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Water Affairs
REPUBLIC OF SOUTH AFRICA
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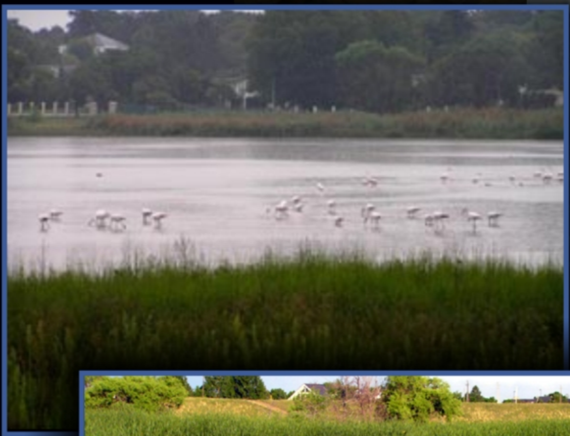
Classification of Significant Water Resources(River, Wetlands, Groundwater and Lakes) in the Upper Middle and Lower Vaal Water Management Areas (WMA) 8,9,10

WATER RESOURCE ANALYSIS REPORT



May 2012

Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10

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Prepared by:

WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants CC, Rivers for Africa eFlows Consulting (Pty) Ltd, Conningarth Economists, Koekemoer Aquatic Services and Zitholele Consulting (Pty) Ltd.

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DOCUMENT INDEX

Reports as part of this project (report status as in July 2011):

Index number	RDM Report number	Report title
1.1	RDM/WMA8,9,10/00/CON/CLA/0111	Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10, Inception Report
1.2	RDM/WMA8,9,10/00/CON/CLA/0211	Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10, Status Quo Report
1.3	RDM/WMA8,9,10/00/CON/CLA/0311	Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10, Quantification of the Ecological Water Requirement Report
1.4	**RDM/WMA8,9,10/00/CON/CLA/0411**	Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10, Water Resource Analysis Report

Bold indicates this report.

Title:	***Water Resource Analysis Report***
Authors:	*HS Swart, CJ Seago, PG van Rooyen*
Study Name:	***Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10***
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Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10

Water Resource Analysis Report

Executive Summary

1. BACKGROUND

*This study entitled "Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10" was commissioned by the Chief Directorate Resource Directed Measures (RDM) of the Department of Water Affairs (DWA) in October 2010. The ultimate purpose of the study is the implementation of the Water Resource Classification System (WRCS) in the above-mentioned three Vaal WMAs according to the 7 step process proposed by the WRCS (**DWAF, 2007**) as described in **Figure D-1** of **Appendix D**.*

*The main objective of this document is to describe the assumptions and database used for the water resource analyses undertaken for this study as part of Steps 5 and 6 of the WRCS (see **Figure D-1**) and to summarise the results presented to the Ecological and Socio-Economic Team for further evaluation.*

2. STUDY AREA

*The core of the study area consists of the Upper, Middle and Lower Vaal River Water Management Areas (WMAs), however, due to the numerous inter-basin transfers that link this core area with other WMAs, the water resource assessments had to be undertaken in the context of the Integrated Vaal River System (IVRS) which also includes portions of the Komati, Usutu, Thukela, Senqu River (located in Lesotho) and Upper Orange (Riet-Modder River) catchments. The study area, therefore, comprises of the water resource and bulk supply systems of the entire Integrated Vaal River System as shown in **Figure A-1** of **Appendix A.** A detailed description of the IVRS and its operation is provided in **Section** 2. It is important to note that the Riet-Modder catchment, which forms part of the Orange River WMA, is not included in the study area.*

3. DECISION SUPPORT SYSTEM FOR IVRS

Due to the highly developed nature of the IVRS and the various inter-basin transfers that exist in the system, operating rules were developed that regulate when and how much water is transferred. The management and implementation of these operating rules (which include the dilution of the TDS concentration downstream of Vaal Barrage) are undertaken by the application of the Water Resource Planning Model (WRPM). The WRPM was subsequently used as the Decision Support System (DSS) for this study. The WRPM system schematics are included in ***Appendix C****. A low confidence high resolution network configuration of the Water Resource Yield Model (WRYM) was used to undertake a cursory quantitative evaluation of the water availability (and consequential implications) at small catchment scale based on land use data from the Validation and Verification study that is currently being undertaken in the three Vaal River WMAs.*

4. HYDROLOGICAL DATABASE

*The WRPM configuration of the IVRS includes the hydrological database resulting from the Vaal River System Analysis Update (VRSAU) Study (****DWAF, 1999****). The VRSAU hydrology covers the period October 1920 to September 1995 (i.e. a period of 75 years). It is important to note that the hydrological analyses of the VRSAU study were not necessarily undertaken at quaternary catchment level as the focus was on the most representative modelling of relevant sub-catchments. The methodology adopted for the disaggregation of lumped hydrology is described in* ***Section 4.4****.*

5. WATER BODIES

A large number of reservoirs form part of the Integrated Vaal River System. These water bodies include major impoundments such as Heyshope, Zaaihoek, Grootdraai, Woodstock, Sterkfontein, Katse, Mohale, Vaal and Bloemhof dams as well as a large number of smaller dams which are mainly used for local municipal water supply, rural water supply, irrigation, livestock and game farming. Impoundments are discussed in ***Section*** 5 *and information on major dams is summarised in* ***Table E-9*** *of* ***Appendix E****.*

6. WATER REQUIREMENT AND RETURN FLOW PROJECTIONS

The WRPM database includes growing water requirements up to the year 2030. Since the Integrated Vaal River System (IVRS) is analysed on an annual basis, the water requirement projections of the major bulk water suppliers (Rand Water, Midvaal Water Company and Sedibeng Water), the strategic water user Eskom, as well as large industries such as Sasol and Mittal Steel (previously known as Iscor), are also updated annually. The most recent water requirement projections of the above-mentioned users (revised as part of the 2011/2012 Annual Operating Analysis) were used for the WRPM scenario analyses undertaken for this study. Two levels of catchment development were considered: Present Day (2011) and a Future (2020) condition. The water requirements and return flows representative of these two development conditions are summarised in ***Table 6-6*** *of* ***Section 6.7*** *and details thereof are provided in* ***Appendix F****.*

7. INTEGRATED UNITS OF ANALYSIS AND BIOPHYSICAL NODES

*Considerations for the identification and selection of the Integrated Units of Analysis (IUAs) are described in the Status Quo Report (**DWA, 2011b**) compiled as part of this study. The identified IUAs for the three Vaal Water Management Areas are shown in **Figures B-1**, **B-2** and **B-3** of **Appendix B** and listed in* **Table 7-1***.*

*The key biophysical nodes are the Ecological Water Requirement (EWR) sites and the selection process of these sites is documented in the recent Reserve studies (**DWAF, 2008e**; **DWAF 2009a** and **b**). Since large sections of the catchment were still unaccounted for additional biophysical nodes (referred to as desktop biophysical nodes) had to be selected. Various tools and information such as the Desktop EcoClassification results generated during the recent Reserve studies and the National Freshwater Ecosystem Priority Areas (NFEPA) were used to identify these additional nodes referred to as desktop nodes. All attempts were made to select nodes that fairly represent the different conditions and operational procedures in the catchment. A total of 115 biophysical nodes were selected in the three Water Management Areas.*

8. ASSESSMENT OF KEY BIOPHYSICAL NODES (EWR SITES)

*The quantification of EWRs at the key biophysical nodes (EWR sites) was undertaken at a Comprehensive Reserve assessment level and the results were summarised from the detailed reports available for this study. The EWR results of all previous Reserve studies were checked to ensure that accurate data could be applied during step 4 of the WRCS. The detailed results of the EWRs at all the sites are provided in the Quantification of the EWR report (**DWA, 2011c**).*

*The Upper Vaal WMA results recommended for use in this study are summarised in **Table 8-2**. In terms of the EWRs for the Middle (**DWA, 2010d**) and Lower (**DWA, 2010e**) Vaal WMA, it was identified during the scenario phase and final decision making of the Comprehensive Reserve study, that the present flow regime and operation of the system should be signed off as the Reserve.*

*The WRPM includes a control mechanism developed to model the EWR in a water resource system. This procedure applies a user defined relationship between selected incremental inflows and specified releases to simulate the EWR. The EWR structures determined for the WRPM are discussed in **Section 8.3** and included in **Appendix G.***

*Recommendations based on the evaluation of the EcoClassification results of the Reserve Determination study, as documented in the Quantification of the EWR report (**DWA, 2011c**) of this study formed the basis for the definition of the EWR scenario to be used for the WRPM scenario analyses. The EWR scenario selected for the WRPM analysis comprises of the following combination of individual EWRs:*

- *The REC EWRs of the following Vaal River EWR sites were considered: RE-EWR1, EWR1, EWR2, EWR3, EWR6, EWR8, EWR9, EWR10, EWR11 as part of this study (EWR sites 4, 5 and*

7 excluded);

- *The EWRs for 8 additional EWR sites defined in the Waterval, Renoster, Schoonspruit and Harts, river catchments were included;*
- *The REC EWRs of the Thukela EWR site downstream of Driel Barrage were included; and*
- *The Senqu Sub-system EWRs were included.*

9. WRPM SCENARIO ANALYSES

*The schematic diagrams shown in **Figures C-1** to **C-12** of **Appendix C** are representative of the WRPM configuration of the IVRS that was used for this study. The WRPM configuration originates from the 2011/2012 Vaal River Annual Operating Analysis and adjustments made as part of this study are described in **Section*** 9.

*The WRPM scenario results of the Reserve Determination study and the subsequent considerations proposed in terms of the EWR sites formed the basis for the definition of the WRPM scenarios to be analysed for this study. The basic assumptions adopted for the WRPM scenario analyses are summarised in **Section 10.4**. The scenarios selected for analysis with the WRPM are summarised in **Table 1**.*

Table 1: Summarised description of WRPM scenarios

WRPM Scenario Reference	***Development Level***	***Status of Ecological Reserve***	***Scenario Description***
Sc 1	*Present Day (2011)*	*Excluded*	• *Base scenario representing the status quo.* • *Sterkfontein release rule adjusted to improve seasonal distribution of flows at EWR8 (refer to **Section 9.2**).* • *Upper Vaal WMA irrigation water use includes unlawful use (see **Section 6.4**).* • *Mine dewatering: No desalination with discharges made to relevant river systems.*
Sc 2	*Present Day (2011)*	*Included*	• *Based on **Scenario 1**.* • *Selected EWR Scenario included (see **Section 8.4** for details).*
Sc 3	*Future (2020)*	*Excluded*	• *Base scenario representing the future 2020 development conditions.* • *Includes proposed Polihali Dam and its conveyance infrastructure.* • *Irrigation water requirements in Upper Vaal WMA based on Existing Lawful Use plus 15% of Unlawful Use.* • *Includes desalination of mine water and proposed re-use thereof.*

WRPM Scenario Reference	Development Level	Status of Ecological Reserve	Scenario Description
Sc 4	*Future (2020)*	*Included*	• *Based on* ***Scenario 3.*** • *Selected EWR Scenario included (see* ***Section 8.4*** *for details).*
Sc 5	*Future (full utilisation)*	*Excluded*	• *Scenario representing the full utilization of available water.* • *Based on current infrastructure which includes the VRESAP pipeline (used for transferring water from Vaal Dam to Eastern Sub-system).* • *Mine dewatering: No desalination and discharges made to relevant river systems.*
Sc 6	*Future (full utilisation)*	*Included*	• *Based on* ***Scenario 5****.* • *Selected EWR Scenario included (see* ***Section 8.4*** *for details).*
Sc 7	*Present Day (2011)*	*Included*	• *Based on* ***Scenario 2****.* • *Alternative to EWR releases from Grootdraai Dam: The Grootdraai compensation rule was included and EWRs at EWR2 and EWR3 were excluded.*
Sc 8	*Present Day (2011)*	*Included*	• *Based on* ***Scenario 1****.* • *Optimisation of Sterkfontein release rule: Optimisation scenario developed specifically for EWR8, aimed at improving the shape of the flow duration curve in the dry season (see* ***Section 9.3****).*
Sc 9a	*Future (full utilisation)*	*Only Douglas EWR*	• *Based on* ***Scenario 5.*** • *Include the optimised Sterkfontein release rule (see* ***Section 9.3****).*
Sc 9b	*Future (2020)*	*Only Douglas EWR*	• *Based on* ***Scenario 3.*** • *Include the optimised Sterkfontein release rule (see* ***Section 9.3****).*

The WRPM scenario results are discussed in ***Sections 10.6.2*** *to* ***10.6.11*** *and the graphical results are presented in* ***Appendices H*** *to* ***Q****. The average annual flows simulated at each of the EWR sites are summarised in* ***Appendix R****. The simulated monthly time series of flows at the EWR sites were provided to the Ecological team for the assessment of the ecological consequences of each of the WRPM scenarios (separate report to be compiled as part of this study).*

10. ASSESSMENT OF DESKTOP BIOPHYSICAL NODES

The resolution of the WRPM configuration does not allow for the explicit modelling of the additional desktop biophysical nodes described in ***Section 7.*** *Although natural hydrology could be derived for these nodes, it was not be possible to simulate present day conditions at these sites. An alternative strategy described in* ***Section 11.1*** *was followed for the assessment of current development conditions. A first order water* *balance assessment was done for the desktop nodes to identify nodes which needed further evaluation.*

*Land use information obtained from the Validation and Verification studies (refer to **Section 11.2**) was used for the assessment. The biophysical node information and water balance results are summarised in **Figures S-1** to **S-3** of **Appendix S**.*

*A low confidence high resolution network configuration of the Water Resource Yield Model (WRYM) was used to undertake a cursory quantitative evaluation of the water availability (and consequential implications) at small catchment scale for selected desktop nodes. The WRYM network configurations used for the analyses are shown in **Figures S-4** to **S-6** of **Appendix S** and the analyses are described in **Section 11.5**.*

The following two scenarios were evaluated with the WRYM:

- ***Present Day (2009) development level scenario**: The purpose of this scenario is to inform the determination of the EWR; and*
- ***Scenario where only the existing lawful use is abstracted**: This scenario where the Existing Lawful Use (ELU) is imposed on the systems will provide an indication of what the potential benefits are if the alleged unlawful irrigation is removed.*

*The results for the desktop nodes evaluated by means of the WRYM analyses are summarised in **Table S-1** of **Appendix S**. From **Table S-1** the following can be concluded for the two scenarios evaluated:*

- ***2009 development level**: The EWR supply was found to be unacceptable for three nodes in the Upper Vaal WMA (UB.2, UB.3 and UB.6) and two nodes in the Middle Vaal WMA (MA.1 and MA.2). For nodes MA.1 and MA.2 the EWR distribution was found to be reasonable but evaluation of the flow duration curves showed that deficits occurred for percentiles less than 50%.*
- ***Existing Lawful Use (ELU) irrigation scenario**: Results for this future scenario showed that the EWR supply was found to be unacceptable for ten of the desktop nodes of which eight nodes are located in the Upper Vaal WMA and two nodes in the Middle Vaal WMA.*

*For nodes where the EWR are met, the relative change in the EWR supply between the two scenarios is also indicated in **Table S-1**.*

11. CONCLUSIONS

In terms of the considerations for the EWR sites evaluated as part of the WRPM analyses the following should be noted:

- *Improvement of the seasonal flow distribution at EWR8 on the Wilge River was one of the objectives of the water resource assessments of this study and resulted in the adjustment of the Sterkfontein release rule. The simulated monthly flow distribution at EWR8, which was based on the optimised*

*Sterkfontein release rule (as described in **Section 9.3**) were found to be an improvement of the initial adjusted rule described in **Section 9.2**. The implication on the system yield was evaluated, and although the HFY was reduced by 5%, stochastic analysis indicated that the assurance of supply to users was not jeopardised by the implementation of the optimised release rule.*

- *The results for WRPM **Scenario 7** indicated that the discrepancy identified between the simulated flows at EWR2 and EWR3 during the Reserve Determination Study, was resolved by implementing the existing Grootdraai compensation release rule and excluding the EWRs for these two sites.*
- *Implementation of the EWR scenario as described in **Section 8.4** did not jeopardise the assurance of supply to users in the Vaal River System.*
- *As expected, implementation of the Douglas EWR (refer to **Section 9.5** for details of the various assumptions) has significant implications on the yield of the Vaal River System. Impact assessments were done for two development conditions. The reduction in yield for a future scenario (representative of development conditions between 2011 and 2020) amounted to about 70 million m^3/a (8%). For the 2020 development conditions it was found that the augmented yield (resulting from the implementation of the proposed Polihali Dam in Lesotho) will be reduced by 99 million m^3/a (6.7%) due to the implementation of the Douglas EWR.*

With reference to the assessment of the desktop biophysical nodes, the following was concluded:

- *Based on the first order water balance assessment it was identified that further analyses were required for 68 of these nodes.*
- *The results from the low confidence high resolution WRYM were fed into the post processing excel module developed for comparing the EWR and the present day simulation results. Two scenarios based on the 2009 development and a future scenario including existing lawful use (ELU) for irrigation, were considered. For the 2009 development scenario the EWR supply was found to be unacceptable for three nodes in the Upper Vaal WMA (UB.2, UB.3 and UB.6) and two nodes in the Middle Vaal WMA (MA.1 and MA.2). Results for the future ELU scenario showed that the EWR supply was unacceptable for ten of the desktop nodes of which eight nodes are located in the Upper Vaal WMA and two nodes in the Middle Vaal WMA.*

12. RECOMMENDATIONS

In view of the findings of the Water Resource analyses, the following recommendations are made:

- *The optimized Sterkfontein release rule as presented in **Section 9.3** should be implemented to improve the distribution of dry season flows at EWR8 on the Wilge River;*

- *The existing Grootdraai compensation release rule should be maintained as opposed to the EWRs at EWR2 and EWR3.*
- *A socio-economic assessment should be undertaken for the impacts due to the implementation of the Douglas EWR. Results of the socio-economic analyses should inform further decisions regarding the feasibility of including the Douglas EWR.*

Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10

Water Resource Analysis Report

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ABBREVIATIONS

Acronym	Meaning
AOA	Annual Operating Analysis
BBM	Building Block Methodology
COMBUD	Computer Based Budgets
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
CV	Coefficient of Variability
DC	Demand Centre
D: NWRP	Directorate: National Water Resource Planning
D: WRPS	Directorate: Water Resource Planning Systems
D: RDM	Directorate: Resource Directed Measures
DRM	Desktop Reserve Model
DSC	Dead Storage Capacity
DWA	Department of Water Affairs
EC	Ecological Category
EGSA	Ecosystem Goods, Services and Attributes
EI	Environmental Importance
EIS	Ecological Importance and Sensitivity
ER	Ecological Reserve
ESBC	Ecological Sustainability Base Configuration
ESKOM	Electricity Supply Commission
EWR	Ecological Water Requirements
FSL	Full Supply Level
GDP	Gross Domestic Product
GFSC	Gross Full Supply Capacity
GGP	Gross Geographic Product
HFSR	Habitat Flow Stressor Response
HFY	Historic Firm Yield
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IVRS	Integrated Vaal River System
IWQMP	Integrated Water Quality Management Plan
IWRM	Integrated Water Resource Management
LIM	Limnophilic Fish Species
LHDA	Lesotho Highlands Development Authority
LHWP	Lesotho Highlands Water Project
LSR	Large Semi-rheophilic Fish Species
LV	Lower Vaal
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	Metres below ground level
MC	Management Class
MD	Municipal District
MOL	Minimum Operating Level
MVI	Marginal Vegetation Macroinvertebrate
MV	Middle Vaal
NFEPA	National Freshwater Ecological Priority Areas
NFSC	Net Full Supply Capacity
NWA	National Water Act

Acronym	Meaning
NWRS	National Water Resources Strategy
PES	Present Ecological State
PIM	Production Industry Model
REC	Recommended Ecological Category
RU	Resource Unit
RWQO	Resource Water Quality Objectives
SAFRIM	South African Inter-industry Model
SAM	Social Accounting Matrix
SCI	Socio-Cultural Importance
SD	Standard Deviation
SQ	Sub-Quaternary
TDS	Total Dissolved Solids
UV	Upper Vaal
VRESAP	Vaal River Eastern Sub-system Augmentation Project
VRESS	Vaal River Eastern Sub-system
VRSAU	Vaal River System Analysis Update
WDM	Water Demand Management
WC	Water Conservation
WIM	Water Impact Model
WMA	Water Management Area
WRC	Water Research Commission
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRSAS	Water Resource Situation Assessment Study
WRSM2000	Water Resources Simulation Model 2000
WRYM	Water Resource Yield Model
WUA	Water User Association

Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8, 9, 10

Water Resource Analysis Report

1 INTRODUCTION

1.1 PURPOSE OF THE STUDY

This report describes the water resource analyses carried out by the appointed Professional Service Provider (PSP) for undertaking the Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10 Study. The study was commissioned by the Chief Directorate: Resource Directed Measures of the Department of Water Affairs (DWA) in October 2010 and the main objective of the study is to determine the Management Class (MC) of the significant water resources in the three Vaal WMAs over a period of 24 months.

The Water Resources Classification System (WRCS), which is required by the National Water Act (Act 36 of 1998), provides a set of guidelines and procedures for determining different classes of water resources. The WRCS prescribes a consultative process to classify water resources (Classification Process) to help facilitate a balance between the protection and use of the nation's water resources. The outcome of the Classification Process will be the approval of the Management Class (MC) by the Minister or her delegated authority for every significant water resource (river, estuary, wetland and aquifer) which will be binding on all authorities or institutions when exercising any power, or performing any duty under the National Water Act (NWA). The MC outlines those attributes that the Department and society require of different water resources. The 7 step process proposed by the WRCS (**DWAF, 2007**) is described in **Figure D-1** of **Appendix D**. The water resource analysis, which is the subject of this document, was undertaken as part of Steps 5 and 6.

1.2 DESCRIPTION OF STUDY AREA

The study area comprises of the water resource of the Vaal River System which includes the catchments of the Upper, Middle and the Lower Vaal Water Management Areas (see **Figure A-1** of **Appendix A)**. Other sub-systems that are linked to the Vaal River System are also shown in **Figure A-1**. The supporting sub-systems will form part of the water resource system analysis (either directly or indirectly) to ensure the Management Class is determined in an integrated manner. A more detailed description of the Integrated Vaal River System

(IVRS) is provided in **Section 2**. It is important to note that the Riet-Modder catchment, which forms part of the Orange River WMA, is not included in the study area.

1.3 PURPOSE AND LAYOUT OF THE REPORT

The purpose of the Water Resource Analysis Report is to:

- Give a description of the Integrated Vaal River System (IVRS) and provide an overview of the operation of the IVRS as well as the various inter-basin transfers (**Section 2**);
- Provide a brief description of the Water Resource Yield Model (WRYM) and the Water Resource Planning Model (WRPM) which were used as the Decision Support Systems (DSSs) for the water resource analysis of the desktop nodes and the Ecological Water Requirement (EWR) sites respectively (refer to **Section 3**);
- Provide summarised information on the hydrological database adopted for the water resource analysis (refer to **Section 4**) and the impoundments included in the WRPM configuration (**Section** 5);
- Discuss and summarise the water requirement and return flow projections of the major water user groups in the IVRS with specific reference to the Present Day (2011) and future (2020) catchment development levels considered for this study (see **Section 6**);
- Discuss the selection of biophysical nodes with specific reference to the Ecological Water Requirement (EWR) sites identified as part of the Comprehensive Reserve Determination Study (**DWA, 2010d**) (see **Section 7.3**) and the desktop biophysical nodes (**Section 7.4**);
- Describe and summarise the Ecological Water Requirement (EWR) information used as input to the WRPM for the assessment of the key biophysical nodes (see **Section 8**);
- Describe the changes made to the WRPM configuration (**Section 9**) and summarise the long-term operating rules adopted for the WRPM analysis of the IVRS for the purposes of this study (see **Section 10.4**);
- Describe the assumptions adopted for the identified WRPM scenarios (**Section 10.5**) and discuss the relevant scenario results (**Section 10.6**)
- Describe the approach adopted for the assessment of the desktop nodes as well as the results (refer to **Section 11**);
- Provide a comprehensive list of references (**Section 13**).

2 DESCRIPTION OF THE INTEGRATED VAAL RIVER SYSTEM (IVRS)

2.1 GENERAL

Owing to a number of inter-basin transfers both to and from the Vaal River catchment, the Vaal River System is inter-linked with various other river basins. The Integrated Vaal River System (IVRS), therefore, comprises all the individual river systems that are linked to the Vaal River (refer to **Figure A-1** of **Appendix A**) and includes the following supporting sub-systems:

- Komati Sub-system (Nooitgedacht and Vygeboom dams);
- Usutu Sub-system (Westoe, Jericho and Morgenstond dams);
- Heyshope Dam Sub-system;
- Zaaihoek Dam Sub-system;
- Upper Thukela Sub-system (Woodstock Dam and Driel Barrage); and
- Senqu Sub-system (Katse and Mohale dams).

A brief description of each supporting sub-system is provided in **Section 2.2**. The Vaal River System is described in **Section 2.3** and summarised information on the relevant inter-basin transfer schemes is provided in **Section 2.4**.

2.2 DESCRIPTION OF SUPPORTING SUB-SYSTEMS

2.2.1 Komati Sub-system

The Komati sub-system comprises the catchment of the Komati River upstream of the Swaziland border (See **Figure A-1** of **Appendix A**). The main components of the sub-system are the Nooitgedacht and Vygeboom dams, with various pumps and pipelines transferring water to a number of power stations in the Upper Olifants catchment. The WRPM configuration of the Komati Sub-system is shown in **Figure C-12** of **Appendix C**. Two dummy dams (combination of farm dams), one in the Nooitgedacht Dam and one in the Gemsbokhoek weir incremental catchments, are included in the system configuration of the Komati Sub-system. Water from these dummy dams is used for irrigation purposes. There are also run-of-river irrigation abstractions taking place in the incremental catchment upstream of Vygeboom Dam.

Water is transferred to the Eskom Power Stations via a network of pumps and pipelines. Water is pumped to the Bosloop reservoir from Gemsbokhoek weir (when there is flow in the river) as well as from Vygeboom Dam. Water from the Bosloop reservoir is then pumped to the Wintershoek reservoir. Water can be transferred from the Wintershoek reservoir to Nooitgedacht Dam or vice versa depending on conditions in the system. Water is then pumped from Wintershoek reservoir (at a maximum transfer capacity of 2.755 m^3/s) to the Arnot Power Station and then gravitated down to Hendrina and Duvha power stations. Water is pumped from Nooitgedacht Dam to the Klipfontein reservoir at a maximum capacity of 1.016 m^3/s. From Klipfontein water can be supplied to either the Komati Power Station or the Hendrina and Duvha Power Stations.

Priority is given to compensation releases from Nooitgedacht and Vygeboom dams which are described below.

- **Nooitgedacht Dam**: A constant release of 0.15 m^3/s (4.73 million m^3/a) is simulated from the dam and it is assumed that the consumptive losses associated with these releases are in the order of 50%. This means that only 50% of the compensation releases made from Nooitgedacht Dam are available either to downstream irrigation water users, as inflow to Vygeboom Dam or for abstraction at Gemsbokhoek Weir to Bosloop reservoir.

- **Vygeboom Dam**: The current system configuration allows for constant compensation releases of 20.5 million m^3/a (0.65 m^3/s) to be made from Vygeboom Dam.

2.2.2 Usutu Sub-system

The location of the Usutu Sub-system which forms part of the IVRS is shown in **Figure A-1** of **Appendix A**. A schematic representation of the Usutu Sub-system comprising of Westoe, Jericho and Morgenstond dams is provided in **Figure C-1** of **Appendix C**. Water is transferred from Westoe Dam (gravity transfer link with maximum capacity of 1.62 m^3/s) and Morgenstond Dam (pumping through two pipelines with a combined maximum transfer capacity of 3.182 m^3/s) into Jericho Dam. Inter-reservoir operating rules determine the support from these two dams into Jericho Dam. From Jericho Dam water is pumped to Onverwacht from where part of it can be transferred to the Komati Sub-system (Nooitgedacht Dam) via the so-called Usutu-Komati (U-K) link with the remainder to be used to directly supply water to the Eskom Power Stations situated in the Upper Olifants catchment.

The transfer link between Morgenstond and Jericho dams were upgraded in 2004 with the construction of a second pipeline and pump station. Updated short-term yield reliability curves were determined for the Usutu Sub-system based on the upgraded transfer link and these were then used to revise the inter-reservoir operating rules. The recommended inter-reservoir operating rules derived as part of the Usutu Operating Rule Study (**DWAF, 2006b**) are represented in the diagram shown in **Figure 2-1** and were adopted for the Vaal River AOA since 2009. The draw down sequence is indicated as numbers in the different reservoir zones.

As shown in **Figure 2-1** storage in Morgenstond Dam below the Minimum Operating Level (MOL) of 1368.32 m was defined as the last storage zone (zone associated with draw down sequence number 7) to be utilised under emergency conditions only. The reason being that system operators indicated that the storage below a level of 1368.32 m (with corresponding dam storage of 10.763 million m^3) could not be pumped from the dam unless structural changes are made to the inlet works of the pump stations.

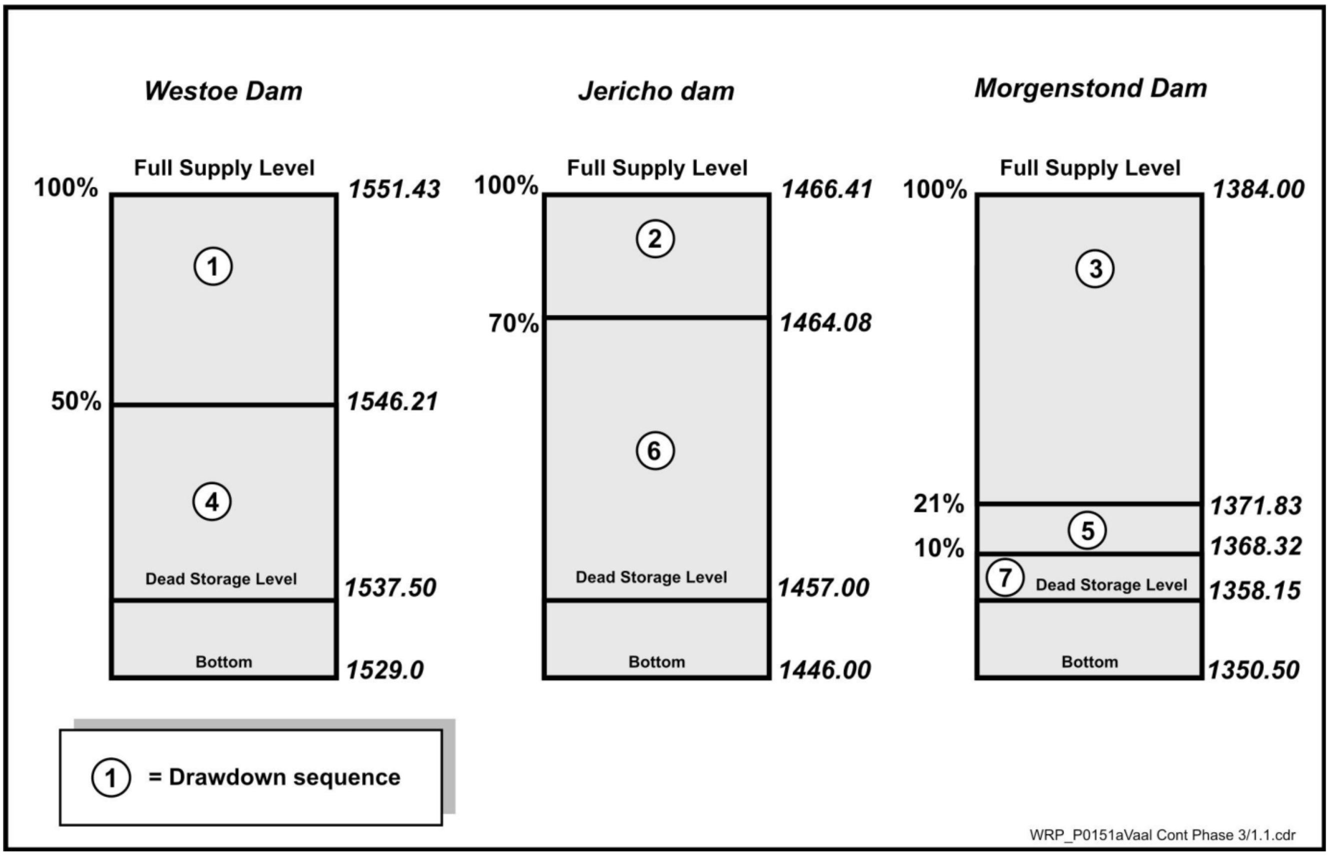

Figure 2-1: Revised (2006) inter-reservoir operating rules for Usutu Sub-system

For the purposes of the WRPM analysis, the two pipelines transferring water from Morgenstond Dam to Jericho Dam were modelled as a single transfer link (Channel 34) and a combined transfer relationship (change in head vs flow rate) was determined based on information obtained from the DWA (Mr. P Jacobs: Operator at Jericho Dam). The transfer relationship based on a 90% availability is provided in **Table 2-1** and was included in the WRPM configuration adopted for all the scenarios analysed as part of this study. From **Table 2-1** it can be seen that the maximum transfer capacity of the Morgenstond-Jericho transfer link amounts to 3.182 m^3/s.

Table 2-1: Morgenstond-Jericho transfer relationship

Variable	Unit	Difference in head (m) and associated discharge (m^3/s)								
Δ Head (#)	m	55.00	68.47	73.47	78.47	83.47	88.47	93.47	98.09	108.0
Discharge	m^3/s	3.182	2.943	2.853	2.763	2.664	2.574	2.475	2.376	2.178

Note: (#) Δ Head is specified as the difference in static head between the upstream reservoir (Morgenstond Dam) and the downstream reservoir (Jericho Dam).

The compensation releases to be made from the three Usutu dams are summarised in **Table 2-2**.

Table 2-2: Compensation releases from Usutu dams

Dam Name	Compensation Release	
	(m^3/s)	**(million m^3/a)**
Westoe Dam	0.037	1.17
Jericho Dam	0.015	0.47
Morgenstond Dam	0.038	1.20
Total for Usutu :	**-**	**2.84**

2.2.3 Heyshope Dam Sub-system

The Heyshope Sub-system is located in the Usutu River Basin and more specifically in the Assegaai River, one of the main tributaries of the Usutu River. The Heyshope System consists of the Heyshope Dam, Geelhoutboom Balancing Dam with pumps and canals system, transferring water from the Heyshope Dam in the Assegaai River to the Upper Vaal WMA, as well as to Morgenstond Dam in the Usutu River Basin.

The WRPM configuration of the Heyshope Dam Sub-system is shown in **Figure C-1** of **Appendix C**. There are a number of small dams, or so-called farm dams, located upstream of Heyshope Dam which have an effect on the inflow to Heyshope Dam. Water from these farm dams, as well as water abstracted directly from the river, is used for irrigation. The main purpose of the Heyshope Dam is to support Grootdraai Dam in the Vaal River Basin and also to support the Usutu System in critical periods with transfers to Morgenstond Dam.

The water is pumped from Heyshope Dam into the Heyshope Canal, from where it flows into the Geelhoutboom Balancing Dam. From the Geelhoutboom Balancing Dam, water is pumped and diverted into Morgenstond Dam via a canal, and also into the Balmoral Canal. From the Balmoral Canal, water is transferred into the upper reaches of the Little Vaal River from where it flows into Grootdraai Dam. Grootdraai Dam is mainly used to supply Tutuka Power Station and the Sasol Secunda Complex as well as Eskom power stations in the Upper Olifants Catchment. Allowance is made for compensation releases of 20.2 million m^3/a (0.64 m^3/s) to be made from Heyshope Dam. These releases include losses and are mainly to supply the water requirements of Piet Retief located downstream of Heyshope Dam.

2.2.4 Zaaihoek Dam Sub-system

The Zaaihoek Dam Sub-system, also known as the Slang River Government Water Scheme (GWS) or the Buffalo-Vaal Sub-system, supplies water to the Majuba Power Station, supplement water supply to Volksrust and the Ngagane River GWS, provides compensation water for irrigation, and transfers surplus water to the Vaal River Catchment.

The WRPM configuration of the Zaaihoek Sub-system is shown in **Figure C-2** of **Appendix C**. Water for the Ngagane River GWS and for irrigation is released into the Slang River. The compensation releases to be made from Zaaihoek Dam in support of downstream water requirements are in the order of 11.4 million m^3/a. The water for Majuba, Volksrust and the Vaal River transfer is pumped from Zaaihoek Dam. Water that is transferred to the Vaal River is released into the Perdewaterspruit, a tributary of the Schulpspruit, upstream of Amersfoort Dam. The water passes through the Amersfoort Dam before flowing into the Rietspruit River and then into the Vaal River upstream of the Grootdraai Dam.

2.2.5 Upper Thukela Sub-system and Thukela-Vaal Transfer Scheme

The Drakensberg Pump Storage Scheme (PSS) consists of the Woodstock Dam, Driel Barrage, Kilburn Dam, Driekloof Dam and a series of pump stations, pipelines, canals, and tunnels. Kilburn Dam, Woodstock Dam and Driel Barrage are situated in the upper reaches of the Thukela River catchment whilst Driekloof Dam is located in the Vaal River catchment just upstream of Sterkfontein Dam. Water is transferred from Driel Barrage in the Upper Thukela Catchment to Driekloof Dam in the Upper Vaal WMA, from where it flows directly into Sterkfontein Dam. Driekloof Dam is submerged as soon as Sterkfontein Dam reaches a storage level of 1699.85 m with an associated storage volume of 2473.703 million m^3 (i.e. at 95% of its Full Supply Capacity).

The purpose of the Drakensberg PSS is twofold:

- To transfer water from the Thukela River basin to the Vaal River basin; and
- To generate electricity during periods of peak power demand.

Woodstock Dam was built to ensure the water supply to the pumps at the Driel Barrage, thus, no water is pumped directly from the Woodstock Dam. Water is pumped from the Driel Barrage to the main canal from where it flows to the Jagersrust Forebay. Water is also diverted from the upper reaches of the Tugela River into the main canal. From Jagersrust, the water is pumped to the Kilburn Dam. From Kilburn Dam the water is pumped via the Eskom Pumped Storage Scheme to the Driekloof Dam. The water spills in a weekly cycle into the Sterkfontein Dam, from where it can be released to the Vaal Dam when required. The Driekloof and Kilburn dams act as the head and tail ponds respectively for the PSS. The overall capacity of the transfer system is 20 m^3/s. Only the main components of the PSS are included in the WRPM configuration as shown in **Figures C-1** and **C-2** of **Appendix C**.

2.2.6 Senqu Sub-system

The Lesotho Highlands Sub-system includes part of the catchment of the Senqu River within the borders of Lesotho. The main tributaries of the Senqu River are the Malibamatsu, Tsoelike and Senqunyane rivers. The Lesotho Highlands Water Project (LHWP) was initiated to transfer water from within Lesotho to South Africa. The initial planning included a series of dams, tunnels and pump stations to be constructed in different phases.

Currently only Phase 1 of the LHWP, consisting of Katse Dam on the Malibamatsu River, Mohale Dam on the Senqunyane River and Matsoku diversion weir on the Matsoku River, has been completed. The second phase comprising of the proposed Polihali Dam and its conveyance infrastructure was identified as the preferred future development option. Since recent studies indicated that there is not sufficient water to develop all the future phases, this second phase option will most probably be the last phase of the Lesotho Highlands Project.

The Lesotho Highlands Phase 1 Scheme which started operating in 1998 comprises the Mohale and Katse dams, Matsoku diversion weir, a series of tunnels and a hydro power station. Water is gravitated through tunnels from Katse Dam (in the Lesotho Highlands) and flows into the Liebenbergsvlei River via Saulspoort Dam (acting only as a weir), down into the Wilge River and eventually flows into the Vaal Dam (See **Figure A-1** of **Appendix A**). The maximum transfer capacity of the tunnels to the RSA is 40 m^3/s although in the Treaty between the RSA and Lesotho it was agreed on a transfer of 27.8 m^3/s (877 million m^3/a) for the full Phase 1 of the LHWP.

The analyses undertaken for this study were based on two catchment development levels, namely the Present Day (2011) and future (2020) development levels. In terms of the Senqu Sub-system the Present Day (PD) development level comprised of the LHWP Phase 1 as described above. The future scenario (2020 development level) includes the proposed Polihali Dam and its associated conveyance infrastructure. The WRPM configuration of the Senqu Sub-system is shown in **Figure C-3** of **Appendix C** with Polihali Dam (node 364) and its associated transfer tunnel (WRPM channel 1394) only operational for the 2020 development level.

In terms of the operation of the Senqu Sub-system, the following information was included in the WRPM configuration used for the analysis:

- **Ecological Reserve**: Information provided in the Lesotho Highlands Development Authority (LHDA) report (LHDA, 2003) was used for defining the Ecological Reserve (ER) release structures that were adopted for Katse and Mohale dams. It should be noted that the LHDA's approach is different to that generally adopted for system modelling (WRYM and WRPM) in South Africa in that annual reference flows are used for the modelling of monthly Ecological Water Requirements (EWRs). An additional EWR release structure accommodating this alternative ER modelling approach was, therefore, incorporated in the WRYM and WRPM.

- **Mohale-Katse transfer tunnel rule**: The finally adopted principle for operating the Mohale tunnel is to keep the difference in water level between Katse and Mohale to below 12 meters unless Katse is near spilling in which case Mohale Dam is allowed to rise in isolation from Katse Dam. Reverse flows from Katse to Mohale are made whenever conditions allow. These decisions are made at the beginning of each month unless Katse Dam is under spill conditions. Furthermore, the operation of the tunnel is such that either it is fully open or it is fully closed.

2.3 DESCRIPTION OF THE VAAL RIVER SYSTEM

With reference to the Vaal River System it is important to distinguish between the Main Vaal System and the smaller sub-systems in the Vaal. The Main Vaal System consists basically of four major storage dams in the Vaal River Basin, i.e. the Grootdraai Dam, Sterkfontein Dam, Vaal Dam and Bloemhof Dam. With the exception of Sterkfontein Dam which is located on the Wilge River tributary, these dams are located on the main stem of the Vaal River. Within the Vaal River Basin there are, however, also several smaller sub-systems which are all operated independently from the main system. These smaller sub-systems are not used to support the Main Vaal System and it is only the spillage from the smaller sub-systems that reaches the Main Vaal System.

As mentioned in **Section 1.2** the Vaal River System comprises of the following three Water Management Areas (WMAs) which are discussed in more detail below:

- Upper Vaal WMA;
- Middle Vaal WMA; and
- Lower Vaal WMA.

2.3.1 Upper Vaal WMA

The Upper Vaal WMA is shown in **Figure B-1** of **Appendix B**. The three incremental catchments included in the Upper Vaal WMA are the Upper Vaal, the Kromdraai and the Mooi River catchments.

The Upper Vaal catchment comprises the Vaal River Catchment down to and including the Vaal Barrage. The major impoundments in this catchment are the Vaal Dam, Grootdraai Dam, Sterkfontein Dam, Saulspoort Dam and the Vaal Barrage. The two main rivers feeding the Vaal Dam are the Vaal and the Wilge rivers. The following major tributaries drain into these two rivers: the Klip, Waterval, Venterspruit, Little-Vaal, Liebenbergsvlei, Blesbokspruit, Klip (south of Johannesburg) and Suikerbosrand rivers. There are a number of small to medium dams in the catchment, mainly to supply water for local towns and/or irrigation. These dams are, for modelling purposes in general, combined into a number of so called dummy dams, which represents the combined effect of the small dams within a sub-catchment.

The Kromdraai River, a tributary of the Vaal, joins the main Vaal River downstream of the Vaal Barrage. There are no major storage dams in this incremental catchment.

There are two major irrigation schemes located in the Mooi River catchment: the Mooi River Government Water Scheme (GWS) and the Klipdrift Irrigation Scheme. The Mooi River GWS consists of four major sources of water, namely Klerkskraal Dam, Boskop Dam, Lakeside Dam, and the Gerhard Minnebron Eye. Potchefstroom Municipality receives water from Lakeside Dam. The Klipdrift Irrigation Scheme is supplied with water from the Klipdrift Dam located in the Loopspruit River, a tributary of the Mooi River. The Mooi River flows into the Vaal River downstream of the Kromdraai River.

2.3.2 Middle Vaal WMA

The Vaal River Basin downstream of the Mooi and Vaal River confluence, down to and including the Bloemhof Dam constitutes the Middle Vaal WMA which is shown in **Figure B-2** of **Appendix B**. The following major tributaries drain into this section of the Vaal River and into the Bloemhof Dam: Renoster River, Vals River, Sand River, Vet River and the Schoonspruit River.

The major dams in this sub-catchment are the Bloemhof, Erfenis, Allemanskraal, Koppies, Serfontein, Rietspruit, Elandskuil and Johan Neser dams. The dams in the Middle Vaal Sub-system are mainly used for irrigation water supply, although some urban/industrial and mining demands are also supplied from these dams. The dams on the tributaries are operated independently from the Vaal River and only the spillage from the dams is captured in Bloemhof Dam.

2.3.3 Lower Vaal WMA

Figure B-3 of **Appendix B** shows the Lower-Vaal WMA which comprises of the Harts River catchment, the Molopo and the Vaal River incremental catchment downstream of Bloemhof Dam and upstream of Douglas Weir.

The major tributary draining into the Vaal River in this region is the Harts River. Although the Riet-Modder Catchment forms part of the Vaal River Basin, it is included as part of the Upper Orange River sub-system, mainly due to the fact that there are several transfers from the Orange River to support water requirements in the Riet-Modder Catchment. The only connection between the Vaal and Riet-Modder rivers is the spills from the Riet-Modder Catchment into the Vaal River just upstream of Douglas Weir. As indicated in **Figure B-3** the Riet-Modder catchment does not form part of the study area.

The major dams in this WMA are Wentzel Dam, Taung Dam and Spitskop Dam, all located on the Harts River, with Vaalharts Weir on the Vaal River and Douglas Weir located at the outlet of the Vaal River catchment. The Vaalharts Irrigation Scheme, which is the largest irrigation scheme in South Africa, is situated in the Harts River catchment.

2.4 DESCRIPTION OF INTER-BASIN TRANSFERS

Summarised information on the inter-basin transfer schemes shown in **Figure A-1** of **Appendix A** is as follows:

- **The Heyshope to Morgenstond Transfer Scheme**: transferring water from Heyshope Dam in the Assegaai River catchment to the Morgenstond Dam (Usutu Sub-system), with a maximum transfer capacity of 1.4 m^3/s.

- **The Heyshope to Grootdraai Transfer Scheme**: transferring water from Heyshope Dam in the Assegaai River catchment to the Upper Vaal WMA (Grootdraai Dam), with a maximum transfer capacity of 4.28 m^3/s.

- **The Zaaihoek to Grootdraai Transfer Scheme**: transferring water from the Zaaihoek Dam in the Slang River in the Buffalo Catchment to the Upper Vaal WMA (Grootdraai Dam), with a maximum transfer capacity of 2.16 m^3/s associated with the conveyance infrastructure.

- **Thukela-Vaal Transfer Scheme**: transferring water from Woodstock Dam and Driel Barrage in the Upper Tugela Catchment to the Upper Vaal WMA (Sterkfontein Dam), with a maximum transfer capacity of 20 m^3/s.

- **The Vaal–Olifants Transfer Scheme (Grootdraai)**: transferring water from Grootdraai Dam in the Upper Vaal WMA via the Vlakfontein canal to the Upper Olifants Catchment, with a maximum transfer capacity of 6.65 m^3/s.

- **The Inkomati Transfer system**: transferring water from Nooitgedacht and Vygeboom dams in the Komati West Catchment to the Upper Olifants Catchment.

- **The Lesotho Highlands Transfer System**: transferring water from Katse and Mohale Dams in Lesotho to the Upper Vaal WMA (Liebenbergsvlei), with a maximum transfer capacity of 35.7 m^3/s.

- **Vaal River Eastern Sub-system Augmentation Project (VRESAP) pipeline**: Transferring water from Vaal Dam to the Sasol Secunda complex and the Eskom Power Stations in the Upper Olifants Catchment, with a maximum transfer capacity of 5.07 m^3/s.

2.5 OPERATION OF THE VAAL RIVER SYSTEM

The operation of the Vaal River System is described within the context of the individual sub-systems in the sections below.

2.5.1 Grootdraai Dam Sub-system

Grootdraai Dam is the main storage dam in this sub-system. Tutuka Power Station in the Upper Vaal WMA is solely supplied with water from Grootdraai Dam. Grootdraai Dam also supplies water to the Sasol Secunda Complex. Matla Power Station in the Upper Olifants Catchment receives water from Grootdraai Dam, via Rietfontein pump station to supply demand shortfalls, when the Usutu Sub-system cannot meet the full demand. Both Kendal and Kriel Power Stations in the Upper Olifants Catchment can be supplied via Rietfontein in the event that the Usutu Sub-system is unavailable. Although this scheme can, in emergencies, also provide most of Eskom's remaining power stations in the Upper Olifants Catchment with water during times of water shortage it is not practical to do so, due to unfavourable water quality.

Water is pumped from the Grootdraai Dam, by the Grootdraai pump station, to Vlakfontein via two steel rising mains from where it gravitates via the Vlakfontein-Grootfontein canal to the Grootfontein pump station. From the Grootfontein pump station the water is pumped to Knoppiesfontein diversion tank where the water is diverted to the Bossiespruit Dam and to Trichardsfontein Balancing Dam. Bossiespruit Dam releases the water to the Sasol Secunda Complex. From Trichardtsfontein balancing dam the water is released into the Rietfontein Weir. From here, the Rietfontein Pumpstation pumps the water to Matla where it can be distributed to Kriel and Kendal as and when required. Water can be released from Rietfontein Weir to flow via the Steenkoolspruit to Witbank Dam in support of Duvha Power Station.

Initially the WRPM system configuration did not allow for any releases to be made from Grootdraai Dam. Mainstream irrigators situated downstream of Grootdraai Dam could, however, be supported from the dam during periods of insufficient incremental runoff. On average, the water requirements of these irrigators amount to 11.39 million m^3/a. The principle of releasing the "normal" inflow (defined as inflow that occurs 70% of the time) to Grootdraai Dam as compensation releases for downstream users was adopted during 2003. Streamflow recorded at river gauging station C1H001 for the period October 1905 to September 1977 was used for determining monthly flow duration tables. The flow duration results were subsequently used to calculate for each calendar month the flow that occurs 70% of the time. During months with extreme high inflow, these releases are however in practice limited to 1.5 m^3/s. This information was used for setting up a compensation release structure for Grootdraai Dam that is dependent on the inflow to the dam. Lekwa Local Municipality (former Standerton) also abstracts its water just downstream of the dam. Based on a time series assessment it was found that, after allowing for the Lekwa abstractions, the compensation releases amount to a long-term average of about 22.1 million m^3/a. The compensation release structure introduced in 2003 was adopted for all subsequent annual operating analyses of the Vaal River System.

2.5.2 Vaal Dam Sub-system

The Vaal Dam Sub-system includes the total Vaal River catchment from Vaal Dam upstream as well as the Upper Thukela River system (comprising of Woodstock Dam and Driel Barrage). All the major Vaal River water requirements are supplied from this sub-system. The main water use centres supplied from this sub-system are Rand Water (RW), Sasol (Secunda and Sasolburg complexes), Eskom, Mittal Steel, Midvaal Water Company and Sedibeng Water. Through the Rand Water distribution network water is also supplied to major urban areas within the Crocodile River catchment.

Sterkfontein Dam receives water from the Thukela-Vaal Transfer Scheme (Woodstock and Driel) and contains the “reserve” water for the Integrated Vaal River System. The long-term operating rule for this transfer scheme is to transfer at maximum capacity of 20 m^3/s until Sterkfontein, Vaal and Bloemhof dams are full. The operating rule of Sterkfontein Dam is such that water is only released from the dam when Vaal Dam is at low levels.

The flow in the Liebenbergsvlei River is dominated by the transfer from the Lesotho Highlands Water Project (LHWP). Transfers from the Lesotho are based on a fixed annual schedule provided by the Lesotho Highlands Development Authority (LHDA). The LHWP water is discharged into the river system upstream of Saulspoort Dam (located in quaternary catchment C83A). Saulspoort Dam supplies water to the town of Bethlehem as well as to irrigation farmers. There are significant irrigation abstractions along the Liebenbergsvlei River, of which a significant portion is considered to be unlawful.

The Vaal River Eastern Sub-system Augmentation Project (VRESAP), comprising of a pump station at Vaal Dam and a pipeline transferring water from Vaal Dam to the Knoppiesfontein diversion tank, has recently been constructed to augment the water supply to users receiving water from the Vaal River Eastern Sub-system. Since the commissioning of the VRESAP pipeline in December 2008, the Sasol Secunda complex and the Eskom Power Stations in the Upper Olifants Catchment have access to two water resources namely Grootdraai Dam (via the Vlakfontein Canal) and Vaal Dam (via the VRESAP pipeline). The adopted long-term VRESAP operating rule specifies that water should be transferred through the VRESAP pipeline at maximum capacity of 160 million m^3/a (5.07 m^3/s) when Grootdraai Dam is below 90% of its Net Full Supply Capacity (NFSC).

Rand Water, as the major water supplier in the sub-system, has a vast network of pipelines which are used to distribute the water to the various demand centres. Water can be abstracted at the two main abstraction points as indicated below:

- Zuikerbosch pumping station: receiving water from the Vaal River, via a canal from Vaal Dam and from the Lethabo intake station.
- Vereeniging pumping station: receiving water from the Vaal Barrage.

The abstraction point from the Vaal Barrage has, however, for the last approximately 20 years not been used and will need upgrading before it can be utilised again. Urban development (increased runoff from paved areas and urban effluent from waste water treatment works) as well as discharges from the mines have a significant impact on the quality of the runoff from the tributaries in the Vaal Barrage incremental catchment. Salinity (Total Dissolved Solids (TDS)) is, therefore, an important driver of the Vaal River System. The water quality downstream of the Vaal Barrage has to be managed and maintained at a pre-determined standard to ensure that downstream users are receiving acceptable quality water. To this end the Vaal River System is operated in such a way that releases are made from Vaal Dam to maintain a TDS concentration of 600 mg/l downstream of Vaal Barrage.

2.5.3 Vaal Barrage Sub-system

The Vaal River reach stretching from Vaal Dam to the Vaal Barrage is dominated by the water body created by the Vaal Barrage dam wall. Management of the flow into this reach is from Vaal Dam and is influenced by the water users in and downstream of the Vaal Barrage, the urban return flows and mine dewatering discharges as well as the releases form Vaal Dam to maintain the TDS concentration at 600 mg/l.

The three main tributaries (Suikerbosrand, Klip and Rietspruit rivers) flowing into the Vaal Barrage, each convey significant volumes of treated wastewater and mine discharge water. Discharges from four mining areas, namely the Eastern, Central, Far-Western and Western basins, are made to the rivers in this incremental catchment and the DWA has adopted a strategy for the management of these discharges. The short-term plan is to enforce the treatment of mine water up to an acceptable standard before it is discharged back into the river whilst the desalination and re-use of mine water is a given option in the medium- to long-term.

2.5.4 Middle Vaal/Bloemhof Dam Sub-system

The following major tributaries drain into this section of the Vaal River and into the Bloemhof Dam: Renoster River, Vals River, Sand River, Vet River and the Schoonspruit River. These tributaries are operated as stand alone sub-systems with only the natural outflows from these river systems entering the main stem of the Vaal.

Two organisations, namely Midvaal Water Company and Sedibeng Water, abstracts water from the Vaal River within the Middle Vaal Sub-system and are briefly described below.

Midvaal Water Company: The Midvaal Water Company has a large abstraction point from the Vaal River, in the Klerksdorp – Orkney area. The Midvaal Water Company purifies water from the Vaal River to supply three TLC's; Klerksdorp, Stilfontein and Orkney, and three Gold Mines; Vaal Reefs, Hartbeesfontein and Buffelsfontein. Water is abstracted from the Vaal River through a pump station and diverted into two pipelines, one to Vaal Reefs general mining, and the other to Klerksdorp, Stilfontein, Orkney and the Hartbeesfontein and Buffelsfontein gold mines.

Sedibeng Water: Sedibeng Water has a major abstraction point from the Vaal River at Balkfontein, upstream of Bloemhof Dam. Water from this abstraction point is purified at the Balkfontein Water Purification Works and distributed from there. Sedibeng Water also abstracts water from Allemanskraal Dam via a canal system in the vicinity of Virginia.

The Bloemhof Dam Sub-system is supported by the Vaal Dam Sub-system which in turn can be supplied from the relevant sub-systems listed in **Section 2.4**. Bloemhof Dam is the main storage reservoir for the Vaalharts irrigation scheme, irrigators along the Vaal River to Douglas, the Vaal-Gamagara transfer scheme and major towns downstream of the dam (including Kimberley).

2.5.5 Lower Vaal Sub-system

For the purposes of this study the Lower-Vaal Sub-system comprises of the Harts River catchment and the Lower Vaal River incremental catchment downstream of Bloemhof Dam and upstream of Douglas Weir (i.e. excluding the Riet-Modder River catchment). As shown in **Figure B-3** of **Appendix B**, the Molopo River Catchment is included in the study area. This catchment was, however, not part of the Vaal River Comprehensive Reserve Determination Study. These rivers are ephemeral and therefore cannot be evaluated with ease by following the standard reserve determination methods. Groundwater resources play an important part in the Molopo catchment. Some work is currently been carried out in this area through the ORASECOM study regarding ecological water requirements. No simulation models have been configured for these areas.

Kimberley Municipality and the Vaal-Gamagara Government Regional Water Supply Scheme, as well as small towns, abstract water for urban/industrial use from the Vaal River downstream of Bloemhof Dam. The larger water related schemes which are in place are linked to either irrigation or abstractions from the Vaal River, which is the only abundant source of water within the sub-system. By far, the most significant of these schemes is the transfer of water from the Vaal River (Bloemhof Dam) to the Vaalharts Irrigation Scheme (see details below).

The VRSAU study results also showed that significant evaporation and operational losses occur in the Vaal River downstream of Bloemhof Dam. Evaporation losses from the Vaal River reach between Bloemhof Dam and Vaalharts Weir were estimated to be in the order of 78 million m^3/a. Operational losses resulted in a reasonable base flow (estimated to be about of 115 million m^3/a) that was observed in the Vaal River reach downstream of De Hoop Weir. An investigation into the response of Bloemhof Dam was undertaken in 2003 (**DWAF, 2003**) and one of the recommendations from this assessment was that the Lower Vaal system be operated in such a way as to minimise these operating losses. Water is also transferred into the Lower Vaal incremental catchment via the Orange-Vaal Transfer Scheme. This scheme transfers water through the canal system from Marksdrift Weir in the Orange River to Douglas Weir in the Vaal River, and is also mainly used for irrigation purposes. Monitoring of system components (e.g. Orange-Vaal Transfer Scheme) undertaken as part of the Orange River Annual Operating Analysis (AOA) study indicated that the above-mentioned operating losses do not necessarily reach Douglas Weir. The possibility that the operation of the Lower Vaal system has been optimised in recent years to reduce these losses should thus be investigated. For the purposes of the Orange River AOA it was, however, assumed that part of these operating losses is consumptive. The magnitude of the consumptive losses was assessed by means of scenario analyses using the simulated supply through the Orange-Vaal Transfer Scheme as basis for the evaluation of results.

Descriptions of the water supply schemes and the Harts River sub-system that are included in the WRPM configuration are provided below.

Vaalharts Government Water Scheme (GWS): The most significant water supply scheme in the Lower Vaal is the Vaalharts GWS, the largest irrigation scheme in South Africa. Water is released from Bloemhof Dam to the Vaalharts Weir, situated on the Vaal River between Christiana and Warrenton, from where it is diverted into a canal. The incremental yield of Bloemhof Dam is less than the water requirements of the Vaalharts Scheme and other irrigators along the Lower Vaal. Bloemhof Dam is consequently supplemented by releases from Vaal Dam in times of shortages. The Vaalharts GWS therefore forms part of the greater Vaal System. Naledi and Greater Taung Municipalities source their water from the Vaalharts scheme, and water is purified at Pudimoe treatment works. Pokwane Municipality also obtain water directly from the Vaalharts canal system to supply Jan Kempdorp, Hartswater, and Pampierstad, with water purified at the Jan Kempdorp, Hartswater and Pampierstad treatment works. Average transfers to the Vaalharts Irrigation Scheme (including distribution losses) are estimated at 450 million m^3/a. The Vaalharts canal system is reasonably old and in need of refurbishment. Distribution losses are therefore high and estimated to be in the order of 127 million m^3/a.

Riverton-Kimberley Scheme: Water is abstracted from the Vaal River at Riverton and purified at the Riverton water treatment plant before being pumped to Kimberley. Projected abstractions for the 2009 planning year were estimated at 19.7 million m^3/a for Kimberley and 21.2 million m^3/a for other towns in the region.

Vaal-Gamagara Government Water Scheme: The Vaal-Gamagara Regional Water Supply Scheme was initiated in 1964 to supply water mainly to the mines in the Gamagara Valley in the vicinity of Postmasburg and further north of this town. An abstraction works and low-lift pumping station are located on the Vaal River near Delportshoop, just below the confluence with the Harts River, from where water is pumped to the water purification works situated next to the Vaal River. Purified water is then pumped to reservoirs on the watershed of the Vaal River Catchment near Clifton. From the reservoirs at Clifton, water is gravity fed over a distance of 182 km along the route via Postmasburg – Sishen - Hotazel - Black Rock. The scheme has an allocation of 13.7 million m^3/a from the Vaal River.

Harts River Catchment: The major dams in this sub-catchment are Wentzel Dam, Taung Dam and Spitskop Dam, all located on the Harts River, with Vaalharts Weir on the Vaal River. Wentzel Dam is the most upstream dam on the Harts River and relies totally on the natural flow from the Harts. The only existing abstraction from the dam is the Schweizer Reneke town demand, reaching 1.02 million m^3/a at 2006 development level. Taung Dam is located downstream of Wentzel Dam not far upstream of the town of Taung. The Taung Dam was built in the Harts River in 1993 to augment irrigation supplies to the Taung irrigation area and possibly support new irrigation areas in the Pudimoe area. Currently the dam is not utilised at all. The DWA initiated a study to investigate and recommend the best supply options to utilize Taung Dam water. Spitskop Dam was constructed in 1975 in order to supply irrigators along the lower Harts upstream of the Vaal confluence. The dam was reconstructed in 1989 due to damage incurred by floods in 1988. The dam is positioned downstream of the Vaalharts Irrigation Scheme and therefore substantial volumes of return flows seep into the dam. The dam is currently only utilised to supply irrigation along the Harts River downstream of the dam.

Douglas Weir (Orange-Vaal Transfer Scheme): Douglas Weir is the most downstream storage structure in the Vaal River situated just upstream of the confluence with the Orange River. Douglas Weir has limited flow-regulating capability. The Douglas Irrigation Scheme, as well as Douglas Town, is supplied from the Douglas Weir and, in addition to the runoff entering Douglas Weir from the upstream incremental catchments, water is transferred (pumped) from the Orange River into Douglas Weir. No releases are made from storage structures in the Vaal, Harts or Riet/Modder river systems to support the water requirements in Douglas Weir. Since these two user groups do not have allocations from the Vaal River Sub-system, they only have access to the outflow from the Vaal. During periods of insufficient flow from the Vaal, the supply to these users is augmented with transfers from the Orange River System by means of the Orange-Vaal Transfer Scheme as mentioned above.

2.6 DESCRIPTION OF INTER-BASIN SUPPORT RULES

The general operating rules derived for the various inter-basin transfers are described in the sections below.

2.6.1 Heyshope-Morgenstond transfer

Operating rules regulating this transfer have been derived through WRPM scenario analysis and comprise of the following two components:

- **Heyshope Dam buffer storage**

  Water is reserved in Heyshope Dam for transfer to the Usutu Sub-system as follows:

  - **May 2011 to May 2018**: Reserve storage below 150 million m^3 for transfer to the Usutu;
  - **May 2018 onwards**: Reserve storage below 58 million m^3 for transfer to the Usutu.

- **Morgenstond Dam Operating Level**

  Transfer from Heyshope Dam is required if storage in Morgenstond Dam drops below a specified level (maximum transfer rate is 1.4 m^3/s):

  - **May 2011 to May 2015**: Transfer when Morgenstond Dam is below 80 million m^3 (1381.34m);
  - **May 2015 onwards**: Transfer when Morgenstond Dam is below 90 million m^3 (1382.63m).

2.6.2 Usutu-Komati transfer

The water requirements of the Eskom Power Stations supplied from the Komati Sub-system (Arnot, Hendrina, Duvha and Komati) may exceed the short-term yield capability of the Komati Sub-system. In such an event water can be transferred from the Usutu Sub-system (Jericho Dam) in support of the Komati (Nooitgedacht Dam). The required support is determined by the water resource allocation algorithm (refer to **Section 3.2**) and the maximum transfer rate is 2.47 m^3/s.

2.6.3 Heyshope-Zaaihoek-Grootdraai transfer

The following alternative support rules are generally considered for dictating the Heyshope and Zaaihoek transfers to Grootdraai Dam:

- **90% Rule**: This rule allows pumping from Heyshope and Zaaihoek dams to Grootdraai Dam in order to maintain Grootdraai Dam at 90 % of its Net Full Supply Capacity (NFSC). The 90% NFSC of Grootdraai Dam represents a storage volume of 314.6 million m^3 with an associated storage level of 1548.02 m. This rule has been adopted as the long-term operating rule for transferring water from the Heyshope and Zaaihoek dams to Grootdraai Dam.

- **75% Rule**: This rule is defined as the reduced transfer option since water is pumped from Heyshope and Zaaihoek dams to Grootdraai Dam in order to maintain Grootdraai Dam at 75 % of its Net Full Supply Capacity (NFSC). The 75% NFSC of Grootdraai Dam represents a storage volume of 262.14 million m^3 with an associated storage level of 1546.47 m.

Depending on the storage state of these dams analyses are undertaken to determine if savings can be achieved on pumping costs, by means of the reduction of transfers to Grootdraai Dam from Zaaihoek and Heyshope dams for the first 12 months of the planning period.

Transfers from Heyshope to Grootdraai Dam can be made at a maximum rate of 4.28 m^3/s. The maximum transfer rate from Zaaihoek Dam is dependant on the surplus water available in the Zaaihoek Sub-system and varies on an annual basis. The surplus water available for transfer to the Vaal is calculated as the difference between the long-term Historic Firm Yield (HFY) and in-basin water requirements of the Zaaihoek Sub-system. The maximum transfer rate from the Zaaihoek Sub-system was calculated to be as follows:

- Present Day (2011) development conditions: 0.670 m^3/s;

- Future (2020) development conditions: 0.551 m^3/s.

2.6.4 Thukela-Vaal transfer

The option of no pumping from the Thukela South sub-system (Woodstock Dam) to Sterkfontein Dam is usually considered during the first two years of the planning period to assess the impact of reduced pumping on the assurance of supply. Pumping from the Thukela may, however, also be influenced by other operating requirements such as maintaining a certain Minimum Operating Level (MOL) in Vaal Dam. In general releases are made from Sterkfontein Dam in support of Vaal Dam when Vaal Dam reaches a MOL of 1471.96m (storage of 376.7 million m^3). Due to outlet capacity constraints, releases from Sterkfontein Dam are limited to a maximum of 70 m^3/s.

In general, the following transfer rules are considered:

- **Reduced pumping option**: Transfer to keep Sterkfontein Dam at its FSC (i.e. transfer from Thukela to make up for evaporation losses from Sterkfontein Dam only);

- **Long-term transfer rule**: Transfer at maximum capacity of 20 m^3/s to fill Sterkfontein, Vaal and

Bloemhof dams. Transfers stop once Bloemhof Dam starts spilling.

The long-term transfer rule was adopted for the purposes of this study.

2.6.5 Lesotho Highlands Water Project (LHWP) transfer

As mentioned in **Section 2.2.6** the maximum transfer capacity of the tunnels to the RSA is 40 m^3/s. In the Treaty between the RSA and Lesotho it was agreed on a target transfer of 27.8 m^3/s (877 million m^3/a) for the full Phase 1 of the LHWP. Since the completion of the LHWP Phase 1 the Lesotho Highlands Water Commission (LHWC) submitted an agreed twelve month delivery schedule which was revised on an annual basis. The initial methodology adopted for the implementation of the LHWP transfers as part of the Vaal River Annual Operating Analysis was to apply the agreed twelve month delivery schedule for the first planning year and to revert back to the target transfer of 877 million m^3/a for the remaining planning period. The agreed delivery schedule for the year 2007, which amounted to 780 million m^3/a, was subsequently recommended as a constant annual transfer to be used all for future transfers and was therefore used for both the Present Day (2011) and Future (2020) development conditions.

2.6.6 Vaal River Eastern Sub-system Augmentation Project (VRESAP) Pipeline

The VRESAP pipeline is aimed at stabilising and extending industrial water supply to the Sasol Secunda Complex and the Eskom power stations in the Upper Olifants catchment. The pipeline was commissioned in December 2008 and the permanent pump station was scheduled for completion by 1 October 2011. The water is pumped from the Vaal Dam, using the new abstraction works, to an upgraded existing diversion structure at Knoppiesfontein. From Knoppiesfontein the water is gravitated to Trichardtsfontein and Bosjesspruit dams, supplying Eskom and Sasol Secunda complex respectively. The VRESAP abstraction structure is designed to be able to deliver its full volume of 5.4 m^3/s with the water level of Vaal Dam at its minimum operating level. A maximum transfer capacity of 5.07 m^3/s (160 million m^3/a) was adopted for the WRPM configuration used for this study.

The most effective operation of the VRESAP pipeline in combination with the supply from Grootdraai Dam via the Vlakfontein canal was determined through WRPM scenario analyses. The following long-term operating rule was derived and used for this study.

Grootdraai Dam buffer storage (long-term VRESAP supply rule): Pump at maximum capacity through the VRESAP pipeline if storage in Grootdraai is below 90% of its FSV (i.e. reserve storage in Grootdraai Dam below 90%).

3 DESCRIPTION OF THE WATER RESOURCE YIELD AND PLANNING MODELS

3.1 BACKGROUND

The Water Resource Yield Model (WRYM) and the Water Resource Planning Model (WRPM) are general multi-purpose multi-reservoir simulation programmes and are based on the assumption that a flow network can represent a water resource system. The WRYM and WRPM are monthly time step network models that use a sophisticated network solver in order to analyse complex water resource systems under various operating scenarios.

The purpose of the WRYM is to quantify the yield capability of a system under a fixed development level (constant level of water requirements and fixed system configuration). The Water Resource Planning Model (WRPM) was developed from the Water Resource Yield Model (WRYM) and has been designed to simulate a dynamic system allowing for growing water demands and changes in terms of the water resource infrastructure. The WRPM can, therefore, be described as a Decision Support System (DSS) with the ability to evaluate the capability of existing and proposed water resource systems. This is achieved through the simulation of the physical, statistical, operational and quality variables that influence the capability of a water resource system. The WRPM is generally used to determine short-term operating rules (analyses undertaken on an annual basis), but can also be applied for long-term development and operational planning purposes.

Although the WRYM is generally used to assess the impact of implementing the Ecological Reserve (ER), the WRPM was used for the water resource assessments carried out for the Comprehensive Reserve Determination Study (**DWA, 2010d**) and will thus also be used for this study. The reasons for this decision are presented in **Sections 3.2** to **3.4** below.

3.2 WATER RESOURCE ALLOCATION ALGORITHM

Due to the highly developed nature of the Integrated Vaal River System and the various inter-basin transfers that exist in the system, operating rules were developed that regulate when and how much water is transferred. The transferred water is, in most cases, discharged into receiving streams or river reaches for which EWRs had to be determined. The management and implementation of the operating rules of the inter-basin transfers are undertaken by the application of the WRPM. The WRPM contains a specific algorithm, the water resource allocation algorithm, which forms an integral part of the transfer operating rules and (in short) determines the transfer volumes based on the short-term water balance of the various sub-systems. Since this allocation algorithm is not included in the WRYM it would not have been possible to simulate the flows in the receiving river reaches as it is being implemented in practice if the WRYM were to be used. The transfers from the Usutu Sub-system (Jericho Dam) to the Komati Sub-system (Nooitgedacht Dam), transfers from Heyshope Dam to Morgenstond Dam and transfers from Zaaihoek Dam to Grootdraai Dam are all examples of inter-basin transfers that are regulated by the allocation algorithm.

3.3 DILUTION OPERATING RULES

Salinity (Total Dissolved Solids (TDS)) has and will be an important driver of the operation of the Vaal River System affecting the flow in the river reach downstream of Vaal Dam. In the past the application of an operating rule has been implemented to dilute the saline water (discharged from the mines, returned by the numerous waste water treatment works and washed off from the highly developed urbanized catchments) through releases from Vaal Dam. The operation planning of this dilution rule is carried out with the WRPM, which contains the necessary functionality to model salinity (TDS). The WRYM does not have the capability to simulate salinity nor does it have the functionality to simulate the blending operating rule as described above.

3.4 DECISION SUPPORT SYSTEM (DSS) FOR INTEGRATED VAAL RIVER SYSTEM

The WRPM network configuration which was available at the start of the study incorporates all the components of the Integrated Vaal River System mentioned in **Section** 2 and is the Decision Support System (DSS) that is being used for the operation and long term development planning of the system. The WRPM has been used for planning in all past studies since 1990 and was applied in the most recent Vaal River Reconciliation study (**DWAF, 2008a**) to evaluate the identified scenarios and reconciliation strategies. The WRPM configuration was further refined as part of the Vaal River Comprehensive Reserve Determination Study (**DWA, 2010d**) to include the identified Ecological Water Requirement (EWR) nodes. The approach adopted for the Annual Operating Analysis (AOA) of the IVRS is to continuously update and enhance the WRPM configuration and database as new information becomes available. The updated WRPM resulting from the 2011/2012 AOA (**DWA, 2012**) was subsequently used as the DSS for the water resource analyses of this study.

3.5 SYSTEM COMPONENTS

As mentioned in **Section 1.2** the Vaal River is one of the most highly utilised rivers in the country. The Vaal River System is also a very complex system consisting of many large dams, pumping stations, pipelines and tunnels transferring water over long distances. The WRPM schematic representation of the IVRS is included in **Appendix C** (**Figures C-1** to **C-12**). As shown in these figures the WRPM configuration of the IVRS includes the modelling of the following system components:

- 205 incremental catchments each with its own natural hydrology time series record (*.INC file) and representative catchment rainfall time series record (*.RAN file);

- 40 major storage dams;

- 179 minor dams (also referred to as dummy dams with each dummy dam representing a group of small dams within a specified incremental catchment);

- 14 major transfer links;

- 358 Demand Centres (DC) representing the water requirements of urban, industrial and irrigation users. Sasol and Eskom are considered as strategic water users and they require that water be supplied to them at a very high assurance level (a 99.5% exceedance probability level or 0.5% risk of failure is associated with these users). Sasol's Secunda and Sasolburg complexes receive water from the Vaal River System. The IVRS also supplies water to thirteen Eskom Power Stations (PSs) which include the new Kusile PS which is currently being constructed. Bulk water suppliers Rand Water, Midvaal Water Company and Sedibeng Water supply water to numerous towns, industries and mines. Irrigation water users were grouped together based on their location and source of water supply. Approximately 126 irrigation areas are being modelled as DCs within the IVRS.

