VIOOLSDRIFT-NOORDOEWER JOINT IRRIGATION AUTHORITY SCHEME

WATER MANAGEMENT PLAN

March 2014

Acknowledgements

MBB Consulting Engineers (South) would like to thank the chairman, secretary, water control officer and members of the JIA for their much appreciated input in compiling this report.

EXECUTIVE SUMMARY

Vioolsdrift and Noordoewer are small towns on opposite banks of the Lower Orange River (LOR), some 350 km from the river mouth. Vioolsdrift is in South Africa and Noordoewer in Namibia. The South African Government constructed a canal system serving the two settlements in 1933. The international Vioolsdrift and Noordoewer JIA is the only one of its kind on the Orange River.

The area is largely arid and experiences a harsh climate. The scheme lies along the South African and Namibian banks of the Orange River. The area is generally characterised by extensive mountains, hills and rock outcrops, and severely dissected terrain resulting from run-off rainwater.

The original farming land was planned and farmed below the canal water level. This was done to irrigate crops using flood irrigation. Lately, more and more land is being developed above the canal.

The scheme has an allocation of 883.7 ha with a quota of 15 000 m^3 per hectare from the river, which is equivalent to an annual volume of 13.256 Mm^3. A wide range of crops are cultivated on both sides of the Orange River, 283.2 hectares of the enlisted land are in Namibia, and the balance of 600.5 hectares is in South Africa. A double-cropping practice basically is followed for the cash crops (vegetable and fodder crops). The crop distribution per farm is shown in Table 2-2 and the locations of these properties are shown in Figure 2-9.

Under the recently-completed Phase 2 of GIZ support for the development of the ORASECOM Basin wide IWRM Plan, the issue of water conservation and water demand management in the irrigation sector was dealt with in some detail. One of the recommendations of the study included the implementation of demonstration projects to show farmers how the implementation of best practices can lead to the saving of water and improvement of yields. This recommendation has been followed through with the implementation of a UNDP-GEF-funded pilot demonstration project on the Lower Orange River in the JIA Irrigation Scheme. The project commenced in November 2011 with the identification of and implementation of 16 best management practices (BMPs) applicable in the JIA scheme over the next 24 months.

The main emphasis of these BMP's was on measurement (efficiencies, water, quality, climate and soil moisture) and transfer of information. An interactive website has also been developed for the JIA.

Water is a scarce commodity and it is important to calculate and report on how it has been supplied and consumed. A water balance summarises the annual volume of inflow, consumption and outflow from the geographical area. Due to the reasons described in the report, a water balance for the JIA scheme based on measurements could not be done. However, with the proper functioning of the systems implemented in the scheme during the next irrigation season, a water balance will be possible. Table 8-1 shows the scheme enlistment as well as the theoretical water balance.

In the absence of a formal water balance/budget, key issues with regard to the management of the scheme were identified for the purpose of this first Water Management Plan (WMP) of the JIA. The key issues are discussed and are summarised in Table 10-1.

The development of a WMP is a process with an annual cycle, which will assist the JIA in realising the economic and social benefits of improved water-use efficiency. Table 11.1 shows the action plan for this first WMP for the JIA.

Operating as it does as a cross-border irrigation scheme, it will be important to establish the appropriate legislation under which the JIA falls and the legal requirements in this regard. The WMP was compiled in terms of the guidelines developed by the South African Department of Water Affairs.

Much has already been done in the scheme to eliminate water losses. The UNOPS demonstration project contributed considerably to this, and offers opportunities on which future WC/DM initiatives by the JIA can be built.

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ABBREVIATIONS

AIC	Average incremental cost
BMP	Best management practice
DWA	Department of Water Affairs
DOA	Department of Agriculture
ET	Evapotranspiration
EWR	Environmental water requirements
GIS	Geographic information system
GWS	Government water scheme
IB	Irrigation Board
JIA	Joint Irrigation Authority
LOR	Lower Orange River
MAE	Mean annual evaporation
MAP	Mean annual precipitation
MISD	Matching irrigation supply and demand
O&M	Operation and maintenance
RAT	Remote assessment tool
RTU	Remote telemetry unit
SLA	Service-level agreement
WARMS	Water allocation registration management system
WAS	Water administration system
WCC	Water conservation coordinator
WCD	Water Control Department
WC/WDM	Water conservation and water demand management

WCO	Water control officer
WMA	Water management area
WMP	Water management plan
WUA	Water Users Association
WUAR	Water use accounting report

GLOSSARY OF TERMS

Application efficiency: The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percentage.

Applied water: Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries

Conduit: Any open or closed channel intended for the conveyance of water.

Conservation: Increasing the efficiency of energy use, water use, production or distribution.

Consumptive use (evapo-transpiration) Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow or intercepted precipitation. Also called crop requirement, crop irrigation requirement, and consumptive use requirement.

Conveyance loss: Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation and transpiration by plants growing in or near the channel.

Conveyance system efficiency: The ratio of the volume of water delivered to irrigators in proportion to the volume of water introduced into the conveyance system.

Cropping pattern: The acreage distribution of different crops in any one year in a given farm area, such as a county, water agency or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops, and/or by cropping existing crops.

Crop water requirement: Crop consumptive use plus the water required to provide the leaching requirements.

Crop irrigation requirement: Quantity of water, exclusive of effective precipitation, that is needed for crop production.

Crop root zone: The soil depth from which a mature crop extracts most of the water needed for evapotranspiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in mm or m. This soil depth may be considered as the rooting depth of a subsequent crop when accounting for soil moisture storage in efficiency calculations.

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

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

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

Distribution loss: See conveyance loss.

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

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

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

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

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

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

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, evapotranspiration.
Farm distribution system:	Ditches, pipelines and appurtenant structures that 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 that 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 water user association/Irrigation Board showing the sequence in which the irrigators will take water,; it is dependent on the scheduled area and the time period in which the irrigator is entitled to receive water
On-farm:	Activities (especially growing crops and applying irrigation water) that occur within the legal boundaries of private property.
On-farm irrigation efficiency:	The ratio of the volume of water used for consumptive purposes and leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).
Operational losses:	Losses at the tail ends, sluices not opened or closed on time or opened too big, and spills.
Operational waste:	Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.
Pan evaporation:	Evaporative water losses from a standardised pan. Pan evaporation is sometimes used to estimate crop evapotranspiration and to assist in irrigation scheduling.
Parshall flume:	A calibrated channel-like device, based on the principle of critical flow, which is used to measure the flow of water in open conduits. Formerly termed the improved Venturi flume.
Percolation:	Downward movement of water through the soil profile or other porous media.
Reservoir:	Body of water, such as a natural or constructed lake, in which water

	is collected and stored for use.
Return flow:	That portion of the water diverted from a stream that finds its way back to the stream channel, either as surface or underground flow.
Return-flow system:	A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse. Sometimes called a reuse system.
Run-off	This is the water produced when irrigation water is applied to fields at rates and in amounts greater than can be infiltrated into the soil profile.
Request form :	A form on which an irrigator requests the quantity of water he requires.
Tail-end water	This is water at the endpoint of a canal.
Telemetry	Involving a wireless means of data transfer.
Water note	A form issued by the Control Officer informing the irrigator of the quantity of water he will be receiving.

1 INTRODUCTION

South Africa is a semi-arid country in which water is a key strategic resource in the development of all sectors of the economy. The domestic, urban and industrial sectors of South Africa are expected to show the largest growth in water utilisation, which will be driven by population growth, urbanisation, and improvement in the quality of life, service provision and economic development. Based on these growth patterns, water usage is expected to double over the next 30 years, showing a growth of 3% per annum. It is predicted that the country will reach the limits of its economically usable, land-based water resources during the first half of this century. Limited water resources have prompted recognition of the importance and challenges of managing and conserving water resources. The Government has the responsibility for ensuring that water resources are protected, utilised, developed, conserved, managed and controlled in a manner that will be equitable, sustainable and beneficial to all. To this end, it promulgated the National Water Act (Act 36 of 1998), which covers all of these issues, and specifically the function of Water Conservation and Demand Management, the foundation of the Water Management Plan (WMP) process.

The primary objective of the WMP is to steadily improve the efficiency of water use over time, both within the Water Users Association/Irrigation Board (WUA/IB) delivery system, and on-farm. The implementation of WMPs will improve water-use efficiency in the agricultural sector. In order to achieve this objective, the following have to be addressed:

- Situation assessments
- Irrigation budget and baseline for the scheme
- Irrigation water management issues
- Opportunities to improve the water-use efficiency
- Setting irrigation-use efficiency targets
- Capacity building in the board of the scheme to implement practices to improve irrigation water-use efficiency

This WMP is the first for the Vioolsdrift-Noordoewer scheme, and therefore is lacking certain information. These gaps should be filled in future annual updates of the plan, while the correctness/validity of existing information also needs to be reviewed.

The successful implementation of the WMP should result in:

- Better irrigation efficiencies, i.e. reduced water use
- Reduced return flows
- Reduced operational cost at scheme and on-farm levels
- Reduced environmental impacts

The structure of the report is as follows:

Chapter 1 provides an overview of the project and the overall objective of compiling WDM plans.

Chapter 2 describes the region in general and the history of the scheme. It also provides information about the scheduled quotas and current land-use practices.

Chapter 3 gives the background to and status of a demonstration project currently being implemented and monitored in the scheme.

Chapter 4 describes the distribution infrastructure of the scheme.

Chapter 5 provides information about best practices (BMPs) implemented in the scheme

Chapter 6 provides a condition assessment of the infrastructure of the scheme.

Chapter 7 describes the scheme operation and operating procedures, followed by a description of the scheme management.

Chapter 8 describes the water balance assessment for the scheme.

Chapter 9 provides information about the existing Water Conservation and Demand Management (WC/WDM) initiatives already implemented in the scheme.

Chapter 10 describes the water management issues faced by the board and their goals in this regard.

Chapter 11 describes the Water Management Plan (WMP) for the scheme

Chapter 12 describes the conclusions and recommendations with regard to the implementation of the WMP for the scheme.

2 BASELINE INFORMATION

The baseline information that appears in this chapter firstly serves to provide a brief history and the existing status of the Vioolsdrift-Noordoewer Joint Irrigation Authority (JIA) scheme, and secondly it provides a basis for planning and implementing improvements in the future.

2.1 Overview

The Orange-Senqu is the only river in southern Africa that arises in cool temperate and alpine regions, but that flows through progressively more arid terrain and ultimately through hyper-arid desert. This extreme range of climatic conditions has resulted in a wide variety of crop types being grown throughout the catchment under irrigation. In the more temperate north-eastern sections of the catchment, rain-fed crop production occurs widely and is interspersed with irrigated cropping. Moving westwards, crop production becomes more dependent on irrigation, to the point where rainfall is too low or too unreliable and only irrigated crop production takes place. In the more temperate north-western sectors, mixed cropping with field crops and fodder crops predominates.

The main field crops are maize, wheat, potato, groundnut, cotton, soybean and dry-bean, while the main fodder crops are lucerne, maize-silage and pastures. Limited areas of orchard crops, such as cherry, apple and peaches, are grown in the high-altitude areas with adequate winter chill. In the drier western areas, permanent orchard and vine crops like table grapes, raisin grapes, wine grapes, citrus and dates predominate. Lucerne is also a popular crop in the drier western areas.

The great majority of irrigation in the basin takes place in South Africa. However, in recent years there has been rapid growth in irrigation on the Namibian side of the river, especially for growing high-value crops such as table grapes.

The location of the JIA scheme is shown in Figure 2-1.

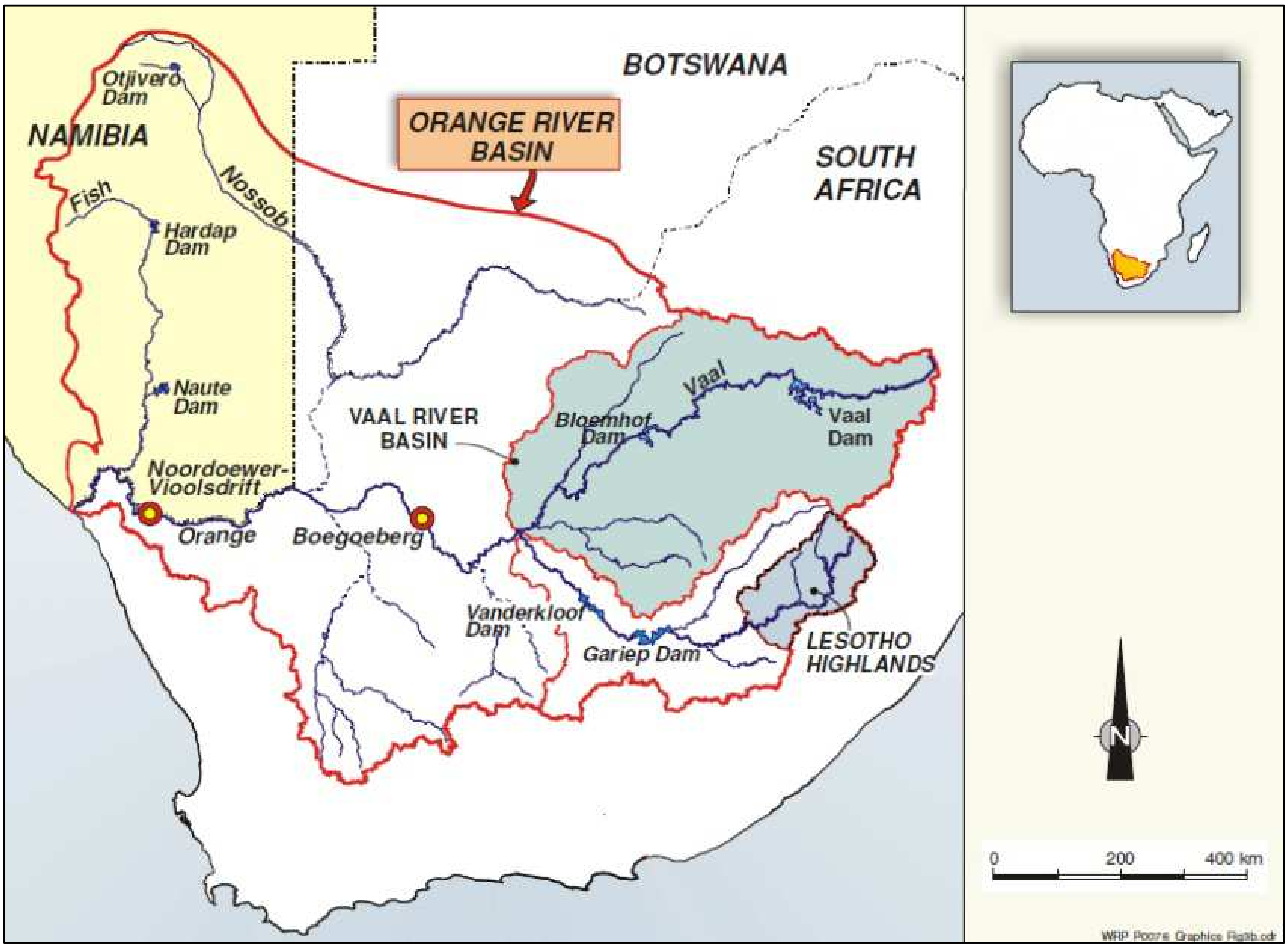


Figure 2-1 Location of JIA scheme

2.1.1 Climate and rainfall distribution

The area is largely arid and experiences a harsh climate. According to the Köppen Climate Map it lies in a region with a hot and dry climate. It has a mean annual rainfall of less than 60 mm, with an ET0 of 1 570 mm. It falls within the D82G Quaternary.

A relatively cool season prevails from May to August, with mean monthly minimum temperatures of below 10°C during which frost could occur on some days. A very hot season occurs from November to February, when mean monthly maximum temperatures rise to 38°C, but absolute daily maximum temperatures can rise up to 47°C.

A transitional thermal regime prevails in the months of September and October, before the summer, and in the months of March and April, before the winter period. This thermal regime is viewed as a valuable climatic resource for crop production where irrigation water is available to permit year-round cropping.

Figure 2-2 and Figure 2-3 show the average climatic characteristics of the region.

