures will delay in the need for the development of additional new water supplies, while ensuring that the natural environment is maintained or is not degraded further. The Department of Water Affairs (DWA) identified that, based on preliminary assessment of water losses in the agricultural sector, there was potential to implement measures to improve water use efficiency in the sector. The overall aim in reducing water losses and improving irrigation water use efficiency levels in the Water User Associations (WUAs)/Irrigation Boards (IBs)/Government Water Schemes (GWS) 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<sup>2</sup> in a number of Water Management Areas (WMAs). One of the approaches in addressing the increasing water scarcity and competition for water is to ensure that existing water users utilise their existing water entitlement efficiently. The Department of Water Affairs (DWA) Directorate: Water Use Efficiency, which has the mandate to ensure the efficient use of the water resources in the country by all water use sectors, identified that since the development of the pilot Water Management Plans (WMPs) for improving water use efficiency in irrigation agriculture, no progress had been made by the irrigation sector with respect to the development and implementation of WMPs for that sector.

In order to ensure the irrigation sector review their current water use efficiency levels and develop strategies to improve their water use efficiency, the DWA has identified a need to

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<sup>2</sup> Water scarcity – this is an imbalance of supply and requirement under prevailing institutional arrangements indicating an excess of water requirements over available water at the required assurance of supply, especially if the remaining supply options are difficult or costly to tap. The current utilisation as a percentage of total available resources at the required assurance of supply can illustrate the scale of the problem and the latitude for policymakers

assist a number of irrigation schemes in developing their irrigation water management plans in order to primarily reduce their water losses. A secondary outcome can be seen as the enablement of irrigators to increase their on-farm irrigation efficiency.

Following the meetings with DWA Directorate: Water Use Efficiency, the LSR WUA and the DWA Regional Office, this report provides the following:

- Overview of the water allocation and irrigation water use situation of the LSR WUA and related institutional arrangement for irrigation water management
- Identification and assessment of the water management issues and management goals expected to address the irrigation water management issues identified.

## 1.2 Study Objectives

The primary objective of the study is the development and implementation of irrigation WMPs for 14 irrigation schemes (see **Figure 1.1** below) to improve water use efficiency in the agricultural sector. In order to achieve this objective, the following tasks have to be undertaken:

- Compilation of a situation assessment of the current water use and irrigation water use practices in the fourteen irrigation schemes;
- Determination of the irrigation water balance assessment and establishing water use baseline for each irrigation scheme;
- Determination of the irrigation water management issues based on the situation assessment and water balance assessments prepared for each irrigation scheme;
- Identification of opportunities to improve water use efficiency in the agricultural sector;
- Benchmarking of irrigation water use efficiency and setting irrigation water use efficiency targets for each scheme;
- Preparation of an irrigation water management plan for each irrigation scheme;
- Capacity building of the Government Water Schemes (GWS's), Irrigation Boards (IBs) and Water User Associations (WUAs) to implement the identified opportunities to improve irrigation water use efficiency.



**Figure 1:1** Location of the 14 irrigation schemes where WMPs have been developed

The development of the WMPs for the selected Irrigation Schemes 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;
- Reduction in system operation and maintenance expenses;
- Potential cost savings due to deferral or downsizing of capital works;
- Benefits which are important but difficult to quantify such as reduced environmental impact resulting from delays in or deferment of construction of water sources and the maintenance of higher water levels in rivers and reservoirs.

### 1.3 Structure of the report

This report has been structured to first provide a perspective of the Lower Sundays River Irrigation Scheme as well as the potential for irrigated agriculture in the Lower Sundays River catchment.

**Chapter 1** 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.

**Chapter 2** describes the catchment characteristics of the Lower Sundays River catchment in which the Lower Sundays River Irrigation Scheme is situated.

**Chapter 3** describes the history of the Lower Sundays River Irrigation Scheme and the scheduled quota. It also describes the catchment and the current land-use practices in the catchment. The chapter also describes the background to the scheme and the institutional arrangements.

**Chapter 4** gives an overview of the inventory of the existing irrigation water management infrastructure which includes the size and capacity of the canals, the dams supplying the scheme; any balancing dams in the Lower Sundays River Irrigation Scheme as well as the flow measurements available in the scheme.

**Chapter 5** describes the condition of the conveyance infrastructure. A framework for determining the condition assessment of the infrastructure is described while the condition of the various sections of the main canals and the branch canals are discussed based on

discussions with scheme operators; surveys conducted during the various site visits, and any available information.

**Chapter 6** of this report describes how the scheme is currently being operated to provide water to the irrigators and any other users. The scheme operating procedures including how the irrigators are supplied during drought periods is presented in this chapter.

**Chapter 7** uses the information from the previous chapters to determine the irrigation water Best Management Practices for the irrigation schemes. This determines how much water losses would be expected if the scheme infrastructure is well maintained. Therefore the approach used to determine the expected seepage losses as well as the evaporation losses are described in this chapter of the management plan. It then describes the standards that can be adopted as appropriate for benchmarking of irrigation water use and management practices.

**Chapter 8** describes the water balance assessment, as conducted, based on the water use and compared with expected irrigation efficiency levels for the different irrigation systems. This chapter also provides the performance benchmarking of the irrigation sector when compared with the expected standards.

**Chapter 9** of this report describes the existing irrigation water management measures that the irrigation scheme is currently undertaking to improve irrigation water management efficiency and reduce the water losses taking place in the irrigation scheme. These include flow measurement, availability of balancing dams, flow monitoring to reduce operational losses if any, canal maintenance during the dry periods; etc.

**Chapter 10** then discusses the water management issues identified from the previous chapters. It then sets the management goals required to ensure any identified water management issues can be addressed.

**Chapter 11** of the report provides an assessment of the identified water management measures that can be implemented to achieved the goals and objectives set in chapter 10. This is the strategic WC/WDM business plan for irrigation agriculture. The chapter also provides an estimate of the capital investment required to implement the strategy. It also provides the performance indicators for monitoring and controlling the implementation of the measures.

**Chapter 12** presents the water management plan. This summarises all the water management issues, the irrigation water saving targets recommended to be achieved and

the water management tasks to achieve the targets set to reduce water losses and improve irrigation water management efficiency of the scheme.

**Chapter 13** provides conclusions and recommendations for the Irrigation Scheme.

## 2 CATCHMENT CHARACTERISTICS OF SUNDAYS RIVER CATCHMENT

### 2.1 Overview

The Lower Sundays River Irrigation Scheme is situated in the Eastern Cape Province within the Sundays River Valley Local Municipality in the Cacadu District Municipality. The main town in the area is Kirkwood which is located within the scheme area. **Figure 2.1** presents the locality map of the Lower Sundays River Irrigation Scheme area. The Sundays River is the main river traversing the scheme. It has its headwaters in the Camdeboo area which is in the Karoo. This area is therefore situated in a dry region and is prone to thunderstorms and severe droughts.

The major tributary of the Sundays River is the Coerney and Wit River which confluence with the Sundays River in the irrigation scheme area. The total catchment area is estimated to 8 395 km<sup>2</sup>. The main storage in the Sundays River catchment is the Mentz Dam (now known as Darlington Dam) which was constructed and is owned by the Department of Water Affairs (DWA) to improve the security of supply to its irrigators.

The Sundays River Valley Irrigation Scheme is bordered by two mountain ranges with the topography of the catchment in the irrigation scheme area generally flat and at an altitude of 200 m to 600 m above mean sea level.

#### 2.1.1 Climate and rainfall distribution

The climate and temperature variations of the Sundays River catchment are closely related to the elevation. The characteristics of the catchment indicate that there two climatic zones with the following mean annual precipitation (see **Figure 2.2** below):

- In the upper catchments where the catchment is characterised by rolling hills and the Winterhoekeberg Mountains, the precipitation is between 500 mm and 599 mm
- In the Lower Sundays River Irrigation Scheme, particularly the right bank of the Lower Sundays River, the middle portion of the irrigation scheme including the left bank as well as the lower part of the irrigation scheme, the precipitation ranges between 400 mm and 499 mm. The low MAP indicates the need for irrigating the lands because of low rainfall.

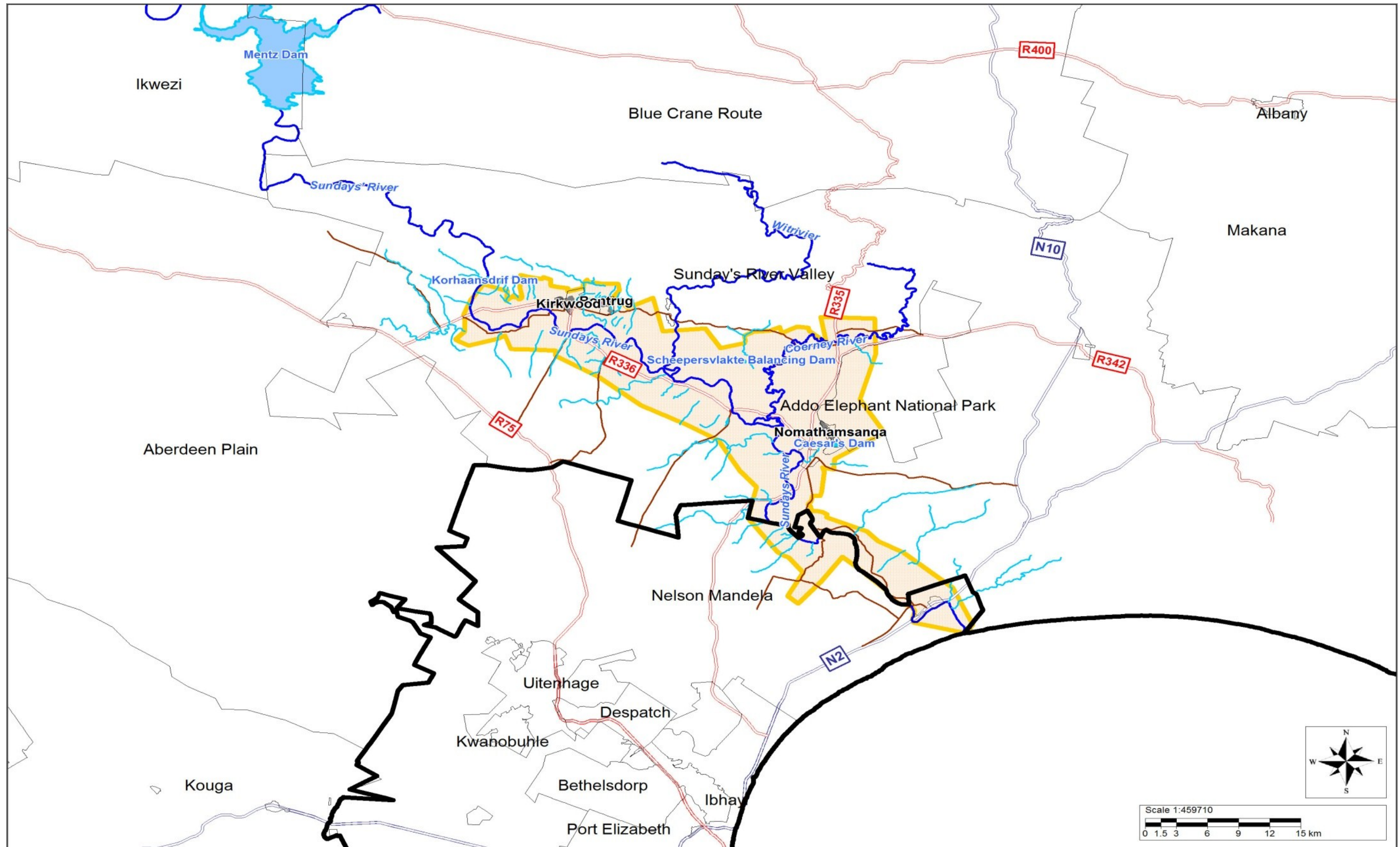


Figure 2.1: Locality Map of Lower Sundays River Irrigation Scheme

### 2.1.2 Evaporation

The Sundays River catchment is divided into three evaporation zones as illustrated in **Figure 2.3** below. These can be described as follows:

- The upper areas of the Lower Sundays River irrigation scheme where the Darlington Dam is located experiences the highest evaporation rate estimated to range between 1700 mm to 1800 mm.
- From downstream of Darlington Dam up to the middle of the Lower Sundays River irrigation scheme, evaporation ranges between 1600 mm to 1700mm. The high evaporation rate has a direct correlation with the irrigation water use requirements in the Lower Sundays River Irrigation Scheme.
- The lower section of the irrigation has the lowest evaporation rate where it ranges between 1500 mm to 1600 mm.

### 2.1.3 Soils of the catchment

**Figure 2.4** below illustrates the types of soils in the Lower Sundays River Irrigation Scheme area. As a result of the predominant geological strata, the topography as well as the climate, the soils of the Lower Sundays River Irrigation Scheme can be categorised as moderately deep clay soils.

There are three main soil types that are predominant in the Lower Sundays River Irrigation Scheme area and are distributed across the scheme area as follows

- The Lower Sundays River Irrigation Scheme* - Most of the LSR Irrigation Scheme has soils which can be characterised as moderate to deep clayey loam soils in flat terrain. The soils possess good balance between ability to convey water and the water holding capacity. The average soil depth is approximately 600 mm.
- The upper right bank of the irrigation scheme* – The soils in the upper right bank of the scheme albeit a small section of the scheme can be characterised as clayey loam soils which are moderate to deep soils with an average depth of 973 mm. The soils are generally in steep terrain. This makes it difficult to determine seepages as there is likely to be deep percolation.
- The lower left bank section of the scheme* - The soils in this section of the scheme albeit a small section of the scheme can be characterised as clayey loam soils which are moderate to deep soils with an average depth of 675 mm. The soils are generally in undulating terrain.

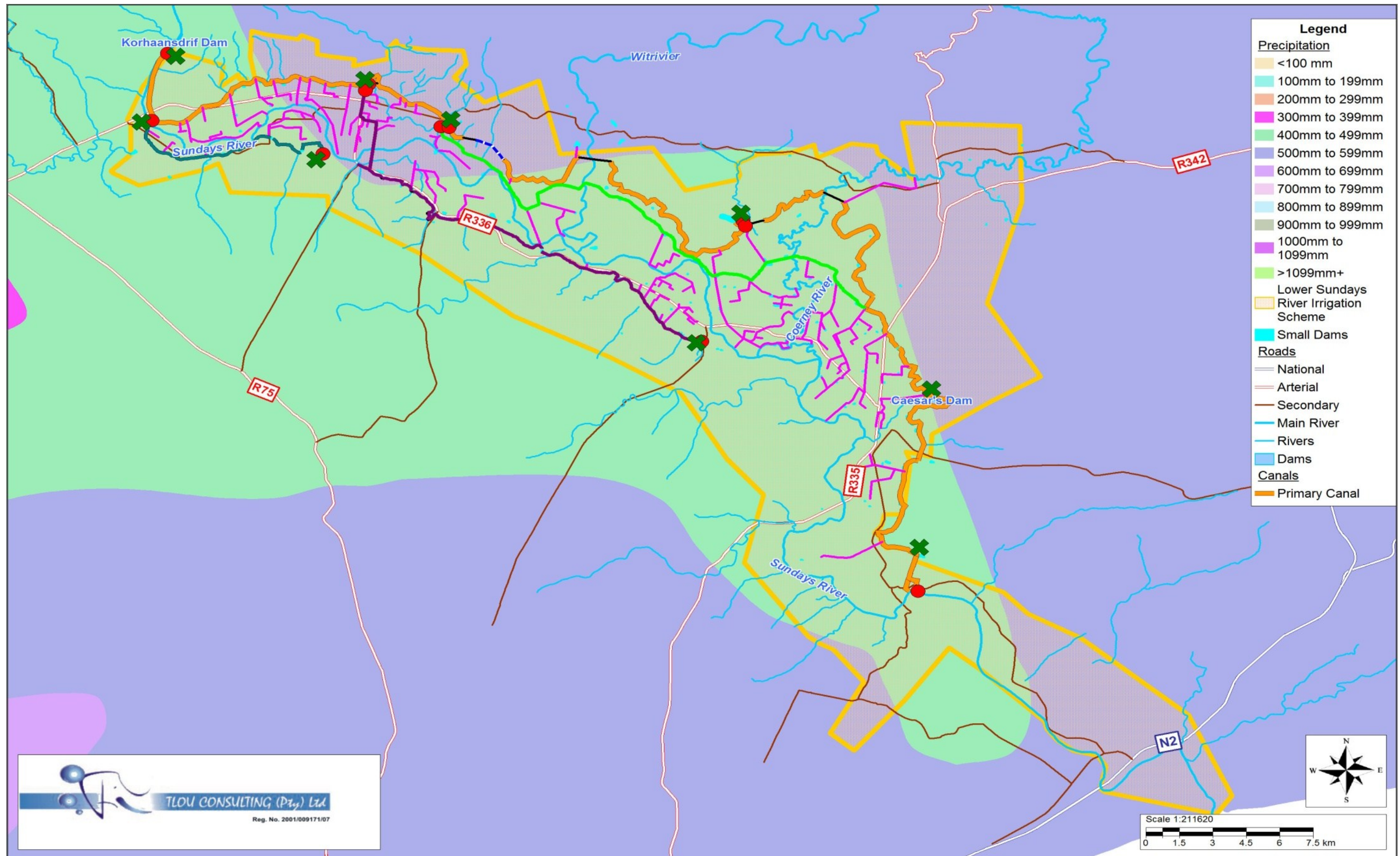


Figure 2.2: Precipitation Map of the Lower Sundays River Irrigation Scheme area

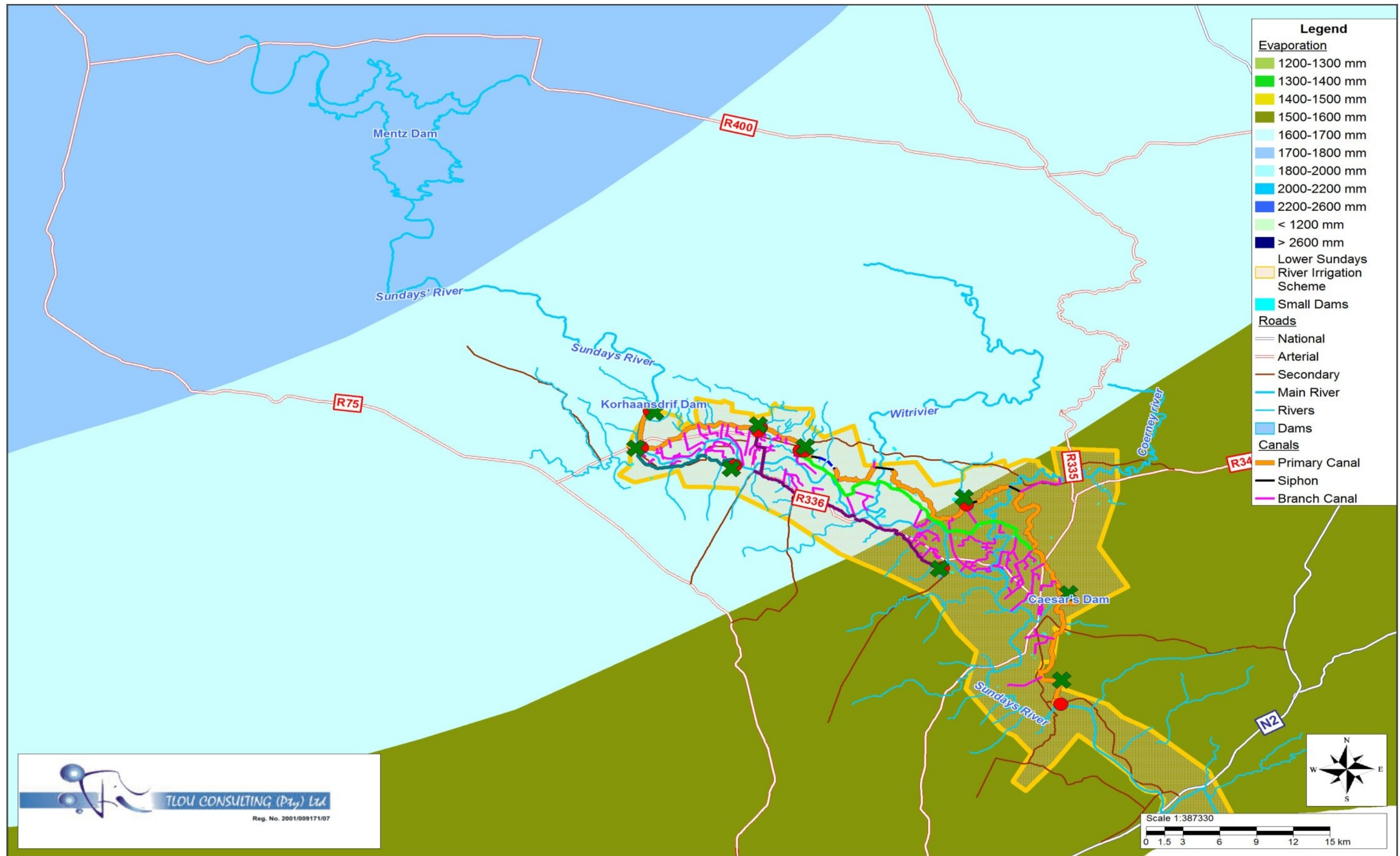


Figure 2.3: Evaporation Map of the Lower Sundays River Irrigation Scheme area

The clay and loam soils in the Lower Sundays River Scheme area contain a greater amount of plant-available moisture within a given range of soil water potential, which is one reason why loam soils are favoured for agriculture. The plant-available moisture, that is held between field capacity and wilting point (c. -0.01 to -1.5 MPa ), is clearly greater in a clay soil than in a Lower Sundays River soil, but root length density (length of roots per unit volume of soil) tends to be higher in lighter textured soils.

As a result, plant-extractable moisture in clay soils is somewhat less than the soil's physical properties alone would imply. In addition, hydraulic conductivity of clay soils decreases from about 10 metres per hour per megapascal ( $\text{m h}^{-1} \text{MPa}^{-1}$ ) at field capacity to around  $0.1 \text{ m h}^{-1} \text{MPa}^{-1}$  at wilting point. Put another way, water movement towards roots is greatly impaired as clay soils dry, while root growth towards sources of water is severely restrained by increasing soil strength. Despite their substantial moisture reserves, fine-textured (clay) soils are generally less hospitable to plant roots than loamy soils. This is the reason for supplementary irrigation which is taking place in the Lower Sundays River Irrigation Scheme.

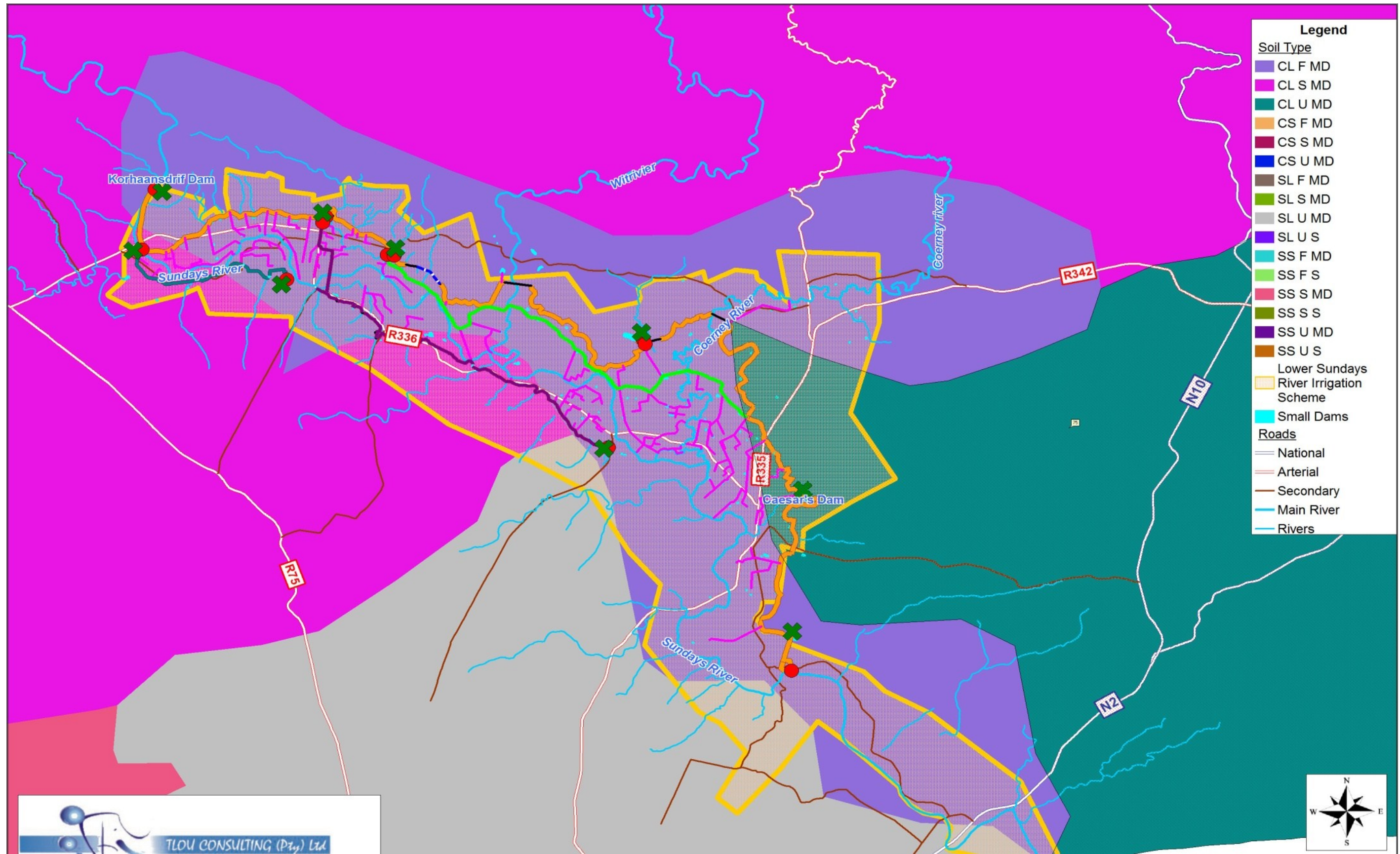


Figure 2.4: Soils Map of the Lower Sundays River WUA

### **3 HISTORY OF THE LOWER SUNDAYS RIVER IRRIGATION SCHEME**

#### **3.1 Overview of the development of the scheme**

This fertile valley of the Lower Sundays River Irrigation Scheme is situated in the Sundays River valley. The area was first settled by Mr James Somers Kirkwood who formed the Sundays River Land and Irrigation Company in 1883. However because of the drought situation and the high returns from ostrich farming in Oudshoorn, the scheme failed and was taken over by Strathsomers Estate Co who started selling land and began developing a diversion weir at Korhaans in 1911. The Korhaans weir was completed in 1913.