3.6 WRPM DATABASE

The hydrological, catchment development and infrastructure information resulting from the Vaal River System Analysis Update (VRSAU) Study (**DWA, 1999**) was used for a major updating of the WRPM database and configuration in 1999. The 1999 system configuration update focused on the Vaal River catchment upstream of Bloemhof Dam as well as the Komati, Usutu, Heyshope (Assegaai), Zaaihoek (Buffalo), Upper Thukela and Senqu sub-systems. Revisions of the entire Thukela and the Lower Vaal River systems, as well as the inclusion of the Witbank, Middelburg, Lower Orange and Fish River sub-systems, were done in subsequent analyses as and when new information from more recent studies became available. Major refinements were made as part of the Comprehensive Reserve Determination Study (**DWA, 2010d**) to allow for the modelling of representative flows at the identified EWR sites. These refinements included the splitting of available hydrological and catchment development data. Information on the hydrological database is summarised in **Section** 4 and **Section** 5 provides information on the water requirements and return flows of the various water use sectors.

4 HYDROLOGICAL DATABASE

4.1 INTRODUCTION

The WRPM configuration of the IVRS includes the hydrological database resulting from the Vaal River System Analysis Update (VRSAU) Study (**DWA, 1999**). The hydrology for sub-catchments within the Komati, Usutu, Thukela and Senqu river basins was also updated as part of the VRSAU study. The VRSAU hydrology covers the period October 1920 to September 1995 (i.e. a period of 75 years). It is important to note that the hydrological analyses of the VRSAU study were not necessarily undertaken at quaternary catchment level as the focus was on the most representative modelling of relevant sub-catchments.

As mentioned in **Section 3.4** the strategy adopted for the Annual Operating Analysis (AOA) of the IVRS is to continuously update and enhance the WRPM configuration and database as new information becomes available. Updated hydrology of the Thukela and Schoonspruit River catchments were subsequently included in the WRPM database. The detailed modelling of the Renoster River catchment resulting from the Voorspoed Mine Study (**DWAF, 2005b**) was also included in the WRPM configuration. The latter merely involved the breaking down of the lumped VRSAU hydrology to quaternary catchment scale. The detailed modelling of the Renoster River catchment and the inclusion of the revised Schoonspruit hydrology required that corresponding adjustments be made to the Bloemhof Dam incremental catchment. Details of the above-mentioned updates can be found in the Vaal River Reconciliation Strategy Study report (**DWAF, 2008a**). The revised hydrology of the Upper Waterval catchment resulting from the most recent BKS study undertaken for the DWA (**DWAF, 2005a**) was included in the WRPM database as part of the Comprehensive Reserve Determination Study (**DWA, 2010d**).

The hydrology of the Komati and Usutu River catchments was updated respectively as part of the Inkomati Water Availability Assessment Study (**DWAF, 2009f**) and the Joint Maputo River Basin Study (JMRBS) (**DWAF, 2009g**). The scale of modelling within the Komati Sub-system was refined to represent smaller sub-catchments at the so-called quinary catchment level. It was also noted that the land use information of the JMRBS was significantly different from that of the VRSAU study. The updated hydrology and refined configurations of the Komati and Usutu sub-systems were included in the WRPM configuration as part if the Usutu Bottleneck Study (**DWA, 2010e**). Comparisons showed that the updated hydrology has a significant impact on the water availability in the Vaal River Eastern Sub-system (VRESS) i.e. more water in the system, which in turn will have implications on the operation and management of the VRESS. The Komati WAAS hydrology underwent a reviewing process whilst the updated JMRBS did not, possibly reducing the confidence level of the Usutu hydrology. Based on the Usutu Bottleneck Study's results it was recommended that a detailed reviewing process be conducted before the JMRBS hydrology is accepted. The updated hydrology and refined configurations of the Komati and Usutu sub-systems were, therefore, not included in the WRPM database used for this study.

The hydrological data included in the WRPM database are briefly discussed in the sections below. A list of all the VRSAU Study reports is provided in **Table E-1** of **Appendix E**. Since detailed information can be obtained from these reports only summarised information is provided in **Appendix E** of this report. The hydrology data are summarised for each incremental catchment. Associated with each incremental catchment are a base name and a hydrology reference number. The base name is used for data file identification purposes and the hydrology reference number refers to the order number of the catchment as it appears in the PARAMK6.DAT file (a file containing the statistical parameter values for stochastic streamflow generation). Both the above-mentioned references are used in the summary tables and are also shown on the WRPM system schematics given in **Appendix C**.

It is important to note that, for the purposes of this study, no information is provided for the Witbank, Middelburg, Fish, Upper and Lower Orange catchments.

4.2 RAINFALL AND EVAPORATION DATA

Net evaporation losses from open water surfaces can be significant. Point rainfall time series records (*.RAN files) and monthly average lake evaporation data are, therefore, required to calculate the net evaporation loss from the open water surfaces of impoundments. Since rainfall can vary significantly fro one year to the next, Owing to the lower variability in potential evaporation from one year to another, it is generally considered to be acceptable to model evaporation data simply by applying 12 average monthly evaporation values over the standard hydrological year, from October to September, for the particular area/dam in question. Details of the rainfall and evaporation data included in the WRPM database are summarised in **Tables E-2** and **E-3** of **Appendix E** respectively.

4.3 STREAMFLOW

All the streamflow data used in the analysis are naturalised monthly streamflow files in million m^3 and are referred to as the .INC files. Details of the naturalised VRSAU Study's incremental flow files are given in **Table E-4** of **Appendix E**. The refined hydrology of the Renoster and the updated hydrology of the Schoonspruit catchments are summarised in **Tables E-5** and **E-6** respectively. **Table E-7** provides information on the natural runoff of incremental catchments influenced by the re-assessment of the Bloemhof incremental hydrology. The incremental sub-catchments associated with the various streamflow files are shown in **Figures C-1** to **C-12** of **Appendix C**.

4.4 HYDROLOGY FOR BIOPHYSICAL NODES

As mentioned in **Section 4.1** the hydrological analyses of the VRSAU study were not necessarily undertaken at quaternary catchment level as the focus was on the most representative modelling of specific sub-catchments of interest. Various catchment development components (e.g. small dams, diffuse and controlled water use) within these larger sub-catchments were also grouped together to simplify the WRPM configuration.

As part of the Comprehensive Reserve Determination Study (**DWA, 2010d**) it was necessary to derive natural runoff time series data for each quaternary catchment located in the Vaal River catchment upstream of Douglas Weir. Natural runoff information was also required for each of the selected Ecological Water Requirement

(EWR) sites. It was, therefore, firstly necessary to disaggregate all the lumped catchment runoff data to obtain incremental quaternary catchment information. Secondly relevant incremental quaternary catchment information had to be combined to provide a natural Mean Annual Runoff (MAR) and natural runoff time series that are representative of each selected EWR site. To this end, it was necessary to establish an acceptable disaggregation methodology utilising the available sources of quaternary catchment information as benchmarks.

The WR90 (Water Resources 1990) study was the first national study initiated by the Water Research Commission (WRC) which provided comprehensive hydrological information at quaternary catchment level for the entire country. Since the WR90 study (**WRC, 1990**) only included information up to the year 1989, the need for updating this database was identified and culminated in the commissioning of the WR2005 study. The final results of the WR2005 Study were not available at the time when assessments were done for the Reserve Study and it was decided to use the WR90 database as source of information at quaternary catchment level.

The following methodology (developed as part of the Comprehensive Reserve Determination Study (**DWA, 2010d**)) was adopted for the disaggregation process:

- The quaternary catchments which are situated within the lumped catchment were identified;
- The total natural WR90 MAR was calculated for the lumped catchment by adding up all the incremental natural WR90 MARs of the relevant quaternary catchments;
- The incremental natural WR90 MARs of the relevant quaternary catchments were then expressed as a ratio of the calculated total natural WR90 MAR;
- The calculated WR90 MAR ratios were applied to the lumped catchment's natural MAR resulting from the VRSAU study to obtain incremental natural VRSAU MARs for each of the relevant quaternary catchments;
- The VRSAU study's natural runoff time series for the lumped catchment was subsequently scaled by applying the calculated WR90 MAR ratios to obtain an incremental natural runoff time series for each of the relevant quaternary catchments.

The following approach was adopted for the determination of a natural VRSAU MAR and a total natural runoff time series at each of the selected EWR sites:

- The catchment area of the EWR site was determined;
- The quaternary catchments upstream of the EWR site were identified;
- The incremental natural VRSAU MARs and incremental natural VRSAU runoff time series of the relevant quaternary catchments were then added to obtain information that is representative of the EWR site;
- In the event where the location of the EWR site was not at the outlet of a quaternary catchment, the portion of the quaternary catchment area located upstream of the EWR site was determined and the

incremental natural VRSAU runoff time series of the quaternary catchment was scaled according to the catchment area ratio.

In addition to the key biophysical nodes (comprising of the EWR sites selected as part of the Comprehensive Reserve Determination Study), the ecological team identified additional biophysical nodes (referred to as desktop nodes) within the project area where no or limited ecological data existed (refer to **Section 7.2** for details). Since hydrological data were required for these additional nodes, the methodology described above was applied for the determination of the natural MAR and corresponding time series data for each of the biophysical nodes.

The gross catchment areas and natural MARs of all the biophysical nodes (including the EWR sites selected as part of the Reserve Study) are summarised in the tables included with **Figures S-1**, **S-2** and **S-3** of **Appendix S**.

5 WATER BODIES

5.1 OVERVIEW

A large number of reservoirs form part of the Integrated Vaal River System. These water bodies include major impoundments such as Heyshope, Zaaihoek, Grootdraai, Woodstock, Sterkfontein, Katse, Mohale, Vaal and Bloemhof dams as well as a large number of smaller dams which are mainly used for local municipal water supply, rural water supply, irrigation, livestock and game farming.

The storage capability of water bodies in catchments makes them a vital and integral part of water resource analysis. Losses through evaporation occur on the surfaces of lakes, dams and weirs by virtue of their surface areas being exposed to the atmospheric demand for water. As mentioned in **Section 4.2** the net evaporation losses from the open surface areas of impoundments can be significant and need to be accounted for in the water balance calculations of water resources.

The impoundments' physical characteristics (i.e. the capacity and surface area relationship) are the major data requirements of the WRYM and WRPM for modelling water impoundments in catchments.

5.2 MAJOR DAMS

Major reservoirs within the IVRS are listed in **Table E-8** of **Appendix E**. Of these Sterkfontein and Vaal dams are by far the largest dams in the sub-system. The area-capacity relationships for the major dams which are included in the WRYM and WRPM configurations were deduced from detailed dam-survey data obtained from the DWA. Dam basin surveys are done on a regular basis depending on the sedimentation loads of individual river systems. In general surveys are done every ten years or so. The area-capacity relationships for the major dams are, therefore, continuously updated as new survey data become available. The Full Supply Storage (FSS) information of the major dams is also summarised in **Tables E-8**.

5.3 SMALL STORAGE DAMS

In cases where a large number of small dams are located within a catchment, such as in the Grootdraai Dam catchment, it is generally considered to be impractical to model each dam individually. Instead, certain defined groups of these dams are identified and the dams within a group are then combined to form a single representative network element, generally referred to as a dummy dam.

A dummy dam represents the combined effect of all the small dams or farm dams in a sub-catchment. The dummy dam for a specific sub-catchment, therefore, has a capacity and surface area equal to that of all the small dams within that sub-catchment combined. The typical demands such as irrigation and even those of the smaller towns, which are supplied from these small dams, are then modelled as a single demand supplied from the dummy dam.

Information on the catchment area commanded by the dummy dam is also required to specify how much of the runoff from the catchment should be routed through the dummy dam. These areas were determined from 1:50 000 topographical maps and are used as input to the WRYM and WRPM.

6 WATER REQUIREMENTS AND RETURN FLOWS

6.1 GENERAL

The system configuration of the IVRS, as defined in the data files of the WRPM model, are presented as schematic diagrams in **Appendix C**. The land use information currently included in the WRPM configuration is mostly based on data obtained as part of the VRSAU Study. As mentioned in **Section 4.1** the various catchment development components (e.g. small dams, diffuse and controlled water use) were also grouped together to represent activities occurring within the larger sub-catchments modelled as part of the simplified WRPM configuration. Refinements were, however, made to the system configuration to enable modelling of the selected EWR sites for the purposes of the Comprehensive Reserve Determination Study (**DWA, 2010d**). It is important to note that various assumptions had to be made in view of these refinements which may impact on the accuracy of simulation results. The locations of the selected EWR sites (refer to **Section 7.2**) are shown on the schematic diagrams presented in **Appendix C**.

The resolution of the WRPM configuration does not allow for the explicit modelling of the desktop biophysical nodes described in **Section 7.4**. Although natural hydrology could be derived for these nodes, it will not be possible to simulate present day conditions at these sites with the use of the WRPM. An alternative strategy as described in **Section 11** was, therefore, followed for the assessment of current development conditions at these nodes. Land use information obtained from the Validation and Verification studies was used for this purpose and this information is also provided in **Section 11**.

The WRPM database includes growing water requirements up to the year 2030. Since the Integrated Vaal River System (IVRS) is analysed on an annual basis, the water requirement projections of the major bulk water suppliers (Rand Water, Midvaal Water Company and Sedibeng Water), the strategic water user Eskom, as well as large industrial users such as Sasol and Mittal Steel (previously known as Iscor), are also updated annually. The most recent water requirement projections of the above-mentioned users revised as part of the 2011/2012 Annual Operating Analysis (**DWA, 2012**) were used for the scenario analyses to be undertaken as part of this study. Details of the individual water user groups are provided in the sections below and the summarised water requirement projections covering the entire planning period from 2011 to 2030 are listed in **Table F-1** of **Appendix F**.

6.2 URBAN AND INDUSTRIAL WATER USE

6.2.1 Rand Water

A number of alternative water requirement projection scenarios were considered for Rand Water (RW) as part of the Vaal River System Reconciliation Strategy Study (**DWAF, 2008a**). This study comprised of two stages and during the duration of the study several refinements were made to the water requirement projections. In November 2008 the Second Stage water requirement and return flow projection scenarios were derived by integrating the projections obtained from the Crocodile West Reconciliation Strategy Study (**DWAF, 2008c**). The High Population Demand Projection without WC/WDM resulting from the integration process was finally selected for the 2009/2010 AOA as well as the 2010/2011 AOA. The Phase 2 Reconciliation Strategy High Population Demand Projection for RW was again revised in October 2010. This revised gross demand projection without WC/WDM (as summarised in **Table 6-1** below) was subsequently used for the 2011/2012 AOA as well as this study.

Table 6-1: Water requirement projection for Rand Water

Description	2011	2015	2020	2025	2030
Water requirement (million m^3/a)	1470	1580	1726	1840	1980

The water requirements and return flows developed for the Rand Water supply area as part of the Vaal River System Reconciliation Strategy Study (**DWAF, 2008a**) were determined with the Water Requirement and Return Flow database model which was developed for the DWA as part of the Crocodile (West) River Return Flow Assessment Study (**DWAF, 2004b**). The model uses Sewage Drainage Areas (SDAs) as modelling component where a sewer pipe network system collects the wastewater for treatment at waste water treatment works before it is discharged into a river system. The methodology that was followed to compile the water requirement and return flow projections is described in the detailed water requirement and return flow report of the Vaal River System First Stage Reconciliation Strategy Study (**DWAF, 2006a**). The water requirement projection shown in **Table 6-1** is therefore a combination of the projections determined for the individual SDAs.

6.2.2 Midvaal Water Company

Midvaal Water Company (Midvaal WC) treats and supplies water to users in the Klerksdorp area and has experienced a decline in water use mainly due to the closing of several mining operations. Midvaal WC provided a new water requirement projection in April 2011 which is 0.6 million m^3/a lower than their previous projection. The revised April 2011 projection for Midvaal WC was selected for use in this study.

6.2.3 Sedibeng Water

Sedibeng Water is the bulk service provider supplying water to both urban and industrial (mining) water users. Sedibeng Water receives water from the Vaal River System from two abstraction locations. The first is Balkfontein on the Vaal River and, the second, from Allemanskraal Dam at their Virginia Works. Virginia Town, which falls within the Sedibeng Water supply area, has an allocation of 15.2 million m^3/a from Allemanskraal Dam. The water use in their supply area has decreased historically mainly due to the descaling mining activity in the region. The revised water requirement projection received from Sedibeng Water in June 2011 was used for this study.

6.2.4 Other Towns and Industries

There are a large number of towns and industries within the Vaal River catchment that do not receive their water from the bulk water suppliers such as Rand Water, Midvaal WC and Sedibeng Water. Since the DWA selected the demand projections of the NWRS Ratio Method to be used for the smaller towns and industries in 2001, these projections were adopted for all subsequent operating analyses.

However, in the case of the following towns, water requirement projections were updated as part of the Demand Determination task of the Bridging Study (**East Vaal Consultants, 2004a**):

- Lekwa Local Municipality (formerly Standerton);
- Msukaligwa Local Municipality (formerly Ermelo);
- Amersfoort;
- Breyten;
- Newcastle;
- Iscor (Newcastle);
- Wakkerstroom and Esizamelani;
- Durnacol, Dannhauser and Siltec;
- Volksrust, Charlestown and Vukhuzakhe.

Three water requirement projections, High, Most Probable and Low, were available for the above users. The Most Probable projection was adopted for the operating analysis of the Integrated Vaal River System undertaken as part of the Bridging Study and was also adopted for subsequent annual operating analyses and this study.

Updated information for a number of smaller towns located within the Vaal River Eastern Sub-System (VRESS) was obtained from the Water Situation Assessment Study of Selected Towns (**DWAF, 2008e**) which was undertaken subsequently. The relevant towns and their water requirement projections are summarised in **Table 6-2**.

Table 6-2: Updated demand projections for selected towns in the VRESS

Name of Town (source of supply)	Demand Scenario	Water requirement projections (million m^3/a)				
		2011	2015	2020	2025	2030
Breyten (Kwadela Municipality) Camden-Lilliput Pipeline [(1)]	High	0.85	0.89	0.91	0.91	0.92
	Base	0.82	0.86	0.88	0.84	0.83
Ermelo (Msukaligwa LM) Camden-Rietspruit Pipeline [(1)]	High	2.39	2.69	2.88	3.04	3.17
	Base	2.25	2.48	2.61	2.81	2.87
Davel (Msukaligwa LM)	High	0.26	0.28	0.28	0.28	0.28

Name of Town (source of supply)	Demand Scenario	Water requirement projections (million m³/a)				
		2011	2015	2020	2025	2030
Rietspruit-Davel Pipeline (1)	Base	0.26	0.27	0.27	0.28	0.27
Kriel (Emalahleni LM)	High	2.60	2.69	2.76	2.85	2.93
Davel-Kriel Pipeline (1)	Base	2.58	2.66	2.71	2.76	2.79
Hendrina (Steve Tshwete Mun)	High	1.21	1.30	1.31	1.34	1.37
Hendrina Pipeline (1)	Base	1.16	1.21	1.23	1.27	1.27
Amsterdam (2)	High	0.28	0.32	0.33	0.33	0.33
	Base	0.22	0.24	0.24	0.26	0.25
Driefontein (1)	High	1.13	1.45	1.53	1.66	1.76
(Supplied From Heyshope)	Base	0.82	1.00	1.05	1.25	1.46
Standerton (1)	High	10.84	11.70	12.02	12.26	12.56
(Supplied From Grootdraai)	Base	10.57	11.11	11.35	11.69	11.82
Morgenzon (1)	High	0.03	0.09	0.12	0.13	0.15
(Supplied From Grootdraai)	Base	0.01	0.06	0.09	0.11	0.11

Note: (1) Net demand projections (i.e. total demand excluding yield from local sources)
(2) Gross demand projections (the yield from local sources can meet demand in full)

As shown in **Table 6-2**, Breyten, Ermelo, Davel, Kriel and Hendrina are supplied via the Eskom water conveyance infrastructure and are referred to as the so-called DWA 3rd Party Users (refer to **Section 6.3.1**). Amsterdam can be supplied from the Westoe-Jericho transfer link. The yield from local sources is, however, sufficient to meet the high demand projection up to 2030. Although the demand projections are shown in **Table** 6-2 Amsterdam's demands were not supplied from the IVRS. Driefontein, Standerton and Morgenzon are modelled as separate demand centres supplied from the indicated water resources. In the case of other small towns and industries, not mentioned above, the NRWS **Scenario B** water requirement projections were adopted for this study.

6.3 LARGE INDUSTRIAL CONSUMERS

6.3.1 ESKOM

Eskom currently operates 12 coal fired electrical power stations which receive water from the Integrated Vaal River System. Some of these stations were decommissioned and are now reinstated to increase supply in response to the growing demand for electrical power to fuel the South African economy. The first new coal fired power station named Kusile (previously referred to as Bravo) is still under construction and was scheduled for commissioning in 2009. Kusile is located close to the existing Kendal Power Station and receives water from the Vaal River Eastern Sub-system (a component of the Integrated Vaal River System). There are plans to build more coal fired stations the locations of which will depend on suitable coal fields. Eskom's April 2011 water requirement projections included projected use for a number of new coal fired (CF) stations and Eskom recommended that the water demands of these (referred to as CF-4 to CF-11) be put on Vaal Dam.

Eskom revise their water requirement projections on an annual basis. Consequently, three projections, namely a Tariff, Base and High Scenario, were provided by Eskom in April 2011. From these alternative scenarios Eskom recommended that the Base and High demand scenarios be considered for the 2011/2012 Annual Operating Analysis. The April 2011 Base Scenario projections were used for this study.

It should be noted that there are several smaller users that are supplied with water along the Eskom water conveyance routes. These users are referred to as the so-called DWA 3rd Party Users. The projections for these users were derived as part of the original TR134 projections and were subsequently refined based on the actual water use information collated as part of the annual operating analysis of the IVRS. As mentioned in **Section 6.2.4** updated demand projections were obtained for some of the smaller towns receiving water from the Eskom pipelines. Two water requirement projections, a Base and a High projection, were compiled for the DWA 3rd Party Users supplied from the Hendrina-Duvha and Camden-Kriel pipelines. The water requirement projections adopted for the 2011/2012 AOA are provided in **Table 6-3** and were also used for this study.

Table 6-3: Water Requirement Projections for DWA 3rd Party Users

Description of supply route	Demand Scenario	Water Requirements (million m³/annum)				
		2011	2015	2020	2025	2030
Komati pipeline	Base	7.14	7.14	7.14	7.14	7.14
Hendrina-Duvha pipeline	High	5.11	5.20	5.21	5.25	5.28
	Base	5.07	5.12	5.14	5.18	5.17
Overwacht, Camden-Rietspruit, Camden-Lilliput, Rietspruit-Davel, Davel-Kriel and Khutala-Kendal pipelines	High	7.29	7.73	8.02	8.28	8.49
	Base	7.11	7.47	7.67	7.88	7.96
Grootdraai-Tutuka, Rietfontein-Matla and Naauwpoort-Duvha pipelines	Base	1.00	1.00	1.00	1.00	1.00
Total for DWA 3rd Party Users:	**High**	**20.54**	**21.08**	**21.37**	**21.67**	**21.91**
Total for DWA 3rd Party Users:	**Base**	**20.32**	**20.73**	**20.94**	**21.19**	**21.28**

6.3.2 Sasol Secunda Complex

The Sasol Secunda Complex's primary source of water is Grootdraai Dam with Vaal Dam as alternative resource. The Vaal River Eastern Sub-system Augmentation Project (VRESAP) became operational in December 2008 and water can be transferred from Vaal Dam through the VRESAP pipeline to Knoppiesfontein to augment the water supply of Sasol and Eskom.

Sasol has submitted revised raw water requirement projections for their Secunda complex in April 2011. The revised projection was based on the assumption that varying portions of the total water requirement will be supplied by Rand Water (intake of 25 ML/d from January 2011, 20 ML/d from 2015 and 10 ML/d from 2020 to 2025). A comparison of some of the more recent water requirement projections for Sasol Secunda showed that the revised 2011 projection is slightly less than the April 2010 projection up to the year 2015 after which there is quite a significant difference with the revised April 2011 projection almost 25 million m^3/a less in 2030. The April 2011 demand projection is in line with the actual water use for the year 2010/2011 which amounts to 83.85 million m^3/a. Sasol explained that reduced electricity generation was the leading cause for consuming less water than anticipated. The April 2011 projection was used for this study.

6.3.3 Sasol Sasolburg Complex

The Sasol Sasolburg Complex is supplied from Vaal Dam which is supported by transfers from the Thukela-Vaal Transfer Scheme as well as the Lesotho Highlands Water Project (LHWP). Revised information on projected raw water abstractions for the Sasol Sasolburg complex (Sasol 1) was also obtained during April 2011. The April 2011 projection is much lower than the 2010 projection with a difference of almost 16% in 2030. Sasol 1 has a permit allocation of 96 Ml/d (35.1 million m^3/a) for raw water and 6 Ml/d (2.2 million m^3/a) for potable water. Owing to the poor water quality being experienced in the Vaal Barrage, it was also confirmed by Sasol that up to 60 Ml/d (21.92 million m^3/a) will be abstracted from the Lethabo Weir before they start abstracting their additional requirement from Vaal Barrage.

6.3.4 Mittal Steel

Mittal Steel (previously known as Iscor) receives its water from Vaal Dam. The water requirement projections for Mittal Steel incorporated in the WRPM configuration was updated as part of the 2010/2011 AOA based on information provided by Mittal in July 2010. Since updated information was not obtained from Mittal Steel in preparation of the 2011/2012 AOA, the revised July 2010 water requirement projection was adopted for the current operating analysis and also for this study.

6.4 IRRIGATION WATER REQUIREMENTS

The irrigation water requirements were revised as part of the Vaal River Reconciliation Strategy Study (**DWAF, 2006f**) and incorporated results from the water use registration, validation and verification processes commissioned by the DWA. Partial validated information (about 70% of the properties in the Upper Vaal Water Management Area (WMA) were validated) were included in the WRPM configuration for the first time as part of the 2008/2009 AOA. Based on this information the total irrigation water use in the Upper Vaal WMA was split into two components, namely the “Possible Existing Lawful Use” and the “Unlawful Irrigation Water Use”. With regards to the WRPM analyses the following assumptions were made in terms of the irrigation water use:

- **Upper Vaal WMA**
    - Assume the growing trend, which was observed over the period 1998 to 2005, continues for two years until 2008. This implies that interventions will take two years to become effective.
    - Eradication of unlawful irrigation water use from 2008 onwards and assuming the water use will

decrease over a period of 4 years.

- o The assumption is made that the interventions will reduce the irrigation to the lawful volume plus 15% of the unlawful component and that this will be achieved in the year 2011. The additional 15% above the estimates of the lawful water use is a conservative assumption providing for possible under estimations from the current data.

- **Middle and Lower Vaal WMA**
  - o Due to the absence of information from validation studies in these areas, it is assumed that the current suggested irrigation water use will remain constant over the planning period.

The configuration of the WRPM was adjusted as part of the Second Stage of the Vaal River Reconciliation Study to include modelling of the irrigation water use by means of irrigation modules. This enhancement of the WRPM configuration facilitates the explicit modelling of irrigation return flows, as well as representative simulated salinity results downstream of these irrigation areas.

Although the legal process dealing with the eradication of unlawful irrigation practices has been initiated, the anticipated reduction in the unlawful irrigation water use (as described above) has not yet been achieved. For the 2011/2012 AOA and the purposes of this study it was, therefore, assumed that the unlawful irrigation water use for the years 2009, 2010 and 2011 will be equal to the projected use for 2008. It was further assumed that the eradication of 85% of the unlawful irrigation water use will be achieved during the next three years (2012, 2013 and 2014) after which the unlawful water use will remain constant at 15%.

Table 6-4 summarises the irrigation water use adopted for this study.

Table 6-4: Comparison of irrigation water use

Description	Irrigation water use (million m^3/a)			
	2011	2012	2013	2014 onwards
Vaalharts & Lower Vaal	541.53	541.53	541.53	541.53
Diffuse in Vaal	11.31	11.31	11.31	11.31
Other irrigation in Vaal	714.03	622.47	530.92	439.37
Total for Vaal:	**1266.87**	**1175.31**	**1083.76**	**992.21**

Error! Reference source not found. presents the projected net unlawful irrigation water requirements as adopted for the 2011/2012 analyses and for this study.

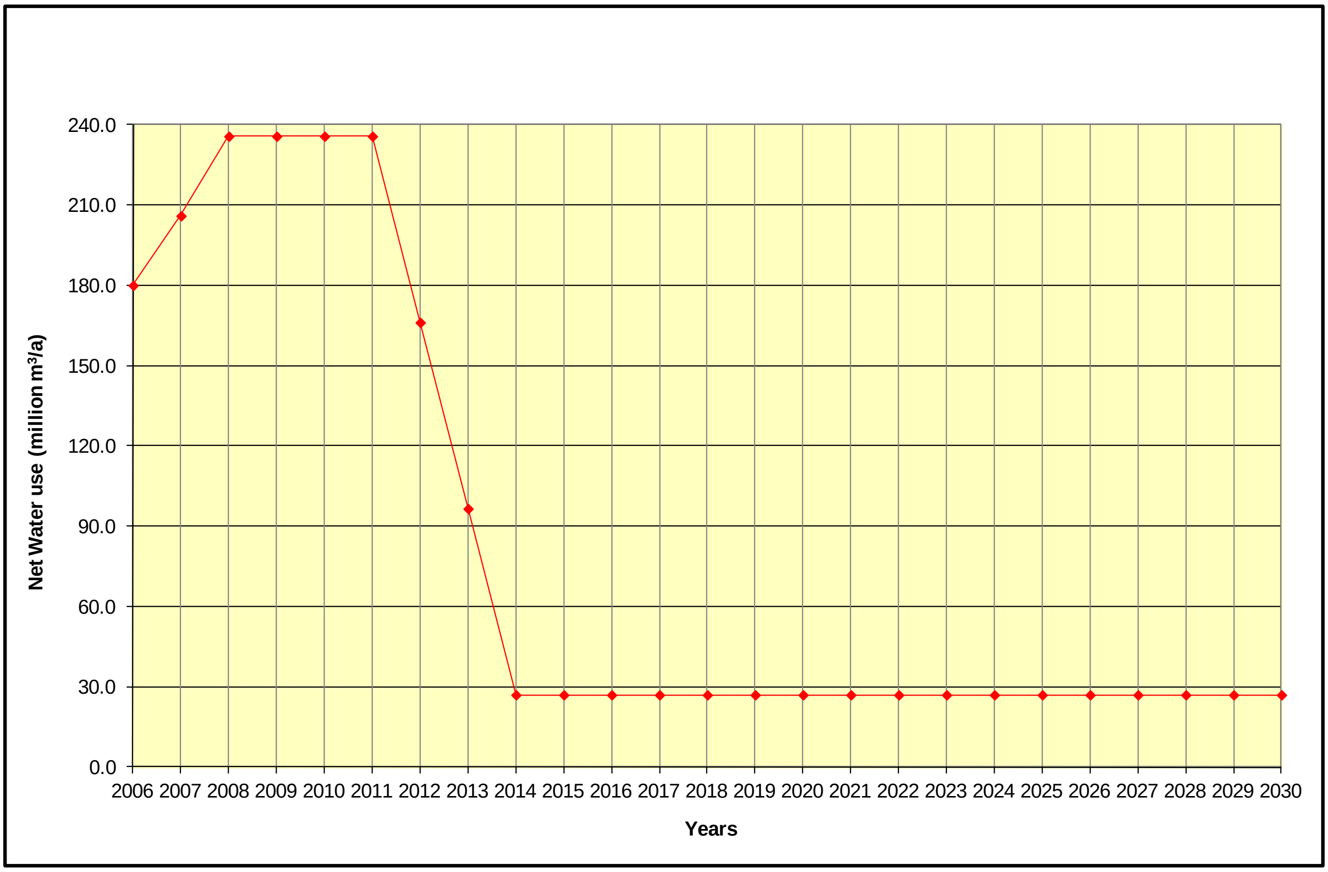

Figure 6-1: Projected net unlawful irrigation water use in the Upper Vaal WMA

6.5 URBAN AND INDUSTRIAL RETURN FLOWS

As mentioned in **Section 6.2.1** the return flow projections developed for the Rand Water supply area as part of the Vaal River System First Stage Reconciliation Strategy Study (**DWAF, 2006f**) were adopted for the 2011/2012 AOA and this study. From the forty seven Sewage Drainage Areas (SDAs) identified in the Rand Water (Gauteng) supply area, only the return flows from those SDAs draining to the south and therefore contributing to the Vaal River System were considered.

Return flows resulting from abstractions made by bulk suppliers such as Midvaal Water Company, as well as Sasol Sasolburg, are automatically calculated during the analysis based on calibrated parameters and are inter alias dependent on rainfall. Return flows associated with smaller urban abstractions are calculated as fixed percentages of the actual water supply.

6.6 MINE DEWATERING

The mine dewatering information and potential re-use options are continuously updated. The re-use option, based on information used as part of the Vaal River Reconciliation Strategy Maintenance Study assessments undertaken in 2010, was adopted for the 2011/2012 AOA and this study. Based on this information about 55.5 million m^3/a of the water pumped from the mines in the Eastern, Central and Western basins, could be treated and provided to Rand Water at a TDS concentration of 200mg/l. The re-use of this mine water was assumed to commence in July 2014 after which it was assumed that only discharges from the Far Eastern mining basin (amounting to 16.44 million m^3/a) will be made to the river systems with an associated TDS concentration of 700 mg/l.

Table 6-5 summarises the discharges from the various mining basins prior to July 2014 (i.e. the date at which re-use was assumed to commence) and the associated TDS concentrations that were used for this study.

Table 6-5: Mining discharges and associated TDS concentrations

Mining Basin	Discharges to river (million m^3/a)					Associated TDS concentration (mg/l)
	2011	2012	2013	2014	2015	
Far Western	16.90	16.44	16.44	16.44	16.44	700
Western	0.00	0.00	0.00	0.00	0.00	3600
Central	4.27	25.57	25.57	4.27 (1)	0.00	6500
Eastern	29.95	29.95	29.95	5.00(1)	0.00	2100
Total:	**51.12**	**71.95**	**71.95**	**25.71**	**16.44**	**-**

6.7 SUMMARY OF WATER REQUIREMENT PROJECTIONS

The following is a brief description of the sources of information adopted for the water requirement components included in **Table F-1** of **Appendix F:**

- **Rand Water Supply Area**: The adopted water requirement scenario for the Rand Water (RW) supply area was compiled based on the Phase 2 Reconciliation Strategy High Population Demand Projection without Water Conservation and Water Demand Management (WC/WDM) initiatives as revised in October 2010.
- **Eskom**: Eskom provided three alternative water requirement scenarios for each existing and planned power station in April 2011. The Base Demand scenario was recommended for planning purposes.
- **Sasol Secunda**: The April 2011 projections provided by Sasol were adopted.
- **Sasol Sasolburg**: The May 2011 projections provided by Sasol were adopted.
- **Mittal Steel**: A revised water requirement projection was obtained from Mittal Steel on 20 July 2010 and was adopted for analysis.
- **Sedibeng Water**: Updated information was received in June 2011 from Sedibeng.

- **Midvaal Water Company (WC)**: The April 2011 projection provided by Midvaal WC was adopted.

- **Other users**: Water requirements for most towns were based on the NWRS projections and in cases where data were available the All Town Reconciliation Strategy Study scenarios were adopted.

- **Irrigation**: The irrigation water requirements of the Vaal River System that were adopted for the 2011/2012 Annual Operating Analysis were applied. These estimates and the portion deemed to be unlawful originated from the Vaal River System: Large Bulk Water Supply Reconciliation Strategy Study (**DWAF, 2008a**).

Table F-2 included in **Appendix F** provides detailed information on individual water users and the information is presented within the context of the various sub-systems of the IVRS. The WRPM configuration was set up to analyse two alternative development levels, i.e. Present Day (2011 conditions) and a Future Development Level (representative of 2020 development conditions). The water requirement projections adopted for the two development levels considered as part of this study are summarised in **Table 6-6**.

Table 6-6: Summary of water requirements and return flows adopted for the analysis

Water Users	**Demand/Discharge (million m^3/a)**	
	2011	**2020**
Water Requirements		
Rand Water (Includes Sasolburg, excludes authorized users)	1479	1729
Mittal Steel (Includes portion supplied from Rand Water)	12	14
ESKOM (Includes DWA 3rd Party Users)	373	416
SASOL Sasolburg (Raw water requirements only)	20	26
SASOL Secunda	82	93
Midvaal Water Company	45	45
Sedibeng Water (Balkfontein abstractions only)	41	43
Other towns and industries	189	191
Vaalharts/Lower Vaal irrigation (Includes distribution losses)	542	542
Diffuse Irrigation and Afforestation (Vaal System)	11	11
Diffuse Irrigation and Afforestation (Supporting Sub-systems)	68	68
Other irrigation in Vaal System (Excludes diffuse irrigation)	714	493
Other irrigation in supporting Sub-systems (Excludes diffuse irrigation)	25	25
Wetland/River Losses	326	329
Return Flows		
Southern Gauteng (Rand Water)	-393	-462

Water Users	Demand/Discharge (million m^3/a)	
	2011	2020
Midvaal Water Company	-1	-1
Sedibeng Water	-2	-2
Other towns and industries	-71	-78
Irrigation	-143	-77
Mine dewatering	-112	-78
Mine water treated for re-use	0	-56
Increased urban runoff	-104	-113
Overall Gross System Demand:	**3928**	**3973**
Overall Net System Demand:	**3102**	**3105**

6.8 PRIORITY CLASSIFICATIONS, USER CATEGORIES AND RESTRICTION LEVELS

The operation of the IVRS system is based on the principle that demands are restricted during severe drought events. The objective of these restrictions is to reduce supply to less essential use to be able to protect the assurance of supply to more essential use. The basis on which restrictions are implemented is defined by means of the user priority classification definition.

The user priority classification definition requires that the different water users be grouped together into user categories and these categories should be classified according to priority for water supply. The four user categories that were considered for the IVRS are Domestic, Industrial, Strategic Industries and Irrigation. The four user categories were each split into three different levels of assurance of supply namely a Low, Medium and High priority level.

The specified priority classifications, assurances of supply and restriction levels adopted for this study were based on information from the report Future Demands and Return Flows (**BKS, 1994**). This information is summarised in **Table 6-7** and was adopted for all the users within the IVRS excluding those supplied from the smaller sub-systems in the Middle Vaal WMA.

Table 6-7: Priority classifications, assurances of supply and curtailment levels

User		User priority classification (assurance of supply)		
		Low (95 %)	**Medium (99 %)**	**High (99.5 %)**
		Proportion of water demand supplied (%)		
1	Domestic	30	20(1)	50(2)
2	Industrial	10	30	60
3	Strategic industries	0	0	100
4	Irrigation	50	30	20
Restriction levels:		0	1	2	3

Note: (1) 70 % of the demand for domestic water in the Vaal System can be supplied with an assurance of at least 99 %

(2) A proportion of 50 % of the domestic water in the Vaal System can be supplied at the high assurance of 99.5%

When restrictions are imposed, low priority users are restricted first, followed by the medium and then the high priority users. Restriction level "0" implies that all requirements are supplied. At a restriction level of "3", all users except for strategic industries are restricted, implying a total failure of the system. If restriction level "1" is used as an example, the restriction of the various users will be as illustrated in **Table 6-8**.

Table 6-8: Restriction at level 1 (example)

User		Restriction (% of total requirement)
1	Domestic	30 %
2	Industrial	10 %
3	Strategic industries	None
4	Irrigation	50 %

Simplified restriction rules were derived for the Klipdrift, Koppies, Allemanskraal and Erfenis dam sub-systems as part of the 2008/2009 AOA and details thereof are documented in the relevant AOA report (**DWAF, 2009h**). The user priority classifications, assurances of supply and restriction level definitions adopted for these sub-systems located in the Middle Vaal WMA are presented in the 2008/2009 AOA (**DWAF, 2009h**).

7 BIOPHYSICAL NODES

7.1 BACKGROUND

Integrated Units of Analysis (IUAs) for the three Vaal Water Management Areas were finalised during Step 1 of the WRCS and within these areas 115 biophysical nodes were selected. The identified IUAs for the three Vaal Water Management Areas and the location of the biophysical nodes are shown in **Figures B-1**, **B-2** and **B-3** of **Appendix B.** The IUAs are listed and described in **Table 7-1** below.

Table 7-1: Description of Integrated Units of Analysis (IUAs)

WMA	IUA Name	Description
Upper Vaal	UA	Vaal River upstream of Grootdraai Dam
	UB	Klip River (Free State)
	UC1	Upper Wilge River
	UC2	Wilge River and tributaries
	UC3	Lower Wilge River
	UD	Liebenbergsvlei River
	UE	Waterval River
	UF	Kromspruit & Skulpspruit
	UG	Vaal River from Grootdraai Dam to Vaal Dam
	UH	Suikerbosrand River
	UI	Klip River (Gauteng)
	UJ	Taaibosspruit
	UK	Kromelmboogspruit
	UL	Mooi River
	UM	Vaal River reach from Vaal Dam to C23L
Middle Vaal	MA	Renoster River
	MB	Vals River
	MC	Schoonspruit River
	MD1	Upper Sand River
	MD2	Lower Sand River
	ME1	Upper Vet River
	ME2	Lower Vet River
	MF	Vaal River from Renoster confluence to Bloemhof Dam
Lower Vaal	LA1	Upper Harts River
	LA2	Middle Harts River
	LA3	Dry Harts River
	LA4	Lower Harts River
	LB	Vaal River from downstream of Bloemhof Dam to Douglas Weir

It is important to note that various tools and information such as the Desktop EcoClassification results generated during the recent Reserve studies and the National Freshwater Ecosystem Priority Areas (NFEPAs) were used to identify additional nodes. The approach adopted for the identification and selection of the IUAs and biophysical nodes is described in the Status Quo Report (**DWA, 2011b**) compiled as part of this study.

The biophysical nodes include key biophysical nodes or Ecological Water Requirement (EWR) sites which represent critical habitat for ecosystem functioning in the Vaal River main stem and major tributaries. Since large sections of the catchment were still unaccounted for additional biophysical nodes (referred to as desktop biophysical nodes) were selected. During Step 2 of the WRCS (see **Figure D-1**) the main objective was to describe the status quo of the water resources within each of the IUAs in terms of the following aspects:

- Water resource infrastructure and availability;
- Ecological status;
- Socio-economic conditions (including framework for impact assessment); and
- Goods and services (communities and their well-being).

In order to complete Step 3 of the WRCS all EWR information and data available from previous Reserve determination studies were analysed and used where appropriate. The criteria used for the selection of the biophysical nodes are briefly summarised in **Section 7.2**. Different approaches were adopted for the water resource assessments of key and desktop biophysical nodes. Information on the two sets of nodes is provided in **Sections 7.3** and **7.4** below.

Detailed information on the quantification of the Ecological Water Requirements (EWRs) and changes in non-water quality Ecosystem Goods, Services and Attributes (EGSAs) can be found in the corresponding study report (**DWA, 2011c**).

7.2 SELECTION AND NAMING OF BIOPHYSICAL NODES

The key biophysical nodes are the Ecological Water Requirement (EWR) sites and the selection process of these sites is documented in the recent Reserve studies (**DWAF, 2008e**; **DWAF 2009a** and **b**). The location of the EWR sites however were focussed on the main stem and key tributaries, i.e. the areas where there are water resource issues and where operational management of the system can be implemented. However, this leaves large sections of the catchment unaccounted for.

The process described in the Classification guideline (which refers to the Desktop EcoClassification and the identification of hotspots (**Louw & Huggins, 2007**) was used as an initial step to identify additional nodes within the project area where no or limited ecological data existed. These biophysical nodes were selected at the outlet of any area with a High or Very High Environmental Importance (EI). During the Desktop EcoClassification process of the Reserve studies for the Upper (**DWAF, 2008f**), Middle (**DWAF, 2009c**) and

Lower (**DWAF, 2009d**) Vaal WMAs, the Ecological Importance (EI) was evaluated by means of using a matrix to determine the rating, and as interpretation can be subjective, this was not necessarily consistent. To ensure consistency during the evaluation of these nodes the Desktop EcoClassification results produced during the Reserve studies for the Upper, Middle and Lower Vaal WMAs were summarised in Excel format and formulas were used to consistently recalculate the EI for all quaternary catchments. The EcoClassification results were presented in the Status Quo Report (**DWA, 2011b**) compiled for this study.

The final set of desktop biophysical nodes comprises of nodes selected as part of the Comprehensive Reserve Determination study as well as additional nodes identified during this study. Since different naming conventions were used for these nodes it was decided to standardise on this and the following naming convention was subsequently adopted for the desktop biophysical nodes:

XY.NO

Where:

X indicates the relevant WMA (e.g. U=Upper Vaal; M=Middle Vaal and L=Lower Vaal);

Y references the IUA in which the node is resident (A, B, C, D etc.); and

NO indicates the unique number (1, 2, 3, 4 etc.) allocated to the node within the IUA.

The standardised naming convention was used for the maps showing the locations of the biophysical nodes (refer to **Figures B-1** to **B-3** of **Appendix B**). However, to allow for compatibility with previous Classification study reports both naming conventions were used in the summary tables presented in this report.

7.3 KEY BIOPHYSICAL NODES (EWR SITES)

7.3.1 EWR Sites in Upper Vaal WMA

A total of thirteen Ecological Water Requirement (EWR) sites were identified in the Upper Vaal WMA as part of the Comprehensive Reserve Determination Study (**DWAF, 2010d**) of which eleven were assessed at a comprehensive level and rapid assessments were undertaken for the remaining two sites. The locations of the EWR sites in the Upper Vaal WMA are shown in **Figure B-1** of **Appendix B** and basic information is provided in **Table 7-2**.

Table 7-2: Basic information on EWR sites in the Upper Vaal WMA

EWR site number	EWR site name	River	Decimal deg S	Decimal deg E	Quaternary Catchment	Total Catchment Area (km^2)	NMAR (#) (million m^3/a)
EWR1	Vaal-Uitkoms	Vaal	-26.8728	29.61384	C11J	4984	288.73
EWR2	Vaal-Grootdraai	Vaal	-26.9211	29.27929	C11L	7995	457.68

EWR site number	EWR site name	River	Decimal deg S	Decimal deg E	Quaternary Catchment	Total Catchment Area (km^2)	NMAR (#) (million m^3/a)
EWR3	Vaal-Gladdedrift	Vaal	-26.99087	28.72971	C12H	15638	852.13
EWR4	Vaal-Deneys	Vaal	-26.84262	28.1123	C22F	38638	1977.26
EWR5	Vaal-Scandinavia	Vaal	-26.93243	27.01367	C23L	49739	2288.02
EWR6	Klip	Klip	-27.36166	29.48503	C13D	1583	93.35
EWR7	Upper Wilge	Klip	-28.20185	29.55827	C81A	170	23.16
EWR8	Wilge-Bavaria	Wilge	-27.80017	28.76778	C82C	7503	474.26
EWR9	Suiker US	Suiker-bosrant	-26.6467	28.38197	C21C	1175	31.31
EWR10	Suiker DS	Suiker-bosrant	-26.68137	28.16798	C21G	3271	86.97
EWR11	Blesbokspruit	Blesbok-spruit	-26.47892	28.42488	C21F	1098	29.14
RE_EWR1 ($)	Klein Vaal	Klein Vaal	-26.91275	30.17497	C11C	318	26.02
RE_EWR2 ($)	Mooi	Mooi	-26.25867	27.15973	C23G	1325	37.69

Note: ($): Rapid Reserves determined for these EWR sites

(#): NMAR = Natural Mean Annual Runoff (Period: 1920 – 1994)

Information for two EWR sites in the Waterval catchment (as provided in **Table 7-3**) was obtained from a BKS study undertaken for the DWA in 2003 (**BKS, 2005b**). These two EWR sites were included in the WRPM configuration adopted for the Comprehensive Reserve Study (**DWAF, 2010d**). As shown in **Figure B-1** of **Appendix B**, both EWR sites fall within the IUA UE which comprises the entire Waterval catchment. The WRPM configuration was refined for the Reserve study to allow for the explicit modelling of these two EWR sites (refer to **Figure C-1** of **Appendix C**). The locations of these two sites were subsequently refined during this study and the assessments of the two nodes were done based on the approach adopted for the desktop biophysical nodes (refer to **Section 11**).

Table 7-3: Basic information for EWR sites in Waterval catchment

EWR site number	EWR site name	River	Quaternary Catchment	Total Catchment Area (km^2)	NMAR (#) (million m^3/a)	Source of information for modelling purposes
WA1 (UE.1)	Upper Waterval	Waterval	C12D	899	76.71	BKS Study (**BKS, 2005b**)
WA2 (UE.4)	Lower Waterval	Waterval	C12G	2232	147.43	BKS Study (**BKS, 2005b**)

Note: (#): NMAR = Natural Mean Annual Runoff (1920 – 1994)

7.3.2 EWR Sites in Middle and Lower Vaal WMA

Seven EWR sites were selected in these two WMAs as part of the Comprehensive Reserve Determination Study and their basic information is summarised in **Table 7-4**.

The Schoonspruit Sub-system Analysis Study (**DWAF, 2006a**) included a Reserve determination task and assessments were made at four EWR sites. The final recommended three EWR sites shown in

Table 7-5 were included in the WRPM analysis.

The locations of the EWR sites selected for the Middle and Lower Vaal WMAs are shown in **Figures B-2** and **B-3** of **Appendix B** respectively.

Table 7-4: Basic information for Reserve Study EWR Sites in Middle and Lower Vaal WMAs

EWR site number	EWR site name	River	Decimal deg S	Decimal deg E	Quaternary Catchment	Total Catchment Area (km^2)	NMAR (#) (million m^3/a)
EWR12	Vermaasdrift	Vaal	26.93615	26.85025	C24A	62305	2546.42
EWR13	Regina Bridge	Vaal	27.10413	26.52185	C24J	70809	2714.89
EWR14	Proklameerdrift	Vals	27.48685	26.81320	C60J/C60G	5930	147.61
EWR15	Fisantkraal	Vet	27.93482	26.12569	C43A	16040	413.55
EWR16	Downstream of Bloemhof Dam	Vaal	27.65541	25.59564	C91A	108474	3303.10
EWR17	Lloyds Weir	Harts	28.37694	24.30305	C33C	31029	147.85
EWR18	Schmidtsdrift	Vaal	28.70758	24.07578	C92B	157685	3407.79

Table 7-5: Basic information for Schoonspruit EWR sites

EWR site number	EWR site name	River	Quaternary Catchment	Total Catchment Area (km^2)	NMAR (#) (million m^3/a)	Source of information for modelling purposes
S1	IFR1	Schoonspruit	C24E	1350	59.38	Schoonspruit Sub-system Analysis Study (**DWAF, 2006a**)
S3	IFR3	Schoonspruit	C24F	-	89.96	Schoonspruit Sub-system Analysis Study (**DWAF, 2006a**)
S4	IFR4	Schoonspruit	C24H	-	102.09	Schoonspruit Sub-system Analysis Study (**DWAF, 2006a**)

As shown in **Table 7-4** the lowest EWR site in the Vaal River considered as part of the Reserve Determination Study is EWR18 located at Schmidtsdrift. The stretch of river downstream of Douglas Weir up to the confluence with the Orange River is very short and significantly influenced by the operation of Douglas Weir. The weir is managed in such a way that Vaal River flows should not reach the Orange.

An EWR site (IFR 1) was identified downstream of Douglas Weir and a Rapid Reserve III assessment was undertaken in 2001 (**IWR Environmental, 2001**). No EcoClassification models existed at the time of the assessment. Ecological Categories derived during 2001 were based on available information. The approach followed was however not consistent or repeatable. During the WRCS study, available information was used to apply the full suite of the EcoClassification model. Adjustments were made during the review and the EcoClassification results of the Douglas Rapid Reserve were summarised in the EWR Quantification Report compiled for this study (**DWA, 2011c**). Based on the review of the 2001 EcoClassification results, the EIS was found to be HIGH for the instream component which implies that, if deemed important enough, flows at the site should be improved.

The Douglas EWR was not included in the analyses undertaken for the Comprehensive Reserve Determination Study (**DWA, 2010d**). Since the Orange River plays an important role as a refuge area for aquatic biota and the migration and movement of the biota between the Orange and Vaal River it was recommended that the impact of including the Douglas EWR be considered.

The natural runoff for the Douglas EWR site IFR1 was calculated based on the information included in the WRPM configuration and provided to the Ecological team to be used for the re-assessment of the EWRs at this site. The basic information relevant to the Douglas EWR site is summarised in **Table 7-6**. It is important to note that the natural hydrology calculated for IFR1 includes the impact of evaporation and bed losses which were determined as part of the VRSAU study.

Table 7-6: Information for Douglas EWR site

EWR site number	EWR site name	River	Quaternary Catchment	Total Gross Catchment Area (km^2)	NMAR [(#)] (million m^3/a)
IFR1	Douglas EWR	Vaal	C92C	194 479	3759

7.4 DESKTOP BIOPHYSICAL NODES

Since the desktop biophysical nodes are not explicitly modelled within the existing WRPM configuration used for this study, the proposed approach to deal with smaller catchment was to undertake qualitative evaluations only, focusing on Ecological as well as Goods and Services aspects. The opportunity to undertake a cursory quantitative evaluation of the water availability (and consequential implications) at small catchment scale based on land use data from the Validation and Verification study that is currently being undertaken in the three Vaal River WMAs was, however, identified subsequent to the Inception Phase of this study. To this end, the data collection and processing, as well as the alternative methodology developed for the assessment of the desktop biophysical nodes are described in **Section 11**.

8 ECOLOGICAL WATER REQUIREMENTS FOR KEY NODES

8.1 GENERAL

Ecological Water Requirements (EWRs) are defined as the flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components. The EWR data prepared by the technical teams as part of the Comprehensive Reserve Determination study comprised of the following for each of the 20 EWR sites identified within the study area:

- "**TAB" data**: A data file with a summary of total Ecological Water Requirements as % of natural MAR.
- **"RUL" data**: A data file containing the rule table with ER and natural flows for each month of the year for a range of percentage assurances. The assurance values are assumed to be equivalent to flow duration percentage points. Two sets of ER flows, including and excluding the high flow requirements respectively, are included in this file.
- **MRV data**: Monthly time series data generated by the Decision Support System (DSS) representing the Ecological Water Requirements.

Although the above-mentioned information was compiled for a number of Ecological Categories (EC), as defined in **Table 8-1** below, the ER scenario based on the Recommended Ecological Category (REC) was adopted for the WRPM scenario analyses of the Reserve Study. The RUL data compiled for the REC were subsequently used as input to the WRPM configuration.

Table 8-1: Generic ecological categories for EcoStatus components (Kleynhans et al., 2007)

Ecological Category	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Several arguments were raised for and against the inclusion of EWRs in the supporting sub-systems of the IVRS (i.e. the Komati, Usutu, Zaaihoek and Chelmsford sub-systems). The EWR sites identified in these sub-systems were finally excluded from the WRPM analyses of the Reserve study due to the lower confidence associated with their EWR results. These EWR sites were therefore not included in this study. Consequently this report does not include any information on these sites.

It is important to note that the TAB and RUL data could not be provided for EWR4 (downstream of Vaal Dam) and EWR5 (Vaal at Scandinavia). It was accepted that the natural flow regimes at these two sites have been highly modified and that improvement from an ER perspective (reduced flows during the winter months) is highly unlikely. The PD flows were, therefore, considered as the benchmark for flows at these two sites. The Desktop Reserve Model, however, does not make provision for EWR requirements that are set higher than the reference hydrology (either present or natural). For example, where the Present Day (PD) flows are used as the reference hydrology and the improved EWR requires more flows in the wet season and less in the dry season than PD, this cannot be accommodated. The so-called fish model was, therefore, used to generate Flow Duration Curves (FDCs) for these two sites that were based on low flows only. The Upper Vaal Technical Reserve Team recommended that these flows be used for comparison purposes and not be imposed on the system as demands.

8.2 QUANTIFICATION OF EWRS

The determination of EWRs at the various EWR sites is of cardinal importance as these results form the baseline for all further steps in the Classification process. The quantification of EWRs at the key biophysical nodes (EWR sites) was undertaken at a Comprehensive Reserve assessment level and the results were summarised from the detailed reports available for this study. The EWR results of all previous Reserve studies were checked to ensure that accurate data could be applied during step 4 of the WRCS. The detailed results of the EWRs at all the sites are provided in the Quantification of the EWR report (**DWA, 2011c**). The Upper Vaal WMA results are summarised in **Table 8-2**.

Table 8-2: Upper Vaal WMA: EWR scenario results

EWR site	nMAR[1]	PMAR[2]	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM[3]	MCM	MCM		MCM	% nMAR	MCM	% nMAR	MCM	% nMAR	MCM	% nMAR
EWR 2	457.70	267.12	58%	C PES, REC	30.21	6.6	5.03	1.1	32.04	7	58.13	12.7
				B AEC up	0.00	11.3	0.00	1.1	0.00	7.6	0.00	16.2
				C/D AEC down	14.19	3.1	5.03	1.1	28.38	6.2	43.48	9.5
EWR 3	858.10	603.09	70%	C PES, REC	90.96	10.6	7.72	0.9	31.75	3.7	125.28	14.6
				B AEC up	90.96	10.6	7.72	0.9	31.75	3.7	125.28	14.6
				C/D AEC down	38.61	4.5	7.72	0.9	27.46	3.2	75.51	8.8
EWR 6	95.30	84.53	89%	B/C PES, REC	17.54	18.4	17.54	18.4	7.72	8.1	22.30	23.4
				C AEC down	8.39	8.8	1.62	1.7	6.19	6.5	14.20	14.9
EWR 7	23.50	23.50	100%	B/C PES, REC	8.18	34.8	0.66	2.8	3.10	13.2	5.64	24
				C AEC down	4.61	19.6	0.66	2.8	1.20	5.1	6.06	25.8

EWR site	nMAR[1]	PMAR[2]	%PMAR of nMAR	EC	Maintenance low flows		Drought low flows		High flows		Long term mean	
	MCM[3]	MCM	MCM		MCM	% nMAR	MCM	% nMAR	MCM	% nMAR	MCM	% nMAR
EWR 8	474.30	425.39	90%	C PES, REC	24.19	5.1	5.69	1.2	31.30	6.6	54.54	11.5
				B/C AEC up	31.30	6.6	5.69	1.2	33.20	7	59.76	12.6
				D AEC down	14.70	3.1	5.69	1.2	27.04	5.7	46.01	9.7
EWR 9	31.30	29.47	94%	C PES	4.41	14.1	1.82	5.8	2.07	6.6	6.60	21.1
				B/C REC	8.48	27.1	1.82	5.8	2.28	7.3	9.83	31.4
EWR 1	288.80	332.72	115%	B/C PES, REC	103.10	35.7	5.20	1.8	28.01	9.7	116.96	40.5
EWR 10	86.98	134.84	155%	C/D PES, REC	26.18	30.1	14.87	17.1	3.74	4.3	35.75	41.1
				C AEC down	25.49	29.3	10.09	11.6	3.57	4.1	29.23	33.6
EWR 11	29.4	80.64	274%	D PES (DRM D)	3.65	12.4	2.70	9.2	1.68	5.7	7.61	25.9
				D REC (DRM C)	4.15	14.1	2.09	7.1	1.68	5.7	6.23	21.2
EWR 4	1977.3	1130.72	57%	C PES	The current status quo will maintain the PES.							
				B/C REC	Both these requirements are higher than the reference time series during certain parts of the year. Therefore neither the PMAR nor nMAR can be used to generate a time series and therefore volumes could not be calculated.							
				C/D AEC down								
EWR 5	2288	1364.54	60%	C/D PES	The current status quo will maintain the PES.							
				C REC	Both these requirements are higher than the reference time series during certain parts of the year. Therefore neither the PMAR nor nMAR can be used to generate a time series and therefore volumes could not be calculated.							

Notes: (1): nMAR = Natural Mean Annual Runoff

(2): PMAR = Present Day Mean Annual Runoff

(3): MCM = million m^3

As stated in the Quantification of the EWR report (**DWA, 2011c**) problems were identified with the Reserve Determination Study's approach adopted for the determination of the EWRs for the Middle (DWA, 2010d) and Lower (DWA, 2010e) Vaal WMAs. During the scenario phase and final decision making of the Comprehensive Reserve study, it was identified that the present flow regime and operation of the system should be signed off as the Reserve. The motivation for this decision was that the current flow regime (modelled as the present day scenario) will maintain the REC which is in all cases the same as the PES. Any problems with the determination of the EWRs are therefore immaterial as those results will not be signed off as the Reserve.

8.3 EWR STRUCTURES FOR WRPM

The WRPM includes a control mechanism developed to model the EWR in a water resource system. This procedure applies a user defined relationship between selected incremental inflows and specified releases to simulate the EWR. The information required for the EWR structure is a list of nodes with incremental inflow that serves as the reference according to which the ER releases are made. For each of the twelve months of the year, a data table is defined relating the EWR releases to the sum of the inflows of the reference nodes.

The following two sets of EWR data structures were determined for each of the EWR sites included in the WRPM configuration:

- **A High Flow (HF) EWR structure**: Based on the REC EWR maintenance low flows including freshets and specified floods; and

- **A Low Flow (LF) EWR structure**: Based on the REC EWR maintenance low flows only.

The most realistic EWR to be modelled at each site was selected in consultation with the technical Reserve teams of the Comprehensive Reserve Determination study. The technical Reserve teams evaluated the feasibility of including the high flow requirements at each of the EWR sites and made a recommendation accordingly. The strategy adopted for this evaluation was that high flows should only be included at an EWR site if it was situated not too far downstream of a dam from which the required peak releases could be made.

Consequently it was decided that the EWRs including High Flows will only be used for the following EWR sites:

- EWR2: Vaal River downstream of Grootdraai Dam;

- EWR9: Upper Suikerbosrant River downstream of the Balfour and Petrus Haarhoff dams;

- RE-EWR2: Mooi River downstream of Klerkskraal Dam;

- EWR16: Vaal River downstream of Bloemhof Dam; and

- EWR17: Harts River downstream of Spitskop Dam.

The REC EWR scenario finally adopted for the WRPM analysis of the Reserve study, therefore, comprised of a combination of high and low flows as shown in **Table G-1** of **Appendix G**. The corresponding EWR structures incorporated in the WRPM configuration for the modelling of the REC EWR scenario are also included in **Appendix G**. The EWR information available from the Reserve Determination study and summarised in **Appendix G** was subsequently used for this study.

8.4 EWR SCENARIO SELECTED FOR THE WRPM ANALYSIS

Recommendations based on the evaluation of the Ecoclassification results of the Reserve study, as documented in the Quantification of the EWR report (**DWA, 2011c**) of this study formed the basis for the definition of the EWR scenario to be used for the WRPM scenario analyses. Key findings are summarised below.

None of the EWR sites in the Middle and Lower Vaal as well as the Schoonspruit have a HIGH EIS, and the general recommendation is that the REC is set to maintain the PES. None of these EWR sites have a PES below a D EcoStatus and therefore the conclusion can be made that present flows with the current operation of the system will maintain the REC. Of the 18 EWR sites, 5 EWR sites located in the Upper Vaal River system and one EWR site (Douglas – IFR1) in the Lower Vaal have a HIGH Environmental Importance (EI). An overview of the current state is summarised in

Table 8-3.

Table 8-3: EWR Sites with High Environmental Importance

IUA	EWR node	PES	FLOW RELATED	NON FLOW RELATED	EIS	EI	REC
UV-A	EWR 1	B/C	Yes	Yes	HIGH	HIGH	B/C
UV-C1	EWR 7	A/B		Yes	HIGH	HIGH	A/B
UV-H	EWR 9	C	Yes	Yes	HIGH	HIGH	B/C
UV -M	EWR 4	C	Yes	Yes	HIGH	HIGH	B/C
UV- M	EWR 5	C/D	Yes	Yes	HIGH	HIGH	C
LV- B	IFR1	C/D	Yes	Yes	HIGH	HIGH	C

In terms of the EWRs, the Upper Vaal WMA results summarised in **Table 8-2** were recommended for use in this study. For the Middle and Lower Vaal EWR sites the review concluded that the present flow regime and operation of the system should be signed off as the Reserve as the present day flow regime will maintain the REC which is in all cases the same as the PES. In summary, the recommended EWRs for the sites determined in the Reserve Study provide a viable and practical Ecological Sustainable Base Condition Scenario (ESBC) against which relative changes can be evaluated.

The selected EWR scenario, therefore, comprises of the following combination of individual EWRs:

- The REC EWRs of the following Vaal River EWR sites were considered: RE-EWR1, EWR1, EWR2, EWR3, EWR6, EWR8, EWR9, EWR10, EWR11 as part of this study (EWR sites 4, 5 and 7 excluded);
- The EWRs for 8 additional EWR sites defined in the Waterval, Renoster, Schoonspruit and Harts, river catchments were included;
- The REC EWRs of the Thukela EWR site downstream of Driel Barrage were included; and
- The Senqu Sub-system EWRs were included.

9 WRPM CONFIGURATION CHANGES

9.1 GENERAL

Extensive refinements were made to the WRPM configuration as part of the Reserve Determination Study to enable modelling of flows at the selected EWR sites. These refinements were included in the WRPM configuration adopted for subsequent Annual Operating Analyses of the IVRS. The WRPM configuration resulting from the 2011/2012 AOA (**DWA, 2012**) was adopted as basis for this study.

The WRPM configuration was changed to run in historic mode with October as the starting month. This means that the WRPM analysis is based on the historic natural streamflow sequences (covering a period of 75 years) and a selected constant development level.

The WRPM configuration was set up to enable modelling of the following constant development levels:

- Present Day (2011) development conditions;
- Future (2020) development conditions; and
- Future (prior to 2020) development conditions representing a full utilization of available water from existing water resources.

The relevant operating rules, as well as the existing and planned future system components (e.g. new infrastructure such as pipelines and proposed augmentation schemes) representative of each of the above-mentioned development levels were implemented in the respective scenario analysis. The basic assumptions applied for the WRPM scenario analyses are summarised in **Section 10.4**.

The schematic diagrammes of the WRPM configuration adopted for the analysis are included in **Appendix C** and the configuration changes made as part of this study is described in Sections **9.2** to **9.5** below.

9.2 INITIAL ADJUSTMENT OF STERKFONTEIN RELEASE RULE

EWR site 8 is located on the Wilge River downstream of Sterkfontein Dam. The flow at this site is consequently influenced by the releases made from Sterkfontein Dam in support of the water supply from Vaal Dam. The WRPM scenario results of Comprehensive Reserve Determination Study (**DWA, 2010d**) as presented for EWR8 in the Wilge River catchment were found to be unacceptable in terms of the simulated monthly flow distributions. The Ecological Team recommended that changes to the operating rules be considered in view of improving the variability of flows at this site (e.g. more flow in summer and less in winter months).

The configuration of the Sterkfontein Sub-system and the Wilge River catchment is shown in **Figure C-1** of **Appendix C** and the components of the Upper Thukela Sub-system is shown in **Figure C-2**.

Since Sterkfontein Dam has a very small catchment contributing to runoff into the dam, the dam is kept at its Full Supply Level (FSL) by means of transfers from the Thukela. The long-term operating rule adopted for the

Thukela –Vaal transfer scheme is aimed at the optimal utilisation of the available water in the Upper Thukela without unnecessary pumping or wastage of water in the Vaal. This means that water is transferred from the Upper Thukela (Woodstock Dam and Driel Barrage) to the Vaal at maximum capacity of 20 m^3/s until Bloemhof Dam (the most downstream major storage dam in the Vaal River catchment) is full.

Original Sterkfontein release rule: Water is released from Sterkfontein Dam in support of Vaal Dam when Vaal Dam reaches a storage level of 1471.96m (with corresponding storage volume of 376.7 million m^3).

The objective with the adjustment of the above-mentioned rule was, therefore, to create additional storage capability within Sterkfontein Dam during the winter months by releasing extra water from the dam during the summer months. The mechanism used within the WRPM configuration to initiate these additional releases was to set monthly maximum operating levels within Sterkfontein Dam for the summer months that are below its FSL. The set of monthly maximum storage levels was determined by means of an iterative approach and the criteria used for assessing whether the adjusted rule meets the requirements of the Ecological Team were as follows:

- The monthly flow distribution at EWR8 should follow a natural seasonal pattern; and
- The dry season stress duration results (as determined for August) indicated that the biotic stress level should move from a stress of 1 to at least a stress of 5 which represents a discharge of 1.23 m^3/s. The simulated discharge at EWR8 associated with a 50% exceedance probability should, therefore, not be more than 1.23 m^3/s (i.e. 3.29 million m^3/month) in August.

The set of maximum operating levels as determined for Sterkfontein and used for the analyses of WRPM **Scenarios 1** to **7** (see **Section 10.5**) is presented in **Table 9-1** and shown graphically in **Figure 9-1**.

Table 9-1: Sterkfontein Dam operating levels used for Scenarios 1 to 7

Description	Reduced levels (m) for indicated months											
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Full Supply Level	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00
Maximum Operating Level	1702.00	1700.96	1699.93	1699.10	1697.85	1697.85	1697.85	1702.00	1702.00	1702.00	1702.00	1702.00
Dead Storage Level	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00

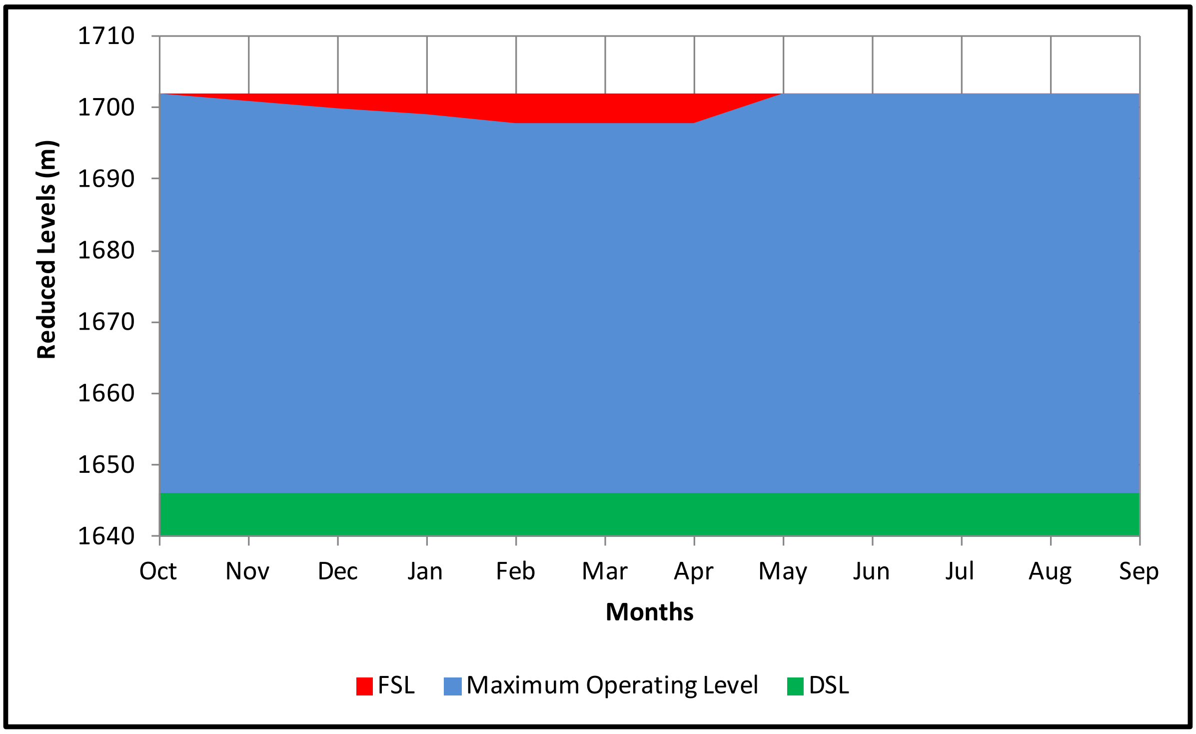

Figure 9-1: Sterkfontein operating levels used for Scenarios 1 to 7

The simulated monthly flow distribution at EWR8 based on the maximum operating levels for Sterkfontein Dam (as listed in **Table 9-1**) is shown in **Figure 9-2**.

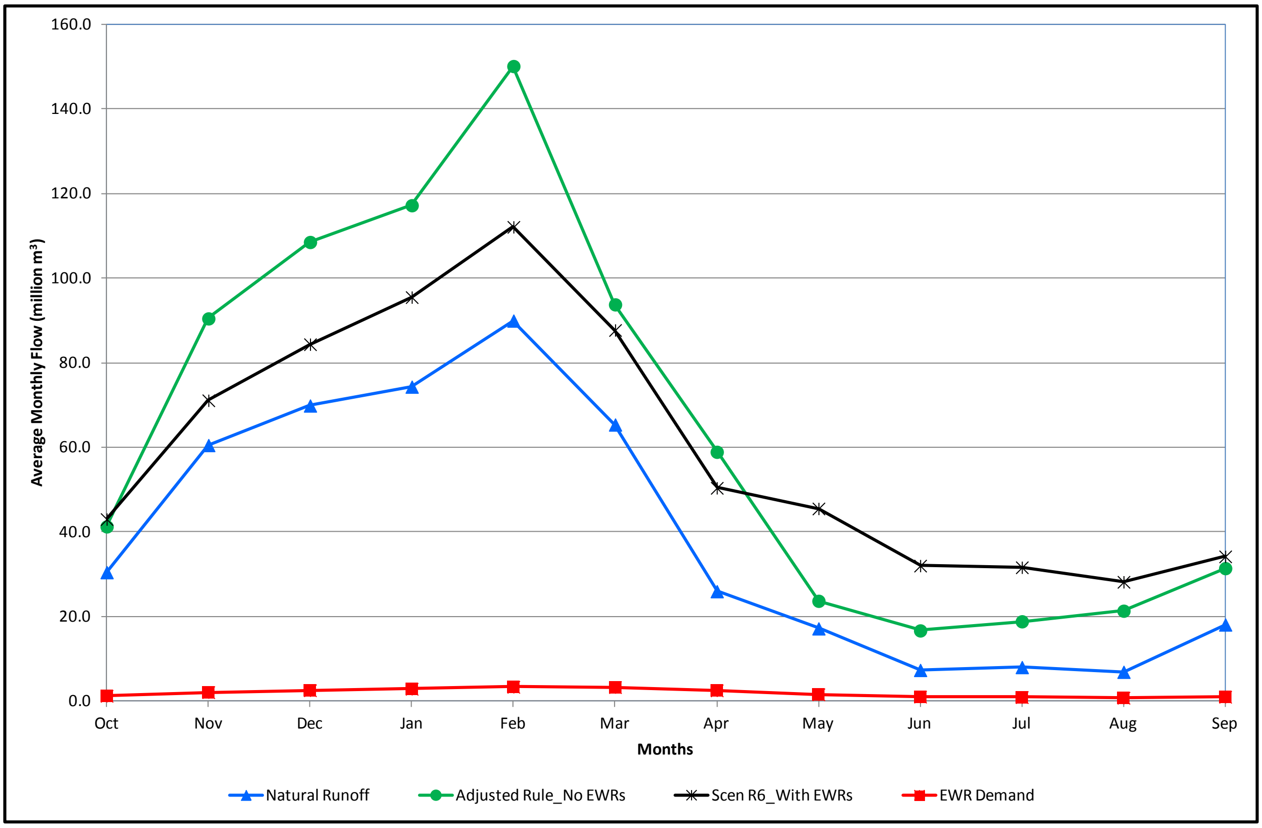

Figure 9-2: Monthly flow distribution pattern at EWR8

Figure 9-2 includes the monthly distributions of the natural flow record and the EWRs as well as that of one of the Reserve Study scenarios (Scen R6_With EWRs). The problem with elevated winter flows is evident from the Reserve Study scenario results (Scen R6_With EWRs) shown in **Figure 9-2**. The reduction in winter flows achieved by the adjusted Sterkfontein release rule caused an increase in flows during the summer months as illustrated in **Figure 9-2**. The corresponding flow duration curves for August are shown in **Figure 9-3**.