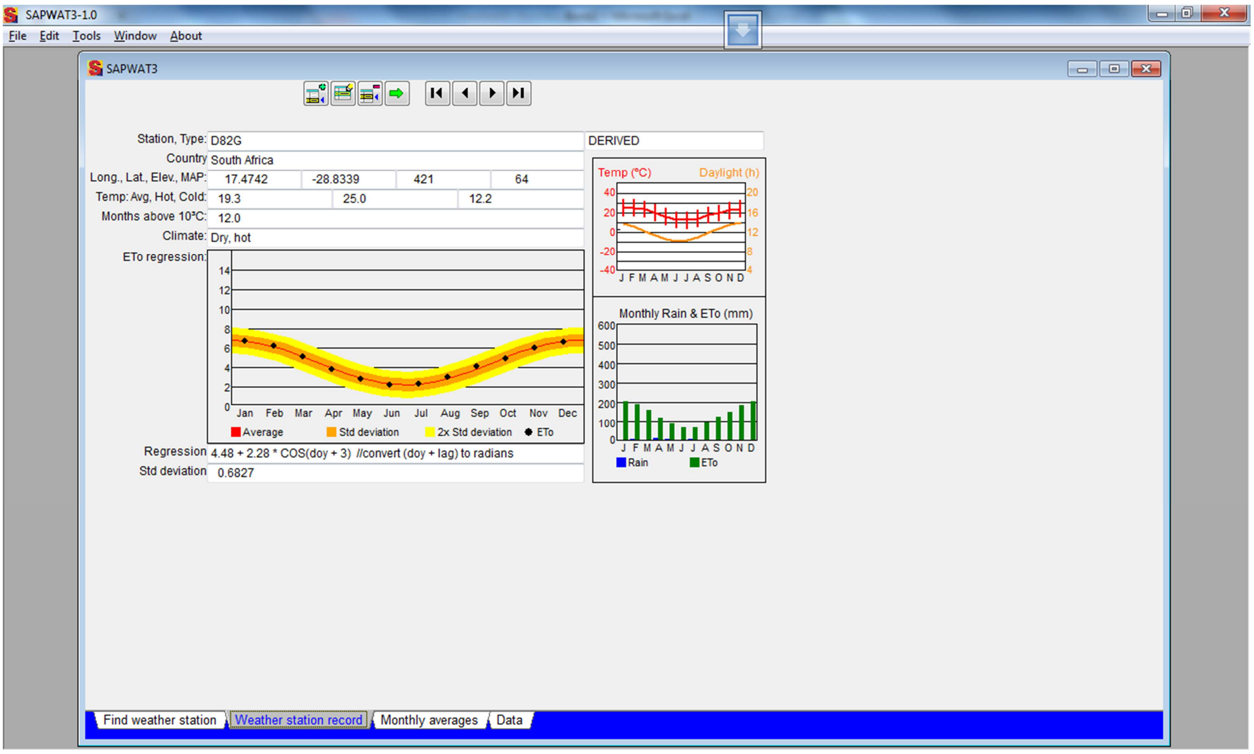
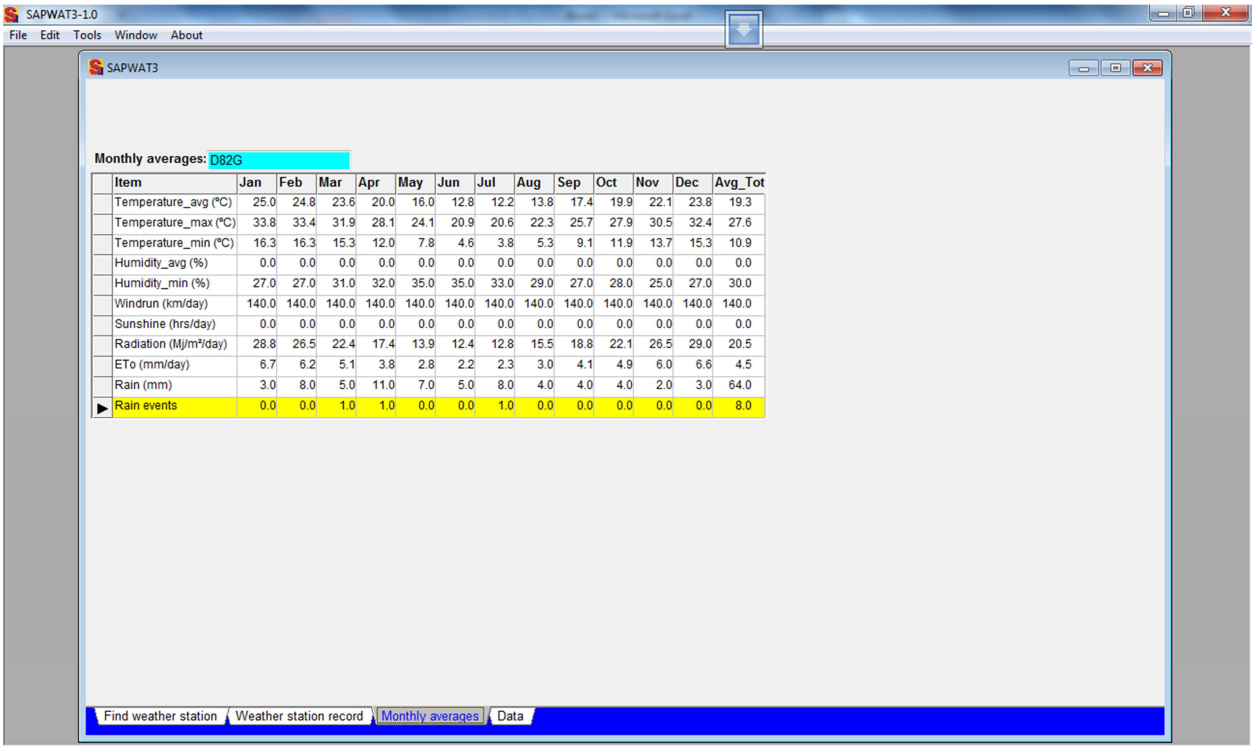


Figure 2-2 ET0, rainfall and temperature distribution for the region



Monthly averages: D82G

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg_Tot
Temperature_avg (°C)	25.0	24.8	23.6	20.0	16.0	12.8	12.2	13.8	17.4	19.9	22.1	23.8	19.3
Temperature_max (°C)	33.8	33.4	31.9	28.1	24.1	20.9	20.6	22.3	25.7	27.9	30.5	32.4	27.6
Temperature_min (°C)	16.3	16.3	15.3	12.0	7.8	4.6	3.8	5.3	9.1	11.9	13.7	15.3	10.9
Humidity_avg (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Humidity_min (%)	27.0	27.0	31.0	32.0	35.0	35.0	33.0	29.0	27.0	28.0	25.0	27.0	30.0
Windrun (km/day)	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
Sunshine (hrs/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Radiation (Mj/m²/day)	28.8	26.5	22.4	17.4	13.9	12.4	12.8	15.5	18.8	22.1	26.5	29.0	20.5
ETo (mm/day)	6.7	6.2	5.1	3.8	2.8	2.2	2.3	3.0	4.1	4.9	6.0	6.6	4.5
Rain (mm)	3.0	8.0	5.0	11.0	7.0	5.0	8.0	4.0	4.0	4.0	2.0	3.0	64.0
Rain events	0.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	8.0

Figure 2-3 General climatic information for the region

2.1.2 Geology and soils within scheme boundaries

The scheme lies along the South African and Namibian banks of the Orange River. The area is generally characterised by extensive mountains, hills and rock outcrops, and severely dissected terrain resulting from run-off rainwater.

In some parts, hills and/or mountains separate the plain from the river. Nonetheless, there also are some relatively flat or gently sloping areas in scattered locations. The soils are covered with gravel and stones on the surface, as well as within the calcareous soil profiles. These soils have high pH values, high sand content, low fertility, low moisture-holding capacity and high infiltration rates, and are subject to wind erosion.

The vegetation is classified as Desert and Succulent Steppe. Vegetation is very sparse and is mostly limited to depressions and watercourses where run-off water collects. The dominant species are xerophytes, which have a very high degree of drought tolerance. The vegetation intensity is so low that it has practically no potential for domestic animal grazing. The Orange River banks support a riverine forest vegetation composed mainly of *Tamarix usneoides* (tamarisk) and *Euclea pseudebenus* (false ebony). A number of aquatic plants thrive in the river.

The original farming land was planned and farmed below the canal water level. This was done to irrigate crops using flood irrigation. Lately, more and more land is being developed above the canal.

2.2 History of the Vioolsdrift-Noordoewer JIA scheme

Vioolsdrift and Noordoewer are small towns on opposite banks of the Lower Orange River (LOR), some 350 km from the river mouth. Vioolsdrift is in South Africa and Noordoewer in Namibia. The South African Government constructed a canal system serving the two settlements in 1933. The canal is fed from a weir upstream of the river crossing. The canal infrastructure has supported agriculture on the southern and northern banks of the LOR for some 70 years.

Between 1933 and the independence of Namibia in 1990, the Vioolsdrift/Noordoewer Irrigation Scheme was under South African jurisdiction. An Irrigation Board was responsible for the local management of the scheme, with support from the South African Department of Water Affairs.

At Namibian independence, an international boundary was established along the LOR, and a border post was constructed between the two towns. This development required new management arrangements for the irrigation scheme. A Joint Irrigation Authority (JIA) was established at the end of 1993, based on an agreement between the governments of Namibia and South Africa.

The Agreement establishing the Vioolsdrift and Noordoewer JIA was signed in 1992. The JIA Board was established in 1993, in terms of Article 6 of the Agreement.

The international Vioolsdrift and Noordoewer JIA is the only one of its kind on the Orange River, and is perhaps a pioneer for further cooperative ventures of this kind. Under the establishment agreement, the JIA has a limited brief. Its key function is to manage and control water supply to the farmers through the irrigation scheme. Representation on the JIA Board and in the JIA itself reflects the restricted brief. The members of the JIA are land-owning irrigators. The Board comprises land-owning representatives of the two farming communities, and representatives of the South African Department of Water Affairs and the Namibian Department of Agriculture (DOA).

2.3 Water-use permits / licenses and contracts

The South African National Water Act (NWA) (Act 36 of 1998), which came into effect in 1998, required that irrigation boards were be transformed into Water User Associations (WUA). Under this policy, all lawful scheduling in terms of Sections 63 and 88 of the Water Act (1956) on Government and Irrigation Board schemes, which had been paid for annually before 1 January 1999, was declared as existing lawful use in terms of Section 33 of the NWA. This also included unexercised water uses that had been paid for.

Since this scheme is located in both countries (each with its own legislation), transformation of the old irrigation board is more complicated, thus the formation of the JIA. The further transformation of the scheme structure still needs to be worked out by the relevant ministries of the two countries.

2.4 Irrigated areas, crops and irrigation systems

The Orange River is the source of water for the JIA irrigation scheme. The water releases from the large dams in the river are managed by the DWA. The scheme has an allocation of 883.7 ha with a quota of 15 000 m^3 per hectare from the river, which is equivalent to an annual volume of 13.256 Mm^3.

A wide range of crops are cultivated on both sides of the Orange River, 283.2 hectares of the enlisted land are in Namibia, and the balance of 600.5 hectares is in South Africa.

Some farms in the scheme have pumps on the river from where the farm, or part thereof, is irrigated. The area irrigated in this way that forms part of the total enlistment of the scheme. Figure 2-4 shows the location of irrigated lands, distinguishing between irrigation from the canals and irrigation directly from the river.

Information on the existing development (2013) was obtained from questionnaires and aerial photography, as well as through personal interviews. Figure 2-5 shows the crop distribution on an aerial photograph, while the aerial photograph in Figure 2-6 shows the location of the different irrigation system types in the scheme. This information is summarised in Table 2-1. A double-cropping practice basically is followed for the cash crops (vegetable and fodder crops). The information is shown graphically in Figure 2-7 and Figure 2-8.

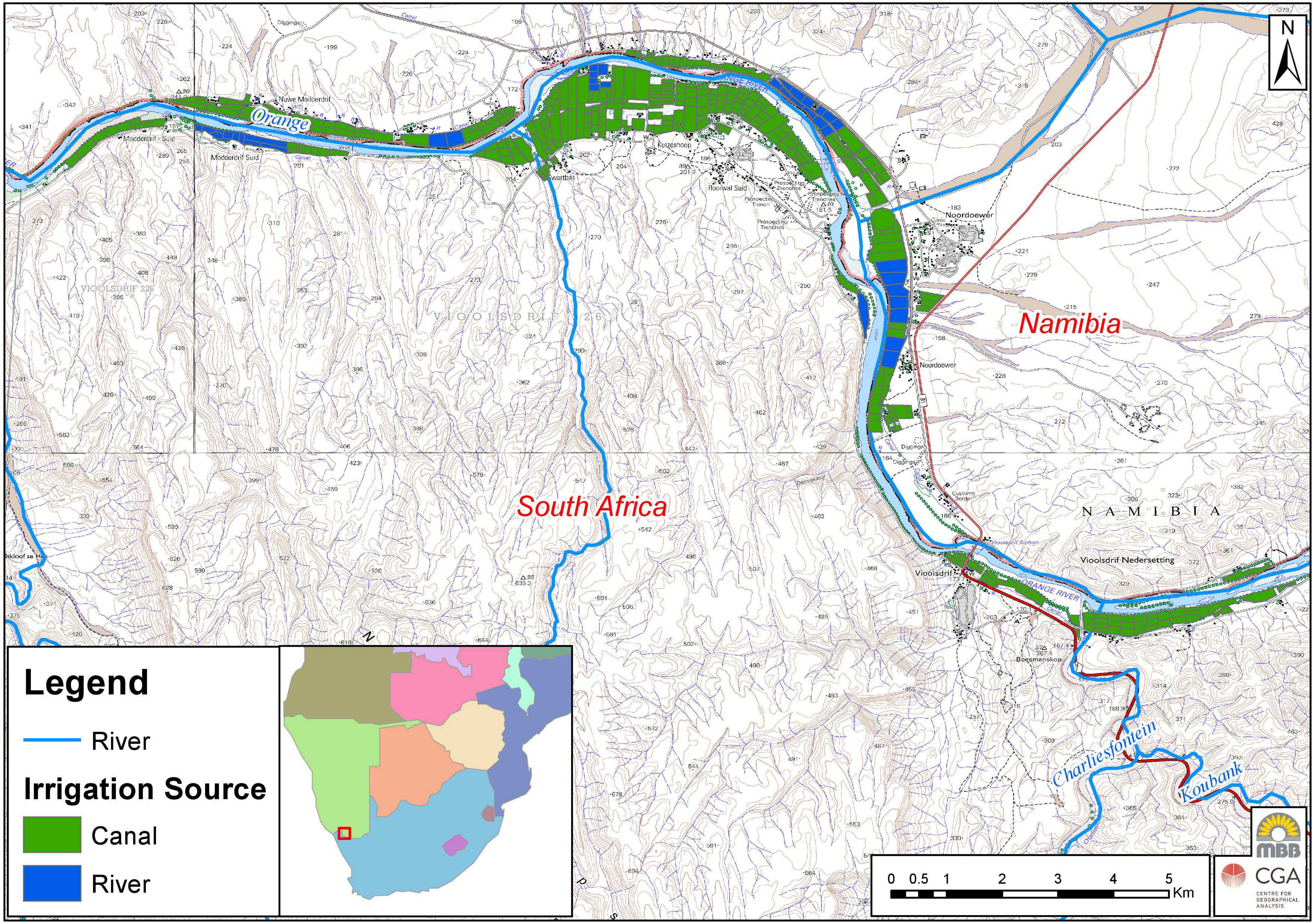


Figure 2-4 Irrigated land in JIA scheme – Irrigation from canal vs. irrigation directly from river

