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THE DEVELOPMENT OF THE LIMPOPO WATER MANAGEMENT AREA NORTH RECONCILIATION STRATEGY

WATER REQUIREMENTS AND RETURN FLOWS

Supporting Document 1: Irrigation Assessment

FINAL

FEBRUARY 2016

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Limpopo Water Management Area North Reconciliation Strategy

Date: February 2016

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Executive summary

The registration process required that all water uses, regardless of the legal status thereof, had to be registered. The only registration requirement was that it must have been an existing use in the qualifying period, whether lawful or not. The qualifying period for groundwater resources was 1 October 1996 to 30 September 1998. For surface water resources the qualifying period was 1 October 1997 to 30 September 1999. The validation of registered water use was therefore critical for the management and control of resources since lack thereof may lead to the establishment of claims to water due to over allocation, an unfair or disproportionate use of water from a resource. The main purposes of the validation and verification processes were inter alia to: (i) determine water use for the 1998/99 and current periods, (ii) verify the extent of existing lawful use and (iii) provide inputs for hydrological modelling.

During the registration process a total taking 495.3 million m^3 was registered for irrigation purposes. The existing lawful water use was determined as 435.0 million m^3/a. The net result of the validation process is an over registration of some 60.3 million m^3/a.

When the existing lawful use of 435.0 million m^3/a is compared with the 1998/99 water use of some 448.8 million m^3/a, it is evident that water users were abstracting some 13.8 million m^3/a more than they were lawfully entitled to. The total water use decreased between 1998/99 and 2013 and the current annual abstraction from all water resources (394.9 m^3/a) is some 40.1 million m^3 less that the existing lawful entitlement.

In terms of area under irrigation, maize (16.6%) is the crop with the largest area under irrigation followed by potatoes (12%) and wheat (10.7%). The top ten crops represent 79% of the total annual crop area under irrigation.

The irrigation efficiency within the Study Area based on irrigation systems is high. 57.7% of all the crops under irrigation are planted under centre pivot irrigation, followed by 20.4% drip irrigation systems. These two systems represent 78% of the total area under irrigation.

An increase in the total storage since 1998 was detected. The total storage in 1998 was some 178.2 million m^3. The latest storage identified in 2013 is some 183.5 m^3. The existing lawful storage is some 155.7 million m^3. While some of the increases in storage were lawful there is currently approximately 27.8 million m^3 of the current storage development that may be unlawful.

All figures are validated totals (preliminary) as the verification of water use under section 35 of the National Water Act (NWA) has not been completed. Although the whole verification process has not been completed yet, some 55% in terms of volume has been finalised. It is therefore necessary to finalise the section 35 process as soon as practically possible.

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LIST OF ABBREVIATIONS AND ACRONYMS

AECOM	AECOM SA (Pty) Ltd
ARDC	Agricultural and Rural Development Corporation
DTM	Digital Terrain Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
FAO	Food and Agriculture Organisation
GIS	Geographical Information System
GWCA	Government Water Control Area
HDI	Historically Disadvantaged Individuals
LDA	Limpopo Department of Agriculture
NWA	National Water Act (1998)
NWRS-1	National Water Resource Strategy First Edition
NWRS-2	National Water Resource Strategy Second Edition
PPP	Public Participation Programme
RSA	Republic of South Africa
RESIS	Revitalisation of Smallholder Irrigation Schemes
SAPWAT	SAPWAT is a computer program used for estimating crop irrigation requirements in South Africa and has been released as Water Research Commission Report No. 624/1/99. The program combines crop and climatic databases that enable the water manager to develop realistic estimates that reflect the complex factors that determine average monthly crop water requirements. The program contains extensive default information on crops, climate, soil, irrigation methods and management practices.
WARMS	Water Authorisation and Resource Management System
WCWDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WRYM	Water Resources Yield Model
WRPM	Water Resources Yield Model

LIST OF UNITS

a	annum
ha	hectare
kℓ	kilolitre
km	kilometer
km^2	square kilometre
ℓ/c/d	litre per capita per day
ℓ/s	litre per second
m	metre
m^3	cubic meter
m^3/a	cubic meter per annum
$m^3/ha/a$	cubic meter per hectare per annum
Mℓ/d	megalitre per day
mm	millimetre

1 INTRODUCTION

1.1 APPOINTMENT OF PROFESSIONAL SERVICE PROVIDER (PSP)

The Department of Water and Sanitation (DWS), then Department of Water Affairs (DWA) appointed **AECOM SA (Pty) Ltd** in association with three sub-consultants **Hydrosol**, **Jones and Wagener** and **VSA Rebotile Metsi Consulting** with effect from 1 March 2014 to undertake the **Limpopo Water Management Area North Reconciliation Strategy**.

1.2 BACKGROUND TO THE PROJECT

The DWS (then DWA) identified a need for the development of the Limpopo Water Management Area (WMA) North Reconciliation Strategy. The Limpopo WMA North refers to the Limpopo WMA described in the first edition of the *National Water Resource Strategy* (NWRS-1) published in 2004. The 19 initial WMAs were consolidated into nine WMAs during 2012 and acknowledged in the second edition of the *National Water Resource Strategy* (NWRS-2) of 2013. The newly defined Limpopo WMA also includes the original Crocodile (West) and Marico WMA as well as the Luvuvhu River catchment, previously part of the Luvuvhu and Letaba WMA. However, these additional areas will not be part of this Reconciliation Strategy.

The Limpopo WMA North comprises of six main river catchments; Matlabas, Mokolo, Lephalala, Mogalakwena, Sand and Nzhelele and are shown in **Figure 1.1**. The very small Nwanedi River catchment forms part of the Nzhelele River catchment. Most of these river catchments rely on their own water resources and are managed independently from neighbouring catchments. This implies that some river catchments require separate and independent reconciliation strategies whilst others need integrated water management reconciliation strategies.

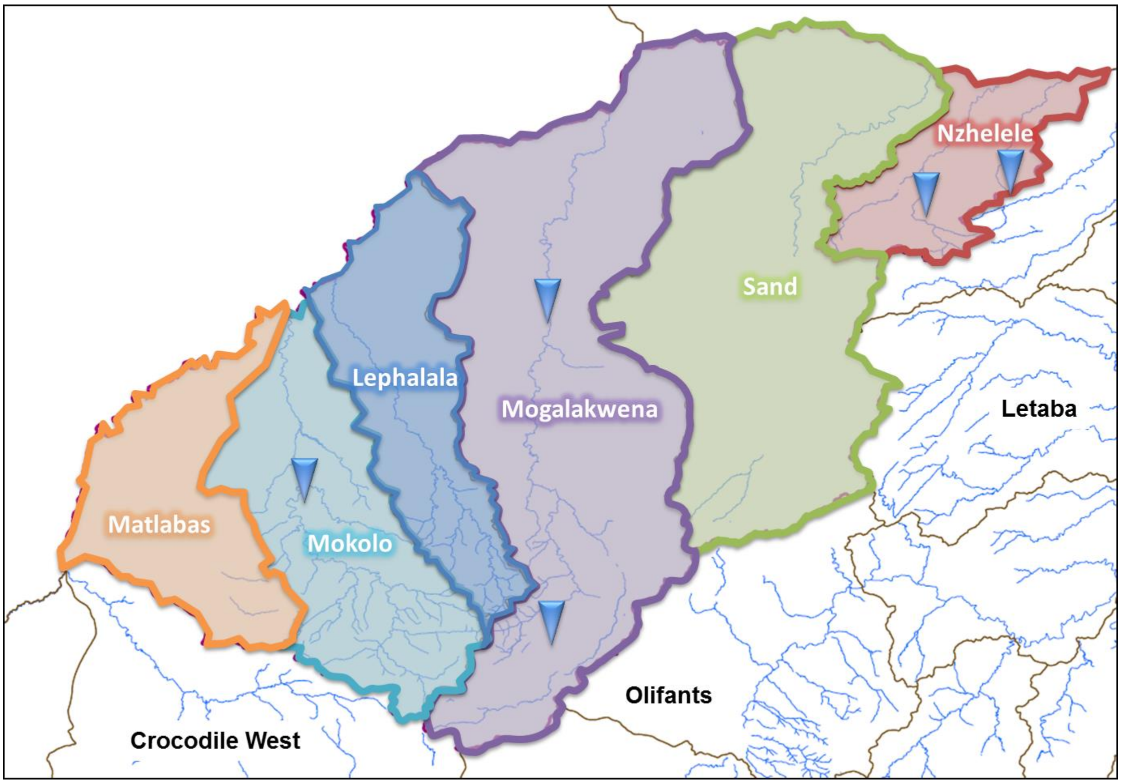

Figure 1.1 Overview of the catchments of the Limpopo WMA North

The main urban areas within the WMA include Mokopane, Polokwane, Mookgophong, Modimolle, Lephalale, Musina and Louis Trichardt. Approximately 760 rural communities are scattered throughout the WMA, mostly concentrated in the central region. The main economic activities are irrigation and livestock farming as well as expanding mining operations due to the vast untapped mineral resources in the area. The water resources, especially surface water resources, are heavily stressed due to the present levels of development. It is crucial that water supply is secured and well managed.

The most western area of the Limpopo WMA North, the Matlabas River catchment, is a dry catchment with no significant dams and with a low growth potential for land-use development.

The large Mokolo Dam, in the Mokolo River catchment, supplies water to the Matimba Power Station, Medupi Power Station, Grootegeluk Coal Mine, the Lephalale Local Municipality (LM) as well as a number of downstream irrigators. The dam is able to meet the bulk of the current requirements but will in future rely on transfers from other WMAs to meet the water requirements at a sufficiently high assurance of supply.

The middle reaches of the Lephalala River catchment have a high conservation value with irrigation activities dominant in the remainder of the catchment. Irrigation in this area is supplied by surface water and alluvial aquifer abstraction.

The bulk of the water resources in the Mogalakwena River catchment have been fully developed. The Doorndraai Dam is over-allocated. Additional water to support the rapid expanding mining activities in the vicinity of Mokopane needs to be augmented by transfers from the Flag Boshielo Dam in the adjacent Olifants

River Catchment. Glen Alphine Dam presently supplies water to emerging farmers, who has not yet taken up their full allocated quota, and is expected to supply the growing domestic requirements in future.

Groundwater resources in the Mogalakwena and the Sand river catchments have been extensively utilised, and possibly over-exploited by the dominating irrigation sector. The expanding urban and industrial requirements of Polokwane and Makhado LMs, currently supplied by Albasini Dam, rely heavily on water transfers from adjacent WMAs. This includes transfers from the Ebenezer Dam, Dap Naude Dam, Flag Boshielo Dam and Nandoni Dam in the Olifants WMA.

Domestic and irrigation water in the small but highly developed Nzhelele River catchment is supplied through the Mutshedzi Dam Regional Water Supply Scheme and the Nzhelele Dam Regional Water Supply Scheme as well as extensively from groundwater resources. The inflows to the Mutshedzi and Nzhelele dams have been reduced as a result of afforestation upstream of these dams. The area is in deficit due to the over-allocation and over development of irrigation.

The Sand and Nzhelele river catchments have high coal mining potential but the availability of local water resources may limit future mining development.

1.3 STUDY AREA

The Limpopo WMA North is the most northern WMA in South Africa and refers to the area described as the Limpopo WMA in NWRS-1. Refer to **Figure 1.2** for the location and general layout of the Study Area. The areas indicated in grey show the additional catchment and WMA areas included in the Limpopo WMA as per NWRS-2 and which do not form part of the Study Area for this reconciliation strategy.

The Limpopo WMA North forms part of the internationally shared Limpopo River Basin which also includes sections of Botswana, Zimbabwe and Mozambique. The Limpopo River forms the entire length of the northern international border between South Africa and Botswana and Zimbabwe before flowing into Mozambique and ultimately draining into the Indian Ocean. The dry Limpopo WMA North is augmented with transfers from the adjacent Letaba, Olifants and Crocodile West river catchments. No transfers are currently made from the Limpopo WMA North to other WMAs.

The main rivers in the Study Area, which form the six major catchment areas, are the Matlabas, Mokolo, Lephalala, Mogalakwena, Sand and Nzhelele rivers. These rivers, together with other smaller tributaries, flow northwards and discharge into the Limpopo River.

The climate over the Study Area is temperate and semi-arid in the south to extremely arid in the north. Mean annual rainfall ranges from 300 mm to 700 mm with the potential evaporation well in excess of the rainfall. Rainfall is seasonal with most rainfall occurring in the summer with thunderstorms. Runoff is low due to the prevalence of sandy soils in the most of the Study Area, however, loam and clay soils are also found.

The topography is generally flat to rolling, with the Waterberg on the south and the Soutpansberg in the north-east as the main topographic features. Grassland and sparse bushveld shrubbery and trees cover most of the terrain.

The southern and western parts of the WMA are mainly underlain by sedimentary rocks, whilst metamorphic and igneous rocks are found in the northern and eastern parts. With the exception of some alluvium deposits and dolomites near Mokopane and Thabazimbi, these formations are mostly not of high water bearing capacity. The mineral rich Bushveld Igneous Complex extends across the south-eastern part of the WMA, and precious metals are mined at various localities throughout the area. Large coal deposits are found in the north-west.

Several wildlife and nature conservation areas have been proclaimed in the WMA, of which the Nylsvley Nature Reserve, Mapungubwe National Park and the Marekele National Park are probably the best known.

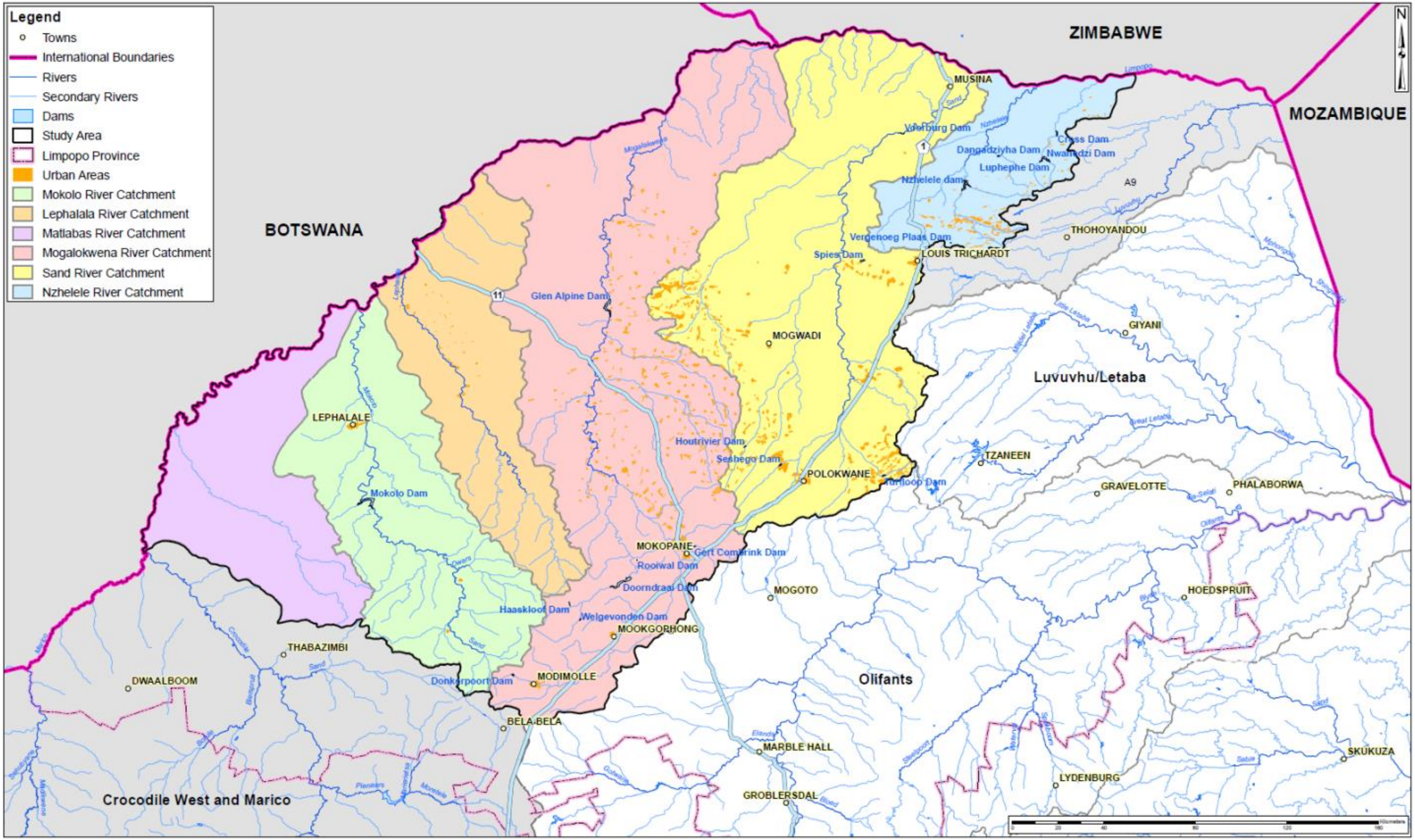

Figure 1.2 General layout of the Study Area

1.4 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to formulate a water resource reconciliation strategy for the entire Limpopo WMA North up to 2040. The reconciliation strategy must a) address growing water demands as well as water quality problems experienced in the catchment, b) identify resource development options and c) provide reconciliation interventions, structural and administrative/ regulatory. To achieve these objectives, the following aspects are included in the study:

- Review of all available information regarding current and future water requirements projections as well as options for reconciliation;
- Determine current and future water requirements and return flows and compile projection scenarios;
- Configure the system models (WRSM2000 rainfall-runoff catchment model, also known as the Pitman Model, the Water Resources Yield Model (WRYM) and the Water Resources Planning Model (WRPM)) in the Study Area at a quaternary catchment scale, or smaller, where required, in a manner that is suitable for allocable water quantification. This includes updating the hydrological data and accounting for groundwater surface water interaction;
- Assess the water resources and existing infrastructure and incorporate the potential for Water Conservation and Water Demand Management (WCWDM) and water reuse as reconciliation options; and
- Develop a preliminary short-term reconciliation strategy followed by a final long-term reconciliation strategy.

1.5 SCOPE OF THIS REPORT

The main scope of this task, and ultimately report, is:

- the quantification of current and existing (1997/99) water use;
- determination of the legality and the quantities of water that the users are legally entitled to;
- reporting on the lawfulness and extent of water use in terms on section 35 of the National Water Act (NWA) of 1998;
- provision of water use patterns for use as input for the modelling of water within the Study Area;
- evaluation of the efficiency of water use in the agricultural sector, and
- a report, documenting the following:
  - A description of the steps and processes followed during the validation and verification of water use;
  - Underlying procedures for the classification of water use;
  - A schedule of validated and verified water use; and
  - Analysis of water use and water demand in the Study Area.

2 OVERVIEW OF VALIDATION AND VERIFICATION PROCESS

The validation of water use includes all the internal measures taken by DWS to ensure that all the information contained on the registration application is correct and that the information is correctly captured in the Water Authorisation and Resource Management System (WARMS) database. Validation therefore is the checking of all the relevant data and correctness of the submitted registration information using the mechanisms in Section 35 of the NWA. This involves an audit of the WARMS data and using appropriate remote sensing data/ maps/ aerial photography or any other relevant information. The validation process should also highlight unregistered water uses. In terms of this Study the objective of validation would be the gathering of water use information in order to be used in the updating of the hydrology. The current yield of the Mokolo Dam could then also be confirmed.