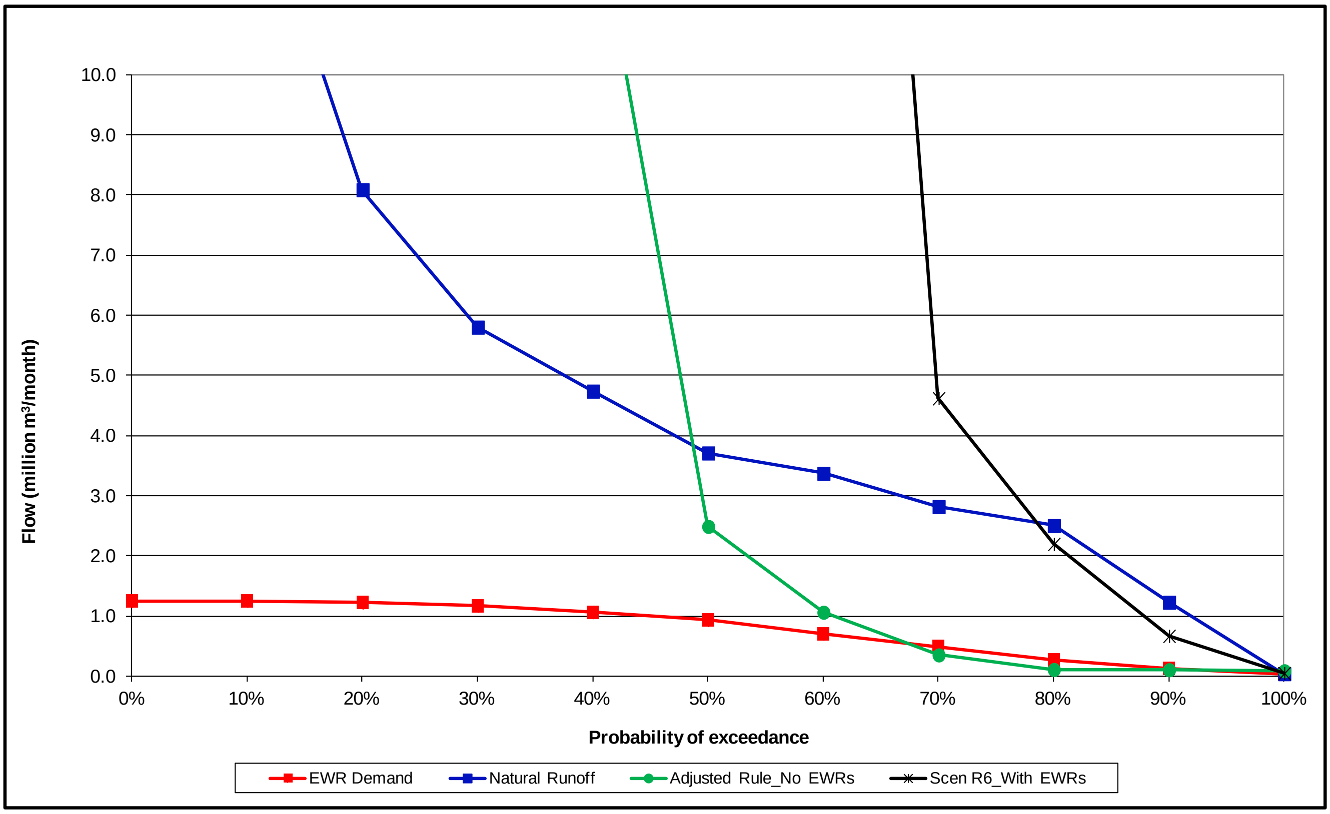

Figure 9-3: Flow duration curves for August (EWR8)

From **Figure 9-3** it is clear that the implementation of the adjusted Sterkfontein release rule has resulted in an acceptable 50% exceedance probability flow value for August of less than 3.29 million m^3 (refer to criteria set by Ecological Team). Similar comparisons were done for the remaining months with specific emphasis on the results for the winter months.

An important proviso for the implementation of the adjusted release rule is that it should not have a negative impact on the assurance of supply within the IVRS. To this end the effect of the adjusted Sterkfontein Dam release rule on the Historic Firm Yield (HFY) of the system as well as the projected assurance of supply or risk of restrictions was determined. Implementation of the adjusted release rule caused a reduction of about 5 million m^3/a (i.e. 0.6%) in the HFY which was within acceptable limits and through stochastic analysis it was confirmed that the assurance of supply to users was also not jeopardised. The adjusted release rule based on the maximum operating levels for Sterkfontein Dam as shown in **Table 9-1** was therefore adopted for the analyses of WRPM **Scenarios 1** to **7** (see **Section 10.5**).

9.3 OPTIMISED STERKFONTEIN RELEASE RULE

The initial Ecological Consequences assessment undertaken by the Ecological Team showed that, despite the implementation of the adjusted Sterkfontein release rule as presented in **Section 9.2**, the seasonal flow pattern at EWR8 in the Wilge catchment was still not acceptable.

In addition to setting maximum operating levels in Sterkfontein Dam, subsequent refinements of the release rule included the adjustment of minimum storage levels in Vaal Dam. The reasoning behind this was to maintain Vaal Dam at a higher minimum storage levels in the summer months so that less water will be required from Sterkfontein to keep Vaal Dam at its MOL during winter.

The evaluation criteria as specified in **Section 9.2** were again use for the refinement of the release rule. The optimised operating levels for Sterkfontein and Vaal Dams, derived through an iterative approach, are summarised in **Table 9-2**. The levels for Vaal Dam are also shown in **Figure 9-4** .

Table 9-2: Optimised operating levels for Sterkfontein and Vaal dams

Description	Reduced levels (m) for indicated months											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Sterkfontein Dam												
Full Supply Level	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00	1702.00
Maximum Operating Level	1702.00	1700.96	1699.93	1697.85	1695.78	1695.78	1695.78	1702.00	1702.00	1702.00	1702.00	1702.00
Dead Storage Level	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00	1646.00
Vaal Dam												
Full Supply Level	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56	1484.56
Maximum Operating Level	1471.96	1476.29	1476.29	1476.29	1476.29	1476.29	1476.29	1471.96	1471.96	1471.96	1471.96	1471.96
Dead Storage Level	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93	1462.93

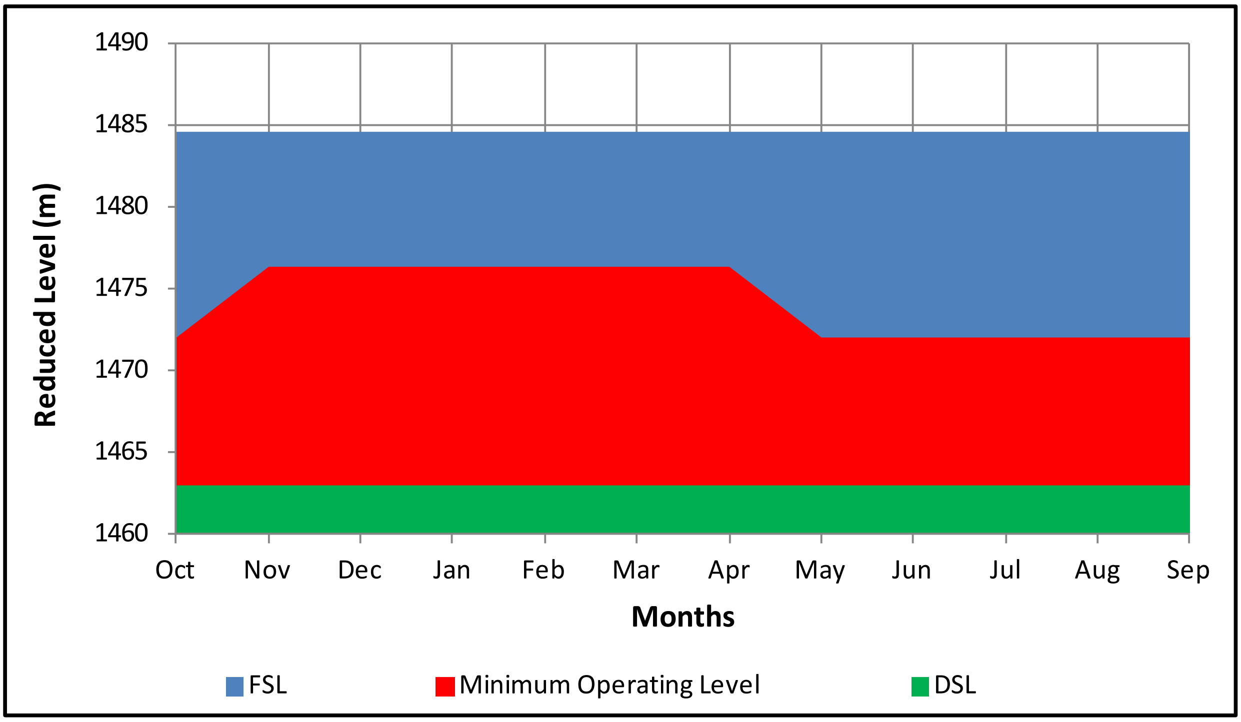

Figure 9-4: Optimised Vaal Dam operating levels

The simulated monthly flow distribution at EWR8 based on the optimised operating levels for Sterkfontein and Vaal dams (as listed in **Table 9-2**) is shown in **Figure 9-5**.

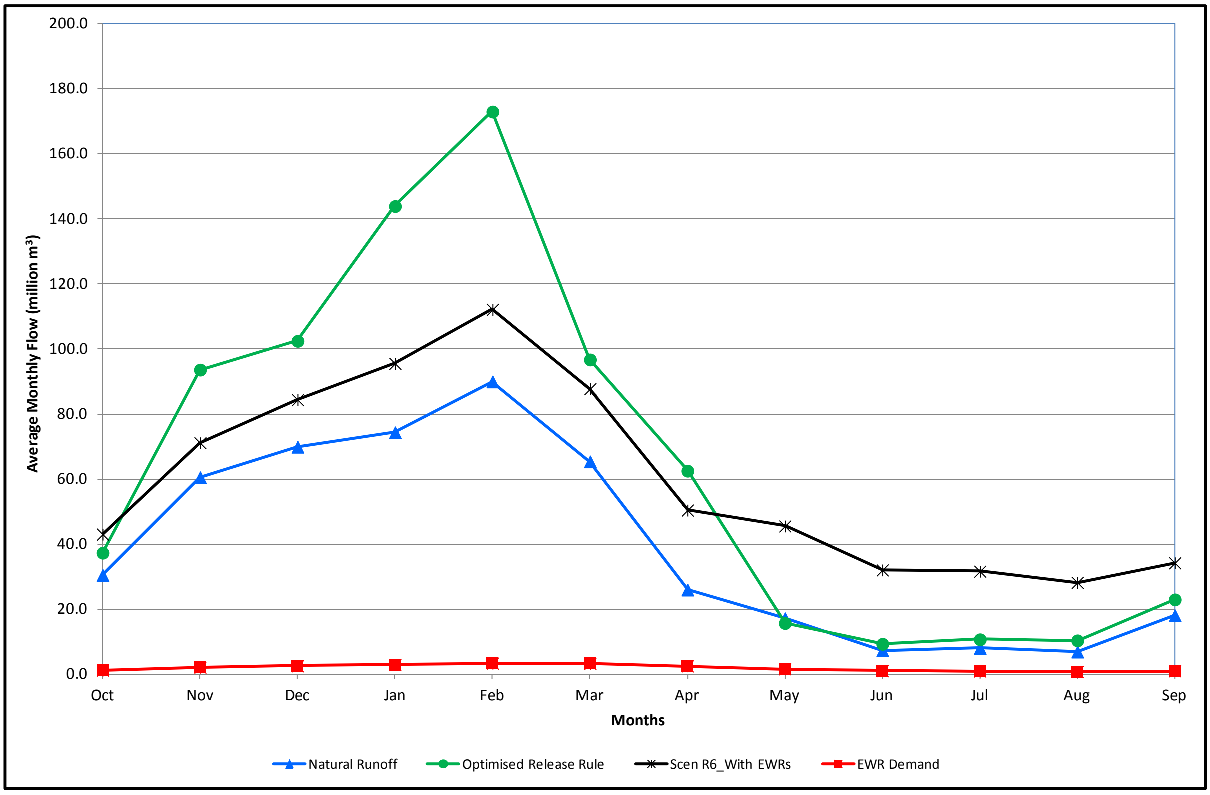

Figure 9-5: Monthly flow distribution at EWR8 for optimised release rule

From **Figure 9-5** it is evident that the optimised release rule resulted in winter flows that closely resemble the natural flow distribution, but as expected at the cost of the wetter months. The corresponding flow duration curves for August are shown in **Figure 9-6**.

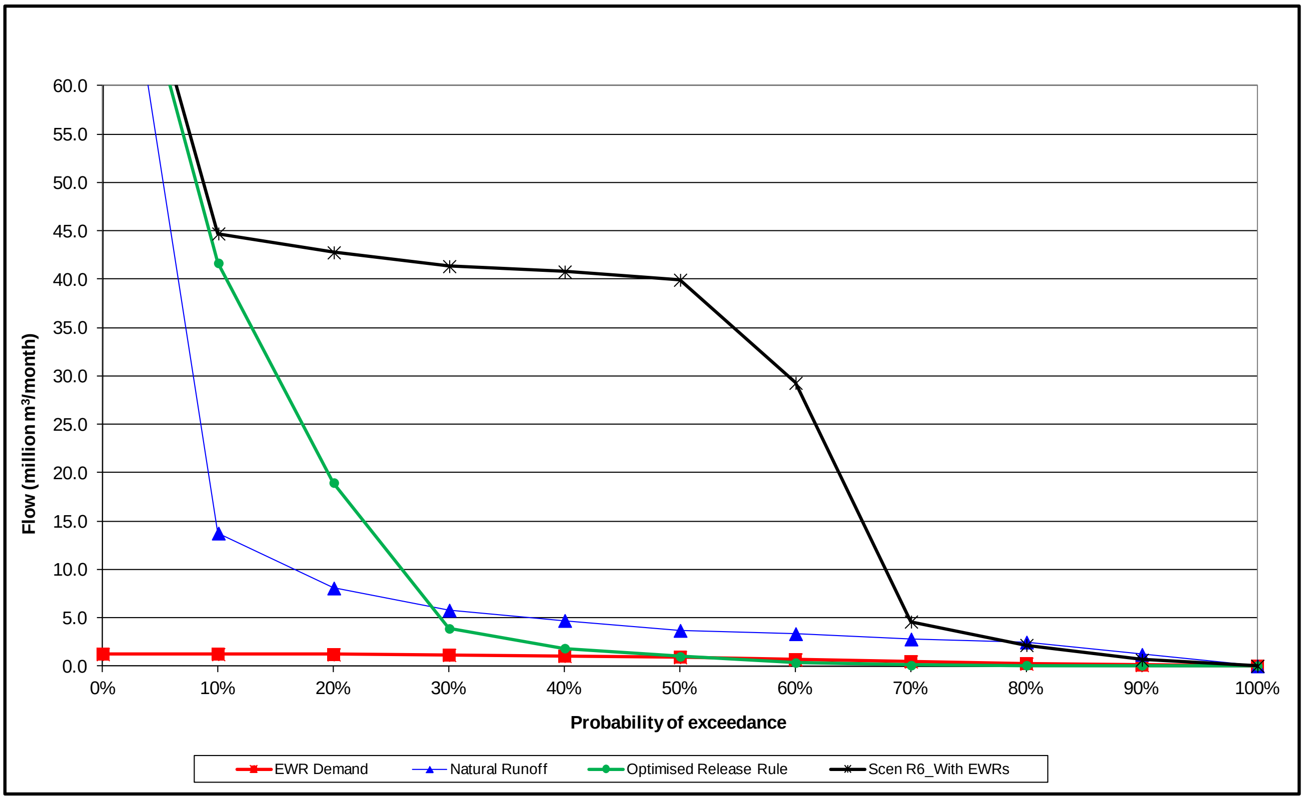

Figure 9-6: Flow duration curves at EWR8 for August based on optimised rule

Implementation of the optimised Sterkfontein Dam release rule caused a reduction of about 45 million m^3/a (5%) in the Historic Firm Yield (HFY). Results obtained from the stochastic analysis confirmed that the assurance of supply to users was not jeopardised. From both an ecological and water resources point of view it was thus decided that the optimised release rule, defined by the operating rules presented in **Table 9-2**, be adopted for the final WRPM scenario analyses (see **Section 10.5**).

9.4 RENOSTER RIVER CATCHMENT: MODELLING OF EWR R1

The two EWR sites identified as part of the Voorspoed Mine Study (**DWAF, 2005b**) were included in the WRPM configuration used for the Comprehensive Reserve Determination Study (**DWA, 2010d**). The location of the upstream EWR site R1 was, however, adjusted as part of this study and the EWR site was renamed as node MA.4. The original location of this site was immediately downstream of Koppies Dam. However, to allow for the flow contribution from the downstream incremental catchment EWR MA.4 was positioned immediately downstream of the confluence of the first tributary in quaternary catchment C70D as shown in **Figure B-2** of **Appendix B**.

Since quaternary catchment C70D was modelled as a single catchment unit it had to be split to represent the incremental catchments upstream and downstream of EWR MA.4 respectively. It was, therefore, necessary to make various assumptions in terms of the splitting of the hydrology as well as the scaling of farm dams and land use activities. The land use information obtained from the Validation and Verification studies undertaken by Schoeman and Vennote (**Schoeman, 2011**) and summarised for all the Desktop Biophysical Nodes (refer to **Section 11**) was used for this purpose.

The refinement of the Renoster River configuration for quaternary catchment C70D is shown in **Figure C-5** of **Appendix C**. The catchment of Desktop Biophysical Node MA.5 corresponds to the incremental catchment of C70D downstream of EWR MA.4. Information provided for node MA.5 was subsequently used for splitting the hydrology and catchment development components within quaternary catchment C70D. In correspondence to the VRSAU study information, it was assumed that 60% of the resulting two incremental catchments are commanded by the two newly defined dummy dams. The natural runoff and catchment area distributions are summarised in **Table 9-3**.

Table 9-3: Splitting of C70D runoff and catchment area

Incremental Catchment	% Split within incremental catchment	Runoff Node Number	NMAR (million m^3/a)	Salt Washoff Node Reference	Catchment Area (km^2)	% Split for C70D.INC
EWR MA.4	60	766	2.83	SW765	151.97	22.5
	0	768	0.00	SW767	0.00	0.0
	40	771	1.89	SW770	101.31	15.0
Sub-total:	**100**	**-**	**4.72**	**-**	**253.28**	**37.5**
MA.5	60	327	4.72	SW89	253.03	37.5
	0	339	0.00	SW90	0.00	0.0
	40	328	3.14	SW91	168.69	25.0
Sub-total:	**100**	**-**	**7.86**	**-**	**421.72**	**62.5**
Total (C70D):	**-**	**-**	**12.58**	**-**	**675.00**	**100.00**

The original C70D dummy dam and irrigation information included in the WRPM configuration as part of the Voorspoed Mine Study (**DWAF, 2005b**) was split by applying the calculated ratios resulting from the assessment of the Schoeman and Vennote information. The dummy dam results are presented in **Table** 9-4 and the irrigation data are summarised in **Table 9-5**. As indicated in **Table 9-5** the source of irrigation water supply was distinguished between farm dams (dummy dams) and run-of-river (mainstream).

Table 9-4: Dummy dam information for incremental catchments in C70D

Incremental Catchment	Dummy Dam Reference Number	Full Supply Volume (FSV) million m^3	Surface Area at FSV (km^2)
EWR MA.4	768	0.57	0.27
MA.5	339 (adjusted)	0.90	0.44
Total (C70D):	**339 (Original)**	**1.47**	**0.71**

Table 9-5: Irrigation data for C70D incremental catchments

Incremental Catchment	Source of Water Supply	Irrigation Module Reference	Irrigation Water Use (million m^3/a)	Irrigation Area (km^2)
EWR MA.4	Dummy Dam	RR769	0.61	0.59
	Mainstream	RR772	0.23	0.29
Sub-total:	**-**	**-**	**0.84**	**0.88**
MA.5	Dummy Dam	RR33	0.30	0.29
	Mainstream	RR34	0.12	0.14
Sub-total:	**-**	**-**	**0.42**	**0.44**
C70D	Dummy Dam	-	0.91	0.88
	Mainstream	-	0.35	0.43
Total (C70D):	**-**	**-**	**1.26**	**1.31**

With reference to the WRPM configuration shown in **Figure C-5** the flow simulated through channel number 2515 was considered to be representative of the flow at EWR site MA.4. The refined Renoster River catchment configuration was adopted for all the WRPM scenarios analysed as part of this study.

9.5 MODELLING OF DOUGLAS EWR

9.5.1 General

The Douglas EWR was not included in the analyses undertaken for the Comprehensive Reserve Determination Study (**DWA, 2010d**). Since the Orange River plays an important role as a refuge area for aquatic biota and the migration and movement of the biota between the Orange and Vaal River it was recommended that the impact of including the Douglas EWR be considered. Modelling of the Douglas EWR required that adjustments be made to the WRPM configuration as shown in **Figure C-6b** of **Appendix C** and discussed below.

Implementation of the Douglas EWR was expected to have a significant impact on the yield of the Vaal River System (VRS). WRPM scenario analyses representative of two different development levels (refer to **Section 10.5**) were carried out to determine the impact of implementing the Douglas EWR. Various assessments were therefore undertaken to ensure that the WRPM configuration of the Douglas Weir and its operation is representative of the current conditions. The following aspects were of specific importance:

- The realistic modelling of the operational losses downstream of Bloemhof Dam;
- To assess the need for as well as the extent of possible consumptive losses in the Lower Vaal; and
- To ensure that the simulated Orange-Vaal transfers are in line with the observed transfers and that simulated spills from Douglas Weir correspond to observed downstream flows.

9.5.2 Operational losses downstream of Bloemhof Dam

The existing WRPM configuration included operating losses in the order of 115.4 million m^3/a at De Hoop Weir. A uniform monthly distribution of 3.655 m^3/s was adopted for these losses. This information was obtained from the VRSAU study undertaken in the mid nineteen nineties. The observed flow data provided by the DWA for streamflow gauge C9H009 (Vaal River at De Hoop) were subsequently analysed to establish whether these operating losses still occur within the Lower Vaal system. The observed flow record at C9H009, covering the period October 1968 to July 2009, comprised of several months with missing and incomplete data. Since the raw data were used for the purposes of this first order assessment, it is important to note that months/years with missing values were merely excluded from the analysis. The minimum monthly flows determined over the period 2001 to 2008 are shown in **Error! Reference source not found.** and confirmed the validity of including operating losses within the WRPM configuration.

Furthermore, in view of the simulated outflow results at Douglas Weir, which showed unexpected base flows in the winter months, it was concluded that the use of a uniform monthly distribution pattern for the operating losses should be revised. To this end, years during which no spills occurred from Bloemhof Dam, were identified from the observed record at C9H009 and an average monthly flow distribution was calculated based on the selected flow data. The calculated monthly flow distribution pattern was subsequently applied to the total operating loss of 115.4 million m^3/a. The resulting monthly operating losses which were finally included in the WRPM configuration are summarised in **Table 9-6.**

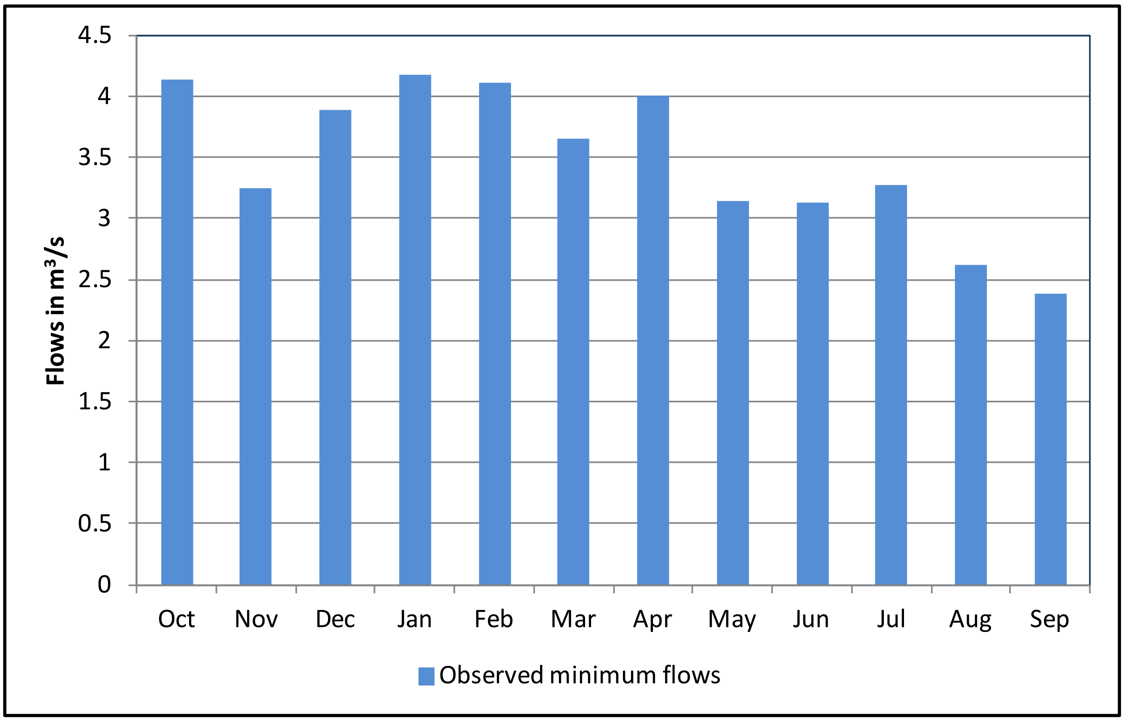

Figure 9-7: Observed minimum flows at De Hoop Weir (C9H009)

Table 9-6: Monthly distribution of operating losses at De Hoop Weir

Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
%	9.86	9.60	9.65	10.95	10.06	10.38	8.14	7.65	5.49	5.30	5.95	6.95
m^3/s	4.246	4.270	4.158	4.717	4.756	4.472	3.622	3.296	2.442	2.283	2.564	3.092

9.5.3 Consumptive losses in Lower Vaal

Initial assessment of the operation of Douglas Weir and the simulated transfers through the Orange-Vaal canal led to the investigation of potential consumptive losses between De Hoop and Douglas weirs. Based on the assumptions adopted for the WRPM analysis user groups abstracting water from the main stem of the Vaal River between De Hoop and Douglas weirs have access to the operating losses discussed in **Section 9.5.2** and the remainder of these losses are available as inflow to Douglas Weir. The simulated supply to the Douglas irrigation area via the Orange-Vaal canal was found to be significantly less than observed indicating that the simulated flow contribution from the Vaal might be over-estimated. The occurrence of consumptive losses was identified as a possible cause for this phenomenon and was therefore investigated.

Flow gauging in the Vaal River downstream of the Vaal-Harts confluence appears to be a problem. Gauging station C9H007 at St Claire was closed in 1977 due to the construction of Douglas Weir (C9R003). The current most downstream monitoring of streamflow in the Vaal River takes place at gauging station C9H024 located at Schmidtsdrift Weir. The observed record at C9H024 covers the period from February 1995 to August 2011. The period prior to the year 2001 is characterised by many missing monthly values rendering only the period after that suitable for evaluation purposes. Comparisons between concurrent flows recorded at De Hoop (C9H009) and Schmidtsdrift (C9H024) weirs were not conclusive in terms of the potential occurrence of consumptive losses in the Vaal River reach stretching between these two monitoring points. The minimum monthly flows observed at Schmidtsdrift over the period 2001 to 2010 are shown in **Error! Reference source not found.** and these results supported the assumption that there are no consumptive losses in this river reach.

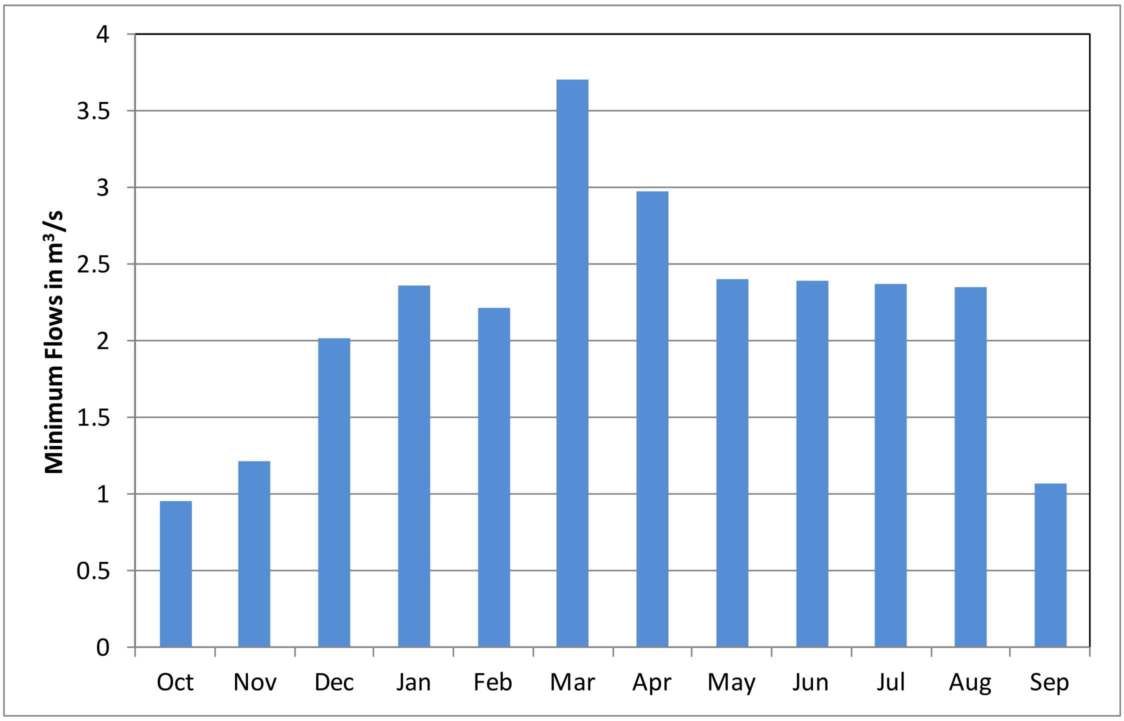

Figure 9-8: Minimum monthly flows observed at Schmidtsdrift Weir (C9H024)

9.5.4 Transfers through Orange-Vaal canal

The users relying on Douglas Weir for their water supply only have access to incremental runoff from the Vaal River catchment. The shortage of water experienced during the eighties drought coupled with the poor water quality of the Vaal River at Douglas prompted the construction of the Orange-Douglas Emergency Canal to bring water from the Orange River to Douglas Weir. The emergency canal has since been made a permanent structure and is used for augmenting the water supply to Douglas Town and the Douglas irrigation area by transferring relatively good quality water from the Orange River basin into Douglas Weir when needed.

The WRPM configuration of the Orange-Vaal canal and Douglas Weir is shown in **Figure C-6** of **Appendix C**. As shown in **Figure C-6** a portion of the water requirements of the Douglas irrigation area is abstracted directly from the Orange-Vaal canal and the remainder is supplied through abstractions from Douglas weir. Distribution losses through the canal system are estimated at 17.5%. Current (2011) irrigation abstractions from the canal are in the order of 26.8 million m^3/a whilst the irrigation water requirements to be supplied from Douglas Weir amount to 92.78 million m^3/a. Douglas Town's present day (2011) water use was assumed to be 2.56 million m^3/a.

The Orange-Vaal canal has a maximum transfer capacity of 8 m^3/s and total transfers through the canal are monitored at gauging station D3H019 at Nottingham. Although D3H019 was commissioned in 1987 information on actual transfers is only available from February 1992 onwards. The observed flow record at D3H019 was used for the evaluation of simulated transfers and relevant statistics calculated over the period 2002 to 2011 (assumed to be representative of current irrigation development level) are summarised in **Table 9-7**.

Table 9-7: Statistics for observed Orange-Vaal canal transfers

Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average Transfer (million m^3)	16.21	13.77	11.86	13.19	11.69	10.18	5.51	2.78	3.16	5.75	7.54	12.78	114.42
Minimum Transfer (million m^3)	13.18	6.88	3.76	7.22	6.85	7.48	2.95	1.76	2.26	3.43	4.82	8.02	68.60
Minimum Transfer Distribution (ratio)	0.19	0.10	0.05	0.11	0.10	0.11	0.04	0.03	0.03	0.05	0.07	0.12	1.00
Fixed Transfer (million m^3)	21.43	11.43	6.25	11.99	11.38	12.42	4.90	2.92	3.76	5.71	8.01	13.34	113.53
Fixed Transfer (m^3/s)	8.000	4.409	2.335	4.477	4.663	4.638	1.889	1.092	1.451	2.130	2.990	5.145	-

As shown in **Table 9-7** observed average transfers were in the order of 114 million m^3/a with minimum transfers totalling 68.6 million m^3/a. Based on these results simulated transfers through the Orange-Vaal canal were found to be unrealistically low and the need for reassessment of the existing WRPM configuration was identified.

The simulated spills from Douglas Weir were also evaluated in view of simulating a representative Present Day (2011) flow at the Douglas EWR site. It was found that reasonable base flows were simulated in the winter months with zero flows prevailing in the month of September. Zero flows were also simulated for the wetter summer months. This was in contradiction with information provided by the DWA Regional Office staff who indicated that non-zero flows are observed for about 70% of the time downstream of the weir.

Since the occurrence of consumptive losses in the Vaal River upstream of Douglas Weir could not be confirmed (refer to **Section 9.5.3**) it was concluded that unaccounted for losses most probably occur within the operation of Douglas Weir itself. The dam balance for Douglas Weir (C9R003) was obtained from the DWA and analysed in an attempt to quantify the extent of these losses and to get some information on observed spills. The dam balance record covered the period 1998 to 2010 and assessment of the minimum monthly outflows that occurred over this period showed non-zero flows for all the months except for October. Evaluation of the inflow to Douglas revealed that there was not a good correlation between the observed flows at Schmidtsdrift and the calculated inflow to Douglas Weir as provided in the dam balance record. Since the relatively short dam balance record is characterised by several missing and incomplete values and the reliability of the data was not confirmed as part of this study, it was decided to make the most appropriate assumptions regarding the operation of Douglas Weir that would result in the realistic simulation of the Douglas Weir and its components.

Through several iterations and after collaboration with the consultant responsible for the Orange River Annual Operating Analysis (AOA) the following assumptions were made relative to the Orange-Vaal transfers and the operation of Douglas Weir:

- A fixed transfer of 114 million m^3/a from Orange River was adopted for the Orange-Vaal canal;
- The minimum monthly transfer pattern shown in **Table 9-7** was used for the distribution of the 114 million m^3/a. The limitation of the maximum transfer capacity of 8 m^3/s was applied to the calculated monthly flow rates. The resulting monthly volumes and flow rates used for the modelling of the Orange-Vaal transfers are also provided in **Table 9-7.**
- Consumptive losses to the amount of 40 million m^3/a were assumed to take place at Douglas Weir. The Douglas irrigation water requirement pattern was used for the distribution of the 40 million m^3/a into monthly values. These losses are summarised in **Table 9-8**.

Table 9-8: Consumptive losses at Douglas Weir

Description	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Irrigation Distribution (ratio)	0.118	0.080	0.102	0.158	0.154	0.127	0.055	0.036	0.018	0.030	0.017	0.106	1.000
Losses (million m^3)	4.70	3.20	4.10	6.32	6.15	5.08	2.21	1.42	0.71	1.19	0.69	4.22	40.00
Losses (m^3/s)	1.755	1.233	1.529	2.360	2.520	1.896	0.854	0.532	0.275	0.446	0.257	1.630	1.268

It is important to note that the above-mentioned assumptions were only used for the analysis of specific WRPM scenarios (as indicated in **Section 10.5** and **Table 10-2**) which included the modelling of the Douglas EWR.

10 WRPM SCENARIO ANALYSIS

10.1 BACKGROUND

Scenarios in the context of water resource management and planning are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Each scenario represents either the Present Day or an alternative future condition, generally reflecting a change to the present condition, and the analysis thereof gives the ability to compare the implications of one scenario against another with the ultimate aim to make a selection of the preferred scenario. In the context of this study the overarching objectives of scenario formulation and analysis are to provide information to decide which of the three Management Classes (MCs) should be selected for each Integrated Unit of Analysis (IUA). At the detail river reach and biophysical nodes level (within an IUA) the options are wider where one of four (A, B, C or D) possible Ecological Categories (EC) needs to be selected for each scenario (refer to **Table 8-1** for definition of EC). Allowing complete "freedom of choice" in the selection of the EC and adding that there are also resource developments and system operating rule changes to be considered, will result in a very large number of scenarios that are impractical to analyse within the constraints of the study timeframe and funding. The approach was therefore to define scenarios by considering the current framework of Integrated Water Resource Management (IWRM) as the point of departure.

Currently the system wide IWRM activities being implemented are those defined in the Vaal River Reconciliation Strategy which consist of the following:

- Eradicate unlawful irrigation water use by the year 2013;
- Continue with the implementation of Water Conservation and Water Demand Management (WC/WDM) to achieve the target savings by the year 2015;
- Implement Phase 2 of LHWP to deliver water by the year 2020; and
- Implementation of the Integrated Water Quality Management Plan and commissioning of a Feasibility Study to recommend the most suitable long term solution to the Acid Mine Drainage (AMD) problem.

A further important characteristic of the Vaal River System (VRS) is the continuous growth in the water needs of the urban areas particularly in Gauteng. This is captured in planning scenarios of future water requirements abstracted from the system and return flows which are discharged back into the rivers as treated sewage effluent.

In addition to the above interventions there are also detailed system operating rules according to which releases and transfers are made between river basins and/or reservoirs (as discussed in **Section** 2). These rules influence the flow regime of various rivers which serve as conveyance conduits to distribute and augment the resource.

Due to the fact that the VRS is a highly utilised system, few areas of high Environmental Importance occur. In general therefore, the setting of the ecological management objectives, defined by the Recommended Ecological Category (REC) for each node, was to maintain the Present Ecological State (PES) where PES is not in a “E” EC.

At nodes where the Environmental Importance is High, improvements were recommended considering the attainability thereof as well as the restoration potential of the environment. Most of the improvements were non-flow related and are unlikely to influence the water balance in such a way that the current upstream water use will be affected.

All of the above-mentioned features result in an extremely complicated set of challenges to be dealt with in the Vaal Catchment. The scope for considering a varied set of scenarios to deal with in the classification system and the possibilities of trade-offs are limited. Since the findings of the WRPM scenarios considered as part the Comprehensive Reserve Determination Study (**DWA, 2010d**) formed the basis for the selection of scenarios to be analysed during this study summarised information on the Reserve Determination study scenarios is provided in **Section 10.2** and considerations for further analysis is described in **Section 10.3**.

10.2 SUMMARY OF RESERVE STUDY SCENARIOS AND RESULTS

Eight WRPM scenarios were analysed as part of the Comprehensive Reserve Determination Study (**DWA, 2010d**). To assist with the interpretation of the Reserve Determination study results and for comparison purposes with this study, the Reserve Determination study scenarios of relevance are summarised in **Table 10-1**.

Table 10-1: Summary of WRP scenarios analysed for Reserve study

Scenario No.	Development Level	EWR Status	Comments
R1	2008	Excluded	• Base scenario representing the status quo.
R4	2008	Included	• Based on Scenario R1. • **Selected EWR Scenario**: With exception of EWR4, EWR5 and EWR7, all EWRs in Vaal, one EWR in Thukela downstream of Driel Barrage and all Senqu EWRs were included.
R5	2020	Excluded	• Base scenario representing the future 2020 development conditions excluding the EWRs. • Includes VRESAP pipeline from Vaal Dam to Eastern Sub-system. • Includes proposed Polihali Dam and conveyance infrastructure. • Includes proposed re-use of mine water. • Includes projected possible transfer to the Crocodile catchment.

Scenario No.	Development Level	EWR Status	Comments
R6	2020	Included	• Based on Scenario 5. • **Selected EWR Scenario:** With exception of EWR4, EWR5 and EWR7, all EWRs in Vaal, one EWR in Thukela downstream of Driel Barrage and all Senqu EWRs were included.
R7	Full utilization (Future development scenario)	Excluded	• Scenario representing the full utilization of available water. • Based on current infrastructure. • Includes VRESAP pipeline from Vaal Dam to Eastern Sub-system. • **Polihali Dam excluded**
R8	Full utilization (Future development scenario)	Included	• Based on Scenario 7. • **Selected EWR Scenario:** With exception of EWR4, EWR5 and EWR7, all EWRs in Vaal, one EWR in Thukela downstream of Driel Barrage and all Senqu EWRs were included.

The scenario analysis results from the Reserve Determination Study identified the following aspects that need to be considered in the scenario formulation for the Classification Study:

- There is a need for improved seasonal flow variability in the Wilge River by implementing alternative release rules to convey water from the Sterkfontein Dam to the Vaal Dam. In particular the flow in the winter months should be reduced to more closely resemble the natural seasonal flow pattern (refer to adjustments made in terms of the Sterkfontein release rule as described in **Sections 9.2** and **9.3**).

- Resolve the apparent flow balance anomaly between the Ecological Water Requirements (EWR) for the two sites downstream of Grootdraai Dam and confirm the appropriate release rule from the dam. The objective is to prevent additional releases from the Grootdraai Dam resulting in additional pumping through the VRESAP pipeline while achieving the Recommended Ecological Category (REC) at both EWR sites.

- The EWR site downstream of the Balfour Dam on the Blesbokspruit requires flow releases from the dam to achieve the REC. The simulation analysis showed that the water is available however it could not be established if the river release capacity of the Balfour Dam is such that the required releases can be made.

- The scenario results indicated that the release rules applied from some of the dams in the tributary catchments of the Middle Vaal WMA resulted in significant negative socio-economic implications on the users receiving water from those tributaries. These analyses were based on simplified release rules from the dams that were determined through extrapolation and flow apportionment methods. The release requirements from these dams (if any) need to be revised and the implication thereof on the flow in the main stem of the Vaal River must also be assessed in the scenario analysis.

- The evaluation of the EWR for the sites in the Middle and Lower Vaal WMAs confirmed that by maintaining the present day flow the Present Ecological State (PES) will be maintained.

- The year 2020 development scenario showed that unacceptable ecological consequences occur due to increased discharges from waste water treatment works in the Suikerbosrand and Blesbokspruit (both rivers are located in the incremental catchments of the Vaal Barrage).

10.3 CONSIDERATIONS RELATED TO EWR SITES

The following aspects were identified for consideration when defining the WRPM scenarios to be analysed in this study.

Mooi River System: The Reserve Determination Study analysed flow release rules from the Klipdrift and Boskop dams that were determined through hydrological proportioning methods. The river downstream of the dams has been significantly altered in terms of structure and functioning and there are severe water quality issues. Flow scenarios or any changes of flow will not address these problems. Sections of the Mooi River, such as the EWR site and possibly the lower Mooi River at the confluence, still function at a D PES. Maintaining the present day flow will maintain the PES (and REC) and no release rule need to be implemented from these dams. For sections that are likely to be in a worse condition, altering release rules will not address the problem.

Schoonspruit River System: An Intermediate Reserve Determination study was carried out for the Schoonspruit Catchment in 2006 and it is proposed that the consequences on the users receiving water from the system be determined for the case where these EWRs are implemented. A portion of the water resource of this catchment originates from the Schoonspruit Eye which implies that groundwater abstractions from the dolomitic compartment also influence the water availability of this System. It was proposed that scenarios of water availability be analysed and that if any reductions in abstractions are needed both the groundwater and surface abstractions be reduced. The dolomitic compartment simulations could be carried out with a groundwater-surface water interaction model that was calibrated as part of the 2006 study. It should be noted that since only low confidence EWR determinations were carried out, the evaluation of the ecological consequences for the scenarios will only be possible in broad terms.

Alternative flow regime in the Wilge River: It was thought possible to change the release rule of Sterkfontein Dam to improve the seasonal variability without impacting on the long term system yield. Alternative rules were derived given specific dry month low flow maxima. The implication on the system yield, as well as the level of achieving the ecological objectives, was evaluated.

Water Quality Management: Evaluate the ecological consequences blending and desalination management options, relating to the high salinity content of the water in the Vaal Barrage and its tributaries, will have on the affected EWR sites. Currently the salinity in the Vaal Barrage is maintained at 600 mg/l by releasing low salinity water from the Vaal Dam for dilution in the Vaal Barrage.

Future development level scenario: It was proposed that the evaluation of scenarios be undertaken for the year 2020 development level based on the target reconciliation scenario where the unlawful irrigation is removed, the Water Conservation and Water Demand Management saving target is achieved and Phase II of the LHWP is implemented.

10.4 BASIC ASSUMPTIONS FOR WRPM SCENARIOS

The base condition assumptions adopted for the WRPM scenario analyses carried out as part of this study are summarised below. Specific references are made for assumptions relating to the Present Day (2011) and Future (2020) development level conditions where applicable.

- Historic streamflow sequences with 75 years of record were used;
- With reference to the starting conditions, all major dams were assumed to be full at the start of the analysis (a median starting storage was however adopted for the proposed Polihali Dam as part of the future 2020 development scenario);
- **Thukela-Vaal transfer**: The long-term operating rule was adopted for this inter-basin transfer, i.e. full pumping from the Thukela (Woodstock Dam and Driel Barrage) to the Vaal at 20 m^3/s over the entire analysis period until Bloemhof Dam reaches its FSL.
- **Heyshope-Zaaihoek-Grootdraai transfer**: The 90% rule was adopted for transfers from Heyshope and Zaaihoek to Grootdraai Dam, i.e. transfers from these two dams are made when Grootdraai Dam is below 90% of its Full Supply Storage (90% storage level of 1547.95m with associated storage volume of 314.57 million m^3).
- **Transfer from Westoe to Jericho**: Transfers are regulated by the Usutu inter-reservoir operating rule as revised in 2006 (refer to **Figure 2-1**) with a maximum transfer capacity of 1.62 m^3/s.
- **Morgenstond-Jericho transfer**: Transfers are regulated by the Usutu inter-reservoir operating rule as revised in 2006 (refer to **Figure 2-1**) with a maximum transfer capacity of 3.182 m^3/s.
- **Heyshope-Morgenstond transfer**:
  - **Present Day Development**: Transfer when storage in Morgenstond Dam is below 80 million m^3 (1381.34m).
  - **Future (2020) Development**: Transfer when storage in Morgenstond is below 90 million m^3 (1382.63m).
- **Heyshope buffer storage**:
  - **Present Day Development**: Reserve storage below 150 million m^3 (1294.54m) for transfer to Usutu.

- **Future (2020) Development**: Reserve storage below 58 million m^3 (1289.63m) for transfer to Usutu.

- **Grootdaai Dam buffer storage (long-term VRESAP supply rule)**: Reserve storage below 90% (level of 1547.95m) by pumping at maximum capacity through the VRESAP pipeline if storage in Grootdraai Dam is below this level.

- **Dilution rule**: Rand Water is supplied directly from Vaal Dam and releases are made from Vaal Dam to limit the TDS concentration to 600 mg/l downstream of Vaal Barrage (Based on the water quality constraint as included in the WRPM model configuration).

- **LHWP scheduled transfers**:

  - **Present Day Development:** The monthly scheduled transfers (totalling 780 million m^3/a) that was obtained from the LHDA in 2007 was adopted as the transfers to be made for the LHWP Phase 1 development.

  - **Future (2020) Development**: A constant transfer of 1037 million m^3/a associated with the Lesotho Highlands Future Phases (LHFP) development, which includes the proposed Polihali Dam and its conveyance infrastructure, was used for the simulation of this future development level.

- The following assumptions were made with respect to compensation releases from major dams:

  - Vygeboom Dam: Release 0.65 m^3/s during the full period of analysis.

  - Nooitgedacht Dam: Release 0.15 m^3/s for full period.

  - Westoe, Jericho and Morgenstond dams: Releases of 0.037 m^3/s, 0.015 m^3/s and 0.038 m^3/s respectively.

  - Grootdraai Dam: Releases based on normal flow (20 million m^3/a).

  - Zaaihoek Dam: Releases based on normal flow (11.4 million m^3/a).

  - Senqu Sub-system: Releases from Katse and Mohale dams modelled by means of the IFR structure based on the Ecological Reserve requirements accepted by the LHDA.

- **Trichardtsfontein Dam MOL**: A MOL of 1630.3m with associated storage of 7.5 million m^3 was adopted.

- **Vaalharts Weir**: Operate at 90% storage level (level of 1189.67m).

- **Bloemhof Dam**: Minimum operating level at 6% (Level of 1219.32m with corresponding storage of 74.55 million m^3).
- **VRESAP pipeline implemented with the following details**:
  - o Permanent abstraction works: Assumed to be fully implemented.
  - o Maximum Transfer Capacity: A maximum transfer of 5.07 m^3/s (160 million m^3/a) was used.
- **VRESAP 3rd Party Users**: Allowance was made for the supply of 2.692 million m^3/a from the VRESAP pipeline to meet the existing allocation of Greylingstad and the indicated water requirements of Burn Stone Mine. The water use of these users was assumed to increase over the next four years to reach the full allocated amount of 9 million m^3/a in 2014. The full allocation of 9 million m^3/a was used for the future (2020) development conditions.
- **Komati Sub-system conveyance infrastructure**: Eskom indicated that the supply capability of the existing conveyance infrastructure will be increased by means of the following interim and long-term augmentation options:
  - o **Soda Ash treatment plant**: A soda ash treatment plant with a maximum capability of 0.75 m^3/s was implemented at Duvha for the treatment of water abstracted from Witbank Dam. The soda ash plant will be operational until the commissioning of the new Rietfontein-Duvha pipeline on 1 September 2012. For the purposes of the Present Day (2011) development conditions it was assumed that the soda ash treatment plant was operational.
  - o **Proposed Rietfontein-Duvha pipeline**: The maximum transfer capacity of the proposed pipeline transferring water from Rietfontein Weir to Duvha Power Station was assumed to be 1m^3/s (31.56 million m^3/a). Eskom indicated that the anticipated implementation date of the proposed pipeline was 1 September 2012. The Rietfontein-Duvha pipeline was considered to be operational for the Future Development (2020) conditions.
- **Proposed Rietfontein-Matla (Kusile) pipeline**: The proposed pipeline will be from Rietfontein to Matla. Matla will then supply to Kusile PS. An average transfer capacity of 0.45m^3/s and a completion date of 1 September 2012 were adopted for analysis. The PD (2011) configuration of the WRPM excluded this pipeline whereas it was included in the modelling of the Future Development (2020) conditions.
- **Modelling of the Senqu Sub-system**: The revised short term yield reliability curves based on the Mohale-Katse transfer tunnel operating rule and Ecological Reserve water requirements adopted by the LHDA were incorporated in the WRPM configuration (new functionalities incorporated in the WRPM).
- **Operating rules for small dams/sub-systems**: The proposed operating rules derived as part of the 2007/2008 and 2009/2010 AOA were implemented for the individual sub-systems that were modelled as follows:

- o **Small dam sub-systems**: Allemanskraal, Erfenis, Koppies and Klipdrift dams were operated as individual sub-systems.
- o **Mooi River Sub-system**: Klerkskraal, Boskop and Lakeside dams were modelled as a single sub-system.

In terms of the WRPM scenario analyses described in **Section 10.5** the following basic assumptions were adopted for the scenarios including the EWRs:

- The EWRs were given priority over all other demands;
- Dummy dams (combination of small dams) were assumed not to contribute towards supplying the EWRs; and
- Principles of "equality" and "minimum proportional flow in a river reach" were applied. This means that each tributary or river reach within the water resource system should contribute its fair share towards supplying the ER and this contribution should remain in the downstream river reaches (i.e. downstream water users should not be allowed access to these EWR releases).

10.5 DESCRIPTION OF WRPM OPERATIONAL SCENARIOS

The scenarios selected for analysis with the WRPM are summarised in **Table 10-2**. It is important to note that the basic assumptions described in **Section 10.4** were adopted for all the scenarios and only additional assumptions relevant to a specific scenario are highlighted in **Table 10-2**.

Scenarios for analysis with the WRPM were defined at various stages throughout the study. Seven scenarios were initially defined and analysed with the WRPM. The results were presented to the Ecological team for evaluation of the ecological consequences. Although the resulting monthly flow distribution at the Wilge River EWR site (EWR8) based on the adjusted Sterkfontein release rule as described in **Section 9.2**, was found to be an improvement relative to the Reserve Determination Study results, it was recommended that further refinements of the release rule be investigated. The Sterkfontein release rule was subsequently optimised as part of the **Scenario 8** analysis. Detailed information on the assessment of the rule is provided in **Section 9.3**. Inclusion of the Douglas EWR site resulted in the assessment of **Scenarios 9a** and **9b**.

Table 10-2: Summary of WRPM scenarios analysed

WRPM Scenario Reference	Reserve Study Scenario Reference	Difference between this study and Reserve Study	Develop-ment Level	Status of Ecological Reserve	Scenario Description
Sc 1	Sc R1	• Development levels as for 2011 (previously 2008). • VRESAP pipeline included. • Thukela-Vaal transfer: Based on long-term operating rule (i.e. transfer at maximum capacity of 20 m^3/s to fill Sterkfontein, Vaal and Bloemhof dams).	Present Day (2011)	Excluded	• Base scenario representing the status quo. • Sterkfontein release rule adjusted to improve seasonal distribution of flows at EWR8 (refer to **Section 9.2**). • Upper Vaal WMA irrigation water use includes unlawful use (see **Section 6.4**). • Mine dewatering: No desalination with discharges made to relevant river systems.
Sc 2	Sc R4	• New Renoster River and Upper Harts (H1) EWRs. • Middle and Lower Vaal EWRs, with exception of Schoonspruit and Upper Harts (H1), excluded.	Present Day (2011)	Included	• Based on **Scenario 1**. • Selected EWR Scenario included (see **Section 8.4** for details).
Sc 3	Sc R5	• Definition of what future 2020 consists of differs from Reserve study (updated water requirements for major water users, revised mine water decant and no transfer to the Crocodile). • Similar to the equivalent Reserve Study scenario, this scenario includes the LHWP Future Phase development (i.e. includes Polihali Dam and associated conveyance infrastructure).	Future (2020)	Excluded	• Base scenario representing the future 2020 development conditions. • Includes proposed Polihali Dam and its conveyance infrastructure. • Irrigation water requirements in Upper Vaal WMA based on Existing Lawful Use plus 15% of Unlawful Use. • Includes desalination of mine water and proposed re-use thereof.
Sc 4	Sc R6	Differences are similar to that of Sc 3.	Future (2020)	Included	• Based on **Scenario 3**. • Selected EWR Scenario

WRPM Scenario Reference	Reserve Study Scenario Reference	Difference between this study and Reserve Study	Develop-ment Level	Status of Ecological Reserve	Scenario Description
					included (see **Section 8.4** for details).
Sc 5	Sc 7	• Same as for Sc 1a (i.e. current infrastructure as for 2011), but includes updated future water use representing full utilisation of available water. • Excludes the Lesotho Highlands Future Phase development meaning this scenario is relevant to a development level prior to that of Sc 3 (i.e. between 2011 and 2020 development).	Future (full utilisation)	Excluded	• Scenario representing the full utilization of available water. • Based on current infrastructure which includes VRESAP pipeline from Vaal Dam to Eastern Sub-system. • Mine dewatering: No desalination and discharges made to relevant river systems.
Sc 6	Sc 8	Differences are similar to that of Sc 5a.	Future (full utilisation)	Included	• Based on **Scenario 5**. • Selected EWR Scenario included (see **Section 8.4** for details).
Sc 7	-	-	Present Day (2011)	Included	• Based on **Scenario 2**. • Alternative to EWR releases from Grootdraai Dam: The Grootdraai compensation rule was included and EWRs at EWR2 and EWR3 were excluded.
Sc 8	-	-	Present Day (2011)	Included	• Based on **Scenario 1**. • Optimisation of Sterkfontein release rule: Optimization scenario developed specifically for EWR8, aimed at improving the shape of the flow duration curve in the dry season.
Sc 9a	-	-	Future (full utilisation)	Only Douglas EWR	• Based on **Scenario 5** • Including the optimised Sterkfontein release rule.

WRPM Scenario Reference	Reserve Study Scenario Reference	Difference between this study and Reserve Study	Develop-ment Level	Status of Ecological Reserve	Scenario Description
Sc 9b	-	-	Future (2020)	Only Douglas EWR	• Based on **Scenario 3**. • Including the optimised Sterkfontein release rule.

With reference to the scenarios presented in **Table 10-2** the following should be noted:

- **Scenarios 1 and 2**: These two scenarios represent the Present Day (2011) development conditions and were analysed to evaluate the impact of implementing the selected EWR scenario as defined in **Section 8.4**. **Scenario 2** was referenced as **Scenario A** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

- **Scenarios 3 and 4**: These two scenarios were based on the future (2020) development conditions which include the Lesotho Highlands Future Phase (LHFP) development option which was identified as the most feasible future option to be considered for augmenting the water resources of the Vaal River System. The preferred LHFP development comprises the proposed Polihali Dam and its associated conveyance infrastructure (see **Section 2.2.6**). The desalination of mine water and the re-use thereof (as discussed in **Section 6.6**) was also included in the configuration used for these two scenarios. The eradication of unlawful irrigation water use in the Upper Vaal WMA (refer to **Section 6.4**) is included in the configuration of these two scenarios. **Scenario 3** was referenced as **Scenario D** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

- **Scenarios 5 and 6**: These two scenarios represent the full utilisation of the available water resources. The development condition upon which these two scenarios is based, is therefore representative of a future development level that falls between the Present Day (2011) and Future (2020) development conditions. The purpose of these two scenarios is to evaluate the impact on the yield of the system when implementing the ER. **Scenario 5** was referenced as **Scenario C** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

- **Scenario 7**: This scenario evaluates an alternative to the EWR releases from Grootdraai Dam. For all the WRPM scenarios where the EWRs are included, the Grootdraai Dam compensation release rule is replaced with the EWR for EWR site 2. The Reserve Determination Study results, however, showed an apparent flow balance anomaly between the Ecological Water Requirements (EWR) for the two sites downstream of Grootdraai Dam (see **Section 10.2**). Since the Reserve Study's PD scenario excluding the EWRs (Sc R1) was found to be acceptable, **Scenario 7** applies the Grootdraai compensation rule without the EWRs at EWR2 and EWR3. **Scenario 7** was referenced as **Scenario B** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

- **Scenario 8**: In view of the Reserve Determination Study's findings and recommendations the

Sterkfontein release rule was revised prior to undertaking the WRPM scenario analyses for this study (refer to **Section 9.2**). The adjusted rule was adopted for all the scenarios listed in **Table 10-2** except **Scenarios 8**, **9a** and **9b**. Evaluation of the ecological consequences at EWR8 for **Scenarios 1** to **7** gave rise to recommendations for further refinement of the Sterkfontein release rule. The **Scenario 8** analysis involved the optimisation of this release rule which is described in **Section 9.3**. **Scenario 8** was referenced as **Scenario E** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

- **Scenario 9a**: This scenario includes only the Douglas EWR and was evaluated to assess the impact there of on the yield of the Vaal River System.
- **Scenario 9b**: This scenario was based on the 2020 development condition and includes only the Douglas EWR. The purpose of this scenario was to evaluate the impact of the Douglas EWR on the Vaal River System subsequent to the implementation of the LHWP Phase 2. This scenario also incorporates the desalination and re-use of mine water as described in **Section 6.6**. **Scenario 9b** was referenced as **Scenario F** at the Project Steering Committee (PSC) Meeting held on 17 May 2012.

10.6 DISCUSSION OF SCENARIO RESULTS

10.6.1 General

The WRPM configuration adopted for this study was refined to allow for the simulation of representative flows at each of the key biophysical nodes (EWR sites). The scenario results provided to the Ecological Team for assessment of the ecological consequences, therefore, comprised of a set of monthly time series records of representative flows at each EWR site. The average annual flows at the key biophysical nodes (EWR sites), as simulated for each of the scenarios analysed, are summarised in **Table R-1** of **Appendix R**.

The impact of supplying demands within a sub-system is reflected in the response of the relevant water resource. Within the context of using the WRPM as DSS, the simulated storage levels within the major reservoirs could thus be used to assess the impact of implementing the EWRs. Graphical results (simulated reservoir storage trajectories for all the major dams) were produced for each of the scenarios analysed. These results were also compared against that of the recently completed Reserve Determination Study. Graphs were compiled for groups of dams and are included in the appendices as indicated in the sections below.

10.6.2 Scenario 1 Results (PD development excluding EWRs)

This scenario is based on the PD development level and excludes the EWRs. The graphical results of **Scenario 1** are presented in **Appendix H** and a few general comments are provided below.

Komati sub-system (Figure H-1): Vygeboom Dam is drawn down first and the water in Nooitgedacht Dam represents the last water in the Komati Sub-system. The results for **Scenario 1** show how the dams were drawn down during low flow periods. Although Vygeboom Dam was emptied during 1.1% of the months, no sub-system failures occurred.

Usutu Sub-system (Figure H-2): The impact of applying the inter-reservoir operating rules as presented in **Figure 2-1** can be seen in the simulated reservoir storage trajectories of Westoe, Jericho and Morgenstond dams. Water stored in Jericho Dam represents the last water in this sub-system and the preferred operating level is 70% of its FSC. No sub-system failures occurred during the analysis period.

Figure H-3 shows the simulated storages of Grootdraai, Heyshope and Zaaihoek dams resulting from the implementation of the 90% rule. The application of the 90% rule implies that water should be transferred from Heyshope and Zaaihoek when Grootdraai is below 90% of its live FSC. The preferred 90% operating level for Grootdraai Dam is evident from the reservoir storage trajectory of the dam shown in **Figure H-3**. Although the dams are drawn down during periods when low runoff occurs none of the dams were emptied during the analysis period.

The simulated storage trajectories of Woodstock, Sterkfontein, Vaal and Bloemhof dams are shown in **Figure H-4**. The long-term transfer rule was adopted for the Thukela-Vaal transfer scheme which implies that water from Woodstock is transferred at maximum capacity to keep Sterkfontein, Vaal and Bloemhof dams full. Woodstock is, therefore operated at relatively low levels with the dam reaching its Minimum Operating Level (MOL) IN 27% of the months. The Sterkfontein release rule as described in **Section 9.2** was adopted for this scenario and the impact thereof on the storage in Sterkfontein is evident in **Figure H-4**. Releases are also made from Sterkfontein Dam in support of Vaal Dam when Vaal Dam reaches a MOL of 1471.96m (376.7 million m^3). From **Figure H-4** it can be seen that Vaal Dam reached the MOL during the early nineteen thirties, the nineteen eighties and the mid nineteen nineties. Consequently releases were made from Sterkfontein Dam during these periods and the impact thereof is reflected in the storage levels of Sterkfontein Dam. Bloemhof Dam can be supported from Vaal Dam and the dam also benefits from the releases made from Vaal Dam to maintain the TDS concentration downstream of Vaal Barrage at 600 mg/l. Bloemhof Dam supplies water to the Vaalharts Irrigation Scheme, as well as urban and irrigation water users abstracting water from the main stem of the Vaal River downstream of Bloemhof Dam. The impact of these operating rules and abstractions is reflected in the Bloemhof storage trajectories shown in **Figure H-4**.

As shown in **Figure H-5** Klerkskraal and Boskop dams are at FSC most of the time due to flow contributions from mine water and urban effluent discharges. Lakeside Dam is operated at 90% for recreational purposes. Johan Neser and Rietspruit dams situated in the Schoonspruit catchment are also at relatively high storage levels.

From **Figure H-6** it can be seen that both Allemanskraal and Erfenis dams are drawn down to their Minimum Operating Levels (MOLs) during low flow periods. Allocations from Allemanskraal Dam exceed the long-term Historic Firm Yield (HFY) of this water resource causing the sub-system to be in deficit with failures occurring 5.9% of the time. The water requirements and HFY of the Erfenis Dam Sub-system are currently in balance, but projected growth in the urban demands supplied from the dam will also cause future failure in supply.

The results for Koppies (Renoster River) and Klipdrift (Loopspruit) dams are also shown in **Figure H-6**. The simulated storage trajectory of Koppies Dam exhibits a seasonal draw down and recovery pattern. The dam is known to respond rapidly to good rainfall events that occur in the upstream catchment. The yield from Klipdrift Dam is significantly influenced by upstream discharges from mines. The impact of the mine water discharges and the supply to the Irrigation Board is reflected in the simulated storages shown in **Figure H-6**. Based on these results, supply failures are expected to occur should there be a future reduction in mine water discharges.

The storage trajectories of the Harts River dams are shown in **Figure H-7**. The water stored in Taung Dam is currently unutilized and the dam is constantly at relatively high storage levels. Return flows from the Vaalharts Irrigation Scheme augment the catchment runoff into Spitskop Dam. The average long-term irrigation return flow was estimated to be in the order of 45 to 50 million m^3/a whilst the demand of downstream irrigators supplied from Spitskop Dam is about 12.46 million m^3/a . Spitskop Dam is, therefore, also operated at fairly high storage levels.

Figure H-8 shows the storage trajectories of Katse and Mohale dams. A constant transfer of 780 million m^3/a to the Vaal was adopted for the PD analysis. The Full Supply Capacities of these two dams are large relative to their natural MARs. Consequently these two dams are operated at relatively low storage levels. It is important to note that the EWRs downstream of these two dams are included in all the scenarios analysed as part of this study.

Basic statistics to be used for comparison purposes are summarized in **Table 10-3.** For the purposes of this study a failure event is defined as a month for which the simulated storage at the end of the month is equal to the Minimum Operating Level (MOL). The % of the months with failures (calculated out of a total of 900 months that were analysed) is also shown in **Table 10-3**.

Table 10-3: Summarised storage statistics for Scenario 1

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Nooitgedacht	78.48	58.28	17.15	5.59	0	0
Vygeboom	83.35	72.63	5.51	5.51	10	1.1
Westoe	60.76	40.18	5.09	5.09	2	0.2
Jericho	59.93	48.04	41.39	7.00	0	0
Morgenstond	100.77	85.80	14.33	10.76	0	0
Heyshope	453.44	301.34	41.52	27.18	0	0
Zaaihoek	184.87	163.19	57.65	37.08	0	0
Grootdraai	350.33	319.97	108.71	34.39	0	0

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Woodstock	373.26	143.51	17.13	17.13	243	27.0
Sterkfontein	2616.92	2387.73	865.46	134.63	0	0
Vaal	2609.80	1872.98	376.72	167.27	0	0
Bloemhof	1241.29	982.74	99.16	74.55	0	0
Klerkskraal	8.02	8.00	6.28	0.09	0	0
Boskop	21.26	21.12	14.13	0.24	0	0
Lakeside	2.03	2.00	1.82	0.00	0	0
Klipdrift	13.58	10.36	0.25	0.00	0	0
Koppies	42.31	30.15	3.44	1.06	0	0
Rietspruit	7.28	7.13	4.15	0.00	0	0
Johan Neser	5.67	5.20	2.88	0.00	0	0
Allemanskraal	179.31	91.76	10.95	12.18	53	5.9
Erfenis	212.20	147.65	3.42	20.79	29	3.2
Taung	65.21	61.43	43.87	0.00	0	0
Spitskop	57.89	50.80	23.03	0.06	0	0
Katse	1950.00	1555.37	700.85	431.40	0	0
Mohale	946.90	586.56	163.37	89.80	0	0

The average annual transfers/releases through major supply routes are summarised in **Table 10-4** and can also be used as a measure for assessing the impact of including the EWRs.

Table 10-4: Average transfers/releases through indicated routes for Scenario 1

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.430	13.57
Usutu transfer to Eskom Power Stations	36	2.803	88.46
Heyshope transfer to Grootdraai Dam	30	1.257	39.67

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Zaaihoek transfer to Grootdraai Dam	920	0.389	12.28
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	14.118	445.53
Spills/releases from Sterkfontein to Vaal Dam	703	12.653	399.30
LHWP Transfers (as per LHDA schedule)	140	24.722	780.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.261	71.35
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.516	79.40

10.6.3 Scenario 2 Results (PD development including EWRs)

This scenario is based on **Scenario 1** and includes the EWRs as defined for the selected EWR scenario (refer to **Section 8.4**). The graphical results of **Scenario 2** are included in **Appendix I** and the basic storage statistics are summarized in **Table 10-5**.

Table 10-5: Summarised storage statistics for Scenario 2

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Nooitgedacht	78.48	58.31	18.92	5.59	0	0
Vygeboom	83.35	73.02	5.51	5.51	9	1.0
Westoe	60.76	40.18	5.09	5.09	2	0.2
Jericho	59.93	48.02	31.09	7.00	0	0
Morgenstond	100.77	85.64	10.66	10.76	2	0.2
Heyshope	453.44	267.05	26.74	27.18	7	0.8
Zaaihoek	184.87	159.51	45.71	37.08	0	0
Grootdraai	350.33	315.62	83.02	34.39	0	0
Woodstock	373.26	140.34	17.13	17.13	251	27.9
Sterkfontein	2616.92	2373.06	802.25	134.63	0	0

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Vaal	2609.80	1870.78	376.72	167.27	0	0
Bloemhof	1241.29	997.12	163.79	74.55	0	0
Klerkskraal	8.02	8.00	6.28	0.09	0	0
Boskop	21.26	21.12	14.13	0.24	0	0
Lakeside	2.03	2.00	1.82	0.00	0	0
Klipdrift	13.58	10.36	0.25	0.00	0	0
Koppies	42.31	27.70	1.31	1.06	0	0
Rietspruit	7.28	6.67	0.00	0.00	2	0.2
Johan Neser	5.67	3.36	0.00	0.00	123	13.7
Allemanskraal	179.31	91.76	10.95	12.18	53	5.9
Erfenis	212.20	147.65	3.42	20.79	29	3.2
Taung	65.21	58.07	35.67	0.00	0	0
Spitskop	57.89	51.70	25.39	0.06	0	0
Katse	1950.00	1554.93	700.85	431.40	0	0
Mohale	946.90	586.14	160.82	89.80	0	0

As expected the impact of implementing the EWRs could be seen in the lower storage levels of all the major dams situated on the main stem of the Vaal River as well as the dams in supporting sub-systems. The Schoonspruit is the only tributary catchment in the Middle Vaal WMA for which EWRs were included and as expected the Rietspruit and Johan Neser dams are operated at lower levels with failures occurring 0.2% and 13.7% of the time respectively. The assurance of supply to users within the Vaal River System can be evaluated by assessing the storage levels of Grootdraai and Sterkfontein dams.

Grootdraai Dam: For **Scenario 2** it was found that although the dam was operated at lower storage levels no failures occurred. There is thus not an increase in failure of supply due to the EWRs.

Sterkfontein Dam: The storage in Sterkfontein Dam represents the last water in the Vaal River System. For **Scenario 1**, Sterkfontein Dam was never drawn down to a minimum storage of 865.46 million m3 whereas for **Scenario 2** Sterkfontein Dam reached a minimum storage level of about 802 million m^3, which is 63 million m^3 less than the minimum storage reached for **Scenario 1**. This means that implementing the EWRs is resulting in less water to be kept in storage in Sterkfontein Dam. Since Sterkfontein is at lower storage levels for **Scenario 2** less water is released to Vaal Dam based on the adopted Sterkfontein release rule causing Vaal Dam to be operated at slightly lower levels as well.

Due to the EWR contributions from the Renoster and Schoonspruit tributaries Bloemhof Dam is operated at slightly higher levels compared to that of **Scenario 1**.

The average annual transfers/releases through major supply routes are summarised in **Table 10-6**. Comparison with the **Scenario 1** results shows that the inclusion of the EWRs resulted in additional transfers of 5.6 million m^3/a and 3.6 million m^3/a from Heyshope and Zaaihoek respectively to Grootdraai Dam. Owing to the supply to the Thukela EWR, which has first priority, less water (about 7.6 million m^3/a) was available for transfer from Woodstock to Sterkfontein Dam. The releases from Sterkfontein to Vaal Dam were consequently also less than that of **Scenario 1**. There was a slight trade off between the supply through the Vlakfontein canal and the VRESAP pipeline and the supply from the Usutu sub-system (WRPM channel 36).

Table 10-6: Average transfers/releases through indicated routes for Scenario 2

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.422	13.32
Usutu transfer to Eskom Power Stations	36	2.8	88.36
Heyshope transfer to Grootdraai Dam	30	1.434	45.25
Zaaihoek transfer to Grootdraai Dam	920	0.504	15.91
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	13.878	437.96
Spills/releases from Sterkfontein to Vaal Dam	703	12.484	393.97
LHWP Transfers (as per LHDA schedule)	140	24.722	780.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.271	71.67
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.51	79.21

10.6.4 Scenario 3 Results (2020 Development excluding EWRs)

This scenario is based on the 2020 development conditions and excludes the EWRs. The graphical results of **Scenario 3** are included in **Appendix J** and the basic storage statistics are summarized in **Table 10-7**. As shown in **Table 10-7** this scenario includes the proposed LHWP Phase 2 development (comprising of Polihali Dam and its conveyance infrastructure) as the next augmentation scheme for the IVRS. The median storage of 1161 million m^3 was adopted as starting storage for Polihali Dam.