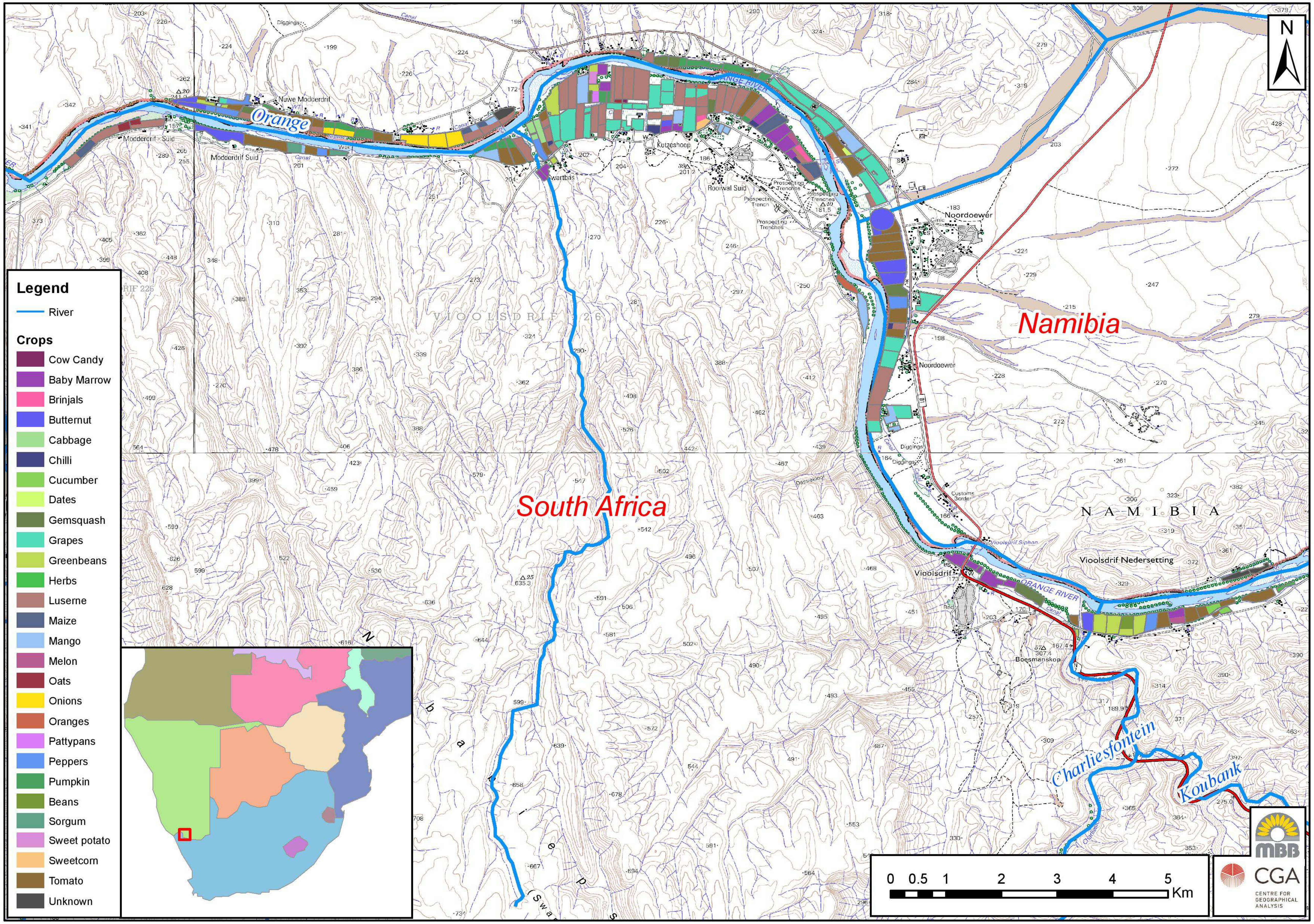


Figure 2-5 Crop distribution in JIA scheme

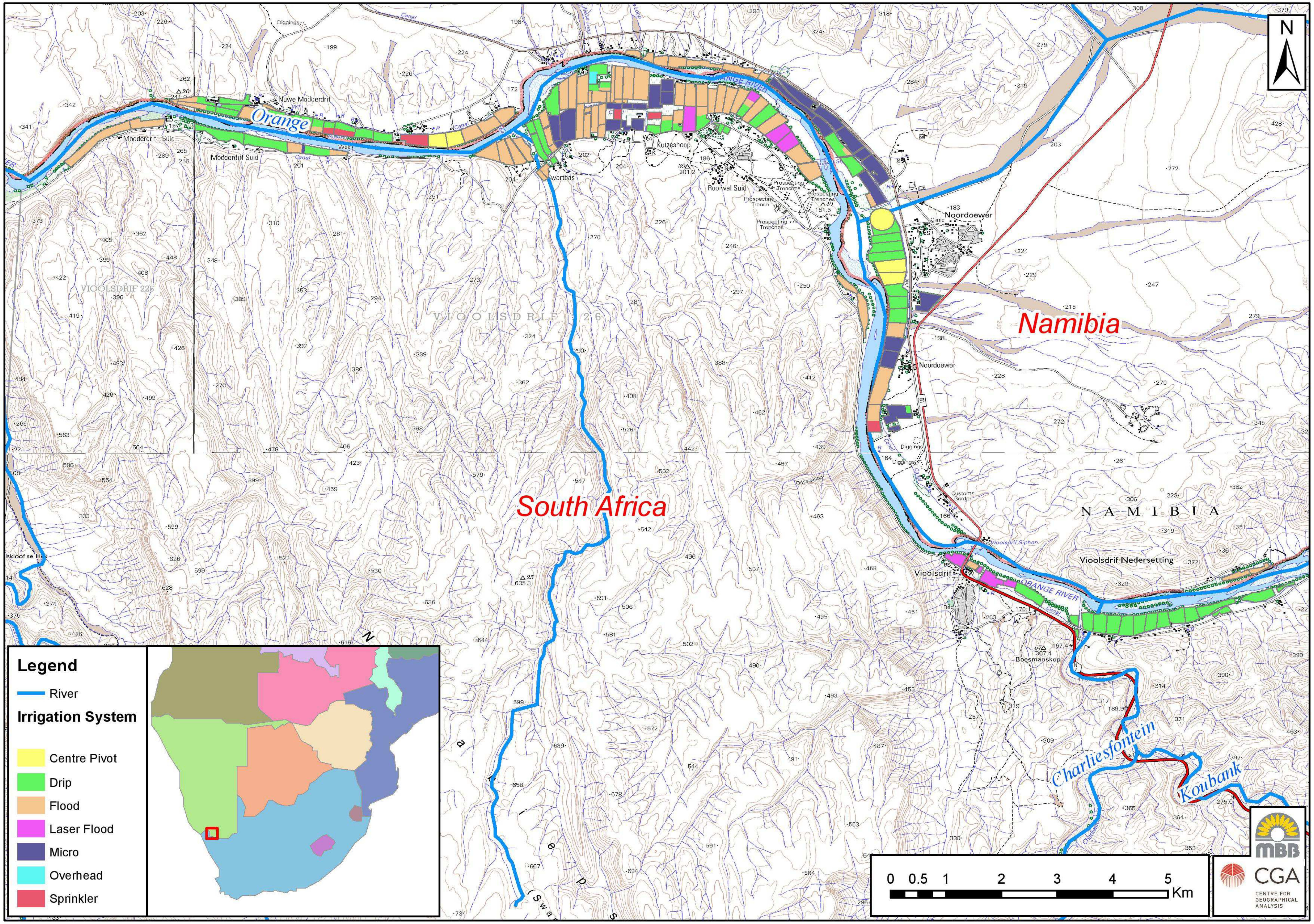


Figure 2-6 Irrigation system distribution in JIA scheme

Table 2-1 Crops irrigated in JIA scheme

Crop	Hectare Planted 2013						
	TOTAL	Flood	Laser Flood	Pivot	Sprinkler	Micro	Drip
Baby Marrow	56.47	8.86	28.05				19.56
Brinjals	4.96	3.36					1.60
Butternut	60.81	9.55		30.89			20.37
Cabbage	8.26						8.26
Chilli	7.21	2.59					4.62
Cow Candy	0.64	0.64					
Cucumber	4.51						4.51
Dates	1.34	1.34					
Gemsquash	31.61	16.44					15.17
Grapes	166.96	10.95	8.87		4.15	140.73	2.27
Greenbeans	40.39						40.39
Herbs	1.48						1.48
Luserne	209.38	204.36			5.02		
Maize	22.39	22.39					
Mango	49.91	30.50				16.18	3.23
Melon	5.08		2.24				2.85
Oats/Sorgum	5.49	5.49					
Oats/Sorgum	6.60	6.60					
Onions	26.82			13.69	13.13		
Oranges	5.81	5.81					
Pattypans	2.31	2.31					
Peppers	27.89						27.89
Pumpkin	36.62	26.58					10.04
Beans	4.67						4.67
Sweet potato	3.00				3.00		
Sweetcorn	2.82						2.82
Tomato	140.55	18.56	2.69				119.30
Unknown	10.69	10.69					
Total	944.69	387.02	41.84	44.58	25.30	156.91	289.03

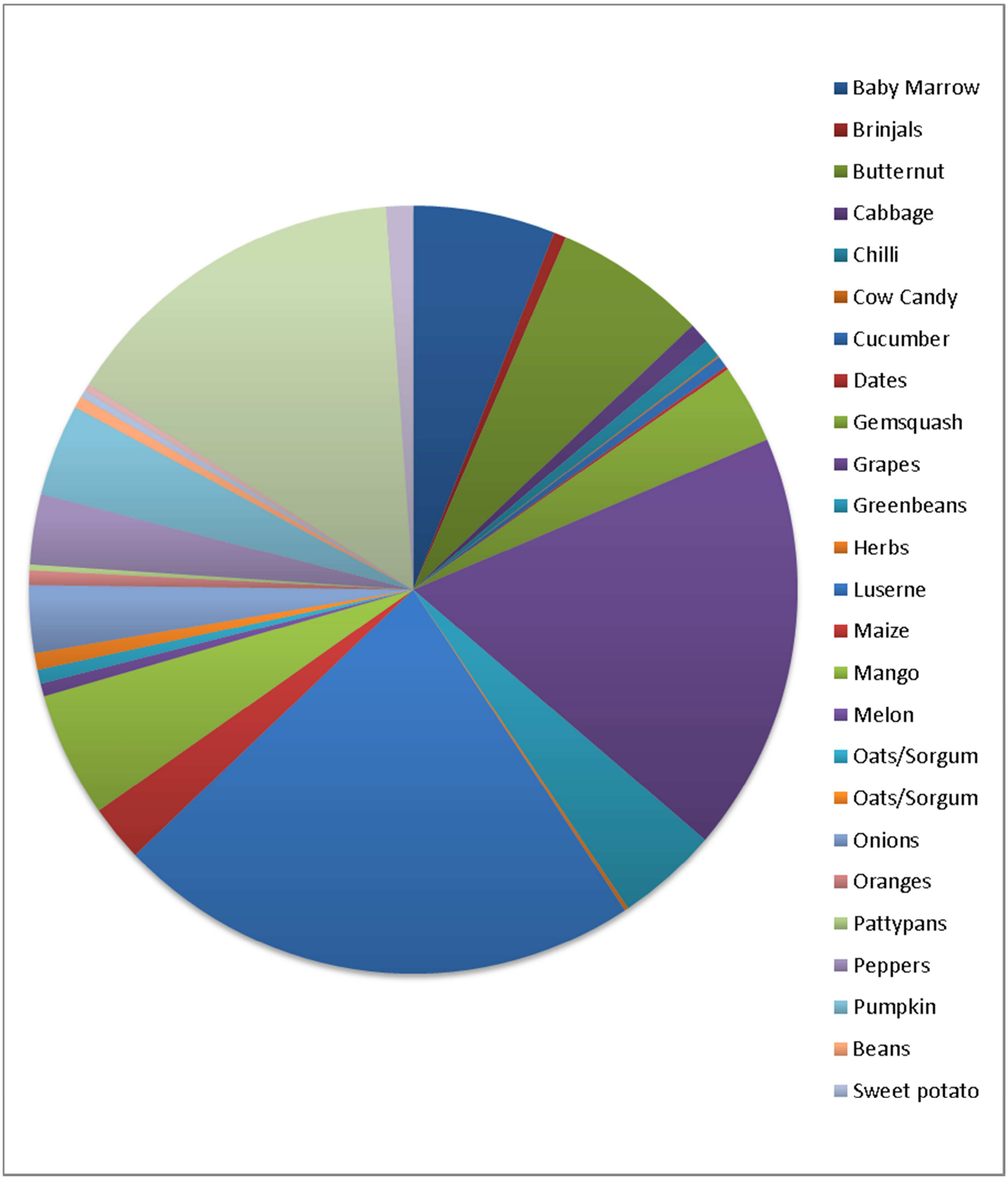


Figure 2-7 Crop distribution (area) in JIA scheme

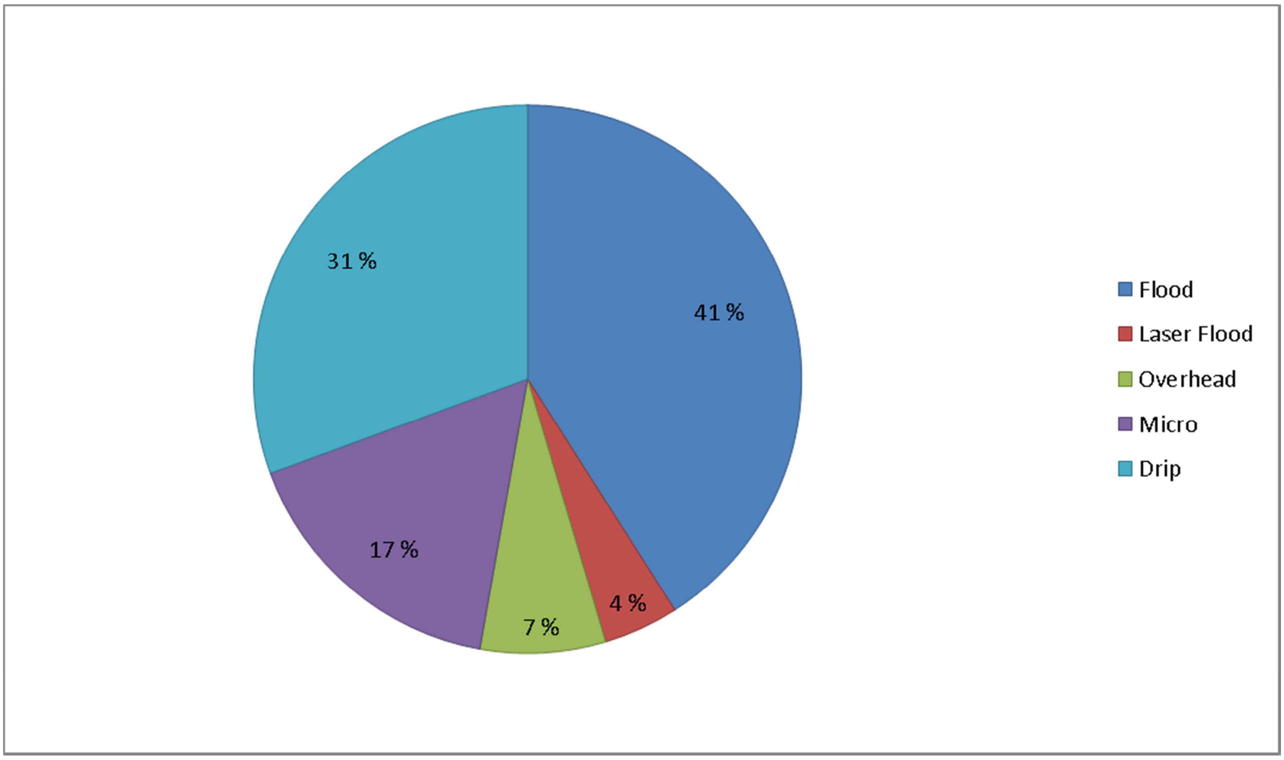


Figure 2-8 Different irrigation systems in JIA scheme (based on hectares)

The crop distribution per farm under the JIA scheme is shown in Table 2-2. The locations of these properties (per farmer) are shown on the aerial photograph in Figure 2-9. The locations of farm off-takes are also shown.

Table 2-2 Crops (2012) per farm under the JIA scheme (To be updated)

Owner/ Tenant	Plot	Source	Luserne	Mangos	Citrus	Vineyards	Dates	Cash Crops	TOTAL
Willem vd Westhuizen	69, 68	Orange River	0	0	0	0	0	14	**14**
Sarel Beets	150, 161	Orange River	0	0	0	0	0	8	**8**
N van der Merwe	186, 188, 204, 386, 206, 429, 237, 233, 231, 229, 227, 225, 239	Orange River	0	0	0	45.3	0	49.5	**94.8**
Win Christopher	294	Orange River	0	0	0	0	0	10.8	**10.8**
Albert May	3, 4, 12, 13	Vioolsdrift Canal	0	0	0	0	0	33.2	**33.2**
Hansie Jansen	5, 6, 7, 8, 9, 10, 11, 176, 296, 155	Vioolsdrift Canal	0	0	0	0	0	50.8	**50.8**
Willem vd Westhuizen	1, 2, 152, 163	Vioolsdrift Canal	0	0	0	0	0	18.4	**18.4**
Abe Olivier	235, 216, 214, 212, 332, 210	Noordoewer Canal	4	0	0	20.17	0	28	**52.17**
N van der Merwe	220, 437	Noordoewer Canal	0	0	0	8.5	0	7	**15.5**
Johan Van der Hoven	218, 222	Noordoewer Canal	0	0	0	0	0	13.2	**13.2**
Danie Mostert	241	Noordoewer Canal	12.5	0	0	0	0	0	**12.5**
Rudolf (Puma Garage)	243, 244	Noordoewer Canal	3.7	7	0	9.2	0	0	**19.9**
Hansie Jansen	17, 18	Rooiwal Canal	0	0	0	0	0	16	**16**
CH Sutherland	21, 23, 24, 25	Rooiwal Canal	0	0	0	0	0	24.16	**24.16**
Herrick Mulder	16, 20, 22, 165, 258	Rooiwal Canal	25.7	0.6	0	0	0	1.5	**27.8**
N van der Heever	119	Rooiwal Canal	0	0.5	0	0	0	0	**0.5**
Sarel Beets	15, 19	Rooiwal Canal	0	0	0	0	0	0	**0**
Win Christopher	26	Rooiwal Canal	3.9	0	0	0	0	2	**5.9**
AP vd Heever	30	Swartbas Canal	0	0	0	10	0	0	**10**
Thys en Bertu Meyer	50, 60, 64, 65, 66, 217, 168	Swartbas Canal	0	4.5	0	6	0	29.5	**10**
Wessel van Niekerk	58, 54, 56	Swartbas Canal	0	0	0	15	0	0	**15**
CH Sutherland	209, 59, 34, 32, 28	Swartbas Canal	7.9	3.5	0	0	0	13.22	**24.62**
Sarel Beets	52	Swartbas Canal	0	0	0	0	0	0	**0**
Eugene Coetzee	46, 231, 63	Swartbas Canal	13	0	0	0	0	0	**13**
Arno Fourie	164, 267, 191	Swartbas Canal	0	3	0	0	0	0	**3**
Johan Weyers	48	Swartbas Canal	3.3	0	0	0	0	3.2	**6.5**
N van der Merwe	180, 182, 184	Modderdrif Main Canal	0	0	0	0	0	15.1	**15.1**
Peter Brand	190, 192, 194	Modderdrif Main Canal	10	1	0	0	0	7	**18**
Eric Hahnel	157, 177	Modderdrif South Canal	13.5	0	0	0	0	2.8	**16.3**
Jacque le Roux	67	Modderdrif South Canal	0	0.5	0	0	0	7	**7.5**
JP (Japie) Maree	322, 324	Bennie vd Hoven Canal	0	0	0	0	0	0	**0**
Abe Olivier	314, 196, 200, 202, 208, 430, 431	Duifieloop Canal	0	8	0	3	1	23	**35**
Danie Mostert	198, 355	Duifieloop Canal	4.5	0	0	0	0	5.5	**10**
CH Sutherland	59	Duin Canal	1.8	0	0	0	0	2	**3.8**
Dirk Olivier	31	Duin Canal	5.5	0	0	0	0	0	**5.5**
Japie Claasens	224, 39, 223, 53, 55, 41, 289, 37	Duin Canal	0	0	0	0	0	56.2	**56.2**
Leon Viljoen	33, 290, 35, 36, 38, 225, 40, 42, 44	Duin Canal	3.2	0	0	32.55	0	0	**35.75**
Sarel Beets	295	Duin Canal	0	0.5	0	0	0	0	**0.5**
Thys en Bertu Meyer	57	Duin Canal	0	0	0	0	0	7	**7**
Win Christopher	27, 29, 43, 294, 49	Duin Canal	10	0	1	4	0	7	**22**
Abe Olivier	393, 394, 395, 161, 163	Modderdrif North Canal	0	0	0	1	0	19.5	**20.5**
N van der Merwe	165, 167, 417, 169, 171, 174, 176, 178	Modderdrif North Canal	10	0	0	0	0	25.35	**35.35**
Total			**132.5**	**29.1**	**1**	**154.72**	**1**	**499.93**	**788.25**