By 1906 there were individual large owners in the Sundays River valley and there were three diversion weirs and each with its own abstraction works while also dependent on the natural flow in the river when it occurred. Because the origins of the Sundays River is in the Karroo, which is a dry region and prone to thunderstorms, irrigation in the Sundays River valley was erratic and was subject to either drought or flood. There was therefore the need to establish a dam to conserve the floodwater so that a more consistent flow for irrigation to the irrigators in the valley could be provided.

The initial irrigated area of the Sundays River was approximately 15 400 hectares when the Darlington Dam was completed. However the dam could not supply the full scheduled area and the scheduled quota was reduced to 7 750 hectares when the government took over the scheme. The enlarged Sundays River Irrigation Board was then established which took over the diversion weirs as well as the separate canals in 1934.

In order to improve the distribution of the irrigation water to the farmers the irrigation board embarked on a betterment programme which included lining of 70 km of the main canal and 155 km of the branch canals. This programme was completed in 1962.

With the improvements in irrigation delivery, and the construction of the Orange Fish Tunnel to improve the reliability of supply to irrigators in the Fish and Sundays River catchment, the scheduled area was then increased to approximately 17 000 hectares at 9 000 m<sup>3</sup>/ha/annum. The total scheduled quota for the Lower Sundays River Irrigation Scheme is approximately 155.64 million m<sup>3</sup>/a.

Since the construction of the Orange Fish Tunnel to supplement the water supplies of the Darlington Dam, the Lower Sundays River Irrigation Scheme has enjoyed a much higher level of assurance of supply.

The level of Darlington Dam is maintained at a lower level to allow the transfer of water through Skoenmakers Canal from De Mistkraal weir in the small Fish River. When demands

in the Lower Sundays increase water is released from the weir to supplement water supplies in the Darlington Dam which releases water for diversion at the Korhaans weir to meet the demands of the irrigators in the irrigation scheme as well as domestic water supply demands for Nelson Mandela Bay Metropolitan Municipality.

The Darlington Dam, Korhaans weir and the main canal flowing to the Scheepersvlakte are assets owned by the DWA. They are however operated and maintained by the Lower Sundays River WUA in terms of a contract.

The Lower Sundays River Water User Association owns the secondary canals as well as the distribution canals and related appurtenances such as water measurement structures.

The scheme comprises a total of 316.08 km; 76.4 km of the primary canal from the Korhaans weir to Scheepersvlakte balancing dam and beyond; with the balance of the canals making up the branch and drainage canals. All the canals are concrete lined with the exception of approximately 5.04 km which is still earth canal.

### **3.2 Water use permits / licenses and contracts**

The Lower Sundays River Water User Association (WUA) does not hold any water use permit and/or license **but has a registered water use** for the irrigation of the 17 290 hectares scheduled for the scheme. Each of the water use of the individual irrigators in the Lower Sundays River Irrigation Scheme area is predominantly existing lawful water use in accordance with the National Water Act. The permit for domestic water use in the Sundays and surrounding communities supplied by the scheme is held by Nelson Mandela Bay Metropolitan Municipality.

The total allocations for the scheme is 155.3 million m<sup>3</sup>/a, at 9 000 ha/a. A review of the Water Allocation Registration Management System (WARMS) database indicates that the total registered water use in the scheme area is 151 million m<sup>3</sup>/a, which is supplied from the canal infrastructure.

Besides the water use permits and licenses held by the irrigators, the Lower Sundays River WUA has an agreement with the Nelson Mandela Bay Metropolitan Municipality to supply Port Elizabeth as well as with Sundays River Valley Local Municipality to supply Kirkwood, Addo and Summerville with water through its conveyance infrastructure. The domestic water is registered with Nelson Mandela Bay Metropolitan is not known but the metro has been abstracting increasingly more water as discussed later with the 2010/11 water year measured as 28.9 million m<sup>3</sup>/a.

The WUA also has a contract to supply domestic water to the towns in Sundays River Valley Local Municipality namely Kirkwood, Enon, Addo and Patterson through its conveyance infrastructure.

### 3.3 Management of the scheme

#### 3.3.1 Water User Association

When the National Water Act (No 36 of 1998) came into effect in 1998, the irrigation boards were required to be transformed into Water User Associations (WUA). In 2000, the Lower Sundays River Irrigation Board was then transformed into a WUA.

The responsibility of the WUA includes the following:

- (i) Operating and maintenance of the irrigation conveyance infrastructure to ensure delivery of the irrigation water as and when required by the irrigators in the scheme area within the constraints of the capacity of the infrastructure
- (ii) To ensure that irrigation requirements are matched by the available water supplies
- (iii) To collect the water use maintenance charges from irrigators to ensure the maintenance of the irrigation scheme as well as collecting water use charges on behalf of the DWA
- (iv) To manage the irrigation scheme in such a manner that water is utilised as efficiently as is possible for the benefit of the scheme

#### 3.3.2 Irrigation Management Zones

The Lower Sundays River Irrigation Scheme is divided into four (4) different management zones as indicated in **Table 3.1** below. The irrigated areas in the four management zone are approximately the same with the two largest zones on the left bank and management zone 4 downstream of Scheepersvlakte Balancing Dam.

**Table 3:1: Irrigation areas per management zone for the Lower Sundays River Water User Association**

Management Zones	Total Ha	Irrigated Hectares	Percentage (%)
1	5254.88	3649.93	21.2%
2	9775.403	4600.646	26.7%

Management Zones	Total Ha	Irrigated Hectares	Percentage (%)
3	6444.566	3767.879	21.9%
4	7565.845	5220.769	30.3%
TOTAL	29040.694	17239.224	100.0%

### 3.4 Organisational arrangements

The Lower Sundays River Irrigation Scheme was established in the 1917s. The Lower Sundays River Irrigation Board was established in 1917 which built and operated and maintained the entire scheme.

The Lower Sundays River Water User Association (LSRWUA) was then established in terms of section 92 of the National Water Act (No. 36 of 1998) in 2002. Its powers and functions are based on schedule 4 of the Act. The membership of the Lower Sundays River WUA includes representatives of the irrigators, other major consumers such as industries, the WSAs which include Nelson Mandela Metro and Sundays River Valley Local Municipality. All these stakeholders benefit from the conveyance infrastructure of the Lower Sundays River Irrigation Scheme.

The LSRWUA is responsible for the operation and maintenance of the whole irrigation scheme, including maintenance of the canals owned by the DWA: Infrastructure Branch.

#### 3.4.1 Water distribution Section

One of the key functions of the Lower Sundays River WUA is the distribution of irrigation water as required and on time as well as civil and/or mechanical maintenance of the Lower Sundays River Irrigation Scheme.

As part of the water distribution and/or operation of the irrigation scheme, the Lower Sundays River WUA supplies not only the irrigators but also the water requirements of domestic users and industries through the canal infrastructure of the scheme.

There are three levels in the water distribution section which include the Chief Water Control Officer, the Water Control Officers; as well as the Water Control Aids or canal guards. Their responsibilities are discussed in the following sections.

### 3.4.1.1 Chief Water Control Officer

The Lower Sundays River WUA has a Chief Water Control Officer for Water Distribution who is responsible for the operation of the whole irrigation scheme. His main function is to collect the information provided by the Water Control Officers, process it and issue the operational orders to be executed. These include the amount and timing of releases from the Lower Sundays River Dam, the setting of the sluice gates and structures to deliver the amount and timing of irrigation water requested by the irrigator on a weekly basis

The job description of the Chief Water Control Officer ideally is mainly to carry out the following tasks:

- (i) Control and approve the weekly water requests from the Water Control Officers (see their job description below);
- (ii) Planning the operation of the scheme in order to match the supply as closely as possible with the irrigation water applications (i.e. demand);
- (iii) Supervise that the orders provided to the WCOs are executed accurately;
- (iv) Coordinate with the WCOs the operation of the main canal gates and the releases required, including the timing of the releases;
- (v) Monitoring of the operation (i.e. collection of data related to water use and preparing accounting reports) and preparation of the annual irrigation plans and reports.

### 3.4.1.2 Water Control Officers

The Lower Sundays River Government Water Scheme is sub-divided into four (4) sections, each with a Water Control Officer (WCO) who is responsible for managing the section. The job description of the WCO is mainly to carry out the following tasks:

- (i) Read the water levels in the canal off takes, river and balancing dams in those sections they are available;
- (ii) Transmit the data to the Water control aids (WCAs) responsible for the different sections;
- (iii) Manipulate or set the sluice gates and structures as indicated by the Lower Sundays River WUA main office;
- (iv) Receive data from the WCAs as to the required amount of water, and transfer the data to the main office;
- (v) Report to the Chief Water Control Officer any malfunctioning of sluice gates and structures and any water thefts;
- (vi) Control and report on the state of maintenance of the stretch of canal for which they are responsible.

### 3.4.1.3 Water control aids (previously Canal Guards)

The Water control aids (WCAs) are the main communication channel between the scheme management and the farmer. Therefore the success of a smooth relationship between the two parties depends on their capabilities and honesty.

Although the job descriptions of the WCAs may vary slightly, the following are considered to be the usual expected tasks to be carried out:

- (i) Distribute and control the flows that each off take must deliver;
- (ii) Open and close off take sluice gates and valves;
- (iii) Collection of the water requests (if necessary);
- (iv) Preparation of the daily forms for the water delivery;
- (v) Communication to the WCOs of the requests of water;
- (vi) Control of the canals and watercourses to avoid unauthorised use of water;
- (vii) Compilation of the agricultural and water data as needed;

In the Lower Sundays River Government Water scheme, the water control aids not only perform functions related to the operation of the system, but also maintenance work during the off-season. The added duties during this period include the following:

- Cleaning of the irrigation canals;
- Small repairs in the small hydraulic works (intakes, siphons, joints, etc.);
- Supervision of major repair works;
- Repairing and maintaining the sluice gates in their section.

### 3.4.2 Civil / Mechanical Maintenance Section

The maintenance section is entrusted with the overall responsibility for keeping the irrigation and drainage infrastructure working in a satisfactory manner, within the limitations imposed by design.

The main functions of the Civil/Mechanical Maintenance Section to be undertaken include the following:

- (i) Planning the maintenance activities;
- (ii) Implementing the maintenance activities planned and those unforeseen. Maintenance activities can be easily undertaken during the dry periods in the off-season;
- (iii) Monitoring the abovementioned activities - a maintenance service requires data for good planning which can be obtained by regular monitoring. Without reliable data on

costs for the different units of work and on productivity no realistic planning can be done.

### 3.5 Irrigated areas and types of crops

The Lower Sundays River Irrigation Scheme area comprises of 56 889 hectares with the irrigation area estimated to be approximately 30.4% of the scheme area at 17 239 hectares.

The typical crop mix across the Lower Sundays River Irrigation Scheme is indicated in **Table 3.2** below. The main crops that are under irrigation include citrus (10 619 ha.), Lucerne (3 566 ha), cash crops (538 ha.), seasonal pastures (804 ha.), and windrow (980 ha.). The table below illustrates the importance of citrus on a hectare basis in the Lower Sundays River Irrigation Scheme with vegetables being the other relatively important crop. Therefore there is very little crop mix taking place in the scheme area as the scheme is driven by the need to meet the export markets for citrus.

#### 3.5.1 Citrus

The citrus industry within the Eastern Cape is largely focused in the Sundays River Local Municipality, where the small town of Kirkwood situated in the Lower Sundays River irrigation scheme is considered to be the citrus capital of the Eastern Cape and is also the centre of one of the largest citrus regions in South Africa.

The irrigation scheme has approximately 12 492.85 ha of citrus orchards which represents 50.3% of the irrigated area. Approximately 8 million cartons of oranges, lemons, grape fruit and soft citrus are exported.

**Table 3:2: Typical irrigated area in Lower Sundays River Irrigation Scheme <sup>a</sup>**

Crop Type	Hectares	Percentage
Citrus	12,492.85	50.3%
Cash crops	1,020.86	4.1%
Fallow land	123.73	0.5%
Grapes	3.16	0.0%
Lucerne	3,311.15	13.3%

Crop Type	Hectares	Percentage
Management & Dams	6,098.97	24.6%
Pastures	700.94	2.8%
Sports fields	14.38	0.1%
Wind rows	1,055.46	4.3%
Total	24,821.50	100.0%
Total less fallow land, management & dams & sports fields	18,584.42	74.9%

<sup>a</sup> Lower Sundays River WUA

Harvesting normally takes place throughout the winter, May to October. Citrus production, i.e. oranges, is mainly produced in the Kirkwood area. This area is highly suitable for the production of oranges under irrigation yielding a potential of 20 to 30 tons per hectare, compared to other areas where it is only marginally suitable for the production of oranges under irrigation with a potential yield of 15 to 25 tons per hectare.

The Lower Sundays River uses the high density spacing method with approximately 660 citrus trees per hectare applied compared to the conventional spacing of 100 trees per hectare.

In 2005, the expected return per hectare of lemons produced, at an average of 60 tons per hectare, where 21 tons would be sold locally would fetch R27 678 per hectare and 39 tons exported would amount to R126, 516. The overall profit earned for the combined market minus the costs is approximately R132, 349.00.

### 3.5.2 Lucerne, Wind row and Pasture

Approximately 13.3% (3 311 ha) of the irrigated area in the Lower Sundays River Irrigation scheme is under lucerne for cattle feed. An additional 2.8% or 700 ha of pasture is being irrigated as well as 4.3% or 1 055 ha of wind rows are irrigated to protect the orchards from fire.

### 3.5.3 Other

There are approximately 1 020 ha of cash crops such as vegetables in the Lower Sundays River Irrigation Scheme area

### 3.6 Irrigation System

A breakdown of the irrigation system types in use in the Lower Sundays River Water User Association (LSRWUA) is provided in **Table 3.3** below.

As illustrated in the table, the predominant irrigation systems include micro-irrigation (16.6%) and drip irrigation (36.4%) which is used in the irrigation scheme. This is consistent with the cultivation of citrus. On-farm irrigation efficiency in the irrigation scheme area is probably fairly efficient given the irrigation types being used.

**Table 3:3: Irrigation systems in the Lower Sundays River scheme area**

Item	Irrigation System	Hectares	Percentage (%)
1	Drip	9,043.74	36.44%
2	Micro	4,123.38	16.61%
3	Centre Point	1,350.55	5.44%
4	Sprinkler-Permanent	2,511.00	10.12%
5	Sprinkler-Moveable	77.94	0.31%
8	Flood - channel supply	459.11	1.85%
9	Raised micro (floppy)	24.70	0.10%
10	Hydroponics		0.00%
	None	7,231.06	29.13%
	<b>Total</b>	<b>24,821.48</b>	<b>100.00%</b>

### 3.7 Historic water use

The most recent seven (7) water years (2005/6 to 2010/11) demonstrate a range of water use in the Lower Sundays River Irrigation Scheme (see **Table 3.4** below). Irrigation agriculture has ranged from 99.1 million m<sup>3</sup>/a in 2004/05 up to 128.4 million m<sup>3</sup>/a in 2008/09 with a seven-year average of 111.7 million m<sup>3</sup>/a.

With the current scheduled quota of 155.6 million m<sup>3</sup>/a, the current average abstraction of 111.7 million m<sup>3</sup>/a represents 72% of the scheduled quota is utilised annually.

There has been a significant increase in demand for domestic water with increases in raw water abstraction from the Lower Sundays Irrigation Scheme canals for Port Elizabeth. The raw water abstraction from 2004/05 ranged from 17.7 million m<sup>3</sup>/a in 2004/05 up to 28.8 million m<sup>3</sup>/a in 2009/10. The abstraction from the Lower Sundays River irrigation scheme canals for domestic purposes in Port Elizabeth has been growing at an annual average growth rate of 10.3% per year over the last 5 years. This has now reached the design capacity of the water treatment works and is not expected to increase until the works are upgraded.

No annual information was provided from the 2010/11 as well as the 2011/12 water years in order to update the historic water use. The weekly water use and diversion information for the period January 2012 to December 2012 was provided and has been used to determine the water losses with a view to setting water loss targets as discussed in the following sections.

**Table 3:4: Historic water use levels (\*1000 million m<sup>3</sup>/a) for Lower Sundays River Irrigation Scheme**

User	2003/4	2004/05	2005/06	2006/07	2007/08	2008/09	2009/2010	7 year (2004 - 2010) average
Irrigation	106 436.36	96 796.02	99 683.02	94 497.70	115 843.23	123 142.14	119 733.10	108 018.79
Metered irrigators	326.03	2 303.24	3 043.52	4 774.70	5 017.32	5 206.15	5 050.07	3 674.43
<i>Irrigation</i>	<i>106 762.39</i>	<i>99 099.26</i>	<i>102 726.54</i>	<i>99 272.40</i>	<i>120 860.55</i>	<i>128 348.29</i>	<i>124 783.16</i>	<i>111 693.23</i>
Domestic	19.045	17 672.70	20 752.60	25 153.60	26 499.70	25 073.50	28 840.00	20 573.02
Total	106 781.44	116 771.96	123 479.14	124 426.00	147 360.25	153 421.79	153 623.16	132 266.25
Diversion	128 163.39	113891.348	117 451.65	117 464.86	142 598.73	149 654.62	145 060.27	130 612.12
	17%	-3%	-5%	-6%	-3%	-3%	-6%	-0.46%

## 4 INVENTORY OF THE EXISTING WATER INFRASTRUCTURE

### 4.1 Overview

The Lower Sundays River Irrigation Scheme comprises of Darlington Dam where water is release to supply the scheme. The main infrastructure includes the following:

- (i) The Korhaans weir where the irrigation water is diverted into the scheme,
- (ii) the main irrigation canal infrastructure and primary irrigation conveyance infrastructure which distribute irrigation water in the scheme area,
- (iii) the Scheepersvlakte balancing weir to provide flexibility in the distribution of irrigation demands and,
- (iv) the canal distribution system which delivers the water ordered to the irrigators at their farm turnouts through ample measuring structures for complete control.

**Figure 4.1** below provides a map of the existing irrigation infrastructure of the Lower Sundays River Irrigation Scheme.

### 4.2 Darlington Dam

#### 4.2.1 Darlington Dam

Construction of the Darlington Dam commenced in 1917 and was completed during 1922. The dam was then further raised twice to increase its storage capacity. Its purpose was to address the water shortages and restrictions that the farmers were experiencing during the low flow periods because of dependency on the run-of-river abstraction from the Sundays River.

The Darlington Dam had a storage capacity of 187 million m<sup>3</sup> which has decreased over time due to siltation. Water is regularly released from the dam to supply Lower Sundays River Irrigation Scheme based on the request submitted by the users in the valley and calculated for the required flows.

The volume of water to be released from Darlington Dam is determined by taking into account any rainwater runoff, leakages from the sluice gates at the dam and any other flows in the Sundays River. The releases also take into account the canal losses and the evaporation losses.

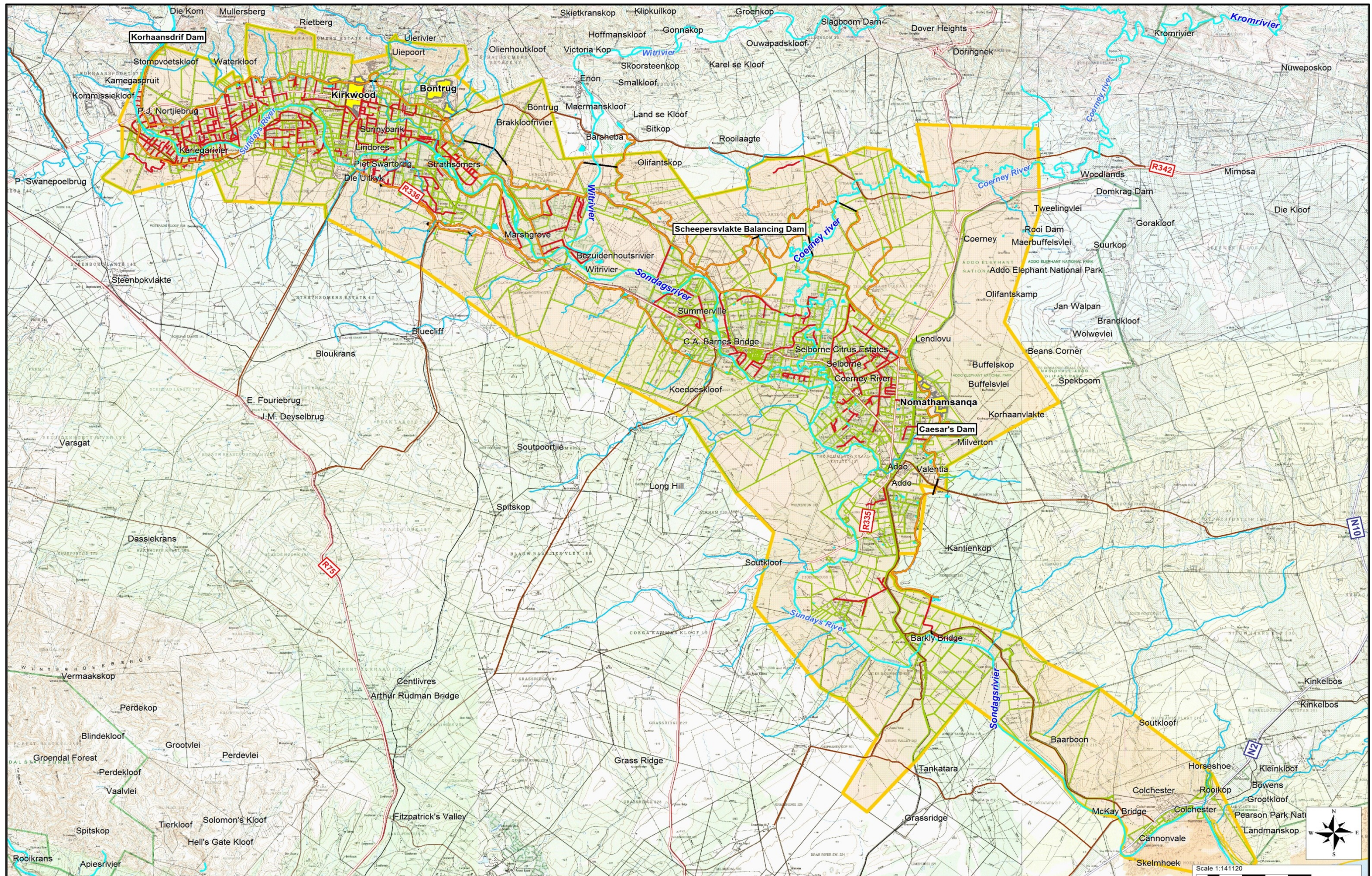


Figure 4.1: Lower Sundays River Irrigation Scheme -Infrastructure

It is important to note that in order to supply the irrigation water requirements to be supplied in time; it takes between 24 to 38 hours dependent on the release flow rate for the water to reach the Korhaans weir from the time it is released from the Darlington Dam although a practical use has been established that generally satisfies every week releases..

The Darlington Dam is operated by the Lower Sundays River Water User Association (LSRWUA).

#### **4.2.2 Orange Fish River Transfer Scheme**

The historical yield of Darlington Dam is not sufficient to meet the irrigation water requirements as well as domestic water supplies without the resource being supplemented. The Orange Fish River transfer scheme was built to improve the reliability of supply in the Fish River system.

The Skoenmakers canal with a capacity of 22 m<sup>3</sup>/s, links the Great Fish River to Darlington Dam. Water is withdrawn from the Gariiep Dam at Oviston through the Teebus tunnel, which discharges, into the Teebus River, which flows into the Great Fish River (see **Figure 4.2** below).