Verification basically refers to the processes described under Section 35 of the NWA and is the next logical step once the validation process is completed. A responsible authority may, in order to verify the lawfulness or extent of an existing water use, by written notice require a person claiming an entitlement to that water use to apply for the verification of that use. A responsible authority may require the applicant to obtain and provide it with other information, in addition to the information contained in the application. The responsible authority may invite written comments from any person who has an interest in the matter and must afford the applicant an opportunity to make representations on any aspect of the application. The verification process is formal and has legal status. The objective of the verification can therefore be seen as the actions that are necessary to accomplish the finalisation of water use entitlements in order to allow for better management of the catchment.

From the initial WARMS registration information it was evident that water used for irrigation purposes constituted some 87% of the total annual taking of water and that the remaining 1% was represented by the Industry, Mining and Water Supply Service sectors. It follows that the main focus of the validation and verification study was on water used for irrigation. It is however important to note that the storage within a catchment can have a major impact on modelling. The registration process required that all properties with a total storage capacity in excess of 10 000 m^3 had to be registered. The validation of the storing of water therefore focussed on all identifiable storage structures and other impeding structures (specifically weirs) identifiable on the 1998/99 and current satellite imagery. Although the Department may decide that the storage does not have to be registered (if the total storage on a property is less than 10 000m^3), the information is available and would render a more accurate picture and enable better modelling.

The registration process required that all water uses, regardless of the legal status thereof, had to be registered. The only registration requirement was that it must be an existing use in the qualifying period, whether lawful or not. The validation and verification of registered water use was critical for the management and control of resources since lack thereof may lead to the establishment of claims to water due to over allocation, an unfair or disproportionate use of water from a resource. This can lead to the unacceptable situation that such use goes unnoticed or is perpetuated in future. Any unlawful water use must be curtailed as soon as possible especially with the high turnover in ownership as it places new owners (including HDI) in an untenable situation. There are also instances where water users who are entitled to use water were unaware of the registration process and consequently did not register their water use.

From the data obtained during the inception phase, some 3 623 properties were validated. A breakdown of the number of properties and validation results per tertiary drainage region are provided in Table 2.1.

Table 2.1 Status quo per tertiary drainage region

Catchment	# of properties	Registered volume (million m^3/a)		Existing lawful use (million m^3/a)		Present day use (million m^3/a)	
		Borehole	Surface	Borehole	Surface	Borehole	Surface
Matlabas	71	3.19	3.59	1.30	2.33	1.40	2.88
Mokolo	632	10.40	59.96	4.98	70.43	5.68	55.78
Lephalala	327	10.85	30.90	16.45	27.39	12.99	30.88
Mogala-kwena	592	12.49	25.49	16.91	15.61	17.57	19.64
	74	2.50	1.05	5.61	1.11	2.97	1.40
	308	34.64	12.04	27.14	3.03	26.39	6.81
Sand	963	148.27	56.18	97.07	34.54	83.62	36.06
	126	17.87	1.30	15.76	0.16	15.25	0.38
Nhzelele	530	4.73	59.90	5.90	56.17	5.64	45.10
Total	**3 623**	**244.93**	**250.40**	**191.12**	**210.77**	**171.50**	**198.94**

3 VALIDATION OF WATER USE

The validation of water use focused on existing (1996-1998 for groundwater and 1997 – 1999 for surface water) and current (2009-2012) water use. Part 2 of the *"Guide to Determine the Lawfulness of Existing Water Uses"* and the latest "*Addendum to the Guide*" provided an exhaustive breakdown of the processes to be followed when water uses are validated.

Although the processes described in the guide were adhered to, the major processes followed during the validation of water uses are described in detail in the following section.

3.1 PROCESS WARMS DATA AND INCORPORATE INTO CUSTOM DATABASE

Most of the registration information is/was entered into WARMS but is not always readily accessible. Currently, this data cannot easily be queried to give certain answers for a specific scenario *(e.g. what is the total area under maize, using centre pivots, for quaternary catchment A51A?)*. Certain vital information such as the extent of a property is necessary during the verification process but the population of this information was not compulsory in the earlier versions of WARMS. This information was obtained and captured on the custom database. Being available in a separate database meant that batch recalculation and updating of irrigation requirements, abstraction volumes, etc. was very quick and easy.

3.2 AUDIT WARMS DATA

The first step in the auditing process was to ensure that the information captured on WARMS and printed out on the Registration Certificate was correct. Apart from checking the correctness of the data, this was also the first step in standardisation. Elements such as language, spelling and standard description of water resources were checked. This is very important since "Nylrivier" and "Nyl River" are different sources for a software program and may lead to conflicting results when the database is queried in future.

Swapping the coordinates for the latitude and longitude of an abstraction point (taking of water) is very easy. Entered coordinates were therefore checked to ensure that the coordinates for any given registered taking of water are within the boundaries of a property or at least within a reasonable radius from that property. It is very unlikely that a property will receive water for irrigation from a borehole that is 20 km away.

Because Title Deed information is continuously changing, new data were obtained from the Registrar of Title Deeds when the study commenced to check and update registered property owners. This data was ordered in bulk electronic format and parsed programmatically to reduce human error as far as possible.

As with Title Deed information, cadastral data is dynamic and forever changing. Properties consolidated or subdivided since water uses were registered. Cadastral information is also ahead in time of Title Deed information and these discrepancies were sorted out and the changes noted for future reference.

3.3 OBTAIN SURVEY AND OTHER WATER RELATED INFORMATION

Several water right determination studies that included irrigation, which cover the Study Area or parts thereof, have been conducted in the past (see **Section 3.9**). Other data sources that were investigated and incorporated into the historical data pool included the Mokolo River, Glen Alpine Dam and Nzhelele River Irrigation Boards information and previous validation efforts for WMA. The data of the Mokolo River Government Water Control Area (GWCA) survey conducted in 1982 was only available in hard copy format and this data was manually captured in electronic format. The Hans Strijdom Dam Catchment GWCA and Nyl River GWCA survey information was available in electronic format and subsequently merged into the custom validation database.

Each surveyed property was verified against the current registered properties (and the properties registered at the Registrar of Title Deeds) to check if any changes have taken place (subdivisions or consolidations) since the date of proclamation of the specific GWCA. These changes and the impact thereof were cross-referenced and amended to reflect the current situation. The historical information was of utmost importance during the determination of lawful water use.

Although lawful water use could have been determined as was envisaged in section 9, 9b and 10 of the NWA (No 54 of 1956) this was not addressed but will need attention when compulsory licensing is undertaken.

3.4 CAPTURE ENTITLEMENTS

During this phase, all gazetted notices, proclamations, entitlements, restrictions, GWCAs, Irrigation Boards and any other relevant information were captured on the Geographical Information System (GIS)GWCA and the supporting database. The total history was captured, showing which proclamations, notices, etc. were withdrawn, replaced or amended by what (if applicable) and on which date.

A map showing the different GWCAs and the Irrigation Board areas is included in **Appendix A.**

3.5 CALCULATE CROP WATER REQUIREMENTS

In order to calculate the crop irrigation requirements as accurately as possible, certain parameters had to be improved. SAPWAT is a computer program used for estimating crop irrigation requirements in South Africa and has been released as *Water Research Commission Report No. 624/1/99*. The program combines crop and climatic databases that enable the water manager to develop realistic estimates that reflect the complex factors that determine average monthly crop water requirements. The program contains extensive default information on crops, climate, soil, irrigation methods and management practices. The SAPWAT program (version 2.6.1 – April 2003) had limited stations in the Study Area and this was not sufficient enough to cater for the different climatic regions. Areas had to be defined within which the irrigation requirements would be valid. By using the latest rainfall information supplied by the team responsible for the *updating of hydrology and systems yield models* and an agro hydrological data set obtained from the *South African Atlas of Agrohydrology and – Climatology* (2006), a SAPWAT station was created for each quaternary drainage region.

By using SAPWAT, standard crop irrigation requirements were determined for each quaternary drainage region.

3.6 SATELLITE IMAGE PROCESSING

The benchmark for determining the lawfulness of existing water uses is aerial photography taken within the qualifying period (1 October 1996 – 30 September 1999). Any other imagery/ photography taken after 30 September 1999 is for water management and control purposes (to identify possible increases/reductions in irrigated areas and/or storage volumes).

Unfortunately no aerial photography existed for the 1996-1999 period. In the absence of aerial photographs taken close to the date of the promulgation of the NWA, Landsat 5 and 7 images were used as the main source to establish existing and current water use. For validation purposes, three dates were identified as important. The first two dates were September 1998 (for groundwater) and September 1999 (for surface water), just before the commencement of the relevant sections of the NWA. The third date reflected the current situation and was selected after all the relevant variables were considered.

The Landsat range of satellites passes over the same location every 16 days. The aim was thus to obtain cloudless images as close to the specified dates as possible. The images used during the study are shown in **Table 3.1**.

Table 3.1 Landsat satellite images

	Landsat scenes		
	170-077	**171-076**	**171-077**
Acquisition dates	1998-07-31	1998-09-24	1998-09-24
	2001-05-12	2004-08-23	1999-08-26
	2002-09-04		2001-06-04
	2004-08-16		2004-09-08

Due to the size of Landsat images (185 km x 185 km), the ortho-rectification is not precise and some adjustments were necessary. This was not achievable on a global scale and the images were therefore divided into smaller blocks, normally based on the 1:50 000 topo-cadastral grids. These smaller individual images were then re-ortho-rectified for a perfect fit onto the cadastral information.

3.7 IRRIGATION IDENTIFICATION

3.7.1 Digitising of irrigated and other cultivated fields

Satellite images were ortho-rectified and the updated cadastral boundaries of the GIS were used as an overlay and no scale determination or further correction was necessary. The areas of irrigation and storing of water on the different dates for each property were identified using spectral analysis (highlighting areas based on their relative spectral signature). The areas identified on the satellite images were manually digitized from the images to ensure that the areas were as accurate as possible.

In the case of pivot irrigation, not all circles were classified as irrigation. By using the information obtained from the water users, the WARMS database and through visual inspection, the team tried to establish the physical number of machines and cropping pattern and classified the fields accordingly (e.g. tobacco is normally cultivated on the same field every third year).

During the linking of WARMS registration information to the digitised fields as identified from the satellite imagery, it became apparent that a lot of the registered crops (fields) could not be identified on the satellite images, especially deciduous orchards. In order to solve this problem and to ensure that the information provided to DWS was as accurate as possible, field visits to the different areas were scheduled.

In addition to irrigated fields, all other cultivated fields were digitised and classified as such. This was done to provide the team responsible for the updating of the hydrology and systems yield models with more accurate modelling capabilities since the characteristics of in terms of runoff etc. vary significantly between cultivated fields and normal veldt. Maps showing the identified fields for the different dates are included in **Appendix A**.

3.7.2 Crop identification

If a water use was registered, the data obtained from the WARMS was cross-referenced with the digitised feature to establish the type of crop. If a water use was not registered, the Maize/Wheat crop combination was used in most cases until the correct information is provided by the water user through the section 35 process or as part of a late registration.

3.7.3 Irrigation system identification

If a water use was registered, the data obtained from the WARMS was cross-referenced with the digitised feature to establish the irrigation system. If the water use was not registered and it could not be identified as centre pivot irrigation, “Sprinkler: Quick Coupling” was used as substitute irrigation system until the correct information is provided by the water user through the section 35 process or as part of a late registration.

3.7.4 Irrigation volume calculation

By using the type of crop and irrigation system per identified field, the irrigation volume was calculated using the field extent and the crop irrigation requirements (see **Section 3.5**). The calculated irrigation volumes were then captured in the custom database.

3.8 DIGITISING OF DAMS AND VOLUME DETERMINATION

The identification of storage structures and the calculation of storage capacities within the Study Area were critical for the calibration of the water use model and any subsequent simulations. By using aerial photographs, 1:50 000 topo-cadastral maps, satellite imagery, dam safety information, a Digital Terrain Model (DTM) and historic survey results, the area and depth of each storage structure was determined and used to calculate the storage capacity.

If a dam was surveyed during the field surveys conducted in the GWCAs and the dam remained unchanged, the capacity calculated during the field survey was assumed to be the most accurate data and that capacity was used.

Based on survey information and visual inspection of available data, storage structures were classified as storage, weirs, pans, gravel pits or mine dams (mining evaporation dams and sewage works).

Maps showing the identified storage structures for the different dates are included in **Appendix A**.

3.9 ESTABLISHING LAWFUL WATER USE

Some areas within the Study Area falls within GWCAs and Irrigation Boards while the rest is previously uncontrolled areas. In some cases the determination of lawful water use was a very complex and time-consuming task. In the case of a GWCA the water use on the date of proclamation needed to be established for each property, as it existed on **that date**. A typical problem occurred where a property falling within a GWCA had a certain “water right” on a specific date (date of proclamation of GWCA), say 1969. Since then the property was subdivided into three portions and one of these three was consolidated with another property. There was no quick fix and a timeline and the effect on water use authorisations had to be drawn up to verify the veracity of water use on an identified property.

3.9.1 Irrigation with surface water

a) Controlled areas

- **Mokolo River GWCA**

The Mokolo River GWCA was established by means of proclamation no. 276 of 24 October 1969. The provisional determination in respect of that portion of the GWCA upstream of the Hans Strijdom Dam was published in the Government Gazette on 24 July 1981 (Notice no. 1531). A notice was published in terms of section 62(2F)(a)) on 11 September 1987 (Notice no. 1928) where the maximum extent of land that could be irrigated, was provided. The notice stated that a maximum of 9 150 m^3 of public water may, if available, be used per annum for the irrigation of each hectare and this volume was used to determine the lawful water use.

If a piece of land was subdivided after the date of inclusion in the area, the owner of the original portion was authorised to determine at his/her discretion by agreement with the owner of the property subtracted, the quantity of water to be transferred to the new property. If the validation team found no agreement, the water use was temporarily apportioned according on the physical location of the irrigated fields during the field survey.

If two or more properties consolidated, the permissible uses were simply added together.

- **Hans Strijdom Dam Catchment GWCA**

The Hans Strijdom Dam Catchment GWCA was established by means of proclamation no. 165 of 20 September 1985. A general permission in terms of section 62 (2B) (a) of the Water Act of 1956, was published in the Government Gazette on 5 June 1987 (Notice no. 1229). In terms of the general permission no new water works may be erected and no existing water work altered of enlarged for the abstraction of any public water that may be used for irrigation and/or stock drinking purposes except by virtue of an authorisation issued in terms of section 62 (2H)(a) of the Water Act of 1956.

In respect of a piece of land with existing irrigation development, the owner of such piece of land (as registered in the office of the Registrar of Title Deeds on the date of inclusion) was provisionally entitled (until a notice was published in terms of section 62(2F)(a)), to continue by means of an existing water work with the abstraction or use of water for irrigation purposes of not more than the quantity of public water actually used for irrigation on that land during the period of twelve months immediately preceding the date of inclusion.

Permission was also granted to any person in control of a piece of land (as registered in the office of the Registrar of Title Deeds on the date of inclusion) and on which no irrigation development or less than 15 hectares of irrigation development existed, to abstract and use on such land a quantity of public water for the irrigation of a maximum of 15 hectares of the potentially irrigable area.

A maximum of 9 150 m^3 of public water may, if available, be used per annum for the irrigation of each hectare.

No water use allocations were published in terms of section 62(2F)(a) of the Water Act of 1956, and the lawful use was therefore taken as the use that existed on the date of inclusion if the irrigated extent was more than 15 hectares, or a maximum of 15 hectares per property (as registered in the office of the Registrar of Title Deeds on the date of inclusion) if the irrigable potential existed.

The lawful annual volume was calculated by multiplying the lawful irrigation area by 9 150 m^3/a.

If a piece of land was subdivided after the date of inclusion in the area, the owner of the original portion was authorised to determine at his/her discretion by agreement with the owner of the property subtracted, the quantity of water to be transferred to the new property. If the validation team found no agreement, the water use was temporarily apportioned according on the physical location of the irrigated fields during the field survey.

If two or more properties consolidated, the permissible uses were simply added together.

- **Doorndraai Dam Catchment GWCA**

The Doorndraai Dam Catchment GWCA was established by means of proclamation no. 193 of 9 November 1984 for the purpose of section 59(1)(b) of the Water Act of 1956, in order to exercise control over the abstraction, utilisation, supply or distribution of water from any public stream in the area for the purposes of section 62 of the Water Act of 1956. It was essential to establish the Control Area to protect the run-off to the Doorndraai Dam in the Sterk River which supply water to irrigators downstream thereof and to Potgietersrus Municipality for domestic purposes.

In terms of the general permission no new water works may be erected and no existing water work altered of enlarged for the abstraction of any public water that may be used for irrigation and/or stock drinking purposes except by virtue of an authorisation issued in terms of section 62 (2H)(a) of the Water Act of 1956.

In respect of a piece of land with existing irrigation development, the owner of such piece of land (as registered in the office of the Registrar of Title Deeds on the date of inclusion) was provisionally entitled (until a notice was published in terms of section 62(2F)(a)), to continue by means of an existing water work with the abstraction or use of water for irrigation purposes of not more than the quantity of public water actually used for irrigation on that land during the period of twelve months immediately preceding the date of inclusion.

A general permission in terms of section 62(2B)(a) of the Water Act of 1956, in connection with the abstraction and use of public water for irrigation purposes in the area was published by Government Notice 2432 of 9 November 1984. In terms of this notice, permission was granted to any person in control of a piece of land within the area on which no or less than 20 ha of irrigation development exist to abstract and use on such land a quantity of public water for the irrigation of a maximum of 20 ha of the potentially irrigable area thereof. A maximum of 7 200 m^3 of public water may, if available, be used per annum for the irrigation of each hectare.

A schedule of irrigation development (as it existed on the date of proclamation) was published in terms of section 62(2D)(a) of the Water Act of 1956, by means of notice No. 834 of 20 June 1997.

No water use allocations were published in terms of section 62(2F)(a) of the Water Act of 1956, and the lawful use was therefore taken as the use that was published in notice No. 834 of 20 June 1997 if the irrigated extent was more than 20 hectares, or a maximum of 20 hectares per property (as registered in the office of the Registrar of Title Deeds on the date of inclusion) if the irrigable potential existed.

The lawful annual volume was calculated by multiplying the lawful irrigation area by 7 200 m^3/a.

If a piece of land was subdivided after the date of inclusion in the area, the owner of the original portion was authorised to determine at his/her discretion by agreement with the owner of the property subtracted, the quantity of water to be transferred to the new property. If the validation team found no agreement, the water use was temporarily apportioned according on the physical location of the irrigated fields during the field survey.

If two or more properties consolidated, the permissible uses were simply added together.

- **Limpopo/Ngotwane GWCA**

The Limpopo River GWCA was established by means of proclamation no. 111 of 25 April 1969. In terms of the general permission no new water works may be erected and no existing water work altered of enlarged for the abstraction of any public water that may be used for irrigation and/or stock drinking purposes except by virtue of an authorisation.

Permission was also granted to any person in control of a piece of land (as registered in the office of the Registrar of Title Deeds on the date of inclusion) and on which no irrigation development or less that 35 hectares of irrigation development existed, to abstract and use on such land a quantity of public water for the irrigation of a maximum of 35 hectares of the potentially irrigable area. A maximum of 9 100 m^3 of public water may, if available, be used per annum for the irrigation of each hectare.

The lawful use was taken as the use that existed on the date of inclusion if the irrigated extent was more than 35 hectares, or a maximum of 35 hectares per property (as registered in the office of the Registrar of Title Deeds on the date of inclusion) if the irrigable potential existed. The lawful annual volume was calculated by multiplying the lawful irrigation area by 9 100 m^3/a.