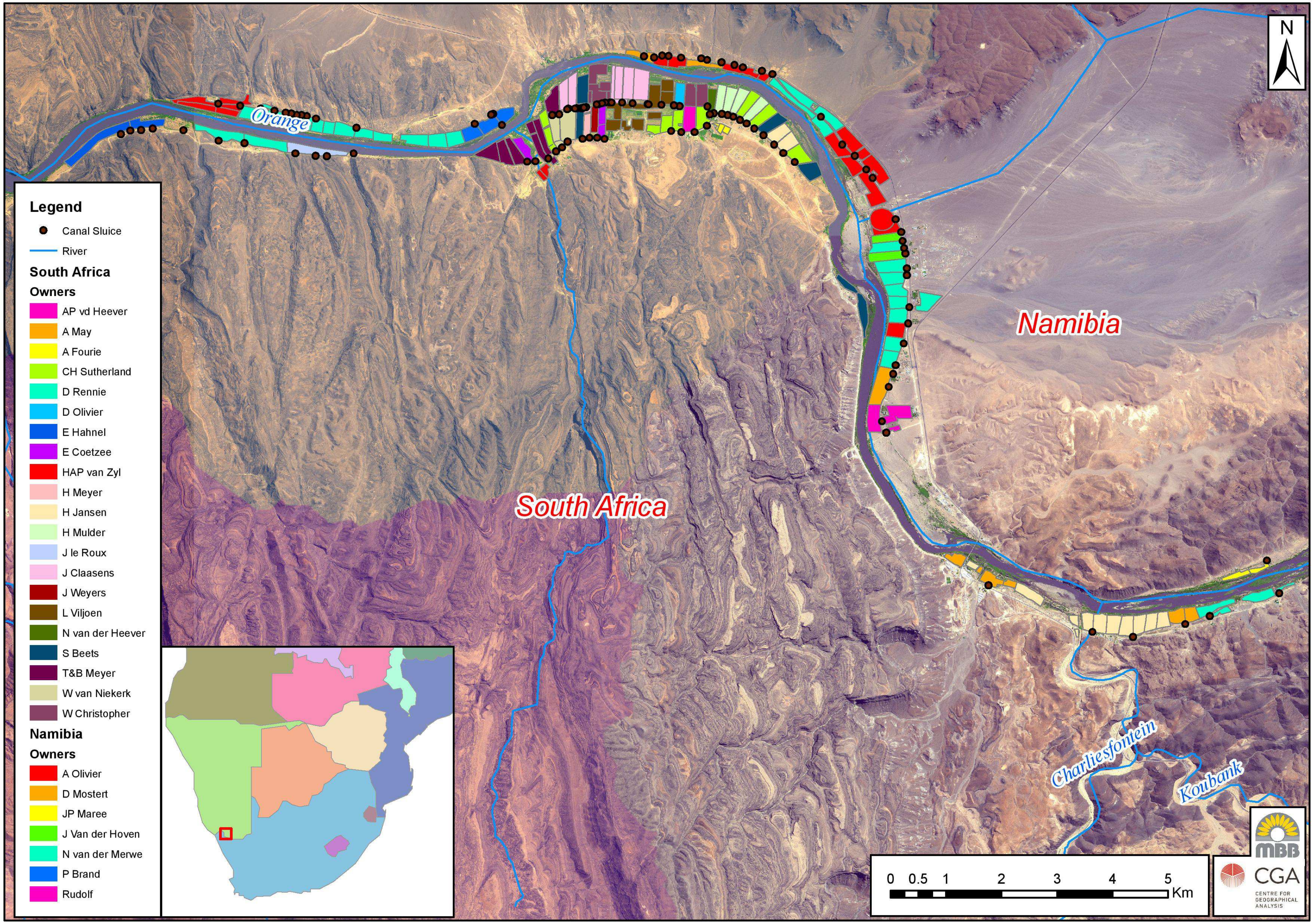


Figure 2-9 Vioolsdrift and Noordoewer farms (irrigated lands)

3 IMPLEMENTATION OF A DEMONSTRATION PROJECT AT THE JIA SCHEME

3.1.1 Water demand management in the irrigation sector

In addition to being the largest user of water in the basin, the irrigation sector is often accused of being the biggest waster of water. This perception is a result of the use of old technology, both in conveying and distributing water, and in the use of less than desirable management practices (UNOPS, 2011). Many of the irrigation areas, especially along the Lower Orange River, were developed in or even before the 1950s, 1960s and 1970s, and with the specific aim of 'job creation' during periods of low economic activity. The preferred conveyance and irrigation systems during this time of plentiful water were open earth canals and flood irrigation. Many of the canals have since been lined and, although many farmers are converting to more efficient irrigation systems, flood irrigation still predominates.

Under the recently-completed Phase 2 of GIZ support for the development of the ORASECOM Basinwide IWRM Plan, the issue of water conservation and water demand management in the irrigation sector was dealt with in some detail. The report, "The Promotion of Water Conservation and Water Demand Management in the Irrigation Sector" (WRP, 2011a), investigated the current extent of irrigated agriculture in the Basin, assessed current irrigation practices in the Basin, and then investigated best management practices both in theory and on the ground. The recommendations of the study included several practical ways in which WCDM can be improved through the implementation of best management practices. One of these is the implementation of demonstration projects to show farmers how the implementation of best practices can lead to the saving of water and improvement of yields.

The demonstration sites should include both irrigation water-supply institutions (supplier sites) and individual irrigators (irrigator sites). The chosen **supplier sites** should represent the main types of water distribution and water management systems in the catchment, and should include specific aspects of best practice that can provide an example for other water supply authorities and can provide benchmarks for the various elements of best practice.

The chosen **irrigator sites** should represent the main irrigation systems being used, the main crops being grown in the catchment and the main irrigation management and scheduling systems being practised. The irrigator sites should also demonstrate specific aspects of best practice that can provide an example to other irrigators, and can provide benchmarks for the various elements of best practice.

Key parameters to be included in the monitoring and evaluation of best management practices (BMPs) are:

- Volume of irrigation applied versus yield obtained (effective rainfall to be included)
- Volume lost as a result of irrigation practices
- Efficiency of scheduling
- System efficiency

This recommendation has been followed through with the implementation of a UNDP-GEF-funded pilot demonstration project on the Lower Orange River in the JIA Irrigation Scheme.

3.1.2 The demonstration project at the JIA scheme in Vioolsdrift and Noordoewer

The project commenced in November 2011. Best management practices (BMPs) identified to be applicable in the JIA scheme were:

- Soil moisture measurement – probes
- Climate measurement – automatic weather stations
- Irrigation system efficiency measurement – field tests
- Canal flow measurement – ultrasonic meter
- Pump flow and electricity measurement – electronic water meters
- Farmer off-take measurement – pressure censors
- Irrigation block and pivot flow measurement – pressure censors
- Water quality measurement – handheld instruments
- Geographical information system (GIS) of JIA scheme – Arc Info Software
- Improved canal management – Water Administration Software (WAS)
- Laser flood systems – field tests
- Subsurface drip – still to be demonstrated
- Production with mulching and cover protection – existing
- Training – different experts
- Visits to other schemes – different schemes in South Africa and Namibia
- Water Management Plan – this document

In the following chapters, more information is given on the BMPs that were implemented.

4 EXISTING INFRASTRUCTURE

4.1 Distribution network

The JIA irrigation scheme comprises a weir in the Orange River that diverts water into main and sub-canals linked with siphons through the river, delivering the water to the farms through a number of sluice gates. There are also a number of pumps that augment water from the river into the canal system. The layout of the scheme is shown in Figure 4-1.

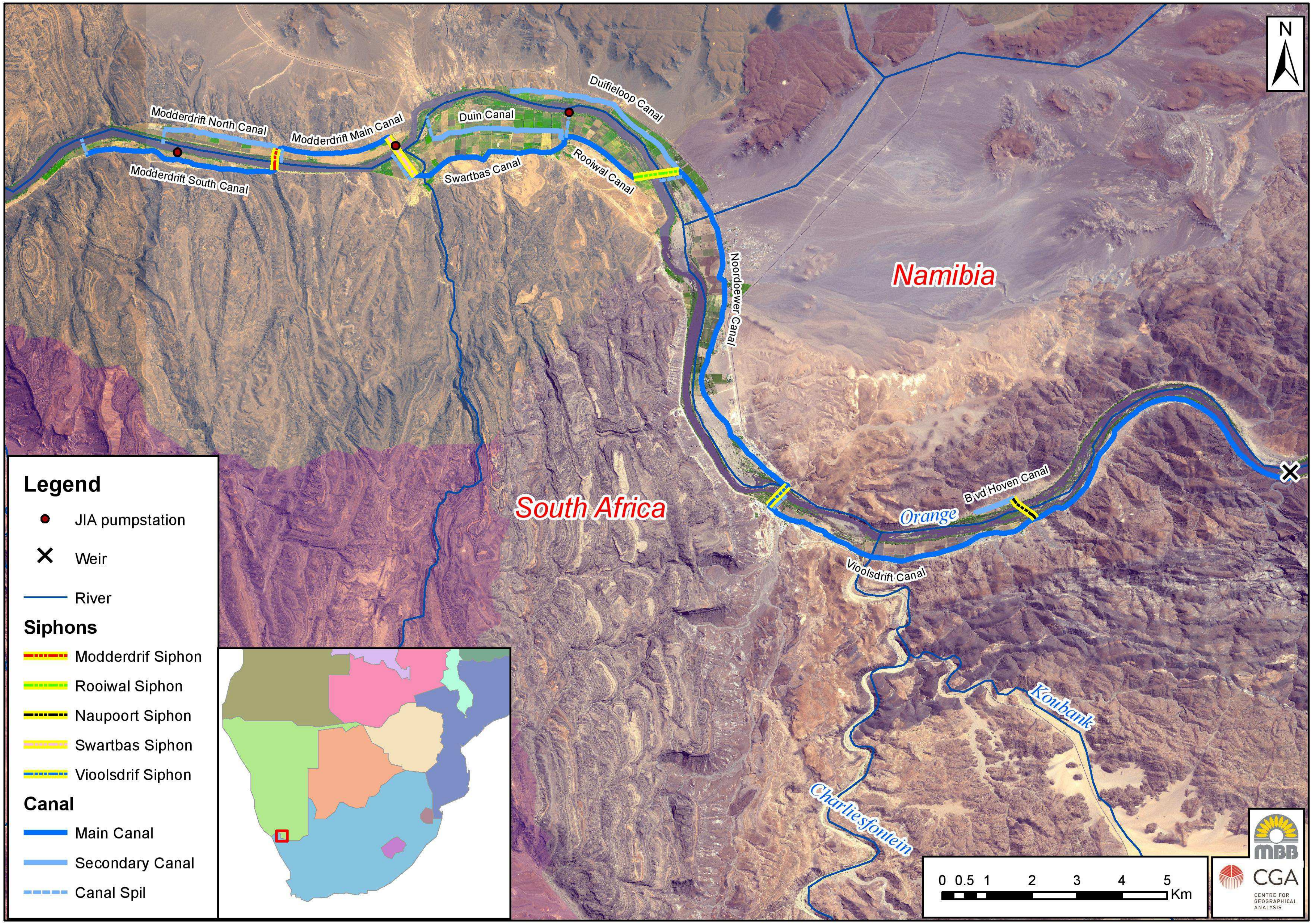


Figure 4-1 JIA irrigation supply system

The system comprises 42 km of canals of different shapes and sizes. The scheme starts with the Vioolsdrift canal on the South African side at a weir in the Orange River, approximately 13 km upstream of the N7 road bridge across the river. The Naupoort siphon is used to transfer water across the border into the Bennie vd Hoven branch canal, which runs for a distance of 1.5 km on the Namibian side.

The main canal crosses the river at the bridge with the Vioolsdrift siphon, and from there it remains on the Namibian side for 7.9 km (Noordoewer canal).

Where the Noordoewer canal ends, part of the flow continues on the Namibian side as the Duifieloop canal (4 km), while the balance of the water is discharged into the Rooiwal siphon. This siphon then transfers the water across the border, back into the Rooiwal canal in South Africa. The length of this canal is 1.7 km before it divides into two canals – the Swartbas- and the Duin. The latter is a branch canal, while the Swartbas discharges its water into the Swartbas siphon, which then crosses the river into Namibia. The lengths of the Swartbas and Duin canals are 3.7 km and 2.5 km respectively.

At the bifurcation of the Swartbas and Duin canals, the Swartbas pump station discharges its water into the system.

Downstream of the Swartbas siphon (on the Namibian side), the Modderdrift main canal feeds the water over a distance of 2.3 km. The Modderdrift pump station's water is discharged into the canal at its start. This canal discharges some of its water into the 2.3 km Modderdrift North branch canal, which remains on the Namibian side, while the balance of the water is discharged into the Modderdrift siphon back across the border into the Modderdrift South canal. The length of this last section of canal is 3.1 km. Approximately halfway along the Modderdrift South canal, the Modderdrift South pump station pumps water into the canal.

Farmers withdraw water all along the canal system by means of sluice gates according to the size of their land listed with the JIA. In a few cases, farmers have their own pump stations on the river from where they abstract their own irrigation water. There are ?? of these pumps on the river.

Water is drawn directly from the canal for household purposes. In most cases this is done with a small centrifugal pump pumping directly from the canal. There are a total of ?? of these pumps on both sides of the river.

Other uses of the canal water are dust control, and providing drinking water to the informal settlement at Rooiwal.

The information about each section of the canal is given in Table 4-1.

Table 4-1 JIA canal sections and attributes

Canal section			Canal attributes				Syphon attributes			
#	Name	Shape	Size: Top Width (mm)	Size: Depth (mm)	Length (km)	Capacity (m^3/s)	Pipe type	Pipe diamete (mm)	Length (km)	Capacity (m^3/s)
1	Vioolsdrift	Parabolic	3350	1500	13	1.28				
2	Vioolsdrift Syphon	Pipe					To be completed			
3	Noordoewer	Parabolic	2700	1500	8	0.99				
4	Rooiwal Syphon	Pipe					To be completed			
5	Rooiwal	Parabolic	2300	990	1.7	0.71				
6	Swartbas	Parabolic	1560	980	3.6	0.5				
7	Swartbas syphon	Pipe					To be completed			
8	Modderdrift Main	Parabolic	1600	920	0.24	0.26				
	Modderdrift Main	Rectangular	940	675	2.07	0.26				
9	Modderdrift syphon	Pipe					To be completed			
10	Modderdrift South	Parabolic	110	400	3.1	0.04				
11	Naupoort syphon	Pipe					To be completed			
12	B vd Hoven	Parabolic	900	450	1.5	0.043				
13	Duifieloop	Parabolic	950	450	4	0.09				
14	Duin	Parabolic	1870	900	2.5	0.3				
15	Modderdrift North	Parabolic	1200	486	2.4	0.09				

Figure 4-2 to Figure 4-8 provide photographs of some of the infrastructure in the water supply system of the JIA scheme.

Figure 4-2 Vioolsdrift weir and start of canal system

Figure 4-3 Vioolsdrift canal downstream of weir

Figure 4-4 Inlet to Vioolsdrift siphon (two pipes)

Figure 4-5 Rooiwal canal

Figure 4-6 Rooiwal canal with spill canal

Figure 4-7 Modderdrift North pump station

Figure 4-8 Swartbas pump station

4.2 Flow measurement

No provision was made for control structures (flumes) in the canal system when it was built. Ideally there should have been a measuring flume at the inlet to each canal section, as well as at the spill positions. Comprehensive alterations to the canal will be necessary to accommodate such structures, as these will reduce the available head, and therefore the capacity, of the canal.

Under the UNOPS Demonstration Project, a number of measuring devices were installed in the system. These, together with other devices, are described in the next paragraphs, and the location of this equipment is shown in Figure 4-9 and Figure 4-10.

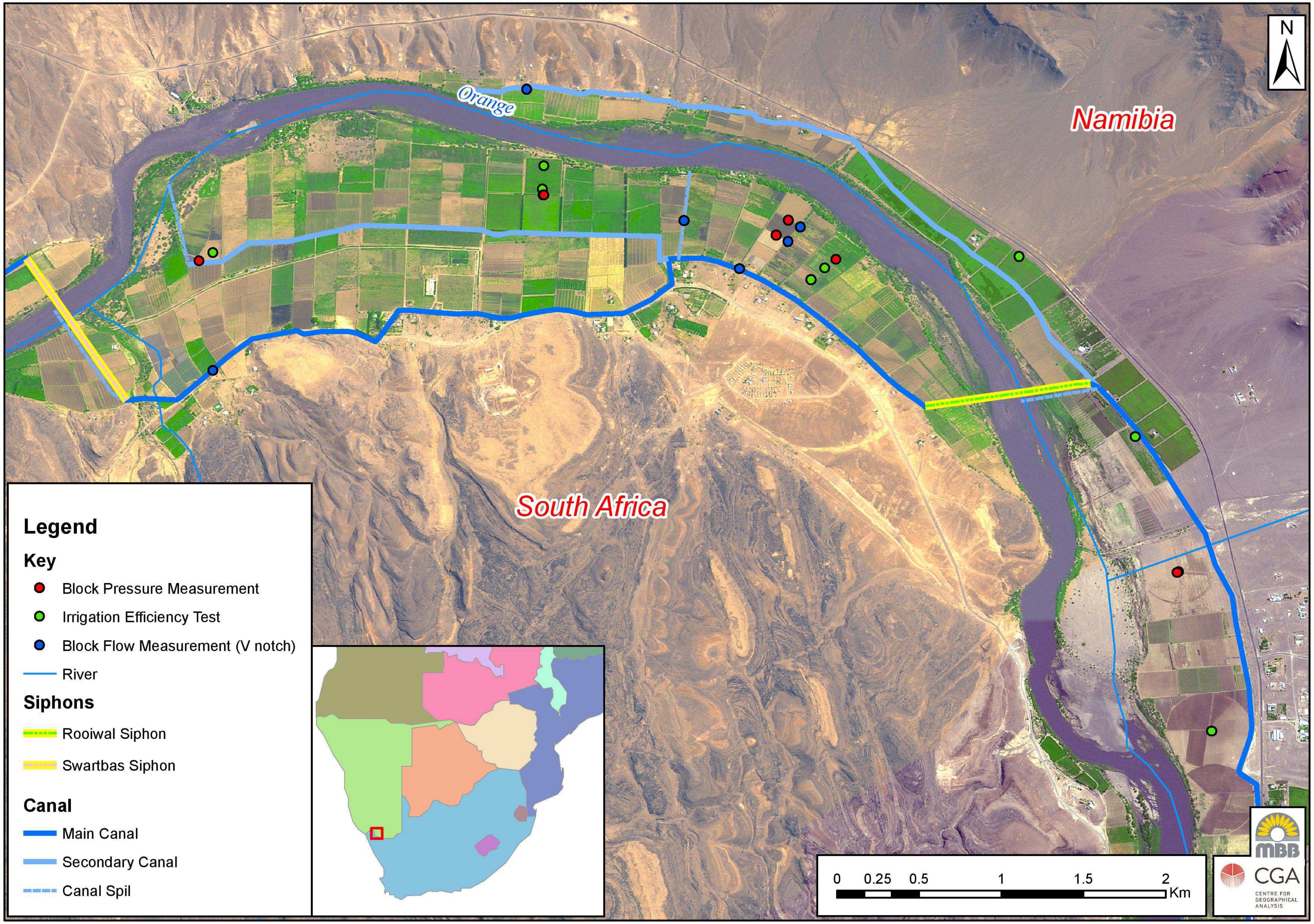


Figure 4-9 Location of irrigation efficiency tests, off-take V-notches and block pressure probes