At the Elandsdrift weir, approximately 15 km downstream of Cradock, the water is diverted into a canal, which flows through the Cookhouse tunnel and discharges into the Little Fish River near Somerset East.

The water flows approximately four kilometres to the De Mistkraal Weir, where the water is lifted approximately four metres into a canal, which discharges into the Skoenmakers River, which flows into Darlington Dam. This water dilutes the salinated water of Darlington Dam and therefore presents an immediate benefit by improving the water quality for citrus farming in the lower Sundays River valley and provides sufficient water to satisfy the requirements of the Farmers but also the Domestic and Industrial Users.. A long-term economic benefit of the weir is the development of irrigation potential in the lower Sundays River valley. As a result of the developments, 17 000 ha have been scheduled at a scheduled quota of 9 000 m<sup>3</sup>/ha/a.

The Orange -Fish River Transfer scheme is operated by the Department of Water Affairs (DWA).

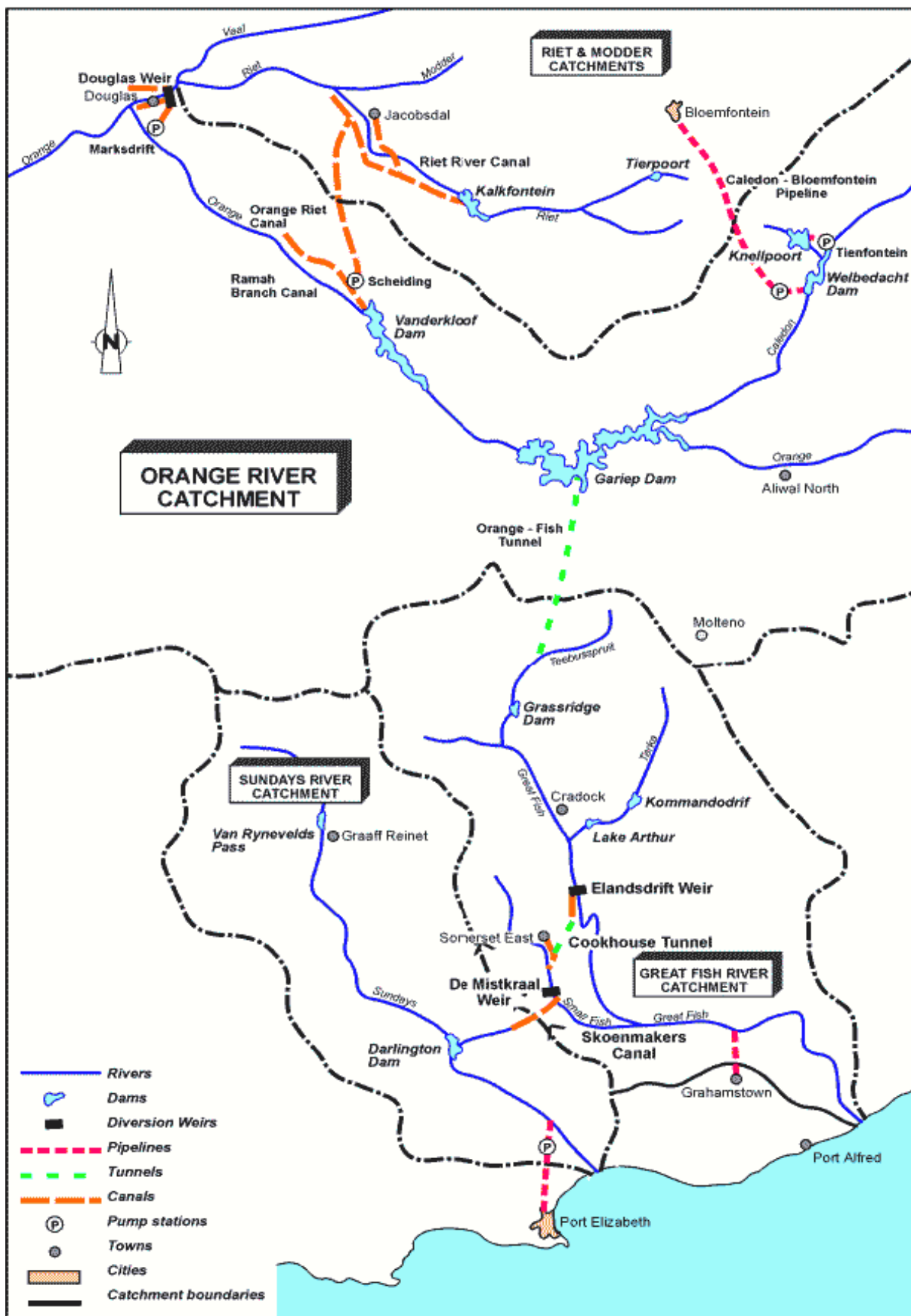


Figure 4.2: Schematic Layout of the Orange Fish River Transfer Scheme

### 4.3 Korhaans weir

The Korhaans weir provides (see **Photo 4.1** below) the diversion structure for the Lower Sundays River irrigation scheme, to extract the require water flow that was released from the Darlington Dam. The irrigation water is diverted into the Lower Sundays River Irrigation Scheme on the left bank of the Sundays River.

Depending on the irrigation water requirements, based on the ordering schedule provided by the irrigators in the Lower Sundays River Scheme, water is diverted into the main canal by adjusting the sluice gates which are connected to the rotorks at the weir (see **Photo 4.2** below).



**Photo 4:1: View of the Korhaans weir from the left bank**



**Photo 4:2: View of the inlet into the main canal with the automated rotork valves and remote telemetry unit (RTU)**

#### **4.4 Irrigation conveyance infrastructure**

As illustrated in **Figure 4.1** above, there are irrigation canals for conveyance and distribution of the irrigation water demands to the Lower Sundays River Irrigation Scheme as well as distribution of water for domestic purposes. Water, is diverted at the Korhaans weir into the main canal known as the Kirkwood canal. The Kirkwood primary canal provides irrigation water to users in the high areas on the left bank of the Sundays up to the balancing dam at Scheepersvlakte. It also supplies irrigators below the balancing dam.

There are three secondary canals which off take from the Kirkwood canal to supply the different areas of the scheme area which include the following:

- (i) Wesbank secondary canal which splits from the Kirkwood primary canal immediately downstream of the Korhaans weir. The canal supplies irrigators on the right bank of the Sundays River
- (ii) Mistkraal secondary canal which off takes from the Kirkwood primary canal near the town of Kirkwood to supply irrigators on the right bank of the Sundays River

- (iii) Tregeron/Selborne secondary canal which off takes from the Kirkwood primary canal to supply irrigators on the lower sections of the left bank of the Sundays River.

There are also branch canals which form the distribution system to the irrigators in the irrigation scheme. The total length of the canal system is 316 km, all of which is concrete lined and with only less than 5.0 km of canal, not lined.

#### 4.4.1 Main canal – Korhaans Weir to Hesse Hoek reach

The main canal comprises 9.4 km of concrete lined canal infrastructure. The maximum design capacity of the main canal is 22.7 m<sup>3</sup>/s. There are branch canals supplying the irrigators along the main canal (see **Figure 4.1** above). The condition of the main canal infrastructure was considered to be in good condition based on visual inspection when it was flowing.

#### 4.4.2 Description of the canal system

**Table 4.1** below lists the canal infrastructure in the Lower Sundays River. This is where most of the irrigation scheme is situated. On the left bank, there is the main canal as discussed above. Furthermore, there is one primary canal, two secondary canals and a series of branch canal systems with a total length of 211.9 km which include the following:

- (i) *Kirkwood Primary canal*: This is the primary canal, which conveys the irrigation water in the upper sections on the right bank of Sundays River. The length of the canal from Korhaans weir to the Scheepersvlakte balancing dam is 43.0 km of concrete lined canal infrastructure. From the balancing dam, to the canal tail end the canal length is 23.43 km. The total length of the Kirkwood primary which is owned by the DWA is 76.43 km of concreted lined canal. The hydraulic capacity of the main canal 22.7 m<sup>3</sup>/s. The capacity is sufficient to convey water to meet the irrigation requirements as well as the water requirements for Nelson Mandela Metropolitan Municipality.
- (ii) *Wesbank secondary canals*: The Wesbank canal is the first secondary canal which off takes from the Kirkwood primary canal to supply the first group of irrigators on the right bank of the Sundays River. The Wesbank secondary canal is a concrete lined canal which is 11.76 km. The maximum hydraulic capacity of canal is provided as 1.14 m<sup>3</sup>/s.
- (iii) *Mistkraal Secondary canal 2*: This is the second secondary canal which off takes from the Kirkwood primary canal near the town of Kirkwood. The Mistkraal secondary canal the crosses the Sundays River to supply the rest of the irrigators on the right bank. The total length of the canal is approximately 28.01 km of concrete lined canal infrastructure. The hydraulic capacity of the canal is provided as 2.71 m<sup>3</sup>/s. This is

sufficient to meet the demands of the irrigators supplied by this main canal during peak periods.

**Table 4:1: Lower Sundays River Irrigation Scheme – Canal Infrastructure on the left bank of Sundays River**

Item No	Canal Name	Type of canal	Canal Length (km)	Hydraulic capacity (m <sup>3</sup> /s)
1	Main canal	Concrete lined	3.88	22.7
2	Primary Canal - Kirkwood Canal	Main canal, concrete lined	72.55	22.7
3	Secondary canal 1 - Westbank	Concrete pipe	11.76	1.1404
4	Secondary canal 2 - Mistkraal	Concrete lined	28.01	2.7119
5	Secondary canal 3 - Tregeron/Selbourne	Concrete lined	28.07	13
6	Branch canals	concrete lined and unlined	158.15	Various
7	Port Elizabeth Pipeline		8.84	
8	Siphons		4.82	
Total length of canal system left bank (km)			316.08	

- (iv) *Tregeron/Selborne Secondary canal:* The last secondary canal which off takes from the Kirkwood primary canal to supply irrigators on the lower sections of the left bank of the Sundays River is the Tregeron / Selborne canal. It comprises approximately 28.07 km of concrete lined canal infrastructure. The maximum design capacity of the canal is provided as 13 m<sup>3</sup>/s. This is sufficient to meet the irrigation requirements of the lower sections right bank catchments during peak periods.

- (v) *Siphons* - There are major siphons which connect the Kirkwood primary canal system. The total length of siphons in the Lower Sundays River irrigation scheme is estimated to be 4.82 km.
- (vi) *Branch canals*: There are a number of branch canals from the above secondary canals that are supplying irrigation water demands to the irrigators in the scheme area. There is approximately 158.15 km of branch canals on both the left bank as well as the right bank of the Sundays River. All these are all concrete lined with the exception of approximately 5.04 km of earth canals.
- (vii) *Port Elizabeth Pipeline* – The Nelson Mandela Metropolitan Municipality (NMMM) is supplied with water from the Scheepersvlakte balancing dam through a gravity pipeline. The pipeline also supplies some of the irrigators who are metered.

## 4.5 Irrigation storage and regulation system

### 4.5.1 General

Besides the Korhaans weir and the canal system for conveyance of the irrigation water to the irrigators' farms, the Lower Sundays River Irrigation Scheme also has a balancing dam.

Besides the balancing dam, the irrigators have farm dams to regulate the supply of water to the farms. This provides additional balancing capacity at on farm. The balancing dam is discussed in the following section.

### 4.5.2 Scheepersvlakte Balancing Dam

The Scheepersvlakte Dam is the main balancing dam in the Lower Sundays River Irrigation Scheme. Initially it was constructed to provide the water requirements of the downstream irrigators. The supply to the Nelson Mandela Metro water treatment works on the right bank of the Sundays River through a gravity pipeline was a later addition to the Scheme. As the function now includes supply to the NMM, the balancing dam now serves as a balancing dam to the downstream users and ensuring that there is sufficient water available to the water treatment works for the NMMM.

The Scheepersvlakte Balancing Dam has a storage capacity of 0.8 million m<sup>3</sup>. The balancing dam still provides significant operational flexibilities to the Lower Sundays River WUA depending on the distribution of users requesting water for the week downstream of the balancing dam, by reducing the delivery time for the downstream irrigators.

Given the fact that the capacity of the water treatment works has been increased to 100 MI/d and is likely to be doubled, the capacity of the balancing dam is not sufficient to meet the dual purpose of supplying the plant as well as reducing the time of delivery to downstream

irrigators. This is if the allowable storage capacity for the plant is approximately 2 days storage.

The lack of sufficient balancing capacity will in future affect the maintenance of the canals. This is due to the fact during the dry periods when the irrigation canals are emptied to carry out maintenance the balancing dam will not be capable of providing water to the downstream irrigators in order to provide sufficient downtime for the canals to be properly maintained.

#### **4.5.3 Farm Dams**

The irrigation water supplied by the Lower Sundays River WUA is delivered mainly to the irrigator's farm dams. The on farm actual water application is dependent on the irrigation scheduling requirements of the individual farmer from the farm dam based on the crop water requirements and the timing of irrigation as determined from the soil-water requirements.

#### **4.6 Irrigation infrastructure distribution system**

As illustrated in **Figure 4.1** and **Table 4.1** above, there are approximately 158.15 km of branch canals in the Sundays River scheme which distribute the irrigation water to approximately 932 off takes with the releases measured downstream of the sluice gates at different types of measurement structures which include Parshall Flumes, Cipolletti, crump and rectangular weirs..

#### **4.7 Flow Measurement and telemetry system**

##### **4.7.1 Measurement of flow into the scheme area**

**Figure 4.3** below provides the ideal and existing location of the flow measurement system required to manage the irrigation water requirements in the Lower Sundays River irrigation scheme. As illustrated, the first measurement of the water diverted from the Sundays River system takes place at the Korhaans weir. There are sluice gates which are automated with rotork actuators which are linked to the telemetry system at Korhaans weir. This provides the flow measurements on a continuous basis as well as monitor and manage the flows diverted into the Korhaans weir.

The weir measures the total volume of water released into the main canal to the Lower Sundays River Irrigation Scheme. It is important to note that of the 932 abstraction points to the irrigators there are only 3 irrigators that get water directly from the Sundays River, within the Lower Sundays River Irrigation Scheme area.

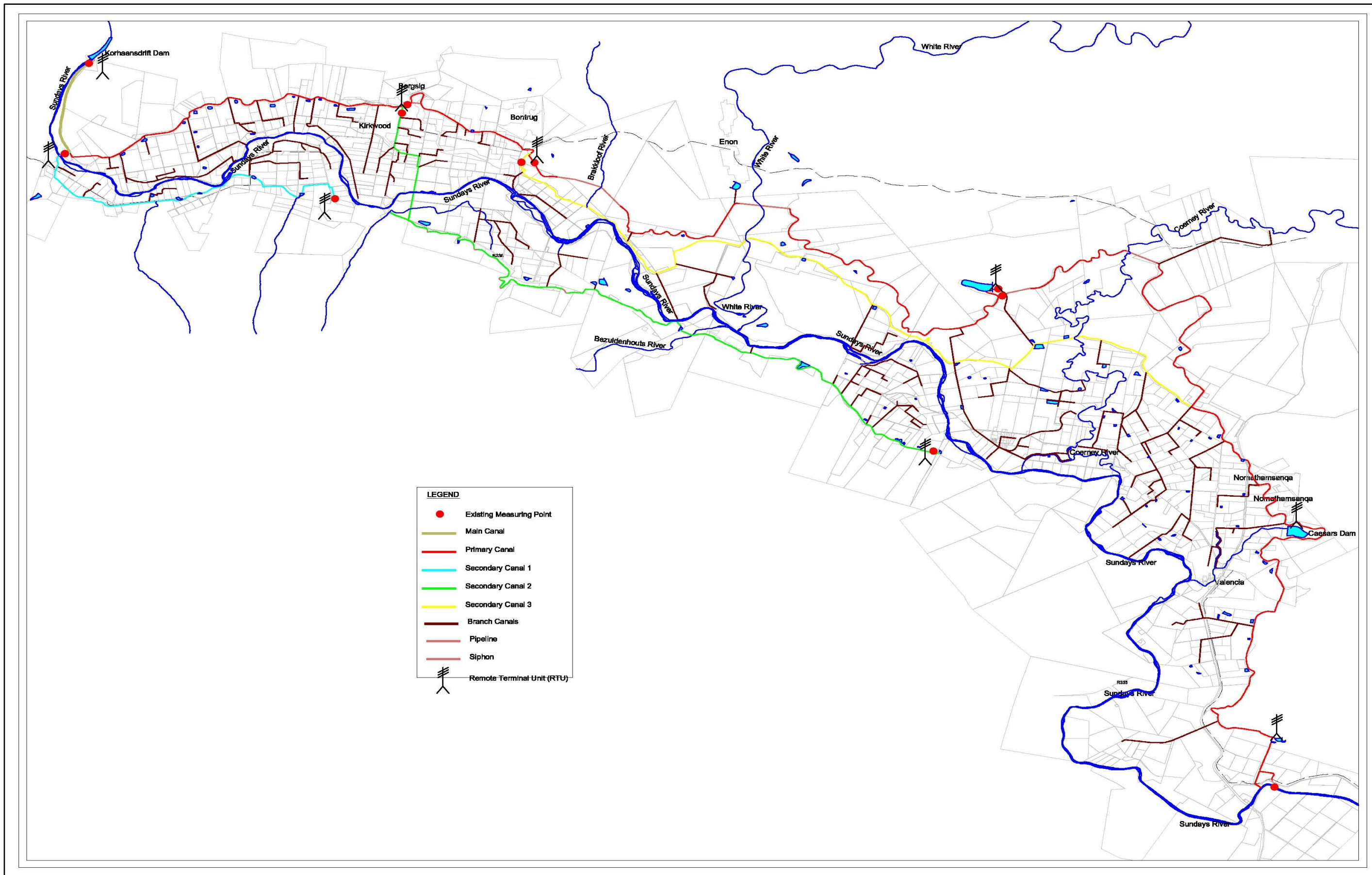


Figure 4.3: Schematic layout of the Lower Sundays River Scheme with the existing water measurement system

#### **4.7.2 Measurement into the various canal systems**

The Lower Sundays River Irrigation Scheme has one primary irrigation canal, which is located on the left bank of the Sundays River. There are sluice valves with rotork actuators at the inlet of the primary canal at Korhaans weir.

At all the diversion points into the secondary canals there are Parshall Flumes which have been automated to monitor the flows and control. . Furthermore there are flow measurement devices, namely Parshall flumes, at the canal tail ends to measure the water returning back to the Sundays River.

No other direct measurements of water, including the branch canal end returns are currently performed in the system as most of the canal tail ends end in a farmer's dam.

#### **4.7.3 Measurement at user outlets**

The Lower Sundays River Water User Association (LSRWUA) measures the weekly volume of water delivered to the water users at the farm gate using the Parshall flumes. There are approximately 932 sluice gates and Parshall flumes in the irrigation scheme area and whatever other structures that are used for measuring namely cipoletti weirs, rectangular weirs, krump weirs where they have been constructed.

#### **4.7.4 Existing telemetry system**

The Lower Sundays River Irrigation Scheme has a telemetry system which it uses to monitor the flow at various sites of the scheme (see **Photo 4.3** below). A telemetry system was installed to cover nine (9) critical diversion points for the Lower Sundays River Irrigation Scheme to periodically, and on demand, poll for data from the field devices (remote telemetry unit (RTU)), process the data into a central data base (base computer) at the Lower Sundays River WUA offices, send controls to field devices and display the data in useful formats to water operation personnel.

A Base System is located at the Lower Sundays River WUA Offices in the town of Sunland and consists of a base computer, which holds the central database to store and convert all of the data from the RTUs, and an antenna to receive from and transmit data to the remote telemetry systems. The base computer is equipped with software that will display current, last 24 hours and monthly water and flow level data of any or all of the RTUs. It also stores all engineering and conversion data necessary for converting flow.

A remote telemetry unit outstation was installed at each of the 9 flow measurement sites. Each system consists of the following:

- Remote Telemetry Unit (RTU)
- Radio and RF Modem
- AC/DC Linear Power Supply.

These items have been mounted inside steel enclosures. The RTU has been connected to the sluice gates fitted with rotork actuators and the system programme with the calibration coefficients for each site to provide the flow reading when in operation.

The above mentioned Telemetry System is currently the only source of data for water audit. The scheme does not have the Water Administration System (WAS) to carry out the detailed water budget and produce the water use accounting reports. There are periods when the telemetry system does not function which present operational problems and manual operation is carried out.



**Photo 4:3: Telemetry system at the main canal downstream of Scheepersvlagte Dam**

## 5 INFRASTRUCTURE CONDITION ASSESSMENT

### 5.1 Overview

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

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

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

- water supply conditions (“head conditions”)
- canal conditions

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

### 5.2 Canal Condition Evaluation

It was not possible to undertake condition assessment of the irrigation canals of the Lower Sundays River Irrigation Scheme. However, a list of criteria for undertaking canal condition assessment was developed for use, later during the implementation phase. The Canal Condition Evaluation component of RAT, includes visual rating methodologies on:

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

There are service factors that are used in this procedure which may be grouped as follows:

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

**Tables 5.1 - 5.5** provide details on the rating factors and definition of numerical values used that are recommended to be used during the dry periods.

**Table 5:1: General Condition rating**

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

**Table 5:2: Criteria for hairline, pencil size and large cracks**

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

**Table 5:3: Noticeable amounts of maintenance and repair (patchwork)**

Rating	Definition
1	None to a few areas
2	A few areas
3	Sparse

4	Moderate
5	Severe

**Table 5:4: Vegetation growing in canal lining**

Rating	Definition
0	None
1	Sparse
2	Moderate
3	Dense

**Table 5:5: Vegetation in drainage canals and along the outer embankment of the canals**

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

### 5.3 Results and analysis of preliminary assessment

#### 5.3.1 Condition evaluation of Darlington Dam

Although no detailed condition assessment could be undertaken on the Lower Sundays River Irrigation Scheme, preliminary information was sourced on the condition of some of the critical assets. These are discussed below.

The gates on the Darlington Dam which releases water for irrigation have been leaking for quite a long time. The leakage appears to be very high considering the river gains that the Lower Sundays River Irrigation Scheme gets because there are very little tributary flows between Darlington Dam and Korhaans weir. The gates require refurbishment to reduce potential water losses from the Sundays River catchment.



**Photo 5:1: Dam wall of Darlington Dam**

The leakage from the Darlington Dam is currently being well managed by factoring it as part of the release for the LSRWUA. However there have been periods when the scheme has not been able to divert the water from the leakage resulting in spills at the Korhaans weir. This is

based on information provided by the hydrological branch about the spills at the Korhaans weir. This is generally very rare.

The quality of the water in the Darlington Dam has been improved because of the transfer of the good quality water from the Orange Fish River transfer scheme to improve the salinity levels and therefore the quality of citrus production in the valley.

### **5.3.2 Condition of the Korhaans weir**

The Korhaans weir was found to be generally in a good to fair condition as illustrated in the **Photo 5.2** below.



**Photo 5:2: Photo of the fair condition of Korhaans weir**

### **5.3.3 Condition evaluation of the main canal section**

Although no formal condition assessment was carried out on the main canal section of the Lower Sundays River Irrigation Scheme, a review of the aerial photographs of the sections, as well as photographs taken during the site visit were reviewed. It is understood that due to the age of the infrastructure, the concrete at some of the sections of the secondary canals is deteriorating in a few locations. There are also sections of cracked concrete through which water is leaking.

Other problematic structures on the canal infrastructure include erosion around the sides of the secondary and branch canals as illustrated in **Photo 5.3** below. This does not affect the flow or losses in the canal and are attended to on an on-going basis.



**Photo 5.3: Erosion around the sides of a branch canal**

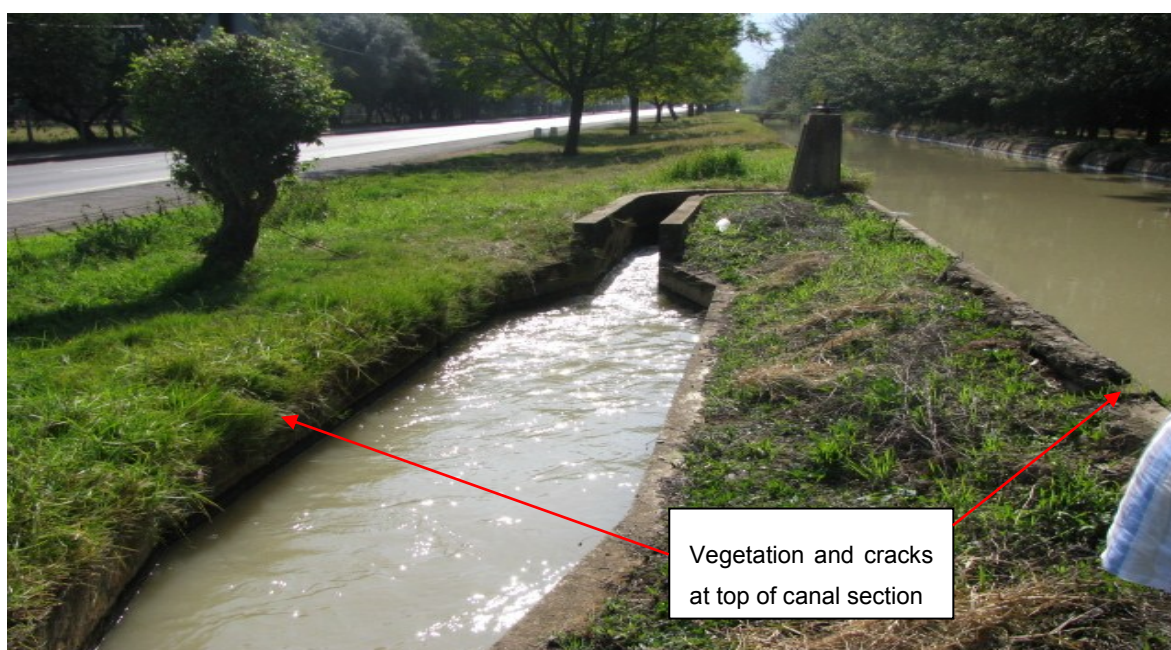
#### **5.3.4 Condition evaluation of the canals**

**Photo 5.4** below indicates the pencil size marks and patchwork on the section of the canal. However, there is no structural damage that could be identified during the site visit. The condition of the Kirkwood primary canal is understood to be in a fair to good condition requiring normal maintenance. No major refurbishment or replacements of sections of the concrete panels is envisaged in the near future.