Table 10-7: Summarised storage statistics for Scenario 3

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Nooitgedacht	78.48	58.41	18.99	5.59	0	0
Vygeboom	83.35	73.02	5.51	5.51	9	1.0
Westoe	60.76	40.20	5.09	5.09	2	0.2
Jericho	59.93	48.44	31.64	7.00	0	0
Morgenstond	100.77	88.54	10.56	10.76	4	0.4
Heyshope	453.44	287.18	26.74	27.18	20	2.2
Zaaihoek	184.87	162.32	59.08	37.08	0	0
Grootdraai	350.33	322.32	148.36	34.39	0	0
Woodstock	373.26	153.22	17.13	17.13	214	23.8
Sterkfontein	2616.92	2499.55	2325.47	134.63	0	0
Vaal	2609.80	2258.73	546.27	167.27	0	0
Bloemhof	1241.29	973.02	74.55	74.55	15	1.7
Klerkskraal	8.02	8.00	6.28	0.09	0	0
Boskop	21.26	21.14	14.39	0.24	0	0
Lakeside	2.03	2.00	1.82	0.00	0	0
Klipdrift	13.58	10.78	1.59	0.00	0	0
Koppies	42.31	30.20	3.45	1.06	0	0
Rietspruit	7.28	7.13	4.15	0.00	0	0
Johan Neser	5.67	5.20	2.88	0.00	0	0
Allemanskraal	179.31	91.76	10.95	12.18	53	5.9
Erfenis	212.20	147.36	3.42	20.79	32	3.6
Taung	65.21	55.28	21.07	0.00	0	0
Spitskop	57.89	50.50	20.03	0.06	0	0
Katse	1950.00	1817.19	1468.15	431.40	0	0
Mohale	946.90	754.25	487.63	89.80	0	0
Polihali	2322.19	2011.70	1142.90	417.85	0	0

Sterkfontein and Vaal dams benefit from the higher Senqu transfers and, as shown in **Figure J-4**, these dams are at higher storage levels than for **Scenario 1**. The re-use of mine water by Rand Water reduces the demand on Vaal Dam slightly, but the most significant impact of the re-use option is the improved water quality downstream of Vaal Barrage. Fewer releases are thus required from Vaal Dam to maintain the TDS concentration downstream of Vaal Barrage at 600 mg/l. The reduced releases from Vaal Dam, however, are causing Bloemhof Dam to be at lower storage levels than for the Present Day scenario. For dams on the tributaries where there are no growth in demands, the **Scenario 3** results will be the same as that of **Scenario 1** (e.g. Allemanskraal Dam). Katse and Mohale dams are operated at higher levels for **Scenario 3** due to the additional water available from the proposed Polihali Dam.

The average annual transfers/releases through major supply routes are summarised in **Table 10-8.** It is important to note that the LHWP transfer adopted for this scenario (as shown in **Table 10-8**) includes the additional transfer that is possible due to the commissioning of Polihali Dam.

Table 10-8: Average transfers/releases through indicated routes for Scenario 3

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.458	14.45
Usutu transfer to Eskom Power Stations	36	2.804	88.49
Heyshope transfer to Grootdraai Dam	30	1.259	39.73
Zaaihoek transfer to Grootdraai Dam	920	0.293	9.25
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	13.533	427.07
Spills/releases from Sterkfontein to Vaal Dam	703	11.651	367.68
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	32.865	1037.14
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	3.391	107.01
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.844	89.75

10.6.5 Scenario 4 Results (2020 Development including EWRs)

This scenario is based on **Scenario 3** and includes the EWRs as defined for the selected EWR scenario (refer to **Section 8.4**). The graphical results of **Scenario 4** are included in **Appendix K** and the basic storage statistics are summarized in **Table 10-9**.

Table 10-9: Summarised storage statistics for Scenario 4

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Nooitgedacht	78.48	58.41	18.99	5.59	0	0
Vygeboom	83.35	73.02	5.51	5.51	9	1.0
Westoe	60.76	39.91	5.09	5.09	8	0.9
Jericho	59.93	48.18	7.92	7.00	0	0
Morgenstond	100.77	87.82	10.11	10.76	8	0.9
Heyshope	453.44	245.29	26.09	27.18	38	4.2
Zaaihoek	184.87	159.60	46.30	37.08	0	0
Grootdraai	350.33	321.05	136.54	34.39	0	0
Woodstock	373.26	151.55	17.13	17.13	223	24.8
Sterkfontein	2616.92	2497.01	2325.33	134.63	0	0
Vaal	2609.80	2262.31	600.77	167.27	0	0
Bloemhof	1241.29	985.24	74.55	74.55	12	1.3
Klerkskraal	8.02	8.00	6.28	0.09	0	0
Boskop	21.26	21.14	14.39	0.24	0	0
Lakeside	2.03	2.00	1.82	0.00	0	0
Klipdrift	13.58	10.78	1.59	0.00	0	0
Koppies	42.31	27.75	1.32	1.06	0	0
Rietspruit	7.28	6.67	0.00	0.00	2	0.2
Johan Neser	5.67	3.37	0.00	0.00	122	13.6
Allemanskraal	179.31	91.76	10.95	12.18	53	5.9
Erfenis	212.20	147.36	3.42	20.79	32	3.6
Taung	65.21	49.86	13.24	0.00	0	0
Spitskop	57.89	51.63	24.90	0.06	0	0
Katse	1950.00	1817.16	1468.15	431.40	0	0
Mohale	946.90	754.25	487.63	89.80	0	0
Polihali	2322.19	2011.13	1135.18	417.85	0	0

The results of this scenario are compared against that of **Scenario 3** to assess the impact of implementing the EWRs. Although no failures occurred at Grootdraai, Heyshope is experiencing more failures due to the support given to Grootdraai and Morgenstond. Failures at Woodstock Dam have increased by 1% whilst failures at Bloemhof have decreased slightly (0.4%). The latter is due to the contribution from tributary EWRs.

The average annual transfers/releases through major supply routes are summarised in **Table 10-10**. Transfers from Heyshope and Zaaihoek to Grootdraai have increased by 7.6 and 2.6 million m^3/a respectively. It is important to note that the excess yield in the Zaaihoek sub-system available for transfer to Grootdraai decreases over time due to the growth of in-basin demands. About 8 million m^3/a less was transferred from the Thukela to Sterkfontein and the Sterkfontein releases/spills also decreased by approximately 7.3 million m^3/a.

Table 10-10: Average transfers/releases through indicated routes for Scenario 4

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.442	13.95
Usutu transfer to Eskom Power Stations	36	2.804	88.49
Heyshope transfer to Grootdraai Dam	30	1.5	47.34
Zaaihoek transfer to Grootdraai Dam	920	0.375	11.83
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	13.28	419.08
Spills/releases from Sterkfontein to Vaal Dam	703	11.419	360.36
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	32.865	1037.14
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	3.487	110.04
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.753	86.88

10.6.6 Scenario 5 Results (Future development excluding EWRs)

This scenario representing the “full utilization” condition formed the basis for assessing the impact of the implementation of the EWRs on the yield of the system. The graphical results of **Scenario 5** are included in **Appendix L** and the basic storage statistics of the relevant dams are shown in **Table 10-11**.

Table 10-11: Summarised storage statistics for Scenario 5

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Heyshope	453.44	298.96	37.00	27.18	0	0
Zaaihoek	184.87	159.28	44.07	37.08	0	0
Grootdraai	350.33	315.37	70.07	34.39	0	0
Woodstock	373.26	142.36	17.13	17.13	244	27.1
Sterkfontein	2616.92	2269.84	151.08	134.63	0	0
Vaal	2609.80	1737.94	376.72	167.27	0	0
Bloemhof	1241.29	973.65	78.39	74.55	0	0
Katse	1950.00	1452.38	465.95	431.40	0	0
Mohale	946.90	520.59	89.80	89.80	2	0.2

The average annual transfers/releases through major supply routes are summarised in **Table 10-12**.

Table 10-12: Average transfers/releases through indicated routes for Scenario 5

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.435	13.73
Usutu transfer to Eskom Power Stations	36	2.813	88.77
Heyshope transfer to Grootdraai Dam	30	1.253	39.54
Zaaihoek transfer to Grootdraai Dam	920	0.403	12.72
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	14.209	448.40
Spills/releases from Sterkfontein to Vaal Dam	703	13.191	416.28
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	25.229	796.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.692	84.95
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.972	93.79

10.6.7 Scenario 6 Results (Future development including EWRs)

This scenario is based on **Scenario 5**, but includes the selected EWR scenario as described in **Section 8.4.** The graphical results of **Scenario 6** are included in **Appendix M** and the basic storage statistics of the relevant dams are summarised in **Table 10-13.**

Table 10-13: Storage statistics for Scenario 6

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Heyshope	453.44	252.32	26.74	27.18	11	1.2
Zaaihoek	184.87	155.79	25.36	37.08	0	0
Grootdraai	350.33	309.12	35.87	34.39	0	0
Woodstock	373.26	139.03	17.13	17.13	253	28.1
Sterkfontein	2616.92	2252.80	134.63	134.63	2	0.2
Vaal	2609.80	1742.13	346.24	167.27	0	0
Bloemhof	1241.29	988.52	143.53	74.55	0	0
Katse	1950.00	1451.57	465.27	431.40	0	0
Mohale	946.90	520.22	89.80	89.80	2	0.2

The average annual transfers/releases through major supply routes are summarised in **Table 10-14**.

Table 10-14: Average transfers/releases through indicated routes for Scenario 6

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.425	13.41
Usutu transfer to Eskom Power Stations	36	2.813	88.77
Heyshope transfer to Grootdraai Dam	30	1.511	47.68
Zaaihoek transfer to Grootdraai Dam	920	0.493	15.56
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	13.945	440.07

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Spills/releases from Sterkfontein to Vaal Dam	703	12.989	409.90
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	25.229	796.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.727	86.06
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.94	92.78

10.6.8 Scenario 7 Results (PD and Grootdraai compensation releases)

This scenario is based on **Scenario 2** and was analysed to evaluate the response of the system by implementing the Grootdraai compensation releases rule (as opposed to including EWR2 and EWR3) in combination with the remainder of the EWRs as defined for the selected EWR scenario (refer to **Section 8.4**). The graphical results of the relevant major dams are included in **Appendix N**. The corresponding storage statistics are summarised in **Table 10-15** and the average annual transfers/releases are provided in **Table** 10-16.

Table 10-15: Storage statistics for Scenario 7

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Heyshope	453.44	276.27	27.14	27.18	4	0.4
Zaaihoek	184.87	159.96	48.91	37.08	0	0
Grootdraai	350.33	319.92	105.41	34.39	0	0
Woodstock	373.26	140.15	17.13	17.13	251	27.9
Sterkfontein	2616.92	2367.98	780.33	134.63	0	0
Vaal	2609.80	1863.54	376.72	167.27	0	0
Bloemhof	1241.29	996.64	163.27	74.55	12	1.3

Table 10-16: Average transfers/releases through indicated routes for Scenario 7

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.425	13.41
Usutu transfer to Eskom Power Stations	36	2.801	88.39
Heyshope transfer to Grootdraai Dam	30	1.373	43.33
Zaaihoek transfer to Grootdraai Dam	920	0.490	15.46
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	13.881	438.05
Spills/releases from Sterkfontein to Vaal Dam	703	12.508	394.72
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	24.722	780.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.501	78.93
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.290	72.27

Comparing the results of **Table 10-16** with that of **Scenario 2** (see **Table 10-6**) it is clear that by adopting the Grootdraai compensation release rule reduces the volume of water to be pumped through the VRESAP pipeline.

10.6.9 Scenario 8 Results (PD and optimised Sterkfontein release rule)

This scenario is based on **Scenario 1** and was analysed to revise the initial Sterkfontein release rule. An iterative approach was adopted for the optimization of the release rule. The finally adopted release rule is described in **Section 9.3** and was used for the analysis of **Scenario 8**. It is important to note that the purpose of **Scenario 8** was to ensure that an acceptable flow distribution (i.e. improvement of the flow duration curve in the dry season) is achieved at EWR8 on the Wilge River as part of the general operation of Sterkfontein Dam and therefore excludes the EWRs.

The graphical results of the relevant major dams are included in **Appendix O**. The corresponding storage statistics are summarised in Table 10-17 and the average annual transfers/releases are provided in **Table** 10-18.

The simulated storage trajectories of Sterkfontein and Vaal dams as shown in **Figure O-2** reflect the respective operating levels that form part of the optimized Sterkfontein release rule.

Table 10-17: Storage statistics for Scenario 8

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Heyshope	453.44	301.34	41.52	27.18	0	0
Zaaihoek	184.87	163.17	57.65	37.08	0	0
Grootdraai	350.33	320.09	109.26	34.39	0	0
Woodstock	373.26	145.24	17.13	17.13	223	24.8
Sterkfontein	2616.92	2270.31	538.09	134.63	0	0
Vaal	2609.80	1909.60	376.72	167.27	0	0
Bloemhof	1241.29	985.02	100.22	74.55	0	0

Table 10-18: Average transfers/releases through indicated routes for Scenario 8

Description	WRPM Channel Number	Simulated average annual transfer/release	
		m^3/s	Million m^3/a
Heyshope transfer to Morgenstond	693	0.430	13.57
Usutu transfer to Eskom Power Stations	36	2.803	88.46
Heyshope transfer to Grootdraai Dam	30	1.257	39.67
Zaaihoek transfer to Grootdraai Dam	920	0.391	12.34
Thukela-Vaal transfer (Woodstock to Sterkfontein)	88	14.168	447.11
Spills/releases from Sterkfontein to Vaal Dam	703	12.844	405.33
LHWP Transfers (includes additional LHWP Phase 2 transfer)	140	24.722	780.17
Supply from Grootdraai to VRESS users (via Vlakfontein canal)	1126	2.259	71.29
Supply from Vaal Dam to VRESS users (via VRESAP pipeline)	491	2.518	79.46

As mentioned in **Section 9.3** implementation of the optimised Sterkfontein release rule will reduce the HFY of the system by about 5%, but stochastic analysis showed that the assurance of supply to the users will not be jeopardised. It is, therefore, recommended that the optimised Sterkfontein release rule be adopted.

10.6.10 Scenario 9a Results (Future development including Douglas EWR)

This scenario is based on **Scenario 5** which represents the full utilization of available water in the Vaal River System. It also includes the optimised Sterkfontein release rule (refer to **Section 9.3**). In order to assess the impact of implementing the Douglas EWR, the following two analyses were undertaken for this scenario:

- An analysis with the full utilization of the available water and excluding the Douglas EWR (to be used as reference); and
- An analysis with the full utilization of the available water including the Douglas EWR.

The graphical results for the major dams excluding and including the Douglas EWR are shown in **Figures P-1** and **P-2** of **Appendix P** respectively and the major storage statistics are summarised in **Table 10-19**.

Table 10-19: Storage statistics for Scenario 9a

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Scenario 9a excluding Douglas EWR						
Woodstock	373.26	144.03	17.13	17.13	236	26.2
Sterkfontein	2616.92	2199.25	155.65	134.63	0	0
Vaal	2609.80	1836.11	376.72	167.27	0	0
Bloemhof	1241.29	979.40	90.53	74.55	0	0
Scenario 9a including Douglas EWR						
Woodstock	373.26	141.83	17.13	17.13	245	27.22
Sterkfontein	2616.92	2143.33	134.63	134.63	13	1.44
Vaal	2609.80	1804.91	167.27	167.27	1	0.11
Bloemhof	1241.29	857.33	74.55	74.55	41	4.56

As shown in **Figure P-1** and reflected in **Table 10-19**, Woodstock Dam is emptied about 26% of the time for the scenario excluding the Douglas EWR, whilst the other major dams are just not failing. For the analysis including the Douglas EWR (see **Figure P-2**) Sterkfontein, Vaal and Bloemhof dams are emptied and the failure statistics are shown in **Table 10-19**. This means that the inclusion of the Douglas EWR reduces the firm yield of the Vaal River System. Through an iterative assessment the reduction in yield due to the implementation of the Douglas EWR was calculated to be in the order of 70 million m^3/a (i.e. about 8%).

10.6.11 Scenario 9b Results (2020 Development including Douglas EWR)

This scenario is based on **Scenario 3** which represents the 2020 development conditions. The optimised Sterkfontein release rule (refer to **Section 9.3**) was included for **Scenario 9b** and adjustments were made to the water requirements to ensure that the system configuration is representative of a full utilization of available water condition. The latter is required to assess the impact of implementing the Douglas EWR on the firm yield of the system.

The major differences between the **Scenario 9a** and **9b** analyses are that the **Scenario 9b** configuration includes the proposed Polihali Dam as well as the desalination and re-use of mine water. Since the yield of the Vaal River System will increase with the implementation of the proposed augmentation scheme, it was deemed necessary to determine the reduction in yield due to the implementation of the Douglas EWR for the 2020 development conditions as well.

The following two analyses were undertaken for this scenario:

- An analysis with the full utilization of the available water and excluding the Douglas EWR (to be used as reference); and
- An analysis with the full utilization of the available water including the Douglas EWR.

The graphical results for the major dams excluding and including the Douglas EWR are shown in **Figures Q-1** and **Q-2** of **Appendix Q** respectively and the major storage statistics are summarised in **Table 10-20**.

Table 10-20: Storage statistics for Scenario 9b

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Scenario 9b excluding Douglas EWR						
Woodstock	373.26	142.83	17.13	17.13	238	26.4
Sterkfontein	2616.92	2201.07	148.47	134.63	0	0

Dam Name	Gross Full Supply Capacity (million m^3)	Average Annual Storage (million m^3)	Minimum Storage (million m^3)	Minimum Operating Level (million m^3)	Number of Failure Events	% of Months with Failures
Vaal	2609.80	1828.92	376.72	167.27	0	0
Bloemhof	1241.29	891.42	74.55	74.55	18	2.0
Scenario 9b including Douglas EWR						
Woodstock	373.26	140.11	17.13	17.13	250	27.8
Sterkfontein	2616.92	2123.78	134.63	134.63	16	1.8
Vaal	2609.80	1789.01	167.27	167.27	4	0.4
Bloemhof	1241.29	775.15	70.66	74.55	73	8.1

As shown in **Figure Q-1** and reflected in **Table 10-20**, Woodstock and Bloemhof dams are emptied about 26.4% and 2% of the time respectively for the scenario excluding the Douglas EWR, whilst the other two major dams are just not failing. For the analysis including the Douglas EWR (see **Figure Q-2**) all the dams are emptied and the failure statistics are shown in **Table 10-20**. This means that the 2020 firm yield of the Vaal River System is reduced due to the inclusion of the Douglas EWR. The reduction in yield due to the implementation of the Douglas EWR was calculated by means of an iterative assessment and was found to be in the order of 99 million m^3/a. This reduction amounts to approximately 6.7% of the 2020 development yield.

11 ASSESSMENTS OF DESKTOP BIOPHYSICAL NODES

11.1 METHODOLOGY ADOPTED FOR ASSESSMENT

The locations of the desktop biophysical nodes are shown in **Figures B-1** to **B-3** of **Appendix B**. As mentioned in **Section 7.4**, these nodes are not explicitly modelled as part of the WRPM configuration of the IVRS and it was initially proposed that only qualitative evaluations be done for these smaller catchments. Subsequent to the Inception Phase of this study, the opportunity was identified to undertake a cursory quantitative evaluation of the water availability (and consequential implications) at small catchment scale based on land use data from the Validation and Verification study that is currently being undertaken in the three Vaal River WMAs.

The methodology established for the quantitative assessment of the desktop nodes included the following steps:

- The natural Mean Annual Runoff (nMAR) and natural runoff time series data determined for each of the desktop nodes (as described in **Section 4.4**) were used as basis.

- The next step was to assess the impact of catchment development on the runoff at these nodes. A first order assessment was made in terms of the water balances for the biophysical nodes by comparing the present day water use and small dam storage capabilities (refer to land use data discussed in **Section 11.2**) with the natural runoff at the nodes. This information was used to identify the nodes for which a more detailed evaluation was required (see **Section 11.4**).

- The Water Resource Yield Model (WRYM) was used for the analysis of the desktop nodes which required a more detailed assessment. The identified biophysical node units were individually configured into the WRYM in order to determine the developed flow at the EWR sites (refer to **Section 11.5** for details).

- The WRYM was run and the developed flows determined for each point.

- A post processing excel module was development to compare the EWR and the present day simulation results.

- Adjustments were made to the EWRs of the desktop nodes based on the results of the post processing excel module developed for comparing the EWR and the present day simulation results of the low confidence high resolution network model.

11.2 INFORMATION ON CATCHMENT DEVELOPMENT

Schoeman and Vennote was approached to assist with the calculation of land use information required for the cursory quantitative evaluation of the water availability at each of the desktop biophysical nodes. Although the Validation and Verification studies were still incomplete at the time when the land use information was required for the purposes of the Classification Study, it was possible to determine (calculate) water use in the small catchments by using preliminary results from the Validation and Verification studies.

90 hydro nodes or small catchments were identified in the three Vaal WMAs for which water use determinations were required. Two time series of monthly water use estimates were prepared for each catchment based on the extent of irrigation as determined for the years 1998 and 2009 (development levels). In addition to the water abstractions, the presence of substantial water storage structures (dams) in a catchment also impacts on the water flow in the rivers. Therefore the combined storage capacity and surface area of dams were also calculated for each of the catchments at the 2009 development level. Preliminary estimations of the lawful irrigation area for each catchment were also determined in order to evaluate the implications that the removal of unlawful irrigation water use could have on the water balance of each catchment. Time series of monthly water use estimates for each catchment, based on the extent of the possible exiting lawful irrigation areas, were prepared. Information on annual non-agricultural water use was also provided for each of the biophysical nodes.

The detailed land use information and the approach adopted for the determination thereof can be found in the report compiled by Schoeman and Vennote (**Schoeman, 2011**). It is, however, important to note that the status of this data should be considered as preliminary since the Validation and Verification studies had not been finalised at the writing of this report.

11.3 QUANTIFICATION OF EWRS

It is important to note that the EWR determination for the desktop nodes did not include field work nor physical measurements and applied extrapolation or estimation methods. Since detailed information on the quantification of EWRs is provided in the relevant study report (**DWA, 2011c**) only key issues relating to the EWRs for desktop biophysical nodes are highlighted in this section. EWRs are either extrapolated from existing EWR sites or estimated where extrapolation is not appropriate. In the case of the Vaal River, almost all nodes require estimation as they are not ecologically similar to the EWR sites within the main rivers in the catchment and extrapolation will therefore not be appropriate. The Desktop Adjustment Model (DAM) (**Birkhead, 2008**), developed subsequent to the design of the EWRCS, was used for the Estimation process of this study (refer to **Chapter 5** of the relevant study report).

Ideally EWRs at each node should be generated for the maintenance of a full-suite of ecological conditions (**DWAF, 2007b**). Considering the time implications as well as practicalities, this was not deemed appropriate for the desktop biophysical nodes. This statement is further supported by the limited flexibility and options in management within the Vaal River. Since the updated DAM requires more intensive work to provide for full categories, it was concluded that there is no need to undertake the extra work if those additional categories (apart from the Present Ecological State (PES) and the Recommended Ecological State (REC)) will not be used within the Vaal Classification study. Further motivation for this decision is provided in the EWR Quantification report of this study (**DWA, 2011c**).

Most of the desktop biophysical nodes with a HIGH Environmental Importance (EI) lie in the Upper Vaal. No nodes with high EI occur in the Middle Vaal and two ephemeral small river reaches within the Lower Vaal have a high EI. All these sites are in a reasonable to good PES and the majority of those in a B/C EC (that should improve to a B EC) will require non-flow related intervention to achieve the required improvements. The desktop biophysical nodes that scored a HIGH EI are listed in **Table 11-1**.

Table 11-1: Summary of the desktop biophysical nodes with a High EI

IUA	VC node	SQ reach	PES	FLOW RELATED	NON FLOW RELATED	EIS	EI	REC
UV-A	8VF5	C11A-01460	B/C		Yes	MODERATE	HIGH	B
UV-B	UV Uklip	C13C-02550	B		Yes	HIGH	HIGH	B
UV-B	C13C	C13D-02416	B/C		Yes	HIGH	HIGH	B
UV-B	C1KLIP-UNSPE1	C13D-02284	B/C	Yes	Yes	MODERATE	HIGH	B
UV-B	C13E	C13E-02228	B/C	Yes	Yes	MODERATE	HIGH	B
UV-C1	8WF1	C81A-02790	B		Yes	MODERATE	HIGH	B
UV-C1	UV25	C81L-02594	B		Yes	MODERATE	HIGH	B
UV-C2	GG	C81G-02882	B		Yes	MODERATE	HIGH	B
UV-D	VC16	C83G-02364	B/C		Yes	MODERATE	HIGH	B
UV-D	VC17	C23H-02395	B/C		Yes	MODERATE	HIGH	B
UV-H	C21A	C12A-01567	B/C	Yes	Yes	MODERATE	HIGH	B
LV A4	VC59	C91D-02838	A/B		Yes	Yes	HIGH	A/B
LV B	VC60	C91D-02838	A/B		Yes	Yes	HIGH	A/B

In this study the DAM was used to determine EWRs for 63 hydro-nodes and the results for 13 other nodes were already available from the Upper Vaal Ecological Reserve Study (using the same approach) - i.e. 76 nodes in total. The output for these nodes is standard Desktop Reserve assurance tables for the Present Ecological State (PES) as well as the Recommended Ecological Category (REC) where it differs from the PES.

Summarised results of the EWR estimation at the desktop nodes are presented in the EWR Quantification report compiled for this study (**DWA, 2011c**).

11.4 WATER BALANCES FOR DESKTOP NODES

A first order assessment was made in terms of the water balances for the biophysical nodes by comparing the present day water use and small dam storage capabilities with the natural runoff at the nodes. This information was used to identify the nodes for which a more detailed evaluation was required. The results of the water balance calculations for the desktop nodes are summarised and presented within the context of the three Vaal WMAs and according to the respective Integrated Units of Analysis (IUAs) in **Appendix S** as follows:

- Upper Vaal WMA: **Figure S-1**;
- Middle Vaal WMA: **Figure S-2**; and
- Lower Vaal WMA: **Figure S-3**.

Based on these results 69 desktop nodes were identified for detailed assessment.

11.5 WRYM SCENARIO ANALYSIS

The Water Resource Yield Model (WRYM) was used for the assessment of 68 desktop nodes which required a more detailed evaluation.

The identified biophysical node units were individually configured into the WRYM in order to determine the developed flow at the EWR sites. Each unit was configured to represent a dummy dam (group of farm dams) upstream, irrigation demand abstractions and other abstractions where applicable. The land use information was provided by Schoeman and Vennote as discussed in **Section 11.2**. The percentage hydrology splits was assessed using Google Earth. The model was run and the developed flows determined for each point. A post-processing excel module was developed to automate the process to abstract the developed flows from the WRYM output files and compare them with the required EWRs.

Systems schematics representing the resulting WRYM configurations for the Upper, Middle and Lower Vaal nodes are shown in **Figures S-4**, **S-5** and **S-6** of **Appendix S** respectively. It is important to note that these WRYM configurations are considered as low confidence high resolution network models used to simulate flow scenarios for the desktop biophysical nodes at a cursory level.

It was proposed that the following two scenarios be evaluated with the WRYM:

- Present Day (2009) development level scenario: The purpose of this scenario is to inform the determination of the EWR; and
- A future scenario where only the existing lawful use is abstracted: This scenario where the Existing Lawful Use (ELU) is imposed on the systems will provide an indication of what the potential benefits are if the alleged unlawful irrigation is removed.

Simulations were carried out with the WRYM and assessments were made of the supply to the EWRs for the 2009 development level water use scenario. The EWRs (time series of monthly flows) described in **Section 11.3** were compared with the simulated present day flows at the nodes based on the results of the WRYM. In cases where the PES and REC for the nodes are the same a further modification was made to the EWR assurance rules to ensure the EWR do not exceed the present day flows. In other words, the EWR were reduced to match the present day flows where the EcoClassification recommended no change is required in the flow regime to what has been experienced in the recent past.

The results of the above-mentioned assessments are summarised in **Table S-1** of **Appendix S**. From **Table S-1** the following can be concluded for the two scenarios evaluated:

- **2009 development level**: The EWR supply was found to be unacceptable for three nodes in the Upper Vaal WMA (UB.2, UB.3 and UB.6) and two nodes in the Middle Vaal WMA (MA.1 and MA.2). For nodes MA.1 and MA.2 the EWR distribution was found to be reasonable but evaluation of the flow duration curves showed that deficits occurred for percentiles less than 50%.
- **Existing Lawful Use (ELU) irrigation scenario**: Results for this future scenario showed that the EWR

supply was found to be unacceptable for ten of the desktop nodes of which eight nodes are located in the Upper Vaal WMA and two nodes in the Middle Vaal WMA.

For nodes where the EWR are met, the relative change in the EWR supply between the two scenarios is also indicated in **Table S-1**.

12 CONCLUSIONS AND RECOMMENDATIONS

12.1 CONCLUSIONS

In terms of the considerations for the EWR sites evaluated as part of the WRPM analyses the following should be noted:

- Improvement of the seasonal flow distribution at EWR8 on the Wilge River was one of the objectives of the water resource assessments of this study and resulted in the adjustment of the Sterkfontein release rule. The simulated monthly flow distribution at EWR8, which was based on the optimised Sterkfontein release rule (as described in **Section 9.3**) were found to be an improvement of the initial adjusted rule described in **Section 9.2**. The implication on the system yield was evaluated, and although the HFY was reduced by 5%, stochastic analysis indicated that the assurance of supply to users was not jeopardised by the implementation of the optimised release rule.

- The results for WRPM **Scenario 7** indicated that the discrepancy identified between the simulated flows at EWR2 and EWR3 during the Reserve Determination Study, was resolved by implementing the existing Grootdraai compensation release rule and excluding the EWRs for these two sites.

- Implementation of the EWR scenario as described in **Section 8.4** did not jeopardise the assurance of supply to users in the Vaal River System.

- As expected, implementation of the Douglas EWR (refer to **Section 9.5** for details of the various assumptions) has significant implications on the yield of the Vaal River System. Impact assessments were done for two development conditions. The reduction in yield for a future scenario (representative of development conditions between 2011 and 2020) amounted to about 70 million m^3/a (8%). For the 2020 development conditions it was found that the augmented yield (resulting from the implementation of the proposed Polihali Dam in Lesotho) will be reduced by 99 million m^3/a (6.7%) due to the implementation of the Douglas EWR.

With reference to the assessment of the desktop biophysical nodes, the following was concluded:

- Based on the first order water balance assessment it was identified that further analyses were required for 68 of these nodes.

- The results from the low confidence high resolution WRYM were fed into the post processing excel module developed for comparing the EWR and the present day simulation results. Two scenarios based on the 2009 development and a future scenario including existing lawful use (ELU) for irrigation, were considered. For the 2009 development scenario the EWR supply was found to be unacceptable for three nodes in the Upper Vaal WMA (UB.2, UB.3 and UB.6) and two nodes in the Middle Vaal WMA

(MA.1 and MA.2). Results for the future ELU scenario showed that the EWR supply was unacceptable for ten of the desktop nodes of which eight nodes are located in the Upper Vaal WMA and two nodes in the Middle Vaal WMA.

12.2 RECOMMENDATIONS

In view of the findings of the Water Resource analyses, the following recommendations are made:

- The optimized Sterkfontein release rule as presented in **Section 9.3** should be implemented to improve the distribution of dry season flows at EWR8 on the Wilge River;
- The existing Grootdraai compensation release rule should be maintained as opposed to the EWRs at EWR2 and EWR3.
- A socio-economic assessment should be undertaken for the impacts due to the implementation of the Douglas EWR. Results of the socio-economic analyses should inform further decisions regarding the feasibility of including the Douglas EWR.

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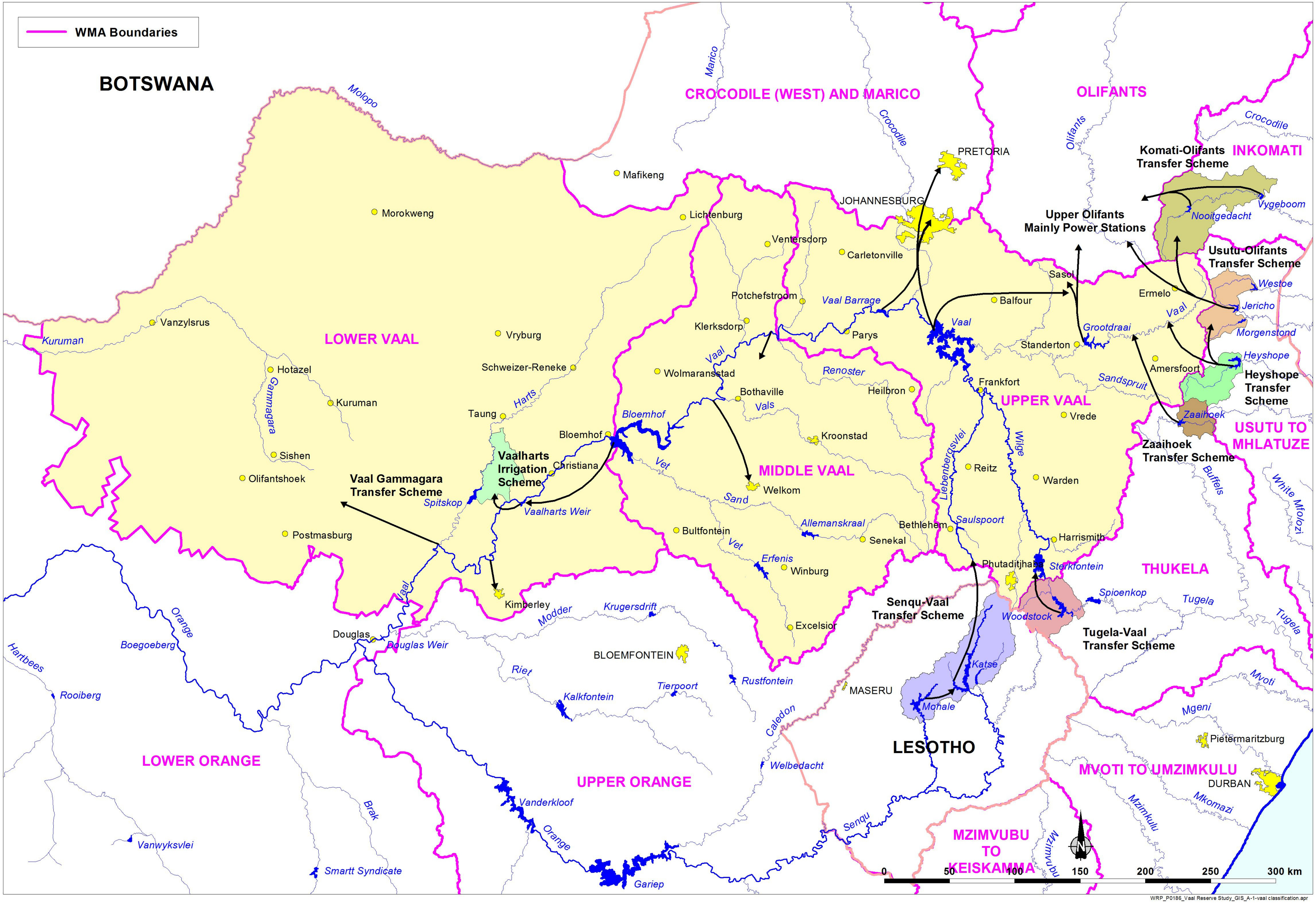
Appendix A:

Map of Study Area and Water Management Areas



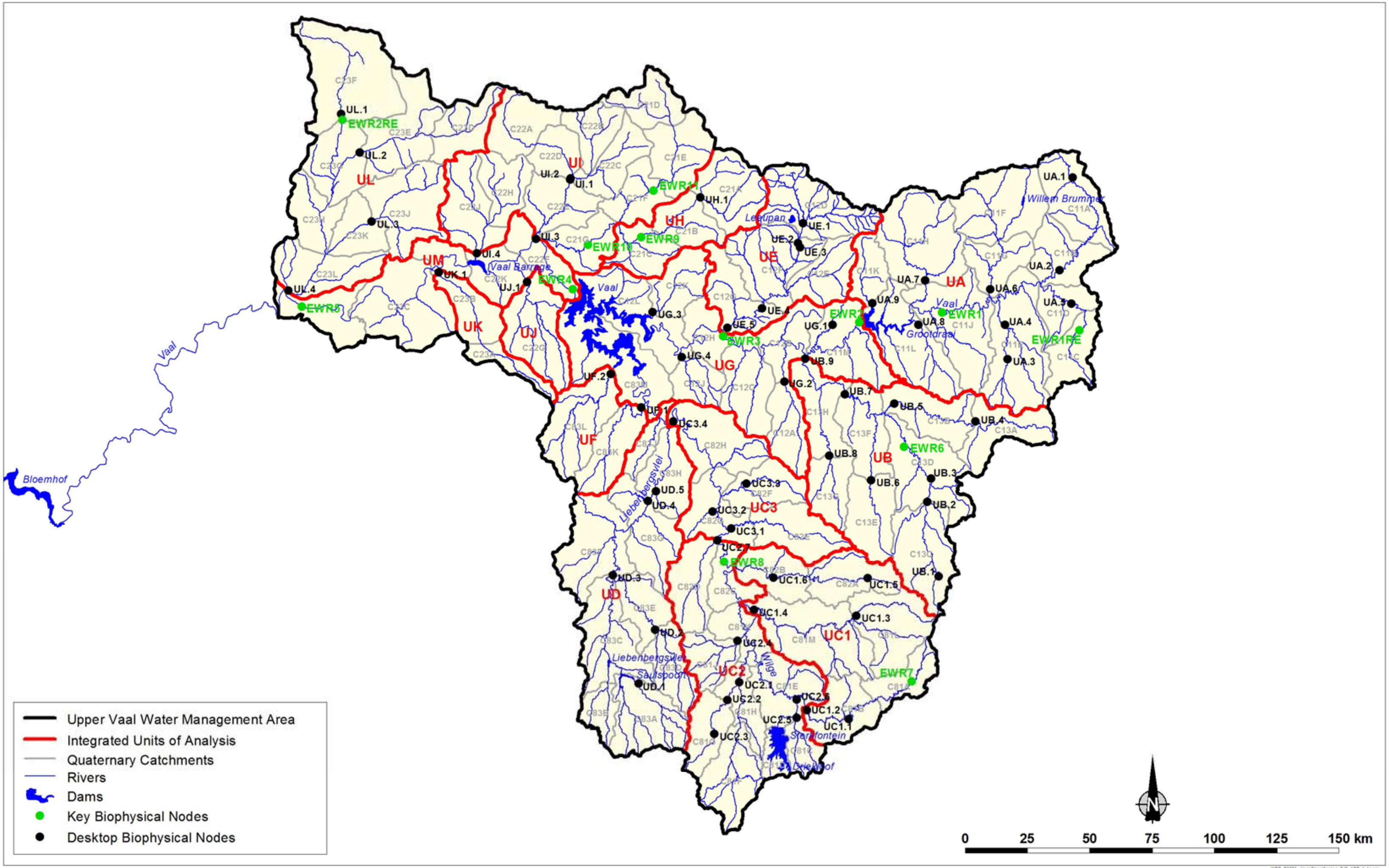
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS, GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8, 9, 10

Integrated Vaal River System

A-1

Appendix B:

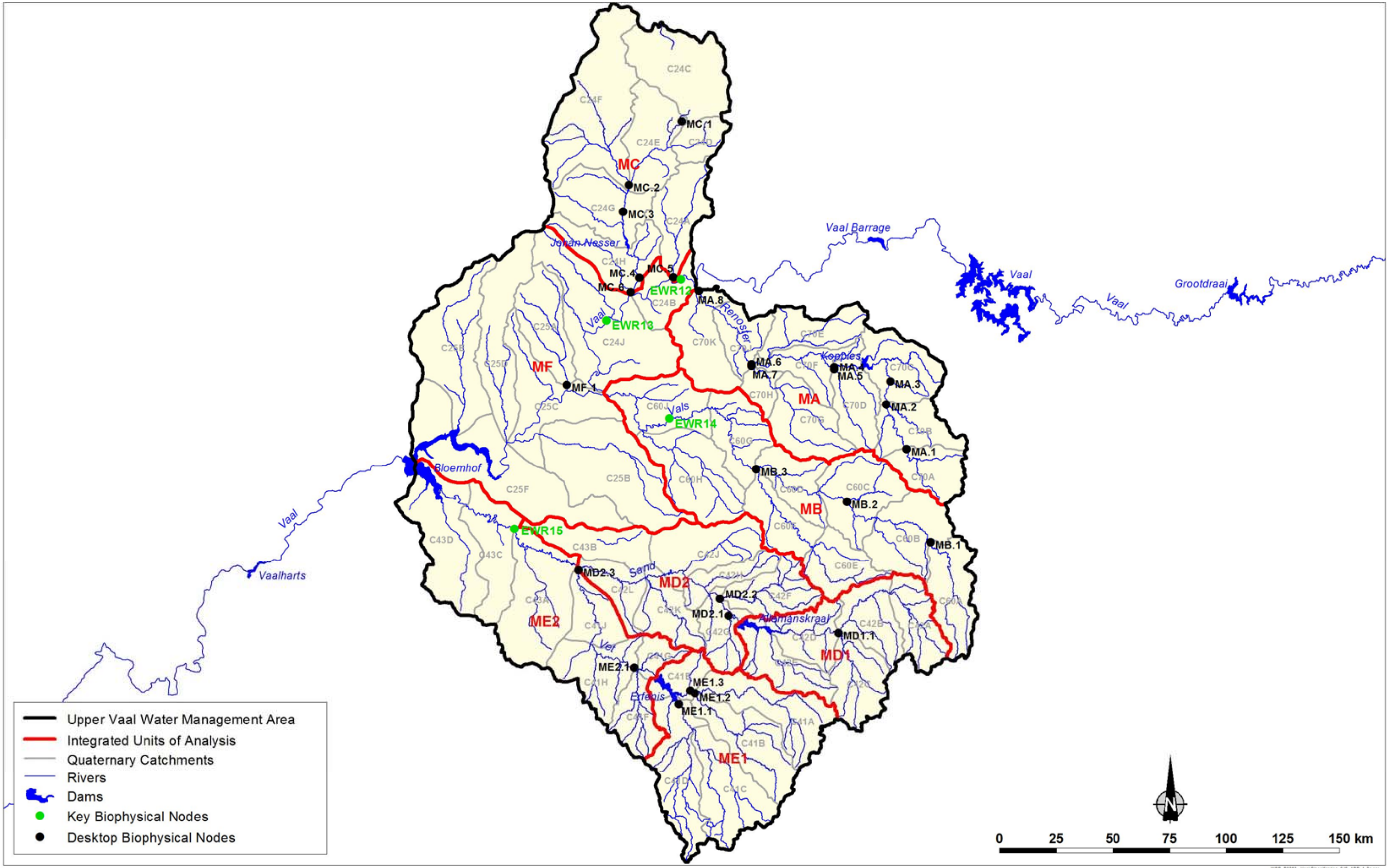
Catchment Maps of the Integrated Units of Analysis



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS, GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8, 9, 10

Upper Vaal Integrated Units of Analysis (IUA)

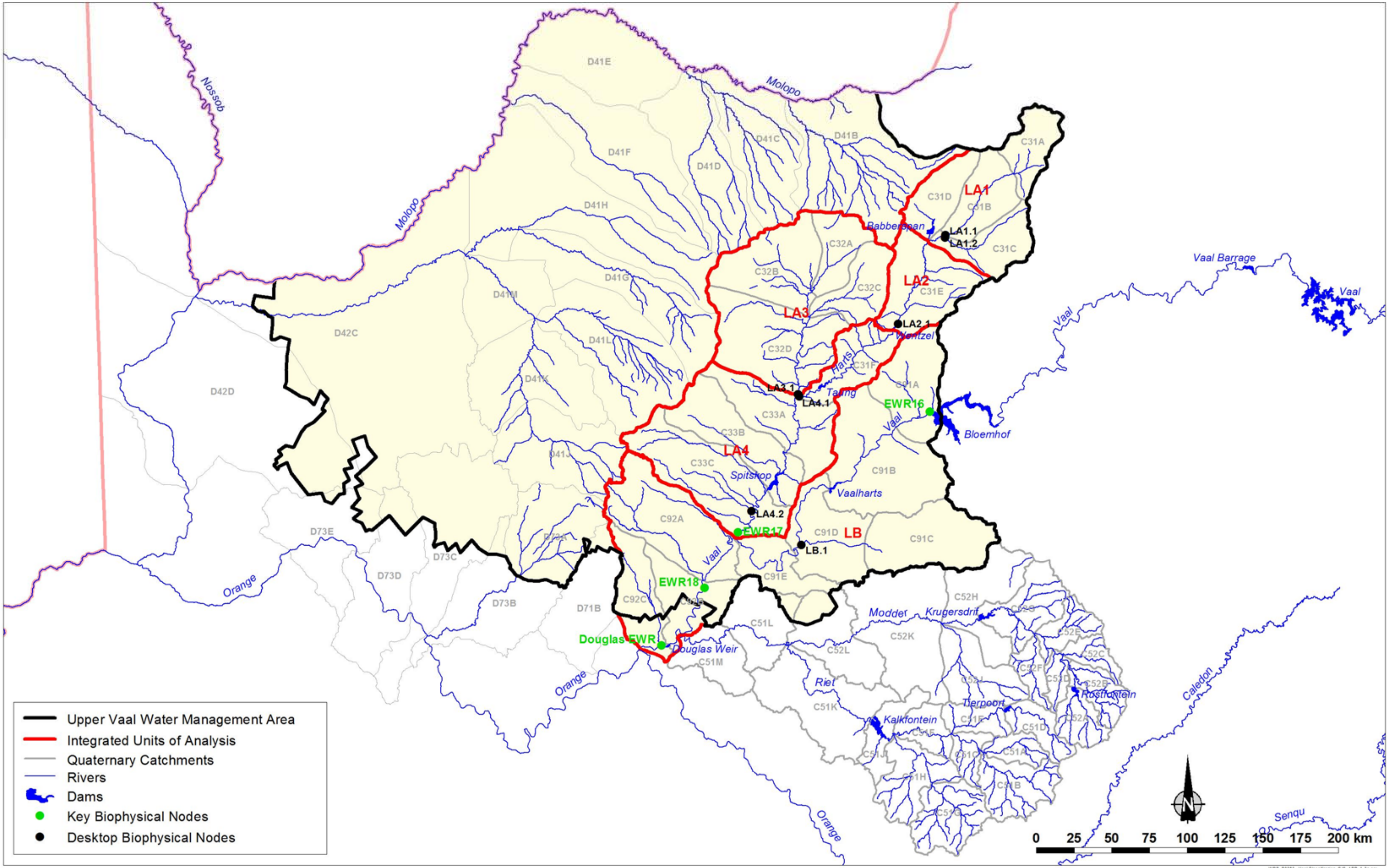
B-1



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS, GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8, 9, 10

Middle Vaal Integrated Units of Analysis (IUA)

B-2



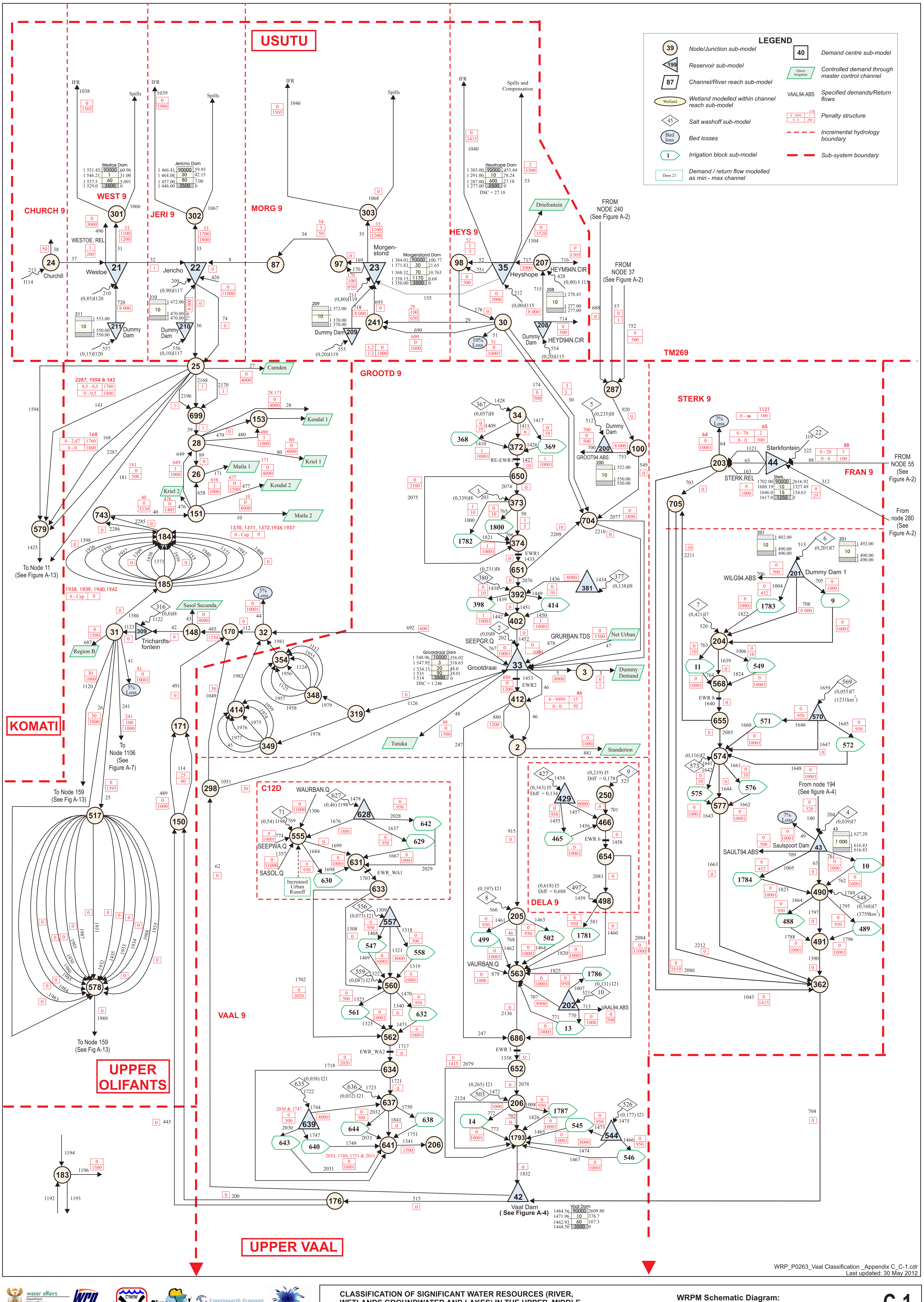
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS, GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8, 9, 10

Lower Vaal Integrated Units of Analysis (IUA)

B-3

Appendix C:

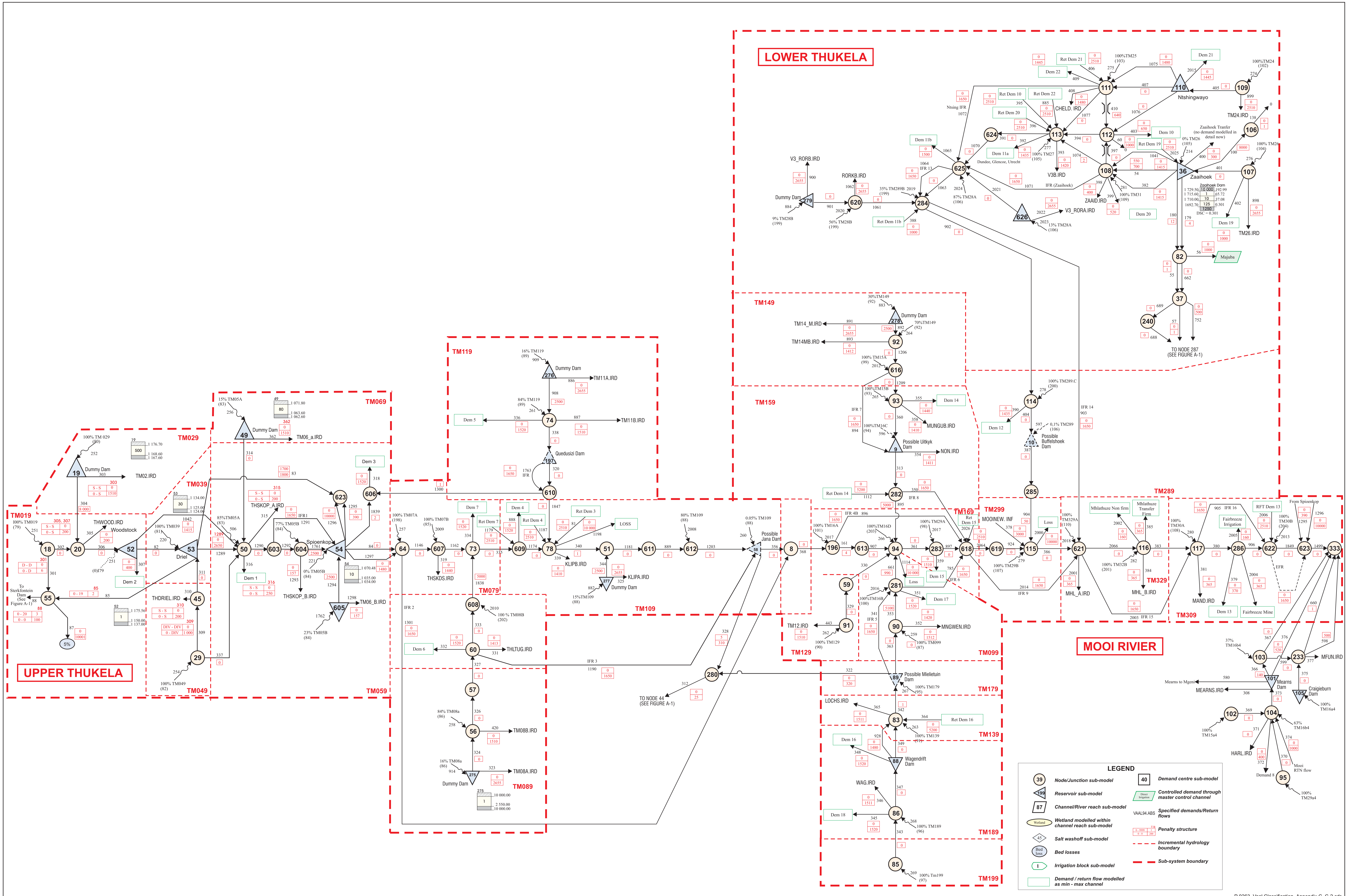
WRPM Schematic Diagrams



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram:
Upper Olifants, Upper Vaal and Usutu Sub-systems

C-1

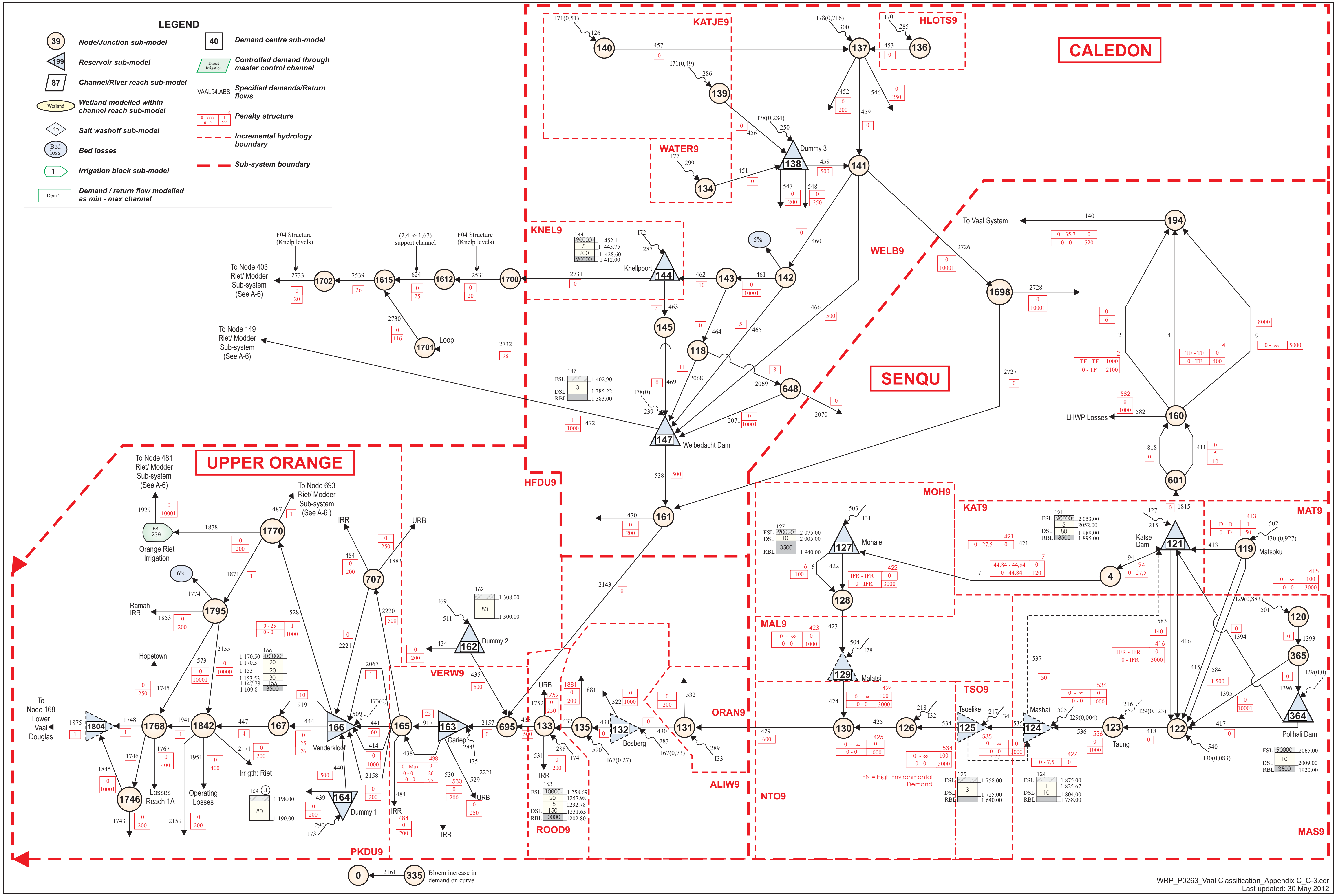


P 0263_Vaal Classification_Appendix C_C-2.cdr
Last updated: 30 May 2012

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Upper Thukela and Lower Sub-systems

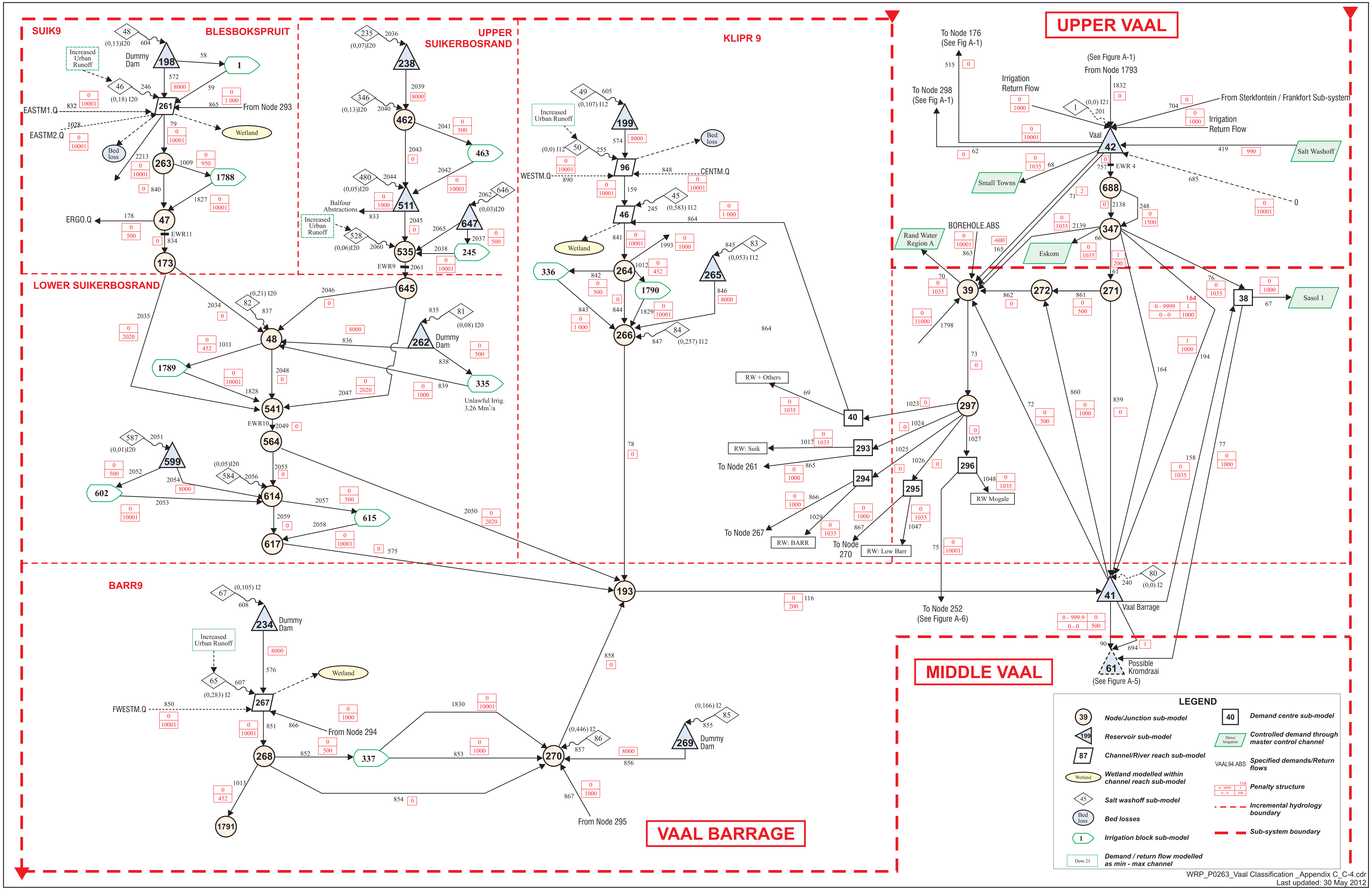
C-2



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Senqu, Caledon and Upper Orange Sub-system

C-3



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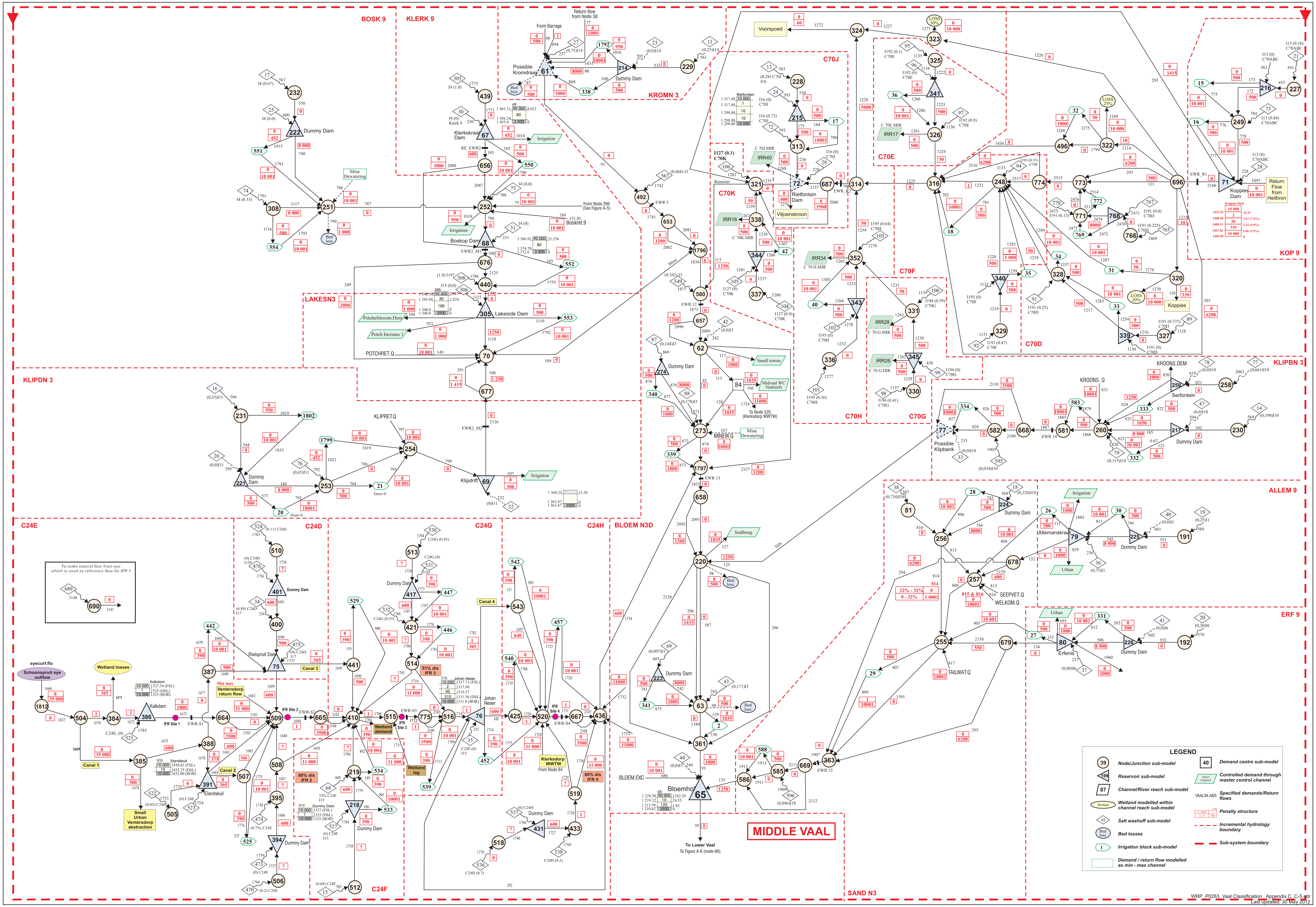
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Vaal Dam to Vaal Barrage

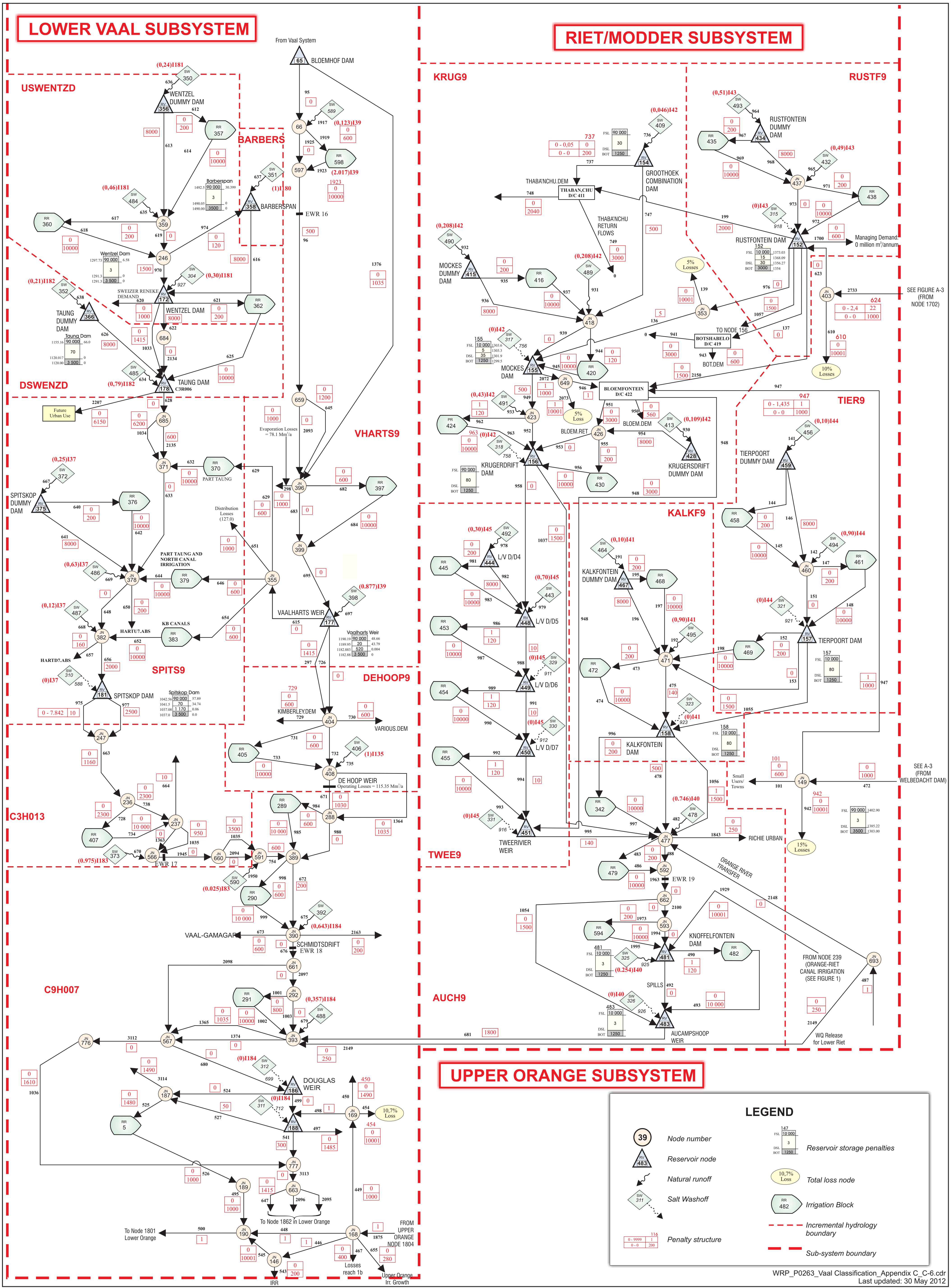
C-4



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic diagram: Middle Vaal Sub-system

C-5



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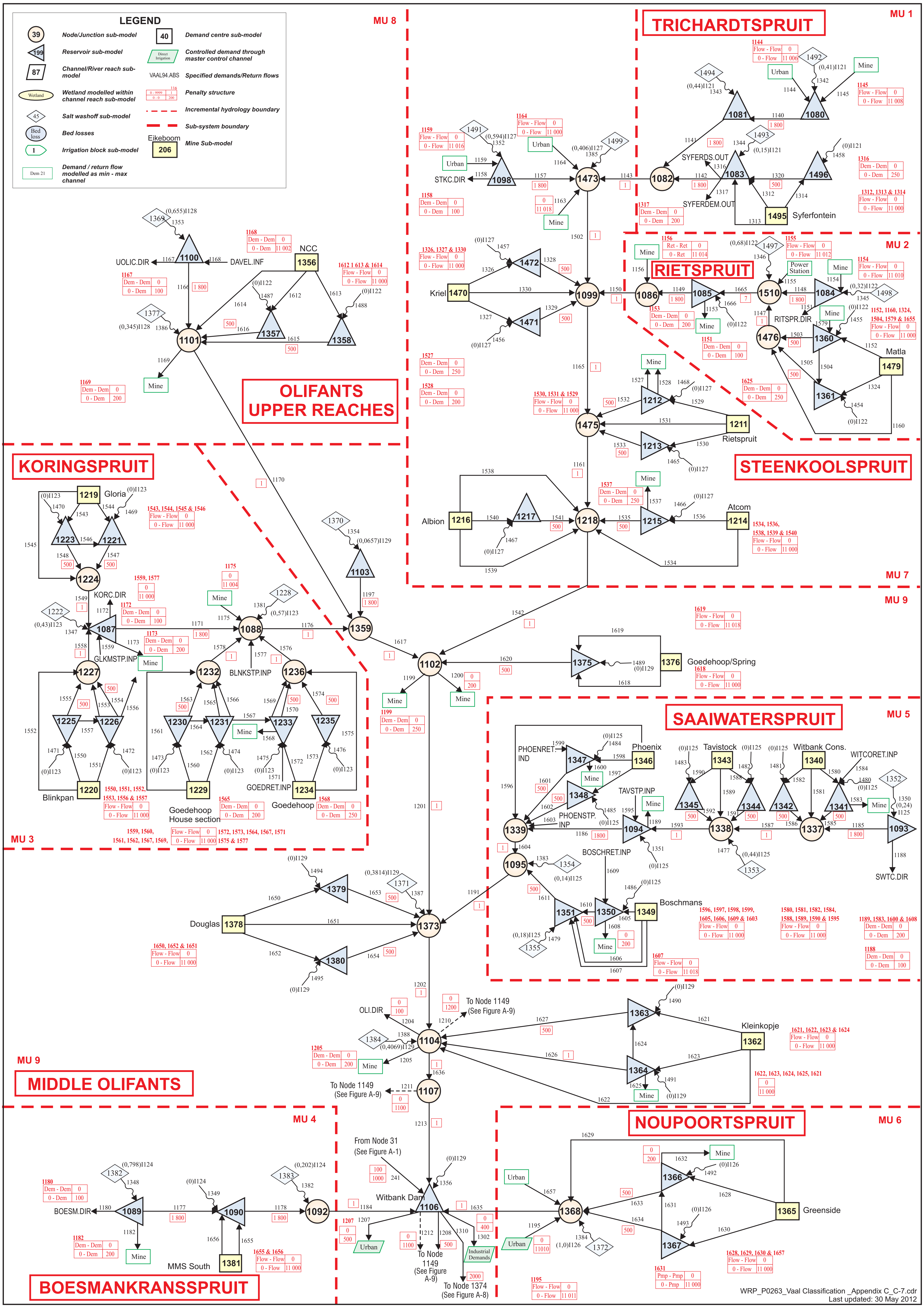
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram:
Lower Vaal & Riet/ Modder Sub-systems

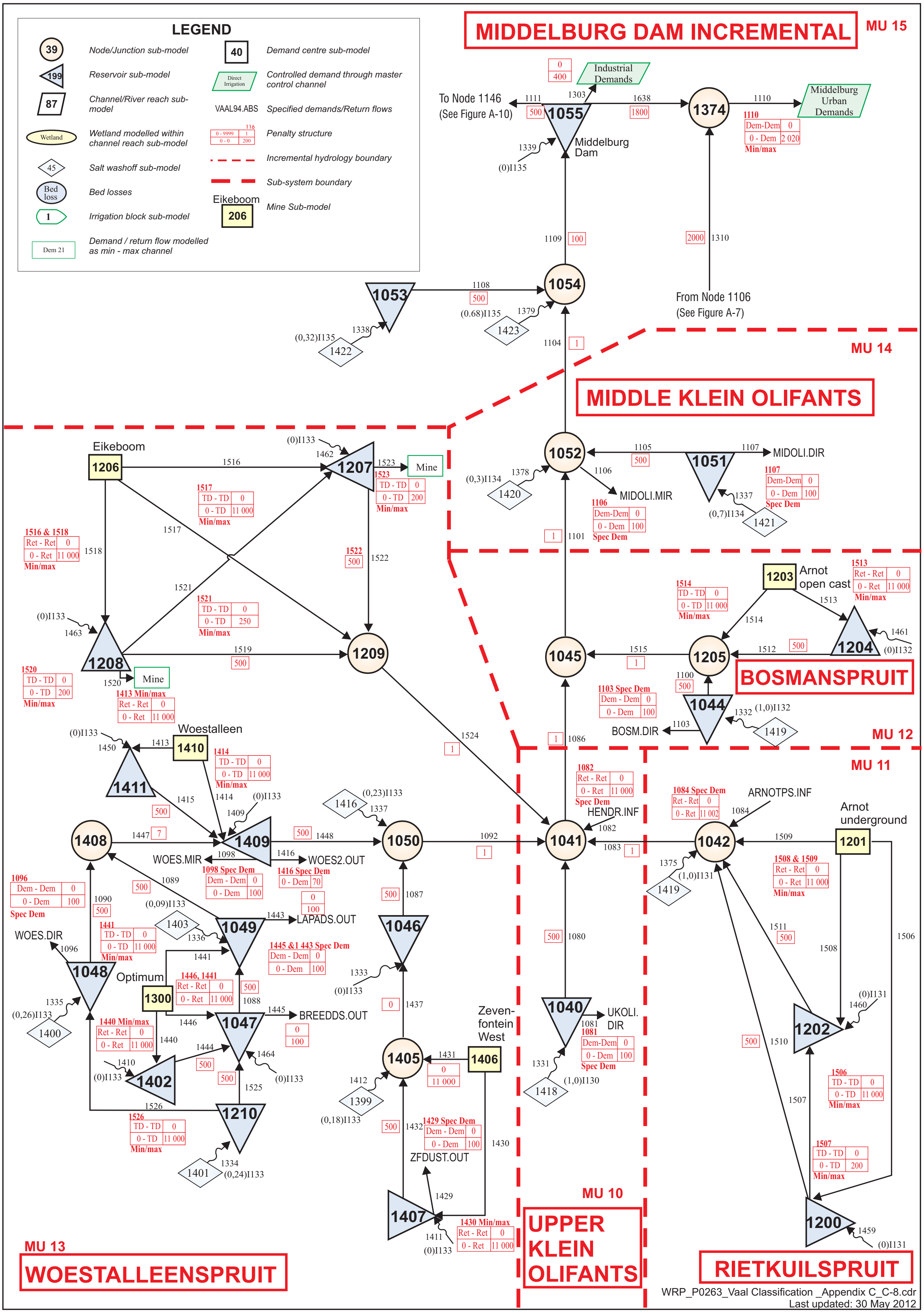
C-6



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Witbank Dam Sub-system with Penalty Structure