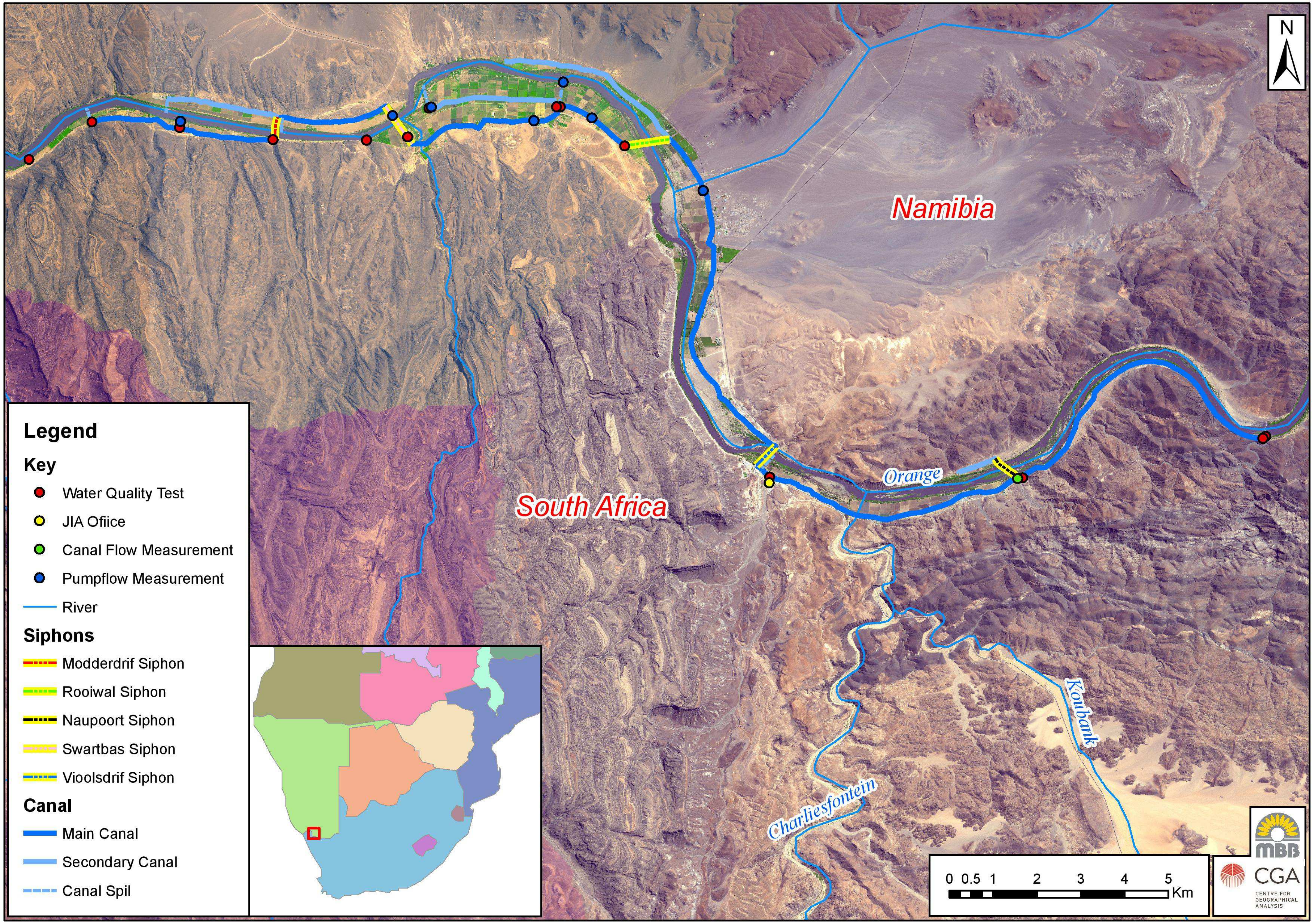


Figure 4-10 Location of JIA office, canal flow – and pump flow measurement, and water sampling positions

Table 4-2 shows the flow meters that have been installed in the system and that are now being monitored.

Table 4-2 Flow meters operational in the JIA irrigation scheme

Flow meter		Purpose	Number	Readings	
#	Type			Interval between readings	Communication method
1	Ultrasonic	Measure flow in canal upstream of first take-off	1	0.25 h	Logger & download on laptop
2	Pressure sensor	Measure farm sluice-gate	4	0.1 h	Logger & download on laptop
3	Pressure sensor	Measure flow in irrigation block/pivot	4	0.1 h	Logger & download on laptop
4	Electronic	Measure JIA pump flows	6	As needed	Modem
5	Electronic	Measure farm pump flows	3	As needed	Modem

Table 4-3 shows typical readings from the canal flow meter. Figure 4-11 shows the graphical report for the sluice gate measurement, and Figure 4-12 shows these for the pressure sensor on a pivot. Figure 4-13 to Figure 4-16 contains photographs of different measurement installations.

Table 4-3 Typical canal-flow measurement readings

?Sample number	Sample time	Area (m^2)	Depth (m)	Flow (m^3/s)	Temp (°C)	Velocity (mean) (m/s)	Volume (total) (m^3)
1	07/11/2012 17:00	2.54	1.029	1.1	28.1	0.44	2560886
2	07/11/2012 17:15	2.55	1.031	1.1	28.0	0.43	2561875
3	07/11/2012 17:30	2.55	1.031	1.1	28.0	0.41	2562835
4	07/11/2012 17:45	2.55	1.032	1.1	28.0	0.43	2563803
5	07/11/2012 18:00	2.55	1.033	1.1	28.2	0.43	2564785
6	07/11/2012 18:15	2.54	1.030	1.0	27.9	0.39	2565722
7	07/11/2012 18:30	2.54	1.030	1.2	27.5	0.45	2566700
8	07/11/2012 18:45	2.55	1.031	1.1	27.1	0.45	2567735
9	07/11/2012 19:00	2.56	1.034	1.1	26.7	0.44	2568756
10	07/11/2012 19:15	2.55	1.033	1.1	26.5	0.44	2569769
11	07/11/2012 19:30	2.55	1.031	1.1	26.4	0.42	2570759
12	07/11/2012 19:45	2.55	1.032	1.1	26.3	0.43	2571735
13	07/11/2012 20:00	2.55	1.031	1.2	26.0	0.48	2572779
14	07/11/2012 20:15	2.55	1.033	1.2	25.8	0.48	2573883
15	07/11/2012 20:30	2.55	1.033	1.2	25.6	0.47	2574976
16	07/11/2012 20:45	2.56	1.035	1.2	25.5	0.46	2576050
17	07/11/2012 21:00	2.56	1.035	1.2	25.4	0.46	2577116
18	07/11/2012 21:15	2.56	1.035	1.2	25.3	0.47	2578192
19	07/11/2012 21:30	2.56	1.035	1.2	25.2	0.47	2579273

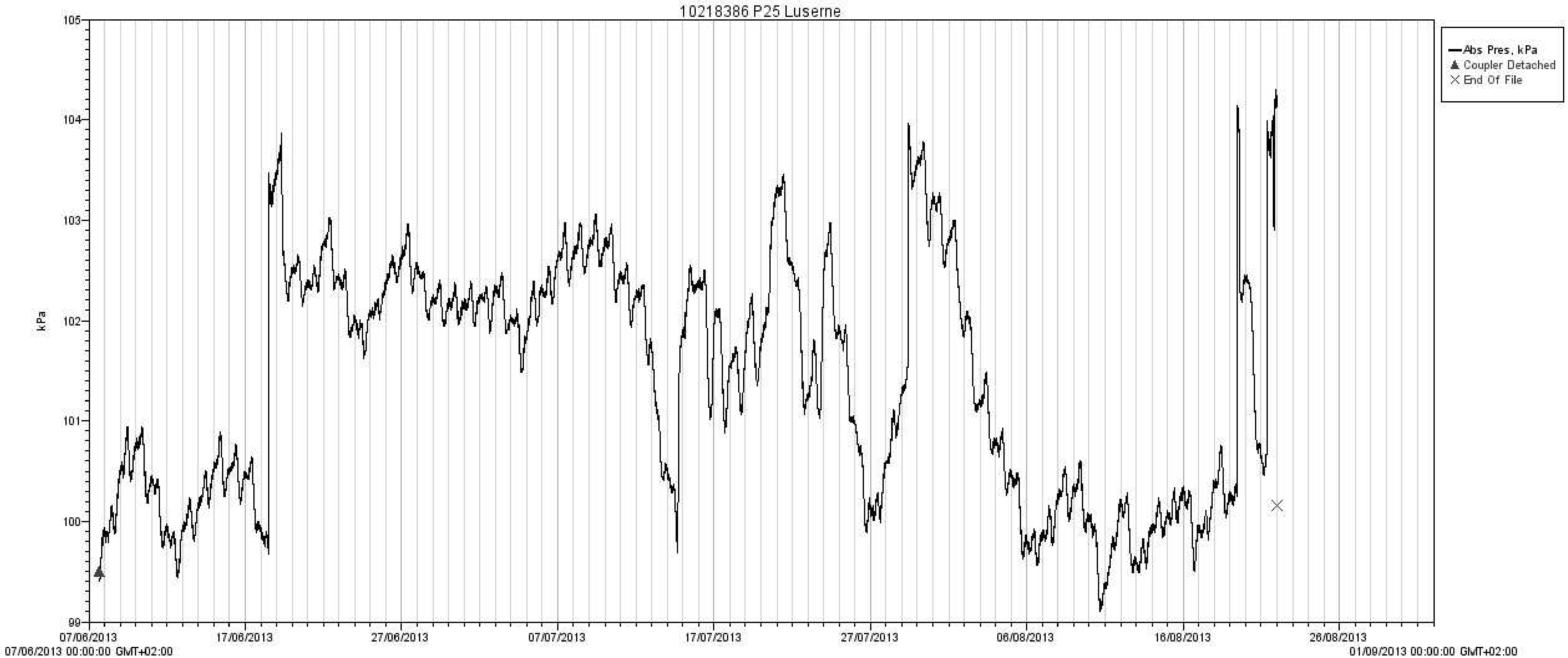


Figure 4-11 Sluice-gate depth measurement

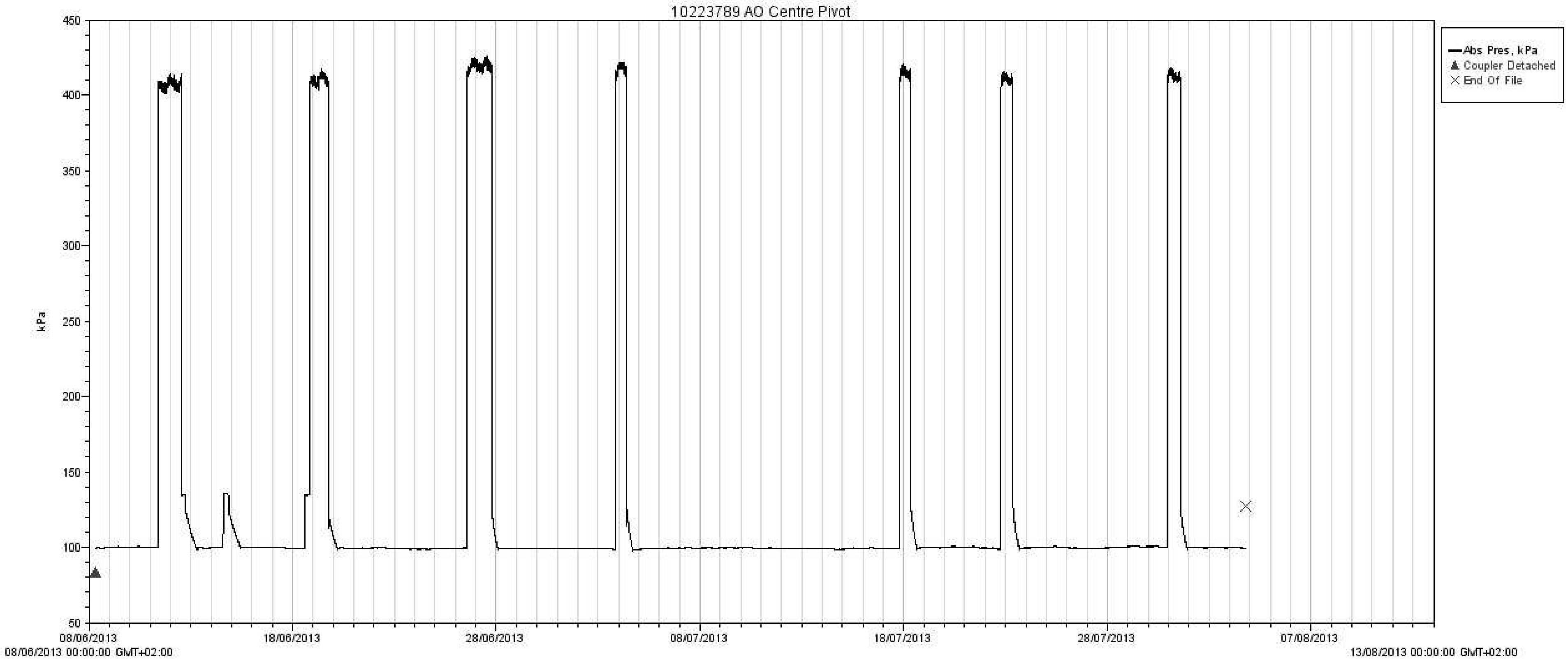


Figure 4-12 Pivot pressure measurement

Figure 4-13 Ultrasonic canal flow measurement

Figure 4-14 V-notch off-take measurement

Figure 4-15 Electronic pump-flow measurement

Figure 4-16 Irrigation block pressure/flow measurement

4.3 Electricity measurement

The power used by each of the six JIA scheme pumps, as well as that used by three of the farm pumps, is measured. These measurements are done with the electronic meters shown in Table 4-2.

4.4 Soil moisture monitoring

There are 28 soil moisture probes installed in the scheme. These probes are installed in pairs, and each pair of probes sends its readings at 15 minute intervals to a nearby radio transmitter, from where it is transmitted to a server in the JIA office in Vioolsdrift. Each probe measures the moisture content and temperature in the soil at five different depths between 20 cm and 80 cm. See Figure 4-19 for the location of the soil moisture probes.

The raw data is automatically e-mailed to a service provider where a software scheduling program analyses the data (with periodic intervention by the service provider). The software generates a report for each monitoring site containing the proposed irrigation schedule for the next seven days. The reported is posted on a website accessible to the JIA, the farmers and other people with an interest in it.

Figure 4-17 shows a typical soil moisture graph produced by the software, and Table 4-4 shows an example of the scheduling report.