**Photo 5:4: Pencil marks and patchworks**

One of the aspects that were picked up during the site visit was that there was vegetation growing in the canal linings. However this is a purely maintenance function and is attended to a specific time during the year. In this instance it does not affect the flow in any way nor does it contribute to any losses of the water. No sprays are allowed only in limited and restrictive conditions.



**Photo 5:5: Vegetation growth and cracks on canals**

### 5.3.5 Condition evaluation of the siphons

There are a large number of siphons in the Lower Sundays River Irrigation Scheme. It is not known whether there are any leakages on these siphons. However any leakages are attended to at the first dry opportunity.

### 5.3.6 Condition of the telemetry system

During the site visit it was noted that some of the remote telemetry outstations (RTUs) were not operational as indicated by the WCO. Although there is approximately 284 ha supplied downstream of this measurement point, no control was available because of the telemetry not being functional (see **Photo 5.6** below). Therefore no flow measurements were available on how much water was being supplied to the downstream users with the potential that any flows more than the downstream users could end up as spills at the canal tail-ends with the spills ending up in the Indian Ocean



**Photo 5:6: Remote Telemetry Outstation (RTU) on the Kirkwood primary canal which was not operational**

## **6 SCHEME OPERATIONS AND OPERATING PROCEDURES**

### **6.1 General scheme options**

Before the construction of Orange -Fish River transfer scheme, to improve the assurance of supply for the irrigators and supply Nelson Mandela Metropolitan Municipality (NMMM), the scheme used to experience not only water shortages on an annual basis but also there were water quality problems which affected the quality of citrus for the export market. This was addressed with the construction of the Orange - Fish River transfer scheme, which provides the irrigators' scheduled quota throughout the year.

The dam is owned by the DWA but is operated by the Lower Sundays River Water User Association (WUA). Water is only released for two reasons; (i) to meet the irrigation water requirements for the Lower Sundays River Irrigation Scheme; (ii) to meet the domestic water requirements of Port Elizabeth which is a very important economic centre in the Eastern Cape.

### **6.2 Water ordering and delivery procedures**

#### **6.2.1 Overview**

In order to ensure that the irrigators receive their scheduled quota as and when required, the Lower Sundays River WUA operates the irrigation scheme based on "delivery on request" where each water user (irrigator) must submit a written request on a weekly basis and the water is delivered to some 932 abstraction points along the canal systems. Instead of water delivery based on areas delivery can be based on requests from farmers or a group of farmers. In such a delivery system, water is directed only to those canals where farmers have announced that they need water.

Because the demand varies, the duration and the size of flow need to be controlled to accommodate this variation. In Lower Sundays Irrigation Scheme the volume of water is adjusted so that the flow can also be subject to request while the time to deliver the volume or stream is also provided to the irrigator. In order to be able to adapt flows to the requests sluice gates are needed in the canal network. By making the opening smaller or larger, the size of the flow can be set. To ensure equitable and efficient distribution, measurement is required at the flow regulating point.

The accuracy and effectiveness of water delivery with respect to demand depend on the flexibility of the system: how much water is available, taking into account other requests that have been made; what capacities have the canals; how accurately can flows be regulated; and how efficient are the operators?

For such a system to work efficiently two things are needed:

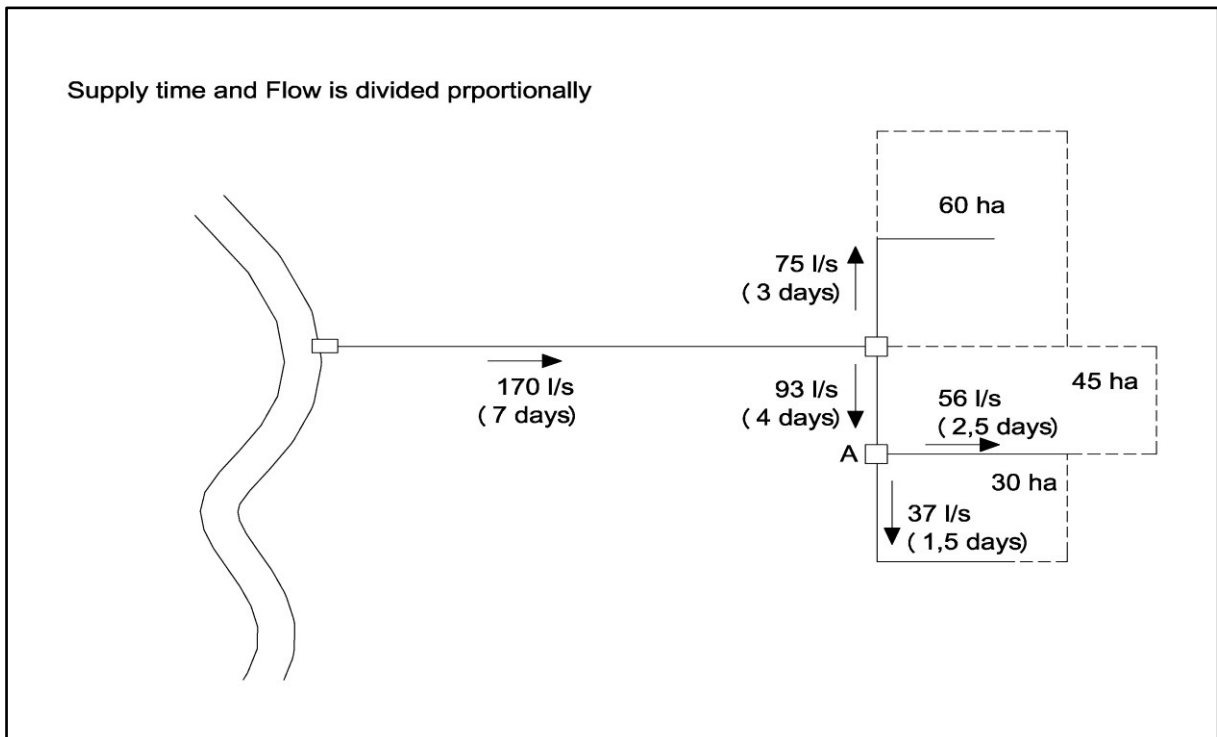
- good structures in which gate settings can be easily and accurately adjusted; and
- a team of well-trained operator

The following is an example of how the scheme operates.

If there are three irrigators irrigating 60ha, 45ha, and 30ha order their water, the flow in the main canal from Korhaans weir is given to the whole scheme, which has a total area of  $60 + 45 + 30 = 135$  ha (see **Figure 6.1** below.)

Each secondary block will receive the entire flow for a period within the 7 days that is proportional to its command area. The first secondary canal serves an area of 60 ha. It will carry the full flow for  $(60/135) \times 7 = 3$  days at a flow of 75 l/s in every period of 7 days. Similarly, the other canals will carry water for  $45/135 \times 7 = 2\frac{1}{2}$  days at a flow of 56 l/s, and  $(30/135) \times 7 = 1\frac{1}{2}$  days at a flow of 37 l/s respectively in each period of 7 day.

This methodology applies to a relatively small section of the scheme. This calculation is done at design phase and once the stream flow is determined that will apply and to increase or decrease the volume is done in ordering more or less hours.



**Figure 6.1:** Flow and supply time is divided proportionally based on the request

The Lower Sundays Water User Association has a formal policy for water ordering and procedures and conditions for delivering water to irrigators as well as households and industrial consumers. Below is a summary of the procedures in the policy.

The procedures followed by the irrigators in ordering their water requirements are as follows:

- (1) Each irrigator determines how much water they require to order for the following week from the scheme, based on their irrigation scheduling which is dependent on the type of crops being irrigated as well as their available scheduled quota and the level of his on farm storage dam.
- (2) The irrigators submit their requests to the Lower Sundays River WUA on the appropriate application form, before Thursday, for their irrigation water requirements to be delivered the following week. Irrigators must specify their needs clearly on the request form and the WUA will endeavour to supply the water, as requested.
- (3) The scheme operators at the Lower Sundays River WUA then reconcile the total requested volume from the beginning of the water year with each irrigator's scheduled quota. The total volume of water required in each branch canal, is then calculated to determine how much water should be supplied within the maximum of 120-hours although generally is worked on 104 hours as being sufficient in each of the different sections of canal systems based on the request.
- (4) The scheme operators then include the expected water losses due to seepage and canal evaporation losses and ensure that the volume of water to be ordered is above the threshold for delivery into the canal section or the volume of water ordered including the expected canal losses does not exceed the maximum hydraulic capacity of the canal system.
- (5) The above process is repeated from the branch canals up to the main canal to determine how much water needs to be released from the Darlington Dam to reach the Korhaans weir in time for releases to reach irrigators at the start of each weekly cycle. This includes the total transmission (compensation) losses required to deliver the requested water.
- (6) The requested water, including the transmission losses for the different canal sections are then reconciled with the available water in the balancing dam in order to determine the volume of water required to be released from the dams over the week.
- (7) Water is then requested by the scheme operators to DWA from Darlington Dam in time to meet the requested water for the following week starting on Monday 05h00 when the irrigation reaches the first irrigators till Friday 17h00 when the sluice gates are closed.

- (8) In the event that the requested volume exceeds the maximum hydraulic capacity of the canal systems, the requested volumes will be reduced proportionally to the determined hydraulic capacity of the canal infrastructure, taking into account the estimated water losses.
- (9) This procedure has not been document in the existing scheme regulations.
- (10) The Water Control Department (WCD) of Lower Sundays River WUA sets up a flow chart of levels of the sluice gates and Parshall flumes based on the water requests of the week. These are given to the Water control aids (WCAs) to set the sluices at levels provided on the chart.
- (11) The information regarding the volume of water allocated to each user is then communicated back by the Scheme Managers to the consumers including their remaining scheduled quota.

The above water ordering and delivery procedures have been formally documented. It is important that the procedures are formally documented to enable all irrigators as well as the water control officers to be aware of the procedures. This will be useful particularly for new irrigators and Scheme Managers to understand the procedures for ordering and processes for delivering the irrigation water requirements.

It is important to note that, in the Lower Sundays River Irrigation Scheme, the water is supplied through sluice gates with the Parshall Flumes measuring the flow and volume delivered by the scheme to the irrigator, which are adjusted according to the water level (i.e. pressure) provided by the long weirs in the canal system.

### **6.3 Procedures during water supply shortages**

Although there have not been frequent water shortages since the construction of the Darlington Dam, there are procedures that are followed to address any water supply shortages. These include the following:

- (i) At the start of the water year which is July, the available water from Darlington Dam and Orange Fish transfer scheme that can be supplied to irrigators is reconciled with the scheduled quota. This is undertaken by the Department of Water Affairs.
- (ii) Where it is envisaged that less water is available, the allocations to irrigators are curtailed equitably. This is reviewed during the year to determine whether additional water is available for allocation to irrigators.
- (iii) Although all water users from the scheme are curtailed, priority of water use during water supply shortages is to the domestic water users which are mainly Nelson Mandela Metropolitan Municipality.

## 6.4 Water trading - Temporary water transfers

There are periods when existing irrigators exhaust their scheduled quota before the end of the water year and may require additional irrigation water. The current practice is as follows:

- (i) Irrigators cannot make a temporary transfer to lands that do not have any water rights. This is because the canals were designed to supply the existing water entitlements and are not likely to meet the additional demand.
- (ii) Irrigators can however transfer water temporarily to another land which has a water use entitlement if there are shortages. However the transfer is subject to the canal having sufficient capacity for the additional stream. Furthermore the temporary transfer can only be supplied during those periods that the canal feeding existing irrigators is not being required by other irrigators. This should however be arranged with the WCO prior to delivery.

The irrigators then approach the Lower Sundays River WUA to facilitate the temporary transfer based on whether there is sufficient hydraulic capacity of the irrigation canal system for the transfer to be delivered to temporary user. Currently the WUA is not involved in any of the negotiations as the water use entitlements are held by the individual water user.

## 6.5 Water pricing structure

### 6.5.1 Setting of the irrigation pricing

#### 6.5.1.1 Water Use Charge

On most Government Water Schemes, the Department of Water Affairs (DWA) sets the water use charge for irrigation water, based on the pricing strategy. This is the case with Lower Sundays River. The irrigators pay the charges as determined by the WUA. The first charge is known as the water use charge which is the cost for the operations of DWA to transfer the water from the Orange River to Darlington Dam. The Water User Charge for scheme which is supplied from Darlington Dam for the 2011/12 financial year was 5.94 cents per m<sup>3</sup>. Based on the schedule quota of 9 000 m<sup>3</sup>/ha/a, irrigators are therefore paying R589.86 per hectare per annum.

### 6.5.2 Operation and Maintenance charge

The second charge is the cost for the operation and maintenance of the canal supply system to the Water User managed and operated by the Lower Sundays River Water User Association. For the 2011/12 financial year the charge is 5.12 cents per m<sup>3</sup> which is R460.35 per hectare per annum.

### 6.5.2.1 Water Resource Management Charge

Besides the water use charge, the pricing strategy requires that all users pay for the management of the catchments including the cost of managing the Reserve, dam safety control, etc. This is the water resource management (WRM) charge. The current WRM charge for irrigation agriculture in the Fish to Tsitsikamma Water Management Area in which the Lower Sundays River Irrigation Scheme is located for the 2011/12 financial year, is 1.11 0.74 cents per m<sup>3</sup>, which amounts to R99.90 per hectare per annum.

### 6.5.3 Collection of the irrigation water use charges

The Lower Sundays River WUA is responsible for collection of the water use charges on behalf of the Department of Water Affairs (DWA) while the O&M charge, the WUA collects the money which it uses to pay operation and maintenance. Irrigators are billed directly by DWA for the WRM charges.

## **7 DETERMINATION OF UNAVOIDABLE WATER LOSSES IN LOWER SUNDAYS RIVER IRRIGATION SCHEME**

### **7.1 OVERVIEW**

Before determining the irrigation water use efficiency of the Lower Sundays River Irrigation Scheme, it was important to assess the expected seepage and evaporation losses based on the premise that the irrigation scheme infrastructure is being maintained as well as taking into account the useful life of the canal system infrastructure.

This is discussed in the following sections of this chapter.

### **7.2 Overview of the water losses**

#### **7.2.1 Overview**

According to Howell (2001), there are four basic losses that can result when water is diverted for irrigation. This can be described as follows:

- 1) Part of the water is consumed in evaporation (e.g. from channels) and transpiration (e.g. vegetation growing next to the channel).
- 2) Some water percolates to surface or subsurface areas (e.g. canal seepage or deep percolation) and cannot be recaptured (e.g. in the vadose zone, the ocean, or a salt sink) or can be recaptured (e.g. interceptor drains into a drainage canal or a drainage well) and used as an additional supply.

Quantifying these losses is the first step in determining the level of efficiency of conveyance and distribution systems and to compare with the Best Management Practices (BMP) for each of the identified water losses.

In order to establish the generally accepted practice that results in more efficient use, conservation or management of water, the estimate of the level of acceptable water losses due to seepage, evaporation and leakage was determined as part of setting the Best Management Practices (BMP) for the Lower Sundays River Irrigation Water Scheme.

#### **7.2.2 Unavoidable water losses due to canal seepage**

Canals continue to be the major conveyance systems for delivering water for irrigation agriculture. The seepage losses from irrigation canals constitute a substantial percentage of usable irrigation water. Therefore computation of the canal seepage losses is an important aspect of determining the best management practices for sustainable irrigation water management practices for the scheme.

Canals are often lined to reduce the seepage losses as is the case in the Lower Sundays River Irrigation Scheme. A perfect canal lining which is well maintained significantly reduces the amount of seepage although the canal lining deteriorates with time and becomes ineffective in controlling the seepage.

Seepage losses from concrete lined, and unlined canals are normally expressed in l/s per 1 000 m<sup>2</sup> of wetted area and appear to fluctuate between approximately 0.35 l/s per 1 000 m<sup>2</sup> wetted area and 1.9 l/s per 1 000 m<sup>2</sup> (Reid, Davidson and Kotze (1986). For design purposes Butler (1980) suggested a value of 1.9 l/s per 1 000 m<sup>2</sup> wetted area. Therefore according to literature depending on the wetted area, this could result in an unavoidable loss rate of up to 15% of the inflow into an irrigation canal. The actual figure was calculated for the canal infrastructure in the Lower Sundays River scheme as discussed below.

The seepage losses from a concrete lined canal system depend on a number of driving factors among which the following can be said to have a marked influence:

- (i) The hydraulic conductivity of the canal lining which is the concrete;
- (ii) Subsurface condition in so far as they affect drainage and the groundwater table;
- (iii) The age of the canal and the amount and fineness of the material carried in suspension;
- (iv) The flow of water in the canal and its depth and velocity;
- (v) The relation between the wetted perimeter and other hydraulic elements of the canal, particularly the discharge;
- (vi) The temperature of the water.

In order to determine the seepage losses of the Lower Sundays River canal system, the geometry of the canals needed to be collected and used to determine the wetted perimeter and flow area of each segment of the canal. This information was not provided. The assessment was therefore done based on the estimate of the canal geometry.

The formula used to calculate the seepage losses for curvilinear canal systems (i.e. parabolic canal geometry) is expressed as follows:

$$q_s = k \cdot y \cdot F \quad (1)$$

where  $q_s$  = seepage discharge per unit length of canal (m<sup>3</sup>/s);  $k$  = hydraulic conductivity of the lining (m/s);  $y$  = depth of water in the canal (m);  $F$  = function of channel geometry (dimensionless); and  $yF$  = width of seepage flow at the infinity. The seepage function,  $F$  for parabolic canals was taken as

$$F = (T/y) + \pi^2/4G \quad (2)$$

Where

T =top width of the channel at the water surface (m); y= flow depth of water (m); pi is 3.14; and G = 0.915965594, known as Catalan's Constant.

The seepage loss per unit length was then calculated using the hydraulic conductivity of the concrete lining; the canal geometry and the seepage rate based on the wetted perimeter. The expected seepage losses for the different canal sections in the Lower Sundays River are indicated in **Table 7.1** below.

**Table 7.1: Expected seepage losses in the LSR canal system**

Canal Name	Max. Hydraulic capacity (m <sup>3</sup> /s)	Seepage Loss, (m <sup>3</sup> /d per unit length)	Total Length of canal (km)	Expected Seepage losses (million m <sup>3</sup> /a)
Main canal	22.7	0.08489	3.88	1.96
Primary Canal - Kirkwood Canal	22.7	0.08489	72.55	4.21
Secondary canal 1 - Wesbank	1.1404	0.03646	11.76	0.62
Secondary canal 2 - Mistkraal	2.7119	0.04646	28.01	1.43
Secondary canal 3 - Tregeron/Selbourne	13	0.06586	28.07	3.82
Branch canals	Various	0.03195	158.15	0.45
Port Elizabeth Pipeline	14 000		8.84	-
Siphons	12 800		4.82	-
Total Seepage Losses in the Canal System			316.08	12.49

As illustrated in **Table 7.1** above, the minimum seepage losses expected in the LSR irrigation scheme canal system is 12.49 million m<sup>3</sup>/a in order to supply the scheduled allocation. As a percentage of the scheduled allocation, the minimum seepage losses that should be provided as additional to the scheduled allocation are 8% of the scheduled allocation but is 12% of the diversion in 2012.

When the above percentage seepage losses are compared with the best management practices, canal seepage would range between 6% and 10% of the input volume (Streutker, 1981 and Muller, 1984). The factors that have an effect on seepage losses are, *inter alia*, soil characteristics, water depth in the canal, flow speed and hydraulic profile of the canal, soil capillary tension, amount of sediment, algae, etc.

The minimum seepage losses as calculated above have been compared with the water losses of each canal system in the Lower Sundays River Irrigation Scheme based on the water balance assessment which is discussed in the following chapter. The difference in the water losses and the minimum seepage losses would have been taken as avoidable water losses.

### **7.2.3 Unavoidable losses due to surface evaporation**

The evaporation loss, expressed as a percentage of total inflow was determined based on the total surface area of the irrigation canals, the mean annual evaporation (MAE) based on the A-pan evaporation figure for the 1957 - 1979 hydrological record.

The total annual evaporation from the irrigation canal surface area was determined to be 0.26 million m<sup>3</sup>/a. This was taken as the average over the seven years records. Based on the calculated evaporation losses, the evaporation losses as a percentage of the total inflows was determined to be 0.4%. This is within the margin of error for the estimated evaporation losses at approximately 0.3% of total released volume (Reid, Davidson and Kotze; 1986).

Therefore the BMP evaporation loss in the Lower Sundays River Irrigation Scheme area that was used was 0.4% of the total inflows which was taken as the unavoidable evaporation losses for the scheme area. This amount has been taken out of the gross water losses.

## **8 LOWER SUNDAYS RIVER IRRIGATION SCHEME WATER BALANCE ASSESSMENT**

### **8.1 Overview**

The key aspects in developing and implementing water management plans (WMP) in the agricultural sector, is to understand:

- how much water is diverted into the irrigation scheme area;
- how much water is delivered to the various sub-schemes or sections of the irrigation scheme;
- how much water is delivered to the irrigators in the various sub-schemes, and
- how much water is returned to the river/water resource.

This approach provides the irrigation water budget to account for any inefficiency in irrigation water management in the scheme. The Lower Sundays River Irrigation Scheme does not use the Water Administration System (WAS) to account for the water used by the scheme and the water use efficiency accounting report (WUEAR) for reporting on matching irrigation supply and demand (MISD). It has its own model it runs which provides similar results.

The purpose of calculating the water balance and water budget is to help Lower Sundays River Irrigation Scheme to answer three questions:

- 1) Are the water requirements requested by the farmers and consumers in the scheme being met?
- 2) How efficiently is water being used within the scheme area?
- 3) Is the scheme receiving its target allocation of water from the sources of supply?

To answer these questions, data need to be collected for a certain period (weekly, monthly and/or annually) and some indicators need to be determined. The irrigation water budget for the Lower Sundays River Irrigation Scheme was undertaken based on the data provided by the LSRWUA. The first level was to determine the overall water budget, with a view to determining the extent of water losses at an irrigation scheme level with the available data.

### **8.2 Quality and integrity of the available information**

#### **8.2.1 Sources of information**

It is however important to note that the available records from the WUA that were used to conduct the historical water balance assessment for the Lower Sundays River irrigation

scheme are for the period 2003/4 to 2009/10. Another source of information for the volume of water released from the Darlington Dam was from the DWA, hydrological branch.

However the last year of records i.e. starting from week 30 of the 2011/12 water year and weeks 1 to 25 for the 2012/13 water years are now available and have been used to determine the water balance of the Lower Sundays River irrigation scheme canal systems with a view to set the water saving targets based on the water use and diversion for the last calendar year. This has been used to determine the extent of water losses taking into account the BMP for seepage and evaporation discussed in the previous chapter. This is discussed later in this section.

## **8.2.2 Integrity of the available data and information**

### **8.2.2.1 Information provided**

The data and information used to date to carry out the water balance assessments for the Lower Sundays River irrigation scheme was from the information provided by the Water User Association (WUA). The data provided for the last water year was based on measured data of the inflows into the canal irrigation; measured data of the irrigation water requested. Some average weekly records were provided for other water users such as Nelson Mandela Metropolitan.

### **8.2.2.2 Information not provided that will affect the water balance**

No measured data was provided for any spills at the canal tail ends or the estimated percentage of additional water determined for different sections of the canals. Furthermore the information on the changes in the storage volume in the Scheepersvlakte balancing was not provided to complete a comprehensive water balance.

The water balance assessment has not included the precipitation during delivery of water to irrigators. The assumption made is that the amount of precipitation during delivery of irrigation water is negligible. This may not be the case during the rainy season and consideration of incorporating information regarding precipitation should be made in future irrigation water use accounting.

## **8.3 Evaluation of the operational losses**

### **8.3.1 Overview**

The determination of operational losses (and mechanisms to minimise it) is one of the most important tools for improving irrigation water use efficiency levels. Higher accuracy in determining these losses, can underpin the efforts to decrease losses over the extent of the

whole canal distribution system. Decreasing “avoidable losses” from irrigation canals is often the only “relatively” inexpensive method available when contemplating water management measures.