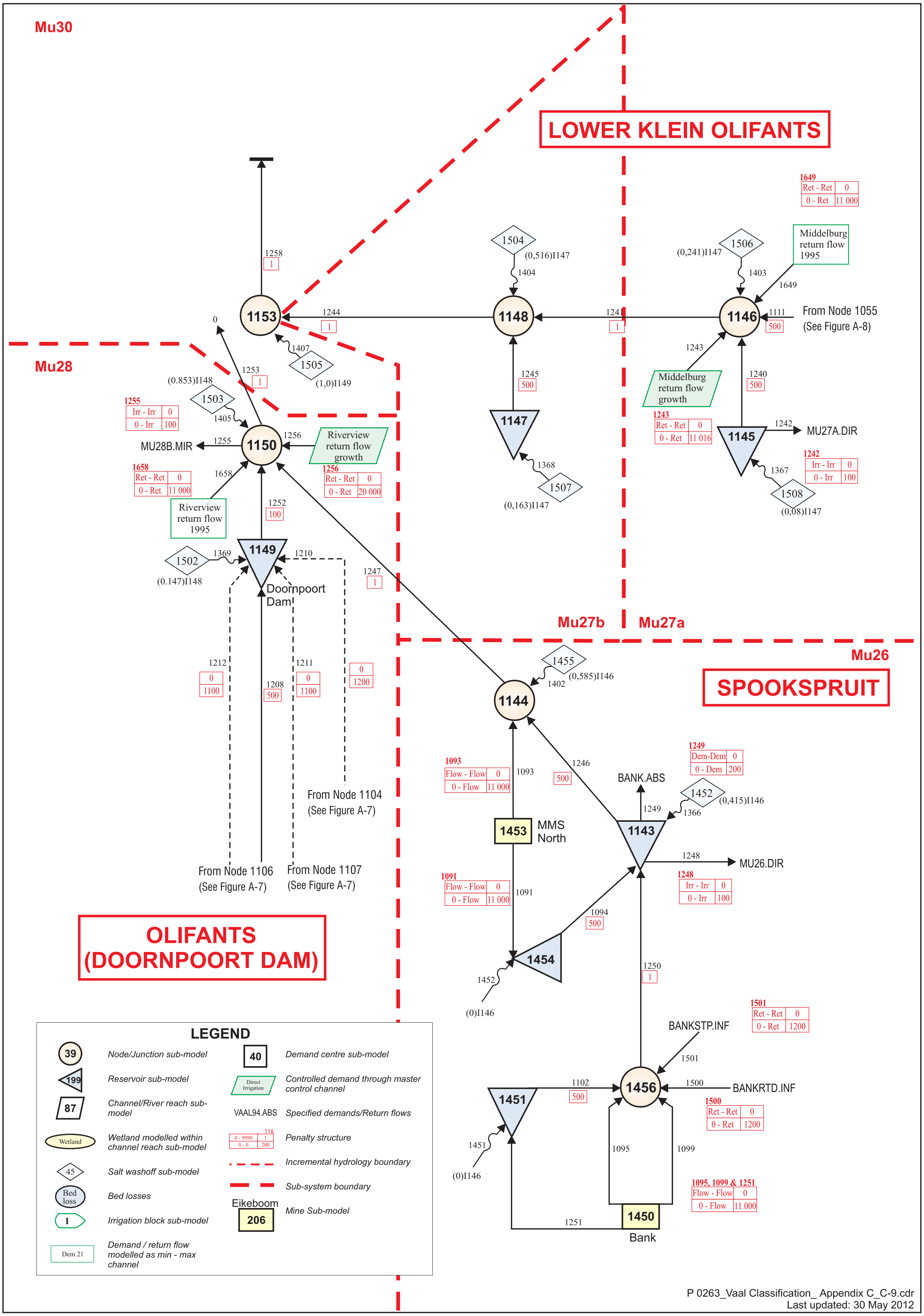
C-7



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Middelburg Dam Sub-system With Penalty Structures

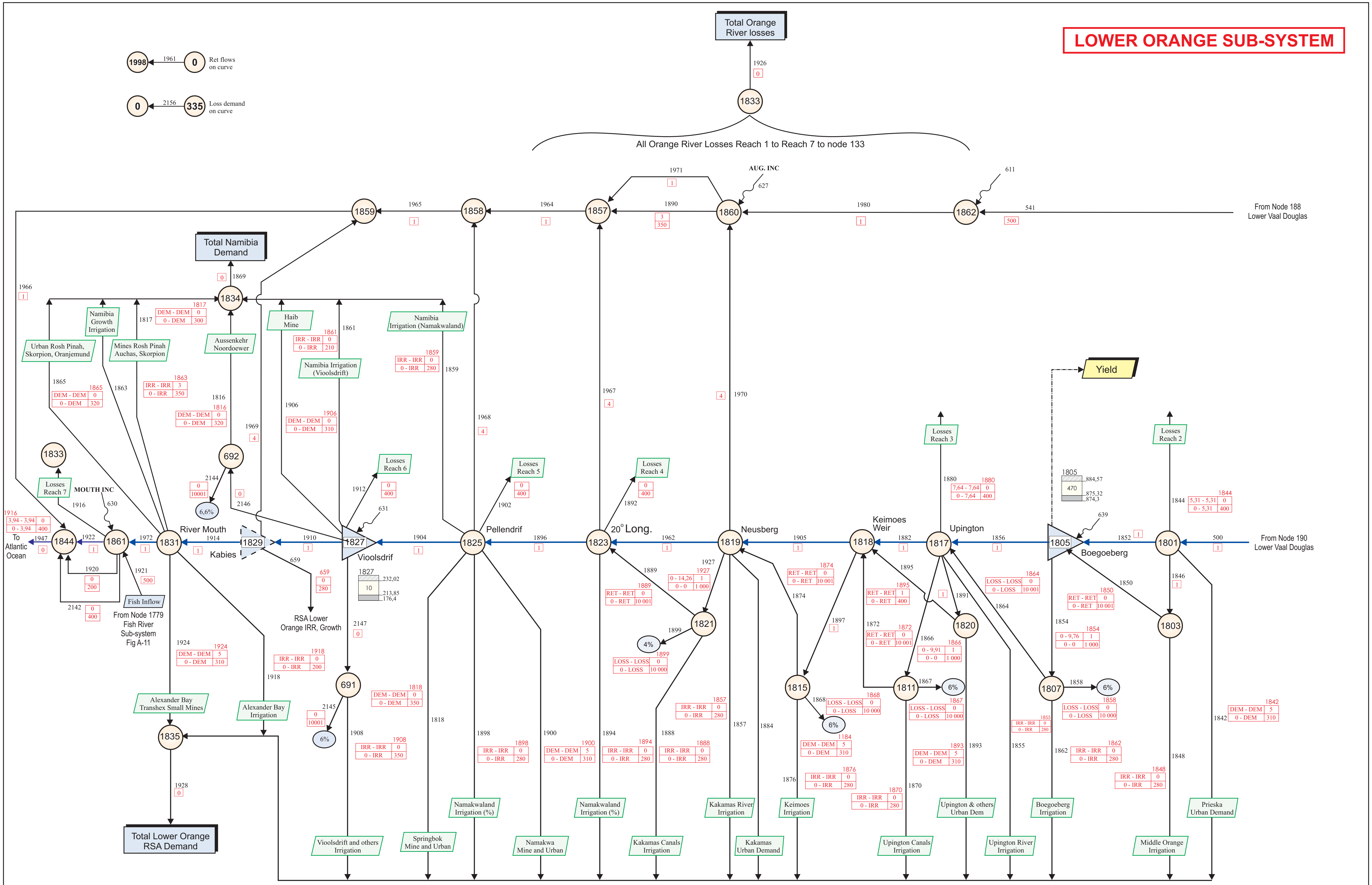
C-8



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Loskop Dam Incremental Sub-system With Penalty Structures

C-9



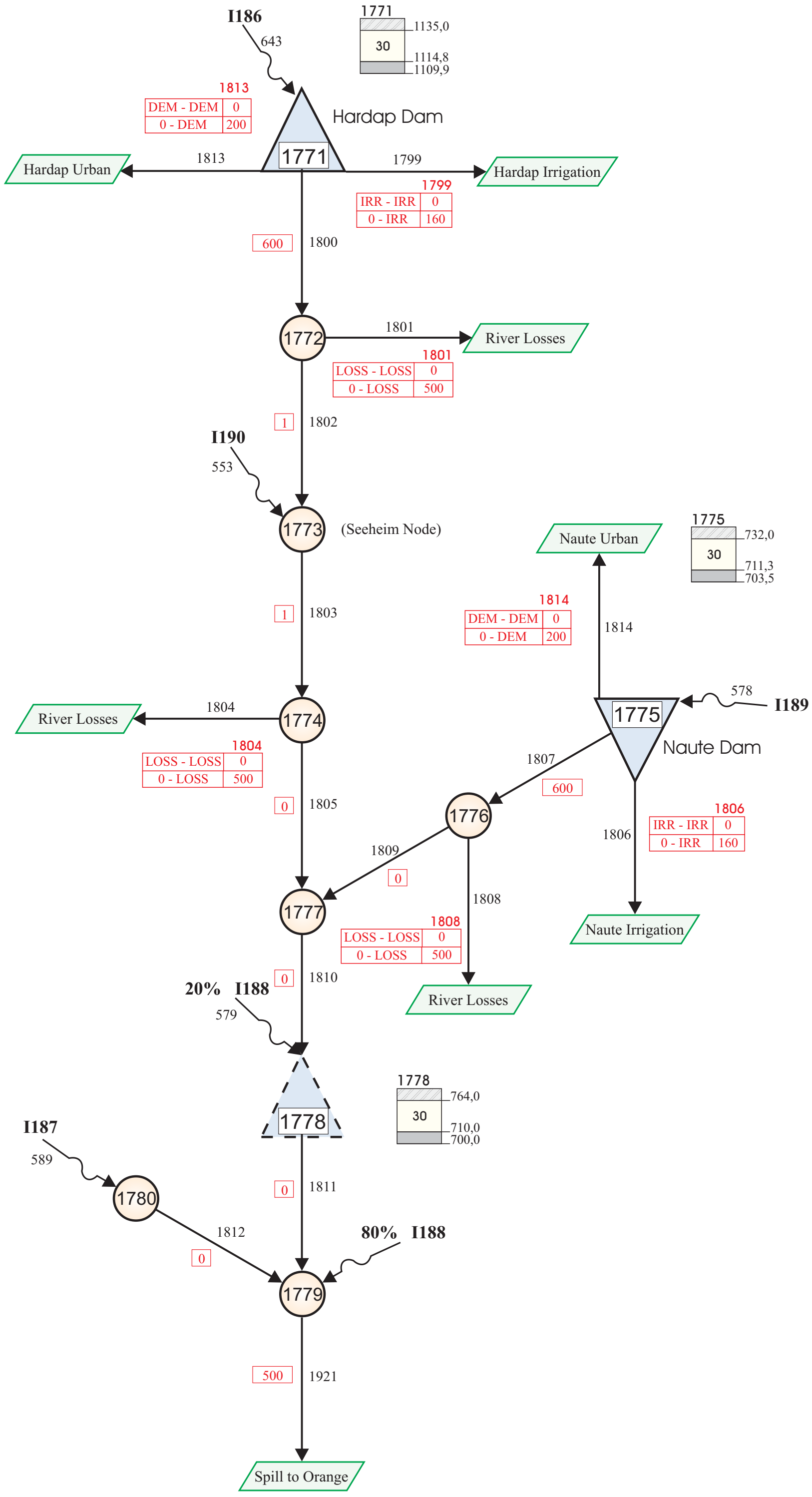
WRP_P0263_Vaal Classification _Appendix C_C-10.cdr
Last updated: 30 May 2012

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

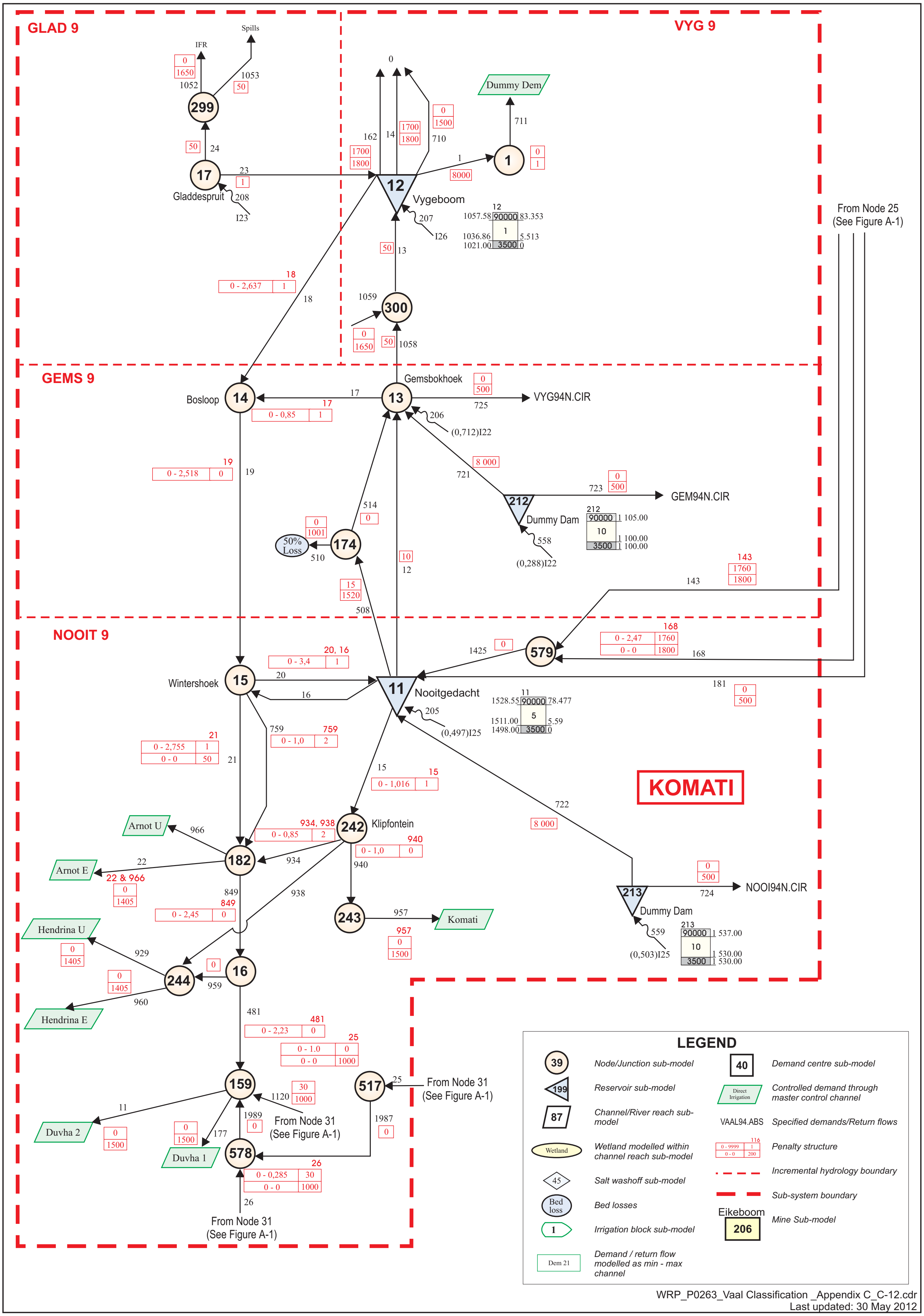
WRPM Schematic Diagram: Lower Orange Sub-system

C-10

NAMIBIA: FISH RIVER SUB-SUSTEM



To Node 1844
(See Figure A-10)



CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRPM Schematic Diagram: Komati Sub-system

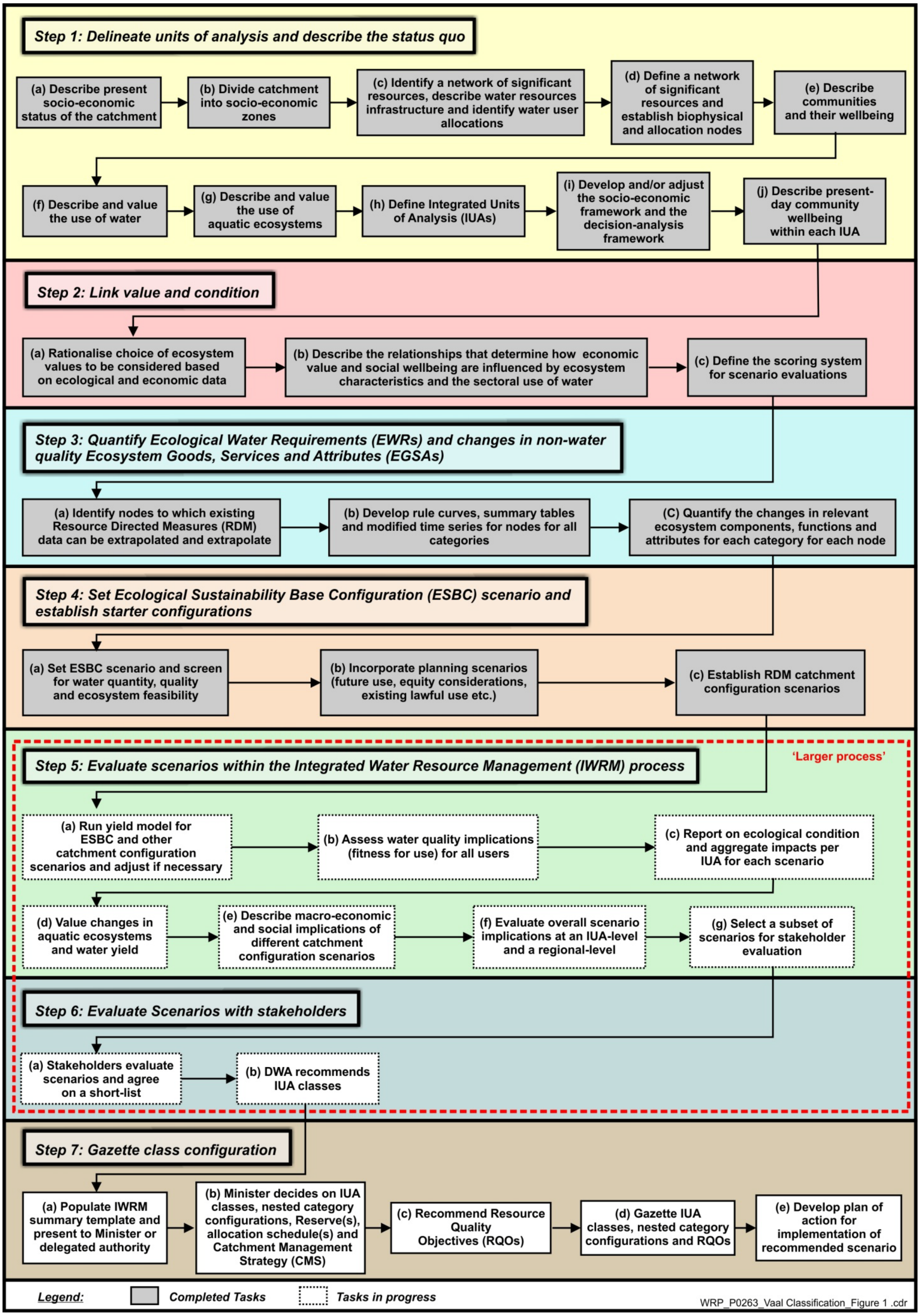
C-12

Appendix D:

Water Resource Classification System Guidelines:

Seven Step Diagram

Figure D-1: Seven Step Diagram of the WRCS Guidelines



Appendix E:

Hydrological Database

Table E-1: Summary of VRSAU Study Reports

Sub-catchment	Hydrology Report : Title and number	Hydro-salinity Report : Title and number	System Analysis Report : Title and number
Upper Vaal	Hydrology of the Upper Vaal Catchment (PC000/00/16296)	Hydro-salinity Model Calibration : Upper Vaal Catchment (PC000/00/18096)	Historic and Long-term Stochastic Yield Analysis of the Grootdraai Dam and Bloemhof Dam sub-systems (PC000/00/17696)
Vaal Barrage	Hydrology of the Vaal Barrage Catchment (PC000/00/ 16396)	Hydro-salinity Model Calibration: Vaal Barrage Catchment Part (b) Monthly Analysis (PC000/00/18196)	
Middle Vaal	Hydrology of the Middle Vaal Catchment (PC000/00/16496)	Hydro-salinity Model Calibration : Middle Vaal Catchment (PC000/00/18296)	
Lower Vaal	Hydrology of the Lower Vaal Catchment (PC000/00/16596)	Hydro-salinity Model Calibration : Lower Vaal Catchment (PC000/00/18396)	
Komati	Hydrology of the Komati Catchment Upstream of Swaziland (PC000/00/16696)	Evaluation of water quality modelling requirements: Komati and Usutu sub-systems (PC000/00//19196)	Historic and Long-term Stochastic Yield Analysis of the Komati and Usutu sub-systems (PC000/00/17496)
Usutu	Hydrology of the Usutu Catchment Upstream of Swaziland (PC000/00/16796)		
Thukela	Tugela-Vaal Transfer Scheme – Streamflow Hydrology : Vol 1 & 2 (PC000/00/12894 & PV000/00/0894)		Historic and Long-term Stochastic Yield Analysis of the Heyshope Dam and Zaaihoek Dam sub-systems (PC000/00/17596)
Senqu	Lesotho Highlands Hydrology (PC000/00/16996)		Historic and Long-term Stochastic Yield Analysis of the Senqu sub-system (PC000/00/17796)

Table E-2: Summary of point rainfall data

Hydrology reference No.	Reservoir name	File name	MAP (mm)
Upper Vaal			
I 5	No reservoir (Represents catchment rainfall)	DELA9.RAN	712
I 7	Saulspoort Dam & dummy dam	FRAN9.RAN	679
I 8	Grootdraai Dam & dummy dam	GROOTD9.RAN	675
I 19	Sterkfontein Dam	STERK9.RAN	735
I 21	Vaal Dam & dummy dam	VAAL9.RAN	643
Vaal Barrage			
I 2	Vaal Barrage & dummy dam	BARR9.RAN	638
I 12	Klip River dummy dam	KLIPR9.RAN	773
I 20	Suikerbosrant River dummy dam	SUIK9.RAN	678
Middle Vaal			
I 1	Allemanskraal Dam & dummy dam	ALLEM9.RAN	591
I 3	Bloemhof Dam & dummy dam	BLOEM9.RAN	493
I 4	Boskop Dam & dummy dam	BOSK9.RAN	597
I 6	Erfenis Dam & dummy dam	ERF9.RAN	579
I 9	Klerkskraal Dam	KLERK9.RAN	605
I 10	Possible Klipbank Dam & dummy dam	KLIPB9.RAN	544
I 11	Klipdrift Dam & dummy dam	KLIPD9.RAN	620
I 13	Koppies Dam & dummy dam	KOP9.RAN	600
I 14	Possible Kromdraai Dam & dummy dam	KROM9.RAN	609
I 15	Johan Neser Dam & dummy dam	NESER9.RAN	577
I 16	Possible Rietfontein Dam & dummy dam	RIETF9.RAN	573
I 17	Rietspruit Dam	RIETS9.RAN	580
I 18	Sand River dummy dam	SAND9.RAN	461
Upper Thukela			
I 79	No reservoir (Represents catchment rainfall)	TM019.RAN	1020
I 80	Woodstock Dam & dummy dam	TM029.RAN	1023
I 81	Driel Barrage	TM039.RAN	1021
I 82	No reservoir (Represents catchment rainfall)	TM049.RAN	987
I 83	No reservoir (Represents catchment rainfall)	TM059.RAN	731

Hydrology reference No.	Reservoir name	File name	MAP (mm)
I 84	Spioenkop Dam & dummy dam	TM069.RAN	731
<u>Komati</u> I25	Nooitgedacht Dam & dummy dam	NOOIT9.RAN	704
I22	Gemsbokhoek dummy dam	GEMS9.RAN	761
I26	Vygeboom Dam	VYG9.RAN	866
I23	Gladdespruit	GLAD9.RAN	1039
<u>Usutu</u> I119	Morgenstond Dam & dummy dam	MORG9.RAN	822
I117	Jericho Dam & dummy dam	JERI9.RAN	852
I120	Westoe Dam & dummy dam	WEST9.RAN	816
I114	Churchill weir	CHURCH9.RAN	865
<u>Assegaai</u> I 115	Heyshope Dam & dummy dam	HEYS9.RAN	859
<u>Slang</u> I 104	Zaaihoek Dam	TM269.RAN	788
<u>Sengu</u> I27	Katse Dam	KAT9.RAN	750
I30	Matsoku Weir	MAT9.RAN	760
I31	Mohale Dam	MOH9.RAN	853

Table E-3 : Summary of lake evaporation data (in mm)

Node no.	Reservoir name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
11	Nooitgedacht Dam	154	154	165	167	151	144	111	94	75	79	107	138	1539
12	Vygeboom Dam	137	137	153	155	144	136	110	94	78	81	100	124	1449
19	Woodstock dummy dam	109	101	107	106	92	92	81	78	63	71	96	108	1104
21	Westoe Dam	126	130	144	139	121	121	100	88	74	78	95	118	1334
22	Jericho Dam	126	125	143	142	127	121	99	83	66	71	88	112	1303
23	Morgenstond Dam	122	132	147	151	136	125	103	88	73	78	96	114	1365
24	Churchill Weir	126	130	144	139	121	121	100	88	74	78	95	118	1334
33	Grootdraai Dam	156	157	175	179	156	146	117	95	75	80	102	133	1571
35	Heyshope Dam	129	139	145	161	140	130	114	97	82	85	96	120	1438
36	Zaaihoek Dam *	113	119	129	127	115	111	89	73	60	65	81	96	1178
41	Vaal Barrage	127	134	149	145	126	115	85	64	48	51	72	101	1217
42	Vaal Dam	146	151	166	165	149	139	103	85	67	62	93	127	1453
43	Saulspoort dummy dam	122	125	135	133	115	107	81	65	52	55	77	104	1171
44	Sterkfontein Dam	151	157	168	170	143	138	107	94	85	87	105	136	1541
49	Spioenkop dummy dam	116	108	114	113	99	98	86	84	67	75	102	115	1177
52	Woodstock Dam	130	148	164	161	143	126	103	83	63	69	90	117	1397
53	Driel Barrage	130	148	164	161	143	126	103	83	63	69	90	117	1397
54	Spioenkop Dam	137	156	168	160	144	132	103	86	67	75	98	123	1449
61	Possible Kromdraai Dam	147	154	169	171	143	130	95	71	53	58	82	115	1388
65	Bloemhof Dam	187	208	226	221	173	162	119	97	72	78	109	150	1802
67	Klerkskraal Dam	153	166	175	160	146	137	110	91	69	74	100	134	1515
68	Boskop Dam	151	161	173	172	146	133	103	84	66	71	98	131	1489
69	Klipdrift Dam	151	161	173	172	146	133	103	84	66	71	98	131	1489

Node no.	Reservoir name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
71	Koppies Dam	164	171	192	182	162	147	114	90	71	79	106	143	1621
72	Possible Rietfontein Dam	148	156	172	171	145	132	96	71	54	58	83	117	1403
75	Rietspruit Dam	173	185	191	190	159	160	125	108	82	85	117	152	1727
76	Johan Neser Dam	164	172	180	176	144	130	102	84	65	75	103	138	1533
77	Possible Klipbank Dam	147	154	169	171	143	130	95	71	53	58	82	115	1388
79	Allemanskraal Dam	154	171	198	194	160	144	102	78	58	64	89	127	1539
80	Erfenis Dam	176	195	220	213	172	157	109	85	63	70	99	141	1700
121	Katse Dam	127	126	122	135	103	103	73	72	49	58	88	105	1162
127	Mohale Dam	126	125	122	134	102	103	73	71	48	57	87	104	1151
198	Upper Suikerbosrant dummy dam	143	145	158	155	134	125	95	76	60	64	90	121	1366
199	Upper Klip River dummy dam	147	154	169	170	143	130	95	70	53	58	82	115	1386
200	Grootdraai dummy dam	121	121	132	132	119	114	87	73	60	63	85	107	1214
201	Frankfort dummy dam	124	125	137	134	116	108	82	66	52	55	78	104	1181
202	Vaal dummy dam	134	137	149	146	127	119	90	72	58	61	86	114	1293
208	Heyshope dummy dam	111	117	127	129	116	112	87	72	59	64	81	103	1178
209	Morgenstond dummy dam	122	132	147	151	136	125	103	88	73	78	96	114	1365
210	Jericho dummy dam	126	125	143	142	127	121	99	83	66	71	88	112	1303
211	Westoe dummy dam	126	130	144	139	121	121	100	88	74	78	95	118	1334
212	Gemsbokhoek dummy dam	108	109	125	133	119	117	89	76	61	65	80	97	1179
213	Nooitgedacht dummy dam	112	113	130	137	123	121	92	79	64	67	83	100	1221
214	Kromdraai dummy	147	154	169	170	143	130	95	71	53	58	82	115	1387

Node no.	Reservoir name	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
	dam													
215	Rietfontein dummy dam	143	149	164	165	139	126	92	69	51	56	79	112	1345
216	Koppies dummy dam	138	145	159	160	135	122	90	67	50	54	77	108	1305
217	Klipbank dummy dam	143	149	164	164	139	126	92	69	52	56	79	112	1345
218	Johan Neser dummy dam	164	172	180	176	144	130	102	84	65	75	103	138	1533
221	Klipdrift dummy dam	151	157	165	161	133	120	93	77	60	68	94	126	1405
222	Boskop dummy dam	151	157	165	161	133	120	93	77	60	68	94	126	1405
223	Lower Bloemhof dummy dam	167	184	194	185	148	132	100	78	63	71	97	134	1553
224	Sand River dummy dam	165	181	190	182	147	130	99	77	62	70	96	131	1530
225	Allemanskraal dummy dam	128	146	169	167	132	114	77	56	40	46	66	99	1240
226	Erfenis dummy dam	132	151	175	173	136	118	80	58	41	47	68	102	1281
234	Upper Vaal Barrage dummy dam	144	152	167	167	141	128	93	70	52	57	81	113	1365
259	Serfontein Dam	143	149	164	164	139	126	92	69	52	56	79	112	1345
262	Lower Suikerbosrant dummy dam	143	145	158	155	134	125	95	76	60	64	90	121	1366
265	Lower Klip River dummy dam	147	154	169	170	143	130	95	70	53	58	82	115	1386
269	Lower Vaal Barrage dummy dam	144	152	167	167	141	128	93	70	52	57	81	113	1365
274	Upper Bloemhof dummy dam	167	184	194	185	148	132	100	78	63	71	97	134	1553

Table E-4: Summary of streamflow data

Hydrology reference No.	Incremental Sub-catchment name	Incremental catchment area (km²)	Natural MAR (million m³/a) (1920 – 94)	.INC File name
Upper Vaal				
I5	Delangesdrift	4 158	249.49	DELA9.INC
I 7	Frankfort	15 498	733.31	FRAN9.INC
I 8	Grootdraai Dam	7 995	457.68	GROOTD9.INC
I 19	Sterkfontein Dam	195	18.12	STERK9.INC
I 21	Vaal Dam	10 792	518.65	VAAL9.INC
Vaal Barrage				
I 2	Vaal Barrage	2 828	68.50	BARR9.INC
I 12	Klip River	2 282	96.24	KLIPR9.INC
I 20	Suikerbosrant River	3 541	92.34	SUIK9.INC
Middle Vaal				
I 1	Allemanskraal Dam	3 628	96.13	ALLEM9.INC
I 3	Bloemhof Dam	13 894	153.69	BLOEM9.INC
I 4	Boskop Dam	1 756	35.78	BOSK9.INC
I 6	Erfenis Dam	4 724	167.46	ERF9.INC
I 9	Klerkskraal Dam	1 001	37.69	KLERK9.INC
I 10	Possible Klipbank Dam	6 765	155.05	KLIPB9.INC
I 11	Klipdrift Dam	890	21.08	KLIPD9.INC
I 13	Koppies Dam	2 160	59.14	KOP9.INC
I 14	Possible Kromdraai Dam	2 028	42.84	KROM9.INC
I 15	Johan Neser Dam	2 829	51.68	NESER9.INC
I 16	Possible Rietfontein Dam	3 605	60.52	RIETF9.INC
I 17	Rietspruit Dam	1 714	36.04	RIETS9.INC
I 18	Lower Sand River	8 463	159.13	SAND9.INC
Sub-total		**100 746**	**3310.56**	
Upper Thukela				
I 79	Upstream of Thukela diversion weirs	198	73.63	TM019.INC
I 80	Woodstock Dam	973	359.46	TM029.INC
I 81	Driel Barrage	107	19.41	TM039.INC
I 82	Driel Barrage (Mlambonja River)	399	219.41	TM049.INC
I 83	Spioenkop Dam	597	88.35	TM059.INC
I 84	Spioenkop dummy dam	207	31.04	TM069.INC
Sub-total		**2 481**	**791.3**	
Komati				
I 25	Nooitgedacht Dam	1 588	66.28	NOOIT9.INC
I 22	Gemsbokhoek	1 015	92.84	GEMS9.INC

Hydrology reference No.	Incremental Sub-catchment name	Incremental catchment area (km²)	Natural MAR (million m³/a) (1920 – 94)	.INC File name
I 23	Gladdespruit	186	48.16	GLAD9.INC
I 26	Vygeboom Dam	529	101.43	VYG9.INC
I 24	Hooggenoeg	2 190	243.38	HOOG9.INC
Sub-total		**5 508**	**552.09**	
Usutu				
I 119	Morgenstond Dam	548	56.33	MORG9.INC
I 117	Jericho Dam	219	23.69	JERI9.INC
I 120	Westoe Dam	533	42.63	WEST9.INC
I 114	Churchill Weir	70	6.88	CHURCH9.INC
Sub-total		**1 370**	**129.53**	
Assegaai				
I 115	Heyshope Dam	1 120	129.03	HEYS9.INC
Slang				
I 104	Zaaihoek Dam	622	99.99	TM269.INC
Senqu				
I 27	Katse Dam	1 867	546	KAT9.INC
I 30	Matsoku Weir	652	94	MAT9.INC
I 31	Mohale Dam	938	302	MOH9.INC
Sub-total		**3 457**	**942**	

Table E-5: Summary of streamflow data for Renoster River catchment

Hydrology reference No.	Incremental/ Quaternary Catchment Reference	Gross Catchment Area (km^2)	Natural MAR (million m^3/a) 1920 to 1994	.INC File name
I13	Koppies Dam (C70A, B & C)	2160	59.14	KOP9.INC
I191	C70D	675	12.58	C70D.INC
I192	C70E	693	11.96	C70E.INC
I193	C70F	564	9.46	C70F.INC
I194	C70G	901	13.95	C70G.INC
I195	C70H	251	3.99	C70H.INC
II96	C70J	521	8.58	C70J.INC
I127	C70K	891	10.92	C70K.INC
Total for Renoster catchment:		**6656**	**130.58**	**-**

Table E-6: Summary of streamflow data for Schoonspruit River catchment

Hydrology reference No.	Quaternary Catchment Reference	Gross Catchment Area (km^2)	Natural MAR (million m^3/a) for period 1920 to 1994	.INC File name
-	Schoonspruit Eye	-	60.60	-
-	C24C	1350	0.00	-
I128	C24D (Rietspruit Dam)	364	7.29	C24D.INC
I129	C24E	925	9.81	C24E.INC
I130	C24F	2020	19.50	C24F.INC
I131	C24G	985	16.85	C24G.INC
I132	C24H	840	8.83	C24H.INC
	Total (excluding eye)	**6484**	**62.28**	**-**
	Total (including eye)	**6484**	**122.88**	**-**

Table E-7: Summary of final updated incremental natural flows for sub-catchments within the new Large Bloemhof Dam incremental catchment

Hydrology reference No.		Gross Area (km^2)	Natural MAR - 1920-1994 (million m^3/a)	.INC File name
I3	Bloemhof Dam (small) incremental	14 113	129.27	BLOEMN3.INC
I14	Kromdraai	2,028	40.86	KROMN3.INC
I11	Klipdrift	890	20.26	KLIPDN3.INC
I10	Klipbank	7 871	150.77	KLIPBN3.INC
I18	Lower Sand/Vet River	10 800	156.60	SANDN3.INC
I197	Lakeside Dam incremental	345	9.36	LAKESN3.INC
-	**New Large Bloemhof incremental**	**36 047**	**507.12**	**-**

Table E-8: Summarised information on major dams in the IVRS

Dam Name	Quaternary Catchment	River	Gross Catchment Area (km^2)	Natural MAR (million m^3/a)	Gross Full Supply Capacity (million m^3)
Komati Sub-system					
Nooitgedacht	X11C	Komati	1 588	66.28	78.48
Vygeboom	X11H	Komati	3 132	260.55	83.35
Usutu Sub-system					
Westoe	W54B	Usutu	533	42.63	60.76
Jericho	W53B	Mpama	219	23.69	59.93
Morgenstond	W53A	Ngwempisi	548	56.33	100.77
Heyshope Dam Sub-system					
Heyshope	W51B	Assegaai	1 120	129.03	453.43
Zaaihoek Dam Sub-system					
Zaaihoek	V31A	Slang	622	99.99	184.87
Grootdraai Sub-system					
Grootdraai	C11L	Vaal	7 995	457.68	356.02
Bloemhof Dam Sub-system					
Woodstock	V11D, V11E	Thukela	1 171	433.13	373.26
Sterkfontein	C81D	Wilge	195	18.12	2616.92
Vaal	C12L, C83M	Vaal	38 638	1 977.3	2609.80
Bloemhof	C25F, C43D	Vaal	108 125	3 315	1241.29
Mooi River Sub-system					
Klerkskraal	C23F	Mooi	1 001	37.69	8.02
Boskop	C23G	Mooi	2 757	73.47	21.26
Lakeside	C23H	Mooi	3 102	82.83	2.03
Klipdrift	C23J	Loopspruit	890	21.08	13.58
Renoster River Sub-system					
Koppies	C70C	Renoster	2 160	59.14	42.31

Dam Name	Quaternary Catchment	River	Gross Catchment Area (km^2)	Natural MAR (million m^3/a)	Gross Full Supply Capacity (million m^3)
Schoonspruit Sub-system					
Rietspruit	C24D	Schoonspruit	1 714	67.89	7.28
Johan Neser	C24G	Schoonspruit	5 644	114.05	5.67
Sand-Vet Sub-system					
Allemanskraal	C42E	Sand	3 628	96.13	179.31
Erfenis	C41E	Vet	4 724	167.46	212.20
Harts River Sub-system					
Taung	C31F	Harts	11 023	45.87	65.21
Spitskop	C33B	Harts	26 922	136.45	57.89
Riet-Modder Sub-system					
Rustfontein	C52A	Modder	937	30.7	71.22
Krugersdrift	C52G	Modder	6 331	145.1	73.19
Tierpoort	C51D	Riet	922	23.8	34.02
Kalkfontein	C51J	Riet	10 268	239.7	325.13
Senqu Sub-system					
Katse (#)	-	Malibamatsu	1 867	551.5	1950.00
Mohale (#)	-	Senqunyane	938	304.8	946.90
Polihali (#) (%)	-	Senqu	3 290	684.4	1857.24

Note: (#) No quaternary catchments in Lesotho

(%) Proposed dam

Appendix F:

Summary of Water Requirement Projections

Table F-1: **Base Scenario (Scenario A) water demand and return flow projections for the Integrated Vaal River System as adopted for the 2011/2012 Annual Operating Analysis**
Based on Rand Water High Population Demand Projections excluding WC/WDM, Midvaal April 2011, Sedibeng Water June 2011 projections, Eskom April 2011 Base projections
Sasol Secunda and Sasol Sasolburg April 2011 projections, July 2010 projections for Mittal Steel and the NWRS demand projections (Ratio Method) for smaller demand centres.

DESCRIPTION		Projected Demands and Return Flows (million m³/a)									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DEMANDS:	Rand Water [1]	1478.64	1504.97	1531.30	1557.03	1587.31	1615.74	1644.91	1674.17	1702.32	1729.31
	Magalies Water (Vaalkop Scheme) [11]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mittal Steel [10]	12.50	12.69	12.89	13.10	13.30	13.51	13.72	13.94	14.16	14.38
	ESKOM [8]	372.56	381.68	379.82	381.06	380.23	384.94	393.26	403.34	408.87	416.31
	SASOL Sasolburg (Raw water req) [9]	20.42	21.91	22.57	23.04	23.48	23.95	24.43	24.92	25.42	25.92
	SASOL Secunda	82.46	86.78	88.50	91.25	93.18	91.76	92.06	92.35	93.88	93.30
	Midvaal Water Company	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
	Sedibeng Water (Balkfontein only)	41.04	40.98	41.37	41.67	41.91	42.11	42.28	42.44	42.57	42.70
	Other towns and industries (Vaal)	188.95	189.64	190.33	191.03	191.73	191.65	191.58	191.51	191.44	191.37
	Other towns and industries(Zaai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vaalharts/Lower Vaal irrigation [2]	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53
	Diffuse Irrig and Aff (Vaal)	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31
	Diffuse Irrig and AFF (Sub systems)	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30
	Other irrigation in Vaal [3]	714.03	622.47	530.92	439.37	439.37	439.37	439.37	439.37	439.37	439.37
	Other irrigation in sup subsystems [3]	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10
	Wetland losses [4]	45.36	45.62	45.88	46.14	46.40	46.66	46.91	47.17	47.43	47.70
	Bed losses [5]	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20
	Mooi River (net losses) [6]	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80
RETURN FLOWS:	Southern Gauteng (Rand Water)	-392.63	-399.64	-406.65	-413.67	-422.60	-430.54	-438.50	-446.46	-454.43	-462.41
	Midvaal Water Company	-1.08	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09
	Sedibeng Water	-1.64	-1.64	-1.65	-1.67	-1.68	-1.68	-1.69	-1.70	-1.70	-1.71
	Other towns and industries	-71.01	-72.43	-73.24	-73.99	-74.91	-75.48	-76.09	-76.70	-77.32	-78.17
	Irrigation [7]	-143.14	-121.17	-99.20	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24
	Mine dewatering	-112.55	-133.38	-133.38	-87.14	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87
	Mine Water treated for Re-use	0.00	0.00	0.00	-46.25	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52
	Increased urban runoff	-103.86	-104.49	-105.14	-105.82	-106.51	-107.81	-109.14	-110.50	-111.89	-113.32
OVERALL GROSS SYSTEM DEMAND:		3928.19	3878.98	3815.82	3755.92	3789.15	3821.93	3860.77	3901.46	3937.70	3972.61
OVERALL NET SYSTEM DEMAND:		3102.29	3045.14	2995.46	2949.08	2971.75	2994.71	3023.65	3054.38	3080.64	3105.29

DESCRIPTION		Extrapolated									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
DEMANDS:	Rand Water [1]	1752.03	1774.85	1797.76	1819.57	1840.24	1867.93	1895.73	1923.63	1951.63	1979.75
	Magalies Water (Vaalkop Scheme) [11]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mittal Steel [10]	14.61	14.84	15.08	15.31	15.56	15.80	16.05	16.31	16.56	16.83
	ESKOM [8]	418.48	414.94	410.42	400.22	389.13	382.66	373.34	358.28	343.41	338.06
	SASOL Sasolburg (Raw water req) [9]	26.44	26.97	27.51	28.06	28.62	29.19	29.78	30.37	30.98	31.60
	SASOL Secunda	92.97	93.32	93.68	95.24	98.06	98.46	98.91	99.46	100.01	100.43
	Midvaal Water Company	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
	Sedibeng Water (Balkfontein only)	42.81	42.91	43.01	43.10	43.18	43.26	43.33	43.40	43.47	43.53
	Other towns and industries (Vaal)	191.35	191.32	191.30	191.28	191.27	191.23	192.16	192.11	192.08	192.04
	Other towns and industries(Zaai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vaalharts/Lower Vaal irrigation [2]	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53	541.53
	Diffuse Irrig and Aff (Vaal)	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31
	Diffuse Irrig and AFF (Sub systems)	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30	68.30
	Other irrigation in Vaal [3]	439.37	439.37	439.37	439.37	439.37	439.37	439.37	439.37	439.37	439.37
	Other irrigation in sup subsystems [3]	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10	25.10
	Wetland losses [4]	47.95	48.21	48.47	48.73	48.99	49.24	49.48	49.73	49.98	50.24
	Bed losses [5]	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20	267.20
	Mooi River (net losses) [6]	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80	13.80
RETURN FLOWS:	Southern Gauteng (Rand Water)	-468.22	-474.03	-479.84	-485.66	-491.48	-497.77	-504.03	-510.28	-516.51	-522.72
	Midvaal Water Company	-1.09	-1.09	-1.09	-1.09	-1.09	-1.10	-1.10	-1.10	-1.10	-1.10
	Sedibeng Water	-1.71	-1.72	-1.72	-1.72	-1.73	-1.73	-1.73	-1.74	-1.74	-1.74
	Other towns and industries	-78.90	-79.57	-80.27	-80.98	-81.87	-82.58	-83.30	-84.03	-84.76	-85.69
	Irrigation [7]	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24	-77.24
	Mine dewatering	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87	-77.87
	Mine Water treated for Re-use	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52
	Increased urban runoff	-114.78	-116.27	-117.80	-119.36	-120.97	-122.56	-124.20	-125.88	-127.61	-129.39
OVERALL GROSS SYSTEM DEMAND:		3998.25	4018.98	4038.83	4053.13	4066.66	4089.37	4110.39	4124.91	4139.74	4164.08
OVERALL NET SYSTEM DEMAND:		3122.94	3135.68	3147.49	3153.69	3158.89	3173.01	3185.41	3191.26	3197.39	3212.81

Notes :

(1): Rand Water's total raw water abstraction includes Sasolburg but excludes Authorised Users (i.e. ESKOM, ISCOR, Sasol Sasolburg , Mittal Steel and Small Users (Mining & Industrial)).
(2): Includes distribution losses within Vaalharts canal system and mainstream irrigation along Vaal River from Bloemhof Dam down to Douglas Weir.
(3): "Other irrigation" excludes diffuse irrigation
(4): Includes evaporation losses associated with wetlands as well as bed losses occuring within the Suikerbosrand and Klip rivers
(5): Vaal River bed losses include evaporation and operating losses associated with releases made from Bloemhof Dam
(6): Mooi River (Wonderfonteinspruit catchment) : Net effect of bed losses and decanting from dolomitic eyes resulting from WQT calibration
(7): Includes flow contribution resulting from the tailwater component at Erfenis Dam
(8): Includes DWA 3rd Party Users supplied from Eskom conveyance infrastructure as well as from the VRESAP pipeline (i.e. Greylingstad and Burn Stone Mine)
(9): It is assumed that Sasol's raw water requirements are not supplied through Rand Water, but that the projections of Rand Water include the potable water allocation of 6Ml/day.
(10): Represents Mittal Steel's total water requirements (i.e. includes the portion of the demand obtained from Rand Water)
(11): Represents portion of Rand Water's demand supplied by Magalies Water (drawn through the Vaalkop Scheme)

Table F-2 : **Base Scenario (Scenario A) water demand and return flow projections for the Integrated Vaal River System as adopted for the 2011/2012 Annual Operating Analysis**
Based on Rand Water High Population Demand Projections excluding WC/WDM, Midvaal April 2011, Sedibeng Water June 2011 projections, Eskom April 2011 Base projections
Sasol Secunda and Sasol Sasolburg April 2011 projections, July 2010 projections for Mittal Steel and the NWRS demand projections (Ratio Method) for smaller demand centres.

KOMATI SUB-SYSTEM		Projections (Million m^3/a)																			
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ESKOM(1):	Komati Power Station	15.24	19.79	18.68	17.15	13.69	10.86	11.16	10.94	11.10	11.39	11.53	11.39	11.20	10.08	6.42	2.77	2.62	2.62	2.62	2.62
	Arnot	29.91	30.47	30.34	30.24	30.47	31.42	31.45	31.34	31.24	30.77	29.84	29.28	28.15	25.63	23.64	23.64	22.74	19.11	14.73	13.32
	Hendrina	29.00	28.31	29.08	29.25	30.30	31.53	31.42	31.73	31.46	31.25	29.56	25.98	22.83	19.21	17.29	14.95	12.23	9.47	5.26	1.29
	Duvha 1 (Groot) - excess(2)	23.67	28.90	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56	31.56
	Duvha 2 (Komati/Usutu)	15.52	14.43	10.27	10.28	13.24	16.49	16.61	17.58	17.31	16.93	16.39	15.82	15.31	14.58	13.36	13.36	12.74	11.51	11.57	11.67
	New Stations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	DWAF 3rd Party Users along Komati Pipeline	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14	7.14
	DWAF 3rd Party Users along Hendrina-Duvha Pipeline	5.07	5.08	5.09	5.11	5.12	5.12	5.13	5.13	5.13	5.14	5.14	5.15	5.16	5.17	5.18	5.18	5.18	5.18	5.18	5.17
	Other Users(3): Total DWAF 3rd Party Users	12.20	12.22	12.23	12.24	12.26	12.26	12.26	12.27	12.27	12.27	12.28	12.29	12.30	12.31	12.31	12.31	12.31	12.31	12.31	12.31
		-12.20	-12.22	-12.23	-12.24	-12.26	-12.26	-12.26	-12.27	-12.27	-12.27	-12.28	-12.29	-12.30	-12.31	-12.31	-12.31	-12.31	-12.31	-12.31	-12.31
IRRIGATION:	Nooitgedacht dummy dam	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16	2.16
	Gemsbokhoek dummy dam	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67
	Gemsbokhoek node	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74	9.74
DIFFUSE:	Gladdespruit Weir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93	18.93
	Vygeboom Dam	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
	"	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24	24.24
	Gemsbokhoek Weir	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06	3.06
	"	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
	Nooitgedacht Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Notes (1): The total ESKOM demand in the Komati System is allocated as follows: 1st 70 million m3/a on channel 11, 2nd 9 million m3/a on channel 177 and rest on channel 22.
(2): Transfers from Grootdraai to Olifants. With present poor water quality in Witbank Dam, it is unlikely that more than 9 million m3/a will be transferred through channel 177.
(3): Other users include DWAF third party users along the Hendrina-Duvha pipeline, as well as users supplied from Nooitgedacht and Vygeboom Dams. \...KOMATI SUB-SYSTEM

USUTU SUB-SYSTEM		Projections (Million m^3/a)																			
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ESKOM:	Camden	19.04	18.35	18.09	17.56	15.75	14.64	14.97	14.65	14.72	14.69	14.61	14.11	13.42	13.19	12.56	11.00	8.60	3.48	0.53	0.53
	Kriel_1 (Usutu-sup from Grootdraai)	39.92	40.77	41.90	41.24	41.17	41.83	42.45	42.45	42.77	42.89	42.13	41.58	40.82	40.82	40.82	40.82	40.82	39.78	35.87	32.22
	Kriel_2 (Grootdraai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kriel (Total)	39.92	40.77	41.90	41.24	41.17	41.83	42.45	42.45	42.77	42.89	42.13	41.58	40.82	40.82	40.82	40.82	40.82	39.78	35.87	32.22
	Kriel (Total)	-39.92	-40.77	-41.90	-41.24	-41.17	-41.83	-42.45	-42.45	-42.77	-42.89	-42.13	-41.58	-40.82	-40.82	-40.82	-40.82	-40.82	-39.78	-35.87	-32.22
	Matla 1 (Usutu capacity)	18.16	17.23	16.14	16.94	17.14	16.35	13.67	9.54	9.18	8.86	9.23	9.74	10.18	10.04	10.22	10.22	10.23	11.36	15.39	19.04
	Matla 2 (Groot) - excess(1)	29.87	31.21	32.54	33.84	35.30	36.85	42.92	50.34	53.60	56.62	56.50	55.92	54.48	52.18	50.58	50.56	49.87	47.53	43.42	39.45
	Matla (total) : Including Kusile) New CF_1 PS	48.03	48.45	48.68	50.78	52.44	53.20	56.59	59.88	62.78	65.48	65.73	65.65	64.66	62.22	60.80	60.78	60.09	58.89	58.81	58.48
	Matla (total)	-48.03	-48.45	-48.68	-50.78	-52.44	-53.20	-56.59	-59.88	-62.78	-65.48	-65.73	-65.65	-64.66	-62.22	-60.80	-60.78	-60.09	-58.89	-58.81	-58.48
	Kendal_1 (Usutu-sup from Grootdraai)	3.73	3.80	3.77	3.63	3.50	3.63	5.69	9.81	9.86	10.06	10.45	10.49	10.81	10.95	10.77	10.77	10.76	10.68	10.55	10.55
	Kendal_2 (Grootdraai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kendal (Total)	3.73	3.80	3.77	3.63	3.50	3.63	5.69	9.81	9.86	10.06	10.45	10.49	10.81	10.95	10.77	10.77	10.76	10.68	10.55	10.55
	Kendal (Total)	-3.73	-3.80	-3.77	-3.63	-3.50	-3.63	-5.69	-9.81	-9.86	-10.06	-10.45	-10.49	-10.81	-10.95	-10.77	-10.77	-10.76	-10.68	-10.55	-10.55
	New Stations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other Users(2)	7.11	7.20	7.29	7.38	7.47	7.51	7.55	7.59	7.63	7.67	7.71	7.75	7.79	7.83	7.88	7.89	7.91	7.93	7.94	7.96
DIFFUSE:	Westoe Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
	Jericho Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
	Morgenstond Dam	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
	"	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31	6.31
	Churchill Weir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes (1): Transfers from Grootdraai to Olifants through channel 10.
(2): Other users include DWAF third party users along the following pipelines: Jericho-Camden-Lilliput and Heyshope-Grootdraai. \...USUTU SUB-SYSTEM

		Projections (Million m³/a)																			
ZAAIHOEK SUB-SYSTEM		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ESKOM:	Majuba	26.55	26.89	24.99	24.10	24.87	26.06	26.55	26.78	27.66	30.30	33.50	36.73	38.80	38.12	36.75	36.75	36.75	36.40	36.75	38.80
URBAN:	Wakkerstroom, Esizamelani	0.45	0.47	0.48	0.50	0.51	0.53	0.55	0.57	0.59	0.61	0.63	0.65	0.68	0.70	0.72	0.74	0.76	0.79	0.81	0.83
	Grootdraai sup from Zaaihoek	-21.15	-20.81	-22.71	-23.60	-22.83	-21.64	-21.15	-20.92	-20.04	-17.40	-14.20	-10.97	-8.90	-9.58	-10.95	-10.95	-10.95	-10.95	-10.95	-8.90
	Volksrust (from Mahawane Dam)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Mahawane Dam yield	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
	Support to Chelmsford Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DIFFUSE:	Zaaihoek Dam Irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Zaaihoek Dam Afforestation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

\...ZAAIHOEK SUB-SYSTEM

		Projections (Million m^3/a)																			
GROOTDRAAI SUB-SYSTEM		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ESKOM:	Tutuka	36.93	35.68	33.48	33.47	33.34	33.01	33.46	34.21	34.38	36.16	38.49	38.42	38.82	39.40	39.40	39.40	39.40	39.40	39.40	39.40
	Other Users(1)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SASOL Secunda:		82.46	86.78	88.50	91.25	93.18	91.76	92.06	92.35	93.88	93.30	92.97	93.32	93.68	95.24	98.06	98.46	98.91	99.46	100.01	100.43
VRESAP Users	Greylingstad	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
	Burn Stone Mine and Others	2.86	4.08	5.82	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31	8.31
URBAN:	Lekwa LM (Former Standerton TLC)	10.57	10.70	10.84	10.97	11.11	11.16	11.21	11.25	11.30	11.35	11.42	11.48	11.55	11.62	11.69	11.72	11.75	11.77	11.80	11.82
	Amersfoort (const.1994 demand)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Amersfoort (growth only)	0.74	0.74	0.75	0.75	0.76	0.77	0.78	0.78	0.79	0.80	0.81	0.82	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89
	Amersfoort (total)	0.91	0.91	0.92	0.92	0.93	0.94	0.95	0.95	0.96	0.97	0.98	0.99	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06
	Amersfoort (total)	-0.91	-0.91	-0.92	-0.92	-0.93	-0.94	-0.95	-0.95	-0.96	-0.97	-0.98	-0.99	-0.99	-1.00	-1.01	-1.02	-1.03	-1.04	-1.05	-1.06
	Breyten (Yield from own sources)	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Breyten (growth only): Supplied from Camden pipeline	0.79	0.80	0.81	0.82	0.83	0.83	0.84	0.84	0.84	0.85	0.84	0.83	0.82	0.82	0.81	0.81	0.81	0.80	0.80	0.80
	Breyten (total)	1.12	1.13	1.14	1.15	1.16	1.16	1.17	1.17	1.17	1.18	1.17	1.16	1.15	1.15	1.14	1.14	1.14	1.13	1.13	1.13
	Breyten (total)	-1.12	-1.13	-1.14	-1.15	-1.16	-1.16	-1.17	-1.17	-1.17	-1.18	-1.17	-1.16	-1.15	-1.15	-1.14	-1.14	-1.14	-1.13	-1.13	-1.13
	Msukaligwa LM (Former Ermelo TLC) (local sources)	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04
	Msukaligwa LM (Former Ermelo TLC) (growth on pipel	2.25	2.31	2.37	2.42	2.48	2.51	2.53	2.56	2.58	2.61	2.65	2.69	2.73	2.77	2.81	2.82	2.83	2.84	2.86	2.87
	Msukaligwa LM (Former Ermelo TLC) (total)	4.29	4.35	4.41	4.46	4.52	4.55	4.57	4.60	4.62	4.65	4.69	4.73	4.77	4.81	4.85	4.86	4.87	4.88	4.90	4.91
	Msukaligwa LM (Former Ermelo TLC) (total)	-4.29	-4.35	-4.41	-4.46	-4.52	-4.55	-4.57	-4.60	-4.62	-4.65	-4.69	-4.73	-4.77	-4.81	-4.85	-4.86	-4.87	-4.88	-4.90	-4.91
	Morgenzon (Demand supplied from own sources)	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Morgenzon (growth exceeding yield from own sources)	0.01	0.02	0.04	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.11
	Morgenzon (total)	0.49	0.50	0.52	0.53	0.54	0.54	0.55	0.56	0.56	0.57	0.57	0.57	0.58	0.58	0.59	0.59	0.59	0.59	0.59	0.59
	Morgenzon (total)	-0.49	-0.50	-0.52	-0.53	-0.54	-0.54	-0.55	-0.56	-0.56	-0.57	-0.57	-0.57	-0.58	-0.58	-0.59	-0.59	-0.59	-0.59	-0.59	-0.59
	Daggakraal	1.18	1.21	1.23	1.26	1.28	1.27	1.26	1.24	1.23	1.22	1.20	1.18	1.17	1.15	1.13	1.11	1.09	1.08	1.06	1.04
	Driefontein	0.82	0.86	0.91	0.95	1.00	1.01	1.02	1.03	1.04	1.05	1.09	1.13	1.17	1.21	1.25	1.29	1.33	1.37	1.41	1.46
REGION B:	Demand on own sources	75.98	75.86	75.74	75.62	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50	75.50
	Part of increase(2)																				
	Losses on transfer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Supply from own sources	-75.98	-75.86	-75.74	-75.62	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50	-75.50
IRRIGATION:	Heyshope mainstream	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71	1.71
	Heyshope dummy dam	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82
	Grootdraai RE-EWR1 Mstr Irrig (RR368)-Unlawful Use	2.20	1.55	0.90	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Grootdraai RE-EWR1 Mstr Irrig (RR369)-Lawful Use	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
	Grootdraai EWR1 Mstr Irrig (RR1782)-Unlawful Use	14.09	9.93	5.77	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
	Grootdraai EWR1 Mstr Irrig (RR1800)-Lawful Use	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
	Grootdraai EWR2 Mstr Irrig (RR398)-Unlawful Use	6.33	4.46	2.59	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	Grootdraai EWR2 Mstr Irrig (RR414)-Lawful Use	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Original irrigation block	Grootdraai mainstream (RR1800)- Lawful Use	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53	12.53
Original irrigation block	Grootdraai mainstream (RR1782)- Sug 2005 - Lawful U	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
DIFFUSE:	Heyshope Dam (Assegaai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
	Grootdraai Dam (RR12)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RETURN:	Ermelo (growth only) (50 %)	-1.13	-1.15	-1.18	-1.21	-1.24	-1.25	-1.27	-1.28	-1.29	-1.30	-1.32	-1.34	-1.36	-1.38	-1.40	-1.41	-1.42	-1.42	-1.43	-1.43
	Bethal	-3.99	-4.11	-4.22	-4.34	-4.45	-4.58	-4.71	-4.83	-4.96	-5.09	-5.25	-5.41	-5.57	-5.73	-5.89	-6.09	-6.29	-6.49	-6.69	-6.89
	Tutuka seepage	-0.97	-0.94	-0.88	-0.88	-0.87	-0.87	-0.88	-0.90	-0.90	-0.95	-1.01	-1.01	-1.02	-1.03	-1.03	-1.03	-1.03	-1.03	-1.03	-1.03
	Mine seepage	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
	Grootdraai RE-EWR Mstr Irrig (RR368)-Unlawful Use	-0.28	-0.19	-0.11	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
	Grootdraai RE-EWR Mstr Irrig (RR369)-Lawful Use	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Grootdraai EWR1 Mstr Irrig (RR1782)-Unlawful Use	-1.77	-1.25	-0.73	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20
	Grootdraai EWR1 Mstr Irrig (RR1800)-Lawful Use	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92
	Grootdraai EWR2 Mstr Irrig (RR398)-Unlawful Use	-0.79	-0.56	-0.33	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
	Grootdraai EWR2 Mstr Irrig (RR414)-Lawful Use	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52
Original irrigation block	Grootdraai irrigation (RR12) Lawful Use	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49
Original irrigation block	Grootdraai mainstream (RR12)- Sug 2005 - Lawful Us	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18
	Ermelo (up to 1994 only - 50 %) (3)	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02	-1.02
PAVED AREAS :	Waterval increased runoff	-7.13	-7.48	-7.86	-8.25	-8.66	-9.09	-9.55	-10.03	-10.53	-11.06	-11.61	-12.19	-12.80	-13.44	-14.11	-14.82	-15.56	-16.33	-17.15	-18.01
		22.62	15.94	9.27	2.59																

Notes (1): Other users include DWAF third party users along the following pipelines: Grootdraai-Tutuka, Trichardsfontein-Matla and Naauwpoort-Duvha-Slang River.

(2): Water transferred from Grrotdraai Dam to drainage region B for urban and industrial use.

(3): Ermelo's return flow based on 1994 demands (abstracted through Ch700) is not considered as part of Ch 47 to overcome problems with negative demands resulting from all urban return flows entering through Ch47

(4): Tutuka 1994 seepage from hydrology report.

VAAL & BARRAGE		Projections (Million m³/a)																			
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
ESKOM:	Grootvlei	14.96	14.47	15.19	15.20	12.03	9.35	9.66	9.47	9.54	9.41	9.24	9.24	9.24	9.24	9.16	7.76	4.46	2.11	0.77	0.77
	Lethabo	46.21	46.19	46.76	46.27	46.18	46.41	46.08	46.19	46.17	46.40	46.40	46.12	46.32	46.54	46.30	46.38	46.19	46.39	46.44	46.16
	Kragbron(1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	New coal fired 3 and 4 (Vaal Dam	0.00	0.00	0.00	0.72	1.94	5.19	5.78	6.92	8.42	9.09	9.06	8.53	8.39	8.54	10.13	12.52	14.15	16.64	18.28	20.40
	New coal fired 2 (Mokolo catchment)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mittal Steel:	(Previously known as Iscor) Incl supply from RW	12.50	12.69	12.89	13.10	13.30	13.51	13.72	13.94	14.16	14.38	14.61	14.84	15.08	15.31	15.56	15.80	16.05	16.31	16.56	16.83
SASOL Sasolburg:	Sasolburg Complex: Raw water from Vaal Rive	20.42	21.91	22.57	23.04	23.48	23.95	24.43	24.92	25.42	25.92	26.44	26.97	27.51	28.06	28.62	29.19	29.78	30.37	30.98	31.60
SMALL USERS:	(Mining & Industrial)(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mining abs. from Blesbokspruit	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56
	Balfour abstractions (Blesboksp)	1.56	1.59	1.61	1.63	1.66	1.67	1.68	1.70	1.71	1.72	1.74	1.75	1.76	1.77	1.79	1.80	1.81	1.82	1.84	1.85
URBAN:																					
	Rand Water Jun99 growth rates																				
DC40: Demand	Rand Water (with Return Flows to Klip River	427.59	435.22	442.85	450.48	460.05	468.53	477.03	485.53	494.04	502.57	508.74	514.93	521.11	527.30	533.50	540.20	546.87	553.53	560.16	566.76
	Rand Water Rgn A+C	-427.59	-435.22	-442.85	-450.48	-460.05	-468.53	-477.03	-485.53	-494.04	-502.57	-508.74	-514.93	-521.11	-527.30	-533.50	-540.20	-546.87	-553.53	-560.16	-566.76
	Rand Water: Southn Gauteng(4	427.59	435.22	442.85	450.48	460.05	468.53	477.03	485.53	494.04	502.57	508.74	514.93	521.11	527.30	533.50	540.20	546.87	553.53	560.16	566.76
	Rand Water: Northern Users - Crocodile	831.66	846.51	861.37	875.62	891.20	906.55	922.63	938.78	953.81	967.66	980.82	994.07	1007.41	1019.64	1030.71	1048.05	1065.53	1083.14	1100.88	1118.76
Supply from Magalies	Rand Water: Northern Users (Vaalkop Scheme	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RW SG: Return Flow	RW Southern Gauteng Total return flow	392.63	399.64	406.65	413.67	422.60	430.54	438.50	446.46	454.43	462.41	468.22	474.03	479.84	485.66	491.48	497.77	504.03	510.28	516.51	522.72
		-392.63	-399.64	-406.65	-413.67	-422.60	-430.54	-438.50	-446.46	-454.43	-462.41	-468.22	-474.03	-479.84	-485.66	-491.48	-497.77	-504.03	-510.28	-516.51	-522.72
DC293 : Demand	Rand Water (with return flows to Suikerbosranc	98.23	100.28	102.32	104.36	106.73	108.84	110.95	113.06	115.18	117.29	118.83	120.38	121.92	123.46	125.01	126.67	128.34	130.00	131.65	133.30
DC294 : Demand	Rand Water (with return flows to Upper Riet	50.13	50.92	51.70	52.48	53.59	54.57	55.55	56.53	57.52	58.50	59.22	59.94	60.65	61.37	62.09	62.86	63.63	64.40	65.16	65.93
DC295 : Demand	Rand Water (with return flows to Lower Riet	58.21	59.08	59.95	60.81	62.14	63.33	64.52	65.71	66.91	68.10	68.97	69.84	70.72	71.59	72.46	73.39	74.32	75.25	76.18	77.11
DC296 : Demand	Rand Water (with return flows to Mooi River	12.81	12.96	13.12	13.27	13.61	13.92	14.24	14.55	14.87	15.19	15.44	15.70	15.96	16.21	16.47	16.76	17.04	17.32	17.60	17.88
Mine Water Re-use	Mine water treated for re-use by Rand Wate	0.00	0.00	0.00	-46.25	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52	-55.52
Boreholes:	Zuurbekom supply to Rand Wate	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56
	Pretoria demand (incl. Rietvlei etc.	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
	Zuurbekom supply to Rand Wate	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56	4.56
	Pretoria demand (incl. Rietvlei etc.	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00	-25.00
Region B:	From R W (Only from Grootdraai)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Towns:	Bethlehem (const.1994 demand	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
	Bethlehem (growth only	2.46	2.41	2.37	2.32	2.27	2.18	2.09	2.00	1.91	1.82	1.73	1.65	1.56	1.47	1.38	1.29	1.20	1.11	1.02	0.94
	Bethlehem (total)	7.94	7.89	7.85	7.80	7.75	7.66	7.57	7.48	7.39	7.30	7.21	7.13	7.04	6.95	6.86	6.77	6.68	6.59	6.50	6.42
	Bethlehem (total)	-7.94	-7.89	-7.85	-7.80	-7.75	-7.66	-7.57	-7.48	-7.39	-7.30	-7.21	-7.13	-7.04	-6.95	-6.86	-6.77	-6.68	-6.59	-6.50	-6.42
	Deneysville	0.94	0.96	0.98	1.01	1.03	1.05	1.07	1.09	1.10	1.12	1.14	1.16	1.18	1.19	1.21	1.23	1.25	1.27	1.29	1.30
	Small Users(5)	3.15	3.15	3.15	3.15	3.15	3.15	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.13	3.13	3.13	3.13	3.13
	Villiers	0.88	0.90	0.92	0.94	0.96	0.98	0.99	1.00	1.01	1.03	1.04	1.05	1.07	1.08	1.09	1.11	1.12	1.13	1.15	1.16
	Frankfort	2.41	2.43	2.46	2.48	2.51	2.52	2.53	2.53	2.54	2.55	2.56	2.57	2.58	2.58	2.59	2.60	2.61	2.62	2.63	2.64
	Harrismith (const.1994 demand	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39
	Harrismith (growth only	2.08	2.16	2.24	2.32	2.40	2.45	2.51	2.57	2.62	2.68	2.73	2.79	2.84	2.90	2.96	3.01	3.07	3.12	3.18	3.23
	Harrismith (total)	4.47	4.55	4.63	4.71	4.79	4.84	4.90	4.96	5.01	5.07	5.12	5.18	5.23	5.29	5.35	5.40	5.46	5.51	5.57	5.62
	Harrismith (total)	-4.47	-4.55	-4.63	-4.71	-4.79	-4.84	-4.90	-4.96	-5.01	-5.07	-5.12	-5.18	-5.23	-5.29	-5.35	-5.40	-5.46	-5.51	-5.57	-5.62
	Memel (const.1994 demand	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Memel (growth only)	0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Memel (total)	0.19	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Memel (total)	-0.19	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20
	Volksrust (Balfour Dam) 1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Volksrust (growth only	1.50	1.57	1.65	1.72	1.80	1.90	2.00	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.95	3.09	3.22	3.36	3.50
	Volksrust (total)	1.50	1.57	1.65	1.72	1.80	1.90	2.00	2.11	2.21	2.31	2.41	2.51	2.61	2.71	2.81	2.95	3.09	3.22	3.36	3.50
	Volksrust (total)	-1.50	-1.57	-1.65	-1.72	-1.80	-1.90	-2.00	-2.11	-2.21	-2.31	-2.41	-2.51	-2.61	-2.71	-2.81	-2.95	-3.09	-3.22	-3.36	-3.50
	Reitz(6)	2.28	2.31	2.34	2.36	2.39	2.40	2.40	2.41	2.42	2.42	2.43	2.44	2.44	2.45	2.45	2.46	2.47	2.47	2.48	2.49
	Warden (up to 1994)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
	Warden (growth only	-0.41	-0.43	-0.45	-0.47	-0.49	-0.50	-0.51	-0.53	-0.54	-0.56	-0.57	-0.59	-0.60	-0.62	-0.63	-0.64	-0.66	-0.67	-0.69	-0.70
	Warden (total)	0.41	0.39	0.37	0.35	0.33	0.32	0.30	0.29	0.27	0.26	0.24	0.23	0.21	0.20	0.19	0.17	0.16	0.14	0.13	0.11
	Warden (total)	-0.41	-0.39	-0.37	-0.35	-0.33	-0.32	-0.30	-0.29	-0.27	-0.26	-0.24	-0.23	-0.21	-0.20	-0.19	-0.17	-0.16	-0.14	-0.13	-0.11

Notes (1): Kragbron is Highveld and Taaibos and their use is registered as "Sasol (Vaal)" as part of the Autorised User
(2): Small Users (Mining & Industrial) include USCO, Vereeniging Refractories, Vereeniging Municipality and TO!
(3): Rand Water's total raw water abstraction includes Sasolburg but excludes Authorised Users (i.e. ESKOM, ISCOR, Sasol I and Small Users (Mining & Industri
(4): Sasolburg is supplied by Rand Water and is included in the Southern Gauteng demai
(5): Small users include Jim Fouche, Oranjeville and Vaal Marina. 1998 consumption not available - interpolation us
(6): Reitz includes Tweeling and Petrus Steyr

Projections (Million m³/a)

VAAL & BARRAGE (Cont 1)