If a piece of land was subdivided after the date of inclusion in the area, the owner of the original portion was authorised to determine at his/her discretion by agreement with the owner of the property subtracted, the quantity of water to be transferred to the new property. If the validation team found no agreement, the water use was temporarily apportioned according on the physical location of the irrigated fields during the field survey.

If two or more properties consolidated, the permissible uses were simply added together.

- **Nzhelele GWCA**

The Nzhelele GWCA was established by means of proclamation no. 207 of 1945. The provisional determination in respect of that portion of the GWCA upstream of the Nzhelele Dam was published in the Government Gazette on 01 May 1948. A notice was published in terms of section 62(2F)(a)) where the maximum extent of land that could be irrigated, was provided. The notice stated that a maximum of 9 820 m^3 of public water may, if available, be used per annum for the irrigation of each hectare and this volume was used to determine the lawful water use.

If a piece of land was subdivided after the date of inclusion in the area, the owner of the original portion was authorised to determine at his/her discretion by agreement with the owner of the property subtracted, the quantity of water to be transferred to the new property. If the validation team found no agreement, the water use was temporarily apportioned according on the physical location of the irrigated fields during the field survey.

If two or more properties consolidated, the permissible uses were simply added together.

b) Uncontrolled areas

Areas of the catchment not included in GWCAs fell under the limitations of section 9 B of the 1956 Water Act (Act 54 of 1956) where a maximum rate of abstraction of 110 ℓ/s from surface water resources was allowed for each property as registered with the Registrar of Title Deeds on 28 May 1975.

3.9.2 Irrigation with groundwater

a) Controlled areas

- **Dorps River Subterranean GWCA**

The Dorps River Subterranean GWCA was established by means of proclamation no. 312 of 16 February 1990. In terms of the proclamation the construction or erection of new water works as well as the enlargement or alteration of exiting works were totally prohibited except by virtue of an authorisation in terms of section 32(1)(a) of the Water Act of 1956.

- **Nyl River Valley Subterranean GWCA**

Nylsvlei Subterranean GWCA was established by means of proclamation no. 56 of 26 March 1971. In terms of the proclamation the construction or erection of new water works as well as the enlargement or alteration of exiting works were totally prohibited except by virtue of an authorisation in terms of section 32(1)(a) of the Water Act of 1956.

b) Uncontrolled areas

Under the previous Water Act of 1956, water abstracted from boreholes was regarded as private water and since the Study Area is not included in a Subterranean GWCAs, no limitations were placed on the abstraction of water from boreholes for irrigation purposes. The lawful water use from boreholes was therefore the use that was exercised within the two years prior to the promulgation of the Act, i.e. 1 October 1996 to 30 September 1998.

3.9.3 Storing of water

a) Controlled areas

- **Mokolo River GWCA**

The Mokolo River GWCA was established by means of proclamation no. 276 of 24 October 1969. The provisional determination in terms of section 62 (2)(a) of the Water Act of 1956 respect of that portion of the GWCA upstream of the Hans Strijdom Dam was published in the Government Gazette on 24 July 1981 (Notice no. 1531). A general permission in terms of section 62 (2B) (a) of the Water Act of 1956 was published in the Government Gazette on 5 June 1987 (Notice no. 1229). In terms of the general permission the construction or erection of new storage works as well as the enlargement or alteration of exiting storage works in any public stream in the area were totally prohibited except by virtue of an authorisation in terms of section 62 (2A)(a) of the Water Act of 1956.

- **Hans Strijdom Dam Catchment GWCA**

The Hans Strijdom Dam Catchment GWCA was established by means of proclamation no. 165 of 20 September 1985. A general permission in terms of section 62 (2B) (a) of the Water Act of 1956 was published in the Government Gazette on 5 June 1987 (Notice no. 1229). In terms of the general permission the construction or erection of new storage works as well as the enlargement or alteration of exiting storage works in any public stream in the area was totally prohibited except by virtue of an authorisation in terms of section 62 (2A)(a) of the Water Act of 1956.

The limits of the general permission with regard to the erection of weirs to provide pumping wells for irrigation purposes and for limited storage for domestic use and stock-watering purposes were amended by means of proclamation no. 1636 of 4 August 1989. The previous general permission was amended by the addition of the following text *“provided that works authorisations in terms of section 62 (2H)(a) of the Act shall on application be* *considered by the Regional Director: Transvaal, Department of Water Affairs, Private Bag X124, Pretoria 0001, for the erection of weirs in public streams within the area up to a maximum storage capacity of 3 000 m^3 per property with a view to the provision of pumping wells for irrigation purposes as well as limited storage for domestic use and stock watering purposes, subject to conditions the said Regional Director deems necessary"*

- **Doorndraai Dam Catchment GWCA**

The Doorndraai Dam Catchment GWCA was established by means of proclamation no. 193 of 9 November 1984. In terms of the general permission no new water works may be erected and no existing water work altered of enlarged for the abstraction of any public water that may be used for irrigation and/or stock drinking purposes except by virtue of an authorisation issued in terms of section 62 (2H)(a) of the Water Act of 1956.

- **Sterk River GWCA**

Proclamation 1133 of 17 June 1998 - Owners of properties riparian to the Sterk River below the Doorndraai Dam to whom permits were issued in terms of section 62 of the Water Act of 1956, for the abstraction of public water, subject to the determinations of Government Notice 243 of 26 February 1965, were permitted to erect new storage works or alter existing works on the basis of a maximum storage capacity of 2 500 m^3 in respect of each hectare which may be irrigated, provided that prior approval therefore is obtained from the Department.

- **Nyl River GWCA**

Increased pressure on the water resources within the area forced the DWS, then the Department of Water Affairs and Forestry (DWAF) to exercise stricter control in terms of Section 9B(1C) of the Water Act (Act 54 of 1956) within the Nyl River catchment.

Control was instituted by means of Proclamation number 719 of 22 April 1994. This proclamation amended the impoundment and storage limits laid down in Section 9B (1)(a) of the Water Act of 1956 in respect of waterworks as far as the Nyl River and all its tributaries up to the confluence thereof with the Magalakwena/Sterk River are concerned. The effect of this was that no water work in which more than 10 000 m^3 of public water can be impounded or stored on a property contemplated in the said section 9B (1) (a), may be constructed, altered or enlarged in so far as it concerns the intended public streams, except on the authority of a permit issued by the Minister.

- **Limpopo/Ngotwane GWCA**

The Limpopo River GWCA was established by means of proclamation no. 111 of 25 April 1969. Through proclamation 2432 of 13 November 1981 and in terms of section 62(2)(a)(ii) of the Act, no new water works may be erected and no existing water work altered of enlarged for the abstraction, impounding or storage of public water or alter, enlarge or replace an existing water work unless such person first obtains a work permit which authorises him/her thereto.

b) Uncontrolled areas

Areas of the catchment not included in GWCAs fell under the limitations of section 9 B of the 1956 Water Act (Act 54 of 1956) where storage of water was limited to 250 000 m^3 for each property as registered with the Registrar of Title Deeds on 28 May 1975.

3.10 CLASSIFICATION OF VALIDATED WATER USES

Since more than one water use may be found on any given property, scenarios arose where water users registered their entitlement to take water from a water resource correctly, but omitted to register the impeding structure on the property and/or under registered the capacity of the storage dam. Given the above, one classification per property (registration) could not yield the correct result and the categorisation was done according to the type of water use and water resource. By using these small data blocks, a general classification for each registration file consisting of combinations of the above, can be compiled at any stage.

The aim of the validation process was to establish 4 values for each identified water use namely:

- Registered use
- Lawful use
- Existing use (1996-1999)
- Current use (2005)

When these four values were known, any question relating to the water use on a specific property was answerable.

For example:

- The existing lawful use would be the lesser of Lawful use and Existing use.
- If the registered use is zero and the existing lawful use is *Q* the water user did not register his lawful entitlement *Q* and it would be classified as **unregistered**.
- If the registered volume is less than the existing lawful use, it would be classified as **possible under registration.**
- If the registered volume is equal to the existing use but the existing use is more than the lawful use, it would be classified as a **possible correct registration** but a part thereof will also be classified as **possible unlawful**.

Using various permutations, all the necessary answers pertaining to validation and lawfulness can be provided.

4 VALIDATION RESULTS

Throughout the validation process, all numerical results obtained were captured on the supporting database for use during the verification process. It is important to note that the results obtained through the validation process are all preliminary. Although the Public Participation Programme (PPP) went to great lengths to inform water users of the validation and verification processes there were still some users who did not respond to the invitations to participate. Only when the verification of water use has been completed, will the true extent of water use (including existing lawful use) be known.

The general conclusion following the validation process is that water use was over-registered. This can mainly be attributed to two factors. Firstly, apart from registering their current water use, some water users also registered their planned irrigation development. In many instances, water users registered their lawful water use entitlement (as published in the Government Gazette) and not their existing water use. Secondly, the registered water use sometimes reflected the general irrigation practice over a certain period and not the annual use. An example is the case where a water user has one twenty-hectare centre pivot that is only planted in summer. The water user either planted maize or tobacco or groundnuts (total of 20 hectares per annum). During the completion of the registration forms the water user registered three crops, each with an extent of 20 hectares. The extent of the registered crops in WARMS therefore amounted to 60 hectares, which is incorrect.

Summaries of the validation results are presented in the following sections.

4.1 IRRIGATION

A summary of the validated water uses in terms of **crop hectares** under irrigation per annum is presented in **Table C.1** (**Appendix C**).

A summary of the validated water uses in terms of irrigation volumes per annum is presented in **Table C.2**.

When the existing lawful use from surface water (46.16 million m^3/a) is compared with the 1998/99 water use (52.22 million m^3/a) it is evident that water users were abstracting some 6 million m^3/a more than they were lawfully entitled to. Although the water use decreased between 1998/99 and 2004, the current annual abstraction from surface water resources (47.9 million m^3/a) is some 1.7 million m^3 more that the existing lawful entitlement.

In terms of groundwater resources the current annual abstraction of 5.7 million m^3/a is some 700 000 m^3 more that the existing lawful entitlement of 5.0 million m^3/a.

It is interesting to note that the actual extent under irrigation from surface water resources decreased by some 3 600 ha or 35 million m^3/a between the mid 1980's and 1998/99. This can be attributed to the fact that irrigators riparian to the river historically relied on natural runoff and were able to cope with the natural variability of the flow. The increased use of water for irrigation also had a huge effect on the flow regime of the river and the only way they could overcome this problem was to increase their storage in order to stabilise supplies. The construction of new dams was however prohibited following the proclamation of the two GWCAs which in effect, blocked further development. The higher risks associated with the unstable flow combined with other factors such as higher agricultural input costs, etc. led to a marked change in agricultural practices in the area. Established irrigation farms were consequently converted to cattle ranches while other farmers switched from crop to game farming.

The detail breakdown of the information presented in the previous two tables is included on the data disk.

4.2 STORAGE

A summary of the validated storage is presented in **Table C.3**.

From the detailed analyses an increase in the total storage since 1998 was detected. The total storage in 1998 was some 178.23 million m^3. The latest storage identified is some 183.53 million m^3. The preliminary existing lawful storage is 155.67 million m^3.

5 IRRIGATION WATER DEMAND

5.1 SUMMARY

In this part of the study, the theoretical water demand of the identified irrigation development was determined. Following this, the actual practical situation was assessed, taking cognisance of on-farm irrigation system efficiency, the effect of droughts on the theoretical irrigation demands and the expected return flows from irrigated fields back to the water resource(-s).

The quaternary catchment was used as the basic unit for output in the study. On request of the modellers, the quaternary catchments were subsequently divided into smaller sub catchments for modelling purposes. Time series, on a monthly resolution, were generated for the theoretical irrigation demands and the practical ("actual") demands, based on both a growth model and a fixed model of irrigation development in every catchment.

In the growth model, the start date of the available rainfall record was used as the base date of the development. From this point the irrigation development was increased up to the date of the present assessment. The growth in irrigation area is not necessarily linear, and in this model it was based on discovered external influences, such as the introduction of awareness programs, changes in cropping patterns, introduction of electricity and the declaration of GWCAs.

In the fixed model, the current irrigation development was retained as fixed over the total time span of the rainfall record, and the time series of demand were analysed statistically to discover to what level of assurance the current irrigation development can be entertained. A quota per field area, based on an acceptable level of assurance, was determined for every catchment from a statistical analysis of the long term irrigation requirements as determined from the fixed model.

This model also calculated the abstraction rate that should be allowed in each quaternary catchment.

The typical monthly crop factors for use with Penman-Monteith ET_0 reference evaporation were also calculated by using the fixed model.

5.1.1 Representative crop

The WARMS database of DWS was scrutinised to determine the type of crop, the irrigation system, the area, the water source and the quaternary catchment of each registered irrigation field in the Study Area. This data was further refined after consultation with the water users during field visits.

The aim of this exercise was to facilitate the definition of a representative crop that mimics the effect of all the crops and irrigations systems within a particular quaternary catchment.

5.1.2 Rainfall

Rainfall records were incorporated in the irrigation demand model to determine a time series of irrigation demands. The extended records, as provided by the modelling team, were used.

The rainfall records were converted into records of effective rainfall (i.e. effective for irrigation fields) by using the methods used in the SAPWAT program, as well as the methods recommended by the Food and Agriculture Organisation (FAO). These records were used in conjunction with the SAPWAT model to determine the irrigation demands.

5.1.3 Evapotranspiration

The monthly Penman-Monteith evapotranspiration grids available from the *South African Atlas of Climatology and Agrohydrology (Schulze et al 2006)* were analysed to determine the representative monthly evapotranspiration per quaternary catchment. From these values, the average and median daily evaporation values were generated as inputs into the SAPWAT model.

5.1.4 SAPWAT Model

Using the median rainfall records (actual, not effective) together with the daily evapotranspiration records, a driver climatic station was generated for each quaternary catchment. By using this approach, the number of usable SAPWAT climate stations was increased from the original 350 to some 1946 countrywide, without sacrificing any accuracy. In the Mokolo catchment, SAPWAT originally provided for only one station, namely Vaalwater. The use of a driver station per quaternary catchment resulted in nine climate stations for this catchment.

Only the basic front end of the SAPWAT model was used in this exercise. No attempt was made to improve the generic data used in the basic front end with further refined soil data, rooting depths, scheduling techniques or refined irrigation practises. The results from the basic front en analysis were captured from the text files that the SAPWAT model generated. Data for both “with rain” and “without rain” were captured and further analysed.

5.1.5 Irrigation demand records

A model was set up to deliver the required irrigation demand records. In the first part of the model, irrigation fields with the same crop and irrigation system were lumped together per quaternary catchment. Where different benchmark data, such as data from previous field surveys were available, such data were also included in the model. SAPWAT was then used to determine the irrigation requirements, both with and without taking rainfall into account.

The SAPWAT results were fed back into the demand model, resulting in a monthly irrigation requirement for every crop/system combination in each quaternary catchment. The results with the effect of rainfall included were used to determine the volumes required for the definition of the existing lawful water uses (based on the median annual rainfall. The results excluding rainfall were subsequently used in the model to determine the monthly irrigation demand time series and to quantify required abstraction rates.

The record generation part of the model used the “SAPWAT without rainfall” results together with the effective rainfall records generated earlier to determine the monthly records of irrigation demands. This part of the model allowed for the generation of different sets of records for different water sources or water resources. Different records were generated for surface water, borehole water and scheme water. A complete set of records was generated for each quaternary catchment. Such a set of records consists of results per water resource, both for the growth model and fixed model described earlier.

5.1.6 Actual irrigation usage

Recognising that during periods of water scarcity the total irrigation demands will most probably not realise as irrigators postpone planting dates until the first rain falls, or even not irrigate at all during a particularly dry year, it was deemed necessary to reduce the demands to be balanced with the expected irrigation practices. The model took this into account by calculating a "drought reduction factor" and subsequently created "actual" irrigation usages based on expected irrigation patterns. The algorithm for this process was based on the mean monthly and the mean annual rainfall in the respective quaternary catchments.

The model generated time series of actual irrigation usage, both for the growth model and fixed model for each quaternary catchment.

It must be stressed that this approach has only been thought through for irrigation in the catchments of the northern part of the country (north of the Orange River). In these parts of the country, irrigation is normally supplemental to rainfall, as the extent of the rainfall is such that it should normally be taken into account. In other parts of the country where rainfall is lower or more erratic, a different approach may be contemplated.

5.1.7 Irrigation efficiency

The output of this part of the study was the evaluation of the weighted efficiencies of infield irrigation practices. The results of this output can be used in the assessment of the existing irrigation practices in a particular quaternary catchment. Low efficiencies may point to areas where intervention may be necessary, while high efficiencies may indicate the awareness of the irrigators of the responsible use of water.

A series of “what if” questions can be addressed, such as “what if a target irrigation efficiency of 85% is encouraged in the catchment?”; “what if the average irrigation efficiency is increased by 10%?” The answers to these and similar questions can be expressed in time series records that may be used in catchment models to describe the overall effect thereof on the available water supplies in that catchment.

5.1.8 Abstraction rate

This output of the study was the required abstraction rate in l/s/ha for each quaternary catchment. These results may be used as licence conditions during future licensing of water use in the area.

5.1.9 Crop factors

The output of this part of the study was the calculated Penman-Monteith crop factors for the representative crop, planting dates and irrigation strategies per quaternary catchment.

5.1.10 Return flows

This output was the evaluation of the return flows generated from the irrigated fields. The return flows were defined as a portion of the total in-field irrigation losses. The weighted average results for every crop/system combination were fed back into the demand model, resulting in a monthly return flow time series for each quaternary catchment.

5.1.11 Model interface

The final output of the model was a spreadsheet interface that allows the user the input of variables, such as irrigated areas, return flow fractions and return flow limitations. It also allows for the calculation of proposed irrigation quotas per field area. The generated time series for any combination of the parameters are included in the model.

5.2 DETAILED REPORTING

5.2.1 Representative crop

a) The first task in identifying the representative crop was the analysis of the depth of irrigation required for the crop/system combination in the relevant quaternary catchment. The process is shown schematically in Figure 5.1.