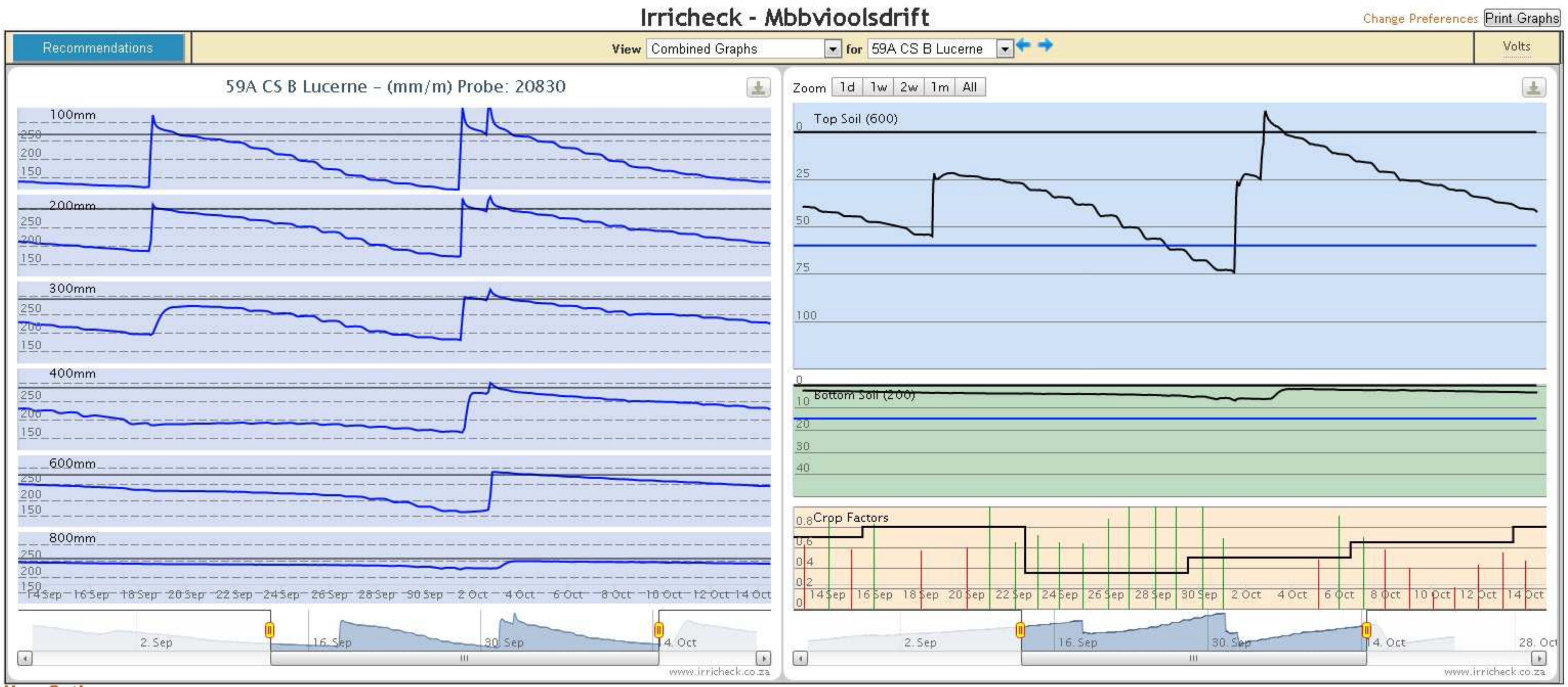


Figure 4-17 Typical soil moisture probe graph

Table 4-4 Typical scheduling programme report

Irricheck - Mbbvioolsdrift

Field Name	Last Reading Age/Date	Status	Recommendations							Rain/Irrigation					Deficit		Weekly Water Use		
			Do 17	Vr 18	Sa 19	So 20	Ma 21	Di 22	Wo 23	Sat	Sun	Mon	Tue	Tot	Top	Bottom	Transp	Evap	Total
200 AO Patat	26 mins 17 Oct 05:00	Topsoil too dry Bottomsoil too dry	33	33											46	24	21	3	24
212 AO P Grapes	26 mins 17 Oct 05:00	Topsoil too wet Bottomsoil too wet					10 (01h13)		10 (01h13)						-2	0	23	1	24
23A	26 mins 17 Oct 05:00	Topsoil okay Bottomsoil okay													4	0	20	0	20
59A CS B Lucerne	26 mins 17 Oct 05:00	Topsoil too wet Bottomsoil too wet													-3	0	17	0	17
22D CS B Tamatie	26 mins 17 Oct 05:00	Topsoil too dry Bottomsoil too dry	35	35	35										86	16	28	2	30
22C CS G Tomato	26 mins 17 Oct 05:00	Topsoil too dry Bottomsoil okay	35 (00h28)	35 (00h28)	35 (00h28)										97	4	10	5	15
204 VDM P Grapes	26 mins 17 Oct 05:00	Topsoil too wet Bottomsoil too wet					10		10						-2	0	23	1	24
Blok 57A Butternuts	26 mins 17 Oct 05:00	Topsoil too dry Bottomsoil okay	10 (36%)	10 (36%)	10 (36%)			10 (36%)	10 (36%)						19	2	25	2	28
33 FB K4 P Grapes	26 mins 17 Oct 05:00	Topsoil okay Bottomsoil too wet			10				10						0	0	22	2	24
33 FB K2 R Grapes	26 mins 17 Oct 05:00	Topsoil okay Bottomsoil okay	10		10				10						8	3	22	2	25
294G WC Patat	26 mins 17 Oct 05:00	Topsoil okay Bottomsoil okay	15 (03h00)				15 (03h00)		15 (03h00)						14	3	21	3	24

Last Update: 5 days ago
Printed: 2013/10/22 08:54:13

4.5 Weather monitoring

An automated weather station was erected at a suitable site near the JIA office, which is approximately midway into the scheme and therefore, from a climate point of view, fairly representative of the conditions in the scheme (see Figure 4-19). Information is transmitted via radio at 15 minute intervals to the JIA server, and then sent together with the soil probe data (Section 4.4) to the service provider to be used for the irrigation scheduling reports. Figure 4-18 shows a photograph of the weather station at Vioolsdrift.

Figure 4-18 Automated weather station at Vioolsdrift

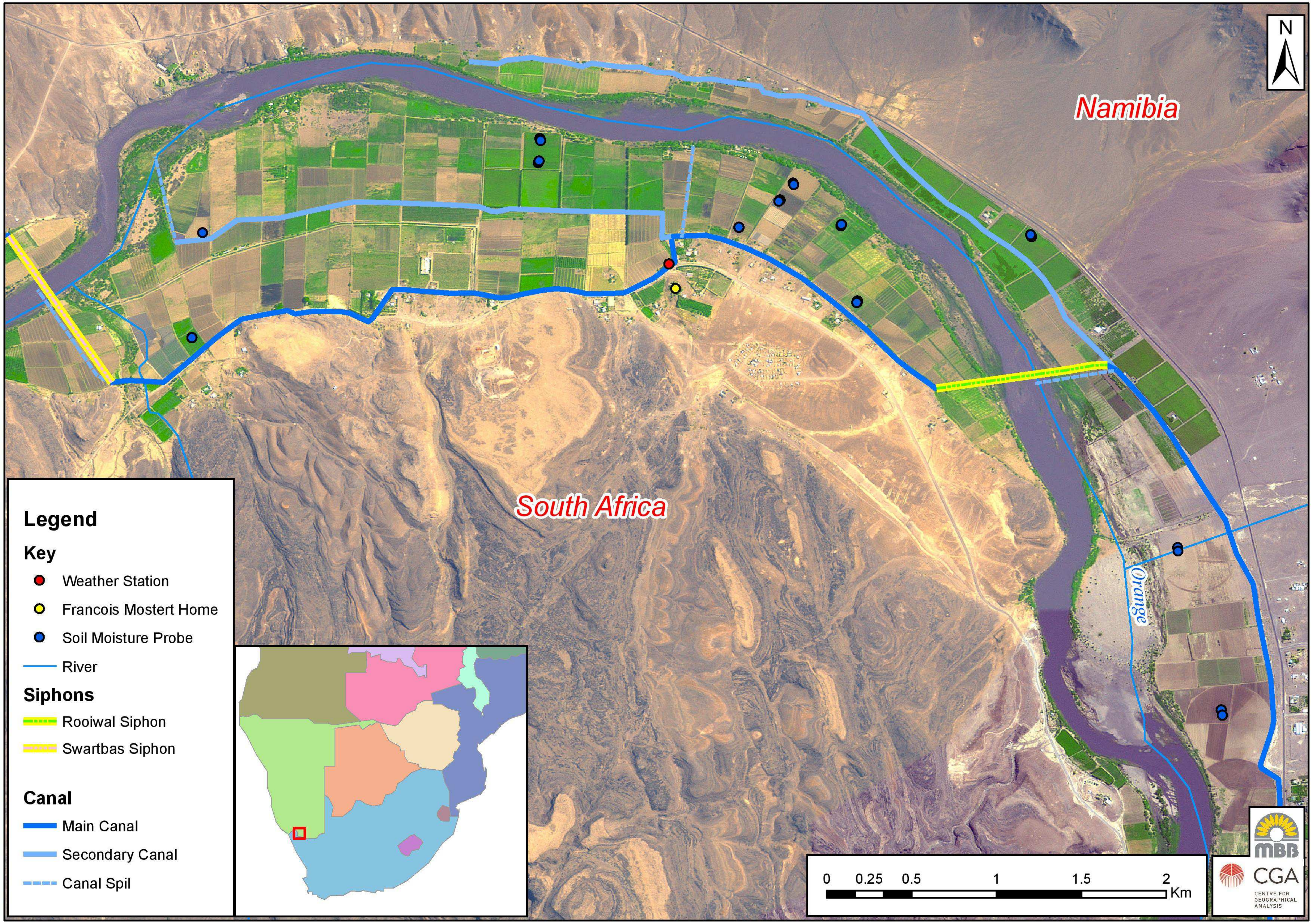


Figure 4-19 Location of soil moisture probes, central management and automated weather station

5 OTHER BEST MANAGEMENT PRACTICES IMPLEMENTED

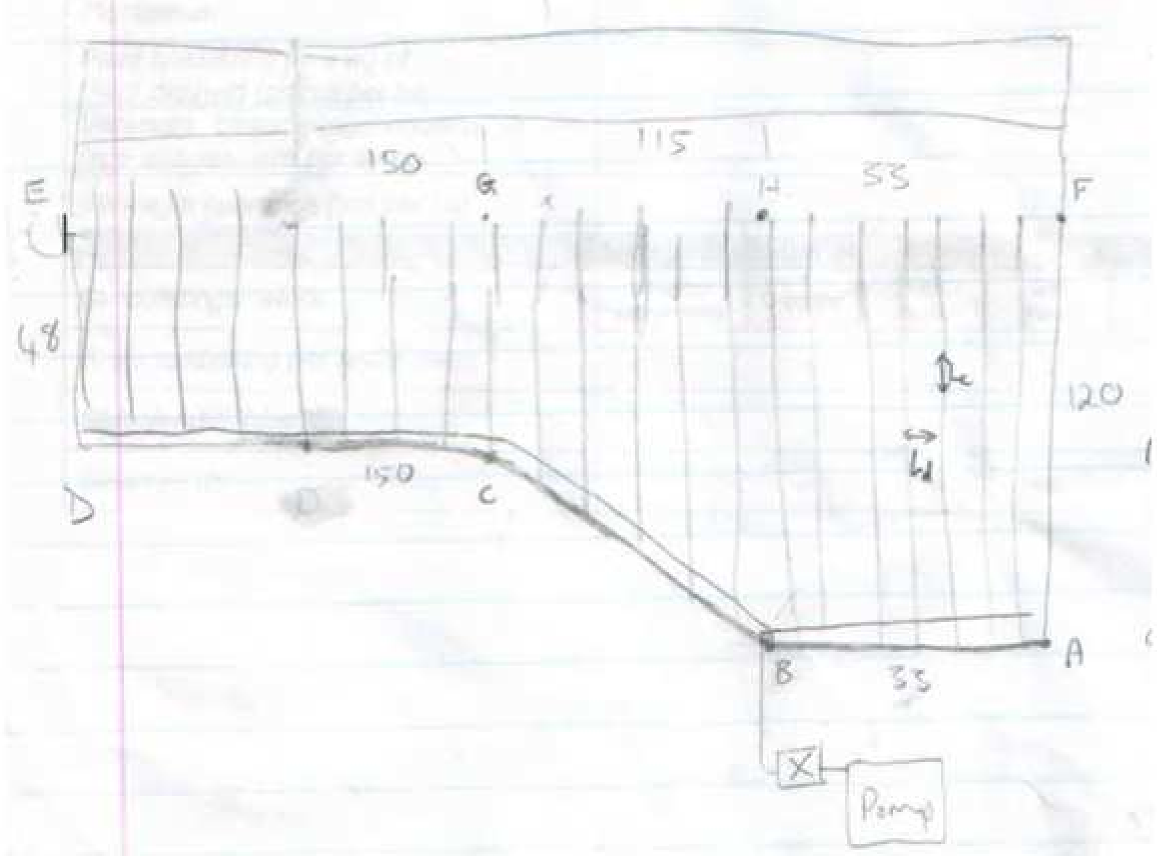
5.1.1 Evaluation of irrigation efficiency

The Agricultural Research Council (ARC) was contracted during July 2012 to perform efficiency evaluations of some of the existing irrigation systems in Vioolsdrift and Noordoewer. The purpose of these tests was to get a sense of how the systems, which have been operating for some years, are performing. These tests were done for three drip systems, four micro-jet systems and two pivot systems. The location of the fields in which these evaluations were done is shown in Figure 4-9.

Figure 5-1 illustrates the testing procedures and Table 5-1 shows an example of the results that were obtained.

Figure 5-1 Infield irrigation system efficiency evaluation

Table 5-1 Example of results obtained from drip block evaluation



Coefficient of variation	**CV**	6.38	%	excellent
Statistical Uniformity	**U_s**	93.62	%	excellent
Emission Uniformity	**EU**	93.33	%	excellent

5.1.2 Water quality measurement

Water analyses are done at monthly intervals in different locations in the system. These locations, both in the river and in canals, appear on the aerial photograph shown in Figure 4-10. The apparatus that is used for this purpose is a portable Extech meter (see Figure 5-2). Typical water quality readings appear in Table 5-2.

Figure 5-2 Apparatus to do water quality tests

Table 5-2 Typical readings obtained from water quality tests

WQ #	River/Canal	Description	Date	Time of Measurement	Temp [°C]	PH [-]	Conductivity [µS]	TDS [ppm]	Salinity [ppm]	Dissolved Oxygen [%]	Dissolved Oxygen [mg/L]	ORP [mV]
WQ1	River	River	26/10/2013	07:20	22.9	8.68	947	662	464	72.2	6.03	96
WQ2	Canal	Vioolsdrift main origin.	26/10/2013	07:35	24	8.66	752	533	380	68	5.6	109
WQ3	Canal	Vioolsdrift main @ "Kliphuis"	26/10/2013	08:20	24.7	8.63	618	431	308	70	5.8	130
WQ4	Canal	Vioolsdrift main @ Vdrift Siphon entry	26/10/2013	08:45	24.3	8.62	662	467	335	68.7	5.74	135
WQ5	Canal	Rooiwal @ Rooiwal Siphon Exit	26/10/2013	09:07	24.4	8.4	786	550	394	66.1	5.38	140
WQ6	Canal	Rooiwal @ pipe inflow	26/10/2013									
WQ7	Canal	Rooiwal @ Canal Split	26/10/2013	09:25	24.2	8.52	764	534	384	70.5	5.82	142
WQ8	Canal	Duin @ End of canal	26/10/2013	10:03	25.5	8.66	773	541	385	75.5	6.08	147
WQ9	Canal	Swartbas @ End of canal	26/10/2013	10:45	25.2	8.65	800	560	397	74.6	6.06	149
WQ10	River	River @ Geelkrans	26/10/2013									
WQ11	Canal	Modderdrif South @ Modderdrif Siphon Exit	26/10/2013	11:04	25.8	8.53	810	567	405	85.5	6.66	150
WQ12	Canal	Modderdrif South @ Pipe inflow	26/10/2013									
WQ13	Canal	Modderdrift South @ End of Canal	26/10/2013	11:29	31	9.14	641	448	321	138.2	10.21	146
WQ14	River	River	26/10/2013	11:52	28.5	8.47	822	574	413	80.5	6.14	154

5.1.3 Geographical information system (GIS)

A detailed survey of all farms, crops and irrigation activities was done, and a geographical information system (GIS) was compiled with this information, assisted by Stellenbosch University. The software package ArcGIS was used for this purpose. All the maps shown in this report are part of the GIS.

5.1.4 Water administration system (WAS)

The Water Administration System (WAS) is an integrated management tool for irrigation schemes that delivers water on demand through canal networks, pipelines and rivers. WAS is used for water distribution management and for the calculation of canal and dam operating procedures for a given downstream demand. WAS uses an open source database called Firebird (SQL-based) as its underlying database. Firebird is a relational database management system (RDBMS) that provides rapid transaction processing and data sharing in a single- or multi-user environment.

The WAS program is currently in use by all the major irrigation schemes and a number of smaller irrigation boards throughout South Africa.

WAS is used for the efficient administration of:

- Address information
- Scheduled areas
- Water quota allocations
- Water delivered through pressure-regulated sluice gates, measuring structures and water meters
- Water distribution sheets
- Water-use efficiency reports
- Water transfers between users (automatic and manual)
- Water-use calculations for planted areas based on crop water-use data
- Date- and time-related flow data collected from electronic loggers or mechanical chart recorders
- Discharge tables to do conversions between water depth and flow rate for measuring structures or vice versa
- List of rateable areas information
- Calculation of scheme water balances
- Dam information time series, including dam levels, dam capacities, dam surface areas, dam spilling, rainfall, evaporation, inflows and outflows
- Calculation of water releases for water distribution through canal networks, pipelines and rivers, taking lag times, evaporation and seepage into account
- A billing system that links to water-use information
- E-mail invoices in PDF format
- Flexible tariff sets based on water usage, a flat rate or scheduled area
- Images and photos that can be linked to different types of information in the database
- Bulk SMS system

The software makes it possible for the manager, accounts personnel and water office personnel to access the database from PCs in their own offices. There is no limitation on the number of PCs that can be linked to the database.

What makes the WAS program unique is the fact that it is an integrated system that includes the water allocations, water use, water distribution, water measurement, crop water use, billing information and a bulk SMS system. WAS will generate monthly invoices automatically, using water usage or scheduled areas information captured in the database.

The main benefits of using the WAS information system are as follows:

- The minimising of water distribution losses

- The improved control of water orders, releases, distribution and usage per farmer
- The management of date- and time-related flow data collected from electronic loggers or mechanical chart recorders
- The availability of an extensive list of water reports on a farm and scheme level
- The increased productivity of scheme management personnel
- The reliance on an integrated accounting system that improves debit management
- The improvement of the overall water management in irrigation schemes

5.1.5 Irrigation training

Three training sessions on irrigation practices and scheduling have taken place. The speakers are specialists in their fields and were invited and facilitated by MBB.

Figure 5-3 shows a photograph taken during one of these sessions.

Figure 5-3 Irrigation training session held at Vioolsdrift for JIA members

5.1.6 Visits to other schemes

Site visits by farmers from the JIA scheme took place on two occasions. The first was a visit to the Boegoeberg and Oranje-Riet schemes in the Northern Cape in February 2012, and the second was a visit to schemes in Namibia, i.e. to Aussenkehr, Naute, Mariental and Stampriet. The main objective of these visits was to see first-hand the BMPs implemented in these schemes. The value of these visits lies in the fact that the farmers found them very informative and valuable, as did the farmers and WUAs that were visited.

Figure 5-4 shows a photograph of a visit to a farmer in Boegoeberg who illustrated how he used his laser-levelled irrigation system on vineyards.

Figure 5-4 JIA members on a site visit to Boegoeberg in the Northern Cape

5.1.7 Night storage dams

The value of night storage dams is illustrated by the existing and newly constructed dams at Vioolsdrift and Noordoewer. Figure 5-5 shows one of these dams under construction at Vioolsdrift.

Figure 5-5 Night storage dam under construction at Vioolsdrift

5.1.8 Laser-levelled flood irrigation systems

As a result of the rising energy prices there is a new interest in flood irrigation systems (no energy required). With this interest came the realisation that flood systems must be more efficient; this is exactly what can be achieved with the laser-levelled preparation of land. The first laser-levelling of land in the JIA scheme took place in 2012, when one of the farmers bought the necessary equipment. To date, approximately 42 ha have been laser levelled, with very satisfactory results.