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
URBAN:																					
Towns:																		0.97	0.97	0.97	0.97
	Vrede (const.1994 demand)	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
	Vrede (growth only)	0.33	0.34	0.34	0.34	0.34	0.34	0.33	0.32	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.24
	Vrede (total)	1.07	1.08	1.08	1.08	1.08	1.08	1.07	1.06	1.06	1.05	1.04	1.04	1.03	1.02	1.02	1.01	1.00	1.00	0.99	0.98
	Vrede (total)	-1.07	-1.08	-1.08	-1.08	-1.08	-1.08	-1.07	-1.06	-1.06	-1.05	-1.04	-1.04	-1.03	-1.02	-1.02	-1.01	-1.00	-1.00	-0.99	-0.98
	Heilbron (1) Used for return flow calcs	1.17	1.18	1.18	1.19	1.20	1.20	1.20	1.20	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.18	1.18	1.18	1.18	1.18
	Heilbron (1) Used for return flow calcs: Correction	-1.17	-1.18	-1.18	-1.19	-1.20	-1.20	-1.20	-1.20	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.18	-1.18	-1.18	-1.18	-1.18
	QwaQwa (const.1994 demand)	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37	9.37
	QwaQwa (growth only)	-0.31	-0.45	-0.59	-0.73	-0.87	-1.04	-1.21	-1.38	-1.56	-1.73	-1.90	-2.07	-2.24	-2.41	-2.59	-2.76	-2.93	-3.10	-3.27	-3.45
	QwaQwa (total)	9.06	8.92	8.78	8.64	8.50	8.33	8.16	7.99	7.81	7.64	7.47	7.30	7.13	6.96	6.78	6.61	6.44	6.27	6.10	5.92
	QwaQwa (total)	-9.06	-8.92	-8.78	-8.64	-8.50	-8.33	-8.16	-7.99	-7.81	-7.64	-7.47	-7.30	-7.13	-6.96	-6.78	-6.61	-6.44	-6.27	-6.10	-5.92
IRRIGATION:	Frankfort Dummy Dam1 (RR9) Lawful Use	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61
	Frankfort Dummy Dam1 (RR1783) Unlawful Use	21.92	15.45	8.98	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
	Frankfort EWR8 mainstream (RR11) Lawful Use	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22	6.22
	Frankfort EWR8 mainstream (RR549) Unlawful Use	16.34	11.52	6.70	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87
	Frankfort Dummy Dam2 (RR571) Lawful Use	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17	4.17
	Frankfort Dummy Dam2 (RR572) Unlawful Use	13.71	9.66	5.62	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
	Frankfort mainstream (RR575) Lawful Use	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01	4.01
	Frankfort mainstream (RR576) Unlawful Use	17.63	12.42	7.22	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02
	Saulspoort Dummy Dam (RR10) Lawful Use	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
	Saulspoort Dummy Dam (RR1784) Unlawful Use	0.89	0.63	0.36	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	Liebenbergsvlei mainstream (RR489) Lawful Use	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46	16.46
	Liebenbergsvlei mainstream (RR488) Unlawful Use	19.55	13.78	8.01	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
	Delangesdrift Incremental Lawful (as diffuse demands)																				
	Delangesdrift Incr (RR465) Unlawful Use	6.71	4.73	2.75	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
	Delangesdrift Incr (RR1781) Unlawful Use	2.96	2.09	1.21	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
	Upper Waterval Dummy dam(RR629) Lawfu	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
	Upper Waterval Dummy dam(RR642) Unlawfu	2.37	1.67	0.97	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
	Upper Waterval Mainstream (RR630) Lawful	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
	Lower Waterval Dummy Dam1 (RR558) Lawful	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	Lower Waterval Dummy Dam1 (RR547) Unlawfu	2.57	1.81	1.05	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
	Lower Waterval Mainstream (RR561) Lawful	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
	Lower Waterval Mainstream (RR632) Unlawful	4.16	2.94	1.71	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Lower Waterval Dummy Dam2 (RR640) Lawful	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
	Lower Waterval Dummy Dam2 (RR643) Unlawfu	2.44	1.72	1.00	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
	Lower Waterval Mainstream (RR638) Lawful	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
	Lower Waterval Mainstream (RR644) Unlawful	5.96	4.20	2.44	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
	Vaal Incr EWR3 Mainstream (RR499) Lawful	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71	13.71
	Vaal Incr EWR3 Mainstream (RR502) Unlawful	25.64	18.07	10.51	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94
	Vaal EWR3 Dummy Dam1 (RR13) Lawful Use	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57
	Vaal EWR3 Dummy Dam1 (RR1786) Unlawful Use	8.55	6.03	3.50	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
	Vaal mainstream (RR14) Lawful Use	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61
	Vaal mainstream (RR1787) Unlawful Use	49.83	35.12	20.41	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71	5.71
	Vaal Dummy Dam2 (RR545) Lawful Use	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
	Vaal Dummy Dam2 (RR546) Unlawful Use	16.61	11.70	6.80	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
	Blesbokspruit Dummy Dam (RR1) Lawful Use	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29
	Blesbokspruit Mainstream (RR1788) Unlawful Use	3.80	2.68	1.56	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
	Upper Suikerbos Mainstream (RR463) Unlawful Use	1.32	0.93	0.54	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
	Upper Suikerbos Dummy Dam (RR245) Lawful Use	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
	Lower Suikerbos Dummy Dam1 (RR335) Lawful Use	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
	Lower Suikerbos Mainstream (RR1789) Unlawful Use	6.63	4.67	2.71	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
	Lower Suikerbos Dummy Dam2 (RR602) Lawful Use	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
	Lower Suikerbos Mainstream (RR615) Unlawful Use	2.29	1.62	0.94	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
	Klip River Mainstream (RR336) Lawful Use	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63
	Klip River Mainstream (RR1790) Unlawful Use	25.17	17.74	10.31	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
	Barrage Mainstream (RR337) Lawful Use	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69	10.69
	Barrage Mainstream (RR1791) Unlawful Use	24.40	17.20	10.00	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
DIFFUSE:	Tugela Diversion Weir	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
	Woodstock Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Driel Barrage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Spioenkop Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sterkfontein Dam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Frankfort incremental (RR11)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Delangesdrift incremental - Lawful Use	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79	2.79
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vaal Dam incremental (RR14)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Suikerbosrand incremental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klip River incremental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Barrage incremental	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	"	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes (1): Only component not supplied by Rand Water. Heilbron from 1998 assumed to be included with demand "Rand Water Rgn A+C

		Projections (Million m³/a)																			
BARRAGE to BLOEMHOF		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
VAALREEFS MINE:	from river	1.70	1.73	1.76	1.79	1.82	1.85	1.89	1.92	1.95	1.98	2.02	2.05	2.08	2.12	2.15	2.18	2.21	2.25	2.28	2.31
MIDVAAL WC:	from river	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
SEDIBENG WATER:	Balkfontein (from Vaal River)	41.04	40.98	41.37	41.67	41.91	42.11	42.28	42.44	42.57	42.70	42.81	42.91	43.01	43.10	43.18	43.26	43.33	43.40	43.47	43.53
	Virginia (from Sand R)(1)	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20
	Virginia (difference)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Virginia (total)	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20
	Virginia (total)	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20	-15.20
URBAN:	Vierfontein (C24B)	0.13	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07
	Parys, Vredefort & C23L	5.57	5.62	5.66	5.71	5.75	5.75	5.74	5.74	5.74	5.74	5.73	5.73	5.73	5.72	5.72	5.72	5.72	5.71	5.71	5.71
	Potch (1994 demand)	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55	12.55
	Potch incr within limit of 19 millio	3.87	4.06	4.24	4.43	4.61	4.78	4.95	5.11	5.28	5.44	5.61	5.78	5.94	6.11	6.27	6.44	6.45	6.45	6.45	6.45
	Potch (total demand)	16.42	16.61	16.79	16.98	17.16	17.33	17.50	17.66	17.83	17.99	18.16	18.33	18.49	18.66	18.82	18.99	19.16	19.32	19.49	19.65
	Potch (total demand)	-16.42	-16.61	-16.79	-16.98	-17.16	-17.33	-17.50	-17.66	-17.83	-17.99	-18.16	-18.33	-18.49	-18.66	-18.82	-18.99	-19.16	-19.32	-19.49	-19.65
	Potch (increase)(2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.32	0.49	0.65
IRRIGATION:	Kromdraai dummy (RR338) Lawful Use	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26
	Kromdraai dummy (RR1792) Unlawful Use	5.12	3.61	2.10	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
	Klerkskraal irrigation (Diffuse) Unlawfu	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Klerkskraal Dam (RR550) Lawfu	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36
	Boskop irrigation (Diffuse) Node 252	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gerhard Minnebron irrigation (RR554) Lawfu	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
	Boskop dummy dam (RR551) Lawful Use	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68	3.68
	Boskop Dam (RR552) Lawful	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80
	Lakeside Dam (RR553) Lawful	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59	8.59
	Klipdrift (Diffuse from Node 231) RR1802 - Unlawfu	0.46	0.32	0.19	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Klipdrift (Diffuse from Node 253) RR1799-Unlawfu	0.55	0.39	0.23	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	Klipdrift Dummy Dam (RR20) Lawfu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipdrift Mainstream (RR21) Lawfu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipdrift Dam meterec	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41	6.41
	Koppies dummy dam (RR15	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39
	Koppies riparian (RR16)	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Koppies Dam GWS Canal Irrigation (RR32)	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
	Koppies Dam GWS River Irrigation (RR31)	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41
	Renoster C70D Dummy Dam (RR33)	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
	Renoster C70D Mainstream (RR34)	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
	Renoster C70E Dummy Dam (RR36)	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
	Renoster C70E Mainstream (IRR17)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70F Dummy Dam (RR35)	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
	Renoster C70F Mainstream (RR18)	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73	2.73
	Renoster C70G Dummy Dam (IRR26)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70G Mainstream (IRR28)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70H Dummy Dam (RR40)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
	Renoster C70H Mainstream (IRR34)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rietfontein dummy dam (RR17	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
	Proposed Rietfontein Dam (IRR40)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70K Dummy Dam (RR42)	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
	Renoster C70K Mainstream (IRR16)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Schoonspruit C24E Mainstream (RR525)	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
	Schoonspruit C24E Mainstream (RR442)	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
	Rietspruit Dam (RR529)	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92	9.92
	Schoonspruit C24F Dummy Dam (RR533)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	Schoonspruit C24F Mainstream (RR534)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	Schoonspruit C24G Dummy Dam (RR447)	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	Schoonspruit C24G Mainstream (RR446)	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
	Schoonspruit C24G Minstream (RR539)	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13
	Johan Neser Dam 1 (RR452)	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
	Johan Neser Dam 2 (RR542)	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
	Johan Neser Mainstream 1 (RR540)	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Johan Neser Mainstream 2 (RR457)	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
	Serfontein Dam (RR333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipbank dummy dam (RR332	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51	6.51
	Klipbank riparian U/S EWR14 (RR583)	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04	13.04
	Klipbank riparian (RR334)	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55	10.55
	Allem dummy dam (RR30	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34
	Allemanskraal Dam (RR26)	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76	36.76
	Erfenis dummy dam (RR331)	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60
	Erfenis Dam (RR27)	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60	43.60
	Sand dummy dam (RR28	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Sand River riparian U/S EWR15 (RR29)	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
	Sand River riparian D/S EWR15 (RR588)	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78	8.78
	Bloem upper dum dam (RR340	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46
	Bloem upper riparian (RR339)	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93	14.93
	Bloem lower dum dam (RR341	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76	3.76
	Bloem lower riparian (RR2)	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83	31.83

DIFFUSE:	All afforestation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kromdraai irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klerkskraal irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Boskop irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipdrift irrigation	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
	Koppies irrigation (RR16)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rietfontein irrigation (RR18)	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28	4.28
	Klipbank irrigation (RR334)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rietspruit irrigation	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	Neser irrigation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Allemanskraal irrigatior	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
	Erfenis irrigation	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
	Sand irrigation (RR29)	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
	Bloemhof incr irrigatior	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		6.13	4.32	2.51																	

Notes (1): Goudveld quota limits abstraction from the Sand River, Virginia, to 12.8 million m3/a (higher for at leat the first year of the projection at 15.2 million m3

(2): Potchefstroom demand above 19 million m3/a supplied from Vaal Rive

		Projections (Million m³/a)																			
BARRAGE to BLOEMHOF (Cont.)		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RETURN:																					
Urban & Industrial	Parys (25 - 40 %)	-1.67	-1.68	-1.70	-1.71	-1.87	-1.87	-1.87	-1.87	-1.86	-2.01	-2.01	-2.01	-2.00	-2.00	-2.15	-2.14	-2.14	-2.14	-2.14	-2.28
	SASOL I (69.5 %)	-14.19	-15.23	-15.68	-16.01	-16.32	-16.65	-16.98	-17.32	-17.66	-18.02	-18.38	-18.75	-19.12	-19.50	-19.89	-20.29	-20.70	-21.11	-21.53	-21.96
	Flip Human Ret Flows to Moo	-8.14	-8.23	-8.33	-8.43	-8.64	-8.84	-9.04	-9.24	-9.45	-9.65	-9.81	-9.97	-10.14	-10.30	-10.46	-10.64	-10.82	-11.00	-11.18	-11.36
	Potchefstroom (within limit	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99	-9.99
	Potch (within limit & increase - 55 %	-2.13	-2.23	-2.33	-2.44	-2.54	-2.63	-2.72	-2.81	-2.90	-2.99	-3.09	-3.18	-3.27	-3.36	-3.45	-3.54	-3.63	-3.72	-3.82	-3.91
	SEDIBENG (Balkfontein - 4 %	-1.64	-1.64	-1.65	-1.67	-1.68	-1.68	-1.69	-1.70	-1.70	-1.71	-1.71	-1.72	-1.72	-1.72	-1.73	-1.73	-1.73	-1.74	-1.74	-1.74
	MIDVAAL WC and Vaalreefs (2.3 %)	-1.08	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.10	-1.10	-1.10	-1.10	-1.10
Irrigation:	Kromdraai dummy (RR338) Lawful Use	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29
	Kromdraai dummy (RR1792) Unlawful Use	-0.51	-0.36	-0.21	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
	Klerkskraal Dam (RR550) Lawfu	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
	Gerhard Minnebron irrigation (RR554) Lawfu	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
	Boskop dummy dam (RR551) Lawful Use	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11
	Boskop Dam (RR552) Lawful	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70
	Lakeside Dam (RR553) Lawful	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
	Klipdrift (Diffuse from Node 231) RR1802 - Unlawfu	-0.04	-0.03	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipdrift (Diffuse from Node 253) RR1799-Unlawfu	-0.05	-0.04	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Klipdrift dummy dam (RR20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipdrift riparian (RR21)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Koppies dummy dam (RR15	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
	Koppies riparian (RR16)	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
	Koppies Dam GWS Canal Irrigation (RR32)	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
	Koppies Dam GWS River Irrigation (RR31)	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
	Renoster C70D Dummy Dam (RR33)	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Renoster C70D Mainstream (RR34)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70E Dummy Dam (RR36)	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Renoster C70F Dummy Dam (RR35)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Renoster C70F Mainstream (RR18)	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
	Renoster C70H Dummy Dam (RR40)	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
	Schoonspruit C24E Mainstream (RR525)	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14	-1.14
	Schoonspruit C24E Mainstream (RR442)	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80
	Rietspruit Dam (RR529)	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16	-2.16
	Schoonspruit C24F Dummy Dam (RR533)	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
	Schoonspruit C24F Mainstream (RR534)	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
	Schoonspruit C24G Dummy Dam (RR447)	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
	Schoonspruit C24G Mainstream (RR446)	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
	Schoonspruit C24G Minstream (RR539)	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30	-0.30
	Johan Neser Dam 1 (RR452)	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Johan Neser Dam 2 (RR542)	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05
	Johan Neser Mainstream 1 (RR540)	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
	Johan Neser Mainstream 2 (RR457)	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16
	Serfontein Dam (RR333)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Klipbank dummy dam (RR332	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65
	Klipbank riparian U/S EWR14 (RR583)	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45
	Klipbank riparian (RR334)	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18	-1.18
	Allem dummy dam (RR30	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60
	Allemanskraal Dam (RR26)	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02	-7.02
	Erfenis dummy dam (RR331)	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
	Erfenis Dam (RR27)	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77	-4.77
	Sand dummy dam (RR28	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14
	Sand River riparian U/S EWR15 (RR29)	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
	Sand River riparian D/S EWR15 (RR588)	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
	Bloem upper dum dam (RR340	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70
	Bloem upper riparian (RR339)	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36
	Bloem lower dum dam (RR341	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29
	Bloem lower riparian (RR2)	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80
Mine Dewatering:	Mines in Wonderfonteinspruit	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27	-36.27
	Mines in Loopspruit	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56	-4.56
	Decanting (Dolomitic eyes)	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00	-51.00
	Mines in Sand-vet catchmen	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80	-1.80
	Sand River (Erfenis tailwater)	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77	-10.77
	Mines in Vaal incrementa	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32	-18.32
BED LOSSES:	Vaal at node 61	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49	15.49
	Vaal at node 220	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45	39.45
	Vaal at node 63	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81	18.81
	Boskop Dam Incr. (node 251)	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80

		Projections (Million m³/a)																			
BLOEMHOF DAM		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
URBAN:	Marquard,Winburg, Exelsior,Verkeerdevlei	1.87	1.90	1.93	1.96	1.99	2.00	2.01	2.03	2.04	2.05	2.06	2.07	2.08	2.10	2.11	2.12	2.13	2.14	2.15	2.16
	Ventersdorp,Coligny,Steynsr,Edenvill	3.29	3.35	3.41	3.46	3.52	3.55	3.59	3.62	3.66	3.69	3.73	3.76	3.79	3.83	3.86	3.90	3.93	3.97	4.00	4.04
	Senekal &Paul Rou	2.29	2.29	2.30	2.30	2.30	2.29	2.28	2.26	2.25	2.23	2.22	2.21	2.19	2.18	2.16	2.15	2.13	2.12	2.11	2.09
	Kroonstad (1994 dev level)	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57	9.57
	Kroonstad increase	2.01	1.95	1.88	1.82	1.75	1.62	1.49	1.36	1.23	1.10	0.97	0.85	0.72	0.59	0.46	0.33	0.20	0.07	-0.06	-0.19
	Kroonstad (total)	11.58	11.52	11.45	11.39	11.32	11.19	11.06	10.93	10.80	10.67	10.54	10.42	10.29	10.16	10.03	9.90	9.77	9.64	9.51	9.38
	Kroonstad (total)	-11.58	-11.52	-11.45	-11.39	-11.32	-11.19	-11.06	-10.93	-10.80	-10.67	-10.54	-10.42	-10.29	-10.16	-10.03	-9.90	-9.77	-9.64	-9.51	-9.38
	Lindley within lim	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Lindley increase	0.24	0.25	0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.30	0.30	0.31	0.31	0.31	0.32	0.32	0.33	0.33	0.34	0.34
	Lindley (total)	0.41	0.42	0.43	0.44	0.44	0.45	0.45	0.46	0.46	0.47	0.47	0.48	0.48	0.48	0.49	0.49	0.50	0.50	0.51	0.51
	Lindley (total)	-0.41	-0.42	-0.43	-0.44	-0.44	-0.45	-0.45	-0.46	-0.46	-0.47	-0.47	-0.48	-0.48	-0.48	-0.49	-0.49	-0.50	-0.50	-0.51	-0.51
	Koppies (incl. Nat Cons)	0.97	0.97	0.97	0.97	0.98	0.97	0.96	0.96	0.95	0.94	0.94	0.93	0.92	0.92	0.91	0.90	0.90	0.89	0.88	0.88
	Voorspoed Mine (Koppies Dam)	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28	5.28
	Viljoenskroon	1.29	1.30	1.30	1.30	1.31	1.30	1.29	1.29	1.28	1.27	1.26	1.25	1.25	1.24	1.23	1.22	1.22	1.21	1.20	1.19
	Theunissen and Bultfontei	3.79	3.83	3.87	3.91	3.95	3.96	3.96	3.97	3.97	3.97	3.98	3.98	3.99	3.99	4.00	4.00	4.00	4.01	4.01	4.02
	Hoopstad	0.88	0.88	0.89	0.90	0.91	0.91	0.91	0.91	0.91	0.91	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.89	0.89	0.89
	Brandfort / Majwemaswe	2.81	2.82	2.83	2.84	2.85	2.84	2.83	2.82	2.81	2.80	2.79	2.79	2.78	2.77	2.76	2.75	2.74	2.73	2.72	2.72
REGION G:	Proj for Other users(2) excluding Vaal Gamagara	21.44	21.57	21.69	21.82	21.94	21.99	22.04	22.10	22.15	22.20	22.25	22.31	22.36	22.41	22.46	22.52	22.57	22.62	22.68	22.73
'	Correction For Total	-21.44	-21.57	-21.69	-21.82	-21.94	-21.99	-22.04	-22.10	-22.15	-22.20	-22.25	-22.31	-22.36	-22.41	-22.46	-22.52	-22.57	-22.62	-22.68	-22.73
LOSSES:	Bloemhof Dam releases																				
RETURN:	Marq,Winb, Exels,Verk vlei (20 %	-0.37	-0.38	-0.39	-0.39	-0.40	-0.40	-0.40	-0.41	-0.41	-0.41	-0.41	-0.41	-0.42	-0.42	-0.42	-0.42	-0.43	-0.43	-0.43	-0.43
	Senekal & Paul Roux (20 %	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.45	-0.45	-0.45	-0.44	-0.44	-0.44	-0.44	-0.43	-0.43	-0.43	-0.42	-0.42	-0.42
	Henneman	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Viljoenskroon (30 %)	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.38	-0.38	-0.38	-0.38	-0.37	-0.37	-0.37	-0.37	-0.36	-0.36	-0.36	-0.36
	Kroonstad (1994 dev level)	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94	-5.94
	Kroonstad increase (51 %)	-1.03	-0.99	-0.96	-0.93	-0.89	-0.83	-0.76	-0.69	-0.63	-0.56	-0.50	-0.43	-0.37	-0.30	-0.23	-0.17	-0.10	-0.04	0.03	0.10
	Welkom	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40
	Heilbron (60% of NWRS demand): Tota	-0.70	-0.71	-0.71	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71	-0.71
	Heilbron (60% of NWRS demand): Correction for Tota	0.70	0.71	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
	Heilbron : 50% to Koppies Dam	-0.35	-0.35	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.35	-0.35	-0.35	-0.35
	Koppies (30 % - 60 %)	-0.39	-0.39	-0.39	-0.39	-0.44	-0.44	-0.43	-0.43	-0.43	-0.47	-0.47	-0.46	-0.46	-0.46	-0.50	-0.50	-0.49	-0.49	-0.49	-0.53

Notes (1): Includes Bultfontein

(2) Other users include Vryburg, Hartswater, Jan Kempdorp, Pampierstat, Bloemhof, Christiana, Boshof, Warrenton, Windsorton, Barkley West and Delportshoo

		Projections (Million m³/a)																			
BLOEMHOF TO CONFLUENCE WITH ORANGE																					
(Including Harts & Riet/Modder Subsystems		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
URBAN:	Kimberley	19.33	19.15	18.98	18.80	18.63	18.36	18.10	17.84	17.57	17.31	17.05	16.78	16.52	16.26	15.99	15.73	15.47	15.20	14.94	14.68
	Other Users(1) Region G	21.44	21.57	21.69	21.82	21.94	21.99	22.04	22.10	22.15	22.20	22.25	22.31	22.36	22.41	22.46	22.52	22.57	22.62	22.68	22.73
	Schweizer Reneke	1.17	1.20	1.24	1.27	1.31	1.34	1.38	1.42	1.46	1.50	1.54	1.59	1.63	1.68	1.72	1.77	1.82	1.87	1.93	1.98
* K	ThabaN'chu	4.49	4.19	3.90	3.60	3.30	3.61	3.92	4.22	4.53	4.84	4.53	4.22	3.92	3.61	3.30	3.58	3.87	4.15	4.44	4.72
* K	Botshabelo	16.93	17.60	18.27	18.93	19.60	20.23	20.85	21.48	22.11	22.74	23.36	23.99	24.62	25.25	25.88	26.56	27.26	27.97	28.71	29.46
	Mangaung LM	18.32	18.59	18.86	19.13	19.40	19.59	19.78	19.97	20.15	20.34	20.53	20.72	20.90	21.09	21.28	21.47	21.66	21.86	22.06	22.26
* K	Bloemfontein	52.05	52.82	53.58	54.35	55.12	55.65	56.18	56.72	57.25	57.78	58.31	58.84	59.38	59.91	60.44	60.99	61.54	62.09	62.66	63.22
	Vaal-Gamagara	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70
* K	Small Users:Welbedacht-Bloem pipeline	1.94	1.95	1.95	1.96	1.96	1.95	1.94	1.93	1.92	1.91	1.90	1.89	1.89	1.88	1.87	1.88	1.89	1.90	1.92	1.93
IRRIGATION:	RR598 Lower Vaal Irrig (U/S of EWR16)																				
	RR397 Lower Vaal Irrig (U/S of VH Weir)	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42
	RR405 Lower Vaal Irrig (U/S of De Hoop)	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06
	RR289 Lower Vaal Irrig (D/s of De Hoop; u/s of Harts)	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20
	RR290 Lower Vaal Irrig (D/s of Harts; u/s of Schmidtsdri	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
	RR291 Lower Vaal Irrig (D/s of Schmidt; u/s of Riet/Mod	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
	RR357 (Wentzel Dummy Dam)	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
	RR360 (Mainstream Wentzel Dam)	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
	RR362 (Wentzel Dam Irrigation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	RR370 Vaalharts GWS Part Taung	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34
	RR379 Vaalharts GWS North Canal & Part Taung	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04
	RR383 Vaalharts GWS West Canal & Barkley West	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38
	RR376 (Spitskop Dummy Dam)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	RR407 (Spitskop Dam Irrigation)	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81
	RR435 (Rustfontein Dummy Dam)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	RR438 (Rustfontein Mainstream)	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29
	RR416 (Mockes Dummy Dam)	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26
	RR420 (Mockes Dam Mainstream)	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43
	RR424 (Krugersdrift Mainstream 1)	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29
	RR430 (Krugersdrift Mainstream 2)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
	RR445 (Lower Modder Diffuse Irrig)	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27
	RR453 (Lower Modder 1)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR454 (Lower Modder 2)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR455 (Lower Modder 3)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR458 (Tierpoort Dummy Dam)	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
	RR461 (Tierpoort Mainstream)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
	RR468 (Kalkfontein Dummy Dam)	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79
	RR469 (Tierpoort Dam)	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
	RR472 (Kalkfontein Mainstream)	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92
	RR479 (Riet River Settlement & Others)	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53
	RR484 (Kalkfontein Canals)	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51
	RR482 (Lower Riet)	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76
DIFFUSE:	Harts River: HARTU7.ABS	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
	Harts River: HARTD7.ABS	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
	All Afforestation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOSSES:	River Evaporation d/s Bloemhof Dam	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10
	Vaalharts Irrigation Distribution Losses	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02
	Lower Vaal Operational Losses	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35

BLOEMHOF TO CONFLUENCE WITH ORANGE (Continued)		Projections (Million m^3/a) 2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RETURN:																					
Urban & Industrial	ThabaN'chu	-2.25	-2.10	-1.95	-1.80	-1.65	-1.80	-1.96	-2.11	-2.27	-2.42	-2.27	-2.11	-1.96	-1.80	-1.65	-1.79	-1.93	-2.08	-2.22	-2.36
	Botshabelo	-7.28	-7.57	-7.85	-8.14	-8.43	-8.70	-8.97	-9.24	-9.51	-9.78	-10.05	-10.32	-10.59	-10.86	-11.13	-11.42	-11.72	-12.03	-12.34	-12.67
	Bloemfontein DC to Tweeriviere Weir	-1.81	-1.84	-1.87	-1.89	-1.92	-1.94	-1.96	-1.98	-1.99	-2.01	-2.03	-2.05	-2.07	-2.09	-2.11	-2.12	-2.14	-2.16	-2.18	-2.20
* K	Bloemfontein DC to Krugersdrift	-24.85	-25.22	-25.59	-25.95	-28.20	-26.57	-26.83	-27.08	-27.34	-27.59	-27.84	-28.10	-28.35	-28.61	-31.00	-29.12	-29.38	-29.65	-29.92	-30.19
	Total Return Flow : Bloemfontein	-26.67	-27.06	-27.45	-27.85	-28.24	-28.51	-28.79	-29.06	-29.33	-29.60	-29.88	-30.15	-30.42	-30.69	-30.97	-31.25	-31.53	-31.81	-32.10	-32.39
	Correction for Bloem Return Flow	26.67	27.06	27.45	27.85	28.24	28.51	28.79	29.06	29.33	29.60	29.88	30.15	30.42	30.69	30.97	31.25	31.53	31.81	32.10	32.39
Irrigation:	RR397 Lower Vaal Irrig (U/S of VH Weir)	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30	-2.30
	RR405 Lower Vaal Irrig (U/S of De Hoop)	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34	-2.34
	RR289 Lower Vaal Irrig (D/s of De Hoop; u/s of Harts)	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27	-2.27
	RR290 Lower Vaal Irrig (D/s of Harts; u/s of Schmidtsdri	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72
	RR291 Lower Vaal Irrig (D/s of Schmidt; u/s of Riet/Mod	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22	-0.22
	RR357 (Wentzel Dummy Dam)	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15
	RR360 (Mainstream Wentzel Dam)	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46
	RR362 (Wentzel Dam Irrigation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	RR370 Vaalharts IS Part Taung	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79
	RR379 Vaalharts IS North Canal&Taung	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74	-40.74
	RR383 Vaalharts IS Remainder	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63	-3.63
	RR376 (Spitskop Dummy Dam)	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15	-0.15
	RR435 (Rustfontein Dummy Dam)	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36	-0.36
	RR438 (Rustfontein Mainstream)	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09
	RR416 (Mockes Dummy Dam)	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57
	RR420 (Mockes Dam Mainstream)	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13	-1.13
	RR424 (Krugersdrift Mainstream 1)	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83	-1.83
	RR430 (Krugersdrift Mainstream 2)	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52	-1.52
	RR445 (Lower Modder Diffuse Irrig)	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49	-1.49
	RR453 (Lower Modder 1)	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74
	RR454 (Lower Modder 2)	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74
	RR455 (Lower Modder 3)	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74	-0.74
	RR458 (Tierpoort Dummy Dam)	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
	RR461 (Tierpoort Mainstream)	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18
	RR468 (Kalkfontein Dummy Dam)	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78
	RR469 (Tierpoort Dam)	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65	-0.65
	RR472 (Kalkfontein Mainstream)	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75
	RR479 (Riet River Settlement & Others)	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82	-6.82
	RR484 (Kalkfontein Canals)	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44	-2.44
	RR482 (Lower Riet)	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71	-5.71

Notes (1): Other users include Hoopstad, Bloemhof, Christiana, Vryburg, Warrenton, Barkley West, Union Lime, Delportshoop, Jan Kempdorp, Hartswater, Pampierstat and Windsorto

Projections (Million m³/a)

		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BLOEMHOF TO CONFLUENCE WITH ORANGE (Including Harts & Riet/Modder Subsystems																					
URBAN:	Kimberley	19.33	19.15	18.98	18.80	18.63	18.36	18.10	17.84	17.57	17.31	17.05	16.78	16.52	16.26	15.99	15.73	15.47	15.20	14.94	14.68
	Other Users(1) Region G	21.44	21.57	21.69	21.82	21.94	21.99	22.04	22.10	22.15	22.20	22.25	22.31	22.36	22.41	22.46	22.52	22.57	22.62	22.68	22.73
	Schweizer Reneke	1.17	1.20	1.24	1.27	1.31	1.34	1.38	1.42	1.46	1.50	1.54	1.59	1.63	1.68	1.72	1.77	1.82	1.87	1.93	1.98
* K	ThabaN'chu	4.49	4.19	3.90	3.60	3.30	3.61	3.92	4.22	4.53	4.84	4.53	4.22	3.92	3.61	3.30	3.58	3.87	4.15	4.44	4.72
* K	Botshabelo	16.93	17.60	18.27	18.93	19.60	20.23	20.85	21.48	22.11	22.74	23.36	23.99	24.62	25.25	25.88	26.56	27.26	27.97	28.71	29.46
	Mangaung LM	18.32	18.59	18.86	19.13	19.40	19.59	19.78	19.97	20.15	20.34	20.53	20.72	20.90	21.09	21.28	21.47	21.66	21.86	22.06	22.26
* K	Bloemfontein	52.05	52.82	53.58	54.35	55.12	55.65	56.18	56.72	57.25	57.78	58.31	58.84	59.38	59.91	60.44	60.99	61.54	62.09	62.66	63.22
	Vaal-Gamagara	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70	13.70
* K	Small Users:Welbedacht-Bloem pipeline	1.94	1.95	1.95	1.96	1.96	1.95	1.94	1.93	1.92	1.91	1.90	1.89	1.89	1.88	1.87	1.88	1.89	1.90	1.92	1.93
IRRIGATION:	RR598 Lower Vaal Irrig (U/S of EWR16)																				
	RR397 Lower Vaal Irrig (U/S of VH Weir)	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42	27.42
	RR405 Lower Vaal Irrig (U/S of De Hoop)	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06	25.06
	RR289 Lower Vaal Irrig (D/s of De Hoop; u/s of Harts)	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20	24.20
	RR290 Lower Vaal Irrig (D/s of Harts; u/s of Schmidtsdri	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
	RR291 Lower Vaal Irrig (D/s of Schmidt; u/s of Riet/Mod	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
	RR357 (Wentzel Dummy Dam)	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
	RR360 (Mainstream Wentzel Dam)	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
	RR362 (Wentzel Dam Irrigation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	RR370 Vaalharts GWS Part Taung	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34	6.34
	RR379 Vaalharts GWS North Canal & Part Taung	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04	270.04
	RR383 Vaalharts GWS West Canal & Barkley West	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38	51.38
	RR376 (Spitskop Dummy Dam)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	RR407 (Spitskop Dam Irrigation)	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81	12.81
	RR435 (Rustfontein Dummy Dam)	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
	RR438 (Rustfontein Mainstream)	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29	3.29
	RR416 (Mockes Dummy Dam)	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26
	RR420 (Mockes Dam Mainstream)	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43
	RR424 (Krugersdrift Mainstream 1)	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29	9.29
	RR430 (Krugersdrift Mainstream 2)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
	RR445 (Lower Modder Diffuse Irrig)	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27	20.27
	RR453 (Lower Modder 1)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR454 (Lower Modder 2)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR455 (Lower Modder 3)	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49	9.49
	RR458 (Tierpoort Dummy Dam)	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66
	RR461 (Tierpoort Mainstream)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
	RR468 (Kalkfontein Dummy Dam)	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79	41.79
	RR469 (Tierpoort Dam)	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
	RR472 (Kalkfontein Mainstream)	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92
	RR479 (Riet River Settlement & Others)	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53	93.53
	RR484 (Kalkfontein Canals)	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51	33.51
	RR482 (Lower Riet)	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76	40.76
DIFFUSE:	Harts River: HARTU7.ABS	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80
	Harts River: HARTD7.ABS	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
	All Afforestation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LOSSES:	River Evaporation d/s Bloemhof Dam	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10	78.10
	Vaalharts Irrigation Distribution Losses	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02	127.02
	Lower Vaal Operational Losses	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35	115.35

Appendix G:

EWR Data and Structures for WRPM

Table G-1: Summarised information for EWR Sites in the Upper, Middle and Lower Vaal WMAs

No.	EWR Site Reference	Description	Recommended ERC	Catchment Area:Gross (km²)	Natural MAR (NMAR) 1920-1994 (million m³/a)	EWR Demand (Comb of HF and LF) REC EWR as selected for analysis (million m³/a)	(% NMAR)	WRPM Channel No.	EWR Demand (INCL HIGH FLOWS) (million m³/a)	(% NMAR)	WRPM Channel No.	EWR Demand (LOW FLOWS ONLY) (million m³/a)	(% NMAR)	WRPM Channel No.
1	RE-EWR1	Klein Vaal	C (LF)	318	26.02	2.53	9.7	2075	6.31	24.3	2075	2.53	9.7	2075
2	EWR1	Vaal - Uitkoms	B/C (LF)	4984	288.73	88.97	30.8	2077	117.02	40.5	2077	88.97	30.8	2077
3	EWR2	Vaal - Grootdraai	C (HF)	7995	457.68	58.21	12.7	247	58.24	12.7	247	27.16	5.9	247
4	EWR3	Vaal - Gladdedrift	C (LF)	15638	852.13	93.15	10.9	2079	126.03	14.8	2079	93.15	10.9	2079
5	WA1	Upper Waterval (C1H004)	D (LF)	899	76.71	2.71	3.5	1702	11.33	14.8	1702	2.71	3.5	1702
6	WA2	Lower Waterval (C1H008)	D (LF)	2232	147.43	9.42	6.4	1718	19.92	13.5	1718	9.42	6.4	1718
7	EWR4	Vaal - Deneysville	B/C (LF)	38638	1977.26	410.53	20.8	248		0.0	248	410.53	20.8	248
8	EWR5	Vaal - Scandinavia	C (LF)	49739	2288.02	712.67	31.1	2082		0.0	2082	712.67	31.1	2082
9	EWR6	Klip River	B/C (LF)	1583	95.35	14.79	15.5	2084	22.33	23.4	2084	14.79	15.5	2084
10	EWR7	Wilge River	A/B	170	23.16					0.0				
11	EWR8	Wilge - Bavaria	C (LF)	7503	474.26	23.42	4.9	2086	54.49	11.5	2086	23.42	4.9	2086
12	EWR9	Upper Suikerbosrant	B/C (HF)	1175	31.31	10.21	32.6	2047	10.21	32.6	2047	7.79	24.9	2047
13	EWR10	Lower Suikerbosrant	C/D (LF)	3271	86.97	55.19	63.5	2050	60.80	69.9	2050	55.19	63.5	2050
14	EWR11	Blesbokspruit	D (LF)	1098	29.14	19.18	65.8	2035	25.65	88.0	2035	19.18	65.8	2035
15	RE-EWR2	Mooi (Klerkskraal)	D (HF)	1325	37.69	8.30	22.0	2088	8.30	22.0	2088	5.79	15.4	2088
16	R1	Renoster (Koppies Dam)	C	2160	59.14	7.97	13.5	293	7.97	13.5	293	7.97	13.5	293
17	R2	Renoster (outlet of C70H)	C	5244	111.08	15.33	13.8	2080	15.33	13.8	2080	15.33	13.8	2080
18	EWR12	Vaal: Vermaasdrift	D (LF)	62305	2546.42	332.14	13.0	2090	508.44	20.0	2090	332.14	13.0	2090
19	S1	Schoonspruit IFR1	D	1350	59.38	21.26	35.8	2102	21.26	35.8	2102	21.26	35.8	2102
20	S3	Schoonspruit IFR3	D		89.96	27.80	30.9	2106	27.80	30.9	2106	27.80	30.9	2106
21	S4	Schoonspruit IFR4	D		102.09	31.81	31.2	2108	31.81	31.2	2108	31.81	31.2	2108
22	EWR13	Vaal: Regina Bridge	C (LF)	70809	2654.29	460.04	17.3	2092	619.95	23.4	2092	460.04	17.3	2092
23	EWR14	Vals: Proklameerdrift	C/D (LF)	5930	147.61	7.63	5.2	2110	23.47	15.9	2110	7.63	5.2	2110
24	EWR15	Vet: Fisantkraal	D (LF)	16040	413.55	32.65	7.9	2112	56.54	13.7	2112	32.65	7.9	2112
25	EWR16	Vaal: d/s of Bloemhof	D (HF)	108474	3242.50	635.80	19.6	645	635.80	19.6	645	541.93	16.7	645
26	H1	Harts River (Taung Dam)		11023	58.96	7.77	13.2	1034	7.77	13.2	1034	7.77	13.2	1034
27	EWR17	Harts: Lloyds Weir	D (HF)	31029	147.85	31.92	21.6	1035	36.32	24.6	1035	29.76	20.1	1035
28	EWR18	Vaal: Schmidtsdrift	C/D (LF)	157685	3347.19	82.16	2.5	2098	199.31	6.0	2098	82.16	2.5	2098
29	EWR IFR1	Vaal: Douglas Weir	C/D (HF&LF)	194479	3759.35	208.43	5.5	1036	208.43	5.5	1036	208.43	5.5	1036

The NMAR of these three sites include the natural outflow from the Schoonspruit Eye (estimated at 60.6 million m³/a)

Table G-2: Summarised information for EWR Site in Upper Thukela (Supporting Sub-system of Vaal)

EWR Site Reference	Description	Recommended ERC	Catchment Area:Gross (km²)	Natural MAR (NMAR) (million m³/a)	EWR Demand (Comb of HF and LF) (million m³/a)	(% NMAR)	WRPM Channel No.	EWR Demand (HIGH FLOWS ONLY) (million m³/a)	(% NMAR)	WRPM Channel No.
T1	IFR1: DS of Driel	D	1278	709.83	115.47	16.3	1291	115.47	16.3	1291

Catchment area up to Driel Barrage (not EWR site)

EWR Structures for WRPM (all flow values in m^3/s)

Thukela Sub-system: Downstream of Driel Barrage (EWR T1)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	1.464	0.971	1.632	1.201	1.762	1.444	7.516	1.878	8.448	3.030	9.147	2.491	8.746	2.006	5.447	1.611	3.993	1.289	2.901	1.003	2.248	0.848	1.721	0.826
90	1.736	1.167	2.488	1.682	5.458	1.887	13.605	2.433	23.709	4.491	17.159	3.316	12.037	2.198	7.355	1.757	5.285	1.403	3.551	1.087	2.860	0.923	2.122	0.901
80	2.248	1.589	5.220	2.435	9.816	2.577	22.513	3.294	29.367	6.771	27.285	4.608	15.154	2.613	8.345	2.072	6.011	1.648	4.211	1.267	3.114	1.084	2.434	1.063
70	2.703	2.068	7.874	3.075	15.883	3.159	27.345	4.007	36.238	8.694	32.848	5.707	16.894	3.083	9.233	2.435	6.547	1.931	4.514	1.478	3.297	1.271	2.867	1.249
60	3.547	2.465	11.987	3.506	24.373	3.546	34.338	4.470	44.866	9.973	39.244	6.446	19.622	3.473	9.901	2.741	7.010	2.173	4.779	1.662	3.745	1.430	3.110	1.406
50	4.540	2.729	14.525	3.757	29.152	3.989	38.594	4.950	49.672	11.977	45.311	7.375	21.007	3.732	10.857	2.950	7.504	2.340	5.279	1.792	3.999	1.540	3.210	1.513
40	7.094	2.879	18.773	3.890	33.038	4.240	51.225	5.217	62.164	13.138	48.809	7.908	24.973	3.879	11.406	3.072	7.959	2.439	5.735	1.871	4.301	1.605	3.573	1.576
30	10.447	2.953	24.969	3.955	38.053	4.473	58.274	5.456	68.830	14.344	53.756	8.421	27.944	3.952	12.608	3.134	8.762	2.490	6.131	1.913	4.506	1.639	3.893	1.608
20	15.240	2.986	28.792	3.985	42.996	4.722	63.807	5.706	88.033	15.716	68.407	8.978	30.849	3.985	14.692	3.163	10.482	2.514	6.971	1.933	5.694	1.655	5.320	1.623
10	18.265	2.994	42.928	3.990	54.839	4.998	78.185	5.980	111.050	17.304	84.901	9.608	41.358	3.993	17.242	3.173	12.095	2.523	8.012	1.942	6.761	1.661	7.600	1.627
Min	9999.9	2.994	9999.9	3.990	9999.9	4.998	9999.9	5.980	9999.9	17.304	9999.9	9.608	9999.9	3.993	9999.9	3.173	9999.9	2.523	9999.9	1.942	9999.9	1.661	9999.9	1.627

Grootdraai Sub-system: Klein Vaal (RE-EWR1)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.022	0.020	0.039	0.036	0.093	0.050	0.175	0.054	0.143	0.075	0.063	0.032	0.027	0.024	0.011	0.001	0.000	0.000	0.007	0.001	0.015	0.001	0.019	0.012
90	0.037	0.023	0.066	0.042	0.187	0.057	0.347	0.062	0.254	0.085	0.097	0.039	0.073	0.030	0.041	0.005	0.019	0.004	0.030	0.004	0.034	0.003	0.027	0.015
80	0.067	0.030	0.266	0.054	0.332	0.072	0.526	0.078	0.352	0.107	0.198	0.057	0.104	0.042	0.052	0.015	0.050	0.012	0.049	0.011	0.041	0.009	0.039	0.020
70	0.101	0.040	0.347	0.072	0.553	0.094	0.672	0.102	0.479	0.138	0.295	0.082	0.123	0.059	0.060	0.029	0.058	0.023	0.052	0.020	0.049	0.017	0.050	0.027
60	0.138	0.051	0.444	0.090	0.840	0.117	1.016	0.127	0.623	0.172	0.437	0.109	0.170	0.077	0.071	0.044	0.062	0.034	0.060	0.031	0.056	0.026	0.058	0.034
50	0.164	0.060	0.613	0.107	1.195	0.137	1.075	0.149	0.819	0.202	0.511	0.133	0.224	0.093	0.086	0.057	0.077	0.044	0.071	0.040	0.067	0.034	0.066	0.041
40	0.235	0.067	0.930	0.119	1.684	0.152	1.557	0.166	1.049	0.223	0.676	0.150	0.336	0.105	0.131	0.067	0.093	0.052	0.078	0.047	0.082	0.040	0.077	0.045
30	0.332	0.072	1.339	0.127	1.986	0.161	1.781	0.176	1.602	0.237	0.907	0.161	0.394	0.113	0.161	0.073	0.116	0.057	0.105	0.052	0.093	0.044	0.108	0.049
20	0.411	0.074	2.481	0.132	3.286	0.167	2.423	0.182	2.008	0.245	1.378	0.167	0.640	0.117	0.254	0.076	0.158	0.060	0.134	0.054	0.112	0.046	0.139	0.050
10	2.080	0.075	3.843	0.134	4.816	0.169	3.517	0.185	6.158	0.249	2.117	0.171	0.926	0.119	0.500	0.078	0.243	0.061	0.168	0.055	0.134	0.047	0.204	0.051
Min	9999.9	0.075	9999.9	0.134	9999.9	0.169	9999.9	0.185	9999.9	0.249	9999.9	0.171	9999.9	0.119	9999.9	0.078	9999.9	0.061	9999.9	0.055	9999.9	0.047	9999.9	0.051

Grootdraai Sub-system: Vaal River at Uitkoms (EWR1)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.228	0.239	0.440	0.289	1.030	0.324	1.923	0.340	1.586	0.362	0.698	0.111	0.289	0.116	0.131	0.067	0.000	0.184	0.078	0.183	0.149	0.183	0.197	0.195
90	0.411	0.443	0.748	0.726	2.080	0.795	3.849	0.847	2.798	0.980	1.057	0.565	0.791	0.501	0.463	0.258	0.201	0.361	0.321	0.352	0.355	0.352	0.313	0.379
80	0.736	0.893	2.955	1.525	3.685	1.658	5.839	1.776	3.904	2.111	2.180	1.395	1.142	1.165	0.582	0.680	0.536	0.752	0.534	0.727	0.470	0.727	0.432	0.785
70	1.101	1.532	3.835	2.453	6.116	2.658	7.430	2.853	5.297	3.424	3.274	2.358	1.373	1.809	0.646	1.278	0.633	1.306	0.582	1.258	0.538	1.258	0.556	1.361
60	1.516	2.222	4.907	3.300	9.300	3.572	11.234	3.836	6.883	4.622	4.842	3.237	1.898	2.577	0.769	1.925	0.702	1.905	0.661	1.832	0.612	1.832	0.637	1.983
50	1.815	2.827	6.813	3.953	13.236	4.276	11.910	4.594	9.075	5.546	5.668	3.914	2.469	3.171	0.956	2.492	0.853	2.431	0.780	2.335	0.758	2.335	0.721	2.529
40	2.584	3.274	10.285	4.394	18.660	4.752	17.238	5.107	11.590	6.170	7.467	4.373	3.711	3.551	1.441	2.912	1.038	2.819	0.885	2.707	0.892	2.707	0.841	2.932
30	3.666	3.559	14.815	4.663	21.972	5.042	19.706	5.420	17.736	6.551	10.032	4.652	4.344	3.775	1.792	3.179	1.281	3.066	1.165	2.944	1.016	2.944	1.204	3.189
20	4.566	3.719	27.450	4.813	36.384	5.204	26.833	5.594	22.235	6.764	15.255	4.808	7.103	3.900	2.804	3.328	1.771	3.205	1.486	3.077	1.243	3.077	1.539	3.333
10	23.010	3.798	42.554	4.891	53.338	5.288	38.915	5.684	68.170	6.873	23.436	4.888	10.228	3.964	5.544	3.403	2.712	3.274	1.863	3.143	1.501	3.143	2.272	3.405
Min	9999.9	3.798	9999.9	4.891	9999.9	5.288	9999.9	5.684	9999.9	6.873	9999.9	4.888	9999.9	3.964	9999.9	3.403	9999.9	3.274	9999.9	3.143	9999.9	3.143	9999.9	3.405

EWR Structures for WRPM (all flow values in m^3/s)

Grootdraai Sub-system: Vaal River at Grootdraai Dam (EWR2)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.362	0.139	0.694	0.306	1.635	0.364	3.047	1.066	2.516	0.787	1.109	0.370	0.459	0.205	0.209	0.012	0.000	0.000	0.127	0.013	0.239	0.012	0.313	0.083
90	0.650	0.196	1.184	0.408	3.297	0.434	6.101	1.246	4.437	0.901	1.676	0.450	1.254	0.248	0.732	0.077	0.320	0.067	0.508	0.094	0.560	0.086	0.498	0.157
80	1.165	0.321	4.684	0.633	5.839	0.610	9.256	1.732	6.186	1.209	3.457	0.650	1.809	0.355	0.926	0.218	0.849	0.191	0.848	0.241	0.747	0.221	0.683	0.293
70	1.747	0.500	6.076	0.952	9.692	0.903	11.776	2.651	8.395	1.792	5.190	0.983	2.176	0.534	1.023	0.419	1.003	0.367	0.922	0.413	0.851	0.378	0.880	0.450
60	2.404	0.693	7.778	1.297	14.740	1.273	17.805	3.982	10.906	2.636	7.676	1.404	3.009	0.759	1.221	0.637	1.111	0.557	1.049	0.569	0.971	0.522	1.011	0.594
50	2.875	0.862	10.795	1.599	20.975	1.642	18.873	5.492	14.381	3.593	8.979	1.824	3.912	0.985	1.512	0.828	1.350	0.724	1.236	0.690	1.198	0.633	1.142	0.705
40	4.096	0.987	16.300	2.051	29.574	2.163	27.319	9.174	18.367	5.544	11.835	2.166	5.883	1.168	2.285	0.968	1.644	0.847	1.400	0.772	1.415	0.707	1.331	0.780
30	5.813	1.066	23.476	2.339	34.819	2.523	31.228	11.969	28.106	7.017	15.898	2.397	6.883	1.292	2.838	1.058	2.029	0.926	1.844	0.822	1.609	0.753	1.906	0.826
20	7.236	1.111	43.499	2.620	57.658	2.863	42.525	15.221	35.238	8.637	24.175	2.529	11.254	1.363	4.443	1.108	2.805	0.970	2.356	0.849	1.968	0.779	2.442	0.851
10	36.466	1.133	67.438	2.925	84.528	3.223	61.675	19.261	108.034	10.577	37.138	2.594	16.211	1.398	8.789	1.134	4.298	0.992	2.953	0.864	2.378	0.792	3.600	0.865
Min	9999.9	1.133	9999.9	2.925	9999.9	3.223	9999.9	19.261	9999.9	10.577	9999.9	2.594	9999.9	1.398	9999.9	1.134	9999.9	0.992	9999.9	0.864	9999.9	0.792	9999.9	0.865

Vaal Dam Sub-system: Vaal River at Gladdedrift (EWR3)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.605	0.115	2.913	0.331	2.789	0.490	4.876	0.667	3.314	1.038	2.039	0.659	0.702	0.327	0.534	0.114	0.505	0.057	0.534	0.006	1.109	0.004	0.625	0.005
90	1.400	0.306	4.630	0.708	6.612	1.065	10.458	1.815	10.968	2.672	4.256	1.754	2.581	0.661	1.157	0.280	0.768	0.139	1.344	0.083	1.333	0.048	1.119	0.067
80	3.323	0.710	7.045	1.510	11.660	2.116	14.751	3.407	15.786	4.938	8.408	3.273	3.603	1.371	1.908	0.633	1.539	0.315	1.676	0.245	1.680	0.143	1.713	0.198
70	4.163	1.205	9.838	2.492	18.731	3.335	25.403	4.864	18.330	7.011	11.190	4.662	5.313	2.242	2.285	1.065	1.775	0.530	1.781	0.445	2.042	0.259	2.103	0.359
60	4.891	1.670	15.532	3.414	22.905	4.449	30.597	5.979	22.550	8.598	14.034	5.725	6.771	3.058	3.013	1.471	2.276	0.732	2.389	0.632	2.356	0.368	2.481	0.510
50	6.183	2.033	26.578	4.135	37.851	5.307	36.238	6.740	27.421	9.682	17.652	6.451	9.317	3.696	3.502	1.788	2.685	0.890	2.767	0.778	2.632	0.453	2.882	0.628
40	8.150	2.280	31.493	4.625	46.446	5.887	44.564	7.220	33.936	10.364	29.813	6.909	10.814	4.130	4.678	2.004	3.194	0.998	3.259	0.878	3.047	0.511	3.480	0.708
30	10.831	2.430	50.494	4.922	64.606	6.241	59.435	7.505	47.173	10.769	34.730	7.180	15.069	4.394	5.910	2.135	4.008	1.063	3.711	0.938	3.674	0.546	3.870	0.756
20	22.450	2.513	71.717	5.087	96.722	6.438	78.883	7.665	81.772	10.998	45.688	7.333	19.244	4.540	8.371	2.208	6.289	1.099	4.611	0.971	4.499	0.566	5.502	0.783
10	69.728	2.556	107.060	5.172	147.965	6.540	116.446	7.752	170.969	11.121	71.121	7.416	29.884	4.615	12.448	2.245	8.615	1.117	6.664	0.989	5.981	0.576	11.053	0.797
Min	9999.9	2.556	9999.9	5.172	9999.9	6.540	9999.9	7.752	9999.9	11.121	9999.9	7.416	9999.9	4.615	9999.9	2.245	9999.9	1.117	9999.9	0.989	9999.9	0.576	9999.9	0.797

Upper Waterval Catchment: EWR WA1

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.007	0.000	0.042	0.001	0.078	0.016	0.078	0.027	0.152	0.003	0.078	0.027	0.039	0.012	0.015	0.009	0.008	0.011	0.007	0.015	0.007	0.020	0.008	0.000
90	0.030	0.003	0.081	0.003	0.138	0.016	0.164	0.027	0.250	0.003	0.138	0.028	0.093	0.014	0.045	0.011	0.023	0.012	0.007	0.016	0.011	0.022	0.008	0.001
80	0.037	0.014	0.147	0.011	0.231	0.023	0.246	0.035	0.500	0.014	0.213	0.036	0.139	0.023	0.067	0.016	0.039	0.015	0.026	0.020	0.015	0.024	0.008	0.005
70	0.045	0.035	0.586	0.030	0.612	0.041	0.653	0.055	0.828	0.043	0.441	0.055	0.170	0.041	0.086	0.026	0.046	0.022	0.030	0.027	0.015	0.030	0.015	0.015
60	0.078	0.065	1.890	0.064	2.087	0.072	2.102	0.093	1.299	0.096	0.795	0.088	0.278	0.068	0.127	0.039	0.050	0.030	0.037	0.036	0.030	0.036	0.031	0.027
50	0.116	0.099	2.739	0.105	3.424	0.114	3.226	0.145	2.573	0.168	1.016	0.130	0.656	0.097	0.161	0.053	0.058	0.039	0.045	0.045	0.030	0.043	0.031	0.041
40	0.134	0.128	4.699	0.147	5.444	0.157	4.861	0.199	3.978	0.241	2.098	0.172	1.312	0.123	0.269	0.066	0.081	0.046	0.049	0.053	0.037	0.050	0.039	0.053
30	1.202	0.147	6.231	0.180	6.489	0.189	6.246	0.239	7.112	0.296	3.734	0.203	2.284	0.141	0.392	0.074	0.147	0.051	0.056	0.058	0.045	0.054	0.046	0.061
20	2.912	0.160	7.677	0.199	8.524	0.210	8.766	0.265	11.746	0.330	6.493	0.222	3.349	0.150	0.971	0.078	0.212	0.054	0.119	0.061	0.075	0.057	0.062	0.065
10	6.504	0.165	11.937	0.207	12.526	0.219	10.745	0.276	15.040	0.345	11.316	0.231	5.698	0.155	1.863	0.081	0.629	0.055	0.918	0.062	0.239	0.058	0.135	0.066
Min	9999.9	0.165	9999.9	0.207	9999.9	0.219	9999.9	0.276	9999.9	0.345	9999.9	0.231	9999.9	0.155	9999.9	0.081	9999.9	0.055	9999.9	0.062	9999.9	0.058	9999.9	0.066

EWR Structures for WRPM (all flow values in m^3/s)

Lower Waterval Catchment: EWR WA2

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.026	0.000	0.228	0.005	0.243	0.031	0.340	0.059	0.217	0.009	0.179	0.058	0.077	0.026	0.067	0.023	0.046	0.023	0.052	0.036	0.052	0.041	0.008	0.000
90	0.093	0.006	0.513	0.008	0.653	0.034	1.247	0.059	1.262	0.013	0.728	0.064	0.185	0.030	0.112	0.026	0.077	0.026	0.082	0.038	0.116	0.042	0.054	0.005
80	0.332	0.027	1.454	0.035	1.057	0.065	2.087	0.089	1.754	0.063	1.053	0.100	0.390	0.060	0.187	0.035	0.093	0.034	0.123	0.046	0.190	0.050	0.147	0.020
70	0.538	0.071	2.427	0.100	2.188	0.146	2.923	0.172	2.401	0.192	1.310	0.187	0.799	0.121	0.310	0.054	0.127	0.049	0.228	0.060	0.287	0.063	0.224	0.048
60	0.788	0.133	4.055	0.210	5.018	0.294	4.014	0.328	3.151	0.430	2.080	0.336	1.208	0.208	0.474	0.082	0.162	0.068	0.321	0.079	0.385	0.080	0.378	0.088
50	1.101	0.202	5.675	0.352	7.467	0.494	5.675	0.543	5.068	0.749	3.035	0.530	1.782	0.304	0.560	0.111	0.297	0.090	0.373	0.099	0.493	0.099	0.448	0.132
40	1.897	0.261	7.442	0.492	8.695	0.694	7.986	0.763	7.014	1.071	4.092	0.719	2.338	0.386	0.661	0.137	0.417	0.108	0.478	0.114	0.642	0.115	0.556	0.169
30	2.587	0.303	9.225	0.598	10.409	0.850	10.596	0.934	11.119	1.319	5.290	0.861	3.349	0.444	0.829	0.154	0.517	0.119	0.665	0.125	0.792	0.125	0.791	0.195
20	6.616	0.326	13.754	0.661	16.331	0.943	15.494	1.038	16.958	1.468	11.387	0.947	4.414	0.476	1.564	0.163	0.745	0.126	0.855	0.131	1.027	0.131	1.007	0.209
10	13.090	0.336	21.744	0.691	22.386	0.987	20.389	1.085	35.042	1.538	18.138	0.988	7.801	0.492	3.483	0.169	1.532	0.130	1.591	0.133	1.281	0.133	1.474	0.216
Min	9999.9	0.336	9999.9	0.691	9999.9	0.987	9999.9	1.085	9999.9	1.538	9999.9	0.988	9999.9	0.492	9999.9	0.169	9999.9	0.130	9999.9	0.133	9999.9	0.133	9999.9	0.216

Vaal River at Deneysville downstream of Vaal Dam : EWR4

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	1.844	2.632	7.353	3.444	6.862	4.778	10.805	5.044	11.267	4.778	6.437	3.444	1.640	3.174	2.427	3.444	1.501	3.444	1.852	3.201	2.576	3.200	1.736	3.200
90	3.715	4.778	10.899	9.371	10.865	9.371	24.761	10.357	23.988	10.029	14.651	8.714	7.230	6.111	3.181	5.578	2.785	5.311	3.763	5.204	3.741	5.200	2.940	5.200
80	7.366	7.673	19.367	13.500	28.006	14.100	43.395	14.400	45.669	14.400	26.157	14.100	12.967	8.714	5.877	7.933	3.708	7.413	4.510	7.074	4.742	7.070	4.275	7.070
70	10.450	9.700	25.089	14.400	45.759	15.850	58.699	16.020	55.154	16.020	32.546	15.000	16.196	10.357	6.997	9.371	4.599	7.933	5.290	7.673	5.612	7.670	5.567	7.670
60	14.076	11.343	39.479	15.000	58.990	16.530	73.824	17.040	64.434	16.700	38.695	15.680	21.701	12.000	8.218	10.357	5.459	8.714	5.742	8.558	6.467	8.560	7.141	8.560
50	18.485	13.050	57.384	16.020	84.058	17.652	88.620	18.230	74.644	17.380	50.892	16.598	23.179	13.950	9.592	11.014	6.412	10.029	6.829	9.536	7.277	9.370	7.897	9.370
40	23.436	15.000	77.022	17.040	101.826	18.060	105.992	19.980	92.552	17.720	64.423	17.380	30.127	15.680	12.944	13.200	7.928	11.671	8.262	11.277	8.606	11.280	9.402	11.280
30	32.366	16.700	113.495	18.060	129.626	19.980	124.201	21.560	113.082	18.400	81.758	17.890	35.212	16.700	15.939	14.700	10.201	12.900	9.364	12.660	9.752	12.660	11.640	12.660
20	69.997	16.700	152.010	18.060	183.401	19.980	177.024	21.560	223.292	18.400	126.034	17.890	63.160	16.700	19.986	14.700	14.468	12.900	11.951	12.660	12.422	14.910	17.157	14.910
10	161.862	16.700	239.464	18.060	288.385	19.980	285.491	21.560	422.513	18.400	174.787	17.890	86.211	16.700	31.108	14.700	21.165	12.900	17.574	12.660	15.558	21.560	25.849	21.560
Min	9999.9	16.700	9999.9	18.060	9999.9	19.980	9999.9	21.560	9999.9	18.400	9999.9	17.890	9999.9	16.700	9999.9	14.700	9999.9	12.900	9999.9	12.660	9999.9	21.560	9999.9	21.560

Vaal River at Scandinavia : EWR5

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	3.256	3.500	8.827	4.675	10.476	6.400	13.702	8.620	13.463	5.500	8.923	5.000	4.321	3.500	4.208	2.700	3.542	3.250	3.741	3.250	4.361	3.000	3.252	3.250
90	5.242	6.250	12.407	9.460	17.384	12.500	28.625	12.200	27.524	13.400	18.780	10.340	9.842	5.950	5.257	5.250	4.819	5.125	5.918	5.125	5.682	5.000	4.988	5.250
80	9.700	9.460	23.299	13.400	33.912	14.000	52.587	27.183	52.114	20.171	30.787	18.114	16.840	11.300	9.140	7.000	6.343	6.925	6.657	7.000	6.840	7.000	6.219	7.180
70	12.351	12.800	34.460	17.429	52.662	19.486	67.201	31.400	63.291	27.183	39.520	24.020	21.277	13.700	10.073	8.800	7.014	8.260	7.747	8.620	7.486	8.800	7.137	9.020
60	17.029	14.000	44.684	24.020	70.800	31.400	86.488	35.620	73.886	37.730	44.504	31.400	27.245	17.429	11.817	11.900	8.758	8.800	8.636	9.680	8.938	9.900	8.870	10.120
50	21.143	17.977	70.054	25.918	89.453	40.473	113.265	47.225	85.914	46.170	59.435	44.482	31.535	20.103	13.030	14.000	9.336	9.020	9.498	10.098	9.797	11.000	9.873	11.000
40	26.001	25.074	97.816	25.918	112.877	40.473	124.429	47.225	100.111	46.170	72.547	48.280	37.994	26.129	17.734	18.800	11.655	11.300	10.712	12.200	11.070	13.490	11.466	13.490
30	35.924	28.237	123.441	25.918	149.347	40.473	147.749	47.225	135.091	46.170	99.138	48.280	43.175	33.510	20.527	22.966	14.167	13.700	12.332	14.686	11.992	16.743	13.827	16.743
20	80.455	35.620	166.686	25.918	217.970	40.473	198.271	47.225	247.021	46.170	154.447	48.280	67.353	48.280	30.100	26.129	19.444	17.429	15.797	18.800	15.140	20.857	20.058	20.857
10	188.990	35.620	333.291	25.918	344.500	40.473	310.420	47.225	454.728	46.170	213.893	48.280	98.657	48.280	41.241	31.400	25.610	26.129	22.831	28.237	19.108	31.400	28.553	31.400
Min	9999.9	35.620	9999.9	25.918	9999.9	40.473	9999.9	47.225	9999.9	46.170	9999.9	48.280	9999.9	48.280	9999.9	31.400	9999.9	26.129	9999.9	28.237	9999.9	31.400	9999.9	31.400

EWR Structures for WRPM (all flow values in m^3/s)

Klip River : EWR6

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.052	0.047	0.112	0.080	0.078	0.048	0.306	0.119	0.164	0.139	0.116	0.106	0.058	0.027	0.052	0.024	0.046	0.035	0.049	0.031	0.041	0.022	0.039	0.026
90	0.097	0.067	0.270	0.120	0.485	0.105	0.579	0.187	1.278	0.236	0.511	0.171	0.174	0.071	0.093	0.053	0.089	0.048	0.071	0.044	0.075	0.031	0.066	0.036
80	0.194	0.111	0.556	0.210	1.001	0.232	1.318	0.338	1.639	0.450	0.724	0.315	0.428	0.167	0.183	0.116	0.131	0.077	0.134	0.073	0.116	0.052	0.104	0.057
70	0.258	0.173	0.729	0.336	1.624	0.411	1.927	0.552	1.922	0.754	1.303	0.519	0.575	0.303	0.235	0.206	0.220	0.118	0.183	0.115	0.149	0.081	0.135	0.088
60	0.366	0.240	1.431	0.473	2.274	0.605	2.617	0.783	2.544	1.083	2.076	0.740	0.934	0.450	0.373	0.303	0.270	0.162	0.220	0.160	0.194	0.112	0.162	0.121
50	0.582	0.299	2.022	0.594	3.035	0.775	3.416	0.985	3.638	1.371	2.423	0.934	1.154	0.579	0.478	0.387	0.301	0.200	0.239	0.199	0.224	0.139	0.208	0.150
40	0.930	0.342	3.364	0.682	4.241	0.900	5.029	1.135	4.261	1.584	3.263	1.077	1.389	0.674	0.594	0.450	0.413	0.229	0.340	0.228	0.265	0.160	0.247	0.172
30	1.486	0.370	5.382	0.739	6.530	0.980	6.564	1.230	6.154	1.720	4.208	1.168	2.133	0.735	0.877	0.490	0.517	0.247	0.437	0.247	0.306	0.173	0.374	0.185
20	3.203	0.386	6.759	0.771	9.543	1.025	9.125	1.284	10.812	1.796	6.470	1.219	2.901	0.769	1.254	0.513	0.745	0.257	0.653	0.257	0.411	0.180	0.610	0.193
10	8.539	0.393	15.486	0.786	17.152	1.048	15.901	1.310	25.008	1.834	8.442	1.245	4.109	0.786	2.072	0.524	1.343	0.262	0.948	0.262	0.676	0.184	1.705	0.197
Min	9999.9	0.393	9999.9	0.786	9999.9	1.048	9999.9	1.310	9999.9	1.834	9999.9	1.245	9999.9	0.786	9999.9	0.524	9999.9	0.262	9999.9	0.262	9999.9	0.184	9999.9	0.197

Wilge River : EWR7

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.022	0.001	0.035	0.035	0.049	0.047	0.082	0.059	0.180	0.079	0.093	0.067	0.027	0.006	0.015	0.002	0.008	0.001	0.000	0.000	0.000	0.000	0.027	0.013
90	0.045	0.015	0.069	0.066	0.105	0.087	0.265	0.141	0.328	0.195	0.187	0.160	0.077	0.044	0.041	0.025	0.027	0.012	0.026	0.006	0.022	0.006	0.039	0.020
80	0.075	0.041	0.212	0.121	0.231	0.159	0.452	0.255	0.537	0.357	0.291	0.289	0.147	0.115	0.060	0.060	0.046	0.034	0.045	0.019	0.049	0.018	0.046	0.035
70	0.086	0.071	0.293	0.186	0.411	0.242	0.556	0.359	0.709	0.504	0.459	0.408	0.220	0.196	0.078	0.078	0.054	0.054	0.049	0.035	0.052	0.032	0.054	0.053
60	0.138	0.100	0.386	0.246	0.556	0.319	0.754	0.439	0.881	0.617	0.571	0.498	0.282	0.270	0.108	0.108	0.069	0.069	0.063	0.049	0.063	0.046	0.066	0.066
50	0.183	0.122	0.498	0.292	0.795	0.377	0.922	0.493	1.053	0.694	0.702	0.560	0.324	0.324	0.134	0.134	0.093	0.093	0.078	0.061	0.071	0.056	0.081	0.081
40	0.302	0.137	0.783	0.324	1.079	0.417	1.247	0.527	1.262	0.743	0.974	0.599	0.471	0.367	0.168	0.168	0.112	0.112	0.093	0.068	0.090	0.064	0.112	0.092
30	0.497	0.146	1.154	0.343	1.393	0.441	1.628	0.548	1.561	0.772	1.217	0.622	0.563	0.390	0.243	0.243	0.139	0.122	0.105	0.073	0.112	0.068	0.150	0.098
20	0.709	0.151	1.690	0.354	1.747	0.455	2.087	0.559	2.266	0.788	1.415	0.635	0.710	0.403	0.310	0.252	0.185	0.126	0.164	0.076	0.153	0.071	0.224	0.101
10	1.359	0.154	2.951	0.359	2.897	0.462	3.069	0.565	4.056	0.797	1.740	0.643	0.910	0.410	0.478	0.256	0.313	0.128	0.284	0.077	0.250	0.072	0.432	0.103
Min	9999.9	0.154	9999.9	0.359	9999.9	0.462	9999.9	0.565	9999.9	0.797	9999.9	0.643	9999.9	0.410	9999.9	0.256	9999.9	0.128	9999.9	0.077	9999.9	0.072	9999.9	0.103

Wilge River at Bavaria: EWR8

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.452	0.019	0.737	0.246	0.952	0.286	1.647	0.330	3.548	0.439	1.900	0.370	0.621	0.283	0.299	0.069	0.197	0.038	0.019	0.017	0.022	0.020	0.521	0.123
90	0.862	0.061	1.439	0.300	2.080	0.349	5.164	0.400	6.408	0.528	3.707	0.451	1.968	0.348	0.814	0.118	0.559	0.072	0.545	0.049	0.448	0.046	0.760	0.148
80	1.512	0.154	4.201	0.418	4.540	0.487	9.577	0.556	10.808	0.724	6.119	0.629	2.955	0.492	1.228	0.226	0.887	0.148	0.874	0.118	0.945	0.102	0.938	0.205
70	1.747	0.285	5.810	0.585	8.094	0.683	10.924	0.778	14.557	1.002	9.013	0.881	4.360	0.696	1.568	0.379	1.096	0.256	0.963	0.217	1.049	0.183	1.038	0.285
60	2.755	0.427	7.589	0.766	11.354	0.895	15.636	1.017	17.396	1.303	11.540	1.154	5.502	0.917	2.169	0.544	1.358	0.372	1.277	0.323	1.273	0.269	1.350	0.371
50	3.689	0.551	9.973	0.925	16.502	1.081	18.836	1.227	22.132	1.567	13.803	1.393	6.362	1.110	2.744	0.689	1.890	0.474	1.576	0.417	1.385	0.346	1.647	0.447
40	5.903	0.643	15.926	1.042	22.166	1.218	25.299	1.382	24.885	1.762	18.963	1.570	9.483	1.253	3.368	0.796	2.373	0.550	1.826	0.486	1.807	0.402	2.238	0.503
30	10.286	0.702	22.635	1.117	28.103	1.305	31.761	1.481	31.064	1.886	24.197	1.682	11.532	1.345	4.757	0.865	2.716	0.598	2.221	0.530	2.177	0.438	3.044	0.539
20	14.064	0.735	35.972	1.159	35.510	1.354	42.813	1.536	49.025	1.956	29.570	1.745	13.870	1.396	6.153	0.903	3.584	0.625	3.237	0.555	3.047	0.458	4.375	0.559
10	29.977	0.751	60.980	1.180	58.330	1.379	63.064	1.564	81.186	1.990	35.880	1.777	18.233	1.421	9.453	0.922	6.134	0.638	5.626	0.567	5.208	0.468	9.194	0.569
Min	9999.9	0.751	9999.9	1.180	9999.9	1.379	9999.9	1.564	9999.9	1.990	9999.9	1.777	9999.9	1.421	9999.9	0.922	9999.9	0.638	9999.9	0.567	9999.9	0.468	9999.9	0.569

EWR Structures for WRPM (all flow values in m^3/s)

Upper Suikerbosrant: EWR9

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.093	0.068	0.077	0.077	0.138	0.082	0.161	0.108	0.201	0.106	0.202	0.071	0.181	0.068	0.127	0.062	0.143	0.059	0.149	0.054	0.138	0.051	0.112	0.051
90	0.108	0.087	0.147	0.108	0.224	0.109	0.235	0.149	0.295	0.149	0.287	0.095	0.266	0.087	0.205	0.079	0.177	0.072	0.183	0.062	0.172	0.057	0.131	0.055
80	0.149	0.127	0.266	0.168	0.310	0.166	0.355	0.240	0.426	0.242	0.414	0.148	0.367	0.131	0.235	0.115	0.220	0.098	0.209	0.082	0.183	0.071	0.147	0.065
70	0.202	0.185	0.421	0.254	0.396	0.248	0.489	0.369	0.471	0.375	0.470	0.223	0.432	0.192	0.310	0.167	0.243	0.136	0.231	0.109	0.194	0.089	0.166	0.080
60	0.254	0.247	0.629	0.347	0.541	0.337	0.597	0.509	0.606	0.518	0.575	0.304	0.509	0.258	0.370	0.223	0.297	0.178	0.246	0.139	0.209	0.110	0.197	0.095
50	0.332	0.301	0.694	0.428	0.661	0.414	0.691	0.632	0.701	0.644	0.668	0.375	0.625	0.316	0.414	0.273	0.340	0.214	0.280	0.165	0.235	0.128	0.201	0.109
40	0.470	0.342	0.868	0.518	0.795	0.531	0.833	0.833	0.840	0.802	0.814	0.428	0.718	0.359	0.478	0.309	0.363	0.241	0.310	0.184	0.265	0.141	0.239	0.119
30	0.564	0.367	1.057	0.576	0.956	0.605	0.915	0.915	0.914	0.903	0.948	0.461	0.837	0.386	0.582	0.332	0.440	0.258	0.377	0.196	0.310	0.149	0.282	0.125
20	0.736	0.382	1.389	0.624	1.273	0.678	1.236	1.101	1.708	0.994	1.198	0.480	0.999	0.402	0.717	0.345	0.617	0.267	0.489	0.203	0.358	0.154	0.332	0.129
10	1.090	0.389	3.287	0.671	1.676	0.756	3.424	1.251	6.264	1.086	2.808	0.489	1.597	0.409	1.314	0.352	0.856	0.272	0.642	0.206	0.482	0.157	0.536	0.130
Min	9999.9	0.389	9999.9	0.671	9999.9	0.756	9999.9	1.251	9999.9	1.086	9999.9	0.489	9999.9	0.409	9999.9	0.352	9999.9	0.272	9999.9	0.206	9999.9	0.157	9999.9	0.130