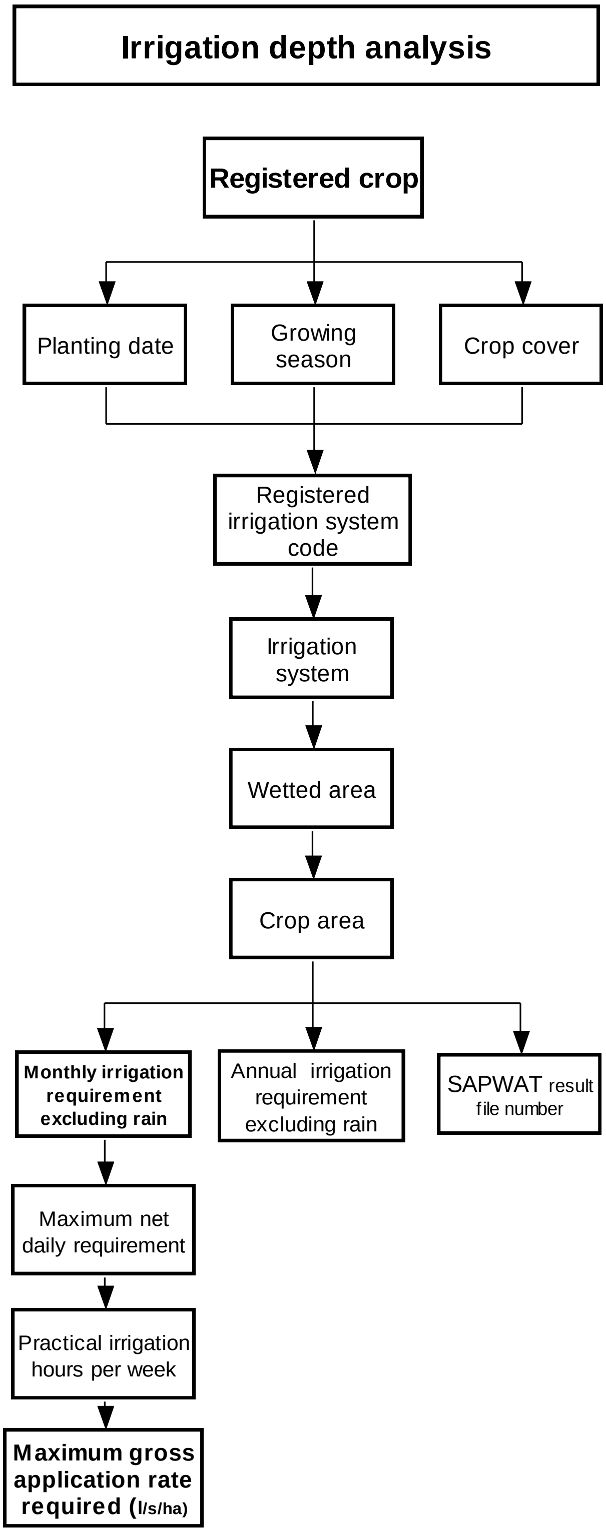

Figure 5.1 Irrigation depth analysis

b) The latest registered information, including information obtained from irrigators during field visits was used to do a normal SAPWAT determination of the irrigation requirements. For each unique crop/irrigation combination, a SAPWAT calculation was completed. During this process, details pertaining to the crop name, planting date, length of the growing period, season during which the crop is cultivated, crop cover, irrigation system and wetted area were fed into SAPWAT. The resultant text file created by SAPWAT named "summary.dat" was then renamed with a numerical prefix and the suffix "csv" and the renamed file saved with the data of that particular catchment. A typical file name would be "23.csv", which is the file of the 23rd crop combination for that particular catchment.

c) The data from the said text file was subsequently imported into a spreadsheet for further analysis. Data for both rainfall included and rainfall excluded were imported. The two-sheet spreadsheet was further populated with the registered crop area under irrigation for every crop combination. This spreadsheet was generically named to reflect the relevant quaternary catchment. A typical name would be "Registered A42A.xls", where A42A is the quaternary catchment.

d) The first sheet on the said spreadsheet computes the total annual depth of irrigation required for each crop combination. It furthermore computes the maximum net daily depth of irrigation required both for "with rain" and "without rain". These depths are then converted to a required continuous abstraction rate, expressed in litres per second per hectare. The net required abstraction rate is then converted to a practical value by limiting the total available hours per week from 168 to 144. The resultant practical abstraction rate (for the case that excludes rainfall) is the suggested allowable abstraction rate for licensing purposes. In the model, these calculations are included in a sheet called Reg_Crops_mm (and Surv_Crops_mm where survey data was available).

e) The second task in the identification of the representative crop was an analysis of the irrigation volumes required. This process is shown schematically in **Figure 5.2**.

f) This task follows on the previous task. As SAPWAT does not provide for the analysis of a time series of records, it was necessary to create a demand excluding rainfall, from which the effective rainfall record can be subtracted, resulting in a time series of irrigation demands. The shortcoming in this method is that the irrigation demands are quantified using average values of evaporation. Although not strictly accurate, this is presently the best approach available, as no representative time series of evaporation is yet available. The same crop and other data as described above, is used in this task. The crop area was multiplied by the depth of irrigation required to obtain monthly volumetric values based on the requirement with rainfall excluded.

g) This task follows on the previous task. As SAPWAT does not provide for the analysis of a time series of records, it was necessary to create a demand excluding rainfall, from which the effective rainfall record can be subtracted, resulting in a time series of irrigation demands. The shortcoming in this method is that the irrigation demands are quantified using average values of evaporation. Although not strictly accurate, this is presently the best approach available, as no representative time series of evaporation is yet available. The same crop and other data as described above, is used in this task. The crop area was multiplied by the depth of irrigation required to obtain monthly volumetric values based on the requirement with rainfall excluded.

h) The volumetric demands for every crop combination were calculated and aggregated per month. The monthly totals were then divided by the total crop areas, resulting in a weighted average monthly demand per crop hectare. These results were then converted back to irrigation depths in millimetre per month for further use in the model. These results mimic the monthly irrigation demand (rainfall excluded) for all of the crop combinations occurring within the relevant quaternary catchment. It therefore defines a single crop representing the effect of all crop combinations. This imaginary crop is called the representative crop.

i) The seasonal classification of the crop combination made it possible to determine the actual field sizes. Although for all of the permanent crops the field sizes equal the crop areas, this is not necessarily true for seasonal crops. Some of the winter crops are cultivated on the same fields that were used for summer crops. In order to express the irrigation demand in terms of a quota per field area, it was deemed necessary to determine the actual field sizes as accurately as possible. In the model the smallest of either the winter or summer crop areas were deemed also to be irrigated during the alternate season. In the whole of the Study Area it was found that the winter areas were always smaller than the summer areas. This resulted in the assumption that the field areas might be calculated by adding the summer and permanent areas. This resultant field area was called the “quota area” in the model. A further factor, called the “quota factor” was developed to facilitate further calculations in the model. The quota factor was calculated by dividing the total crop area by the quota area. In any particular quaternary catchment dividing the total crop area by the quota factor will thus result in the actual field area for that catchment. Dividing the irrigation demand by the quota factor will result in the demand per field hectare.

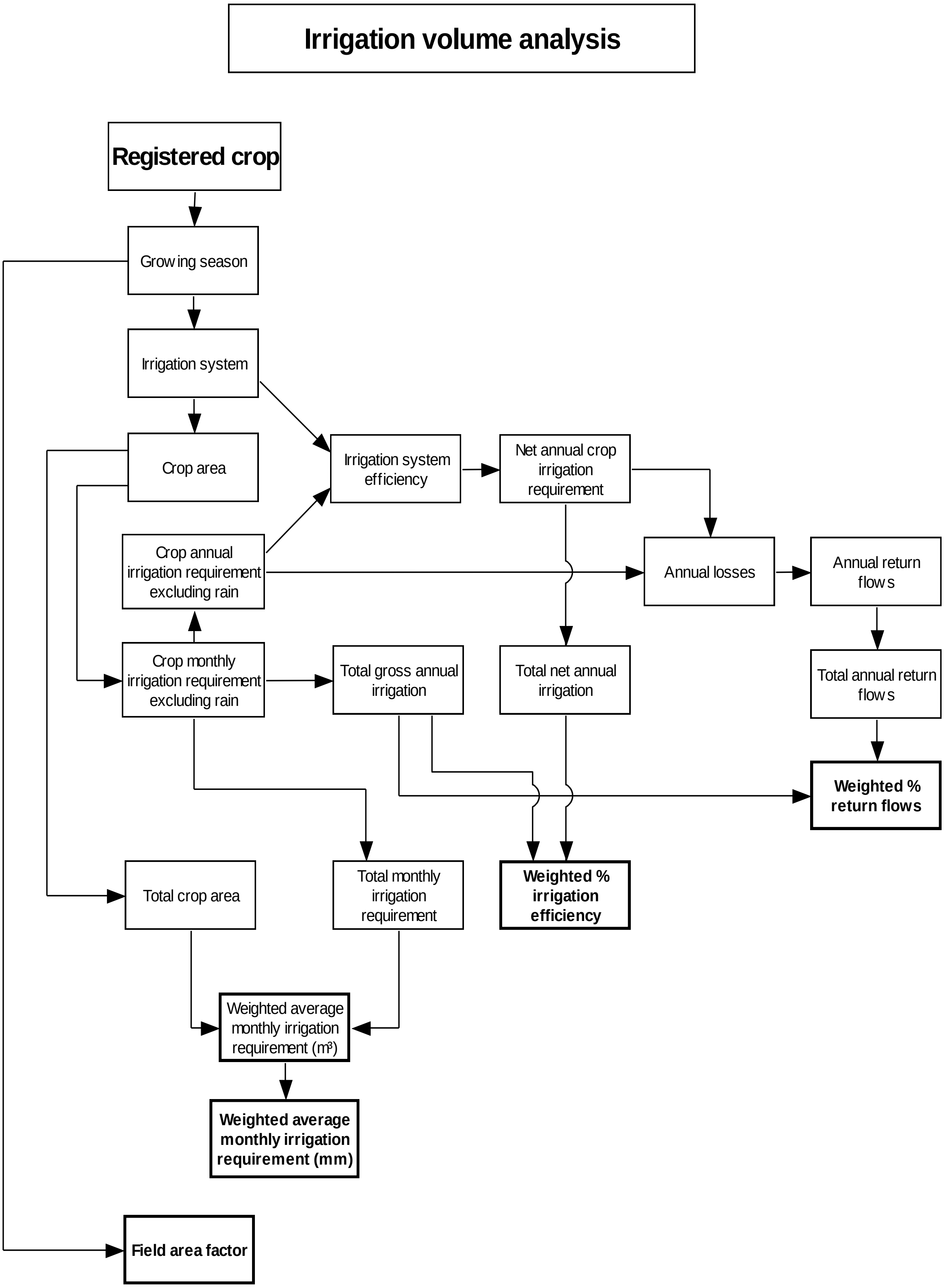

Figure 5.2 Irrigation volume analysis

j) This task follows on the previous task. As SAPWAT does not provide for the analysis of a time series of records, it was necessary to create a demand excluding rainfall, from which the effective rainfall record can be subtracted, resulting in a time series of irrigation demands. The shortcoming in this method is that the irrigation demands are quantified using average values of evaporation. Although not strictly accurate, this is presently the best approach available, as no representative time series of evaporation is yet available. The same crop and other data as described above, is used in this task. The crop area was multiplied by the depth of irrigation required to obtain monthly volumetric values based on the requirement with rainfall excluded.

k) The volumetric demands for every crop combination were calculated and aggregated per month. The monthly totals were then divided by the total crop areas, resulting in a weighted average monthly demand per crop hectare. These results were then converted back to irrigation depths in millimetre per month for further use in the model. These results mimic the monthly irrigation demand (rainfall excluded) for all of the crop combinations occurring within the relevant quaternary catchment. It therefore defines a single crop representing the effect of all crop combinations. This imaginary crop is called the representative crop.

l) The seasonal classification of the crop combination made it possible to determine the actual field sizes. Although for all of the permanent crops the field sizes equal the crop areas, this is not necessarily true for seasonal crops. Some of the winter crops are cultivated on the same fields that were used for summer crops. In order to express the irrigation demand in terms of a quota per field area, it was deemed necessary to determine the actual field sizes as accurately as possible. In the model the smallest of either the winter or summer crop areas were deemed also to be irrigated during the alternate season. In the whole of the Study Area it was found that the winter areas were always smaller than the summer areas. This resulted in the assumption that the field areas might be calculated by adding the summer and permanent areas. This resultant field area was called the “quota area” in the model. A further factor, called the “quota factor” was developed to facilitate further calculations in the model. The quota factor was calculated by dividing the total crop area by the quota area. In any particular quaternary catchment dividing the total crop area by the quota factor will thus result in the actual field area for that catchment. Dividing the irrigation demand by the quota factor will result in the demand per field hectare.

m) The SAPWAT irrigation demands include the effect of the efficiency of the relevant irrigation systems. In order to determine the net crop requirement, this task also analysed the effect of the system efficiencies. The irrigation demands were multiplied by the generic system efficiencies contained within SAPWAT, resulting in the crop (net) water requirements. The time series of annual irrigation demands were analysed to obtain the time series of crop water demands. Aggregating the latter time series and dividing it by the aggregated irrigation water demands resulted in the weighted average irrigation efficiency within the catchment. This representative efficiency was subsequently used in the model used to calculate the representative crop evapotranspiration factor (Etc).

n) The final part of this task analysed the potential return flows from the crop areas. The hypothesis was that 50% of the difference between the irrigation demand and the crop water demand will be available as return flows. These calculated values were once again aggregated on an annual basis. Dividing the aggregated return flows by the total crop area within the relevant catchment resulted in a weighted return flow percentage per crop hectare. This value was used further down in the model to determine a time series of monthly return flows.

In the model, these calculations are included in a sheet called **Reg_Crops_m3** (and **Surv_Crops_m3** where survey data was available).

5.2.2 Generation of time series records

a) The defining driver for all of the time series records generated by the model was the rainfall record for each quaternary catchment. These records were obtained from AECOM.

b) The process of converting the rainfall records for purposes of this model is shown in Figure 5.3:

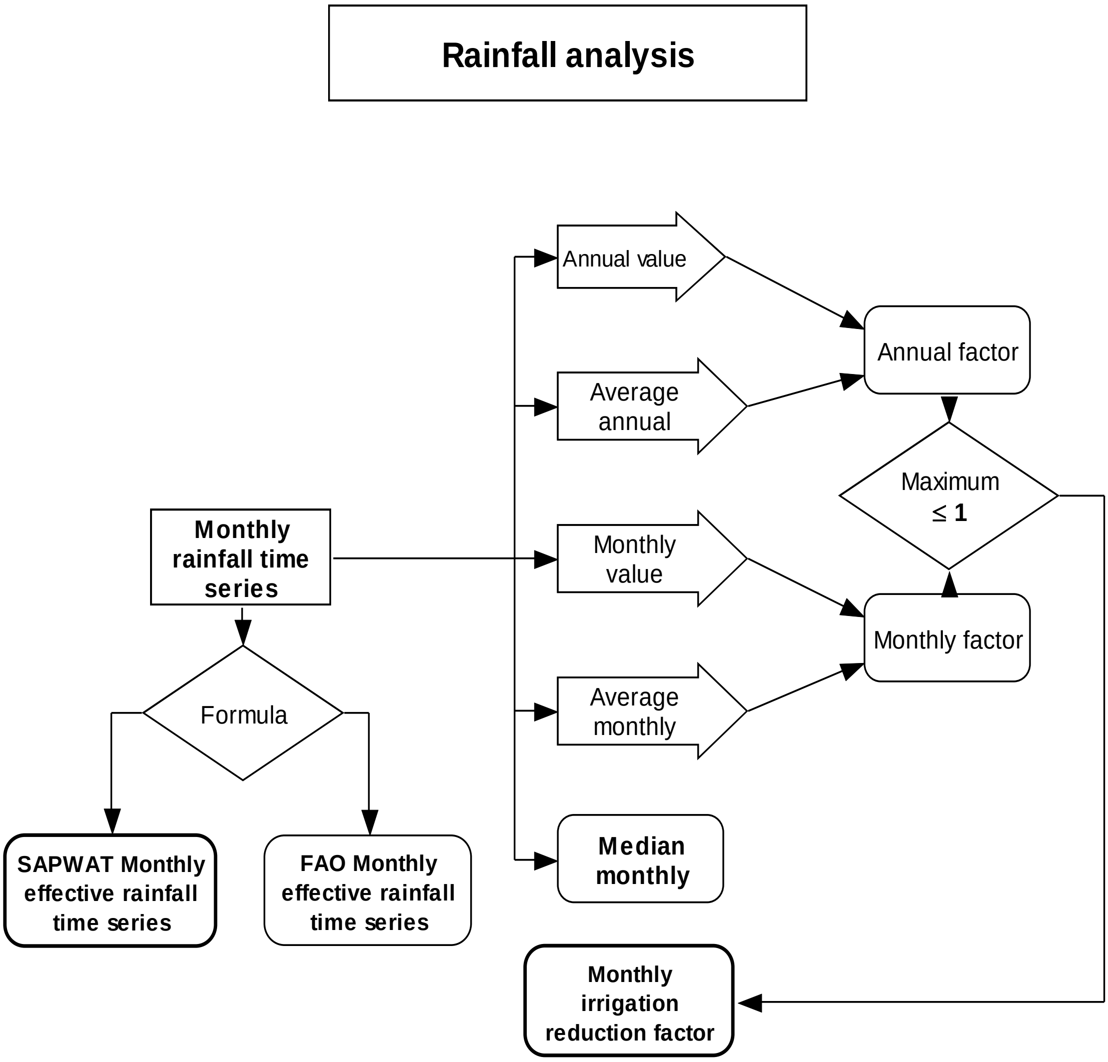

Figure 5.3 Rainfall analysis

c) The first task in this process was to convert the monthly rainfall values to effective rainfall (effective for irrigation). Two approaches were used during this task. Firstly, a formula developed by the FAO was used. This formula only operates on the actual rainfall and does not take cognisance of the available water retaining capacity of the soil profile. This formula is:

Effective Rainfall = (0.6 * Total Rainfall) - 10	... (Total Rainfall < 70 mm)
Effective Rainfall = (0.8 * Total Rainfall) - 24	... (Total Rainfall > 70 mm)

The FAO formula was only used for comparative reasons and is not discussed further.

Equation 5.1 Conversion of monthly rainfall to effective rainfall

$$r_e = ET\left(-0{,}001\frac{r^2}{ET} + 0{,}025\frac{r^2}{ET^2} + 0{,}0016r + 0{,}6\frac{r}{ET}\right) \text{ where } ET \text{ is limited to 75 mm}$$

d) The formula used by SAPWAT was discussed with the developers of the program. The relevant reference literature is found in the minutes of meetings of the steering committee responsible for the development of SAPWAT. We accept the accuracy and theoretical basis of the formula. This formula does take cognisance of the available water retaining capacity of the soil in that it evaluates the monthly evapotranspiration. In SAPWAT the maximum monthly evapotranspiration considered is limited to 75 mm.

In this formula:

- r_e = the effective monthly rainfall
- r = the actual monthly rainfall
- ET = the monthly crop evapotranspiration

A time series of effective rainfall was subsequently compiled by using this equation, and using the actual rainfall for every month of the record plus the weighted monthly crop evapotranspiration.

The drought reduction factors were then calculated as the **second task**. The algorithm for this process was based on the actual and mean monthly and the actual and mean annual rainfall in the respective quaternary catchments. For every month of the time series, the rainfall for that particular month was divided by the mean rainfall for that particular month over the whole time series. Should this result be greater than 1, it was limited to 1 and memorised. A result smaller than 1 was also put into memory. While evaluating that particular month, the actual rainfall for the hydrological year in which that specific month falls, was divided by the mean annual rainfall for all hydrological years of the time series. Once again, this result was limited to a maximum of 1. These results were then compared with the monthly results held in memory. The model then defines the **drought reduction factor** for that particular month as the larger of these two values.

The reasoning behind this algorithm is that a single dry month in an otherwise normal or wet year will not limit the planting of irrigation crops. The actual planting date may be postponed by a month or two, or alternative crops may be planted should the year turn out to be normal or wet. During a particularly dry year, a smaller area of planted crops, or even no planting at all, may reasonably be expected.

This approach obviously does not take into account the irrigation of permanent crops such as orchards. Care should be taken not to use a drought reduction factor that mimics actual irrigation use at levels lower than those required for the permanent crops. No such problem was encountered in the Study Area.

The drought reduction factors were used deeper down in the model to reduce the theoretical irrigation demands to actual (drought restricted) irrigation demands.

In the model these calculations are included in a sheet named **Rain**.

e) The third task was to develop time series based on a fixed area of irrigation.

The gross monthly irrigation requirements (mm) for the representative crop, excluding rainfall, are used as the point of departure. For every month of the time series, the effective rainfall is the subtracted from the gross irrigation requirement for that month. These results were limited to a minimum of 0 and are included under a heading of **Net irrigation requirements (mm)** in a sheet named **Flow_Fix_m3**.