Figure 5-6 shows typical normal flood irrigation, while Figure 5-8 shows flood irrigation on laser-levelled land. Figure 5-7 shows a double ring infiltration meter that was built for the scheme to do in-situ infiltration tests to determine the appropriate slopes for land preparation.

Figure 5-6 Normal basin irrigation

Figure 5-7 Double ring infiltrometer test apparatus

Figure 5-8 Laser-levelled basin irrigation

5.1.9 Sub-surface drip irrigation

Sub-surface drip irrigation has a place as a BMP for certain conditions. It is still being considered for demonstration as part of the UNOPS demonstration project. Figure 5-9 shows a typical sub-surface drip system for a tomato field.

Figure 5-9 Sub-surface drip irrigation

5.1.10 Mulching and crops under protection

Good results are achieved in the scheme with plastic mulching on vegetable crops. Use is made of drip irrigation, which is installed below the mulch. With almost no evaporation from the wetted soil surface, and the absence of weeds, a high level of water-use efficiency is achieved. Figure 5-10 shows an example of a butternut field with plants covered by a 'frost cloth'.

Figure 5-10 Crop production under protection

5.1.11 Web page for JIA

An interactive website has been developed for the JIA. This website provides very useful information about the scheme. Raw real time data obtained from the monitoring equipment installed on the farms can be accessed on the website (password protected).

The home page of the JIA website is http://jia.orasecom.org.

5.2 Scheme inventory

An inventory of the canal infrastructure, summarised by section, is shown in Table 5-3.

Table 5-3 Infrastructure summary (To be completed by the JIA)

Type of structure	Section									Total
	Vioolsdrift	Naukloof	Noordoewer	Duifie	Rooiwal	Swartbas	Duineloop	Modderrivier North	Modderrivier South	
Canals/pipelines (km)										
Pipe lines (km)										
Aqueducts										
Siphons										
Flow measuring structures										
Bulk water sluices										
Property sluices										
Sluice measurement installations										
Pump measurement installations										
Spill/reject structures										
Vehicle bridges										
Foot bridges										
Automated weather station										
Automated soil moisture probes										

6 INFRASTRUCTURE CONDITION ASSESSMENT

Between the years 2000 and 2005 several studies were undertaken to determine the extent and feasibility of refurbishment required. This was done due to serious operational problems as a result of the poor condition of most of the canals. Figure 6-1 to Figure 6-3 show some examples of the poor condition of the canals at that stage.

Figure 6-1 Missing panels along Swartbas canal before refurbishment

Figure 6-2 Section on Swartbas spill canal before refurbishment

Figure 6-3 Panel that has moved along Noordoewer canal

Obtaining funding for the refurbishment was problematic, but in 2008 both the South African and the Namibian Government provided funds for the refurbishment 75 % and 25 % respectively. The total cost amounted to approximately R 9 million. It was carried out in three phases, the first phase starting in May 2008 and the last phase completed in September 2013.

The refurbishment was very successful and minimal shortages are currently experienced.

A condition assessment was not undertaken specifically for the purpose of the WMP. However, generally speaking, the condition of the scheme infrastructure can be described as good to very good.

7 SCHEME OPERATIONS AND OPERATING PROCEDURES

7.1 General scheme operations

7.1.1 The JIA

The JIA is managed by a board consisting of three farmers from each side of the border, as well as one official from the Ministry of Agriculture, Water and Forestry (Namibia) and one official from the Department of Water Affairs and Forestry (South Africa). Meetings are held on a quarterly basis.

JIA board meetings take place three times per year. These meetings are also attended by the DWA officials from South Africa and Namibia. Every three years a general meeting attended by scheme members are held, these meetings can be more frequent should a member request such a meeting

Board members are re-elected every three years for a term of three years. Board members can be removed should there be dissatisfaction about whether or not they are fulfilling their functions satisfactorily.

The number of votes that a particular member has is not determined by his/her enlistment in the scheme; each member has one vote..

The day-to-day operation and maintenance of the canals and siphons are managed by a water bailiff/water control officer (WCO)/technician and a workforce of four, employed by the JIA. An additional two workers operate the pumps on both sides of the river that are used to supplement the canal sections when shortages occur during the summer months.

7.1.2 Water ordering and delivery procedures

Farmland is situated on both sides of the Orange River and is privately owned. Meaningful changes that have taken place during the last decade or so are:

- Less flood irrigation and more permanent systems
- Decrease in number of farmers – larger area per farmer
- Movement away from cash crops to permanent crops

The JIA does not order water from the DWA; this is controlled by the department (SA) and is made available to the JIA on demand. For this control the DWA makes use of a number of gauging stations in the river. The only gauging station within the JIA scheme is at the Vioolsdrift weir. The closest system control is located at the Van der Kloof Dam, from where the water takes approximately four weeks to reach the Vioolsdrift weir.

Although there is a ‘turn’ schedule for the scheme members, this is not used fully any more. This schedule appears in **Appendix A**.

The JIA does not use a water-ordering system to supply water to its members. Members along the different canal sections make arrangements between themselves regarding when each would prefer to withdraw water. Since the refurbishment of the canals, this arrangement has worked well in general. Some problems are experienced occasionally in one section of the canal, viz. the Duin canal.

Fields irrigated with flood systems from the canal are irrigated during the day, while water for permanent systems (overhead and micro/drip) that use water pumped from the canal are irrigated round the clock.

The WCO controls the inflow by observing the canal levels at certain strategic points in the canals, mainly spill structures for high-flow conditions, and certain critical sluices for low-flow conditions. When the water level drops below certain minimum levels in the Swartbas, Duin and Modderdrift canals, pumps will be started (manually).

Each farmer is allocated 0.042 m^3/s/ha for a period of six hours per week. The board does not do the opening and closing of farm sluice gates, as this control is exercised by the farmers themselves.

Members with river pumps also control their own equipment according to their irrigation demand. All pumped water in the scheme (excluding the JIA pumps) is irrigated by means of pressurised infield irrigation systems, i.e. not using flood irrigation.

When the canal is flowing at full capacity, the flow at the canal inlet is 1.28 m^3/s. The total capacity of the six pumps that can add flow to the system is approximately 0.43 m^3/s; the total system capacity therefore is 1.71 m^3/s.

The canal flows continuously, therefor excess water in the canal (mainly during the night) flows back into the river through the spill structures and canals.

The canal is shut down on a routine basis twice a year for maintenance and cleaning. When there is excessive build-up of algae and/or water grasses (as was the case in 2013), it can also be shut off at other times. Sections of the canal are shut off at different stages, using the river pumps to keep certain sections of the canal operational. Members are informed at least a week in advance that a shutdown will take place. A typical schedule for a maintenance shutdown appears in **Appendix B**. Figure 7-1 to Figure 7-3 show photographs of typical maintenance issues.

Figure 7-1 Water grass in canal

Figure 7-2 Water grass taken from canal

Figure 7-3 Sand build-up in canals

Sluice gates on the farms were originally equipped with measuring notches (trapezium shaped) according to which the opening of the gate was set. These are no longer in use, as they are mostly heavily corroded and, in most cases, operate under submerged conditions. At present, the opening of the gates is done by the farmer, who uses his/her own experience to decide on the volume of the stream to allow effective operation of the irrigation system.

7.2 Operating rules and regulations

There are few violations of the rules and regulations of the JIA, and farmers generally do not exceed their allocated use rights. The Board has the right to withdraw the abstraction rights of a member should such member contravene its regulations.

7.2.1 Polices

The paragraphs below describe policies that apply to different aspects of the scheme operation. Some of these have not been developed yet, and others have not been applied to date.

- Water shortages – *existing allocation policy in case of water shortage*
- Water wastage – *strategies in place to reduce wasteful usage of water that are enforced in times of sufficient water as well as shortages*
- Return-flows and drainage – *policies to reduce return-flows and drainage and record the quality of this water*
- Water transfers – *policies on the management of voluntary water transfers between members to maximise beneficial water use, as well as transfers to other WUAs*
- Spill recovery system – *dealing with water that was released but not committed and that might be wasted*
- Pricing and tariff structure – *the current water pricing methods and tariff structures*
- Unlawful withdrawals – *measures used to control unlawful withdrawals, including incentives and mechanisms for members to report them promptly*
- Invasive alien plants – *policy on the eradication of invasive alien plants*

7.2.2 Operating capabilities and scheme operation

With the mechanisms and procedures currently in place, the scheme is managed satisfactorily. The position of JIA secretary was held without continuity for the past 18 months, which caused considerable inconvenience, with certain administrative tasks falling behind. Fortunately the previous secretary was prepared to assist again, which was of great value. With the appointment of a new secretary in August 2013, it is expected that the discontinuity is a problem of the past.

The following documents/reports are distributed by the JIA office on a routine basis:

- Water accounts
- Notices before canals are closed for maintenance purposes
- Flood warnings
- Annual reports and financial statements (available on request)
- Minutes of meetings to board members (also available to members on request)

7.2.3 Water trading - Temporary water transfers

Water markets are an important mechanism for improving water-use efficiency. Unused water allocations are surrendered to the water user association / irrigation board, which then trade them at a premium to a willing buyer. This additional income makes a contribution to the costs of managing the water user association and improving overall water-use efficiency. From a practical point of view, trading or temporary water transfers can be done per canal section, or between sections in an upstream direction.

The JIA did not implement trading of water or temporary water transfers.

7.2.4 Water pricing structure

The JIA endeavours to break even in the recovery of costs, while maintaining a reserve fund at a certain level. The present cost of water for the various users is given in Table 7-1.

Table 7-1 JIA water tariffs

Water-use sector	Annual Tariff (Excl VAT)	
	South Africa	Namibia
Agricultural water: From canal	R 657 per ha	R 657 per ha
From river	R 507 per ha	R 12.80 per ha
Domestic water	R 123.50 per household	
Water to businesses	R 1 407 per business	
Industrial use	R 0.37 per m^3	

If a member prefers to pump (part of) enlistment from the river (for various reasons) he/she is free to do this, but the tariffs charged by the JIA will be as if the water is taken from the canal.

The approximate allocation of JIA costs to be recovered and for which the tariffs must provide appears in Table 7.2.

Table 7-2 JIA water tariff allocation

Cost item	Approximate allocation
Personnel	50 %
Administration	11 %
Consumables e.g. weed killers	1.5 %
Electricity	26 %
Maintenance supply system	4.5 %
Depreciation	3 %
Other costs	4 %

8 WATER BALANCE/BUDGET OF JIA IRRIGATION SCHEME

8.1 Introduction

Water is a scarce commodity and, for the sake of efficiency in its use, it is important to calculate and report on how it has been supplied and consumed, which is why this is a key element of the baseline study. A water balance summarises the annual volume of inflow, consumption and outflow from the geographical area served by the WUA/IB: it brings to account how the water allocated has been used, or wasted.

The water audit is a key element of the baseline study, as it provides the basis against which future improvements in water management can be measured. As the annual cycle of developing WMPs matures, it is the single source of the most important information the WUA/IB will use to determine its strategic goals. It identifies those aspects which, if attended to during the course of implementing the WMP, will deliver the greatest return in efficiency for the smallest input.

Rather than thinking about irrigation efficiency as a percentage, irrigation system performance should be considered in terms of a water balance. A water balance is an accounting of all water volumes that enter and leave a three-dimensional space over a specified period of time (Burt, 1999). Changes in internal water storage must also be considered. Both the spatial and temporal boundaries of a water balance must be defined clearly in order to compute and discuss a water balance. A complete water balance is not limited only to irrigation water or rainwater or groundwater, etc., but includes all water that enters and leaves the spatial boundaries.

A recent paper by Perry (2007) presents the newly developed analytical framework for irrigation efficiency as approved by the International Commission on Irrigation and Drainage (ICID). In the paper, the author describes in detail the history of and subsequent confusion regarding the calculation and interpretation of so-called irrigation or water-use “efficiency” indicators. The framework and proposed terminology are scientifically sound, being based on the principle of continuity of mass. The framework promotes the analysis of irrigation water-use situations or scenarios in order to expose underlying issues that can be addressed to improve water management, rather than simply the calculation of input-output ratios, as done in the past.

The proposals were reviewed and accepted by the ICID as the analytical framework and associated terms that will better serve the needs of technical specialists from all water-using sectors, as well as policymakers and planners, in achieving more productive use of water and tracing the implications of interventions on other uses and users. The ICID recommends that this terminology be used in the analysis of water resources management at all scales, and form the basis for its research papers and other published outputs.

A schematic representation of the ICID framework as described by Perry (2007) is shown in Figure 8-1 and discussed further in this document.

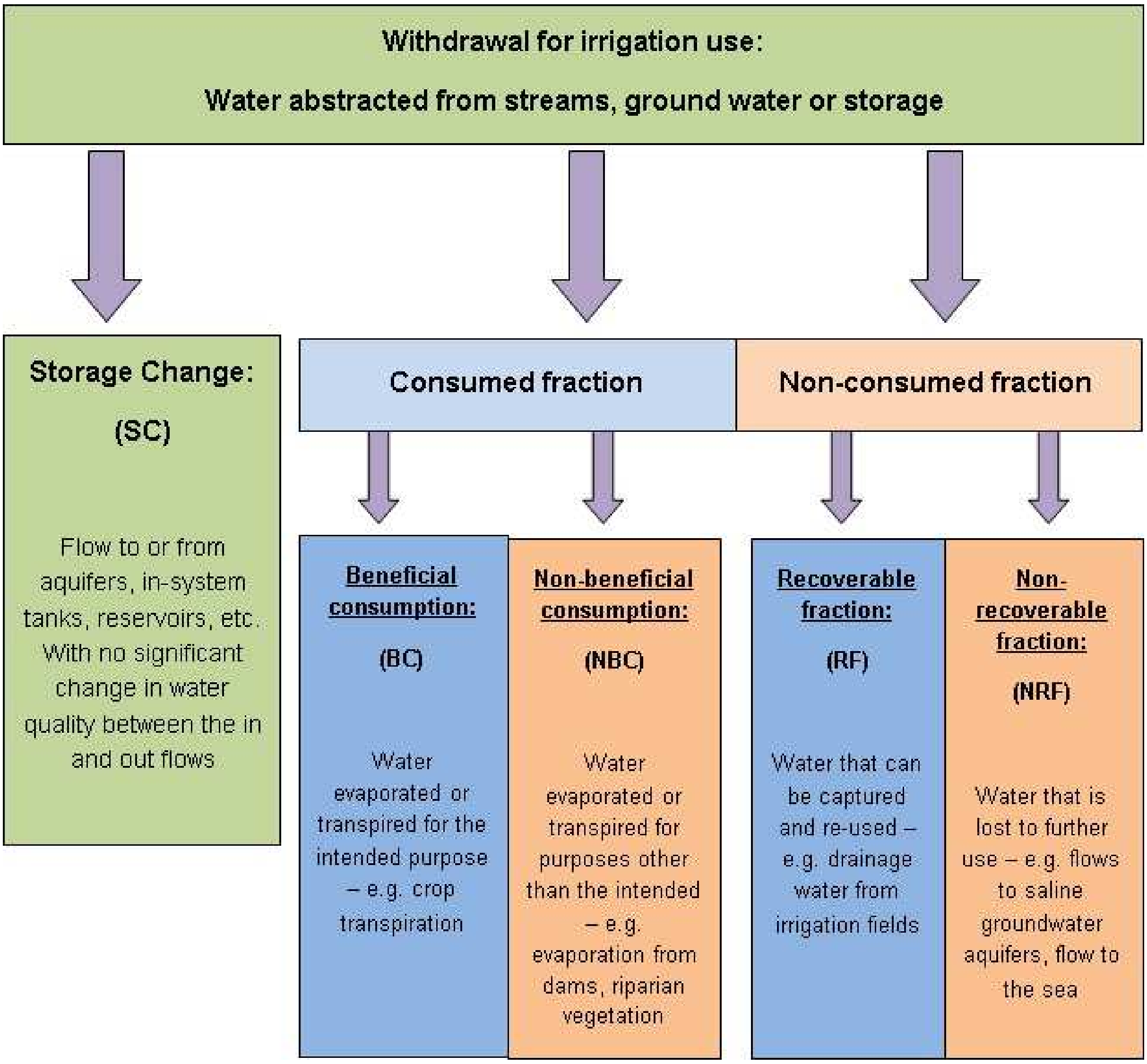


Figure 8-1 ICID analytical framework for irrigation water management (after Perry, 2007)

Definition of terms:

1. Water use: any deliberate application of water to a specified purpose. The term does not distinguish between uses that remove the water from further use (evaporation, transpiration,

flows to sinks) and uses that have little quantitative impact on water availability (navigation, hydropower, most domestic uses).

2. Withdrawal: water abstracted from streams, groundwater or storage for any use – irrigation, domestic water supply, etc.

a. Changes in storage (positive or negative) – changes in storage include any flows to or from aquifers, in-system tanks, reservoirs, etc. The key characteristic of storage is that the water entering and leaving is essentially of the same quality.

b. Consumed fraction (evaporation and transpiration), comprising:

i. Beneficial consumption: water evaporated or transpired for the intended purpose – for example evaporation from a cooling tower, transpiration from an irrigated crop.

ii. Non-beneficial consumption: water evaporated or transpired for purposes other than the intended use – for example, evaporation from water surfaces, riparian vegetation and waterlogged land.

c. Non-consumed fraction, comprising:

i. Recoverable fraction: water that can be captured and re-used – for example, flows to drains that return to the river system and percolation from irrigated fields to aquifers; return flows from sewage systems.

ii. Non-recoverable fraction: water that is lost to further use – for example, flows to saline groundwater sinks, deep aquifers that are not economically exploitable, or flows to the sea.

The basis of the framework is that any water withdrawn from a catchment for irrigation use will contribute either to storage change, to the consumed fraction or to the non-consumed fraction at a point downstream of the point of abstraction. The water that is consumed will either be to the benefit of the intended purpose (beneficial consumption) or not (non-beneficial consumption). Water that is not consumed, but remains in the system, will either be recoverable (for re-use) or non-recoverable (lost to further use). To improve water availability in the catchment, the relevant authority will have to focus its attention on reducing non-beneficial consumption and the non-recoverable fraction.