Lower Suikerbosrant: EWR10

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.254	0.706	0.224	0.823	0.403	0.818	0.467	0.903	0.533	1.034	0.605	0.900	0.536	0.877	0.399	0.816	0.424	0.789	0.437	0.745	0.414	0.705	0.316	0.702
90	0.310	0.780	0.432	0.940	0.612	0.947	0.739	1.136	0.869	1.388	0.792	1.173	0.876	1.041	0.571	0.932	0.509	0.876	0.511	0.803	0.474	0.760	0.370	0.764
80	0.414	0.937	0.849	1.187	0.960	1.223	1.228	1.511	1.348	1.958	1.150	1.613	1.061	1.388	0.780	1.181	0.640	1.061	0.579	0.927	0.526	0.877	0.424	0.894
70	0.534	1.130	1.123	1.490	1.176	1.560	1.471	1.869	1.475	2.500	1.378	2.031	1.289	1.814	0.952	1.485	0.756	1.287	0.657	1.078	0.549	1.020	0.467	1.054
60	0.694	1.311	1.636	1.774	1.501	1.877	1.852	2.147	1.577	2.922	1.788	2.357	1.466	2.214	1.045	1.771	0.806	1.499	0.728	1.221	0.597	1.154	0.513	1.205
50	0.818	1.453	2.033	1.996	2.001	2.124	2.165	2.337	2.102	3.211	1.997	2.580	1.829	2.526	1.206	1.995	0.949	1.665	0.799	1.332	0.642	1.258	0.586	1.322
40	1.057	1.549	2.326	2.147	2.475	2.293	2.408	2.457	2.671	3.393	2.292	2.721	2.191	2.738	1.355	2.146	1.057	1.778	0.892	1.408	0.765	1.330	0.629	1.402
30	1.344	1.607	2.635	2.239	2.729	2.395	2.770	2.528	2.999	3.500	2.867	2.803	2.666	2.867	1.751	2.239	1.227	1.847	1.001	1.454	0.874	1.373	0.710	1.451
20	1.983	1.640	3.762	2.290	3.562	2.452	3.715	2.567	4.036	3.560	4.226	2.850	3.148	2.939	2.341	2.290	1.721	1.885	1.355	1.479	0.952	1.397	0.914	1.478
10	2.625	1.656	7.569	2.316	4.615	2.481	10.391	2.588	14.217	3.592	7.504	2.875	4.695	2.975	3.715	2.316	2.353	1.904	1.706	1.492	1.172	1.409	1.408	1.491
Min	9999.9	1.656	9999.9	2.316	9999.9	2.481	9999.9	2.588	9999.9	3.592	9999.9	2.875	9999.9	2.975	9999.9	2.316	9999.9	1.904	9999.9	1.492	9999.9	1.409	9999.9	1.491

Blesbokspruit: EWR11

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.090	0.036	0.069	0.302	0.127	0.303	0.168	0.345	0.131	0.376	0.220	0.345	0.201	0.344	0.161	0.324	0.150	0.303	0.157	0.302	0.157	0.301	0.120	0.301
90	0.112	0.065	0.147	0.325	0.209	0.340	0.224	0.453	0.291	0.496	0.276	0.456	0.316	0.399	0.220	0.373	0.189	0.340	0.183	0.325	0.172	0.309	0.139	0.309
80	0.134	0.126	0.266	0.375	0.265	0.418	0.358	0.626	0.402	0.691	0.377	0.634	0.409	0.516	0.310	0.477	0.247	0.418	0.213	0.375	0.183	0.327	0.154	0.327
70	0.164	0.201	0.367	0.436	0.299	0.515	0.470	0.791	0.475	0.876	0.508	0.803	0.463	0.659	0.343	0.604	0.274	0.515	0.239	0.436	0.209	0.349	0.170	0.349
60	0.235	0.272	0.405	0.494	0.526	0.605	0.526	0.920	0.549	1.020	0.579	0.935	0.567	0.793	0.392	0.724	0.316	0.605	0.265	0.494	0.224	0.370	0.189	0.370
50	0.276	0.327	0.579	0.539	0.609	0.676	0.594	1.008	0.651	1.119	0.698	1.026	0.610	0.897	0.470	0.817	0.355	0.676	0.299	0.539	0.239	0.387	0.201	0.387
40	0.355	0.364	0.652	0.569	0.698	0.723	0.668	1.063	0.795	1.181	0.829	1.082	0.864	0.969	0.538	0.880	0.421	0.723	0.340	0.569	0.284	0.398	0.228	0.398
30	0.407	0.387	0.733	0.588	0.784	0.753	0.788	1.096	1.082	1.217	1.049	1.116	1.019	1.012	0.646	0.919	0.502	0.753	0.388	0.588	0.317	0.404	0.258	0.404
20	0.590	0.400	1.034	0.598	0.948	0.769	1.101	1.114	1.291	1.238	1.415	1.135	1.238	1.036	0.918	0.940	0.683	0.769	0.482	0.598	0.358	0.408	0.316	0.408
10	0.754	0.406	1.273	0.603	1.352	0.777	3.256	1.124	4.077	1.249	1.833	1.145	1.551	1.048	1.325	0.951	0.872	0.777	0.616	0.603	0.422	0.410	0.459	0.410
Min	9999.9	0.406	9999.9	0.603	9999.9	0.777	9999.9	1.124	9999.9	1.249	9999.9	1.145	9999.9	1.048	9999.9	0.951	9999.9	0.777	9999.9	0.603	9999.9	0.410	9999.9	0.410

EWR Structures for WRPM (all flow values in m^3/s)

Mooi River at Klerkskraal Dam: RE-EWR2

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.392	0.107	0.386	0.117	0.370	0.114	0.306	0.116	0.414	0.205	0.437	0.123	0.529	0.129	0.541	0.117	0.556	0.119	0.571	0.114	0.534	0.113	0.494	0.114
90	0.482	0.108	0.486	0.118	0.459	0.114	0.504	0.116	0.557	0.206	0.609	0.125	0.679	0.132	0.657	0.119	0.640	0.123	0.616	0.118	0.586	0.116	0.559	0.116
80	0.526	0.115	0.575	0.124	0.560	0.119	0.635	0.121	0.672	0.233	0.698	0.134	0.760	0.148	0.706	0.130	0.683	0.135	0.650	0.130	0.620	0.127	0.590	0.125
70	0.549	0.129	0.625	0.139	0.635	0.133	0.717	0.135	0.766	0.301	0.792	0.155	0.860	0.180	0.821	0.151	0.741	0.156	0.698	0.151	0.665	0.147	0.617	0.142
60	0.605	0.149	0.691	0.164	0.721	0.158	0.810	0.161	0.901	0.426	0.896	0.192	0.957	0.228	0.885	0.181	0.802	0.186	0.788	0.179	0.736	0.174	0.702	0.167
50	0.676	0.171	0.768	0.197	0.866	0.191	0.960	0.196	1.049	0.594	1.049	0.240	1.076	0.279	0.963	0.213	0.899	0.216	0.892	0.207	0.803	0.202	0.756	0.193
40	0.758	0.190	0.934	0.253	0.963	0.247	1.086	0.255	1.245	1.017	1.284	0.287	1.354	0.324	1.146	0.240	1.046	0.242	0.960	0.230	0.874	0.225	0.810	0.215
30	0.881	0.203	0.976	0.295	1.086	0.290	1.314	0.302	1.446	1.345	1.572	0.323	1.674	0.355	1.370	0.258	1.188	0.259	1.030	0.246	1.012	0.241	0.961	0.231
20	1.131	0.210	1.296	0.337	1.430	0.332	1.542	0.345	1.934	1.715	1.882	0.344	2.157	0.373	1.688	0.269	1.574	0.269	1.381	0.256	1.232	0.250	1.088	0.240
10	1.770	0.214	1.736	0.381	1.990	0.376	2.289	0.389	2.929	2.162	2.759	0.354	2.789	0.381	2.042	0.274	2.253	0.274	1.945	0.260	1.949	0.255	1.952	0.244
Min	9999.9	0.214	9999.9	0.381	9999.9	0.376	9999.9	0.389	9999.9	2.162	9999.9	0.354	9999.9	0.381	9999.9	0.274	9999.9	0.274	9999.9	0.260	9999.9	0.255	9999.9	0.244

Renoster River at Koppies Dam: EWR R1

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.030	0.009	0.023	0.010	0.049	0.010	0.075	0.010	0.049	0.012	0.049	0.010	0.050	0.011	0.026	0.010	0.050	0.010	0.056	0.009	0.056	0.009	0.046	0.008
90	0.045	0.010	0.127	0.010	0.217	0.010	0.523	0.011	0.279	0.012	0.198	0.011	0.127	0.012	0.056	0.010	0.077	0.012	0.071	0.010	0.071	0.010	0.062	0.010
80	0.071	0.010	0.289	0.011	0.455	0.011	0.620	0.013	0.541	0.017	0.314	0.013	0.170	0.015	0.071	0.011	0.093	0.012	0.086	0.010	0.075	0.010	0.069	0.010
70	0.108	0.010	0.382	0.012	0.963	0.017	1.505	0.028	0.742	0.030	0.459	0.029	0.255	0.023	0.090	0.011	0.108	0.012	0.093	0.010	0.097	0.010	0.081	0.010
60	0.157	0.011	0.837	0.014	1.393	0.032	1.841	0.057	1.278	0.054	0.612	0.064	0.355	0.032	0.116	0.012	0.120	0.013	0.108	0.011	0.123	0.010	0.093	0.010
50	0.396	0.011	1.786	0.022	1.740	0.060	3.166	0.170	1.794	0.090	0.967	0.101	0.467	0.044	0.164	0.015	0.131	0.015	0.134	0.011	0.142	0.010	0.123	0.010
40	0.560	0.013	2.531	0.039	2.718	0.080	4.394	0.313	2.200	0.214	1.538	0.226	0.629	0.060	0.224	0.019	0.150	0.017	0.161	0.012	0.179	0.011	0.158	0.012
30	0.806	0.023	3.943	0.096	3.543	0.283	5.742	0.672	4.298	0.663	2.998	0.592	0.945	0.154	0.325	0.027	0.212	0.021	0.213	0.015	0.220	0.011	0.224	0.012
20	1.665	0.044	5.930	0.208	6.399	0.586	6.728	0.909	6.514	0.956	4.185	0.750	2.079	0.328	0.653	0.071	0.285	0.032	0.287	0.024	0.306	0.011	0.262	0.012
10	6.119	0.324	9.641	0.711	10.794	0.769	12.074	0.992	11.754	1.045	7.217	0.813	3.302	0.486	1.019	0.172	0.463	0.066	0.373	0.041	0.470	0.019	0.532	0.024
Min	9999.9	0.324	9999.9	0.711	9999.9	0.769	9999.9	0.992	9999.9	1.045	9999.9	0.813	9999.9	0.486	9999.9	0.172	9999.9	0.066	9999.9	0.041	9999.9	0.019	9999.9	0.024

Renoster River at Outlet of C70H (downstream of Voorspoed Mine abstraction): EWR R2

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.041	0.011	0.066	0.012	0.119	0.023	0.116	0.029	0.090	0.025	0.052	0.015	0.131	0.018	0.056	0.015	0.077	0.012	0.078	0.011	0.101	0.009	0.066	0.008
90	0.086	0.023	0.231	0.031	0.329	0.056	0.739	0.090	0.459	0.077	0.310	0.061	0.228	0.074	0.105	0.033	0.139	0.053	0.131	0.045	0.127	0.032	0.108	0.027
80	0.108	0.037	0.448	0.050	0.650	0.106	1.101	0.119	0.815	0.121	0.590	0.108	0.374	0.115	0.157	0.055	0.162	0.057	0.153	0.053	0.138	0.040	0.120	0.032
70	0.157	0.049	0.640	0.093	1.449	0.175	1.841	0.217	1.516	0.223	0.844	0.203	0.517	0.162	0.194	0.073	0.197	0.069	0.164	0.059	0.157	0.046	0.135	0.035
60	0.287	0.056	1.154	0.155	1.882	0.306	2.961	0.394	1.975	0.375	1.086	0.403	0.610	0.214	0.250	0.086	0.216	0.077	0.187	0.064	0.183	0.049	0.143	0.039
50	0.519	0.090	2.049	0.289	2.434	0.461	4.641	0.636	2.663	0.650	1.897	0.643	0.829	0.374	0.306	0.101	0.266	0.089	0.224	0.071	0.220	0.054	0.189	0.042
40	0.806	0.183	3.538	0.458	3.749	0.605	5.836	0.849	3.646	0.921	2.707	0.844	1.142	0.517	0.418	0.146	0.309	0.104	0.280	0.090	0.280	0.063	0.239	0.050
30	1.053	0.317	5.185	0.703	4.984	0.798	7.015	1.077	6.133	1.163	4.622	1.035	2.716	0.702	0.728	0.198	0.428	0.155	0.385	0.108	0.332	0.071	0.343	0.062
20	2.221	0.376	6.759	0.794	7.508	0.884	9.330	1.193	9.468	1.347	7.967	1.163	3.326	0.772	0.974	0.372	0.490	0.220	0.489	0.179	0.489	0.112	0.502	0.150
10	6.649	0.392	14.186	0.838	15.356	0.934	15.226	1.247	19.473	1.408	12.082	1.213	6.181	0.795	1.807	0.395	0.829	0.245	0.638	0.201	0.806	0.182	0.795	0.234
Min	9999.9	0.392	9999.9	0.838	9999.9	0.934	9999.9	1.247	9999.9	1.408	9999.9	1.213	9999.9	0.795	9999.9	0.395	9999.9	0.245	9999.9	0.201	9999.9	0.182	9999.9	0.234

EWR Structures for WRPM (all flow values in m^3/s)

Vaal River at Vermaasdrift: EWR12

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	4.678	4.565	10.185	5.313	11.526	5.466	15.416	6.188	17.015	7.065	13.676	6.545	7.600	5.333	5.410	4.590	5.324	4.386	5.671	4.721	5.977	4.947	5.135	4.019
90	6.683	6.236	13.665	5.970	20.266	6.135	31.030	7.505	33.751	10.516	22.820	9.187	13.194	6.567	8.184	5.618	7.253	6.106	7.710	7.469	7.415	7.564	6.740	6.258
80	11.436	7.804	25.706	7.171	39.225	7.360	57.870	9.331	56.424	13.753	37.918	11.666	19.919	8.277	11.402	7.043	8.804	7.720	8.766	8.987	8.572	8.315	7.801	7.494
70	14.830	8.902	40.166	8.564	57.609	8.780	74.630	11.001	72.636	16.020	44.631	13.402	25.860	9.842	13.598	8.347	9.660	8.850	10.114	9.797	9.823	8.638	9.217	8.154
60	20.131	9.611	52.539	9.836	77.979	10.077	99.141	12.279	81.498	17.484	53.121	14.522	31.590	11.039	14.748	9.344	11.115	9.579	11.563	10.252	11.858	8.807	11.061	8.525
50	24.556	10.049	75.818	10.817	101.613	11.077	120.863	13.152	94.903	18.387	69.112	15.215	38.557	11.857	16.136	10.026	12.114	10.030	13.187	10.514	12.511	8.903	12.288	8.739
40	30.119	10.311	108.206	11.480	123.283	11.753	140.942	13.703	108.190	18.931	82.056	15.631	41.755	12.372	21.274	10.455	15.775	10.301	14.460	10.671	13.844	8.963	14.275	8.866
30	40.046	10.467	138.773	11.885	155.447	12.165	164.665	14.029	147.800	19.251	116.204	15.876	52.500	12.678	24.216	10.710	17.473	10.460	16.039	10.765	15.674	9.001	17.076	8.943
20	92.675	10.557	177.998	12.110	228.984	12.395	206.687	14.213	253.519	19.438	170.897	16.019	80.583	12.850	35.951	10.853	25.617	10.553	19.702	10.823	18.474	9.027	25.602	8.990
10	190.905	10.610	366.235	12.226	371.132	12.514	333.654	14.312	521.145	19.546	239.804	16.102	137.785	12.944	52.012	10.932	31.316	10.607	30.481	10.860	24.813	9.045	35.158	9.020
Min	9999.9	10.610	9999.9	12.226	9999.9	12.514	9999.9	14.312	9999.9	19.546	9999.9	16.102	9999.9	12.944	9999.9	10.932	9999.9	10.607	9999.9	10.860	9999.9	9.045	9999.9	9.020

Schoonspruit River IFR1: EWR S1

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.512	0.061	0.534	0.079	0.469	0.072	0.476	0.121	0.574	0.209	0.513	0.189	0.562	0.133	0.536	0.075	0.538	0.076	0.505	0.064	0.486	0.058	0.487	0.064
90	0.946	0.210	0.982	0.285	0.935	0.248	0.965	0.282	1.133	0.322	1.029	0.317	1.128	0.216	1.075	0.187	1.096	0.184	1.042	0.200	1.010	0.208	1.009	0.194
80	1.045	0.399	1.088	0.505	1.075	0.444	1.098	0.427	1.299	0.441	1.191	0.462	1.335	0.348	1.262	0.343	1.238	0.375	1.217	0.389	1.161	0.397	1.154	0.411
70	1.262	0.639	1.325	0.713	1.288	0.610	1.258	0.565	1.430	0.544	1.331	0.587	1.433	0.493	1.344	0.524	1.373	0.592	1.309	0.607	1.284	0.625	1.319	0.643
60	1.359	0.788	1.408	0.818	1.378	0.716	1.400	0.650	1.528	0.611	1.404	0.663	1.481	0.596	1.482	0.654	1.501	0.721	1.426	0.765	1.408	0.788	1.443	0.812
50	1.605	0.893	1.653	0.887	1.643	0.779	1.591	0.701	1.774	0.650	1.680	0.710	1.780	0.664	1.744	0.738	1.752	0.817	1.648	0.872	1.620	0.899	1.676	0.922
40	1.953	0.946	1.979	0.922	1.986	0.807	1.941	0.725	2.200	0.667	2.042	0.730	2.103	0.697	2.031	0.780	2.114	0.862	2.009	0.918	1.975	0.946	2.018	0.975
30	2.326	0.972	2.394	0.939	2.305	0.822	2.371	0.738	2.690	0.677	2.468	0.740	2.517	0.714	2.438	0.801	2.500	0.884	2.410	0.943	2.395	0.972	2.446	1.001
20	2.662	0.982	2.728	0.946	2.617	0.828	2.726	0.742	2.979	0.681	2.737	0.745	2.855	0.720	2.737	0.809	2.820	0.893	2.755	0.952	2.726	0.982	2.789	1.012
10	2.994	0.982	3.086	0.946	3.006	0.828	3.020	0.742	3.290	0.681	3.011	0.745	3.194	0.720	3.108	0.809	3.166	0.893	3.095	0.952	3.058	0.982	3.133	1.012
Min	999.9	0.982	999.9	0.946	999.9	0.828	999.9	0.742	999.9	0.681	999.9	0.745	999.9	0.720	999.9	0.809	999.9	0.893	999.9	0.952	999.9	0.982	999.9	1.012

Schoonspruit River IFR3: EWR S3

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.672	0.165	0.876	0.188	0.830	0.206	0.998	0.237	0.939	0.299	0.881	0.331	0.841	0.231	0.699	0.170	0.649	0.156	0.585	0.150	0.558	0.147	0.546	0.141
90	1.090	0.180	1.159	0.195	1.185	0.209	1.372	0.237	1.584	0.302	1.411	0.341	1.454	0.245	1.282	0.186	1.279	0.180	1.182	0.178	1.113	0.170	1.084	0.156
80	1.273	0.256	1.435	0.245	1.400	0.255	1.609	0.279	1.758	0.349	1.579	0.412	1.659	0.322	1.501	0.256	1.451	0.257	1.318	0.258	1.262	0.245	1.238	0.221
70	1.398	0.412	1.518	0.365	1.669	0.374	1.801	0.392	2.135	0.473	1.997	0.583	1.800	0.481	1.624	0.395	1.557	0.398	1.462	0.399	1.396	0.382	1.414	0.348
60	1.505	0.640	1.898	0.571	1.893	0.591	2.113	0.607	2.405	0.699	2.319	0.876	2.211	0.710	1.897	0.592	1.736	0.588	1.583	0.585	1.535	0.566	1.520	0.528
50	1.740	0.889	2.188	0.837	2.289	0.884	2.509	0.902	2.933	1.002	2.683	1.253	2.679	0.962	2.076	0.804	1.921	0.786	1.809	0.776	1.770	0.758	1.784	0.722
40	2.121	1.103	2.488	1.230	2.726	1.353	2.875	1.333	3.478	1.358	3.132	1.623	2.909	1.178	2.490	0.984	2.276	0.951	2.139	0.934	2.124	0.918	2.149	0.887
30	2.546	1.251	2.840	1.532	2.925	1.717	3.252	1.669	3.999	1.633	3.676	1.903	3.424	1.328	2.742	1.108	2.674	1.064	2.544	1.042	2.505	1.028	2.525	1.001
20	2.864	1.335	3.202	1.803	3.244	2.054	4.047	1.959	6.014	1.832	5.959	2.070	4.174	1.413	3.121	1.179	3.094	1.129	2.923	1.104	2.882	1.091	2.878	1.066
10	3.166	1.376	4.047	2.074	3.892	2.400	8.135	2.234	13.800	1.979	18.970	2.149	9.894	1.454	3.609	1.213	3.403	1.160	3.252	1.133	3.159	1.121	3.268	1.097
Min	999.9	1.376	999.9	2.074	999.9	2.400	999.9	2.234	999.9	1.979	999.9	2.149	999.9	1.454	999.9	1.213	999.9	1.160	999.9	1.133	999.9	1.121	999.9	1.097

EWR Structures for WRPM (all flow values in m^3/s)

Schoonspruit River IFR4: EWR S4

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.679	0.165	0.889	0.188	0.847	0.206	1.042	0.237	1.009	0.297	0.940	0.332	0.883	0.231	0.723	0.170	0.664	0.156	0.602	0.150	0.570	0.147	0.555	0.146
90	1.113	0.179	1.190	0.207	1.370	0.220	1.516	0.237	1.751	0.345	1.465	0.530	1.522	0.312	1.309	0.216	1.302	0.194	1.198	0.177	1.129	0.161	1.092	0.162
80	1.333	0.252	1.466	0.322	1.527	0.401	1.841	0.531	1.946	0.716	1.721	1.117	1.779	0.580	1.546	0.375	1.478	0.302	1.337	0.253	1.281	0.211	1.250	0.239
70	1.422	0.404	1.638	0.532	1.947	0.694	2.067	0.891	2.372	1.008	2.106	1.497	1.906	0.864	1.676	0.590	1.597	0.470	1.486	0.389	1.417	0.313	1.429	0.409
60	1.576	0.623	2.041	0.797	2.139	1.009	2.244	1.201	2.757	1.200	2.561	1.829	2.230	1.094	1.919	0.802	1.790	0.663	1.602	0.568	1.546	0.472	1.539	0.687
50	1.833	0.863	2.305	1.049	2.477	1.272	2.731	1.500	3.231	1.346	2.890	2.025	2.828	1.254	2.134	0.972	2.000	0.838	1.833	0.752	1.781	0.661	1.792	1.030
40	2.158	1.069	2.828	1.380	2.841	1.630	3.308	1.686	3.708	1.429	3.625	2.128	3.048	1.354	2.554	1.088	2.296	0.969	2.173	0.904	2.143	0.838	2.160	1.358
30	2.572	1.213	3.063	1.593	3.187	1.841	3.627	1.829	4.654	1.486	4.200	2.186	3.644	1.413	2.787	1.159	2.689	1.054	2.576	1.008	2.524	0.968	2.535	1.603
20	2.946	1.294	3.353	1.782	3.801	2.034	5.122	1.952	7.506	1.531	7.460	2.219	4.560	1.445	3.147	1.198	3.129	1.100	2.953	1.067	2.938	1.045	2.890	1.748
10	3.203	1.333	4.338	1.973	4.562	2.231	10.930	2.071	21.110	1.570	26.990	2.237	12.360	1.461	3.691	1.217	3.432	1.123	3.271	1.096	3.175	1.081	3.283	1.817
Min	999.9	1.333	999.9	1.973	999.9	2.231	999.9	2.071	999.9	1.570	999.9	2.237	999.9	1.461	999.9	1.217	999.9	1.123	999.9	1.096	999.9	1.081	999.9	1.817

Vaal River at Regina Bridge: EWR13

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	6.870	0.444	11.481	0.621	13.646	1.195	18.754	2.908	19.391	10.231	16.704	3.068	8.812	1.022	6.291	0.394	6.671	0.341	6.493	0.344	8.057	0.333	7.384	0.338
90	8.326	4.240	16.161	5.712	23.443	8.508	34.050	13.389	38.614	24.825	26.030	14.172	15.999	7.002	10.346	3.253	9.155	3.130	9.737	3.401	9.386	3.418	8.414	3.336
80	13.728	8.504	30.158	11.723	41.719	14.458	60.555	18.845	59.956	29.012	41.290	20.133	23.488	12.363	13.605	6.974	10.880	6.423	10.887	6.626	10.723	6.425	9.680	6.500
70	16.200	11.100	42.936	15.707	61.346	17.895	76.587	21.599	76.573	30.814	47.704	23.234	28.492	15.887	15.636	9.931	12.369	8.606	12.339	8.396	12.455	7.876	11.323	8.236
60	22.894	12.317	55.397	17.771	82.885	19.708	104.491	23.065	88.573	31.752	57.755	24.929	35.401	18.014	17.305	11.832	13.075	9.738	13.628	9.132	13.325	8.395	12.473	8.957
50	25.769	12.803	78.596	18.689	104.096	20.620	124.907	23.874	97.411	32.292	71.181	25.888	41.782	19.242	19.612	12.902	14.742	10.241	15.323	9.390	14.412	8.550	14.402	9.210
40	32.303	12.976	113.769	19.056	126.146	21.067	148.391	24.333	114.716	32.624	87.104	26.445	47.789	19.931	23.421	13.451	17.855	10.442	16.510	9.441	16.398	8.550	15.953	9.260
30	44.179	12.976	143.526	19.140	157.882	21.282	172.737	24.599	154.212	32.838	123.637	26.776	61.721	20.310	26.452	13.713	19.742	10.488	17.940	9.441	18.048	8.550	19.641	9.260
20	97.185	12.976	180.556	19.140	232.329	21.342	210.562	24.756	267.970	32.981	192.899	26.975	87.890	20.517	38.389	13.831	27.701	10.488	22.797	9.441	20.128	8.550	27.091	9.260
10	193.018	12.976	374.969	19.140	382.363	21.342	343.168	24.850	558.989	33.080	251.001	27.098	147.693	20.628	56.455	13.831	36.424	10.488	34.431	9.441	26.770	8.550	38.488	9.260
Min	9999.9	12.976	9999.9	19.140	9999.9	21.342	9999.9	24.850	9999.9	33.080	9999.9	27.098	9999.9	20.628	9999.9	13.831	9999.9	10.488	9999.9	9.441	9999.9	8.550	9999.9	9.260

Vals River at Proklameerdrift: EWR14

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.037	0.004	0.019	0.008	0.019	0.010	0.078	0.013	0.111	0.014	0.063	0.012	0.042	0.003	0.060	0.004	0.050	0.003	0.019	0.002	0.075	0.002	0.000	0.000
90	0.063	0.004	0.089	0.008	0.243	0.010	0.582	0.013	0.238	0.014	0.265	0.012	0.139	0.004	0.105	0.006	0.093	0.005	0.086	0.005	0.101	0.004	0.069	0.002
80	0.116	0.007	0.363	0.020	0.485	0.025	1.150	0.025	0.758	0.037	0.553	0.033	0.251	0.014	0.138	0.013	0.131	0.010	0.123	0.013	0.123	0.009	0.093	0.005
70	0.127	0.018	0.590	0.073	1.169	0.140	1.736	0.309	1.319	0.203	0.657	0.118	0.432	0.048	0.157	0.031	0.158	0.022	0.134	0.025	0.146	0.019	0.120	0.015
60	0.220	0.048	1.057	0.194	2.158	0.383	2.938	0.783	3.585	0.556	1.826	0.312	0.872	0.125	0.213	0.069	0.201	0.043	0.164	0.041	0.183	0.037	0.150	0.038
50	0.470	0.101	2.025	0.336	3.256	0.559	4.540	0.906	4.748	0.812	3.592	0.540	1.092	0.241	0.287	0.123	0.266	0.070	0.209	0.057	0.254	0.060	0.177	0.077
40	1.038	0.163	2.986	0.417	4.559	0.602	7.068	0.906	5.424	0.875	4.577	0.671	1.906	0.348	0.538	0.177	0.320	0.095	0.280	0.070	0.325	0.081	0.208	0.122
30	2.165	0.205	4.641	0.439	6.287	0.602	10.652	0.906	8.723	0.875	6.340	0.706	2.616	0.404	0.926	0.210	0.509	0.114	0.377	0.078	0.385	0.097	0.285	0.158
20	3.446	0.222	7.863	0.439	12.810	0.602	13.280	0.906	13.610	0.875	9.188	0.706	4.961	0.420	1.725	0.224	0.806	0.124	0.624	0.083	0.631	0.106	0.914	0.176
10	6.526	0.225	16.451	0.439	24.937	0.602	21.315	0.906	30.179	0.875	25.620	0.706	9.765	0.420	3.125	0.226	1.921	0.128	1.273	0.086	2.020	0.109	2.608	0.181
Min	9999.9	0.225	9999.9	0.439	9999.9	0.602	9999.9	0.906	9999.9	0.875	9999.9	0.706	9999.9	0.420	9999.9	0.226	9999.9	0.128	9999.9	0.086	9999.9	0.109	9999.9	0.181

EWR Structures for WRPM (all flow values in m^3/s)

Vet River at Fisantkraal: EWR15

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.164	0.217	0.154	0.191	0.071	0.134	0.411	0.420	0.332	0.435	0.586	0.324	0.309	0.264	0.291	0.397	0.201	0.247	0.209	0.260	0.358	0.299	0.285	0.243
90	0.329	0.489	0.694	0.539	0.736	0.527	1.736	0.877	1.618	0.885	1.105	0.870	0.752	0.741	0.519	0.605	0.355	0.501	0.306	0.434	0.437	0.299	0.378	0.438
80	0.519	0.616	1.262	0.691	1.807	0.859	3.678	1.161	2.593	1.215	2.498	1.198	1.393	0.837	0.627	0.620	0.502	0.624	0.426	0.478	0.497	0.364	0.451	0.531
70	0.818	0.638	2.076	0.829	2.852	1.061	4.406	1.611	4.158	1.546	5.048	1.508	2.508	1.030	0.821	0.653	0.575	0.652	0.463	0.495	0.582	0.394	0.544	0.576
60	1.520	0.683	3.850	1.096	4.626	1.173	6.310	1.755	5.973	2.234	6.313	2.164	4.344	1.416	1.064	0.698	0.822	0.671	0.545	0.504	0.694	0.409	0.694	0.598
50	2.277	0.730	5.027	1.164	6.874	1.232	8.882	1.831	10.451	2.336	8.684	2.269	5.355	1.833	1.591	0.806	1.042	0.687	0.668	0.508	0.870	0.417	0.980	0.609
40	3.069	0.739	8.009	1.191	9.834	1.263	16.103	1.870	14.372	2.389	13.120	2.323	7.990	1.952	1.878	0.952	1.219	0.734	0.810	0.511	1.027	0.421	1.254	0.618
30	5.272	0.743	13.723	1.204	13.288	1.278	24.369	1.890	31.236	2.416	19.777	2.350	15.150	1.975	2.699	1.217	1.404	0.738	0.904	0.513	1.236	0.423	1.887	0.618
20	8.191	0.746	27.434	1.211	22.278	1.286	36.906	1.900	54.199	2.429	34.943	2.364	23.738	1.986	7.949	1.295	1.998	0.741	1.128	0.514	1.807	0.425	2.894	0.620
10	17.223	0.746	38.646	1.211	36.996	1.286	65.942	1.900	75.512	2.429	66.051	2.364	39.282	1.986	13.601	1.295	4.213	0.741	1.557	0.514	2.737	0.425	6.007	0.620
Min	9999.9	0.746	9999.9	1.211	9999.9	1.286	9999.9	1.900	9999.9	2.429	9999.9	2.364	9999.9	1.986	9999.9	1.295	9999.9	0.741	9999.9	0.514	9999.9	0.425	9999.9	0.620

Vaal River downstream of Bloemhof Dam: EWR16

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	7.318	5.413	11.647	7.032	14.188	7.004	21.251	8.305	20.362	13.982	17.507	12.605	9.059	10.965	6.638	5.737	7.423	4.739	7.045	4.691	8.681	3.812	8.260	4.814
90	9.491	8.434	16.574	9.047	26.340	12.948	43.388	15.354	41.847	30.268	28.192	20.038	19.410	13.291	10.969	10.606	10.000	8.762	10.297	8.673	10.118	5.939	9.394	7.501
80	15.177	11.268	35.374	12.088	47.566	16.230	68.164	19.245	64.950	32.077	48.671	23.215	30.706	15.139	14.875	13.295	11.609	10.982	11.675	10.871	11.320	7.935	10.849	10.021
70	19.168	13.253	46.570	14.218	70.542	17.983	82.381	21.325	90.708	33.205	60.424	24.783	35.660	16.308	17.010	14.438	13.272	12.169	13.131	12.046	13.068	9.333	12.353	11.835
60	25.041	14.534	73.283	15.592	98.846	18.966	126.844	22.490	110.787	34.553	69.366	25.721	43.407	17.897	18.989	15.128	14.958	12.834	14.811	12.728	14.378	10.236	14.167	13.087
50	30.470	15.325	82.072	20.153	121.505	19.535	152.087	23.165	118.519	35.793	82.012	26.800	46.578	18.507	21.916	15.479	15.752	13.219	16.476	13.132	15.797	10.793	16.393	13.639
40	40.935	15.801	129.317	25.289	150.034	19.873	183.386	28.049	138.291	37.211	110.469	27.856	57.975	19.518	28.431	15.946	19.514	13.447	17.723	13.320	18.119	11.128	18.106	14.091
30	54.925	16.082	170.853	25.814	188.250	20.077	213.639	39.792	176.360	39.063	206.911	28.655	93.029	20.471	35.592	16.103	21.856	13.585	19.489	13.472	20.098	11.325	22.141	14.311
20	117.559	16.245	230.274	27.261	253.170	20.203	270.277	53.430	328.691	52.687	242.100	62.813	120.019	23.526	51.785	16.327	33.144	13.671	25.624	13.547	24.384	11.441	30.081	14.470
10	241.465	16.340	408.299	58.826	430.119	20.282	472.274	65.676	636.054	87.040	374.847	65.974	219.124	25.344	78.013	16.614	47.388	13.724	39.352	13.585	34.129	11.507	42.342	14.532
Min	9999.9	16.340	9999.9	58.826	9999.9	20.282	9999.9	65.676	9999.9	87.040	9999.9	65.974	9999.9	25.344	9999.9	16.614	9999.9	13.724	9999.9	13.585	9999.9	11.507	9999.9	14.532

Harts River downstream of Taung Dam: EWR H1

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90	0.000	0.000	0.000	0.000	0.067	0.002	0.187	0.004	0.078	0.007	0.052	0.010	0.019	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80	0.000	0.000	0.054	0.006	0.261	0.008	0.411	0.020	0.430	0.034	0.314	0.042	0.069	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	0.000	0.000	0.112	0.017	0.672	0.024	0.687	0.066	0.696	0.105	0.526	0.119	0.193	0.124	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60	0.000	0.000	0.143	0.036	0.788	0.054	1.045	0.151	0.979	0.235	1.060	0.253	0.432	0.235	0.030	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.011	0.011	0.386	0.061	1.157	0.095	1.703	0.269	1.586	0.409	1.460	0.424	0.625	0.357	0.067	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	0.034	0.024	0.586	0.084	1.411	0.135	2.367	0.389	1.995	0.585	1.885	0.592	0.752	0.461	0.119	0.119	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.108	0.028	1.154	0.103	1.844	0.167	3.043	0.483	2.884	0.721	3.902	0.719	0.895	0.533	0.228	0.163	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.228	0.030	1.829	0.114	2.591	0.186	4.387	0.539	8.092	0.802	5.544	0.795	2.064	0.574	0.411	0.175	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000
10	1.012	0.031	3.839	0.119	4.447	0.195	11.832	0.566	17.207	0.840	14.031	0.831	7.064	0.594	0.892	0.181	0.297	0.035	0.052	0.007	0.030	0.006	0.174	0.010
Min	9999.9	0.031	9999.9	0.119	9999.9	0.195	9999.9	0.566	9999.9	0.840	9999.9	0.831	9999.9	0.594	9999.9	0.181	9999.9	0.035	9999.9	0.007	9999.9	0.006	9999.9	0.010

EWR Structures for WRPM (all flow values in m^3/s)

Harts River downstream of Spitskop Dam: EWR17 (EWR capped at 7,6 m^3/s due to oulet capacity constraint of Spitskop)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	0.000	0.000	0.000	0.000	0.015	0.015	0.067	0.037	0.041	0.041	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90	0.000	0.000	0.008	0.008	0.149	0.030	0.228	0.037	0.221	0.048	0.403	0.403	0.035	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
80	0.000	0.000	0.073	0.073	0.553	0.030	0.937	0.037	0.774	0.048	1.008	0.443	0.108	0.108	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	0.000	0.000	0.127	0.127	0.933	0.030	1.389	0.037	1.508	0.048	1.553	0.443	0.451	0.451	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
60	0.004	0.004	0.228	0.228	1.773	0.030	1.897	0.037	2.089	0.048	2.666	0.443	0.880	0.880	0.049	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
50	0.026	0.019	0.467	0.437	2.438	0.030	3.618	0.037	2.548	0.048	3.883	0.443	1.235	1.235	0.105	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
40	0.075	0.019	0.945	0.437	3.170	0.030	4.577	0.037	5.978	0.918	6.481	4.303	2.357	2.357	0.220	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.175	0.175	1.501	0.437	4.223	0.347	8.106	1.554	9.878	3.998	8.699	7.600	4.641	4.641	0.478	0.036	0.008	0.008	0.000	0.000	0.000	0.000	0.000	0.000
20	0.545	0.545	3.615	0.437	5.384	2.410	13.908	4.095	23.410	6.319	15.715	7.600	9.279	7.524	0.788	0.745	0.046	0.031	0.004	0.004	0.004	0.004	0.019	0.019
10	1.460	1.460	5.691	5.508	6.732	4.238	22.222	5.380	30.412	7.211	30.940	7.600	24.796	7.540	1.348	1.348	0.359	0.359	0.545	0.545	0.153	0.153	0.714	0.714
Min	9999.9	1.460	9999.9	5.508	9999.9	4.238	9999.9	5.380	9999.9	7.211	9999.9	7.600	9999.9	7.540	9999.9	1.348	9999.9	0.359	9999.9	0.545	9999.9	0.153	9999.9	0.714

Vaal River at Schmidtsdrift: EWR18

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	7.318	0.752	11.647	1.740	14.740	1.965	22.797	2.431	20.616	3.233	17.563	2.796	9.151	2.139	6.638	1.330	7.423	0.921	7.045	0.765	8.681	2.124	8.260	0.793
90	9.573	0.752	16.701	1.740	28.103	1.965	48.645	2.431	42.113	3.233	29.816	2.796	19.549	2.139	11.204	1.330	10.617	0.921	10.450	1.210	10.118	2.482	9.676	1.256
80	15.218	0.991	36.979	1.780	47.584	1.965	69.616	2.431	67.216	3.233	49.634	2.796	31.860	2.139	14.934	1.330	11.779	0.988	11.675	1.639	11.582	2.542	10.849	1.700
70	19.209	1.393	48.387	1.970	70.542	1.965	85.573	2.431	91.109	3.233	63.766	2.796	38.387	2.139	17.514	1.367	13.318	1.224	13.131	1.853	13.068	2.567	12.353	1.922
60	25.041	1.837	74.502	2.347	100.358	2.040	134.196	2.443	111.693	3.233	77.718	2.809	44.761	2.221	20.053	1.551	15.050	1.532	14.882	1.967	14.378	2.580	14.167	2.041
50	30.470	2.212	85.394	2.851	121.994	2.295	153.595	2.524	123.746	3.258	92.746	2.903	52.623	2.499	22.024	1.913	16.227	1.814	16.536	2.031	15.834	2.589	16.393	2.107
40	42.115	2.474	134.977	3.340	161.044	2.826	191.891	2.821	145.350	3.391	126.337	3.245	69.348	3.077	28.607	2.356	19.788	2.017	18.246	2.068	18.119	2.595	18.233	2.145
30	54.940	2.634	174.857	3.701	200.411	3.503	222.297	3.522	199.721	3.913	218.832	4.054	102.230	3.816	37.534	2.724	22.025	2.141	19.990	2.089	20.098	2.599	22.141	2.167
20	117.563	2.720	231.856	3.908	260.749	4.034	284.629	4.444	381.309	5.150	259.853	5.118	155.980	4.394	54.786	2.945	33.731	2.207	25.638	2.102	25.829	2.602	30.081	2.181
10	242.824	2.762	408.306	4.004	434.808	4.288	483.662	5.033	725.955	6.382	407.150	5.797	228.912	4.672	80.548	3.043	47.415	2.238	39.371	2.110	34.879	2.604	42.415	2.189
Min	9999.9	2.762	9999.9	4.004	9999.9	4.288	9999.9	5.033	9999.9	6.382	9999.9	5.797	9999.9	4.672	9999.9	3.043	9999.9	2.238	9999.9	2.110	9999.9	2.604	9999.9	2.189

Vaal River downstream of Douglas Weir : Douglas EWR (IFR1)

Excedance	Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep	
Probability	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR	Ref Flow	EWR
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
99	6.847	0.551	11.559	3.539	14.714	3.838	23.772	4.241	20.805	5.150	17.772	4.644	9.217	2.951	7.157	1.847	7.122	1.046	6.959	0.045	8.371	0.049	8.063	0.549
90	9.972	0.675	17.215	3.599	28.831	3.896	52.580	4.305	47.206	5.227	35.073	4.713	20.664	3.075	10.932	2.066	10.502	1.451	10.279	0.963	9.950	0.473	10.050	0.777
80	16.047	1.214	41.015	3.875	47.133	4.166	76.098	4.598	74.586	5.583	51.609	5.030	32.797	3.612	15.300	2.977	12.029	2.883	11.555	3.342	11.514	1.977	10.652	1.728
70	19.960	2.279	53.704	4.490	73.525	4.766	88.609	5.250	104.585	6.375	72.499	5.733	43.129	4.673	17.634	4.482	13.140	4.704	13.008	5.264	13.232	3.888	12.523	3.298
60	26.191	3.784	79.005	5.492	113.030	5.745	134.158	6.313	123.312	7.666	87.112	6.882	51.049	6.172	20.262	6.161	14.803	6.287	14.942	6.371	15.065	5.550	13.634	5.049
50	31.814	5.404	94.302	6.730	137.653	6.954	158.692	7.627	131.367	9.261	106.579	8.300	59.336	7.786	23.219	7.566	16.667	7.363	16.413	6.899	17.036	6.680	16.339	6.515
40	47.159	6.782	140.502	7.912	172.428	8.108	211.735	8.881	161.205	10.784	137.444	9.653	93.769	9.159	29.260	8.502	19.649	7.972	18.638	7.120	18.365	7.319	18.445	7.491
30	57.613	7.733	194.803	8.796	219.489	8.971	242.029	9.819	298.611	11.923	243.687	10.666	125.370	10.106	41.704	9.016	22.234	8.270	21.251	7.205	21.076	7.632	24.448	8.027
20	131.705	8.275	242.122	9.320	262.575	9.483	365.274	10.375	457.194	12.598	353.259	11.267	157.886	10.647	66.211	9.254	34.884	8.400	26.553	7.205	26.747	7.768	31.412	8.276
10	253.483	8.534	429.171	9.569	445.542	9.726	502.643	10.639	952.327	12.918	460.286	11.551	281.671	10.905	86.499	9.348	49.070	8.431	39.247	7.205	38.960	7.801	49.055	8.374
Min	9999.9	8.534	9999.9	9.569	9999.9	9.726	9999.9	10.639	9999.9	12.918	9999.9	11.551	9999.9	10.905	9999.9	9.348	9999.9	8.431	9999.9	7.205	9999.9	7.801	9999.9	8.374

Appendix H:

Scenario 1 Results

(Present Day without EWRs)

Figure H-1: Reservoir response for Komati dams (Present Day Excluding EWRs)

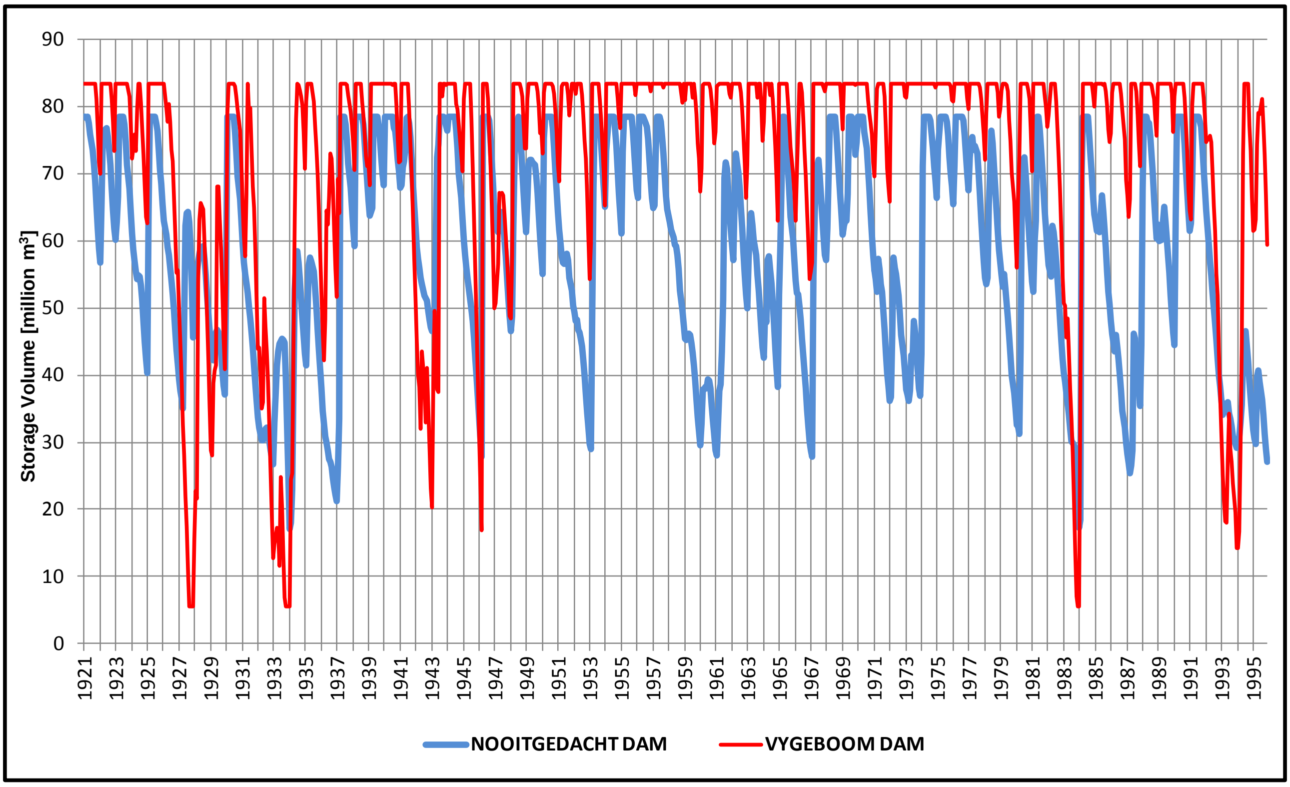


Figure H-2: Reservoir response for Usutu dams (Present Day Excluding EWRs)

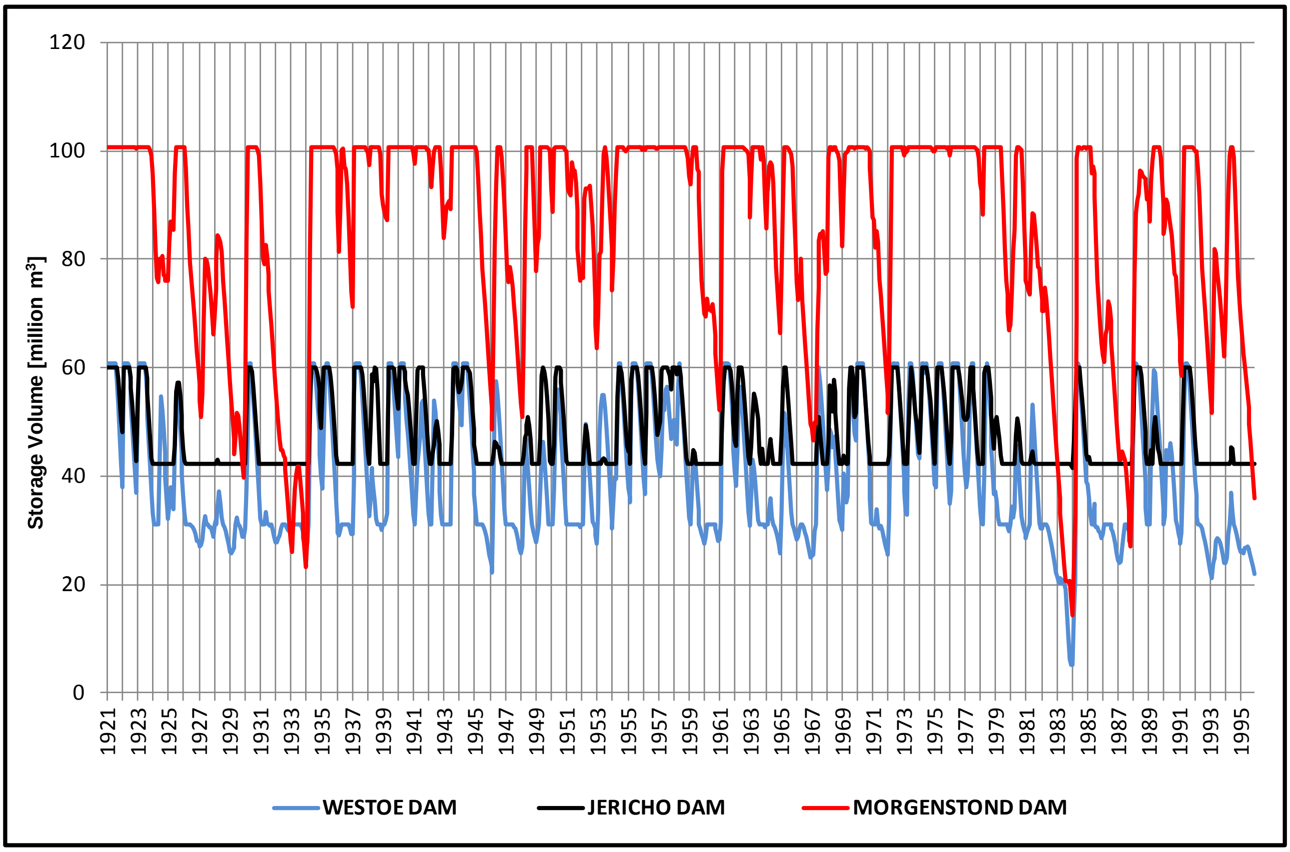


Figure H-3: Reservoir response for other VRESS dams (Present Day Excluding EWRs)

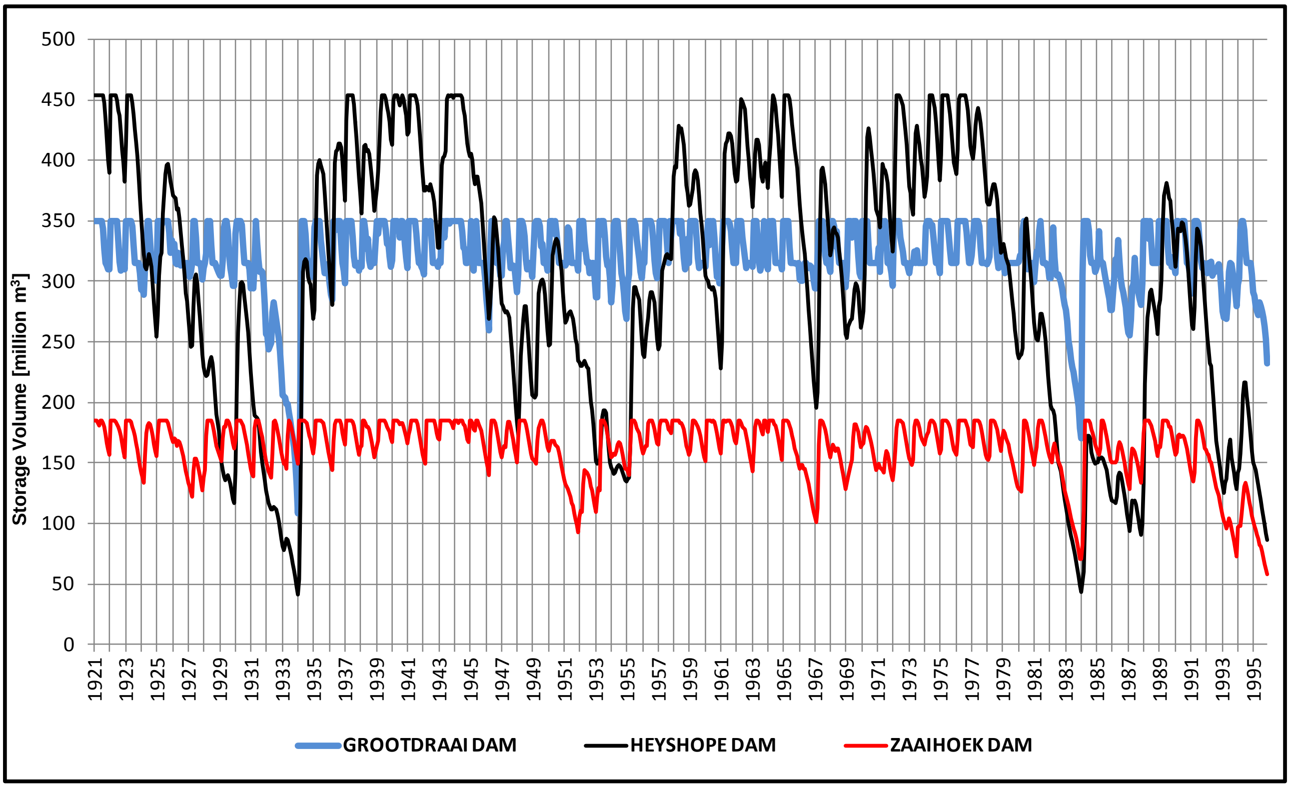


Figure H-4: Reservoir response for major dams (Present Day Excluding EWRs)

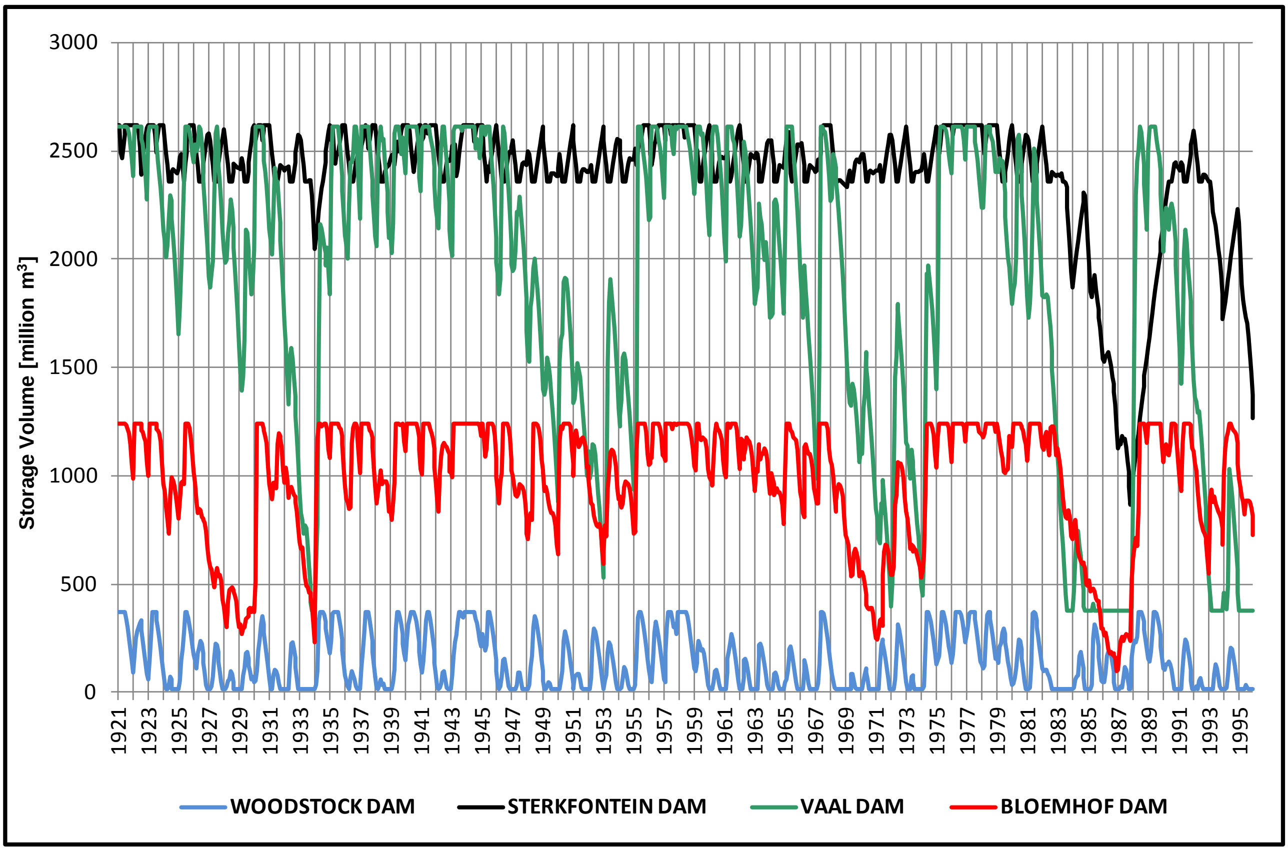


Figure H-5: Reservoir response: Mooi & Schoonspruit (Present Day Excluding EWRs)

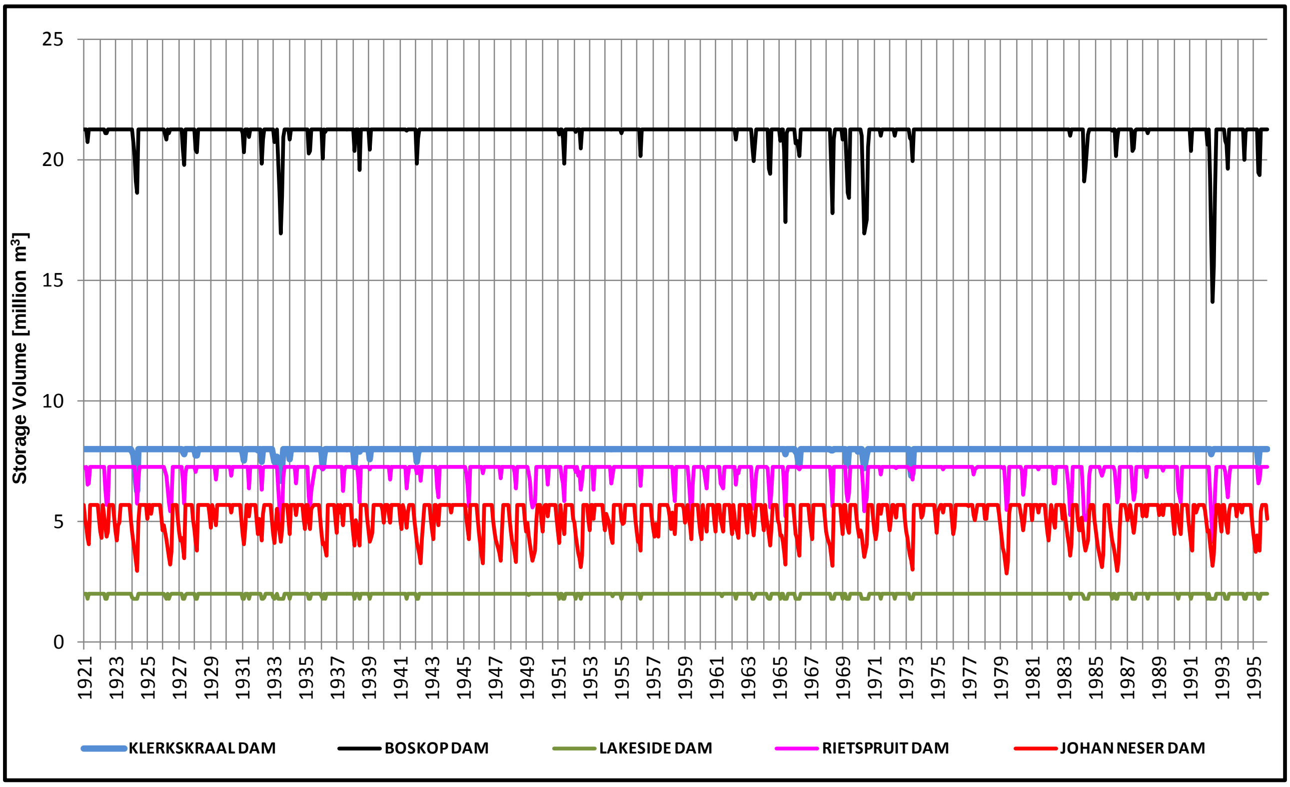


Figure H-6: Reservoir response: Sand & Vet, Renoster and Loopspruit (Present Day Excluding EWRs)

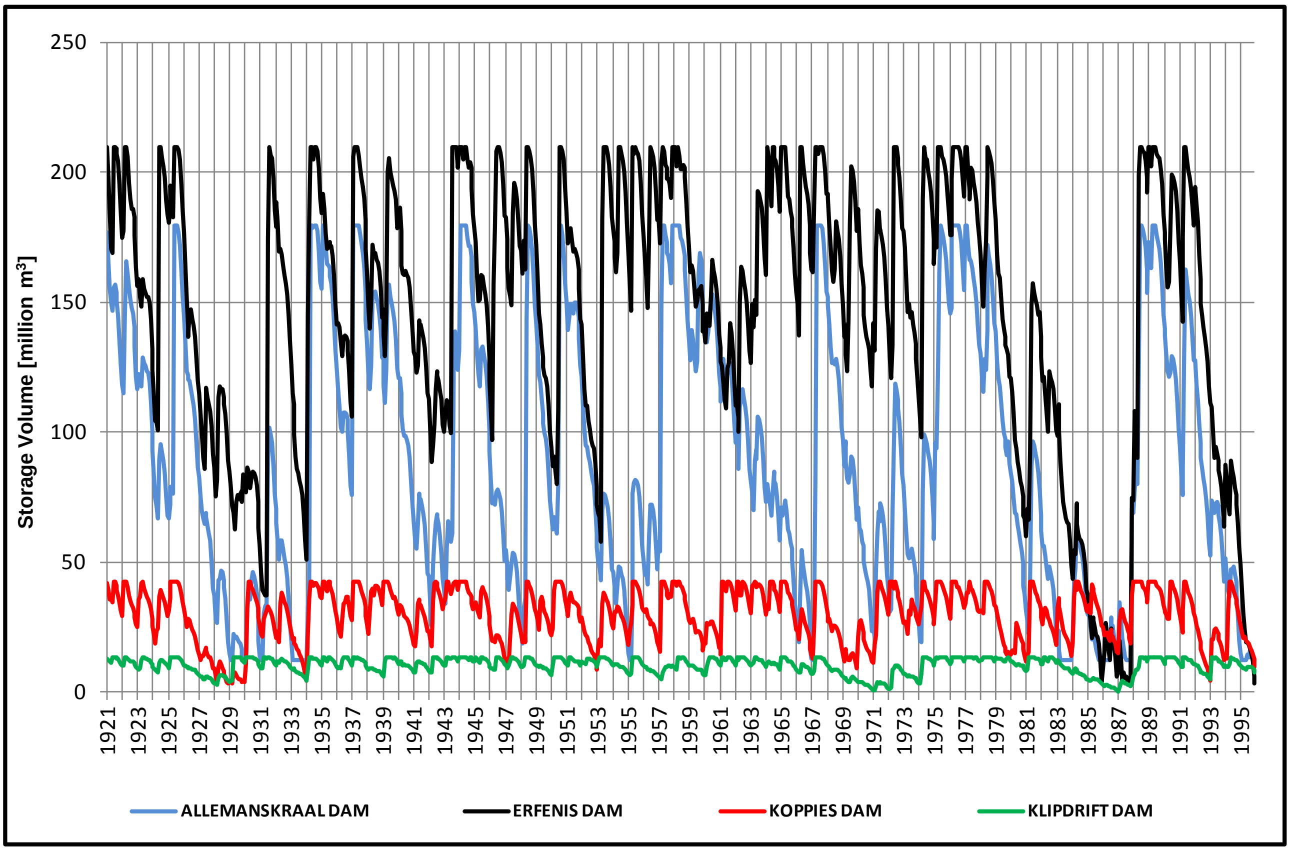


Figure H-7: Reservoir response: Harts River dams (Present Day Excluding EWRs)

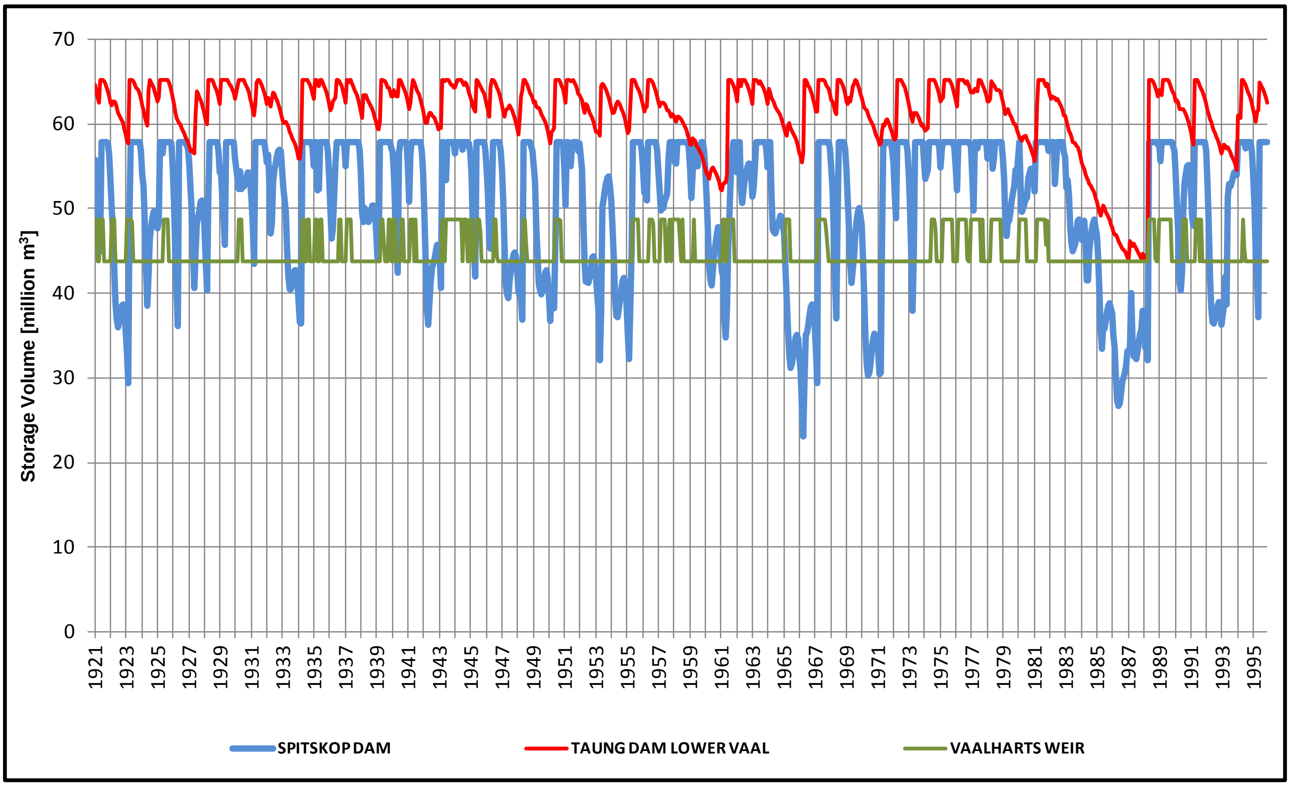
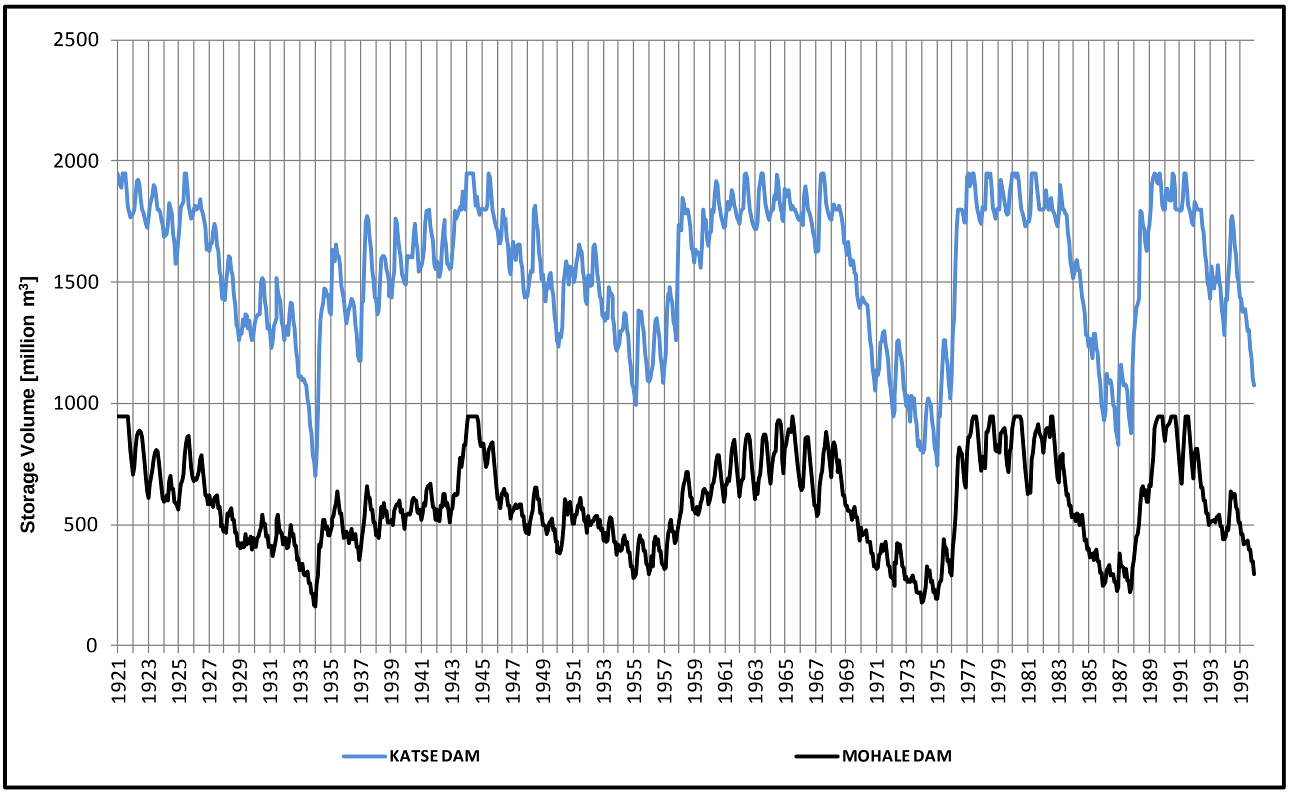


Figure H-8: Reservoir response: Senqu dams (Present Day Including EWRs)



Appendix I:

Scenario 2 Results

(Present Day including EWRs)

Figure I-1: Reservoir response for Komati dams (Present Day Including EWRs)

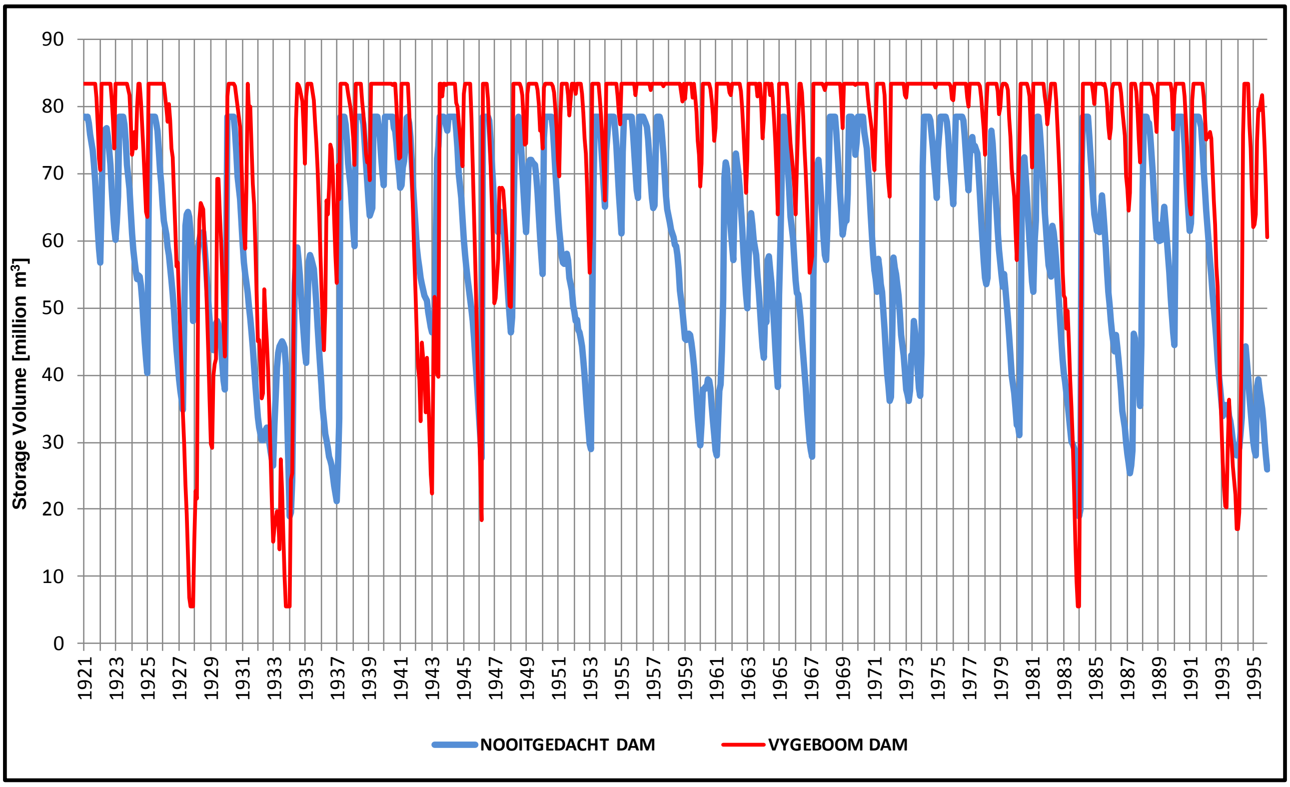


Figure I-2: Reservoir response for Usutu dams (Present Day Including EWRs)