The total annual irrigation requirements obtained from this time series were then analysed statistically to obtain the annual irrigation depth that will satisfy the demands at different levels of assurance. The depths were converted into a volume per field area by multiplying the crop area with the quota factor described earlier. These results are shown to the right of the table containing the net irrigation requirements.

The time series for the depth of irrigation requirements was then converted to a time series of the volume of irrigation requirements. This is shown under the heading ***Net irrigation requirements (m³).***

The next time series in the model, under the heading ***Drought reduction factor*** **included** is the result when the net irrigation requirements (m³) are multiplied with the drought reduction factor calculated earlier.

In the last part of the sheet **Flow_Fix_m3** the return flows are quantified. The weighted average return flow percentage is multiplied by the corresponding monthly irrigation requirements. In the model, the return flows during drought restricted months is reduced by multiplying the results with a factor of 0,75. This is done in order to appreciate higher losses during severe droughts and also to cater for drier soil profiles, holding back more water than during wetter periods.

The results of the calculations done on the sheet **Flow_Fix_m3** are carried over to a sheet called **Flow_Fix_Record**, and are portrayed in a format that is user friendly for further modelling purposes. The values are expressed in million m^3 under the headings ***Net irrigation requirements (10^6 m³), Drought reduction factor included and Return flows*** respectively.

The **fourth task** was to develop time series of irrigation demands based on the growth in irrigation areas over the whole period of the available record. This task follows the same procedures described earlier for a fixed area of irrigation, except that the calculations are based upon a growing area of irrigation.

f) The fifth task was to reverse engineer the calculations done earlier to obtain representative monthly crop factors for the representative crop.

In this task the calculated crop evapotranspiration Et_c as calculated by multiplying the monthly irrigation requirement by the system efficiency, was compared with the Penman-Monteith evaporation. The following relationship was used:

$\mathbf{Et_c = K_c * Et_0}$, where Et_c is the crop evapotranspiration, Et_0 is the Penman-Monteith evaporation and K_c is the representative crop factor.

The K_c-values are shown in sheet **ETo** in the model.

Graphical results showing the time series for the fixed area model is included in sheet **Fix_Model_Graph** and that for the growing area model is included in sheet **Grow_Model_Graph** of the model.

5.3 MODEL INTERFACE

A user friendly model interface was developed for each quaternary catchment. This interface allows the user to evaluate all aspects described in this part of the report and facilitates the development of different time series, as required by the user.

The model interface is contained in a sheet called ***Variables.*** The input structure was designed so that the user can input areas for both the growth model and the fixed area model. The left hand part of the input table contains the data used in the scenario that the user wants to analyse, while the right hand part contains the data found under our assignment. A set of radio buttons was developed to facilitate the quick evaluation of different alternatives for water resources and crop seasons.

6 CROP ANALYSIS

6.1 SUMMARY

A summary of the crops (sorted by crop type) under irrigation per tertiary drainage region within the Study Area is presented in **Table D.1** (**Appendix D**). The values contained in this table exclude the crops under irrigation within Government Water Schemes and Irrigation Boards.

A summary of the crops (sorted by crop extent) under irrigation per tertiary drainage region within the Study Area is presented in **Table D.2.** The values contained in this table exclude the crops under irrigation within Government Water Schemes and Irrigation Boards.

From **Table D.2** it is evident that in terms of area under irrigation, maize (16.6%) is the crop with the largest area under irrigation followed by potatoes (12%) and wheat (10.7%). The top ten crops represent 79% of the total annual crop area under irrigation. It is also clear that the Sand River catchment has the largest area under irrigation in terms of crop area under irrigation.

7 IRRIGATION EFFICIENCY

7.1 SUMMARY

A summary of the irrigation systems sorted by type per tertiary drainage region within the Study Area is presented in Table 7.1. The values contained in this table exclude the irrigation within Government Water Schemes and Irrigation Boards.

Table 7.1 Summary of irrigation systems

System	Tertiary drainage region						Total (ha)
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele	
Flood: Basin		3.4	24.4	40.1	13.8		81.7
Flood: Border				1.1	0.7	24.0	25.8
Flood: Furrow		0.7		18.7	214.7	1 698.1	1 932.2
Sprinkler: Big gun		55.2		38.9	5.7		99.8
Sprinkler: Boom		2.9		1.5	6.9		11.3
Sprinkler: Dragline		145.5	9.6		78.4	14.5	248.0
Sprinkler: Hop-along		10.0		0.8	154.7		165.5
Sprinkler: Permanent	21.2	10.0	8.0	76.1	483.0		598.3
Sprinkler: Quick-coupling	99.7	571.8	849.6	1 463.4	3 415.8	121.0	6 521.3
Sprinkler: Side roll				31.5	27.1		58.6
Sprinkler: Travelling Boom		11.5		2.2	14.4		28.1
Sprinkler: Travelling gun					4.8	79.5	84.3
Centre pivot	516.7	6 932.7	5 111.8	7 640.7	15 938.5		36 140.4
Linear					74.5	2.0	76.5
Micro spray	12.6	298.6	243.2	1 315.8	1 058.0	194.3	3 122.5
Micro sprinkler	12.5	122.7	95.2	181.3	183.5	16.0	611.2
Drip	74.1	306.2	1 956.6	2 611.9	7 703.7	130.9	12 783.4
Subsurface			1.4	6.0	0.0		7.4
Total	**736.8**	**8 471.1**	**8 299.8**	**13 430.0**	**29 378.2**	**2 280.3**	**62 596.2**

A summary of the irrigation systems sorted by extent under irrigation per system per tertiary drainage region within the Study Area is presented in Table 7.2.

Table 7.2 Summary of irrigation systems ranked by area under irrigation

System	Tertiary drainage region						System total (ha)
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele	
Centre Pivot	516.7	6 932.7	5 111.8	7 640.7	15 938.5		36 140.4
Drip	74.1	306.2	1 956.6	2 611.9	7 703.7	130.9	12 783.4
Flood: Basin		3.4	24.4	40.1	13.8		81.7
Flood: Border				1.1	0.7	24.0	25.8
Flood: Furrow		0.7		18.7	214.7	1 698.1	1 932.2
Linear					74.5	2.0	76.5
Micro spray	12.6	298.6	243.2	1 315.8	1 058.0	194.3	3 122.5
Micro sprinkler	12.5	122.7	95.2	181.3	183.5	16.0	611.2
Sprinkler: Big gun		55.2		38.9	5.7		99.8
Sprinkler: Boom		2.9		1.5	6.9		11.3
Sprinkler: Dragline		145.5	9.6		78.4	14.5	248.0
Sprinkler: Hop-along		10.0		0.8	154.7		165.5
Sprinkler: Permanent	21.2	10.0	8.0	76.1	483.0		598.3
Sprinkler: Quick-coupling	99.7	571.8	849.6	1 463.4	3 415.8	121.0	6 521.3
Sprinkler: Side roll				31.5	27.1		58.6
Sprinkler: Travelling boom		11.5		2.2	14.4		28.1
Sprinkler: Travelling gun					4.8	79.5	84.3
Subsurface			1.4	6.0	0.0		7.4
Total	**736.8**	**8 471.1**	**8 299.8**	**13 430.0**	**29 378.2**	**2 280.3**	**62 596.2**

The irrigation efficiency within the Study Area based on irrigation systems is high. 57.7% of all the crops under irrigation are planted under centre pivot irrigation, followed by 20.4% drip irrigation systems. These two systems represent 78% of the total area under irrigation.

8 VERIFICATION OF WATER USES

The verification of water use can be described as the process of exchange of information between DWS and the water user in order to make a final determination of the existing lawful water use on a property. During the validation of water use and the determination of the lawful use, very little formal communication between the water user and DWS takes place. The classification of the registered use and the identification of unlawful water use are “internal” investigations and the answers obtained are not final.

The main aim of the verification process is to inform a water user of the outcomes of the validation process and to offer the water user (if he/she disagrees) the opportunity to make representations regarding any determinations made during the validation process. The verification of water use is a formal process described under Section 35 of the NWA. The section 35 process can only be initiated by DWS, and all the correspondence is between DWS and the water user.

The whole Section 35 process requires very careful monitoring and administration in terms of dates specified for feedback on the various communications between the Department and water user(s).

In an attempt to speed and simplify up the whole verification process, field visits to the various catchment areas were undertaken. During these visits the water had the opportunity to sit with the team (on a one to one basis) and carefully examine the satellite images used for the identification and calculation of water use and on agreement, sign the Application for verification.

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

In Circular 18 of 2001 the Director General stated that “all lawful scheduling it terms of section 63 and 88 of the WA for which all due water use rates and charges were paid on 30 September 1998, should be treated as existing lawful water uses in terms of section 33 of the WA. As there is no authority for the Minister to attach conditions to a declaration of an existing lawful water use, the three-year period to develop unutilised water allocations as granted in terms of Circular 59 of 1999 is hereby withdrawn. These unutilised rights can be treated as existing lawful water use until compulsory licensing is required.” A copy of this Circular is included in **Appendix B**.

Due to the abovementioned declaration the water uses on Government and Irrigation Board schemes were not verified in terms of Section 35 of the NWA.

A summary of the verification process is presented in **Table E.1** (**Appendix E**). This table provides a summary of the properties where the water use was confirmed in From the table above it is evident that in term of volume, 55% of the water use have already been verified, which represents 45% of the total number of properties involved.

9 FUTURE IRRIGATION WATER REQUIREMENTS

The water resources, especially surface water resources, are heavily stressed due to the present levels of development and the surface water resources in the Study Area are almost fully developed. Future water requirements will need to rely on the extensive groundwater resources within the area.

The irrigation sector is the largest water user in the Study Area and is responsible for approximately 78% of the total water requirement. The four large dams in the Study Area (Mokolo, Doorndraai, Glen Alpine and Nzhelele) mainly support large-scale irrigation. Groundwater is also extensively used for irrigation supply, especially in the middle region of the Study Area and along the Limpopo River main stem.

In 1996 the Limpopo Department of Agriculture (LDA) established the Agricultural and Rural Development Corporation (ARDC) which mainly focussed on the former homelands of Gazankulu, Lebowa and Venda. The LDA realised that the ARDC was not producing the desired impact on the farmers' livelihoods, so all financial and management support was withdrawn and schemes were handed over to the farmers which presented a serious problem to the cash-constrained farmers. Consequently, most of the schemes were left fallow and unproductive or produced at subsistence levels well below potential (Stimie et al., 2001). Between 1996 and 2004 the LDA tried to address these constraints and settled for a programme called the Revitalisation of Smallholder Irrigation Schemes (RESIS) in 2004.

As a result of the above the majority of these schemes were not in operation during the two years prior to the promulgation of the NWA and can therefore not be classified as existing lawful water use. These uses were however stopped for a good reason which means that they could be declared as existing lawful water use by the Responsible Authority in terms of Section 33 of the NWA. Following consultation with the LDA a schedule was provided which summarised the schemes included in the RESIS program. These uses are therefore not included in the results of the *Validation and Verification Study* and can therefore be regarded as future irrigation requirements.

A breakdown of the schemes is shown in **Table 9.1**.

Table 9.1 Smallholder irrigation schemes

Catchment	Scheme Name	Municipality	Extent (ha)	Boreholes	Surface	River
A6	Galakwena	Mogalakwena	38	0.25	0.00	
	Gillemburg Citrus	Mogalakwena	450	2.93	0.00	
	Mapela	Mogalakwena	72	0.00	0.47	Pholotshi
	My Darling vegetable	Blouberg	5	0.03	0.00	
	Praque	Aganang	30	0.20	0.00	
	Sekgakgapeng	Mogalakwena	28	0.18	0.00	
	Zeekoeigat	Mogalakwena	14	0.00	0.09	Mogalakwena
Subtotal A6			**637**	**3.58**	**0.56**	
A7	Capesthorne	Makhado	99	0.00	0.64	Dorp
	Devonia	Molemole	130	0.85	0.00	
	Gogobole	Makhado	2	0.01	0.00	
	Hamutsha	Makhado	7	0.05	0.00	
	Klein Tshipise	Musina	9	0.00	0.06	
	Kutama	Makhado	12	0.08	0.00	
	Mununzwu	Makhado	255	0.00	1.66	
Subtotal A7			**514**	**0.98**	**2.35**	
A8	Beaconsfield	Makhado	35	0.00	0.23	Mtshedzi
	Cordon A	Makhado	73	0.00	0.47	Tshiluvhadi/Mutshedzi
	Cordon B	Makhado	53	0.00	0.34	Tshiluvhadi/Mutshedzi
	Cross Mango	Musina	12	0.00	0.08	Nwanedi
	Diepkloof	Makhado	40	0.00	0.26	Tshanzhe
	Garside	Makhado	52	0.00	0.34	Tshitedzi Fountain
	Joubertstroom	Makhado	70	0.00	0.46	
	Luvhada	Makhado	28	0.00	0.18	Spring/eye
	Mamuhohi	Makhado	78	0.00	0.51	Mutshedzi
	Mandiwana	Makhado	67	0.00	0.44	Mutshedzi
	Mphaila	Makhado	71	0.00	0.46	Mutshudzi
	Mphephu	Makhado	114	0.00	0.74	
	Phadzima	Makhado	82	0.00	0.53	Tshiluvhadi
	Rabali	Makhado	87	0.00	0.57	Nzhelele
	Ralipaswa	Makhado	15	0.00	0.10	Mutshedzi
	Vhutuwangadzebu	Makhado	18	0.00	0.12	Mtshedzi
Subtotal A8			**895**	**0.00**	**5.81**	
TOTAL			**2 046**	**4.56**	**8.73**	

Appendix A

Maps

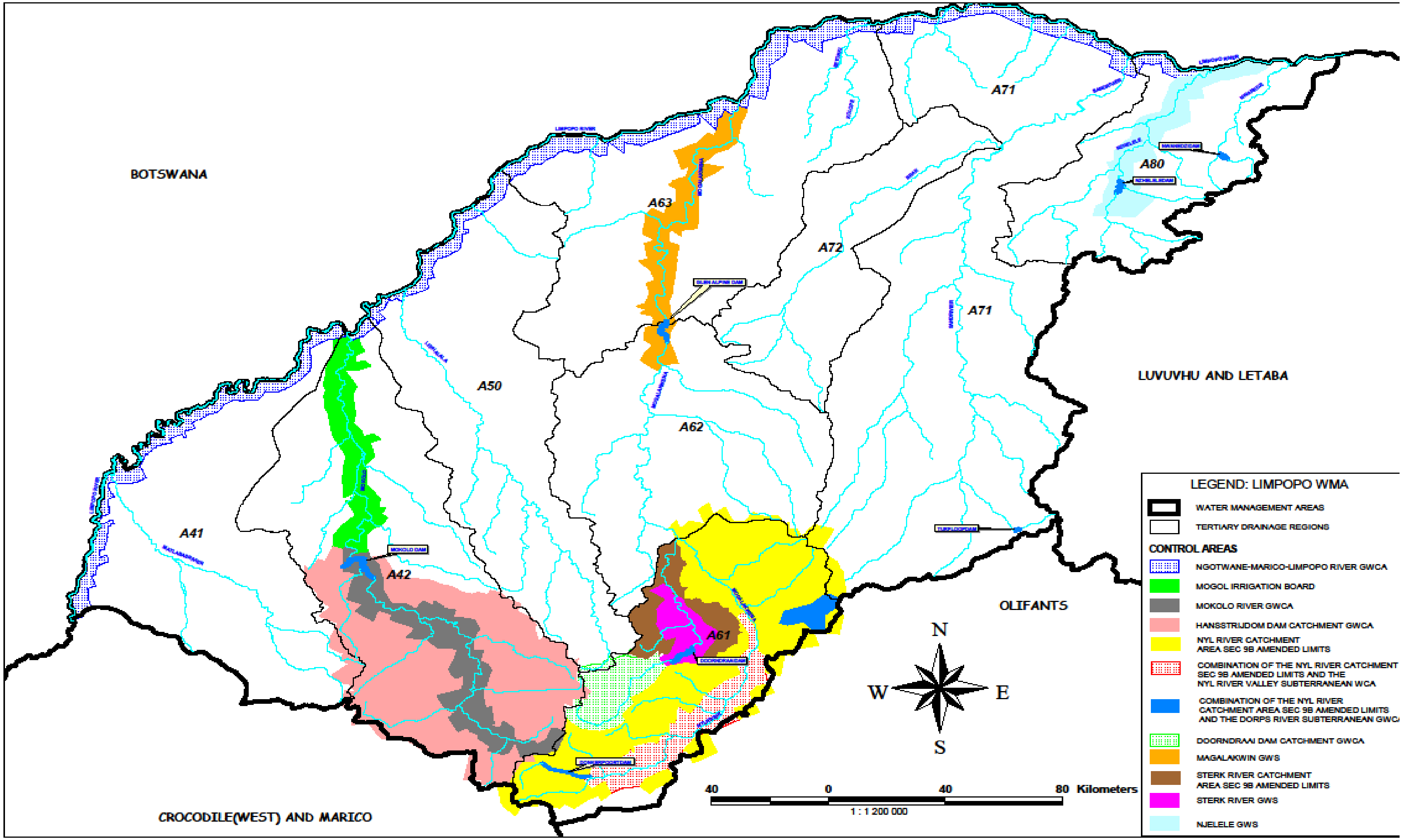

Figure A.1 Irrigation Boards, Government Water Schemes and Government Water Control Areas

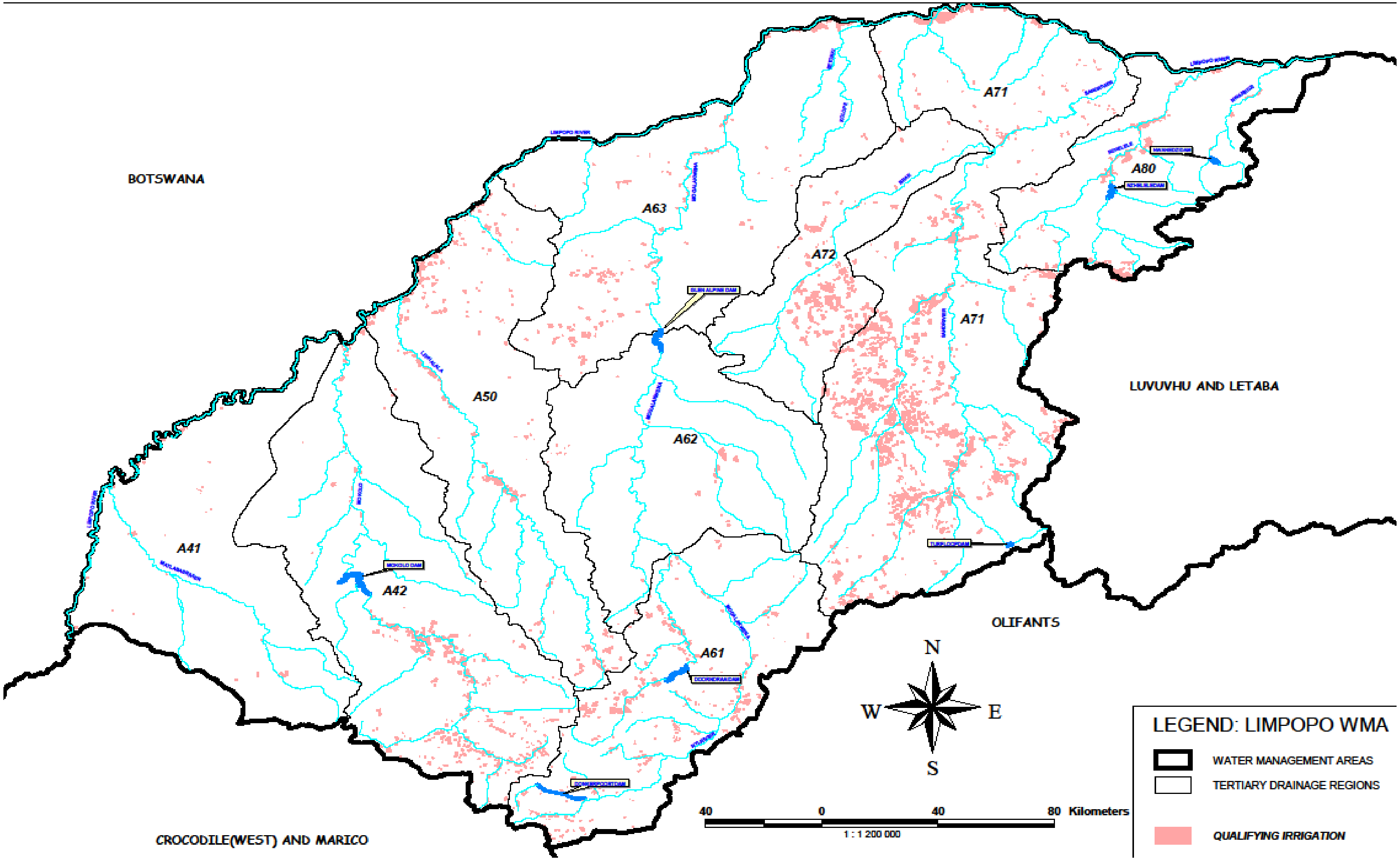

Figure A.2 Identified irrigation (Qualifying irrigation)