Avoidable losses occur as a result of inefficient management in the operation of the canal system and can mainly be attributed to poor canal maintenance (leaks), incorrect headwork and inefficient runtime release 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.

### **8.3.2 Determination of the water losses**

#### **8.3.2.1 Overview**

Because the historical records had information that was unreliable and were mainly estimates, these have not been used in the water balance assessment. Instead the water balance assessment for the Lower Sundays River Irrigation Scheme has been based on half of the 2011/12 water year of records as well as half of the weekly records for the current irrigation water year (2012/2013). The water balance was based on information from the primary data on applications and releases provided by the scheme operators.

The records of inflows or releases into the canals which consist of all the sources of water supply to the Lower Sundays Irrigation Scheme as well as the irrigation and assuming the domestic water use were provided on a weekly basis in some periods. These flows (weekly inflows and irrigation water demands) have been used to determine the water losses for the Lower Sundays River canal systems.

## **8.4 Scheme Level Water Balance Assessment**

### **8.4.1 Inflows into Lower Sundays River Irrigation Scheme**

The first measurement of water takes place at the Korhaans weir, where water is diverted from the Sundays River after release from Darlington Dam into the main irrigation canal. There are no other measurements that were provided as inflows into the irrigation scheme.

Weekly records of the inflows into the main canal at the Korhaans weir were evaluated as illustrated in **Table 8.1** below.

**Table 8:1: Lower Sundays River Irrigation Scheme - Water Balance**

Scheduled Area	
Canal Irrigators - area	17,292.70
River irrigators - area	-
<b>Total scheduled area</b>	<b>17,292.70</b>
Scheduled quota	9,000.00

Scheduled allocation	
Scheduled Quota	9,000.00
Canal Irrigators	155,634,300.00
River Irrigators	-
<b>Total scheduled allocation</b>	<b>155,634,300.00</b>

Unavoidable Losses			
Expected Seepage Loss	12,467,570.65	11.70%	8%
Evaporation Losses	-	0.4%	-

WRM Charge	1.49
------------	------

26.77

73.34

Month & Year	INFLOWS					OUTFLOWS					GROSS WATER LOSSES			NON BENEFICIAL WATER LOSSES			BENEFICIAL WATER LOSSES			UTILISATION		
	Lower Sundays Canal	Storage release	Balancing Dam	Precipitation	Total inflows	Irrigation water application	Households / Stock Consumption	Industrial	Municipality	Downstream demands	Total Outflows	Total water losses	% of inflow	Evaporation	Seepage	Unavoidable water losses	Canal End Point	Leakage & spills	Total avoidable losses		% avoidable water losses	% of scheduled volume
23 January 2012	3,638,640.00				3,638,640.00	3,214,972.96			134,262.04		3,349,235.00	289,405.00	8.0%	13,099.10	425,760.85	438,859.95					0.0%	
30 January 2012	3,750,710.00				3,750,710.00	3,290,214.06			541,849.94		3,832,064.00	-81,354.00	-2.2%	13,502.56	438,874.27	452,376.82					0.0%	
06 February 2012	2,091,375.00				2,091,375.00	1,866,553.40			257,948.60		2,124,402.00	-33,027.00	-1.6%	7,528.95	244,713.85	252,242.80					0.0%	
13 February 2012	2,135,869.00				2,135,869.00	1,614,423.76			719,544.24		2,233,968.00	-97,999.00	-4.6%	7,689.49	249,931.83	257,621.32					0.0%	
20 February 2012	3,497,716.00				3,497,716.00	2,789,909.36			802,545.64		3,592,455.00	-94,738.00	-2.7%	12,591.78	409,271.19	421,862.97					0.0%	
27 February 2012	3,615,728.00				3,615,728.00	3,020,236.72			788,709.28		3,808,946.00	-193,218.00	-5.3%	13,016.62	423,079.89	436,096.51					0.0%	
05 March 2012	3,416,942.00				3,416,942.00	2,750,444.48			710,702.52		3,461,147.00	-44,305.00	-1.3%	12,300.63	399,808.04	412,108.68					0.0%	
12 March 2012	3,459,875.00				3,459,875.00	2,729,618.72			621,679.28		3,351,298.00	108,577.00	3.1%	12,455.55	404,843.38	417,298.93					0.0%	
19 March 2012	3,092,635.00				3,092,635.00	2,701,808.92			500,595.08		3,202,404.00	-109,769.00	-3.5%	11,133.49	361,872.26	373,005.75					0.0%	
26 March 2012	2,798,806.00				2,798,806.00	2,191,815.00			708,580.00		2,900,395.00	-101,589.00	-3.6%	10,075.70	327,491.04	337,566.75					0.0%	
02 April 2012	2,017,807.00				2,017,807.00	1,860,056.52			284,294.48		2,144,351.00	-126,744.00	-6.3%	7,263.99	236,082.18	243,346.17					0.0%	
09 April 2012	2,011,169.00				2,011,169.00	1,211,857.32			765,789.68		1,977,647.00	-33,522.00	-1.7%	7,240.21	235,328.86	242,569.07					0.0%	
16 April 2012	2,091,487.00				2,091,487.00	1,117,833.11			872,455.89		1,990,289.00	101,198.00	4.8%	7,529.35	244,726.95	252,256.31					0.0%	
23 April 2012	2,147,218.00				2,147,218.00	1,831,882.16			377,496.84		2,209,379.00	-62,161.00	-2.8%	7,729.98	251,248.09	258,978.08					0.0%	
30 April 2012	1,836,983.00				1,836,983.00	1,216,293.40			519,257.60		1,735,551.00	101,432.00	5.5%	6,613.14	214,947.19	221,560.33					0.0%	
07 May 2012	2,245,461.00				2,245,461.00	2,035,905.72			-76,809.72		1,959,096.00	286,365.00	12.8%	8,083.66	262,743.60	270,827.26		15,537.74	15,537.74		0.7%	
14 May 2012	2,627,024.00				2,627,024.00	2,110,546.36			44,474.64		2,155,021.00	472,003.00	18.0%	9,457.29	307,390.68	316,847.95		155,155.05	155,155.05		5.9%	
21 May 2012	1,876,422.00				1,876,422.00	1,069,828.96			417,531.04		1,487,360.00	189,062.00	11.3%	6,035.12	196,159.78	202,194.91					0.0%	
28 May 2012	2,018,562.00				2,018,562.00	1,578,580.08			382,928.92		1,959,489.00	59,073.00	2.9%	7,266.82	236,193.93	243,460.75					0.0%	
04 June 2012	2,167,175.00				2,167,175.00	1,594,338.20			423,427.80		2,017,766.00	149,409.00	6.9%	7,801.83	253,583.28	261,385.11					0.0%	
11 June 2012	1,802,786.00				1,802,786.00	1,008,460.00			459,536.00		1,467,996.00	334,790.00	18.6%	6,490.03	210,945.76	217,435.79		117,354.21	117,354.21		6.5%	
18 June 2012	1,736,861.00				1,736,861.00	1,336,267.76			325,061.24		1,661,329.00	75,332.00	4.3%	6,251.98	203,208.41	209,460.39					0.0%	
25 June 2012	1,360,474.00				1,360,474.00	874,872.96			418,617.04		1,293,490.00	66,984.00	4.9%	4,897.71	159,180.40	164,088.11					0.0%	
<b>2011/12 Water Year</b>	<b>57,237,325.00</b>				<b>57,237,325.00</b>	<b>44,914,699.93</b>			<b>11,000,378.07</b>		<b>55,915,078.00</b>	<b>1,322,247.00</b>	<b>2.3%</b>	<b>206,054.37</b>	<b>6,697,395.72</b>	<b>6,903,450.09</b>		<b>288,047.00</b>	<b>288,047.00</b>		<b>0.5%</b>	<b>36%</b>
						All Consumers																
02 July 2012	1,481,290.00				1,481,290.00	1,383,924.00					1,383,924.00	97,366.00	6.6%	5,332.64	173,327.20	178,659.84					0.0%	
09 July 2012	1,874,132.00				1,874,132.00	1,770,101.00					1,770,101.00	104,031.00	5.6%	6,746.88	219,294.03	226,040.90					0.0%	
16 July 2012	736,870.00				736,870.00	678,746.00					678,746.00	58,124.00	7.9%	2,652.73	86,221.88	88,874.62					0.0%	
23 July 2012	1,111,899.00				1,111,899.00	986,299.00					986,299.00	125,600.00	11.3%	4,002.84	130,104.40	134,107.23					0.0%	
30 July 2012	1,435,364.00				1,435,364.00	1,458,351.00					1,458,351.00	-22,987.00	-1.6%	5,167.31	167,953.35	173,120.66					0.0%	
06 August 2012	1,152,298.00				1,152,298.00	1,499,974.00					1,499,974.00	-347,676.00	-30.2%	4,148.27	134,831.52	138,979.80					0.0%	
13 August 2012	615,939.00				615,939.00	686,130.00					686,130.00	-70,191.00	-11.4%	2,217.38	74,289.01	76,506.39					0.0%	
20 August 2012	1,397,992.00				1,397,992.00	1,554,938.00					1,554,938.00	-156,946.00	-11.2%	5,032.77	163,580.42	168,613.19					0.0%	
27 August 2012	2,347,462.00				2,347,462.00	2,335,735.00					2,335,735.00	11,727.00	0.5%	8,450.86	274,878.84	283,329.70					0.0%	
03 September 2012	2,012,054.00				2,012,054.00	2,296,298.00					2,296,298.00	-284,244.00	-14.1%	7,243.39	235,432.42	242,675.81					0.0%	
10 September 2012	2,171,513.00				2,171,513.00	2,219,931.00					2,219,931.00	-48,418.00	-2.2%	7,817.45	254,090.87	261,908.32					0.0%	
17 September 2012	2,441,276.00				2,441,276.00	2,151,281.00					2,151,281.00	289,995.00	11.9%	8,788.59	285,656.11	294,444.70					0.0%	
25 September 2012	2,179,612.00				2,179,612.00	1,832,582.00					1,832,582.00	347,030.00	15.9%	7,846.60	255,038.54	262,885.15		84,144.85	84,144.85		3.9%	
01 October 2012	2,390,065.00				2,390,065.00	2,610,175.00					2,610,175.00	-220,110.00	-9.2%	8,604.23	279,663.66	288,268.09					0.0%	
08 October 2012	2,571,127.00				2,571,127.00	2,692,216.00					2,692,216.00	-121,089.00	-4.7%	9,256.06	300,850.10	310,106.16					0.0%	
15 October 2012	1,799,614.00				1,799,614.00	2,192,365.00					2,192,365.00	-392,751.00	-21.8%	6,478.61	210,574.61	217,053.22					0.0%	
22 October 2012	462,367.00				462,367.00	518,074.00					518,074.00	-55,707.00	-12.0%	1,664.52	54,102.02	55,766.54					0.0%	
29 October 2012	736,942.00				736,942.00	865,716.00					865,716.00	-128,774.00	-17.5%	2,652.99	86,230.31	88,883.30					0.0%	
05 November 2012	846,286.00				846,286.00	1,419,882.00					1,419,882.00	-573,596.00	-67.8%	3,046.63	99,024.76	102,071.39					0.0%	
12 November 2012	2,633,528.00				2,633,528.00	2,303,762.00					2,303,762.00	329,766.00	12.5%	9,480.70	308,151.70	317,632.40		12,133.60	12,133.60		0.5%	
19 November 2012	2,752,469.00				2,752,469.00	2,944,241.00					2,944,241.00	-191,772.00	-7.0%	9,908.89	322,069.11	331,977.99					0.0%	
26 November 2012	3,111,979.00				3,111,979.00	3,189,600.00					3,189,600.00	-77,621.00	-2.5%	11,203.12	364,135.73	375,338.85					0.0%	
03 December 2012	3,130,327.00				3,130,327.00	3,550,499.00					3,550,499.00	-420,172.00	-13.4%	11,269.18	366,282.64	377,551.82					0.0%	
12 December 2012	3,096,417.00				3,096,417.00	3,214,343.00					3,214,343.00	-117,926.00	-3.8%	11,147.10	362,314.80	373,461.90					0.0%	
18 December 2012	2,963,062.00				2,963,062.00	2,899,959.00					2,899,959.00	63,103.00	2.1%	10,667.02	346,710.80	357,377.82					0.0%	
24 December 2012	2,032,145.00				2,032,145.00	1,965,526.00					1,965,526.00	66,619.00	3.3%	7,315.72	237,783.29	245,099.01					0.0%	
<b>2012/13 Water Year</b>	<b>49,484,029.00</b>				<b>49,484,029.00</b>	<b>51,220,648.00</b>					<b>51,220,648.00</b>	<b>-1,736,619.00</b>	<b>-3.5%</b>	<b>178,142.50</b>	<b>5,790,174.93</b>	<b>5,968,317.43</b>		<b>96,278.45</b>	<b>96,278.45</b>		<b>0.2%</b>	<b>33%</b>
													#DIV/0!								#DIV/0!	
	<b>106,721,354.00</b>																					

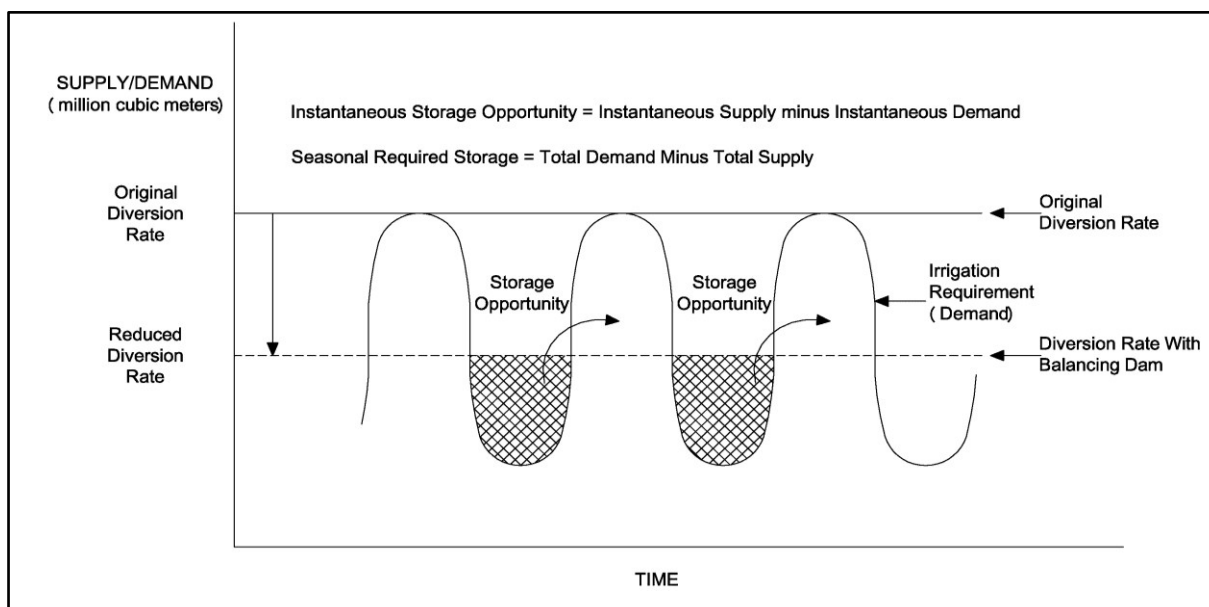
The total diversion at Korhaans weir for the 12 calendar months of records in 2012, was determined to be 106.7 million m<sup>3</sup>/a. The maximum diversion took place in the weeks between November and March when the weekly diversion can be as high as 3.75 million m<sup>3</sup>/a.

#### 8.4.2 Changes of volume in storage of Scheepersvlakte Balancing Dam

The impact of a regulatory storage such as Scheepersvlakte Dam and the potential benefit in management flexibility and improved water use efficiency associated with balancing dams in irrigation schemes is illustrated in **Figure 8.1** below.

The Scheepersvlakte balancing dam is currently not being included in the water inflow into the canal system. Because there is a major balancing dam, Scheepersvlakte which has a capacity of 1.5 million m<sup>3</sup>, it is crucial that the capacity at the beginning of the week is included as inflows because it supplies NMMM as well as some metered irrigators along the Nooitgedacht gravity pipeline.

Currently no measurements were available on a weekly basis on the capacity of the balancing dam. This is because there is not flow meter that measures the flow to the NMMM water treatment works in order to determine changes in the storage capacity of the balancing dam. As illustrated in **Figure 8.1** below, the available storage capacity in Scheepersvlakte Dam is supposed to reduce the releases from the Darlington Dam depending on how much storage is available in the next irrigation schedule.



**Figure 8.1: Possible demand and supply relationship and potential benefit in flexibility from a balancing dam**

### 8.4.3 Water use

#### 8.4.3.1 Overview

The supply to individual water users is measured through Parshall Flumes. Each irrigator is provided with the period from which he/she can abstract their water.

The weekly data on releases at the Parshall Flumes are aggregated to provide records of water used by the irrigators. For irrigators who are metered, flow readings are taken weekly to determine the weekly volume used by each metered irrigator.

The abstraction by irrigator was taken as the crop evapo-transpiration (ET). However it is important to note that there is a large number of irrigators with farm dams which they use to regulate the irrigation water requirements on the farm.

Records of weekly deliveries to other water users, namely Sundays Local Municipality and Nelson Mandela Metropolitan Municipality (NMMM) for domestic supply were provide for the period January 2012 to June 2012. However they were not disaggregated from July to December 2012. It has been assumed that the total water requirements as provided include all the demands supplied from the irrigation canal system. This also includes the metered irrigators.

#### 8.4.3.2 Irrigation water demands

The volume of water that is requested by the irrigators in the Lower Sundays River Irrigation Scheme area varies from year to year, as does the cropping pattern for each year. For the past 12 calendar months of 2012, the irrigation water application has ranged from 0.8 million m<sup>3</sup> in October to 3.8 million m<sup>3</sup> in January. Over the past 12 calendar months, the weekly average irrigation water demands was 1.96 million m<sup>3</sup>/a. This includes the metered irrigators whose demands have been increasing substantially over the last few years.

#### 8.4.3.3 Other demands

Besides irrigation water demands, the Lower Sundays River Irrigation Scheme also supplies two major water users namely the Sunday River Valley Local Municipality for domestic water use mainly in Kirkwood, Bontrug and Addo; and Nelson Mandela Metropolitan Municipality for domestic water supply in Port Elizabeth. In the records provided for the first six (6) months of 2012, the domestic water supply to the water treatment works for NMMM has averaged approximately 0.48 million m<sup>3</sup> per week.

Based on the above weekly average, the raw water supplied to the NMMM water treatment works in 2012 is estimated to have been 27 million m<sup>3</sup>. This is equivalent to the maximum design capacity of the water treatment works which is 75 Ml/d.

Taking into account the irrigation and domestic water requirements, the total average water demand from the Lower Sundays River Irrigation Scheme, dependent on the canal infrastructure, delivered to the water users has been 107 million m<sup>3</sup> over the last 12 calendar months of 2012. This is more than the volume of water diverted at Korhaans weir which was 106.7 million m<sup>3</sup> for the same period.

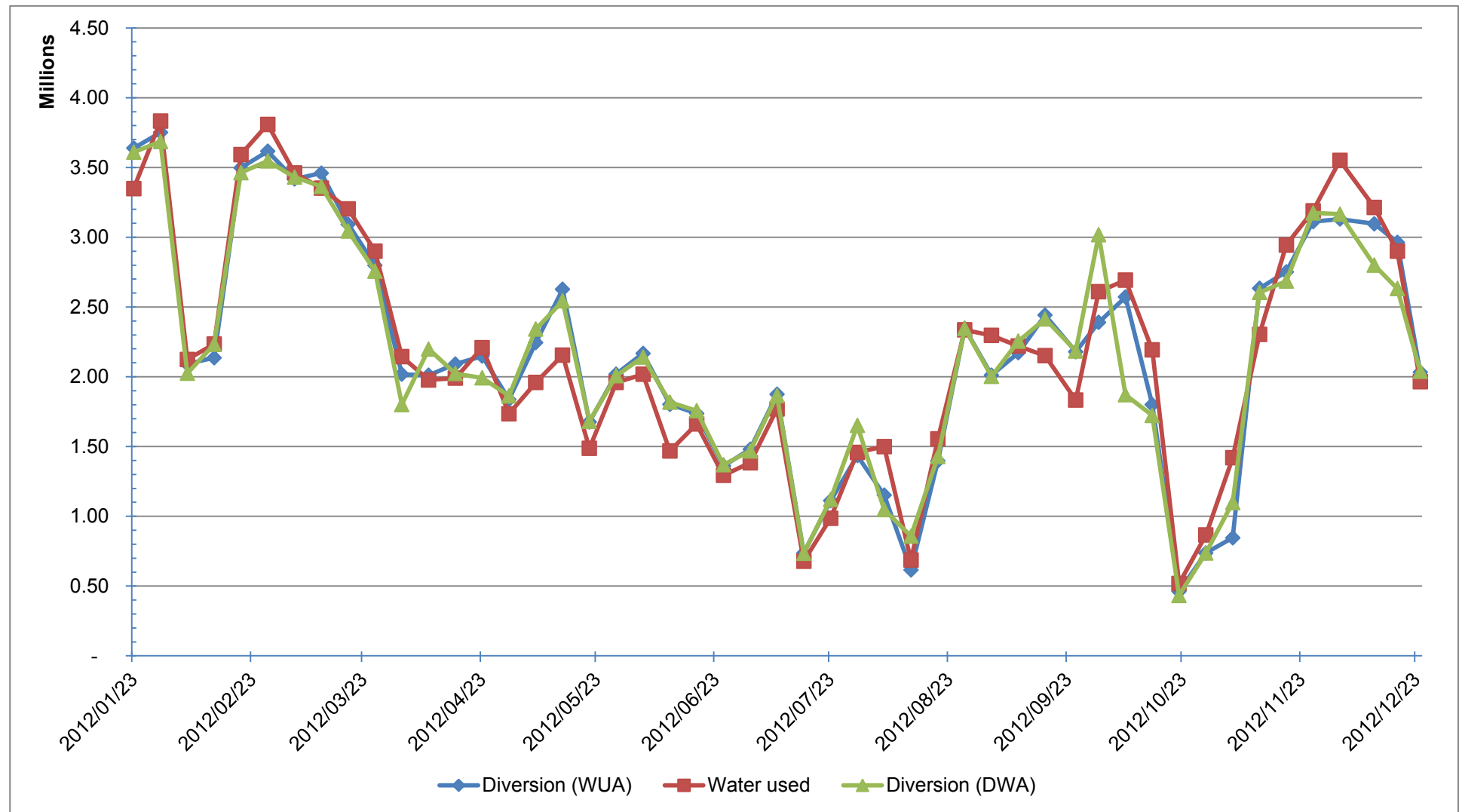
#### **8.4.4 Comparison of monthly diversions with monthly demands**

##### **8.4.4.1 Comparison between the WUA and DWA records of diversion at Korhaans weir**

Before a comparison was made between the diversion and the water use, the records of diversion at Korhaans based on the LSRWUA records and the Department of Water Affairs records were compared (see **Figure 8.2** below). Although there were outliers for some weeks the difference between the two records averaged 1% which is within an error margin for water measurements. Therefore the water measurements provided were taken as correct.

##### **8.4.4.2 Comparison of monthly diversions with monthly demands**

Further analysis was conducted to assess the whether there is a correlation between the weekly diversions at the Korhaans weir into the Lower Sundays River irrigation canals with the weekly irrigation and domestic water use. **Figure 8.2** below illustrates that of the 52 weeks of records provided; 26 weeks indicate that more water was used than was diverted at the Korhaans weir. This is not possible considering that the expected seepage losses and canal evaporation losses have not been factored. It is not possible to have the difference between the diversion and water use being negative. There cannot be negative water losses as reflected in the water balance provided in **Table 8.1**.