The advantages of using a water balance approach are the following:

- It can be applied at all levels of water management and potentially to all water-use sectors within a catchment
- It necessitates the management authority to develop an understanding of water movement within its area of jurisdiction through proper hydrological analysis

This approach avoids the use of confusing performance indicator terminology.

8.2 Inflows

Although measurement of the inflow into the JIA scheme has been implemented, the many disruptions in taking readings make the flow records very incomplete. However, the system is now ready for monitoring.

8.3 Consumptive use

The supply to individual water users is not measured. However, as described in Chapter 4 of this report, four farm take-off points (sluice-gates) have been equipped with measuring devices. These are monitored by MBB.

8.4 Outflows

Water flowing from the scheme out of its area of operation can be classified as either recoverable (drainage from field back into the river, reject flows from canals back into the river) or non-recoverable (flow into saline groundwater, flow into the sea).

Outflows are not measured in the JIA scheme, but it can safely be said that the non-recoverable fraction is negligible in relation to the recoverable fraction.

8.5 Measurement the quality of water used

Water quality measurements were done at a number of locations in the scheme over the past 18 months. The results of these measurements as well as laboratory water analysis appear in **Appendix C**. Preliminary findings based on these measurements and analyses are:

- The quality of the water withdrawn from the Orange-Senqu is of good quality (S?C? classification)
- There is not a significant reduction in the quality of the water over the irrigation season
- There is not a significant drop in quality of the water along the canal route (from the most upstream to the most downstream farm)
- The rise in temperature of water in the canal is greater than 7°C. This results in additional algae growth in the canals towards the lower sections of the canals.

8.6 Overall scheme water balance

Due to the reasons given in the previous paragraphs, a water balance for the JIA scheme based on measurements could not be done. However, with the proper functioning of the systems implemented in the scheme during the next irrigation season, a water balance will be possible. For this balance it will be necessary to consider conveyance and operational losses.

Table 8-1 shows the theoretical water balance. The water requirement (on scheme level) is based on SAPWAT analyses, taking into account crops, irrigation systems and climate. The results of the SAPWAT analyses are shown in Appendix D. Table 8-1 also shows the scheme enlistment, illustrating that, on a scheme level, the water use is theoretically well within the water-use rights of the scheme. However, if all cash crop fields are double cropped, the water use will be approximately the same as the enlisted volume.

Table 8-1 Theoretical water balance for the JIA scheme

Crop	Irrigation Water Requirement (mm)						Irr Rqmnt
	Flood	Laser Flood	Pivot	Sprinkler	Micro	Drip	(m^3)
Baby Marrow	503	486				434	265,786
Brinjals	645					413	28,298
Butternut	573		483	483		411	287,636
Cabbage						291	24,033
Chilli	900					573	49,795
Cow Candy	600						3,854
Cucumber	722					484	21,850
Dates	2132						28,583
Gemsquash	468					365	132,292
Grapes	1787	1651		1468	1374	1289	2,365,726
Greenbeans						287	115,918
Herbs						385	5,689
Luserne	1843			1484			3,840,866
Maize	1133						253,735
Mango	2537				2043	1925	1,166,525
Melon	699	580				537	28,255
Oats/Sorgum	1254						68,821
Oats/Sorgum	1254						82,778
Onions			493	493			132,224
Oranges	1977						114,945
Pattypans	503						11,621
Peppers						551	153,690
Pumpkin	511					400	176,003
Beans						349	16,300
Sweet potato				569			17,070
Sweetcorn						402	11,336
Tomato	746	674				584	853,294
Unknown	1094						116,908
Total (m^3)	591244	31378	21669	21723	226428	144941	10,373,828
Enlistment for 883 Ha @ 15000 m^3	15,000						13,255,500

9 EXISTING WATER MANAGEMENT MEASURES AND PROGRAMMES

9.1 Overview (JIA to complete)

The key irrigation best management practices that are demonstrated by the JIA are listed below. It should be emphasised that a number of these practices were made possible by the demonstration project funded by UNOPS, and the JIA is grateful that their project was selected as a demonstration site.

- The management and operations team maintains a high level of service to irrigators
- The recent promotion of laser levelling of flood irrigation areas is resulting in an increase in laser levelling for flood irrigation. Although a very small percentage of existing flood irrigation land has been laser levelled, it is expected that there will be a rapid move towards this type of irrigation
- Invoicing *of irrigators for water used is done every six months retrospectively. A record is kept of every irrigator's requests and receipts*
- The JIA provides water to ?? sluice-gates, of which four are measured
- *An Excel spreadsheet is used to manage the water measurements and prepare accounts for irrigators*
- *Unlawful use of water is monitored using a spot-check system and reported shortages in the canal*
- Relining of the canals at a cost of R 9 million
- Exposure to various 'tools' to use water more efficiently (demonstration project)
- Continuous maintenance of the scheme infrastructure
- Growing of crops under protection
- Mulching is used on many farms
- Limited cash crops are cultivated during the very hot period between November and February

10 WATER MANAGEMENT ISSUES AND GOALS

10.1 Overview of the management issues

In the absence of a formal water balance/budget, key issues with regard to the management of the scheme were identified for the purpose of this first Water Management Plan of the JIA, based on good knowledge of the scheme as well as discussions with people involved in the scheme and scheme management. The key issues are discussed in the following sections of this chapter, and are summarised in Table 10-1.

10.2 Flow measurement data and assessments

10.2.1 Adequacy of flow data

A start has been made to install flow measurement in the scheme. This should ideally be extended to a few other critical positions in the canal system. The most important of these are:

- Water reject positions (those with significant flows)
- Just upstream of the three river pump stations
- Pump stations of JIA members on the river
- Farmer off-takes

Figure 10-1 provides a schematic representation of the locations of the above in the JIA scheme.

Certain of these measurements will be more difficult and costly to implement than others, and prioritisation is necessary to suit the available budget and level of importance. One consideration would be to equip the measurement equipment with telemetry in order to read remotely from the JIA office and/or from service providers

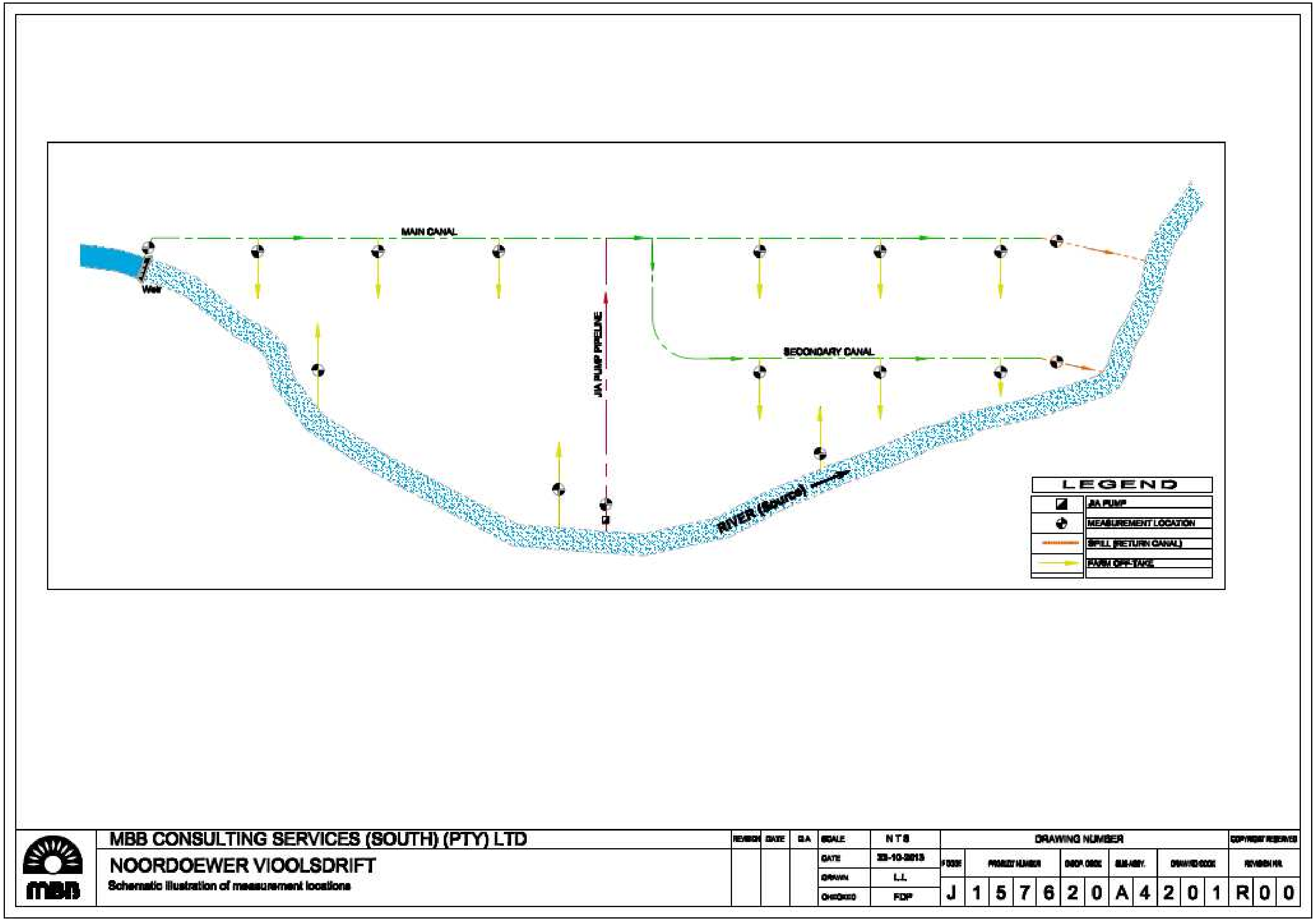


Figure 10-1 Schematic layout of the scheme with ideal water measurement system

10.2.2 Management Goal 1

The proposed measurement will address the following in an effort to reach this goal of improved management of the scheme:

- Measured information about in- and out-flows of the JIA scheme
- Consumptive use in the scheme
- Losses in the scheme
- Better management of JIA pumps

10.3 Operational water-management issues

10.3.1 The installed WAS is not operational yet

The water administration system (WAS) has been implemented in the scheme, but is not yet fully operational. This software package is a tool for irrigation schemes to optimise their irrigation water management and to minimise management-related distribution losses in a bulk supply system. It consists of seven modules, and these modules can be implemented separately or as a whole.

The modules are:

(i) Administration module

(ii) Water order module

(iii) Water accounts module

(iv) Water release module

(v) Measured data module

(vi) Crop water use module, and

(vii) Report module

In recent years there has been a problem with continuity of JIA personnel, and therefore also with the efficiency of use of administrative processes/tools. The WAS software can greatly assist in standardising the JIA procedures.

10.3.2 Management Goal 2

Completion of data population of the WAS program should be done and the software should be fully functional within six months after the completion of the WMP. The WAS program will standardise certain administrative functions of the JIA, and will be an excellent tool to assist with system administration and operations.

10.3.3 Consider (partial) reintroduction of 'turn' system

It is unavoidable that some of the water pumped into the canal system (at considerable cost in terms of electricity) returns to the river at the end of an irrigation day (when farmers stop with irrigation while canals are still running).

A 'turn' system to manage the canal operation (a system whereby farmers take turns to receive water) will greatly reduce the need to run the JIA river pumps, or even make it completely unnecessary to run them during the routine operation of the scheme.

Problems experienced in the Duin canal will also benefit from applying a turn system in this section of the scheme.

10.3.4 Management Goal 3

A (partial) turn system will improve scheme operation and will reduce running costs.

10.4 Infrastructure-related issues

In order to properly develop the water management plan, it will be necessary to do an assessment of the overall condition of the facilities to identify potential issues. The following paragraphs describe possible issues in this regard.

10.4.1 Scheme balancing capacity

Night storage dams will greatly decrease the pressure on the canal system, to the extent that there will be little or no need to run the six augmentation river pumps. The feasibility of night storage dams should be investigated.

These dams will be more applicable to take-offs from which pressurised irrigation is done (with pumps). For a flood irrigation system with balancing, a pump will have to be incorporated to lift the water from the dam basin into the irrigation furrows.

10.4.2 Management Goal 4

There are five night storage dams in the JIA scheme (two of these were built during the last irrigation season). The absence of these dams limits the security of water supply during normal operation in the absence of a turn system, during maintenance periods or when major canal failures are experienced. The goal is to investigate the possibility of constructing additional storage capacity that will assist in operating the system as effectively as possible.

10.4.3 Canal maintenance

The present canal maintenance is done well. Certain sections of the canal system require more maintenance than others, e.g. the sand accumulation in the Noordoewer canal. Consideration should be given to measures that can be applied to reduce overall maintenance costs. Using (chemical) treatments against algae and water grasses is another example.

10.4.4 Management Goal 5

Implementation of measures that will reduce maintenance costs will lead to a saving in running costs.

10.4.5 Irrigation-scheduling tools

Several types of very useful irrigation-scheduling 'tools' have been implemented in the JIA scheme under the UNOPS Demonstration Project. A good understanding of the information produced/generated by these tools, and an easy process to circulate this information among JIA members, will certainly increase the efficiency of irrigation in the scheme.

At present a webpage is being implemented on which all the relevant information will be published, and which will be accessible to all JIA members.

10.4.6 Management Goal 6

Making use of scheduling tools has been identified as a BMP that will contribute significantly towards more efficient irrigation. Best use should be made of the equipment and software implemented under the UNOPS project.

10.5 Institutional water management Issues

10.5.1 Updating and implementing the Water Management Plan

The JIA will be responsible for the annual updating and implementation of the WMP for the scheme. A decision needs to be taken regarding the responsible role players for the different tasks involved. Responsibilities in this regard will be:

- Record flow measurements obtained from meters installed in the system
- Use the WAS program to generate relevant reports and submit these to relevant authority on a quarterly basis
- Develop improved targets for water savings
- Maintain and modernise irrigation infrastructure
- Consider WC/WDM initiatives that have been successful in other schemes
- Review and update WMP annually

10.5.2 Management Goal 7

Implement, monitor, review and update the WMP and present reports on the status of water losses, water savings targets, goals and objectives.

10.6 Summary

Table 10-1 summarises the water management issues described in the previous paragraphs.

Table 10-1 Water management issues to be addressed in the JIA scheme

Item		Comments
(#)	Description	
1	Flow measurement data and assessments	Utilise instruments which will enable a water balance analysis for the scheme
2	Operational water management issues	Utilise WAS system and consider meassures to improve efficiency of operations
3	Infrastructure related issues	Consider investment in infrastructure which will lead to a reduction in running costs of the scheme
4	Institutional Water Management Issues	Implement the WMP

11 JIA WATER MANAGEMENT PLAN

11.1 General

The development of a WMP is a process with an annual cycle, which can assist WUA/IBs in realising the economic and social benefits of improved water-use efficiency. Specific financial benefits flow from this. Depending on the crop type, markets and water supply costs, these include any or all of the following:

- Improved yields,
- Improved quality of produce, especially for the export markets, which pay a premium for quality,
- Reduced water supply costs,
- Reduced water wastage, therefore extra water for sale and increased income to the WUA, and
- Easier management, especially with automated systems.

11.1.1 Legal provision for developing and implementing a WMP

(Confirm which South African and Namibian legislation applies to the JIA scheme, and what the legal requirements are to which the JIA has to conform).

11.1.2 Setting of water savings targets

The water losses (non-recoverable, non-consumed fraction) in the JIA scheme are considered to be low. No breakdown of losses was done for the purpose of this WMP, and a target of approximately 15% of total inflow should be set in this regard.

11.2 Action plan for implementation

The following paragraphs describe the goals identified for implementation, and the action plan appears in Table 11-1.

11.2.1 Measurement of water

It would be ideal to have flow measurements at all locations as described in Section 10.2. However, due to the high costs involved, this will not be achievable in the short term. Information that can already be obtained from the existing flow meters in the scheme should be used to assist in the management of the water supply.

The following additional measuring instruments will be considered for introduction during the implementation of this WMP (next 12 months):

- **(JIA)**
- …….
- ….

11.2.2 Measurement of weather, soil moisture and water quality

The BMPs implemented under the UNOPS project are powerful instruments for improving the water use in an irrigation scheme, and the JIA fully realise the value thereof and opportunity to be selected as the site where a demonstration project was to be installed. A special effort will be made to maintain the equipment and to utilise the results of the measurements and analyses as well as possible to improve the irrigation efficiency of the JIA scheme, and to reduce the operational costs of the scheme.

11.2.3 Implementation of WAS program

The full implementation of the WAS software should improve the operation of the JIA irrigation scheme substantially. The action plan to follow is:

Table 11-1 Action plan to implement WMP (JIA to complete)

Item		Action Plan	Time line	Responsibility
(#)	Description			
1	Flow measurement data and assessments	Make use of instruments already implemented	...	....
		Implement further meters accrding priority	...	....
2	Operational water management issues	Populate the WAS system	...	....
		Use WAS for scheme administration	...	....
		Consider (partial) reintroduction of turn system	...	....
3	Infrastructure related issues	Consider additional scheme balancing (night dams)	...	....
		Address problem sections in the canal system	...	....
		Make optimal use of scheduling tools already implemented	...	....
4	Institutional Water Management Issues	Implement, monitor, review and update the WMP	...	....

11.3 Funding of the implementation of the WMP in the JIA scheme

Substantial costs will be incurred in the implementation and operation of the WC/DM measures described in this WMP.

12 CONCLUSIONS AND RECOMMENDATIONS

Operating as it does as a cross-border irrigation scheme, it will be important to establish the appropriate legislation under which the JIA falls and the legal requirements in this regard. The WMP was compiled in terms of the guidelines developed by the South African Department of Water Affairs.

This WMP for the JIA irrigation scheme was developed to address water losses in the scheme and to improve the irrigation water management thereof. This is the first WMP for the scheme, and it should be reviewed and updated on an annual basis.

Much has already been done in the scheme to eliminate water losses. The UNOPS demonstration project contributed considerably to this, and offers opportunities on which future WC/DM initiatives by the JIA can be built.

13 REFERENCES

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