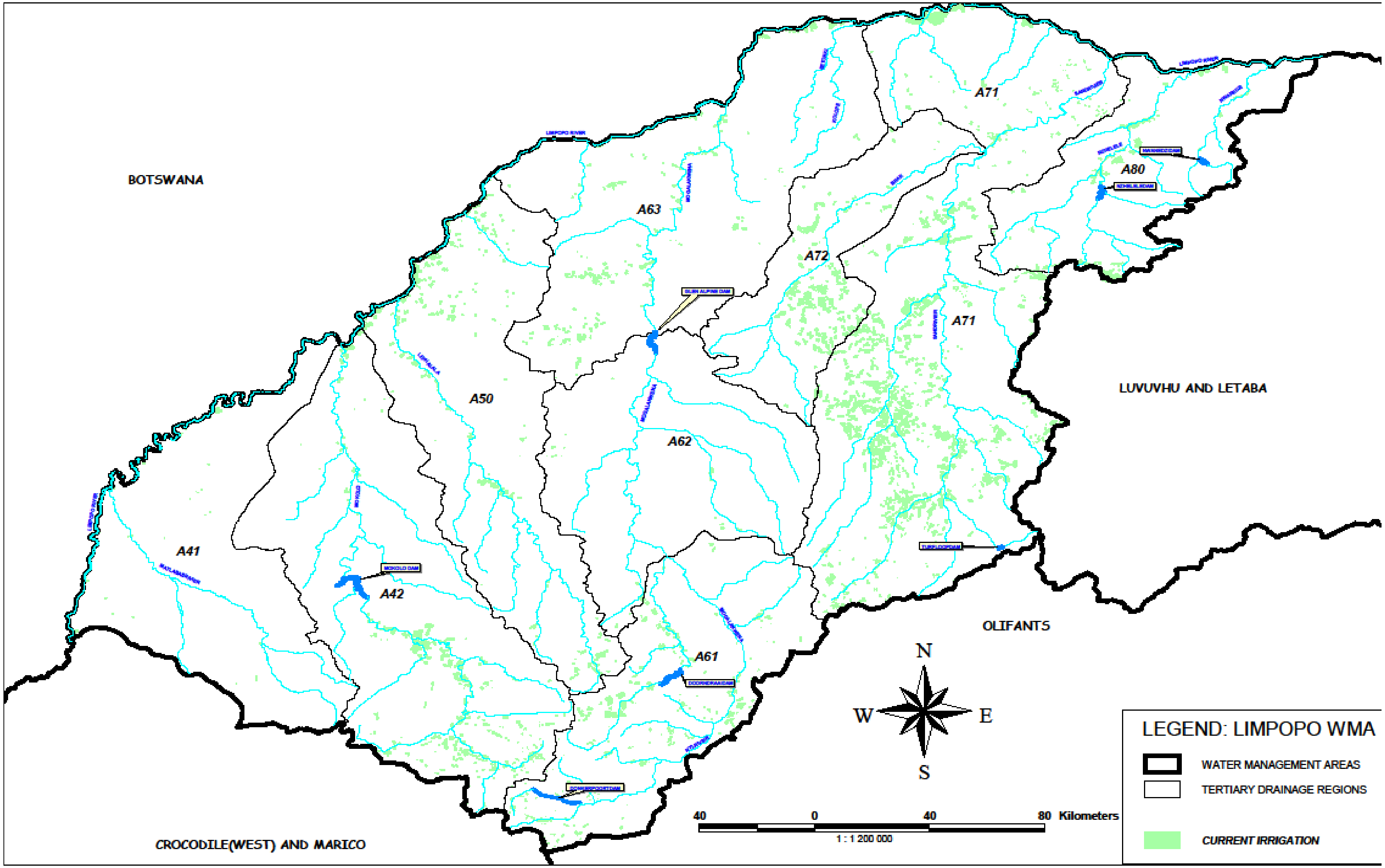

Figure A.3 Identified irrigation (Current irrigation)

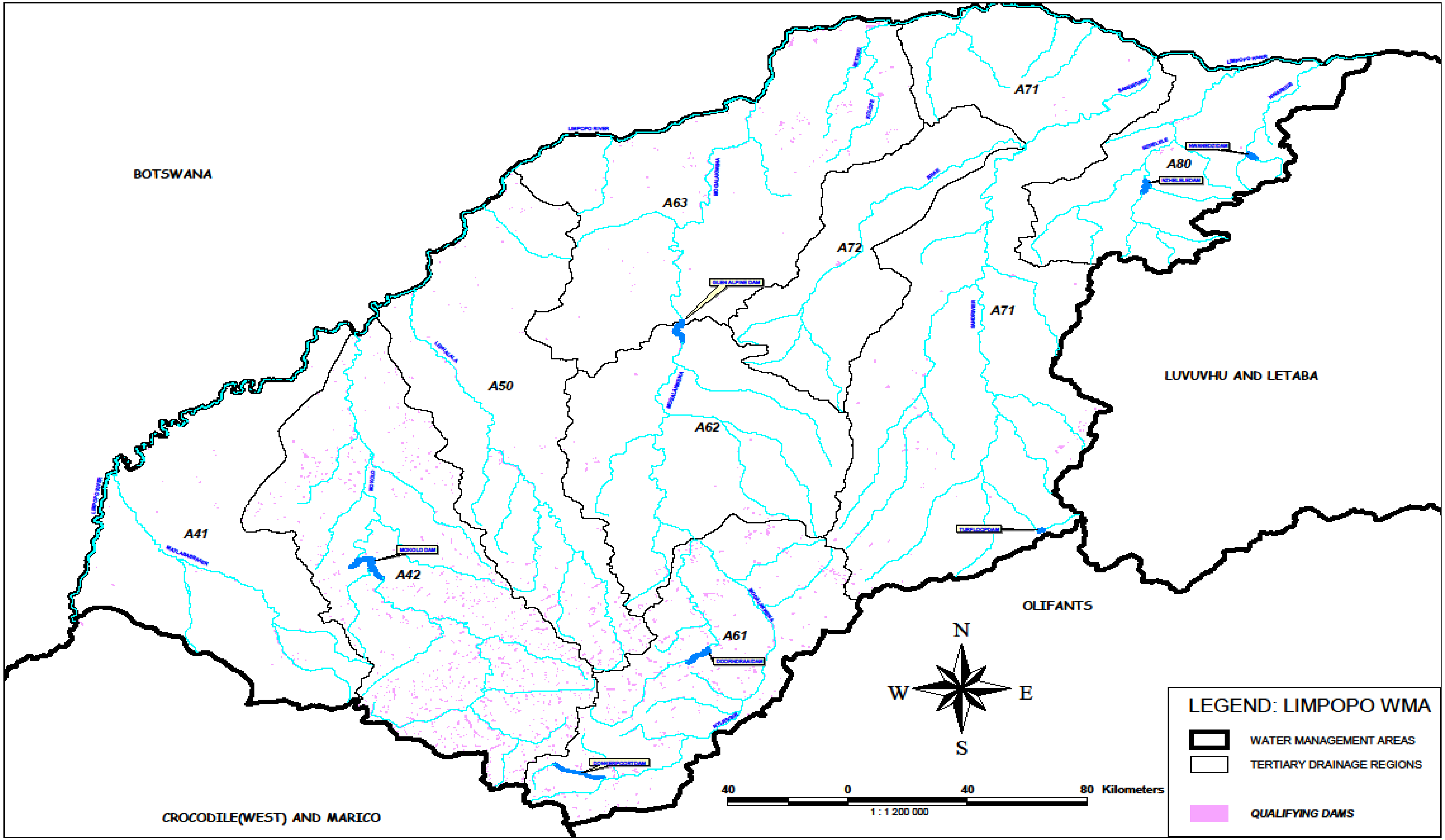

Figure A.4 Identified storage (Qualifying dams)

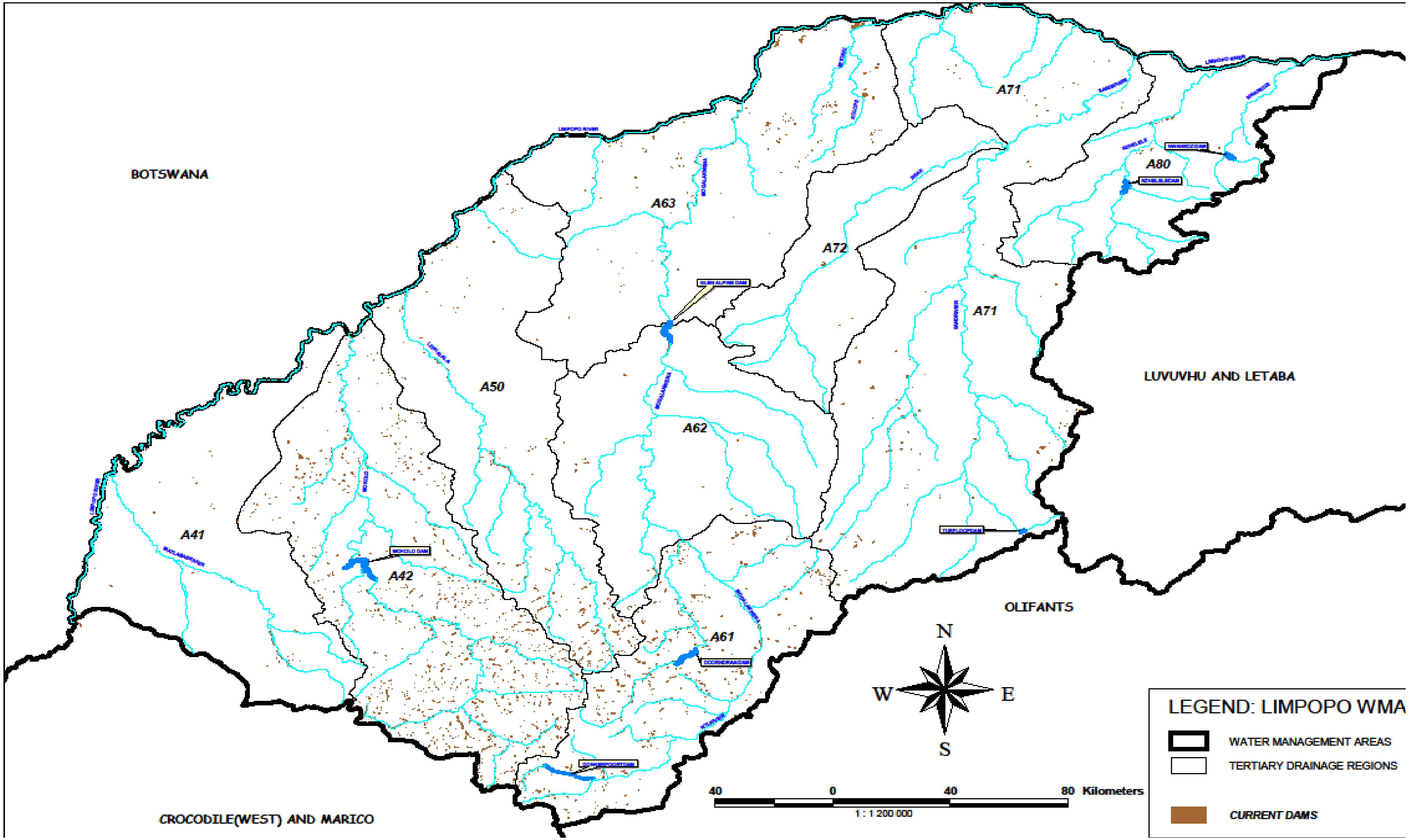

Figure A.5 Identified storage (current dams)

Appendix B

Declarations of water use as existing lawful use in terms of Section 33

Policy proposal: 1999-05-10

PF Pretorius
8806
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B31/1

MINISTER

POLICY PROPOSALS REGARDING THE TREATMENT OF SCHEDULED IRRIGATION ALLOCATIONS ON GOVERNMENT AND IRRIGATION BOARD SCHEMES AS EXISTING LAWFUL WATER USE IN TERMS OF SECTION 33 OF THE NWA, 1998.

1) BACKGROUND.

Part 3 of chapter 4 of the National Water Act, 1998 (NWA) permits the continuation of an existing lawful water use until compulsory licenses are required. Water uses not exercised within two years before 1 January 1999, when section 33 of the NWA came into operation, must be declared an existing lawful use to be further permissible. The responsible authority may, on its own initiative declare such an unexercised water use to be an existing lawful use if it is satisfied that steps towards effecting the use had been taken in good faith before 1 January 1999.

In terms of the Water Act, 1956, temporary descheduling of irrigation areas scheduled in terms of section 63 of the Act was allowed on Government water schemes, which exempted such areas from the payment of annual rates and charges. This led to underrecovery of costs and it was later decided to conduct a rescheduling process on most of the major schemes where the farmers were given the choice to either forfeit the descheduled allocations (permanent descheduling) or to be rescheduled for their full water rights with the proviso that annual tariffs and charges must from then onwards be paid for in full, whether the water rights are fully exercised or not.

Farmers who had temporary descheduled rights, invariably chose to reschedule their full quotas in order to maintain the relatively high value of their properties. Those who did not subsequently develop their unused rights were allowed to transfer them temporarily or permanently to other properties serviced by the scheme. However, these transfers could not readily be accomplished on all schemes due to factors such as the limited irrigable areas per farming plots and the high assurance of supply on some schemes, obviating the need to negotiate temporary transfers as a strategic reserve for use during seasons when water restrictions are imposed.

The outcome of the past policy, is that there are still some farmers on State irrigation schemes who are either temporary descheduled or have not developed their full allocations but have paid the annual rates and tariffs for their total scheduled areas.

In the case of Irrigation Boards, farmers are also in some cases scheduled in terms of Section 88 of the Water Act, 1956, for larger areas than they actually irrigate. A reduction in this scheduling may seriously jeopardise the economic viability of the Board scheme, as the Board's running costs and other financial obligations must be covered by rates and charges imposed on the scheduled areas.

The purpose of this submission is to seek your approval for proposals regarding the declaration under certain conditions of scheduled irrigation allocations as existing lawful use in terms of section 33 of the NWA, 1998.

2) DISCUSSION

2.1 Payment for full scheduled water use could be construed as exercised water use since it is being held as a strategic reserve. Water use that has been transferred on a temporary basis for use by someone else can also be regarded as a step taken in good faith towards effecting the use which would warrant the treatment of such use as existing lawful use in terms of section 33 of the NWA.

2.2 Loans were granted and investments made by Irrigation Boards on the premise that approved scheduling and existing defined water rights under the Water Act, 1956 would be utilisable and transferable. Any reduction or moratorium on such entitlements can lead to claims for compensation.

2.3 Reduction in scheduling on schemes will lead to increases in the charges for the remaining users which can not readily be justified without their consent. The subsidy, on the operations and maintenance costs of Government Water Schemes are presently phased out in terms of a negotiated agreement.

2.4 The intended process of registration of existing lawful water use for future water pricing purposes will be considerably expedited and more cost-effective if the scheduling on 1 January 1999 of Government and Irrigation Board schemes could be treated as existing lawful water use. The extent of unused rights on these schemes is considered to be of a minor nature and does not warrant the process of rescheduling before registration.

3) POLICY PROPOSALS

It is proposed that:

3.1 All lawful scheduling in terms of sections 63 and 88 of the Water Act, 1956 on Government and Irrigation Board schemes, which have been annually paid for before 1 January 1999, be declared as existing lawful use in terms of section 33 of the NWA, 1998.

3.2 Undeveloped water rights in the above category be given another three years to develop and continue to be paid for in full. Thereafter permanent descheduling and the re-allocation of water will be considered, where applicable.

3.3 No temporary descheduling of water rights be further allowed on State water schemes, merely for saving annual payments.

3.4 Dormant water rights paid for, can also be permanently descheduled on condition that:

- the representative body of remaining water users (Advisory Committee, Water User Association or Irrigation Board) accept the descheduling and the resulting higher rates and charges, or
- the said rights be traded to a willing buyer on the same scheme or even outside the scheme if such trading can be facilitated in terms of the NWA, 1998 and funds for the annual obligations in respect of such water would accrue to the Irrigation Board / Government Water Scheme / Water User Association, etc.

3.5 Dormant water rights, which have been temporarily descheduled, be treated in terms of the conditions pertaining to the said descheduling and / or the permit holder must be given the choice either to permanently deschedule or start the payment of tariffs. A maximum period of 3 years extension for development will also be applicable from the date when payment of charges for such dormant rights commences.

(Signed) .E M Mokeyane

ACTING DIRECTOR-GENERAL
DATE: 1999-04-26

POLICY PROPOSALS CONTAINED IN PARAGRAPH 3

APPROVED / ~~NOT APPROVED~~

(Signed) K Asmal
MINISTER
DATE: 1999-05-10

DWAF Circular: 18 of 2001

22/04 2006 07:56 FAX

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TO ALL REGIONAL DIRECTORS
AREA MANAGERS

2001 -03- 26

CIRCULAR 18 OF 2001

SURRENDERING OF EXISTING LAWFUL WATER USES ON GOVERNMENT IRRIGATION SCHEMES

1. Circular 59 of 1999 dated 18 May 1999, regarding the policy on the treatment of scheduled irrigation allocations on government and irrigation board schemes as existing lawful water use in respect of section 33 of the National Water Act, 1998, is hereby withdrawn and replaced by this circular.

2. In view of some confusion with regard to the implementation of the National Water Act, 1998 (NWA), and the relevant provisions of the repealed Water Act, 1956, (WA), these matters are summarised as follows:

2.1 All farmers with unexercised water allocations who do not want these allocations to be declared an existing lawful water use and whose entitlement to use water therefore elapsed on the commencement date of the NWA, are only obligated to pay water use rates and charges assessed under the WA for the period of time until 30 September 1998.

2.2 All farmers with existing lawful water uses on the commencement date of the NWA, 1 October 1998, who subsequently failed to pay water use rates or charges assessed under the WA, thereby failed to comply with the existing conditions and obligations of their existing lawful water use as required under section 34(1)(a) of the NWA and may have their water use withdrawn or suspended under section 54(1)(a).