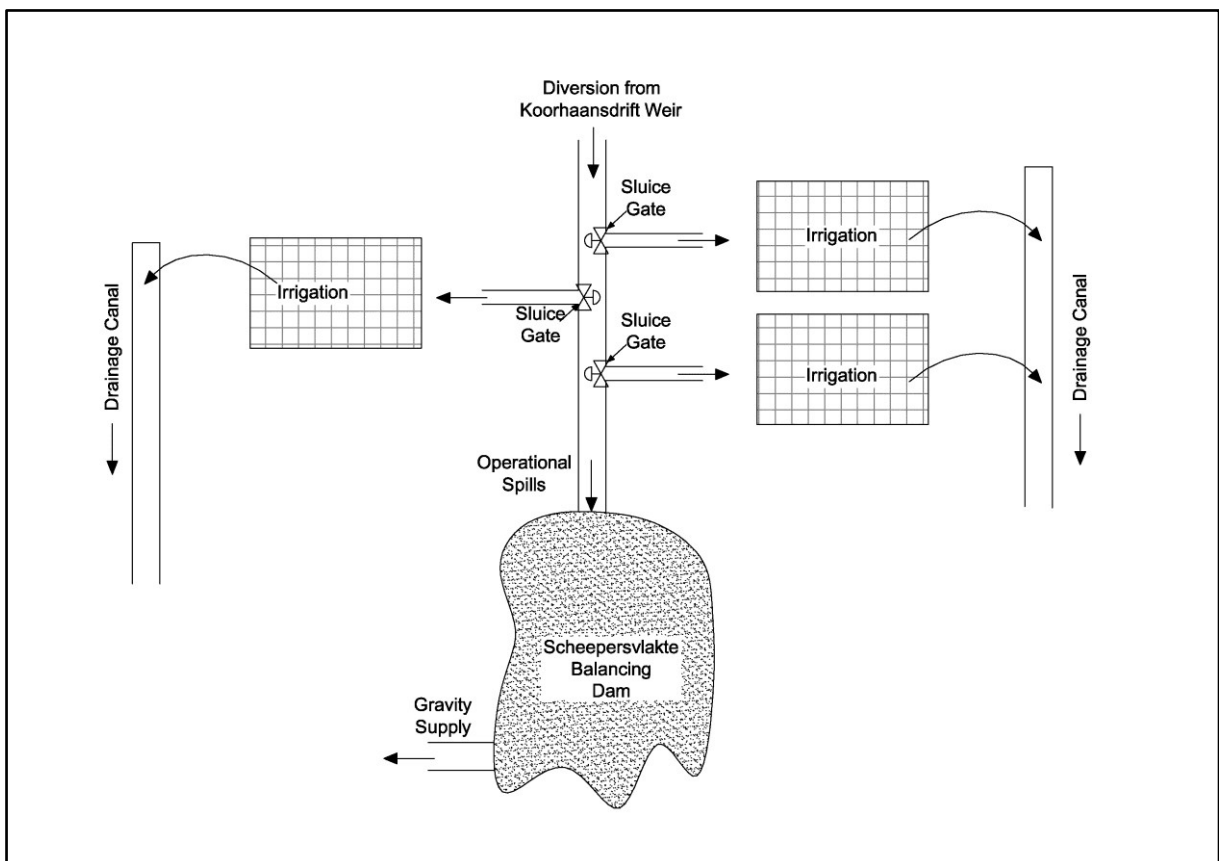
**Figure 8.2: Comparison of water diverted at Korhaans weir (DWA and WUA) records and the demands based on original data provided**

Given the fact that there is strong correlation between the records of diversion at Korhaans from the WUA and the DWA, there are likely to be errors in the measurements taking place at the off takes from the canals. Therefore the percentage gross water losses cannot be determined given the integrity issues with the water use figures provided for the same period.

The percentage gross water losses according to the 2012 records is -0.4 million m<sup>3</sup> or -0.39% of the total water diverted at Korhaans weir. The lack of including Scheepersvlakte balancing dam could be contributing to the negative figures in the gross water loss column of **Table 8.1** and illustrated in **Figure 8.2** above.

There may be irrigators who do not take up the full amount of water they have requested which ends up in the Scheepersvlakte balancing dam, which would have been accounted as a demand (see **Figure 8.3** below).

The above percentage for the 2011/12 water year has been benchmarked against best management practice (BMP) in order to determine the extent required to meet the BMP for irrigation operation of the Lower Sundays River Irrigation Scheme.



**Figure 8.3: Balancing Dam may also capture spills**

## 8.5 Gross Water losses

An analysis of the percentage of inflow to the Lower Sundays River main canal indicates that for the 2012 period, the WUA diverted on average 0.39% less water from the Korhaans weir than the water use of 107.1 million m<sup>3</sup>/a from all the water users for the same period.

**Table 8.1** indicates that the average gross water losses including the return flow, has been - 0.39% of the total flow released into the Lower Sundays River canal system. Given the fact that the gross water losses also include both minimum expected seepage and evaporation losses (i.e. unavoidable water losses) and avoidable water losses such as operational losses, leakage and canal spills which may be beneficial to downstream water users, the calculated gross water losses cannot be correct.

### 8.5.1 Unavoidable water losses in the Lower Sundays River canal system

There was no data to disaggregate further the water losses into evaporation, seepage, leakage, filling losses and operational spills. There were also no records being taken at the canal tail ends to determine the operational spills. Direct measurement of operational spills at the canal tail end returns can be conducted as there are Parshall flumes at most canal tail ends which can be measured.

**Table 8.2** below provides a summary of the water losses in the Lower Sundays River canal system. As illustrated in the table, the minimum seepage losses as calculated in the previous chapter for the Lower Sundays River canal system is 12.49 million m<sup>3</sup>/a while the evaporation losses was calculated based on the canal surface area and the MAE as 0.38 million m<sup>3</sup>/a. The total minimum unavoidable losses that has to be added to the irrigation water requirements or the schedule allocation is 12.87 million m<sup>3</sup>/a, or 12% of the total volume diverted into the Lower Sundays River canal system for 2012.

### 8.5.2 Avoidable water losses

#### 8.5.2.1 Total avoidable water losses

The avoidable losses could not be determined because of the following:

- (i) The gross water losses were calculated to be -0.4 million m<sup>3</sup> for the 2012 calendar year. It is not possible in any week to divert less water than what is actually used unless there is already excess water in the irrigation which is not being accounted for in the water balance assessment.
- (ii) There are either metering errors in the water measurements for the off takes which are causing the errors in the calculation

- (iii) The weekly changes in storage in the Scheepersvlakte balancing dam are not included in the balancing which may be the reason for the negative gross water losses.

**Table 8:2: Summary of the water losses for the Lower Sundays River Irrigation Canals (million m<sup>3</sup>/a)**

Description	Unavoidable losses	Avoidable losses	Total losses	% of total losses	Volume released into Scheme
Seepage	12.49		12.49	94%	
Evaporation	0.38		0.38	3%	
Filling losses		0.38	0.38	3%	
Leakages				0%	
Spills				0%	
Operational Losses				0%	
Over delivery to users			0.00	0%	
Canal end returns			0.00	0%	
Other			0.00	0%	
<b>Total</b>	<b>12.87</b>	<b>0.38</b>	<b>13.26</b>		<b>106.72</b>
% of total losses	97%	3%	100%		
% of total volume released into system	12%	0%	12%		

If the weekly negative figures are excluded the avoidable water losses are determined to be 0.4 million m<sup>3</sup>/a, or 3% of the gross water losses.

### **8.5.3 Operational best management practices:**

There are water losses on the canal system which can be classified as operational losses due to the way the scheme is operated. Such losses include weekly start-up and shut-down losses, operational wastage due to the lack of quick response to changes in demand, water not used (outflows) due to unexpected drops in demand and losses due to inaccurate metering.

These losses cannot be avoided because of the lack of complete automation and human errors. These losses are estimated to fluctuate between 9% and 28% of the irrigation water losses (Reid, Davidson and Kotze, 1986). It was however not possible to assess what the operational best management practices for the Lower Sundays River scheme because of the issues with the water balance assessment as discussed above.

### **8.5.4 Avoidable operational losses**

The avoidable water losses due could not be determined because the water balance assessment indicated a negative gross water loss for the 2012 calendar year which is not possible.

#### **8.5.4.1 Canal tail-ends**

There are no records in the available information to evaluate whether there are operational spills at the canal tail ends. Therefore this needs to be included in future water balance assessments.

#### **8.5.4.2 Water Losses due to calibration and metering error**

The negative gross water losses may be due to calibration and inaccurate water measurements. The LSRWUA needs to verify and justify the accuracy of the current water measurements of the irrigation water use as well as the raw water delivered to the water treatment works for the NMMM.

#### **8.5.4.3 Canal filling**

During the maintenance of the canal sections particularly during the winter periods, the canals are emptied. There then filled before the water can be supplied to irrigators. The canal filling represents operational losses. This further provides evidence that the gross water losses that are calculated from the water balance assessment can only be positive.

#### 8.5.4.4 Leakage losses:

No information is available as to the estimate of the additional water added for different canal sections to evaluate the LSRWUA assessment of the leakage losses that are added in order to deliver the weekly irrigation water applications.

The determination of the volume of water that is wasted as a result of leakages is very difficult to calculate as discussed above. This can only really be determined through accurate measuring or undertaking tests such as ponding tests on the irrigation canals. Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network due to its.

An important factor that has a marked effect on leakages is the water depth in a canal system. The leakage losses which can be avoided is due to the constant movement of water through the bottom and sides of the canal system due to small cracks including abnormally large cracks in the canal infrastructure which can be reduced through canal maintenance. 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.

#### 8.5.4.5 Aquatic weeds and algae:

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

- (i) A negative influence on hydraulic capacity and flow speeds in the canals. This decrease in canal capacity occurs particularly when the water demand is at its highest.
- (ii) Overestimation of the amount of water supplied, because of the artificially increased water levels that are measured at calibrated weirs.
- (iii) Water loss because of the flooding of canals.
- (iv) Impediment of floodgate and sluices at dividing structures.
- (v) Water logging of long-weirs.
- (vi) Structure (slab) failure of concrete-lined irrigation canals due to flooding.
- (vii) Aquatic weed fragments block irrigation systems and filters at water purification plants.

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

The aquatic weeds and algae is not a major issue in the Lower Sundays River Irrigation Scheme and have not been considered as such.

#### **8.5.5 Total avoidable water losses - Lower Sundays River irrigation canal irrigation system**

The total avoidable water losses cannot be determined until the current water measurements are evaluated as to their correctness. The LSRWUA therefore needs to evaluate why negative water losses are calculated with the current weekly water records as discussed above.

### **8.6 Factors affecting high irrigation water losses**

#### **8.6.1 Age and condition of the canal infrastructure**

There could be significant canal leakages, because of the age and condition of the canal infrastructure. Leaks normally occur in broken sections of the canals and at the top sections of canal bodies and can be attributed to maintenance problems and the general deterioration of the canal network owing to its age.

#### **8.6.2 Flow measurement errors and accuracy of Parshall Flumes:**

##### **8.6.2.1 Accuracy of the Parshall Flumes**

Given the problems in determining a meaningful water balance, the accuracy of the water measurements such as Parshall Flumes in particular need to be confirmed by the LSRWUA.

## **9 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES**

### **9.1 Overview**

The Lower Sundays River Irrigation WUA has been implementing measures to improve the management of delivery to the irrigators. These have included continuous flow delivery of irrigation water, which reduces the amount of canal seepage; annual maintenance of the irrigation canals to reduce avoidable water losses, as well as having flow measurements in place to audit the water delivery. These existing water management measures are discussed in more detail below.

### **9.2 Flow measurement**

In order to carry out a comprehensive water measurement and accounting system an irrigation scheme should have flow measurements at all points in the diversion, conveyance and delivery system where flow division takes place, including balancing dams, farm turnouts and tail water, drainage, and system spill locations.

The Lower Sundays River WUA has installed flow measurements at the critical diversion points to measure how much water is diverted at different points of the irrigation scheme. The LSRWUA may be taking the flow measurements. However the problem currently is that, although the infrastructure is in place, the measurements are not being incorporated in determining water budgets which introduces errors as discussed in the previous chapter.

With the above existing flow measurement infrastructure, there are sufficient measurements to determine the scheme water budget to a large extent is sufficient to ensure that detailed water budgets can be conducted at scheme level as well as at sub-scheme level.

### **9.3 Use of telemetry and automated infrastructure**

#### **9.3.1 Existing telemetry system**

The Lower Sundays River Irrigation Scheme is one of a few schemes where there is a telemetry system which to a large extent is operational and the critical flow measurement points are automated.

The existing telemetry system provides real-time monitoring and control of the flows at nine (9) critical points in the canal network. Data on flows using remote sensors is conveyed to the RTU where the information is sent through radio waves to the central control station at the WUA's offices. This information can then be used to monitor any changes in flows.

### 9.3.2 Automated controls

The LSRWUA has automated the gates at the critical diversion points. The automation has provided the WUA with instant information about flows and gate openings. This has provided the WUA and given them the ability to change gate settings and flows without visiting the site. Benefits of automation can include more precise control of flows, more reliable service to irrigators, less waste through unnecessary spills, and reduced labour.

The telemetry and automation provides the necessary infrastructure to allow for efficient management of the irrigation water if the existing infrastructure is used as a monitoring and control tool to improve water efficiency and accounting reporting for the scheme.

### 9.4 Use of WAS

There are 7 modules of the WAS programme. However, the Lower Sundays River WUA is currently not utilising the WAS, which is making it difficult to account for the water losses.

### 9.5 Flexibility in the Balancing Dam

One of the ways the Lower Sundays River Irrigation Scheme uses to manage and match the supply to the delivery is the use of Scheepersvlakte Balancing Dam.

Scheepersvlakte Dam plays an important role in helping the WUA match water deliveries to irrigation water requirements. Together with the farm dams that are in the scheme the reservoirs allow farmers to use their allocations at their convenience, both in terms of time of irrigation and the amount of water used. In addition to increasing water delivery flexibility, the storage reservoirs are used to:

- (i) Reduce overall system spills as well as capture spills from upstream users to the benefit of the scheme
- (ii) Capture storm water runoff which provides an additional source of supply

Although the Lower Sundays River Irrigation Scheme also has the ability to check or shut down canals and branch canals to avoid spills, the current automation needs to be operational. The LSRWUA has contractual problems which need to be addressed in order to enable the full utilisation of the existing telemetry system. However, the loss is taken to the account of the farmer who requested the water, although it will be a loss to the scheme.

### 9.6 Irrigators responsibilities

In order to ensure that irrigators only apply for the water they require, the Lower Sundays River WUA has put the onus on irrigators to apply for any reduction in the water application

in time. If there is any amount of the water that the irrigator does not take up for whatever reason such as the farm dam being full or rainfall during the week, the loss is taken to the account of the farmer who requested the water.

The problem with this principle, however is that there is a likelihood of reducing the level water losses if the reduction is not factored in the water balance assessment. Therefore the water not taken up may result as flow at canal tail ends, which will be a loss to the scheme.

### **9.7 Operation and maintenance of the canal infrastructure**

The ownership of the Korhaans weir, Kirkwood primary canal infrastructure is with the DWA with the rest of infrastructure owned by the Lower Sundays River Irrigation Scheme. However through a contract which includes the service level agreements the LSRWUA is responsible for the operation and maintenance of the entire infrastructure in the scheme area.

During winter periods, significant maintenance is carried out on the primary canal and secondary canals. The availability of Scheepersvlakte balancing dam provides the flexibility to the downstream irrigators although because of increased abstraction for the NMMM this has limited the flexibility unless the balancing dam is increased.

## 10 WATER MANAGEMENT ISSUES AND GOALS

### 10.1 Overview the management issues

The water balance analysis discussed in the previous chapter together with discussions held with Lower Sundays River WUA, has helped to identify several key water management issues. These are discussed in the following sections of this chapter.

In addition to the water balance analysis, some limited discussions were held with the management and other people who are knowledgeable about the Lower Sundays River Irrigation Scheme. This was done to determine the key issues the irrigation scheme is facing. **Table 10.1** below provides the key issues identified and these are discussed in more detail in the following sections of this chapter.

### 10.2 Flow measurement data and assessments

#### 10.2.1 Water balance assessment indicates negative gross water losses

The water balance assessment indicates that in 26 weeks of the 52 weeks of 2012 calendar year, less water was diverted at the Korhaans weir than was used. This is not possible unless additional or excess water was available for those weeks in the scheme area.

The water balance assessment could not therefore determine the extent of water losses that are expected in the irrigation scheme. If the unavoidable water losses such as seepage losses because of conductivity of the concrete, as well as the canal surface evaporation losses are taken into account with other operational losses, it was expected that the diversion at Korhaans weir would have been 12% or 12.87 million m<sup>3</sup> more than the water use for the 2012 year.

The flow records at the Korhaans weir were found to be accurate because of calibration done between the measurements provided by the DWA and the LSRWUA. The discrepancies are on the actual water used in the scheme.

#### 10.2.2 All flow records are not available

Good information is fundamental to making decisions on managing irrigation water at any irrigation scheme. The availability of flow measurements helps inform both the water user and the WUA about the quantity, timing, and location of water use and therefore enables the WUA to conduct a water budget not only at scheme level but also for sub-schemes within the irrigation scheme. This also provides the WUA with a management tool to monitor and control the flows to enable efficient management of the irrigation water.

**Table 10:1: Lower Sundays River Irrigation Scheme: Identified water management issues**

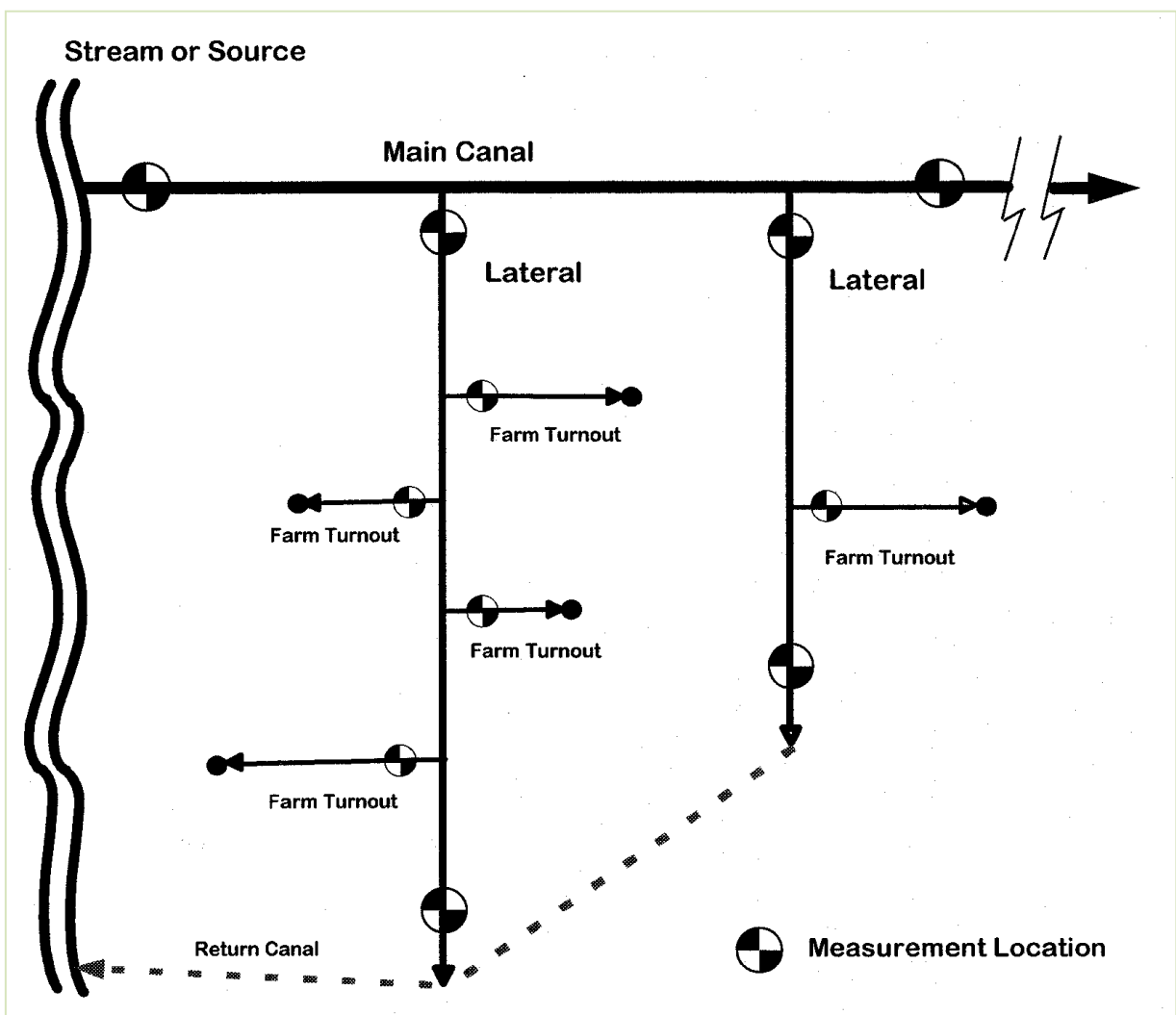
Item No.	Issue description	Comments
1	<p>The flow measurements were installed to improve management of water delivery system operations;</p> <ul style="list-style-type: none"> <li>(i) However, these are not being fully utilised, resulting in some of critical flow measurements not being included in the irrigation budgets</li> <li>(ii) There are no flow measurement records of the balancing dam as well as at the canal tail ends to determine operational spills</li> <li>(iii) There are no records on the secondary canals to determine water budgets at sub-scheme level</li> </ul>	<p>The LSRWUA should ensure that all flow records at scheme, sub-scheme, balancing dam and tail ends are captured.</p>
2	<p>Water balance assessment indicates more water is used than is diverted at the Korhaans weir</p> <ul style="list-style-type: none"> <li>(i) A comparison between the DWA records and the WUA records of weekly diversion at Korhaans weir indicate an average margin of error of only 1% except for some outliers</li> <li>(ii) There is additional water in the scheme not being accounted for (e.g. volume changes in Scheepersvlakte balancing dam)</li> <li>(iii) Accuracy of water measurements at the off takes may be an issue</li> </ul>	<p>The LSRWUA must incorporate the Scheepersvlakte volume changes as well as confirm the accuracy of water measurements at the off takes</p>
3	<p>Current water budgets being conducted at Lower Sundays River are not comprehensive.</p>	<p>Implement detailed water budgets which incorporate the following: (i)</p>

Item No.	Issue description	Comments
	<ul style="list-style-type: none"> <li>(i) The available quantity of water in Scheepersvlakte Balancing Dam is not included in the water balance</li> <li>(ii) The flow records at the tail-water discharges are not being included in the water budget to determine the extent of operational spills and tail-water volumes.</li> <li>(iii) There are no sub-scheme water budgets being conducted to assist in determining where the focus should be in repairs and maintenance of the irrigation canals during the periods</li> <li>(iv) Water budget contains estimates of water losses - there are no measurements</li> <li>(v) Water budget does not include precipitation</li> </ul>	Scheepersvlakte, (ii) the operational spills at the tail water ends and; (iii) spills at emergency exits. The water budget must be conducted at scheme and sub-scheme levels by the beginning of the 2012 water year
4	<p>The existing telemetry system is not being fully utilised because of the following:</p> <ul style="list-style-type: none"> <li>(i) There are contractual matters that need to be resolved with the contractor</li> <li>(ii) There are some remote telemetry outstation that will require upgrading and maintenance</li> </ul>	The LSRWUA needs to address the contractual issues with the manufacturer of the existing telemetry system
5	<p>The water administration system to manage water use is not being utilised to generate water accounting reports:</p> <ul style="list-style-type: none"> <li>(i) LSRWUA has got the WAS model which it is not fully utilising.</li> <li>(ii) It is not known how much and where water losses are occurring in the scheme area</li> </ul>	Implement use of the existing WAS to conduct detailed scheme and sub-scheme irrigation water budget within 1 year

Item No.	Issue description	Comments
6	<p>Darlington Dam gates are leaking and there is a likelihood that the risk of the dam is being compromised</p> <p>(i) The operating rules of the dam cannot be optimised until the leaks are address</p> <p>(ii) The leakage may be increasing the amount of water transferred from the Orange Fish transfer scheme</p>	<p>Repair the gates at Darlington Dam to reduce the water losses from the Dam</p>
7	<p>With the Kirkwood primary canal owned by the DWA, while the rest of the infrastructure are owned by the LSRWUA, there are concerns around the following:</p> <p>(i) The existing contract needs to be reviewed and update where necessary to ensure it addresses the responsibilities of the two parties.</p> <p>(ii) Assets are owned by DWA while the O&amp;M is carried out by Lower Sundays River WUA. There is a likelihood of a disjuncture in ensuring the assets are maintained, resulting in deterioration of the infrastructure and increase in water losses</p> <p>(iii) The lack of clarity may result in some of the issues such as refurbishment of the infrastructure not being carried out in time to reduce water losses from the canal infrastructure</p>	<p>Review and update the contract between the DWA and Lower Sundays River WUA</p>

**Figure 10.1** below provides the extent of flow measurement that is ideal for conducting an irrigation scheme water budget. As illustrated in **Figure 10.1** below, it would be ideal to have flow measurements at the inlet to the primary canals as well as at the tail water ends. This would assist in determining the water losses in each section of the canal system, as well as the operational spills if there are any.

As indicated in **Figure 3.2**, the Lower Sundays River Irrigation Scheme appears to have adequate flow measurement data to conduct a water budget analysis at both scheme and sub-scheme level. The WUA makes regular measurements of flows into all the measurement points. These include weirs and Parshall flumes on the canals, and flumes and rated sluice gates on the laterals to the individual farmers.



**Figure 10.1: Irrigation Scheme with ideal water measurement system**

Source: Bureau of Reclamation

However, the accuracy and reliability of the water measurement at the off takes needs to be confirmed as illustrated by the water balance assessment. With the Lower Sundays River Irrigation Scheme operating at normally high flows, devices such as Parshall Flumes do not operate well in high flow situations. Therefore there is scope for un-accounting of the water diverted and delivered to the irrigators.

The LSRWUA is not fully utilising the information that is available from the flow measurements to enable comprehensive water budgets to be carried out which would assist in planning for the maintenance of the infrastructure during the dry periods.

Although there are also flow measurements at the canal tail end of the primary canal, it is not clear whether there are flow measurements at the canal tail ends of the secondary canals as well as at the emergency exits as these would measure the water that is lost from the irrigation scheme. This must be investigated as part of the WMP review.