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2.3 All farmers with existing lawful water uses who have registered their water uses pursuant to Regulations Requiring that a Water Use be Registered, Regulation 1352, dated 12 November 1999 (R.1352), remain liable for water use rates and charges assessed under the WA until the date of registration, unless they were descheduled under section 7(A) of the WA. The responsible authority had broad discretion in approving or rejecting applications for descheduling but the decisions had to be supported by good reasons.

2.4 All farmers with existing lawful water uses that have been registered, remain liable for water use charges assessed under the NWA until they are deregistered pursuant to Regulation 8 of R.1352. Because section 59(1) of the NWA provides that water use charges may only be made in respect of a water use to which a person is voluntarily committed, deregistration is virtually automatic upon application, subject to the considerations contained in Regulation 8(2).

2.4.1 Any entitlement holder registered under the NWA, may apply for deregistration under R.1352 and such applications must be considered in terms of Regulation 8.

2.4.2 An application for deregistration must be considered proof that the applicant is no longer voluntarily committed to the water use. Upon deregistration, the liability for water use charges under the NWA is relieved.

2.4.3 In order to enable the Department to control existing lawful water use, as well as to provide an opportunity for irrigators to apply for deregistration if they are not interested in using their scheduled water, all farmers on Government Water Schemes have to complete the prescribed form at Annexure A.

2.4.4 It must be pointed out that deregistration implies that the applicant will lose that water use and it will no longer be regarded as an existing lawful use.

2.5 Pursuant to section 34(1), a person may continue with an existing lawful water use subject to any existing conditions or obligations attaching to that use or any other limitation or prohibition by or under the NWA.

3. The policy regarding the treatment of water allocations on government and irrigation board schemes, is in view of the above revised as follows:

3.1 All lawful scheduling in terms of section 63 and 88 of the WA for which all due water use rates and charges were paid on 30 September 1998, should be treated as existing lawful water uses in terms of section 33 of the NWA. As there is no authority for the Minister to attach conditions to a declaration of an existing lawful use, the three-year period to develop unutilised water allocations as granted in terms of Circular 59 of 1999 is hereby withdrawn. These unutilised rights can be treated as existing lawful use until compulsory licencing is required.

3.2 Any entitlement holder who fails to make subsequent payments of due water use rates and charges, may have their water use withdrawn or suspended pursuant to section 54(1)(a) of the NWA.

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3.3 The abovementioned existing lawful uses can be traded to a willing buyer on the same scheme or even outside the scheme if such trading can be facilitated in terms of section 25 of the NWA, and the annual charges for such traded uses would be paid for by the buyer.

3.4 Water users on Government Water Schemes can apply to the Department for deregistration of existing lawful use in terms of Regulation 1352.

4. The policy principles according to letter B31/1 dated 19 February 2001, regarding considering the transfer of water rights, are now applicable and must be adhered to.

DIRECTOR: GENERAL

Appendix C

Validation Results

Table C.1 Validation results – Irrigated crop extent (ha)

Quat	Water use during qualifying period (ha)			Preliminary existing lawful use (ha)			Present water use (ha)		
	Surface	Borehole	Total	Surface	Borehole	Total	Surface	Borehole	Total
A41A	156	30	186	156	30	186	8	30	38
A41D	241	140	381	90	140	230	310	155	465
A41E	357	39	396	326	39	365	315	36	350
Total A41	**754**	**209**	**963**	**572**	**209**	**781**	**633**	**220**	**853**
A42A	2 184	239	2 423	1 822	239	2 061	1 648	184	1 832
A42B	1 569	141	1 709	1 207	141	1 348	1 360	164	1 524
A42C	1 701	268	1 969	1 497	283	1 780	1 640	315	1 955
A42D	474	44	518	474	44	517	345	0	345
A42E	2 291	244	2 535	2 248	244	2 492	1 841	216	2 057
A42F	992	163	1 156	896	163	1 060	910	148	1 059
A42G	76	2	79	620	2	622	76	2	79
A42H	110	11	121	887	11	898	250	11	261
A42J	950	73	1 023	1 733	84	1 818	729	94	824
Total A42	**10 347**	**1 185**	**11 532**	**11 384**	**1 211**	**12 595**	**8 799**	**1 136**	**9 934**
A50A	1 163	3	1 166	1 163	3	1 166	1 149	2	1 151
A50B	166	0	166	166	0	166	182	0	182
A50C	327	38	365	327	38	365	212	0	212
A50E	1 560	12	1 573	861	12	873	1 293	2	1 296
A50F	56	5	61	56	5	61	10	0	10
A50G	368	110	478	368	110	478	209	70	279
A50H	1 651	1 956	3 607	1 324	1 957	3 281	1 555	1 928	3 483
A50J	504	985	1 489	427	985	1 412	579	1 046	1 625
Total A5	**5 795**	**3 110**	**8 905**	**4 691**	**3 111**	**7 802**	**5 190**	**3 048**	**8 238**
A61A	512	188	700	512	188	700	327	164	491
A61B	101	41	143	101	41	143	40	34	73
A61C	166	440	607	146	388	534	207	360	567
A61D	21	315	335	21	247	268	26	343	368
A61E	17	1 167	1 184	17	1 098	1 115	6	1 010	1 016
A61F	74	566	640	74	520	595	57	301	357
A61G	151	159	310	151	159	310	78	53	131
A61H	2 790	117	2 906	1 424	117	1 541	2 377	107	2 484
A61J	787	340	1 127	732	340	1 072	847	230	1 076
A62A	36	50	85	36	50	85	62	49	110
A62C	7	0	7	7	0	7	0	0	0
A62D	0	76	76	0	76	76	0	77	77

Quat	Water use during qualifying period (ha)			Preliminary existing lawful use (ha)			Present water use (ha)		
	Surface	Borehole	Total	Surface	Borehole	Total	Surface	Borehole	Total
A62F	0	957	957	0	957	957	24	355	379
A62G	22	4	27	22	4	27	0	5	5
A62J	0	6	6	0	6	6	0	6	6
A63A	0	1 984	1 984	0	1 984	1 984	0	2 014	2 014
A63B	0	189	189	0	189	189	0	240	240
A63C	389	210	599	365	210	574	469	385	854
A63D	19	205	224	19	205	224	0	264	264
A63E	577	1 509	2 086	79	1 509	1 588	310	1 454	1 764
Total A6	**5 669**	**8 523**	**14 192**	**3 705**	**8 289**	**11 995**	**4 829**	**7 448**	**12 276**
A71A	383	4 228	4 611	383	4 190	4 573	257	4 044	4 301
A71B	0	1 137	1 137	0	1 137	1 137	0	1 020	1 020
A71C	255	3 193	3 448	255	3 239	3 494	162	3 169	3 330
A71D	10	1 015	1 025	10	1 017	1 027	33	868	900
A71E	41	1 511	1 552	41	1 509	1 550	41	1 519	1 560
A71F	126	1 419	1 545	80	1 519	1 598	98	1 600	1 698
A71G	73	2 266	2 339	82	2 433	2 514	68	1 936	2 004
A71H	94	365	459	66	234	300	47	194	241
A71J	436	2 113	2 549	436	2 108	2 544	451	2 016	2 467
A71K	73	251	324	73	250	323	55	292	347
A71L	4 938	3 986	8 924	4 938	4 056	8 994	4 058	3 836	7 894
A72A	134	3 262	3 395	134	3 262	3 395	100	2 880	2 980
A72B	40	759	799	40	703	743	40	596	636
Total A7	**6 602**	**25 503**	**32 105**	**6 537**	**25 655**	**32 192**	**5 409**	**23 969**	**29 378**
A80B	83	17	100	83	17	100	78	36	115
A80D	14	0	14	14	0	14	14	0	14
A80E	28	186	214	28	226	254	13	141	154
A80F	0	93	93	0	93	93	0	44	44
A80G	233	275	508	226	265	491	183	326	509
A80J	1 020	20	1 041	1 020	20	1 040	763	15	778
Total A8	**1 378**	**592**	**1 970**	**1 371**	**621**	**1 992**	**1 051**	**561**	**1 612**
Grand Total	**30 545**	**39 122**	**69 667**	**28 260**	**39 096**	**67 356**	**25 911**	**36 382**	**62 292**

Table C.2 Validation results – Annual irrigation volumes (million m^3)

Quat	Water use during qualifying period			Preliminary existing lawful use			Present water use		
	Surface	Borehole	Total	Surface	Borehole	Total	Surface	Borehole	Total
A41A	1.00	0.21	1.21	1.00	0.21	1.21	0.06	0.21	0.27
A41D	2.94	0.97	3.91	0.93	0.97	1.90	3.85	1.15	4.99
A41E	2.64	0.34	2.97	2.33	0.34	2.66	2.36	0.30	2.66
Total A41	6.58	1.52	8.10	4.26	1.52	5.77	6.26	1.66	7.92
A42A	14.34	1.61	15.96	12.42	1.62	14.04	10.50	1.20	11.69
A42B	10.11	0.88	10.98	9.50	0.88	10.38	8.50	0.92	9.42
A42C	10.38	1.64	12.02	9.73	1.78	11.51	9.67	1.76	11.43
A42D	2.46	0.29	2.75	2.46	0.29	2.75	1.59	0.00	1.59
A42E	14.91	1.54	16.45	14.82	1.54	16.36	11.60	1.32	12.92
A42F	6.03	0.95	6.98	5.62	0.95	6.57	5.66	0.89	6.55
A42G	0.43	0.01	0.44	4.33	0.01	4.35	0.43	0.01	0.44
A42H	0.86	0.09	0.95	6.21	0.09	6.30	1.91	0.09	2.00
A42J	7.10	0.55	7.65	12.14	0.55	12.69	5.76	0.64	6.41
Total A42	66.62	7.56	74.18	77.26	7.70	84.96	55.62	6.83	62.45
A50A	6.74	0.01	6.76	6.74	0.01	6.76	6.77	0.01	6.78
A50B	0.92	0.00	0.92	0.92	0.00	0.92	0.99	0.00	0.99
A50C	2.09	0.23	2.32	2.09	0.23	2.32	1.27	0.00	1.27
A50E	10.24	0.07	10.31	6.05	0.07	6.13	8.26	0.02	8.28
A50F	0.39	0.03	0.42	0.39	0.03	0.42	0.07	0.00	0.07
A50G	2.49	1.09	3.58	2.49	1.09	3.58	1.90	0.59	2.49
A50H	12.11	12.02	24.13	9.63	12.02	21.65	10.70	10.90	21.60
A50J	2.80	5.77	8.57	2.33	5.77	8.10	3.05	5.62	8.67
Total A5	37.79	19.23	57.02	30.64	19.23	49.87	33.01	17.13	50.14
A61A	3.78	1.21	5.00	3.78	1.21	5.00	2.25	0.97	3.23
A61B	0.95	0.31	1.26	0.95	0.31	1.26	0.30	0.26	0.56
A61C	1.00	2.99	4.00	1.00	2.73	3.73	1.22	2.77	3.99
A61D	0.14	1.85	1.99	0.14	1.41	1.55	0.19	2.20	2.39
A61E	0.16	7.78	7.94	0.16	7.29	7.45	0.05	6.29	6.34
A61F	0.37	3.49	3.86	0.37	3.23	3.60	0.27	1.52	1.80
A61G	1.05	1.29	2.34	1.05	1.29	2.34	0.62	0.39	1.01
A61H	16.61	0.73	17.33	8.27	0.73	9.00	13.49	0.59	14.08
A61J	4.11	2.00	6.11	3.84	2.00	5.83	5.05	1.51	6.57
A62A	0.27	0.24	0.51	0.27	0.24	0.51	0.38	0.24	0.62
A62C	0.04	0.00	0.04	0.04	0.00	0.04	0.00	0.00	0.00
A62D	0.00	0.52	0.52	0.00	0.52	0.52	0.00	0.66	0.66

Quat	Water use during qualifying period			Preliminary existing lawful use			Present water use		
	Surface	Borehole	Total	Surface	Borehole	Total	Surface	Borehole	Total
A62F	0.00	8.00	8.00	0.00	8.00	8.00	0.16	2.92	3.08
A62G	0.09	0.04	0.13	0.09	0.04	0.13	0.00	0.04	0.04
A62J	0.00	0.05	0.05	0.00	0.05	0.05	0.00	0.05	0.05
A63A	0.00	11.91	11.91	0.00	11.91	11.91	0.00	11.81	11.81
A63B	0.00	1.25	1.25	0.00	1.25	1.25	0.00	1.70	1.70
A63C	3.77	1.16	4.93	3.52	1.16	4.68	3.73	2.24	5.97
A63D	0.21	1.75	1.96	0.21	1.75	1.96	0.00	2.35	2.35
A63E	6.09	11.67	17.76	0.89	11.67	12.57	2.95	12.04	14.98
Total A6	38.65	58.23	96.88	24.59	56.78	81.37	30.65	50.57	81.22
A71A	3.05	25.35	28.40	3.05	25.11	28.16	2.32	23.07	25.40
A71B	0.00	5.29	5.29	0.00	5.29	5.29	0.00	4.79	4.79
A71C	1.28	15.61	16.89	1.28	15.60	16.88	0.97	15.39	16.36
A71D	0.07	4.88	4.95	0.07	4.89	4.96	0.23	4.33	4.55
A71E	0.17	6.45	6.61	0.17	6.45	6.61	0.17	6.48	6.65
A71F	0.62	6.21	6.83	0.42	6.63	7.05	0.63	7.02	7.65
A71G	0.36	11.22	11.58	0.42	11.33	11.74	0.33	10.42	10.76
A71H	0.60	2.14	2.74	0.45	1.40	1.85	0.29	1.06	1.35
A71J	2.76	10.51	13.26	2.76	10.42	13.18	2.54	10.30	12.84
A71K	0.36	1.42	1.78	0.36	1.44	1.79	0.24	1.60	1.85
A71L	44.19	33.98	78.16	44.19	33.91	78.09	38.75	30.44	69.19
A72A	1.15	16.71	17.86	1.15	16.71	17.86	0.91	14.99	15.90
A72B	0.27	4.65	4.92	0.27	4.34	4.60	0.21	3.35	3.55
Total A7	54.86	144.42	199.29	54.57	143.51	198.08	47.59	133.24	180.84
A80B	0.80	0.15	0.95	0.80	0.15	0.95	0.75	0.38	1.13
A80D	0.07	0.00	0.07	0.07	0.00	0.07	0.07	0.00	0.07
A80E	0.13	1.46	1.60	0.13	2.00	2.14	0.05	1.46	1.50
A80F	0.00	0.72	0.72	0.00	1.65	1.65	0.00	0.25	0.25
A80G	1.56	2.02	3.58	1.52	2.17	3.69	1.41	2.53	3.94
A80J	6.36	0.11	6.47	6.36	0.11	6.47	5.34	0.10	5.44
Total A8	8.91	4.47	13.38	8.87	6.09	14.96	7.61	4.72	12.33
Grand Total	213.42	235.42	448.84	200.19	234.82	435.02	180.74	214.15	394.90

Table C.3 Validation results - Storing of water (million m^3/a)

Quat	Water use during		Preliminary existing		Present water use	
	# of dams	Volume	# of dams	Volume	# of dams	Volume
A41A	11	1.21	11	1.15	13	1.27
A41B	2	0.29	2	0.25	3	0.32
A41C	4	0.01	4	0.01	4	0.01
A41D	15	1.23	10	0.05	16	1.26
A41E	27	1.18	24	1.03	27	1.18
Total A41	**59**	3.93	**51**	2.50	**63**	4.05
A42A	130	1.83	125	1.63	131	1.77
A42B	104	4.46	112	4.27	103	4.55
A42C	110	2.98	116	2.19	103	2.88
A42D	14	0.15	13	0.15	12	1.63
A42E	138	5.01	111	4.54	139	5.32
A42F	41	1.54	32	1.43	35	1.51
A42G	4	0.03	2	0.03	3	0.01
A42H	3	0.03	2	0.03	4	0.03
A42J	6	0.63	10	0.44	6	0.63
Total A42	**550**	16.67	**523**	14.73	**536**	18.35
A50A	79	3.87	72	3.15	83	4.60
A50B	44	1.59	41	1.40	49	1.56
A50C	35	1.48	34	1.34	39	1.52
A50D	13	0.82	13	0.70	15	0.83
A50E	18	2.11	18	1.06	19	2.12
A50F	12	0.78	10	0.47	12	0.78
A50G	1	0.00	1	0.00	1	0.00
A50H	36	3.76	28	2.03	40	3.77
A50J	29	3.27	16	0.08	29	3.27
Total A5	**267**	17.69	**233**	10.24	**287**	18.45
A61A	70	2.97	70	2.97	77	3.03
A61B	41	0.42	38	0.39	41	0.42
A61C	50	0.98	45	0.91	60	1.28
A61D	19	0.38	19	0.38	25	0.39
A61E	65	0.91	62	0.89	65	0.91
A61F	93	2.38	93	1.81	91	2.38
A61G	52	4.11	50	3.88	43	4.07
A61H	59	5.93	46	4.44	61	5.94
A61J	141	49.06	117	48.27	155	49.27
A62A	20	1.93	17	0.65	17	1.87
A62C	0	0.00	0	0.00	0	0.00
A62D	9	0.67	7	0.38	8	0.66

Quat	Water use during		Preliminary existing		Present water use	
	# of dams	Volume	# of dams	Volume	# of dams	Volume
A62E	0	0.00	0	0.00	0	0.00
A62F	14	0.46	14	0.39	11	0.41
A62G	1	0.00	1	0.00	1	0.00
A62H	0	0.00	0	0.00	0	0.00
A62J	5	15.95	5	15.95	5	15.95
A63A	16	0.15	13	0.03	18	0.15
A63B	33	1.20	10	0.05	39	1.16
A63C	33	2.01	24	0.86	38	2.38
A63D	33	0.83	19	0.23	39	0.90
A63E	74	3.93	52	0.74	86	4.81
Total A6	**828**	94.27	**702**	83.23	**880**	96.00
A71A	44	4.71	34	4.71	44	4.71
A71B	0	0.00	0	0.00	0	0.00
A71C	16	9.82	9	9.79	16	9.82
A71D	5	0.21	5	0.21	5	0.21
A71E	8	0.90	8	1.90	8	1.98
A71F	22	4.55	16	4.55	22	4.55
A71G	11	1.69	11	1.69	11	1.69
A71H	18	3.80	18	3.80	18	3.80
A71J	44	0.32	3	0.32	44	0.32
A71K	21	9.57	20	9.57	21	9.50
A71L	28	5.96	23	5.89	28	5.96
A72A	7	1.68	5	0.09	7	1.68
A72B	0	0.00	0	0.00	0	0.00
Total A7	**224**	43.21	**152**	42.52	**224**	44.22
A80A	2	0.09		0.09	2	0.09
A80B	2	0.11	1	0.11	2	0.11
A80D	2	0.05	2	0.05	2	0.05
A80E	1	0.02	1	0.02	1	0.02
A80F	0	0.00		0.00	0	0.00
A80G	10	2.17	10	2.17	10	2.17
A80J	4	0.03	4	0.03	4	0.03
Total A8	**21**	2.46	**18**	2.46	**21**	2.46
Grand Total	**1 949**	178.23	**1 679**	155.67	**2 011**	183.53