### **10.2.3 Telemetry system is not always operational**

The Lower Sundays River Irrigation Scheme has installed a Telemetry System on the existing gates in order to undertake flow measurements at approximately 9 diversion points within the scheme area. The system was permanently installed to monitor deliveries to the different canal sections as well as to monitor any operational spills or tail water return flows that are not used in the scheme, and thereby improve management of water delivery system operations. The flows and levels are intended to be sent by telemetry system to the Lower Sundays River WUA offices.

However, the telemetry system is not fully operational because of contractual matters which have affected the full use of the system. Furthermore the telemetry system is not being fully utilised with the Water Administration System (WAS) to undertake water accounting reports.

### **10.2.4 Management Goal 1**

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

- (i) Confirm the accuracy of the water measurements at the canal off takes such as Parshall Flumes, Cipolletti weirs, crump weirs and rectangular weirs
- (ii) Ensuring that all measuring devices in the scheme are in good operating condition and regularly calibrated.
- (iii) Continuation of regular measurement of flows into all primary and secondary canals, measurements of the inflows and outflows at the Scheepersvlakte Balancing Dam as well as measurement at the tail end of the canal system

### **10.3 Irrigation water budget and balance assessment**

#### **10.3.1 Less water is being diverted than is used**

Approximately 50% of the weekly records indicate that less water is diverted than is used in the irrigation scheme. If the unavoidable water losses due to seepage and evaporative losses of the canal surface an additional 12.87 million m<sup>3</sup> would have been diverted than is reflected in the water balance assessment.

The accuracy of the measurement of the irrigation diversion at Korhaans weir was confirmed by comparing the weekly records from the DWA information and the WUA information for the period. Except for a few outliers, the differences in the two measurements averaged 1% for the 52 weeks the records were evaluated.

Therefore there may be issues with the accuracy of the water measurements at the canal off takes which the WUA need to investigate.

Furthermore not including the changes in the weekly volume of water in the Scheepersvlakte balancing dam in the water balance assessment may have contributed to negative water losses in the water balance.

#### **10.3.2 Irrigation water budget is not conducted in detail**

Although a lot of data is available from the different flow measurements in the Lower Sundays River Irrigation Scheme, there are some components of the water budget that are either not being measured although measurements are available or being measured but the measurements are not included in the water balance assessment. These include the following:

- (i) Measurement of evaporation using pan evaporation, to determine local evaporation losses, is currently not being conducted. Therefore the losses calculated at present from the water budget are unreliable or inaccurate.
- (ii) Measurement of operational spills at the rejects, as well as at the tail water ends. These measurements where they are available have not been included in the water use accounting report

#### **10.3.3 Irrigation outfalls and operation spills are not included in the irrigation water budget**

The irrigation water balance at scheme level for the Lower Sundays River Irrigation Scheme provides the scheme "gross water losses", comprising seepage losses, evaporative losses, operational spills as well as the losses at the canal tail ends if any. At present there are the

operational spills at canal tail ends were not measured and included. Because irrigation water losses such as operational spills at canal tail ends are not being measured the water balance is not accurate. There are flow measurement structures which can be used to determine these losses. The LSRWUA should therefore be in a position to incorporate these measurements into the water budget and have the necessary tools to manage the operational spills.

Examples of measures that the LSRWUA has to control operational spills and outfalls include:

- (i) the automation of flow-control structures and measurement devices and the optimisation of channel operations, using computer software;
- (ii) the imposition of penalties on irrigators when they reject water they have ordered; – providing incentives for channel operators to minimise outfalls; and
- (iii) resisting pressure from irrigators to keep flow levels in the canals high, or to supply water more frequently.

Although there are Parshall Flumes to measure the inflows into most of the canals as well as the canal tail end points in the Lower Sundays River Irrigation Scheme, the measurements from these points are currently not being included in the determination of a comprehensive irrigation water budget at both scheme and sub-scheme level. The available flow measurements can provide a more detailed water budget if the measurements are included in the WAS programme. This would assist the Lower Sundays River WUA to determine which of the sub-schemes has the highest seepage losses and where to focus on reducing the losses, instead of refurbishing the whole irrigation canal infrastructure system.

Although there are flow measurements at the main canals, there are secondary canals which discharge water back into the river or tributaries. Discussions with the LSRWUA indicated that there were spills at these secondary canals. However the measurements at the discharge points are not reflected to confirm that there are no spills at these points. At this stage, it is difficult to determine how much water is returned back to the Sundays River at the 2 canal tail ends at Barclay Bridge. It is understood that these canal tail ends are controlled but no evidence is available that there are no operational spills taking place.

#### **10.3.4 Management Goal 2**

The goal to address the above issue is to ensure that all the flow measurements in the Lower Sundays River Irrigation Scheme are included in determining water budgets and calculating water losses at scheme as well as sub-scheme level. This will enable the WUA to determine the water losses which cannot be done at this stage. The WUA will be able to undertake

comprehensive water audits from where priority areas for improving irrigation water management as well as reducing water losses can be identified.

## **10.4 Operationalise the Water Administration System**

### **10.4.1 The installed WAS is currently not being fully utilised**

The Water Administration System (WAS) was developed as a tool to be used by Irrigation Boards/Schemes to optimise their irrigation water management and minimise management-related distribution losses in irrigation canal systems. The WAS consists of seven modules, integrated into a single programme and these modules can be implemented partially or as a whole. The system includes the following seven modules:

#### 10.4.1.1 Administration module

This module provides the details of all water users on an irrigation scheme. Information managed by this module includes addresses, notes, cut-off list, list of rateable areas, scheduled areas, household and livestock pipes installed on canals, industrial water quotas, crops and areas planted and crop yields. This module was installed and is currently operational.

#### 10.4.1.2 Water request module

This module captures all the weekly and monthly water requested by each farmer in the scheme. It also includes any additional water requests or any cancellations of water orders.

#### 10.4.1.3 Water release module

This module takes information from the water request module and calculates the volume of water to be diverted from the water supply sources into the main canal and all its branches allowing for lag times and any water losses and accruals to supply the request for the week.

A schematic layout of the total canal network or river system, is captured with detail such as the cross sectional properties, positioning of sluices or pumps, canal or river slope, structures and canal or river capacities. Discharges are converted to the corresponding measuring plate readings where needed, so that the sluice gates can be set to deliver the volume of water requested.

The Lower Sundays River WUA is currently not utilising the WAS and is not linked with the telemetry system, in order to provide flexibility in the operation of the conveyance systems.

#### 10.4.1.4 Measured data module

This module provides the field data that is measured from the rates and volume of water delivered to each user and the rate and volume of water released at the Korhaans weir, as well as the rate and flow at different points in the canal system. This data is very useful in conducting water budget not only at scheme level but also at sub-scheme level.

Currently the data is measured manually because the telemetry system as mentioned is not functioning.

#### 10.4.1.5 Other modules

The above three modules are the key modules in accounting for water use in an irrigation scheme. However there are other modules which include the following:

- (i) *Water accounts module*- this module administers all water accounts for an irrigation scheme or water management office. The water accounts module is a full debit system, from which monthly reports can be printed, including invoices on pre-printed stationery, reconciliation reports, age analysis and audit trail reports.
- (ii) *Crop water use module* is used to calculate the water usage per crop between two specified dates for all the planted crops on a scheme, based on the planting date, the area planted and the crop water use curve.
- (iii) *Reporting Module* – includes an extensive range of water and financial reports. Water balance sheets, distributions sheets, WUEAR and various other operator defined reports can be generated.

However, at present the WAS is only being fully utilised at scheme level. There will be substantial benefit in utilising the WAS system to undertake Water Use Efficiency Accounting Reporting (WUEAR), at sub-scheme level or at irrigation wards with a view to determining which of the irrigation wards are experiencing significant water losses. This can provide priority areas, where issues need to be addressed in irrigation water management in the Lower Sundays River Irrigation Scheme.

It has been estimated that field measurements indicated water savings of between 10% and 20% on implementing the water release module of the WAS program alone. In the case of Lower Sundays River Irrigation Scheme, the WAS programme has been installed for about 10 years but the records indicate that these savings have not been achieved because the WAS programme has not been utilised at sub-scheme level.

### **10.4.2 Management Goal 3**

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

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

## **10.5 Leakage at Darlington Dam**

### **10.5.1 Gates on the dam are leaking**

The LSRWUA is dependent on water releases from Darlington Dam. The gates on the dam are leaking badly. As a result of the leakage water being lost more water than is necessary is transferred from the Orange Fish River scheme at a cost. The value of the additional water transferred should be compared with the cost of repairing the gates at Darlington Dam.

Preliminary estimates of the leakage from the dam indicate that approximately 20 million m<sup>3</sup>/a, or 0.4 million m<sup>3</sup> per week, depending on the level of the dam which operate at 46% of its supply capacity. The releases for Lower Sundays River Irrigation Scheme are based on request. Therefore there is likelihood that there are periods when the leakage from the dam is not beneficial to the irrigation scheme when the demands are less than the leakage.

### **10.5.2 Management Goal 4**

The management objective to address this issue is for the Department of Water Affairs (DWA) to undertake a detailed cost benefit analysis of the potential benefits of repairing the gates at Darlington Dam taking into account the volume of water saved as well as the water quality management that will benefit irrigators.

## **10.6 Capacity of Balancing Dams and availability of farm dams**

### **10.6.1 Overview**

There is a balancing dam in the Lower Sundays River Irrigation Scheme. There is the Scheepersvlakte balancing dam which regulates flows to supply NMMM as well as downstream irrigators in the Lower Sundays River canal system.

One of the benefits of having regulating structures such as balancing dams, is that balancing dams will reduce the time it takes to deliver water to the irrigators, thereby reducing the seepage losses and leakages in the conveyance system. However in order to determine the benefits of having balancing dams, it is important to know the changes in storage capacity of the balancing dam. This is a problem in the Lower Sundays River irrigation scheme as discussed below.

### **10.6.2 Scheepersvlakte balancing dam capacity**

The total capacity of the Scheepersvlakte is provided as 0.8 million m<sup>3</sup>/a. This has been taken as the net full capacity. This was when it was constructed. However, with the siltation, the current net full supply capacity may have decreased.

There are not sufficient measurement structures particularly to the NMMM water treatment works in order to determine the changes in the storage for input into the water balance assessment. The lack of sufficient water measurements means that the weekly changes in balancing capacity are not being included in the water balance assessment.

### **10.6.3 Management Goal 6**

The management goal to address this operational problem is undertake the following:

- (i) Install flow measurement to enable the changes and actual water use by the NMMM to be included in the water balance assessment.
- (ii) Start measuring the inflow and outflow of the balancing dams in order to determine the impact of the dams on supplying the downstream water users including the sufficiency of the current balancing dam capacity.
- (iii) Ensure that the capacity of the balancing dam at the end of the week is incorporated in the calculation of water balance assessments. Not including the changes in the balancing dam may be one of the reasons for the negative water losses.

## **10.7 Updating and Implementation of the Water Management Plan**

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

The roles and responsibilities of the applicable Scheme Manager for the updating and implementation of the WMP will be the following:

- (i) Take flow measurements and conduct a detailed water balance assessment on a weekly basis at scheme and sub-scheme level

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

#### **10.7.1 Management Goal 7**

The overall management goal is to ensure that the Scheme Manager takes responsibility for the implementation and updating of the WMP.

## 11 IDENTIFICATION AND EVALUATION OF WATER MANAGEMENT MEASURES

### 11.1 Overview

There are numerous water management measures that accomplish a wide range of the goals identified in the previous section. However, only a few of the measures have the capacity to accomplish the goals to improve irrigation water use efficiency in the Lower Sundays River WUA.

The priority water management measures to improve irrigation water use efficiency on the Lower Sundays River WUA include the following:

- (i) Water measurements of the flow rates, duration and volume of flows at all the critical points which include the inflow and outflow at the balancing dams, the branch canals, as well as the canal tail ends, etc.
- (ii) Preparation of more detailed water balance assessments for the Lower Sundays River irrigation scheme, as well as the sub-schemes.
- (iii) Confirm the accuracy of the water measurements used to determine actual water used by the irrigators
- (iv) Ensure that the contractual arrangements with telemetry system contractor are address to enable full use of the telemetry system
- (v) Implementation of all modules of the WAS programme to enable irrigation monitoring and control of water use to reduce operational losses such as canal tail end spills to be carried out as well as undertake water balance assessment at scheme as well as sub-scheme level.
- (vi) Repair of the Darlington Dam gates by the DWA to improve the management of the releases for the Lower Sundays River WUA and NMMM.
- (vii) Developing an incentive based water pricing structure to improve irrigation water use efficiency and reduce significant fluctuations in demand.
- (viii) Maintenance and refurbishment of the existing delivery canals as well as the siphons, in order to reduce leakage losses, improve flow rates and increase head at diversion points.

## **11.2 Best Management Practices for irrigation water management in the Lower Sundays River WUA**

### **11.2.1 Overview**

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) envisaged in the Lower Sundays River WUA that takes account of the technical and managerial capacity of the Water User Association. This is discussed in the following sections.

### **11.2.2 Gross/Total water losses**

The water losses in the Lower Sundays River Irrigation Scheme could not be determined because of measurements which provide negative water losses of -0.39% of the total release into the canal system.

### **11.2.3 Unavoidable water losses**

It was determined in Chapter 7 that the unavoidable water losses due to evaporation losses and seepage due to the expected hydraulic conductivity of lined canals in the Lower Sundays River canal system was 12.87 million m<sup>3</sup>/a based on the total releases into the canal system in the 2011/12 water year, which translates into 12% of the total volume of water diverted into the Lower Sundays River canal system.

### **11.2.4 Best Management Practice for operational and distribution efficiency**

Besides the seepage and evaporation losses which are unavoidable because of the type of conveyance infrastructure which are open channels and are liable to leak because of the hydraulic conductivity of the concrete lining, there are operational losses which are unlikely to be recovered at a scheme level due to a number of factors. These factors include the following:

- (i) Canal filling – The Lower Sundays River WUA allows for the maintenance of the canal infrastructure and repairs necessary during the winter periods. During this period the canal is emptied to allow for the maintenance to be carried out. A significant volume of water is then required to fill the canals before they can deliver the irrigation applications to the users in the scheme. This canal filling is included as part of the operational losses which cannot be recovered through any major intervention measures.

- (ii) Operational performance losses – The existing sluices and Parshall flumes have an inherent error that needs to be included in the operational performance of the scheme even after improving the calibration of the flow measurements. These metering errors have to be taken into account when determining the Best Management Practice (BMP) for the Lower Sundays River WUA distribution efficiency
- (iii) Untimely deliveries of water that cannot be used as a result of cancellations. These losses can result in either operational spills at the canal tail ends representing a loss to the scheme or excess water which is delivered to downstream storages or canals within the scheme.

A Water Research Commission (WRC, TT466/10) 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 (WRC 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 Lower Sundays River and Lower Sundays River irrigation canal systems. This has been used in setting the water savings and the acceptable water losses of each of the two canal systems.

#### **11.2.5 Acceptable water losses in the Lower Sundays River WUA**

The unavoidable water losses in the Lower Sundays River WUA were determined to be 12% for the Lower Sundays River canal. This water is additional to the irrigation water use required at the farm edge.

Furthermore there are operational performance inefficiencies in operating the Lower Sundays River Lower Sundays River WUA including trying to match the delivery to the irrigation applications as mentioned in the previous section. Based on the WRC study the attainable range of operational losses which are not likely to be recovered through water management intervention measures is 10% of the total releases into the Lower Sundays River canal systems. **Table 11.1** below provides the water loss target for the Lower Sundays River canal system.

As illustrated in **Table 11.1** below, the expected water losses taking into account the unavoidable water losses and the expected inefficiencies in the distribution of irrigation water

due to problems of matching supply and delivery as well as metering errors and canal filling losses will be 22% of the total releases into the Lower Sundays River canal system.

**Table 11:1: Acceptable water losses in the Lower Sundays River canal system**

Description	Unavoidable losses	BMP Distribution Efficiency	Acceptable water losses	Target water savings	Total losses
Seepages	12.49		12.49		12.49
Evaporation	0.38		0.38		0.38
Filling losses		10.67	10.67	N/A	10.67
Over delivery to users					
Leakages					
Spills					
Operational Losses					
Canal end returns					
Other					-
<b>Total</b>	<b>12.87</b>	<b>10.67</b>	<b>23.54</b>	<b>-</b>	<b>23.54</b>
% of total volume released into system	12%	10%	22%	0%	22%
% of total losses	55%	45%	100%	0%	100%
Total releases					106.72

### **11.3 Task 1: Flow measurements at critical points of the irrigation scheme, calibration of the flow measurements and detailed water balance assessment**

#### **11.3.1 Confirm the accuracy of the water measurement**

No target water savings can be determined at this stage for the Lower Sundays River WUA. The accuracy of the water measurements needs to be evaluated and calibrated where necessary.

There is an urgent need to carry out an inventory of the accuracy of the existing Parshall Flumes in order to calibrate those that are found to be inaccurate. Furthermore the existing Flumes may be operating in submergence conditions resulting in inaccurate measurement of actual water delivered to the farmers.

#### **11.3.2 Incorporate the Scheepersvlakte balancing dam in the water balance**

The influence of the Scheepersvlakte balancing dam needs to be included in the water balance assessment in order to determine actual weekly losses.

### **11.4 Task 2: Updating of flow monitoring system**

#### **11.4.1 Ensure the Telemetry system is fully functional**

Some of the existing telemetry system outstation was not operational during the first site visit.

The Lower Sundays River Irrigation Scheme has contractual issues with the contractor who installed the telemetry system. The first urgent action to be undertaken by the Lower Sundays River WUA is to ensure that the contractual matters are addressed and the existing telemetry system is compatible with the WAS programme so that the flow measurements from the diversion points can be monitored on a real-time basis and the reading can be entered directly into the Water Administration System (WAS) for use by the release module.

### **11.5 Task 3: Management Systems**

#### **11.5.1 Overview**

One of the critical aspects of improving water use efficiency in the Lower Sundays River Water User Association is to ensure that all the relevant technical, managerial, information system is available.

### **11.5.2 Task 3.1: Asset Management System including development of canal infrastructure management plan**

Millions have already been invested in developing the Lower Sundays River Lower Sundays River Irrigation Scheme with significant investment in canal infrastructure and related infrastructure. Therefore the performance and return on investment of their infrastructure needs to be managed having understanding (i) What infrastructure is being managed by the WUA; (ii) Where is it located?; (iii) What condition the infrastructure is in?; (iv) What on-going work is required?, as well as (v) What is the value of the assets?

The current environment generally requires better management of assets, more flexible operations, faster rectification of failures and more effective customer service. Being able to predict problems, develop proactive strategies (such as not waiting for failures to occur) and take the necessary action, are critical tasks of advanced asset management. In addition, it is important to fully understand the cost of maintenance services. Too often these services have been contracted out without fully understanding the costs. This can result in the contractor having all the knowledge of the costs associated with the network, and more importantly, the ability to be able to dictate terms to the WUA

In order for the Lower Sundays River Water User Association (LSRWUA) to manage the existing canal infrastructure it is important that the WUA establish an infrastructure management system. The LSRWUA already has a GIS which it can leverage into an information management system to enable the linking of the spatial information with the data on the location, capacity and performance as well as the condition of the assets.

### **11.5.3 Task 3.2: Full implementation of WAS and alignment with the telemetry systems**

#### **11.5.3.1 Implementation of WAS release module**

The importance of relevant and opportune information in decision making cannot be overemphasized. Managing irrigation systems is no exception to the rule. On the contrary, information is vital since daily decisions with regard to water deliveries and other aspects may affect the well-being of many farmers. Traditionally, managers of irrigation systems have tried to cope with this problem through the compilation of field information that was manually processed.

Unfortunately, the number of users in the Lower Sundays River irrigation system runs in the order of hundreds and manual processing of information becomes a lengthy and costly

exercise. As a consequence, relevant information is often not available on time or is incomplete and many *ad hoc* decisions have to be made.

#### 11.5.3.2 Review the current use of WAS

As mentioned earlier, the Lower Sundays River Scheme does not have a comprehensive water accounting system to not only track water deliveries but also determine the areas of improving irrigation water management. The scheme is not using all the modules of the WAS programme to manage and reduce water losses.

Therefore, the Lower Sundays River Irrigation Scheme (WUA) needs to ensure that they implement, particularly the release module of WAS together with the telemetry system.

#### 11.5.4 Initial Capital Expenditure and O&M Costs

The Lower Sundays River WUA already has the WAS programme installed at their offices. However, in order to ensure that all WAS modules are operational, will require the training of the water control personnel. The programme should also be set up to enable water balance assessments at sub-scheme levels (i.e. for each of the six canals in the irrigation scheme).

The estimated operation and maintenance costs for operating the WAS programme includes an annual fee of R24 000 to obtain the latest updates of the programme and maintenance of the programme.

### 11.6 Task 4: Incentive based water pricing

#### 11.6.1 General

To achieve an incentive for efficient water use, the price of irrigation water must be directly related to the volume delivered unlike the current situation where it is based on the scheduled quota. A review of the on farm irrigation in the Lower Sundays River scheme indicated that there may be significant over-irrigation taking place.

In order to encourage irrigators to use water efficiently, it is recommended that incremental water pricing is considered, based on the optimal crop water requirements for the sugar cane which is the main crop. The implementation of incentive water pricing in irrigation agriculture, requires that comprehensive regulatory and operational criteria to be met before considering the economic criteria for incentive based pricing of irrigation water.

#### 11.6.2 Regulatory aspects for incentive pricing

An orderly system of distributing water is already in place in the Lower Sundays River irrigation scheme, based on the regulatory framework for distributing water among the

farmers. The rules and procedures defining the water ordering and water releases are in place. These include responsibilities of the WUA and those of the irrigators, priorities in case of shortage or excess supplies; penalties for breach of rules, and so on. Based on this, there is immediate scope for improving water distribution through pricing. Furthermore, there are already flow measurement devices (i.e. sluice gates and Parshall flumes), for measurement of the quantity delivered.

From a regulatory perspective, the water pricing strategy can be used to in determining incentive pricing structure with two or three levels of pricing, to encourage efficient use of irrigation.

### **11.6.3 Operational aspects for incentive pricing**

Measurement and charging at the farm level will require substantial investment in equipment, and an associated administrative bureaucracy, to collect and collate data on farm-level deliveries, and undertake the billing process.

The Lower Sundays River irrigation scheme already has the operational systems in place such as weekly ordering, as well as the sluice gates (however not very accurate) to measure each irrigator's use. Furthermore, with the WAS programme, the scheme has the administrative system to carry out billing based on actual use, rather than on a scheduled basis.

With the above operational aspects in place, the direct link between service and payment are achieved, and the efficiency incentive that pricing is designed to produce, can be met.

### **11.6.4 Economic aspects for incentive pricing**

The current pricing, based on the scheduled quota does not provide the economic incentives for improving water use efficiency at farm level, as irrigators feel that they are entitled to the full use of their scheduled quota, even when they can achieve higher levels of production with less water.

If the charging system is to have an impact on consumption, then the system of payment must be such as to induce the desired economic response. In the case of Lower Sundays River, the benefit of incentive pricing means irrigators can expect to pay less for their irrigation compared to the current scheduled quota based pricing which provides an economic incentive to the irrigators at farm level.

Any savings made from reduction in water use at field edge, can be sold to other users such as the domestic sector whose demand is growing. This will provide additional funds to improve the management of water in the irrigation scheme.

#### **11.6.5 Initial capital costs and O&M costs**

As indicated above, the regulatory, operational and economic criteria are in place to implement incentive based pricing. Therefore, the initial capital costs are envisaged to be minimal with the initial capital on accurate flow measurement. However, the operation and maintenance costs are likely to be high to ensure billing is carried out on actual use.

## 12 LOWER SUNDAYS RIVER WATER MANAGEMENT PLAN

### 12.1 General

#### 12.1.1 Legal provision for developing and implementing a WMP

The development and implementation of a Business Plan is a legal requirement to be undertaken by a WUA in terms of section 21 of Schedule 4 of the National Water Act (Act 36 of 1998). As part of the business plan, the WUA is required to have a water management plan to improve water use efficiency in its scheme area. 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 a 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."*

Although the above section of the act is not prescriptive, there is a business case in light of the above legal requirements for the Lower Sundays River WUA to develop a WMP in terms of the provisions of the act to enable it to manage the irrigation water in the scheme effectively and efficiently.

## 12.2 Establishment of water saving targets for Lower Sundays River Irrigation Scheme

### 12.2.1 Use of equivalent depth per actual unit area

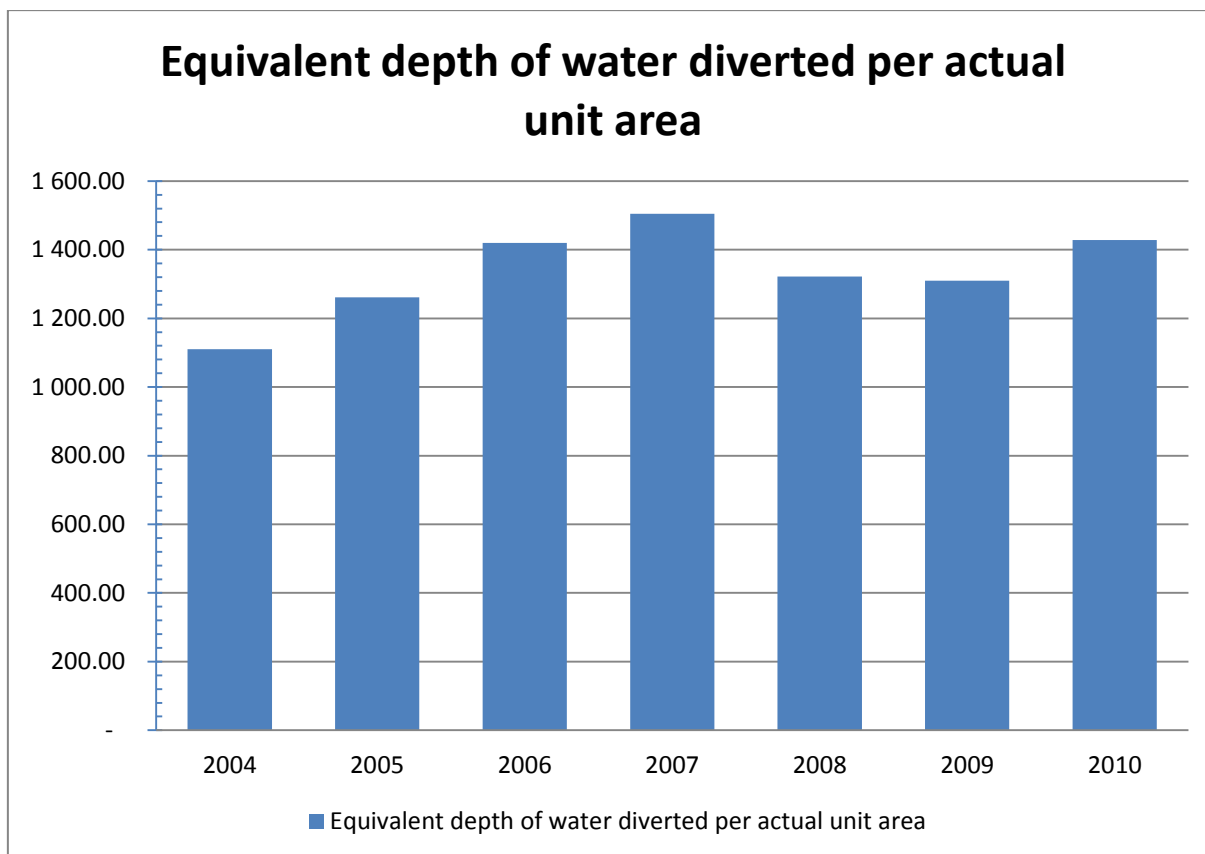
The implementation of a Water Management Plan for the Lower Sundays River Irrigation Scheme to reduce water losses will imply reducing the water diverted/released per unit of the land area irrigated in the scheme. As is expected this will not affect the yields of the wheat, maize and potatoes that are being irrigated in the scheme area. Therefore reducing the water diverted per unit of land area would mean an increase in productivity per unit of water which would be a clear indication of progress towards greater efficiency for the Lower Sundays River Irrigation Scheme assuming the scheduled quota of 9 000 m<sup>3</sup>/ha/a remains constant.

In the Lower Sundays River Irrigation Scheme, the trend-line indicates an increase in the diversion per unit of irrigated areas from 2004 to 2010 water years for the Lower Sundays River canal system (see **Figure 12.1** below). Although there was a decline between 2007 and 2008, the diversions per unit of irrigated land have been increasing since 2008. This is an indication that there was a major decline in irrigation water use efficiency during the period when the records were available. This may be due to the poor condition of the canal infrastructure as discussed previously as well as operational losses during the period.

As the irrigation area has been constant over the period from 2008 to 2010, the allocated water per unit has increased in the case of the Lower Sundays River.

Any improvements for example in on-farm water use efficiency may be likely to be offset with the increase in water losses. This conclusion has however only been reached with very limited data as no other historical data was available and will need to be verified in time.

Therefore in setting water saving targets for the Lower Sundays River Irrigation Scheme, the use of the equivalent depth per unit area irrigated as a performance indicator is proposed. Any decrease per unit of actual irrigated area will indicate progress being made by the scheme towards greater irrigation water use efficiency. This performance indicator can be used at scheme as well as at sub-scheme level. Currently this measure is not being used when the irrigation schemes submit their WUEARs.



**Figure 12.1: Trend line of increasing irrigation water diversion/released from Darlington Dam expressed as an equivalent depth of water diverted per actual unit area irrigated for the Lower Sundays River canals (m<sup>3</sup>\*10<sup>3</sup>)**

### 12.2.2 Recommended water saving targets

Because there has not been a decline in the trend-line of the diversions per unit area irrigated over the observed period for the Lower Sundays River canal, it would appear there is scope in implementing the irrigation management intervention measures, once the accuracy of water measurements is confirmed.

### 12.3 Implementation plan to achieve the water saving targets

#### 12.3.1 Target 1: Conduct flow measurement at all critical measurement points in the scheme

**Table 12.2** below provides the plan of activities required to ensure all flow measurements are taken by the Lower Sundays River WUA and detailed water balance assessments are conducted on a quarterly basis and a management report presented to DWA on the status of water losses, water saving targets as well as the actions taken to reduce water losses.

As discussed in the previous chapters, the Lower Sundays River irrigation scheme has all the measurement structures to enable the WUA to taken flow measurements at all critical points.

The Lower Sundays River WUA may be taking all the water measurements. However the accuracy of these measurements needs to be confirmed. It needs to ensure that these measurements are reflected in the water balance assessment by including the following in the water balance:

- (i) All the weekly measurements at the canal tail ends even when the records indicate no flows at the tail ends.
- (ii) Incorporate the balancing dam information by taking flow measurements at the inflow and outflow of the Scheepersvlakte balancing dam so that changes in storage capacity is included in the water balance assessment.

### **12.3.2 Target 2: Conduct detailed water balance assessment at sub-scheme level**

In order for the Lower Sundays River WUA to benefit from taking the flow measurements, detailed water balances should be prepared to incorporate actual flow measurements. Currently the WUA relies on estimates, particularly of the water losses. As a first step, four water balance assessments, (i) one for the Kirkwood primary canal; (ii) Wesbank secondary canal; (iii) Mistkraal secondary canal and (iv) Tregrone / Selbourne secondary canal should be conducted including the measurements at the balancing dam as well as the canal tail ends. This will enable to determine which of the above sub-schemes has the highest water losses.

**Table 12:1: Lower Sundays River Irrigation Scheme: Water Management Measures and action plan**

Priority	Goal	Action Plan	Timeline	Responsible Authority
1	To ensure all measurements are accurate in the Lower Sundays River irrigation scheme	<ul style="list-style-type: none"> <li>(i) Confirm the accuracy of flow measurements in the irrigation scheme area.</li> <li>(ii) Install a bulk water meter at the gravity pipeline from the Scheepersvlakte water treatment works</li> <li>(iii) Measure the inflow and outflow at the balancing dam to determine weekly changes in storage as well as at canal tail ends.</li> <li>(iv) Calibrate measurement structures as required</li> </ul>	<ul style="list-style-type: none"> <li>June 2013</li> <li>October 2013</li> <li>Oct. 2013</li> <li>Oct 2013</li> </ul>	Lower Sundays River WUA
2	Undertake detailed water balance assessments of the scheme	<ul style="list-style-type: none"> <li>(i) Split the Lower Sundays River scheme into the sub-schemes and prepare a water balance assessment and WUEAR for each sub-scheme to DWA</li> <li>(ii) Prepare detailed water balance assessment for the sub-schemes and split the losses to reflect operational losses from canal tail ends</li> <li>(iii) Set water saving targets based on update information to reduce water losses above the unavoidable losses and the operational losses</li> </ul>	<ul style="list-style-type: none"> <li>October 2013</li> <li>Oct 2013</li> <li>Oct 2013</li> </ul>	Lower Sundays River WUA

Priority	Goal	Action Plan	Timeline	Responsible Authority
3	To enable real or near real time flow monitoring	<ul style="list-style-type: none"> <li>(i) Review existing telemetry system and remote telemetry units (RTU) required for flow measurement and ensure contractual issues have been addressed to operate the system</li> <li>(ii) Ensure telemetry system infrastructure including software to ensure compatibility with WAS</li> <li>(iii) Calibrate the flow measurements such as flumes and sluices to improve the accuracy in flow measurement</li> <li>(iv) Prioritise areas of significant water losses</li> </ul>	<ul style="list-style-type: none"> <li>Oct. 2013</li> <li>Oct 2013</li> <li>May 2014</li> <li>June 2014</li> </ul>	Lower Sundays River WUA
4	To fully implement the WAS programme	<ul style="list-style-type: none"> <li>(i) Review current use of WAS programme modules</li> <li>(ii) Implement the full use of the WAS ordering, release and report modules</li> <li>(iii) Set up WAS programme to carry out water balances at scheme and sub-scheme level</li> </ul>	<ul style="list-style-type: none"> <li>May 2013</li> <li>June. 2013</li> <li>June. 2013</li> </ul>	Lower Sundays River WUA

Priority	Goal	Action Plan	Timeline	Responsible Authority
5	To conduct the refurbishment of the canals	<p>(i) Classify the condition of all canal segments based on the condition of the canals. In cooperation with scheme personnel, conduct field reconnaissance to obtain attribute data and rate the condition of segments;</p> <p>(ii) Prepare a motivation to DWA for refurbishment of the poor sections of the canals owned by DWA requiring total construction as well as relining;</p> <p>(iii) Engage with the DWA Infrastructure branch to motivate for refurbishment of the identified canal sections;</p> <p>(iv) If applicable prepare tender documents &amp; specifications for total reconstruction of canal sections and relining of the canals.</p> <p>(v) Assess water savings made from total construction of sections of the canal and relining of canal sections</p>	<p>June 2013</p> <p>Oct. 2013</p> <p>November 2013</p> <p>March 2014</p> <p>May 2019</p>	<p>Lower Sundays River WUA</p> <p>DWA / LSRWUA</p> <p>DWA</p> <p>DWA</p>
6	To implement incentive pricing structure for the	<p>(i) Review current irrigation water pricing strategy and update administration systems</p> <p>(ii) Provide inputs in updating the DWA water pricing strategy</p>	<p>June 2013</p> <p>July 2013</p>	<p>DWA / Lower Sundays River WUA</p>

Priority	Goal	Action Plan	Timeline	Responsible Authority
	WMA in 3 years	<ul style="list-style-type: none"> <li>(iii) Engage with irrigators on incentive pricing structure</li> <li>(iv) Install accurate flow measurement &amp; implement water billing based on incentive pricing rate</li> <li>(v) Update the operating rules of Darlington Dam to supply irrigators based on incentive pricing rate</li> </ul>	<ul style="list-style-type: none"> <li>August 2013</li> <li>March 2014</li> <li>June 2014</li> </ul>	
7	To implement management systems to assist in water savings	<ul style="list-style-type: none"> <li>(i) Update the Geographic Information System to install an asset management system</li> <li>(ii) Update the WAS programme to enable sub-scheme water balances</li> <li>(iii) Financial systems – Review current pricing structure and update for future sustainable maintenance</li> <li>(iv) Administration systems – Review the roles &amp; responsibilities of current personnel</li> <li>(v) Assess and revise additional administration requirements to enable</li> </ul>	<ul style="list-style-type: none"> <li>June 2013</li> <li>June 2013</li> <li>May 2014</li> <li>October 2013</li> <li>June 2014</li> </ul>	Lower Sundays River WUA

Priority	Goal	Action Plan	Timeline	Responsible Authority
		implementation of the plan		
8	To align the WMP to the catchment management plan	(i) Engage with the catchment forum to present the WMP (ii) Align activities between the catchment process and the WMP (iii) Update the WMP including the tasks and related activities from the catchment process	June 2013 July 2013 August 2013	Lower Sundays River WUA/ Catchment Forum
9	Undertake water quality monitoring of the river upstream Lower Sundays River canals.	(i) Identify water sampling points. (ii) Taking water samples for analyses (i.e. Microbiological and Chemical) from identified points. (iii) Feedback Analyses reports to users.	March 2013 May 2013 June 2013	

### 12.3.3 Target 4: Full implementation of WAS programme

The benefits of the rehabilitation of the telemetry system cannot be fully realised without the full implementation of all the modules of the WAS programme, which needs to be linked with the data and records from the telemetry system. The WAS programme can then use the information and flow records to match the water releases and the water requested, to minimise operational spills, as well as to reduce any current flows at the tail ends.

The flow at the tail ends is considered as a loss, although it may have a beneficial use downstream. The downstream demands can however be supplied by direct flows in the Sundays River and/or releases from Darlington Dam without diversions made at Korhaans weir into the canal infrastructure for purposes of users downstream of canal tail-ends.

The full implementation of the WAS programme, together with the telemetry system, will substantially improve the operation of the Lower Sundays River Irrigation Scheme and reduce current operational losses in particular, which are considered to be high. The target reduction in operational losses, estimated to be 4.1 million m<sup>3</sup>/a, can be achieved within the current water year, by implementing these two priority measures.

### 12.3.4 Target 5: The refurbishment of canal infrastructure

Besides the need to reduce operational spills and losses through improving irrigation water management using the flow measurement and the WAS programme, the seepage losses and leakages were also determined to be high. Therefore priority in relining of canals and resealing of the conveyance infrastructure is an imperative.

The losses due to the deteriorating condition of the concrete canal can be reduced by refurbishment of the canals. This requires first engaging with the DWA in order to jointly conduct condition assessments of the canal infrastructure owned by DWA as well as by the LSRWUA. The findings of the asset infrastructure condition assessment are to enable a refurbishment programme to be developed for implementation. As they own the asset, it is envisaged that the DWA can utilise the refurbishment budget to replace any canals and siphons.

The actions to be undertaken are indicated in **Table 12.1** above. It is important to note that because the actual amount of leakage has not yet been fully established, a pond test is recommended to determine how much water is lost before a final decision is made on replacing the siphon. Once the pond test indicates that the amount of leakage justifies replacing the pipe, this can be implemented within the time frame as illustrated in **Table 12.1** above.

### **12.3.5 Priority 6: Updating and implementation of the Water Management Plan**

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

The roles and responsibilities of the applicable Scheme Manager for the updating and implementation of the WMP will be the following:

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

### **12.3.6 Target 7: Implement incentive pricing**

This requires a review and updating of any regulatory and operational criteria required to enable the Lower Sundays River WUA to implement incentive based pricing. The action plans and time frame including the responsible authority are indicated in **Table 12.2** above. Although the Lower Sundays River WUA is indicated as the responsible authority, the DWA

will need to play a significant role to ensure that the structuring of the incentive based pricing is done within the framework of the water pricing strategy. The focus is in trying to reduce any over-irrigation and the current volume of on-farm irrigation water by implementing incentive based pricing.

Implementation of incentive based pricing requires a review and updating of any regulatory and operational criteria required to enable the Lower Sundays River WUA to implement incentive based pricing. The action plans and time frame including the following:

- (i) Review and update the regulatory aspects of incentive based water pricing structure by providing inputs into the updating of the water pricing strategy;
- (ii) Evaluate the average actual water use by irrigators as a percentage of their scheduled allocation. This can be done through a questionnaire and reviewing the historical records of irrigation demands;
- (iii) Determine the fixed operation and maintenance costs of the Lower Sundays River Irrigation Scheme and assess the revenue requirements for sustainable operation of the scheme;
- (iv) Establish the base price of irrigation water per unit of water based on the revenue requirements of the scheme to meet the O&M costs;
- (v) Determine the marginal costs per unit of water in excess of the base price and design one or more pricing levels above the base price;
- (vi) Establish that the operational and accounting aspects of water pricing are in place;
- (vii) Implement the incentive based water pricing structure for Lower Sundays River Irrigation Scheme.

Besides the additional revenue that the Lower Sundays River Irrigation Scheme may benefit from implementing incentive based pricing, the reduction in on-farm irrigation will help the scheme to:

- (i) Reduce erosion;
- (ii) Improve the crop yield and quality;
- (iii) Reduce fertiliser leaching; and
- (iv) Reduce drainage problems and downstream water quality problems.

As the DWA's water pricing strategy is currently under review and update, where amendments may be required to encourage incentive based pricing in the strategy, this should be considered.

## 12.4 Funding of the Lower Sundays River Irrigation Scheme WMP

### 12.4.1 General

All of the Water Conservation and Demand Management measures involve an initial capital investment requirement including the replacement costs over the useful life of the infrastructure. This is followed by on-going operations and maintenance which is required to ensure the installed infrastructure assets can provide the required performance for its intended use.

It has been proven in the analysis of the identified water use efficiency measures that implementation of these measures provides the most viable option at present to improving irrigation water use efficiency and reduce water losses in the Lower Sundays River Irrigation Scheme. This was done using the least cost planning approach where the average incremental costs (AIC) of each intervention measure were determined.

However the financing of the candidate measures should take into account the beneficiaries from water savings made during the implementation of the above identified measures. This is discussed in the following section.

### 12.4.2 Financing by Lower Sundays River WUA

The benefits in implementing monitoring the flows to irrigators will directly benefit the Lower Sundays River irrigators and ensure that they receive their allocation when required and on time. Therefore based on the fact that the beneficiaries are the irrigators in the Lower Sundays River Irrigation Scheme, the financing of the following aspects should be borne by Lower Sundays River;

- (i) Calibration of the flow measurement and replacement of inaccurate measurement structures
- (ii) Providing additional flow measurement and ensuring that the telemetry system is fully operational.
- (iii) Providing the full operation of the WAS programme to enable water accounting to be conducted as well as to fulfil the legal requirements in terms of the Act to provide annual reporting to the DWA on the irrigation water management for the scheme.

### 12.4.3 Financing by the DWA

The Darlington Dam supplying the Lower Sundays River Irrigation Scheme is owned by the Department of Water Affairs (DWA) who has an agreement with the Lower Sundays River WUA to operate and carry out management of the dam. However as the condition of some of

the infrastructure has deteriorated to the extent that it requires refurbishment, the cost of refurbishment is prohibitive and requires the DWA to provide the financing necessary to reduce the water losses due to the condition of the infrastructure.

It is therefore recommended that the DWA provide the funding necessary to reduce water losses for the following:

- (iv) Refurbishment of the canal infrastructure that is owned by the DWA
- (v) Refurbishment of the gates on the Darlington Dam to reduce the water leakage.
- (vi) Implementation of the incentive based pricing by Lower Sundays River WUA

## 13 CONCLUSIONS AND RECOMMENDATIONS

### 13.1 Conclusions

The following can be concluded from the assessment of the water supply/requirements conducted for the Lower Sundays River Irrigation Scheme area and can be summarised as follows:

- The Lower Sundays River Irrigation Scheme is situated in the Cacadu District Municipality. The scheme has a scheduled quota of 17 292.7 ha at an allocation of 9000 ha per annum. The total water allocation for Lower Sundays River WUA is 156 million m<sup>3</sup>/a.
- The main crops that are under irrigation include citrus.
- The Lower Sundays River Irrigation Scheme receives its raw water supplies from Darlington Dam from where irrigation water is released into the Sundays River before it is diverted at the Korhaans weir into the main canal to deliver irrigation water to the scheme.
- The Darlington Dam has a capacity of 187 million m<sup>3</sup>. Water is regularly released from the dam to supply Lower Sundays River Irrigation Scheme, as the Sundays River flow cannot meet the demands of the irrigators based on the weekly orders.
- The Lower Sundays River Irrigation Scheme has a total length of approximately 316 km of irrigation canal which supplies the irrigators as well as Nelson Mandela Metropolitan Municipal and other towns downstream of the irrigation scheme. The canals distribute irrigation and domestic water to approximately 932 sluice gates and Parshall flumes.
- Although no detailed condition assessment could be undertaken on the Lower Sundays River Irrigation Scheme, a preliminary assessment and discussion with scheme operator indicated that the Lower Sundays River canals are in a good to fair condition.
- In order to ensure that the irrigators receive their scheduled quota as and when required, the Lower Sundays River WUA operates the irrigation scheme based on “delivery on request” where each water user (irrigator) must submit a written request on a weekly basis and the water is delivered to some 932 abstraction points along the canal systems. These procedures are all formerly documented.
- The total irrigation water use in the Lower Sundays River for the past 12 calendar months of records was 107.1 million m<sup>3</sup>/a. The total water diverted within the Lower Sundays River Irrigation Scheme for the same period was 106.7 million m<sup>3</sup>/a.

- An irrigation water balance assessment conducted for Lower Sundays River Irrigation Scheme indicated that the water losses averaged -0.39% of the total water diverted. This is not possible as the scheme is not capable of generating water and the fact that additional water is required to deliver the water required because of the canal seepage losses and canal surface evaporation losses which are unavoidable.
- The total unavoidable water losses comprising evaporation losses and unavoidable seepage due to the age and condition of the infrastructure was determined to be 12.87 million m<sup>3</sup> of the total water diverted at the Korhaans weir. This figure is only for 12 calendar months of records and do not reflect the total water losses for the whole water year.
- The operational BMP to take into account the filling losses, the time to respond to changes in demand and metering errors was calculated based on WRC study estimated at 10% of the diversion. This was determined to be 10.67 million m<sup>3</sup> for the 12 calendar months of records.
- Based on the unavoidable water losses as well as the expected operational performance inefficiencies, the current water balance assessment cannot be used to determine the avoidable water losses. These avoidable losses are considered to be due to operational wastage and leakage and spills at canal tail ends which can potentially be avoided.
- The irrigation water balance assessment together with discussions with Lower Sundays River WUA operators highlighted that there were number of management issues which included the following:
  - (i) There are issues regarding the accuracy of the water measurements in the LSR irrigation scheme because the water balance cannot provide negative total losses. The accuracy of the water records at the Korhaans weir were found to be accurate based on comparing the DWA records and the LSRWUA weekly flow measurements at the weir
  - (ii) Although there are flow measurements, there are a number of measurements which are being read but are not included in the water balance. The most critical points to measure and monitor flows which are not being included are the changes in volume of the Scheepersvlakte balancing dam, the spills if any at the 2 canal tail ends. Because these critical points are currently not being measured, the integrity and validity of the WUEARs currently being submitted are questionable.
  - (iii) Although there may be measurements being taken at the sub-schemes the data is currently not available to conduct water balance assessment for each

sub-scheme. This would assist in identifying the priority canal system where water losses are high.

- (iv) The existing telemetry system is not fully operational to enable flow monitoring taking place. This is because of contractual issues which need to be resolved between the WUA and the contractor. This is affecting the full operation of the telemetry system at some of the critical points such as canal tail ends and secondary canals.
  - (v) Not all the modules of the WAS programme which was installed are being utilised to undertake water use accounting reports. The main one which is the water release module is currently not being used.
  - (vi) The WUA is currently not submitting water use efficiency and accounting reports to the DWA. This has resulted in the inconsistent structure of the WUA report compared to other irrigation schemes which are submitting reports
- Based on the above water management issues, a number of measures were identified to address the issues with the main management goal being to reduce the high water losses and improve irrigation water use efficiency in Lower Sundays River WUA. These measures were evaluated and prioritised based on the water savings and the average incremental cost (AIC) of implementing the measures.

## 13.2 Recommendations

### 13.2.1 Lower Sundays River Water Management Plan

Although the unavoidable water losses have been determined, it is not possible at this stage to determine the avoidable water losses in the Lower Sundays River Irrigation Scheme. This is because more water is being used than is currently being diverted at the Korhaans weir, which is not possible.

The WMP for Lower Sundays River Water User Association is therefore to undertake the following:

- (iv) *Accuracy of scheme water measurements* - The WUA must investigate the reasons why the 50% of the weekly records indicate that less water is diverted than is used in the scheme. This will include evaluating the accuracy of the water measurements in the scheme; incorporating the Scheepersvlakte balancing dam into the water balance; incorporating the water measurements if any at the canal tail ends.
- (v) *Water balance assessment at sub-scheme level* – According to discussions with the WUA these is sufficient information to conduct water balance assessments at sub-

- scheme level. The WUA must undertake water balance assessments for the four canals, namely the Kirkwood primary canal (this will enable DWA to assess the need for refurbishment where losses are found to be very high); the Wesbank secondary canal; the Mistkraal secondary canal; and the Tregerone/Selbourne secondary canal.
- (vi) *Ensure existing telemetry system* is fully operational – The WUA should engage with the contractor responsible for the installation of the telemetry to ensure that all contractual issues are resolved to enable full utilisation of the telemetry system.
  - (vii) *Full implementation of WAS programme* - This measure is aligned to the above measures and is considered to be important for implementation in the short term. The WUA must ensure that the WAS programme or a similar system which is compatible with the existing telemetry system is fully operational in order to generate water use efficiency accounting reports.
  - (viii) *Monthly reporting of water use efficiency* – The WUA must ensure that they submit monthly water use efficiency reports to the DWA in the format and standard prescribed by the Department and as discussed in this plan.
  - (ix) *Incentive based pricing* - This measure is considered a national issue which does not only affect the Lower Sundays River irrigation scheme. It is dependent on whether the irrigators would require changes to the current water pricing which are area based and the implications to revenue management by the irrigation scheme which may not be stable.

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