Appendix D

Crop Analysis

Table D.1 Crop summary sorted by crop type

Crop	Tertiary Drainage Region						Total (ha)	% of total
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Almonds					45.9		45.9	0.07
Apples				0.7	0.0		0.7	0.00
Apricots				0.7	0.0		0.7	0.00
Avocado		2.0		12.5	25.7	215.5	255.7	0.41
Babala		37.5	0.6	1.5	0.0		39.6	0.06
Baby Marrows					6.7		6.7	0.01
Beans	14.1			65.0	360.2	90.5	529.8	0.85
Beans Dry			19.8	47.5	0.0		67.3	0.11
Beans-Green		1.0		0.6	3.7		5.3	0.01
Beans-Sugar		20.7		30.0	0.0		50.7	0.08
Beetroot					1.2	2.5	3.7	0.01
Berries					1.5		1.5	0.00
Brinjals			0.5		0.0		0.5	0.00
Butternuts		4.5	34.7		30.1	2.2	71.5	0.11
Cabbage		13.9		61.2	207.6	48.2	330.9	0.53
Canola					7.3		7.3	0.01
Carrots				27.1	76.3		103.4	0.17
Cassava					224.6		224.6	0.36
Chillies		16.3		32.9	22.5	5.5	77.2	0.12
Citrus	14.6	116.9	283.9	1 739.5	897.8	56.5	3 109.2	4.97
Coriander					3.8		3.8	0.01
Cotton	30.0		237.4	101.4	3 176.5	2.0	3 547.3	5.67
Cow Peas					3.9		3.9	0.01
Cucumbers			0.4		0.0		0.4	0.00
Cut Flowers		2.4		1.4	0.0		3.8	0.01
Dates					13.3		13.3	0.02
Fesque - Grazing			4.7		0.0		4.7	0.01
Figs					0.5		0.5	0.00
Garlic		0.7			61.3	2.0	64.0	0.10
Gooseberries					7.3		7.3	0.01
Granadillas		10.8		34.2	31.5	6.0	82.5	0.13
Grapes		67.1	25.7	79.6	0.0		172.5	0.28
Grazing		3.0	10.4		0.0		13.4	0.02
Green Feed				13.4	0.0		13.4	0.02
Green Peppers			77.9	33.6	33.4		144.9	0.23

Crop	Tertiary Drainage Region						Total (ha)	% of total
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Groundnuts	30.0	335.2	25.0	63.3	3.6	141.4	598.5	0.96
Guavas				4.4	19.4	4.3	28.1	0.04
Kikuyu				104.4	10.1		114.5	0.18
Kiwifruit					1.5		1.5	0.00
Lavender					1.5		1.5	0.00
Lettuce					4.9		4.9	0.01
Litchis					0.5		0.5	0.00
Lucerne	90.0	64.7	337.7	362.9	505.6	51.0	1 411.9	2.26
Macadamia nuts		14.6		84.0	15.7		114.3	0.18
Maize	33.9	2 123.0	1 461.6	2 745.9	2 026.0	768.7	9 159.0	14.63
Mangoes		4.6		5.7	156.0	81.0	247.3	0.40
Mealies		69.2		161.1	11.6		241.9	0.39
Melons					491.3	1.0	492.3	0.79
Nursery		4.7	2.6	3.6	21.8	1.4	34.1	0.05
Oats	29.1		13.7	9.2	29.3		81.3	0.13
Olives		6.9		5.9	72.2		85.0	0.14
Onions	10.5	26.7	538.2	178.2	2 765.0	65.3	3 583.9	5.73
Paprika		6.4	73.7	98.0	38.8		216.9	0.35
Pastures-perennial	19.9	202.7	54.4	128.0	20.2		425.2	0.68
Pastures-summer	24.2	35.0	261.6	520.6	651.2	67.0	1 559.6	2.49
Pastures-winter				1.9	0.0		1.9	0.00
Pawpaw					3.2	15.0	18.2	0.03
Peaches		235.1		177.9	156.5		569.5	0.91
Peanuts		16.3	10.3	20.0	17.6	4.5	68.7	0.11
Pears			3.0	0.7	2.9		6.6	0.01
Peas					1.2		1.2	0.00
Pecan nuts		21.0		149.6	9.2	12.0	191.8	0.31
Peppadews					0.5		0.5	0.00
Peppers					22.9	5.2	28.1	0.04
Plums		8.0	84.5		0.0	1.0	93.5	0.15
Potatoes	44.5	54.6	342.2	854.4	6 244.8	4.0	7 544.5	12.05
Prickly pears				10.6	0.8		11.4	0.02
Proteas			11.6		0.0		11.6	0.02
Prunes					0.7		0.7	0.00
Pumpkins	15.5	63.5	874.7	409.3	2 760.9	2.2	4 126.1	6.59
Quince				0.7	0.0		0.7	0.00

Crop	Tertiary Drainage Region						Total (ha)	% of total
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Rye grass		37.5		6.0	3.9		47.4	0.08
Scheduled use		60.8		471.4	0.0		532.2	0.85
Seed maize		310.7			0.0		310.7	0.50
Sorghum				37.9	15.4		53.3	0.09
Soy beans			168.5	9.1	0.0		177.6	0.28
Spinach					1.5	46.4	47.9	0.08
Squash			34.8	6.6	0.0	0.5	41.9	0.07
Stone fruit			119.6		0.0		119.6	0.19
Strawberries		5.0		0.3	24.7		30.0	0.05
Sugar cane					0.0	1.0	1.0	0.00
Sunflowers					11.9		11.9	0.02
Sweet potatoes	15.5	33.7		40.9	103.9	23.9	217.9	0.35
Sweet corn			18.6	50.1	170.5		239.2	0.38
Tobacco	11.9	1 852.8	921.3	938.8	239.4		3 964.2	6.33
Tomatoes		46.6	285.1	723.8	3 257.4	322.1	4 635.0	7.40
Triticale			4.4		0.0		4.4	0.01
Unregistered	276.5	5.7	396.7	418.7	0.0		1 097.6	1.75
Vegetables-summer	60.7	90.1	256.3	657.6	1 872.4	204.5	3 141.6	5.02
Vegetables-winter	15.9	163.9	397.9	198.4	24.7	25.0	825.7	1.32
Walnuts				1.9	0.0		1.9	0.00
Watermelons		37.6	162.2	9.2	105.2	1.0	315.2	0.50
Wheat		2 237.7	743.9	1 476.5	2 237.3		6 695.3	10.70
Grand Total	**736.8**	**8 471.1**	**8 299.8**	**13 430.0**	**29 378.2**	**2 280.3**	**62 596.2**	**100.00**

Table D.2 Crop summary sorted by extent under irrigation

Crop	Tertiary Drainage Region						Total	Cum %
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Maize	33.9	2 123.0	1 461.6	2 745.9	2 026.0	768.7	9 159.0	14.63
Potatoes	44.5	54.6	342.2	854.4	6 244.8	4.0	7 544.5	26.68
Wheat		2 237.7	743.9	1 476.5	2 237.3		6 695.3	37.38
Tomatoes		46.6	285.1	723.8	3 257.4	322.1	4 635.0	44.79
Pumpkins	15.5	63.5	874.7	409.3	2 760.9	2.2	4 126.1	51.38
Tobacco	11.9	1 852.8	921.3	938.8	239.4		3 964.2	57.71
Onions	10.5	26.7	538.2	178.2	2 765.0	65.3	3 583.9	63.44
Cotton	30.0		237.4	101.4	3 176.5	2.0	3 547.3	69.10
Vegetables-summer	60.7	90.1	256.3	657.6	1 872.4	204.5	3 141.6	74.12
Citrus	14.6	116.9	283.9	1 739.5	897.8	56.5	3 109.2	79.09
Pastures-summer	24.2	35.0	261.6	520.6	651.2	67.0	1 559.6	81.58
Lucerne	90.0	64.7	337.7	362.9	505.6	51.0	1 411.9	83.83
Unregistered	276.5	5.7	396.7	418.7	0.0		1 097.6	85.59
Vegetables-winter	15.9	163.9	397.9	198.4	24.7	25.0	825.7	86.91
Groundnuts	30.0	335.2	25.0	63.3	3.6	141.4	598.5	87.86
Peaches		235.1		177.9	156.5		569.5	88.77
Scheduled use		60.8		471.4	0.0		532.2	89.62
Beans	14.1			65.0	360.2	90.5	529.8	90.47
Melons					491.3	1.0	492.3	91.26
Pastures-perennial	19.9	202.7	54.4	128.0	20.2		425.2	91.94
Cabbage		13.9		61.2	207.6	48.2	330.9	92.46
Watermelons		37.6	162.2	9.2	105.2	1.0	315.2	92.97
Seed maize		310.7			0.0		310.7	93.46
Avocado		2.0		12.5	25.7	215.5	255.7	93.87
Mangoes		4.6		5.7	156.0	81.0	247.3	94.27
Mealies		69.2		161.1	11.6		241.9	94.65
Sweet corn			18.6	50.1	170.5		239.2	95.04
Cassava					224.6		224.6	95.40
Sweet potatoes	15.5	33.7		40.9	103.9	23.9	217.9	95.74
Paprika		6.4	73.7	98.0	38.8		216.9	96.09
Pecan nuts		21.0		149.6	9.2	12.0	191.8	96.40
Soy beans			168.5	9.1	0.0		177.6	96.68
Grapes		67.1	25.7	79.6	0.0		172.5	96.96

Crop	Tertiary Drainage Region						Total	Cum %
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Green peppers			77.9	33.6	33.4		144.9	97.19
Stone fruit			119.6		0.0		119.6	97.38
Kikuyu				104.4	10.1		114.5	97.56
Macadamia nuts		14.6		84.0	15.7		114.3	97.74
Carrots				27.1	76.3		103.4	97.91
Plums		8.0	84.5		0.0	1.0	93.5	98.06
Olives		6.9		5.9	72.2		85.0	98.19
Granadillas		10.8		34.2	31.5	6.0	82.5	98.33
Oats	29.1		13.7	9.2	29.3		81.3	98.46
Chillies		16.3		32.9	22.5	5.5	77.2	98.58
Butternuts		4.5	34.7		30.1	2.2	71.5	98.69
Peanuts		16.3	10.3	20.0	17.6	4.5	68.7	98.80
Beans dry			19.8	47.5	0.0		67.3	98.91
Garlic		0.7			61.3	2.0	64.0	99.01
Sorghum				37.9	15.4		53.3	99.10
Beans-sugar		20.7		30.0	0.0		50.7	99.18
Spinach					1.5	46.4	47.9	99.26
Rye grass		37.5		6.0	3.9		47.4	99.33
Almonds					45.9		45.9	99.40
Squash			34.8	6.6	0.0	0.5	41.9	99.47
Babala		37.5	0.6	1.5	0.0		39.6	99.53
Nursery		4.7	2.6	3.6	21.8	1.4	34.1	99.59
Strawberries		5.0		0.3	24.7		30.0	99.64
Guavas				4.4	19.4	4.3	28.1	99.68
Peppers					22.9	5.2	28.1	99.73
Pawpaw					3.2	15.0	18.2	99.76
Green feed				13.4	0.0		13.4	99.78
Grazing		3.0	10.4		0.0		13.4	99.80
Dates					13.3		13.3	99.82
Sunflowers					11.9		11.9	99.84
Proteas			11.6		0.0		11.6	99.86
Prickly pears				10.6	0.8		11.4	99.88
Canola					7.3		7.3	99.89
Gooseberries					7.3		7.3	99.90
Baby marrows					6.7		6.7	99.91

Crop	Tertiary Drainage Region						Total	Cum %
	A41 Matlabas	A42 Mokolo	A5 Lephalale	A6 Mogalakwena	A7 Sand	A80 Nzhelele		
Pears			3.0	0.7	2.9		6.6	99.92
Beans-green		1.0		0.6	3.7		5.3	99.93
Lettuce					4.9		4.9	99.94
Fesque grazing			4.7		0.0		4.7	99.94
Triticale			4.4		0.0		4.4	99.95
Cow peas					3.9		3.9	99.96
Coriander					3.8		3.8	99.96
Cut flowers		2.4		1.4	0.0		3.8	99.97
Beetroot					1.2	2.5	3.7	99.98
Pastures-winter				1.9	0.0		1.9	99.98
Walnuts				1.9	0.0		1.9	99.98
Berries					1.5		1.5	99.98
Kiwifruit					1.5		1.5	99.99
Lavender					1.5		1.5	99.99
Peas					1.2		1.2	99.99
Sugar cane					0.0	1.0	1.0	99.99
Prunes					0.7		0.7	99.99
Apples				0.7	0.0		0.7	99.99
Apricots				0.7	0.0		0.7	100.00
Quince				0.7	0.0		0.7	100.00
Brinjals			0.5		0.0		0.5	100.00
Figs					0.5		0.5	100.00
Litchis					0.5		0.5	100.00
Peppadews					0.5		0.5	100.00
Cucumbers			0.4		0.0		0.4	100.00
Grand Total	**736.8**	**8 471.1**	**8 299.8**	**13 430.0**	**29 378.2**	**2 280.3**	**62 596.2**	

Appendix E

Verification of Water Users

Table E.1 Verification status (million m^3/a)

Drainage Region	Preliminary ELU (Validation)				Verified ELU				% of properties verified	% of volume verified
	# of prop.	Surface volume	Borehole volume	Total	# of prop.	Surface volume	Borehole volume	Total		
A41A	5	1.00	0.21	1.21	2	0.55	0.00	0.55	40%	45%
A41D	18	0.93	0.97	1.90	10	0.38	0.83	1.21	56%	64%
A41E	22	2.33	0.34	2.66	4	0.75	0.00	0.75	18%	28%
Total A41	**45**	4.26	1.52	5.77	**16**	1.67	0.83	2.51	**36%**	**43%**
A42A	103	12.42	1.62	14.04	69	7.26	0.88	8.15	67%	58%
A42B	47	9.50	0.88	10.38	39	6.22	0.56	6.78	83%	65%
A42C	89	9.73	1.78	11.51	51	5.34	0.67	6.01	57%	52%
A42D	10	2.46	0.29	2.75	7	1.75	0.00	1.75	70%	64%
A42E	33	14.82	1.54	16.36	32	10.33	0.97	11.30	97%	69%
A42F	22	5.62	0.95	6.57	11	3.88	0.47	4.35	50%	66%
A42G	44	4.33	0.01	4.35	44	4.33	0.01	4.35	100%	100%
A42H	65	6.21	0.09	6.30	65	6.21	0.09	6.30	100%	100%
A42J	82	12.14	0.55	12.69	82	0.00	12.14	12.14	100%	96%
Total A42	**495**	77.26	7.70	84.96	**400**	45.33	15.80	61.13	**81%**	**72%**
A50A	26	6.74	0.01	6.76	9	1.83	0.00	1.83	35%	27%
A50B	4	0.92	0.00	0.92	4	0.00	0.00	0.00	100%	0%
A50C	11	2.09	0.23	2.32	8	0.88	0.00	0.88	73%	38%
A50D	19	6.05	0.07	6.13	2	0.00	0.00	0.00	11%	0%
A50E	4	0.39	0.03	0.42	4	1.70	0.00	1.70	100%	404%
A50G	16	2.49	1.09	3.58	4	0.91	0.54	1.45	25%	41%
A50H	91	9.63	12.02	21.65	22	4.28	3.36	7.65	24%	35%
A50J	47	2.33	5.77	8.10	4	0.00	0.90	0.90	9%	11%
Total A5	**218**	30.64	19.23	49.87	**57**	9.61	4.80	14.41	**26%**	**29%**
A61A	49	3.78	1.21	5.00	20	1.62	0.43	2.05	41%	41%
A61B	31	0.95	0.31	1.26	11	0.05	0.07	0.12	35%	9%
A61C	46	1.00	2.73	3.73	24	0.90	1.53	2.43	52%	65%
A61D	40	0.14	1.41	1.55	10	0.13	0.25	0.38	25%	24%
A61E	48	0.16	7.29	7.45	21	0.01	5.60	5.61	44%	75%
A61F	30	0.37	3.23	3.60	18	0.06	0.96	1.02	60%	28%
A61G	10	1.05	1.29	2.34	5	0.41	0.79	1.20	50%	51%
A61H	44	8.27	0.73	9.00	27	5.24	0.07	5.32	61%	59%
A61J	45	3.84	2.00	5.83	20	1.26	0.66	1.92	44%	33%
A62A	4	0.27	0.24	0.51	2	0.16	0.00	0.16	50%	31%
A62B	0	0.00	0.00	0.00	0	0.00	0.00	0.00	100%	100%
A62C	1	0.04	0.00	0.04	0	0.00	0.00	0.00	0%	0%

Drainage Region	Preliminary ELU (Validation)				Verified ELU				% of properties verified	% of volume verified
	# of prop.	Surface volume	Borehole volume	Total	# of prop.	Surface volume	Borehole volume	Total		
A62D	8	0.00	0.52	0.52	0	0.00	0.00	0.00	0%	0%
A62E	0	0.00	0.00	0.00	0	0.00	0.00	0.00	100%	100%
A62F	13	0.00	8.00	8.00	5	0.00	0.54	0.54	38%	7%
A62G	3	0.09	0.04	0.13	0	0.00	0.00	0.00	0%	0%
A62H	0	0.00	0.00	0.00	0	0.00	0.00	0.00	100%	100%
A62J	1	0.00	0.05	0.05	0	0.00	0.00	0.00	0%	0%
A63A	61	0.00	11.91	11.91	15	0.00	2.73	2.73	25%	23%
A63B	17	0.00	1.25	1.25	0	0.00	0.00	0.00	0%	0%
A63C	33	3.52	1.16	4.68	4	0.55	0.12	0.67	12%	14%
A63D	19	0.21	1.75	1.96	1	0.00	0.05	0.05	5%	3%
A63E	23	0.89	11.67	12.57	5	0.00	2.85	2.85	22%	23%
Total A6	**526**	24.59	56.78	81.37	**188**	10.39	16.65	27.05	**36%**	**33%**
A71A	183	3.05	25.11	28.16	82	1.47	13.42	14.89	45%	53%
A71B	34	0.00	5.29	5.29	14	0.00	3.74	3.74	41%	71%
A71C	76	1.28	15.60	16.88	22	0.99	7.90	8.89	29%	53%
A71D	38	0.07	4.89	4.96	7	0.00	0.41	0.41	18%	8%
A71E	29	0.17	6.45	6.61	3	0.04	0.48	0.52	10%	8%
A71F	50	0.42	6.63	7.05	14	0.42	1.25	1.67	28%	24%
A71G	76	0.42	11.33	11.74	20	0.06	3.67	3.73	26%	32%
A71H	49	0.45	1.40	1.85	0	0.00	0.00	0.00	0%	0%
A71J	56	2.76	10.42	13.18	18	0.60	3.36	3.95	32%	30%
A71K	46	0.36	1.44	1.79	9	0.09	0.33	0.42	20%	23%
A71L	31	44.19	33.91	78.09	22	41.95	33.23	75.18	71%	96%
A72A	73	1.15	16.71	17.86	24	1.15	6.32	7.47	33%	42%
A72B	28	0.27	4.34	4.60	9	0.00	2.51	2.51	32%	55%
Total A7	**769**	54.57	143.51	198.08	**244**	46.77	76.62	123.39	**32%**	**62%**
A80B	5	0.80	0.15	0.95	0	0.00	0.00	0.00	0%	0%
A80D	1	0.07	0.00	0.07	0	0.00	0.00	0.00	0%	0%
A80E	6	0.13	2.00	2.14	0	0.00	0.00	0.00	0%	0%
A80F	12	0.00	1.65	1.65	9	0.00	0.94	0.94	75%	57%
A80G	26	1.52	2.17	3.69	19	1.37	2.12	3.49	73%	95%
A80J	20	6.36	0.11	6.47	15	4.78	0.11	4.89	75%	76%
Total A8	**70**	8.87	6.09	14.96	**43**	6.15	3.16	9.32	**61%**	**62%**
Total	**2 123**	200.19	234.82	435.02	**948**	119.93	117.87	237.80	**45%**	**55%**