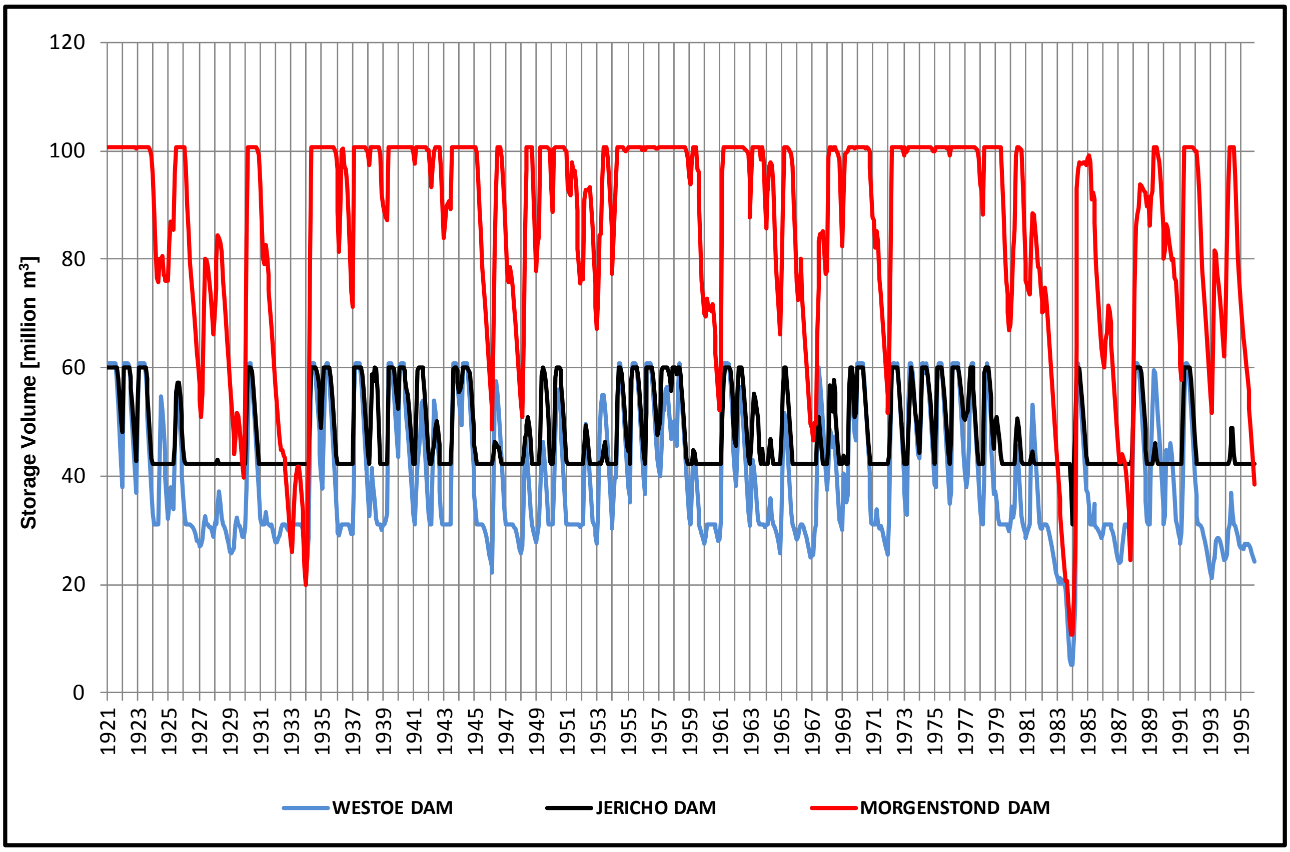


Figure I-3: Reservoir response for other VRESS dams (Present Day Including EWRs)

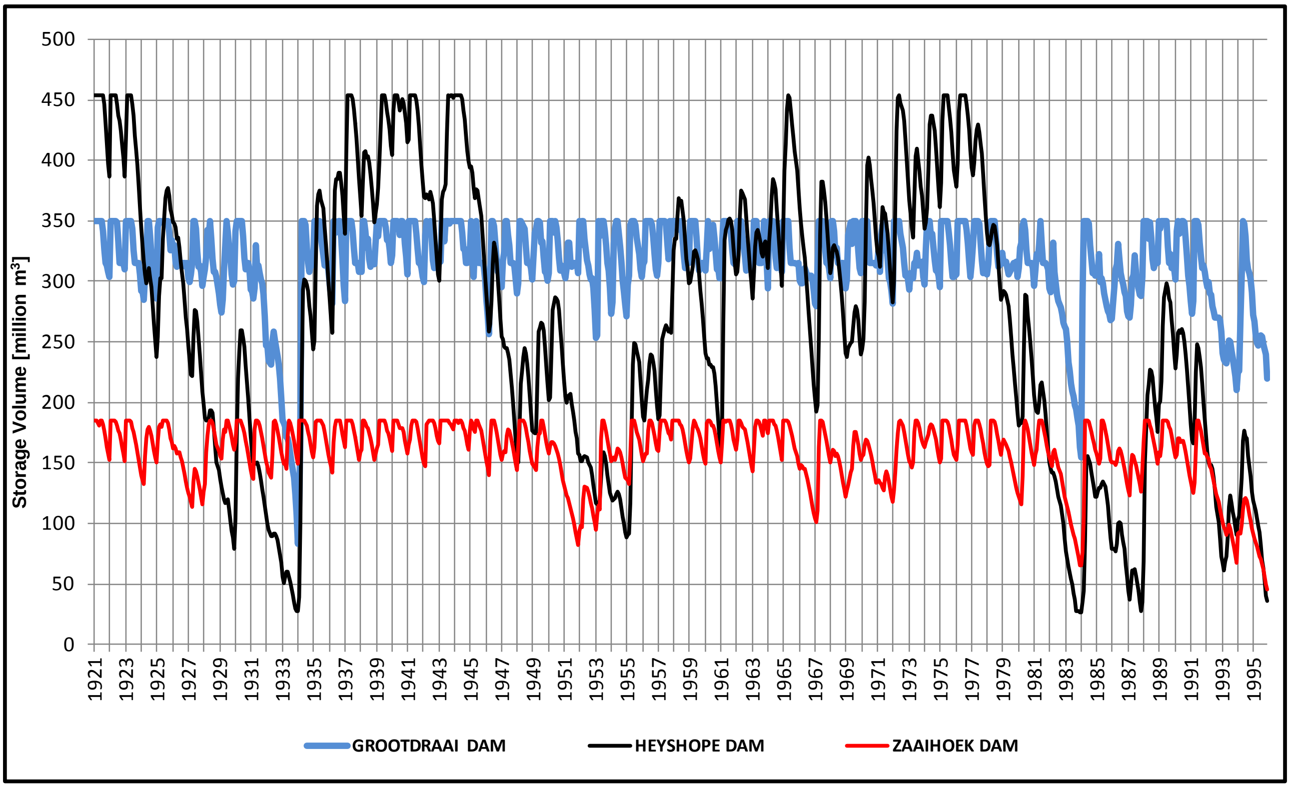


Figure I-4: Reservoir response for major dams (Present Day Including EWRs)

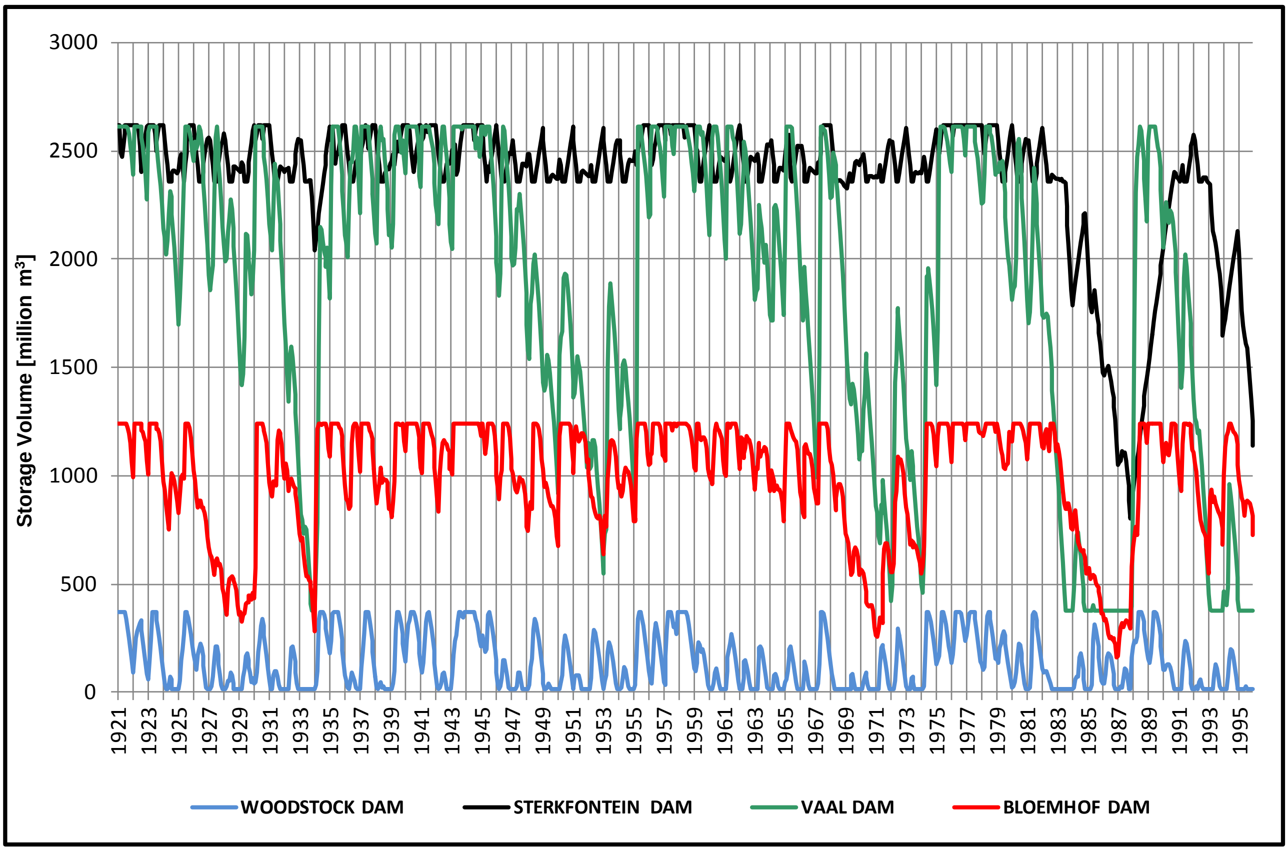


Figure I-5: Reservoir response: Mooi & Schoonspruit (Present Day Including EWRs)

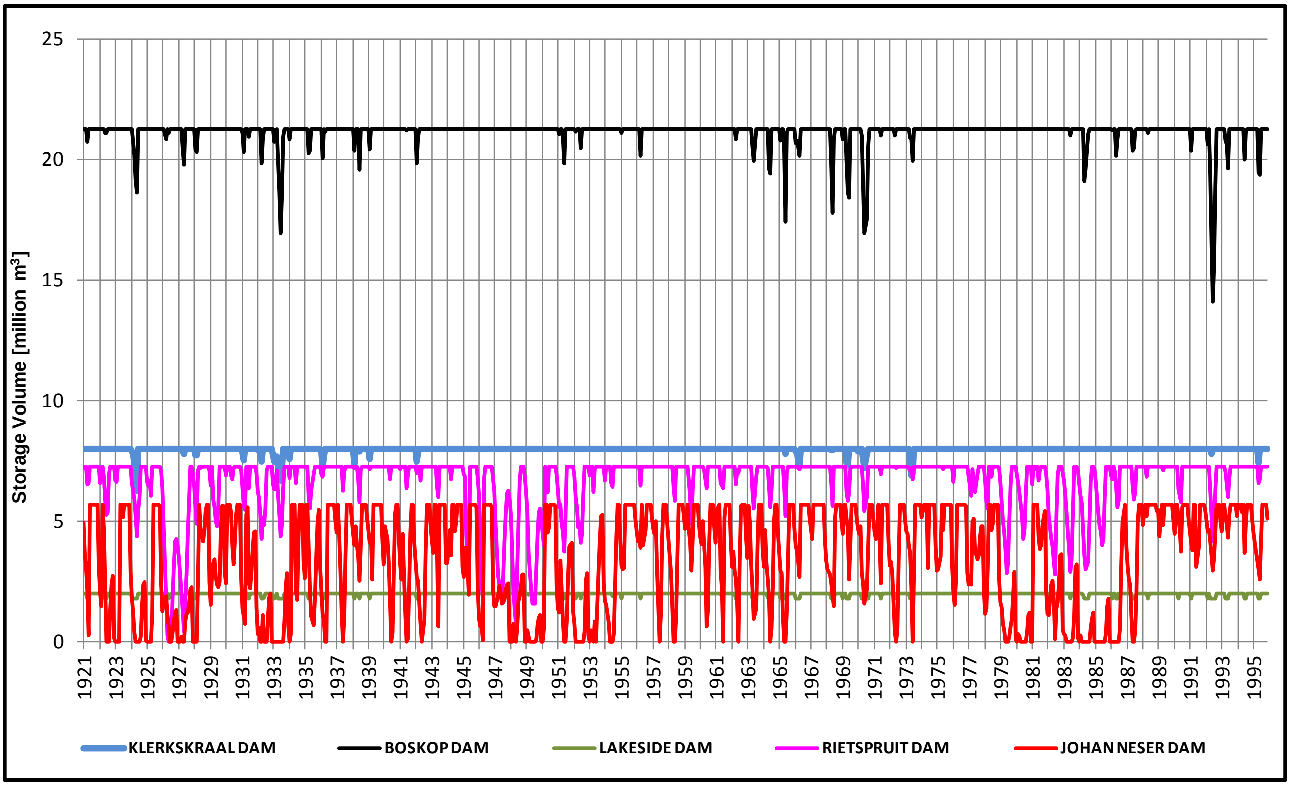


Figure I-6: Reservoir response: Sand & Vet, Renoster and Loopspruit (Present Day Including EWRs)

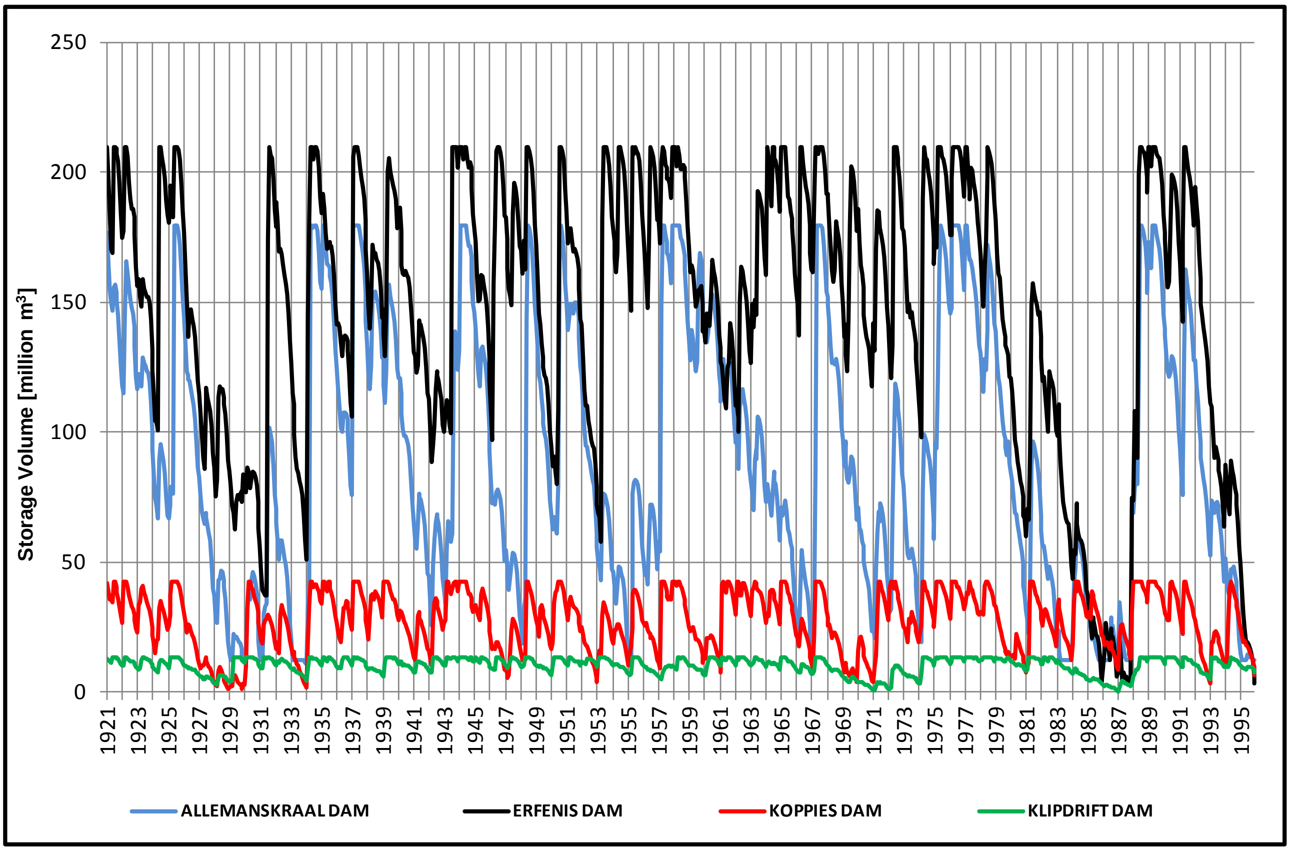


Figure I-7: Reservoir response: Harts River dams (Present Day Including EWRs)

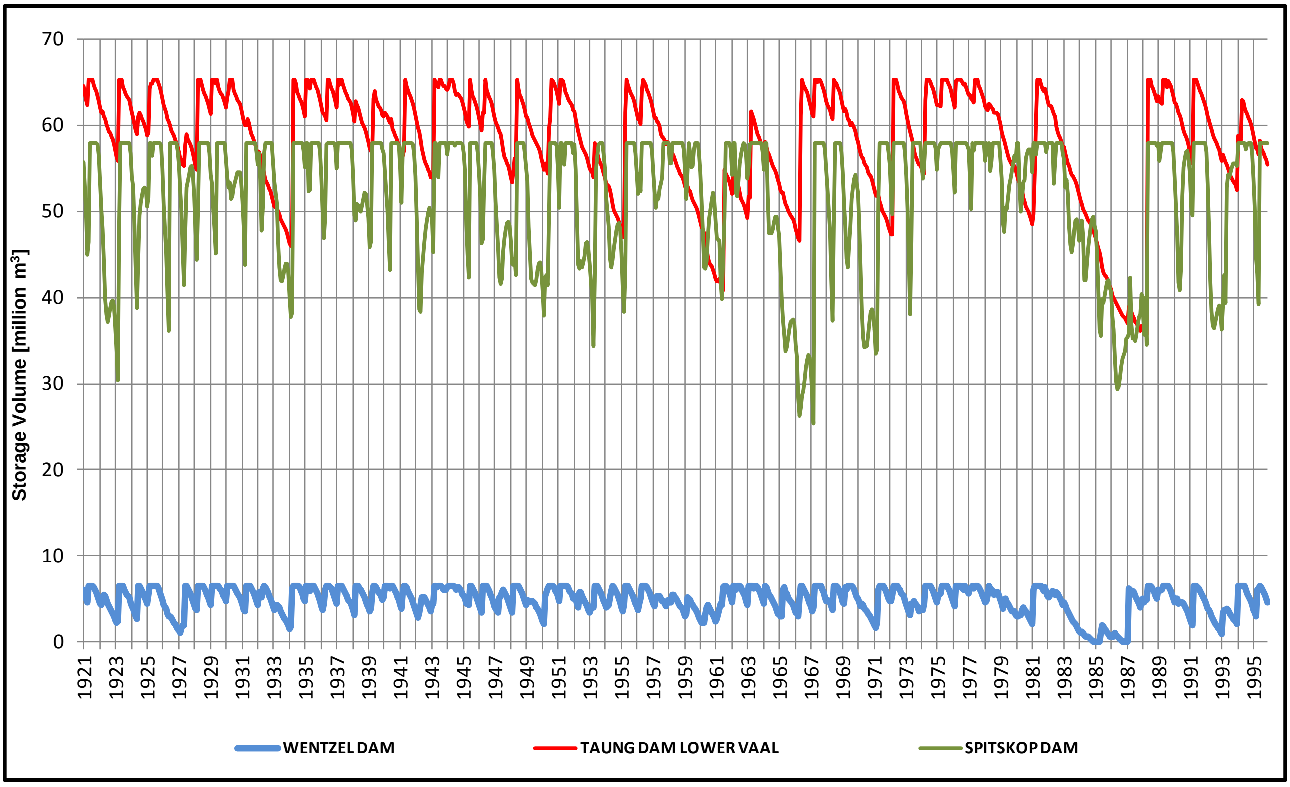
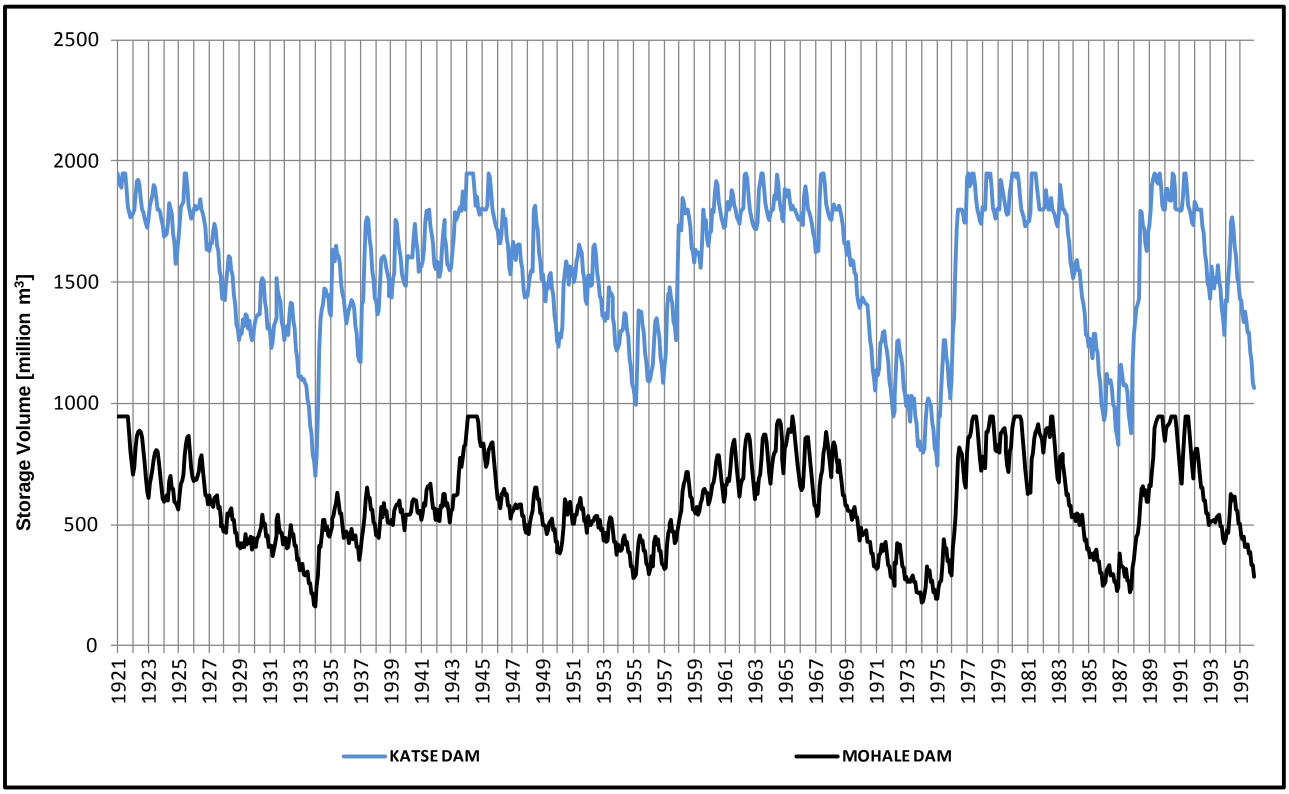


Figure I-9: Reservoir response: Senqu dams (Present Day Including EWRs)



Appendix J:

Scenario 3 Results

(2020 Development without EWRs)

Figure J-1: Reservoir response: Komati dams (2020 Development, Excluding EWRs)

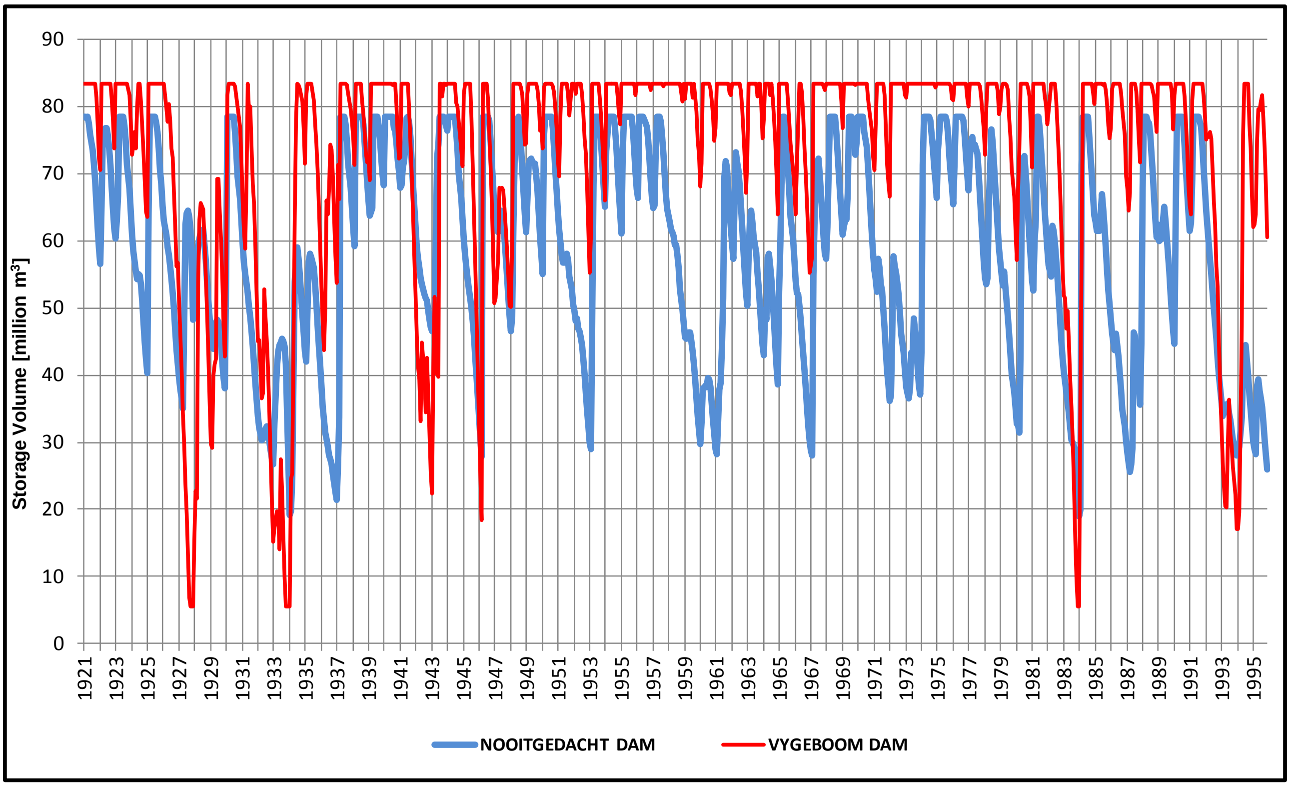


Figure J-2: Reservoir response for Usutu dams (2020 Development Excluding EWRs)

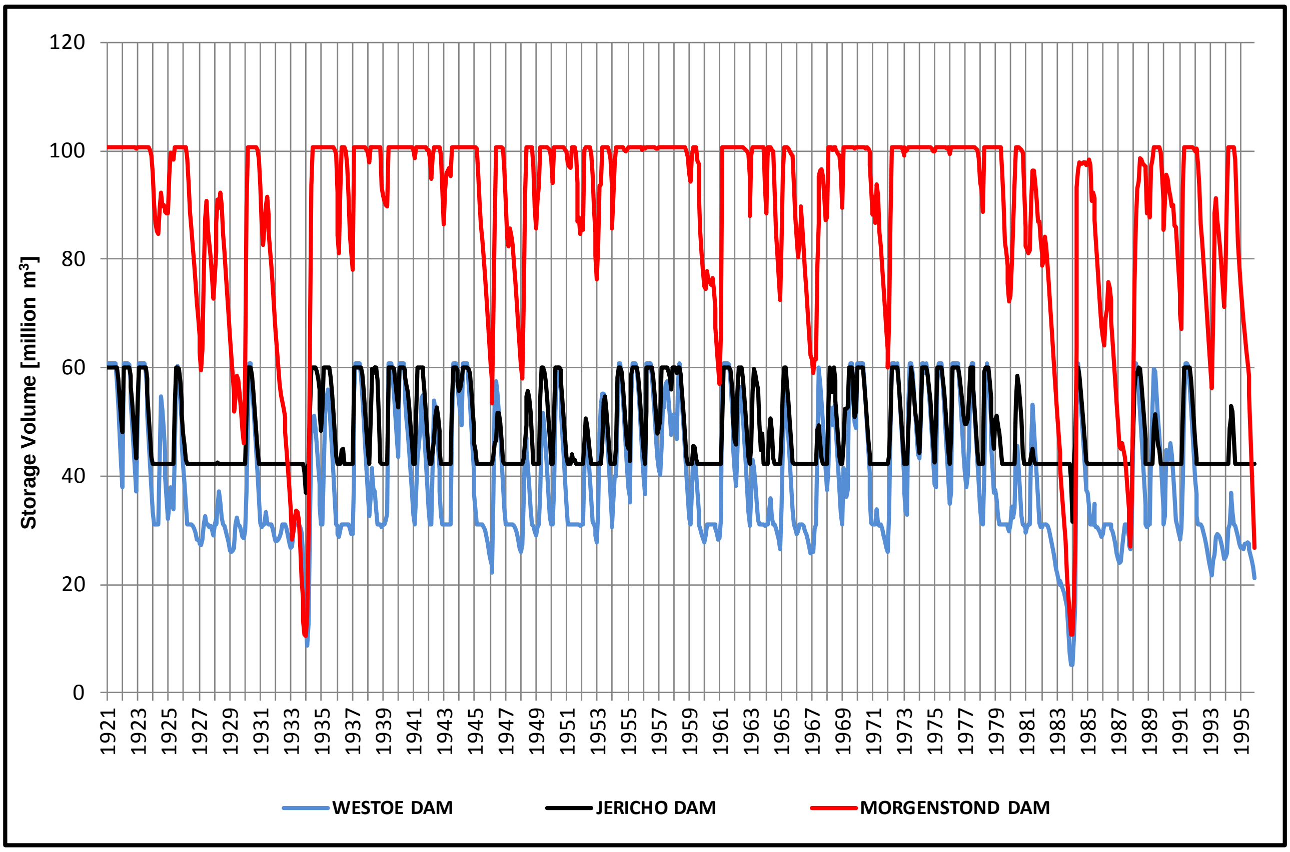


Figure J-3: Reservoir response for other VRESS dams (2020 Dev Excluding EWRs)

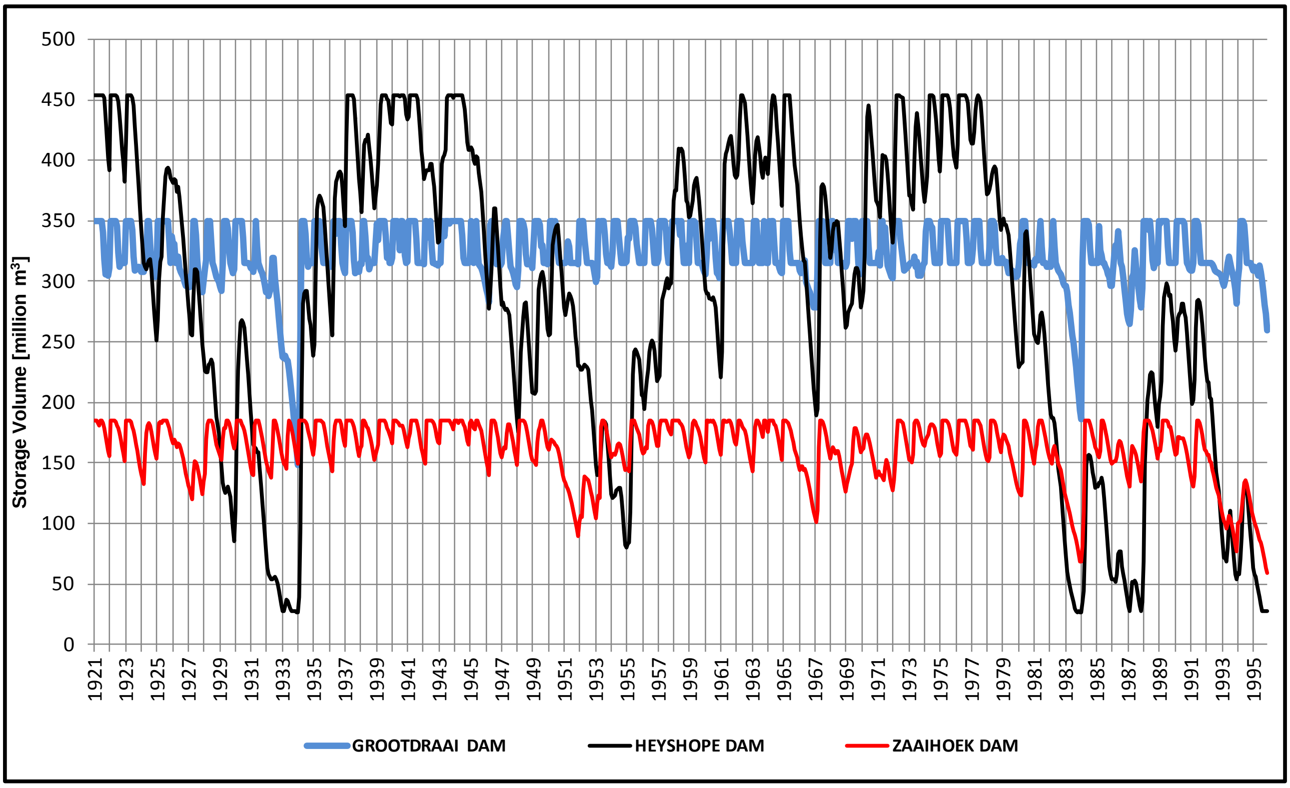


Figure J-4: Reservoir response for major dams (2020 Dev Excluding EWRs)

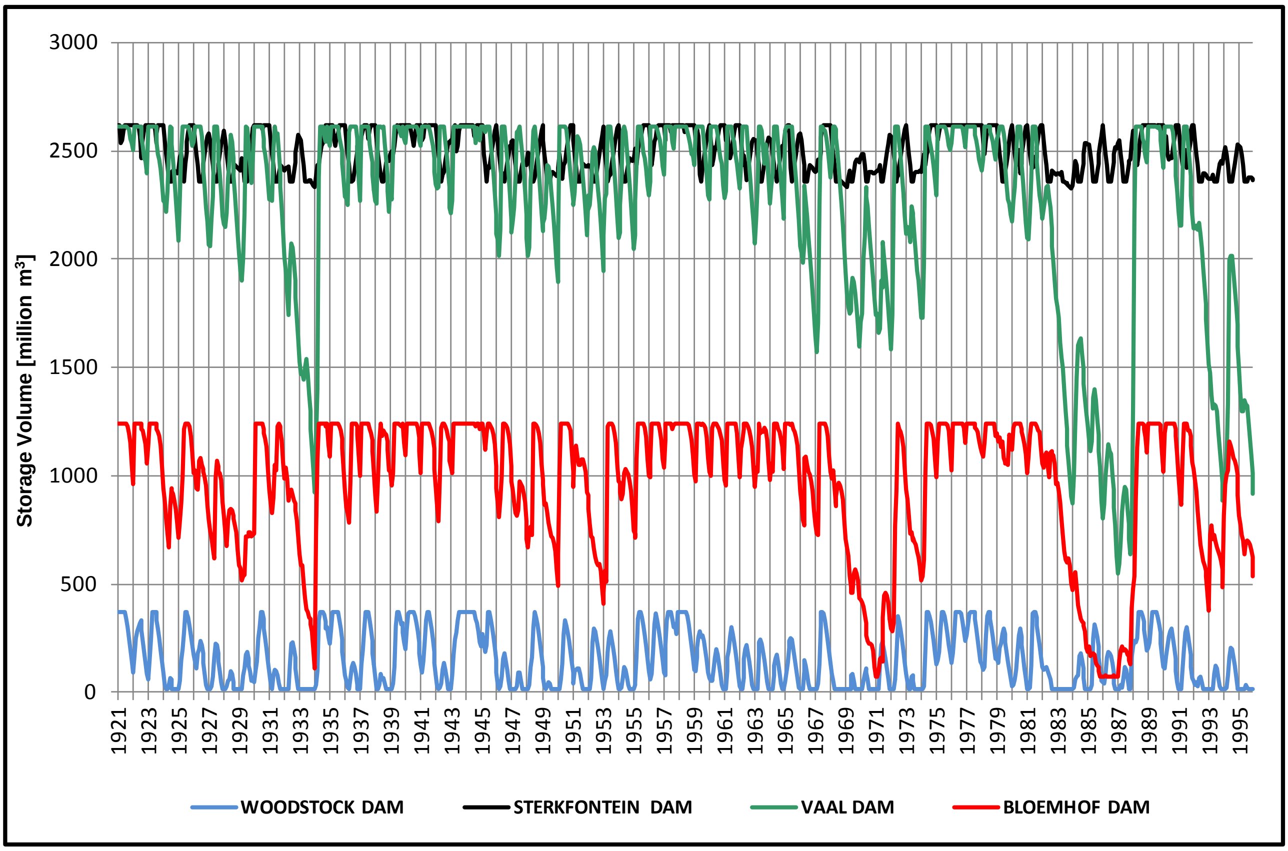


Figure J-5: Reservoir response: Mooi & Schoonspruit (2020 Dev Excluding EWRs)

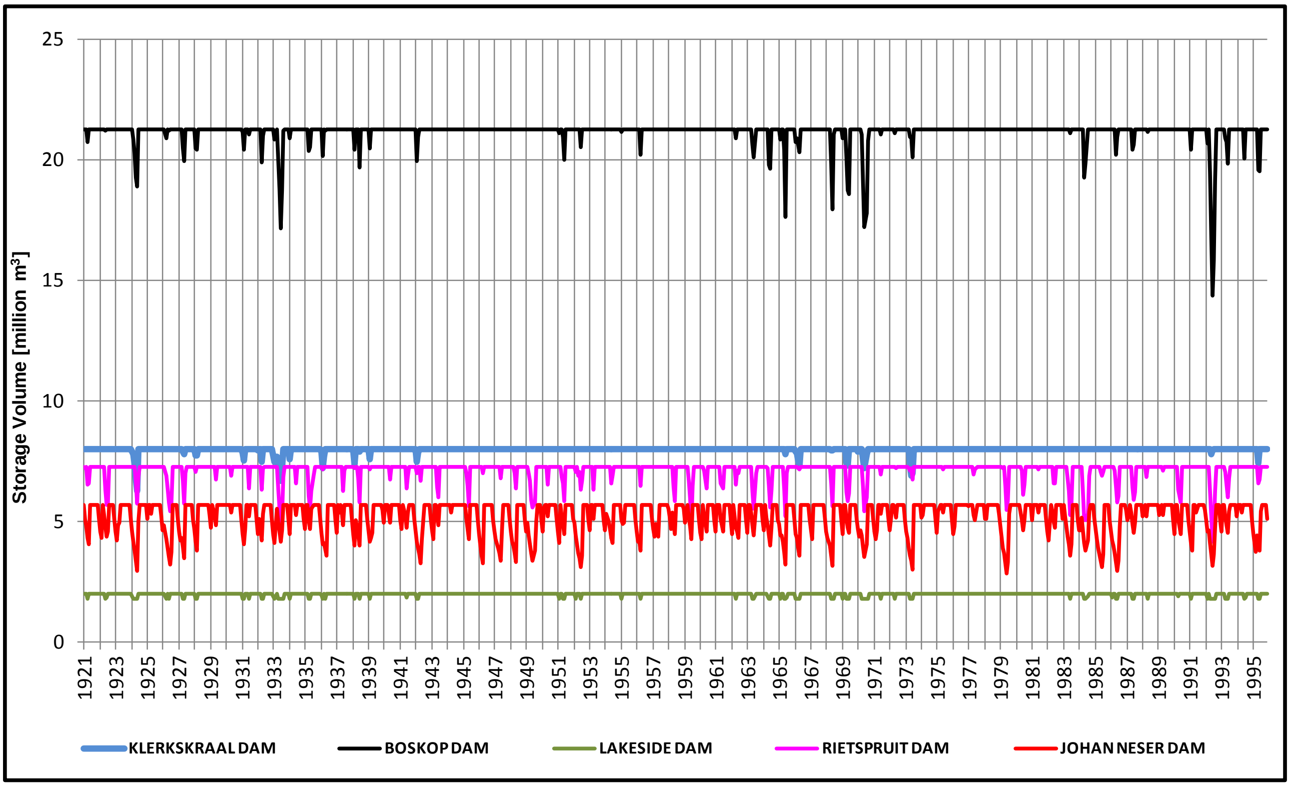


Figure J-6: Reservoir response: Sand & Vet, Renoster and Loopspruit (2020 Dev Excluding EWRs)

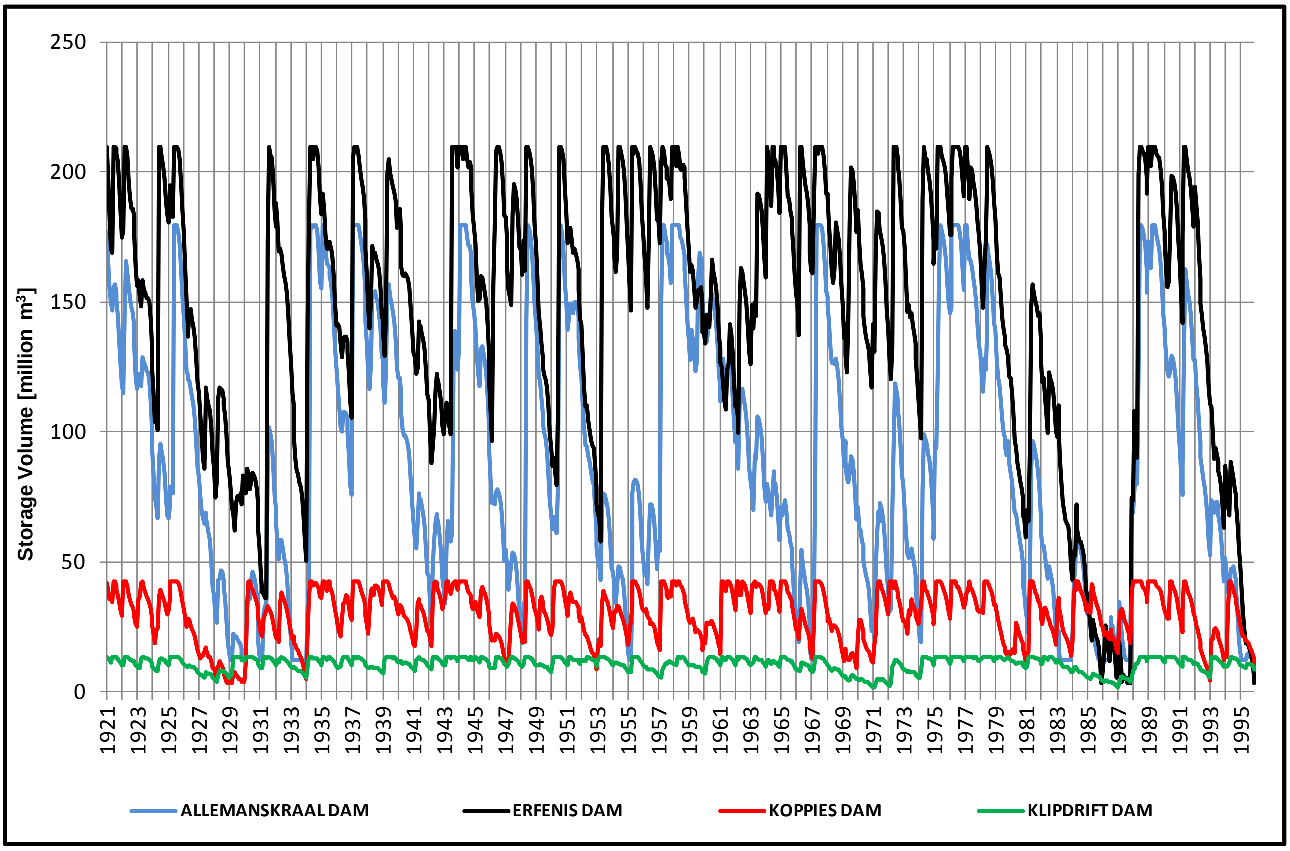


Figure J-7: Reservoir response: Harts River dams (2020 Dev Excluding EWRs)

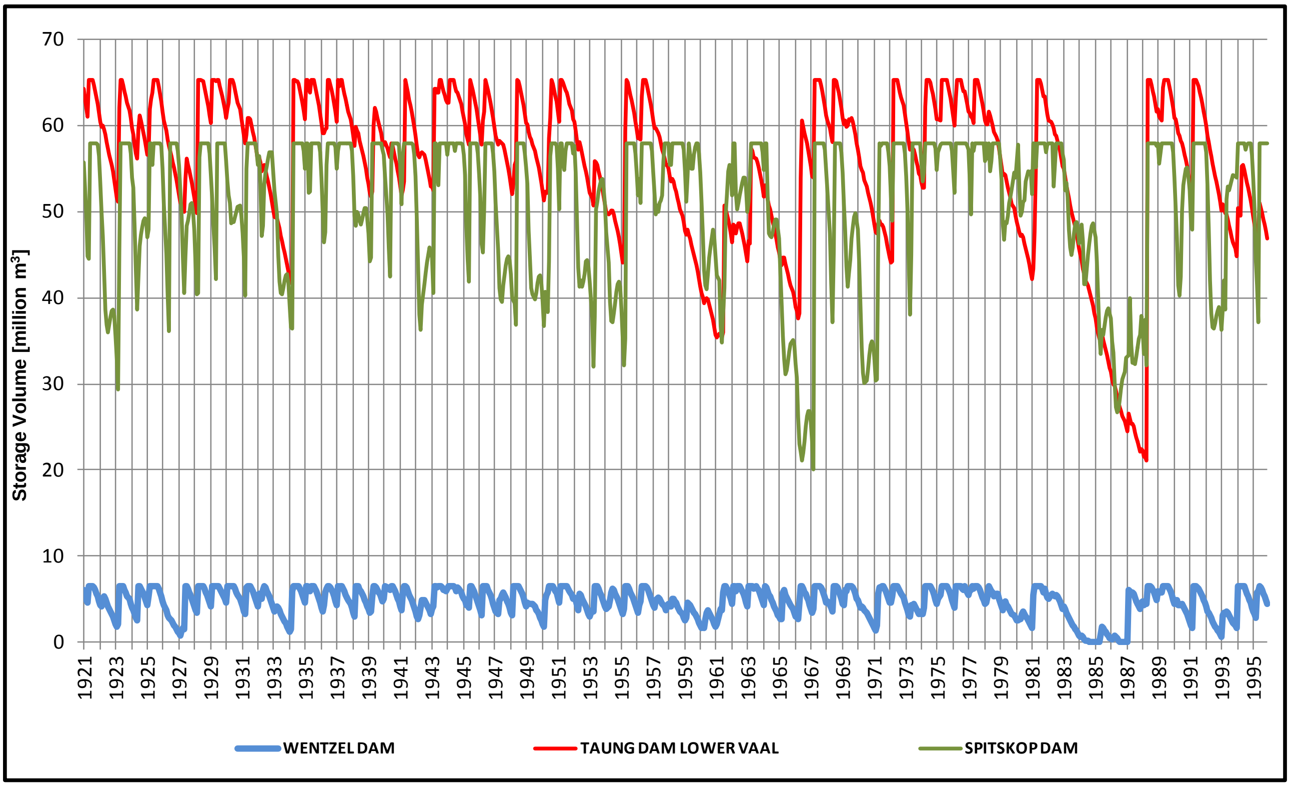
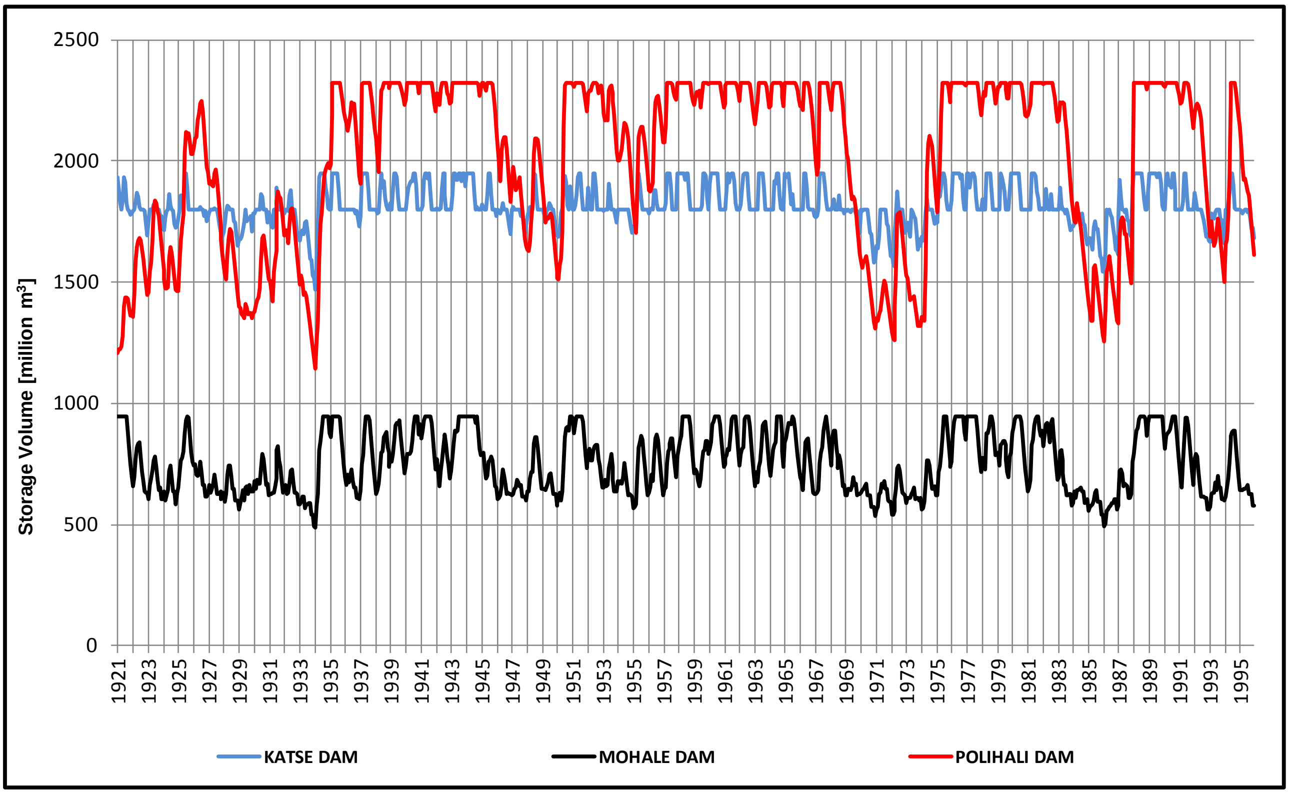


Figure J-9: Reservoir response: Senqu dams (2020 Dev Including EWRs)



Appendix K:

Scenario 4 Results

(2020 Development including EWRs)

Figure K-1: Reservoir response: Komati dams (2020 Development, Including EWRs)

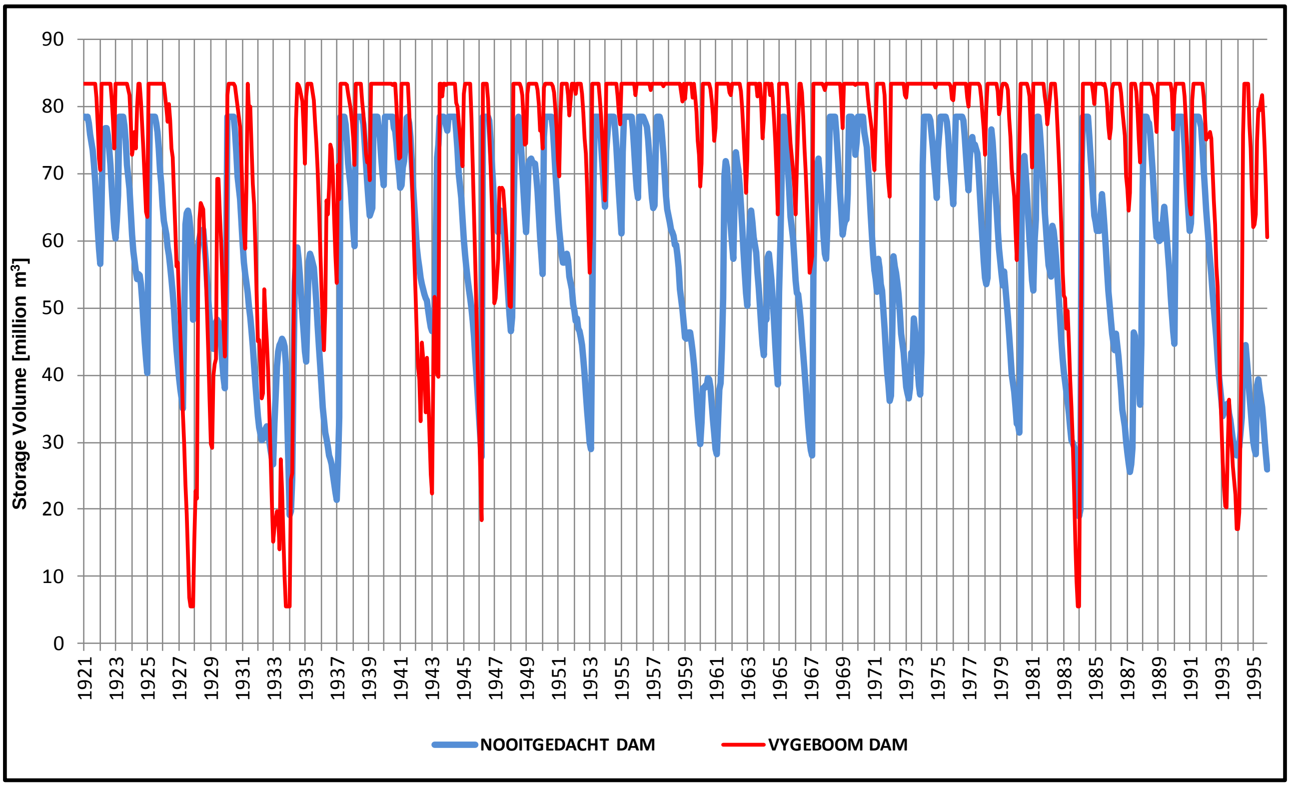


Figure K-2: Reservoir response for Usutu dams (2020 Development Including EWRs)

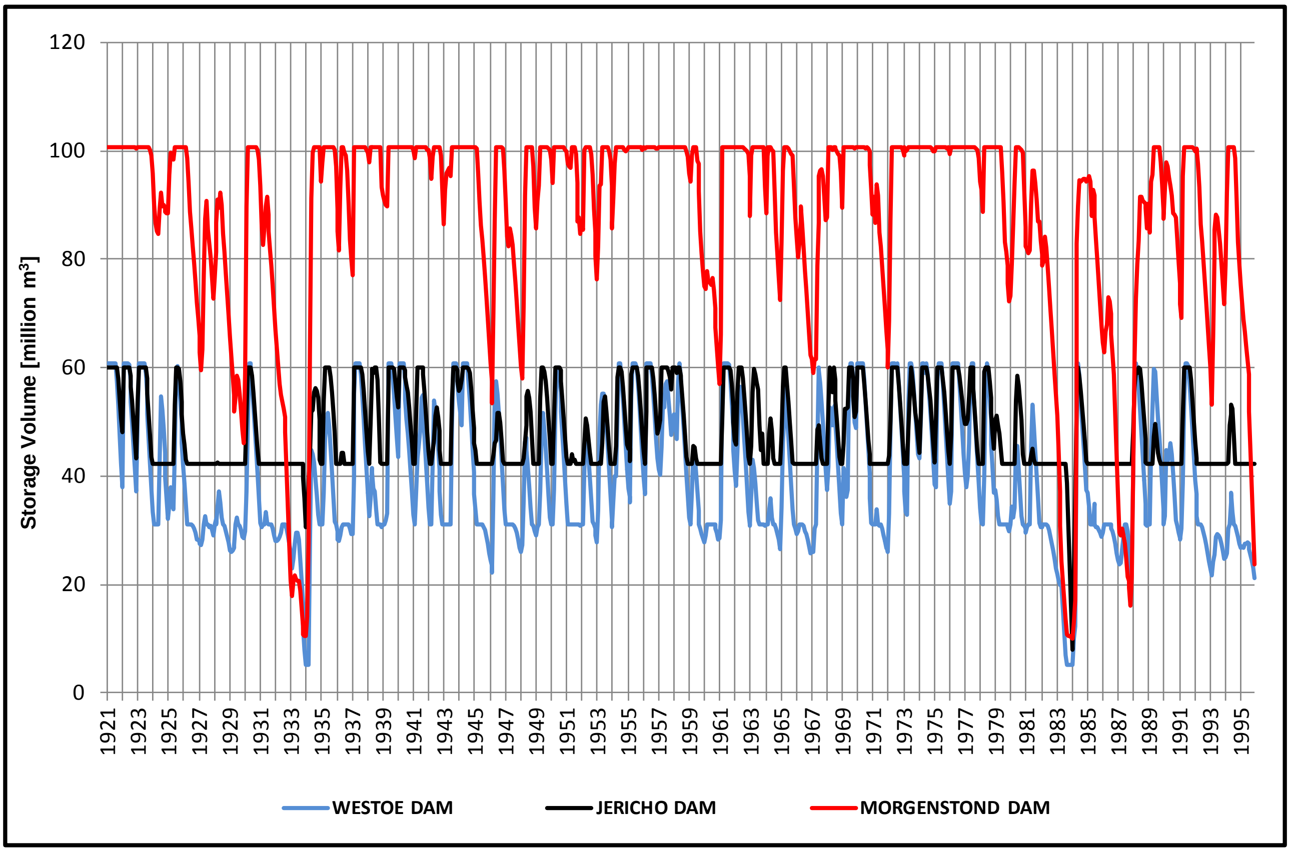


Figure K-3: Reservoir response for other VRESS dams (2020 Dev Including EWRs)

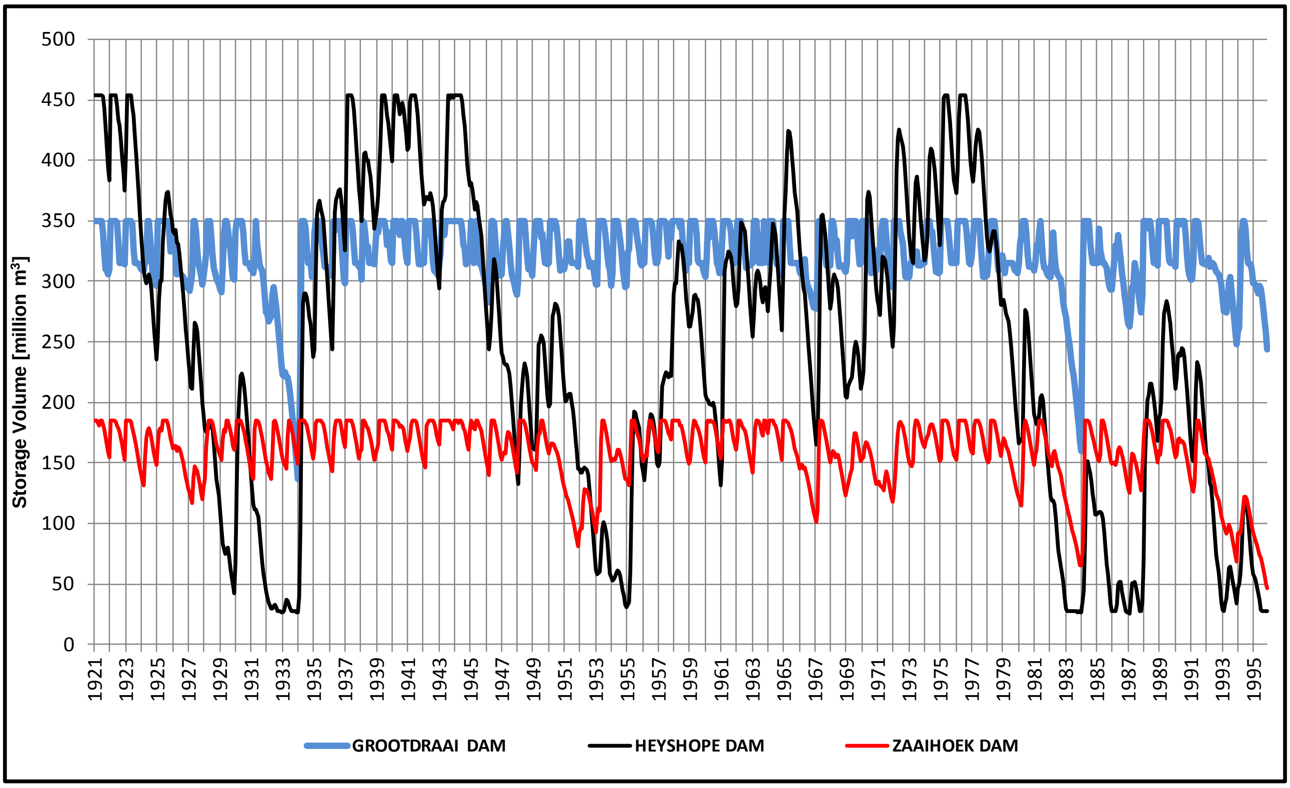


Figure K-4: Reservoir response for major dams (2020 Dev Including EWRs)

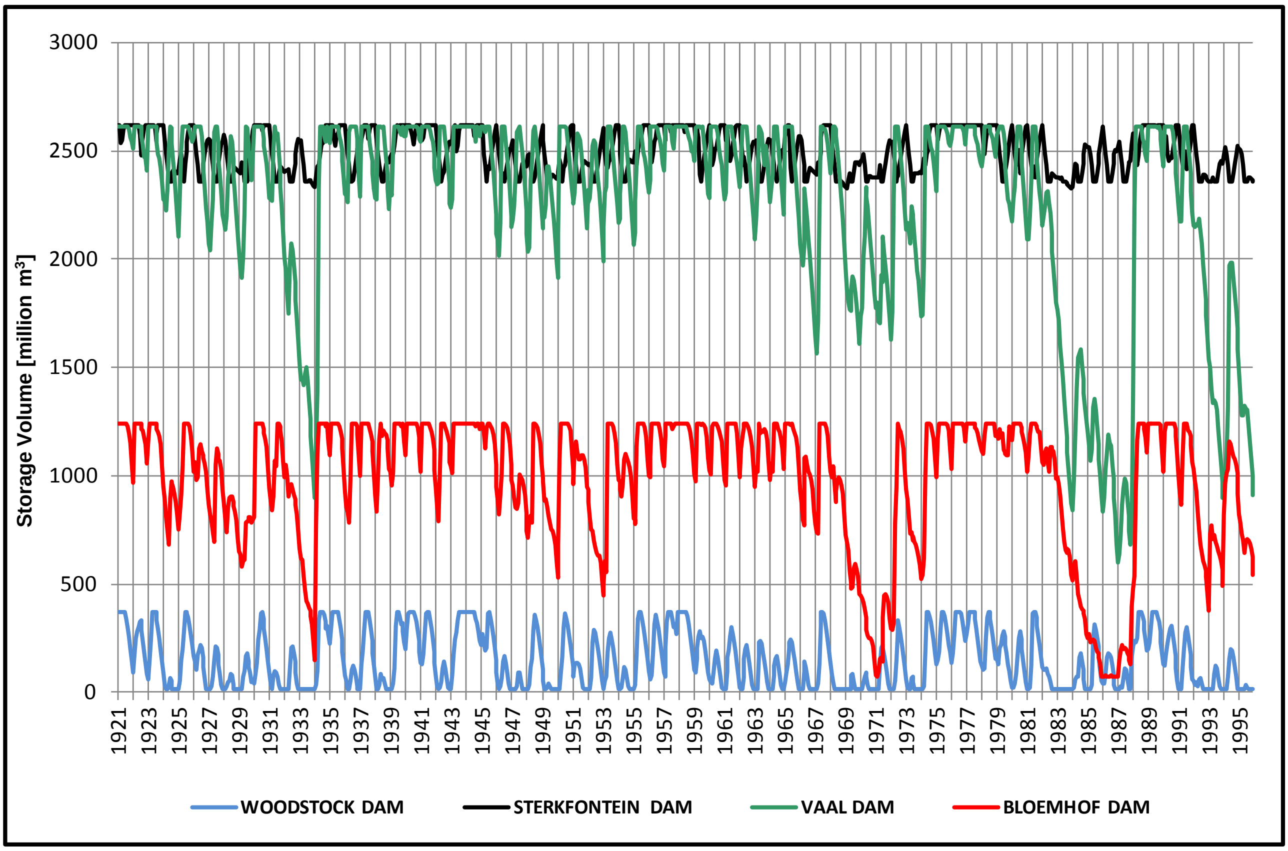


Figure K-5: Reservoir response: Mooi & Schoonspruit (2020 Dev Including EWRs)

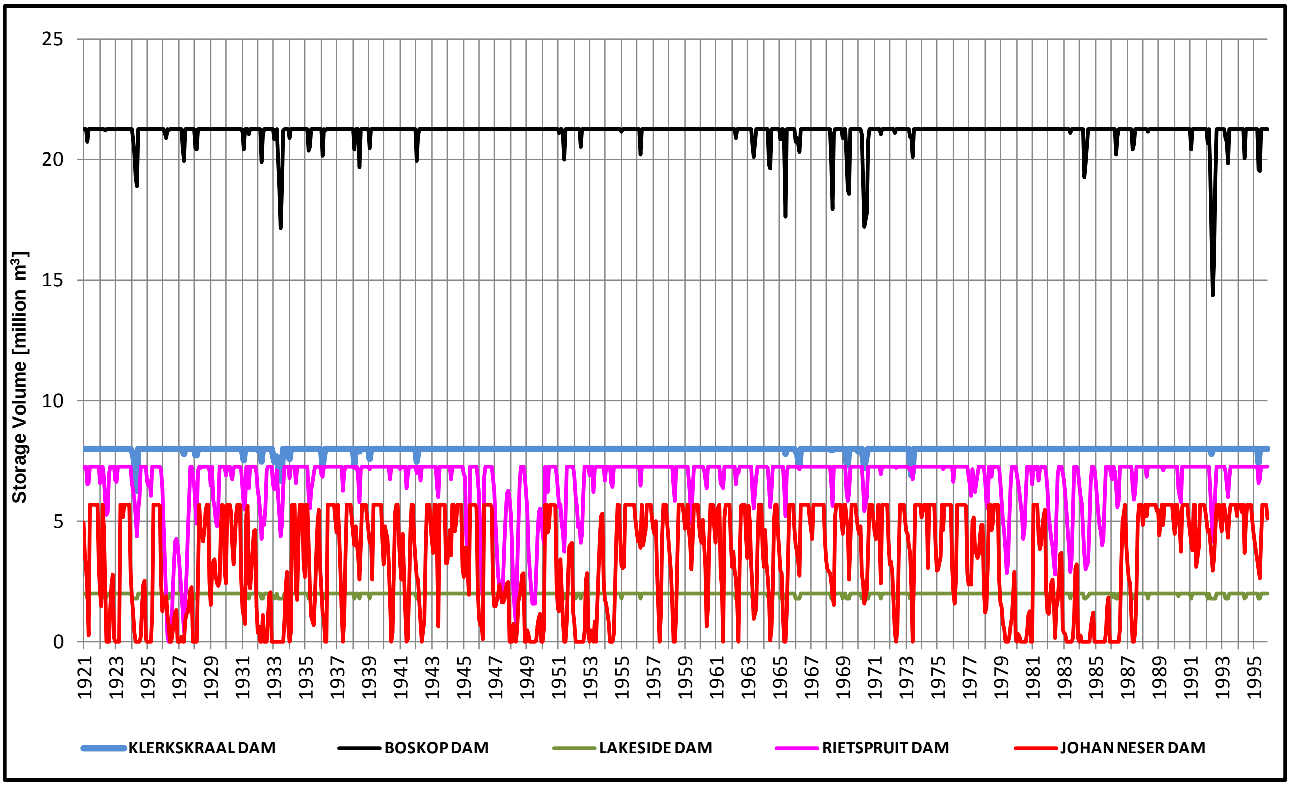


Figure K-6: Reservoir response: Sand & Vet, Renoster and Loopspruit (Future Dev Including EWRs)

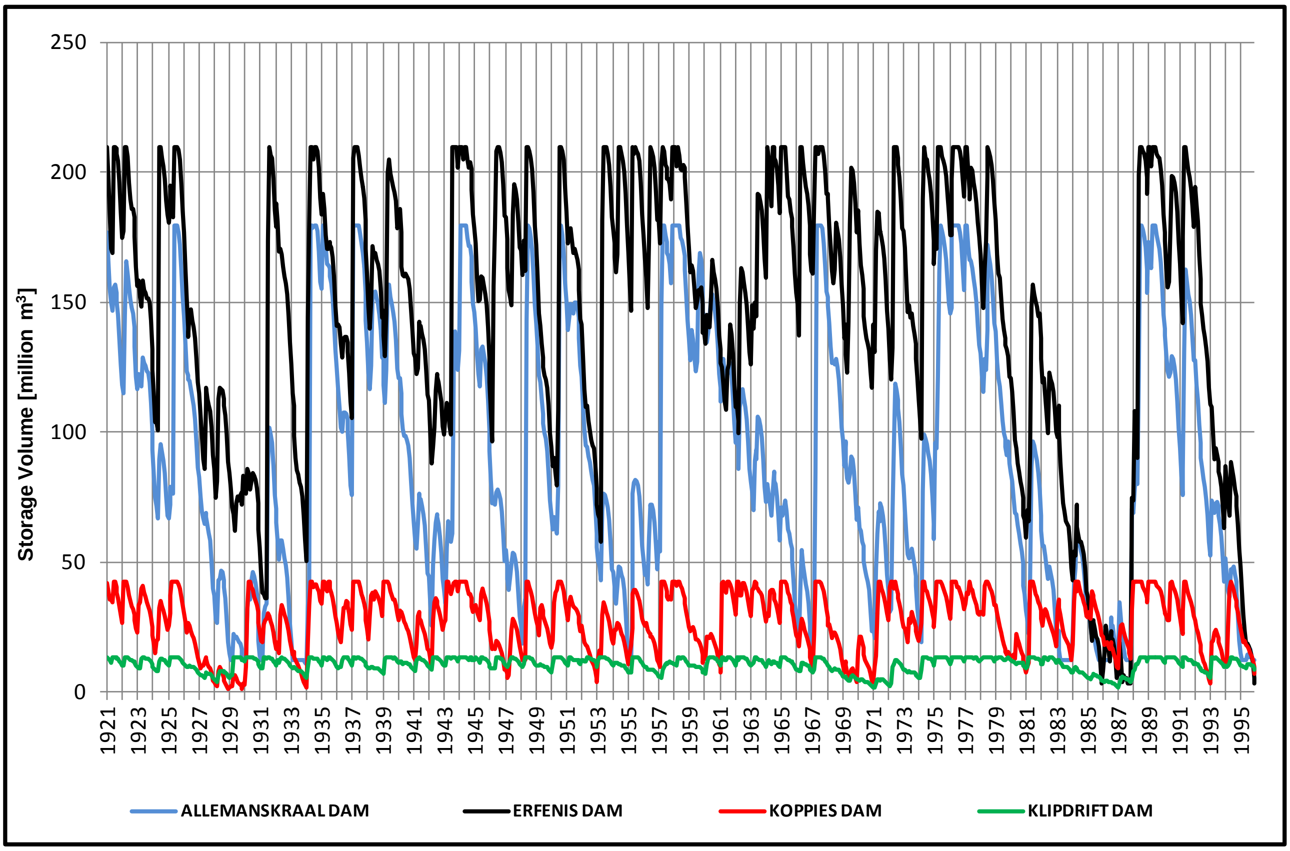


Figure K-7: Reservoir response: Harts River dams (2020 Dev Including EWRs)

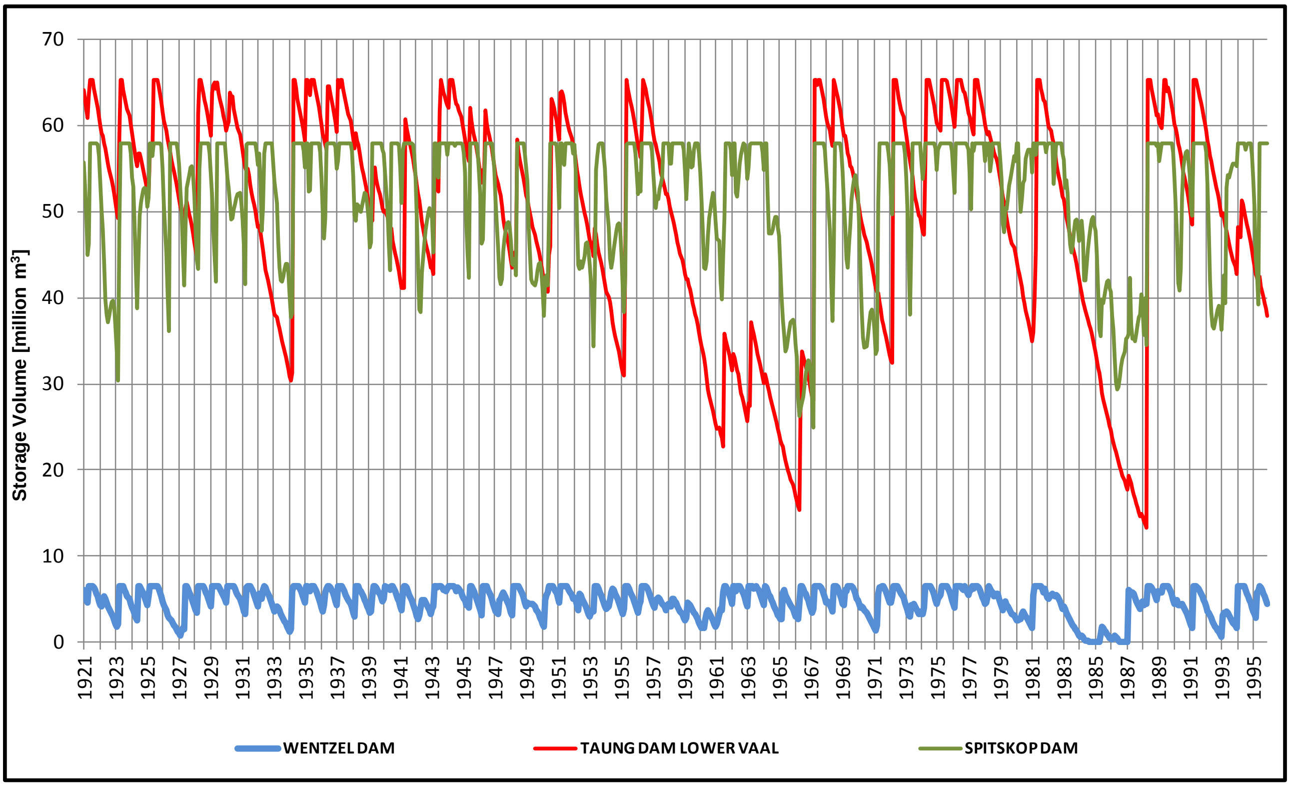
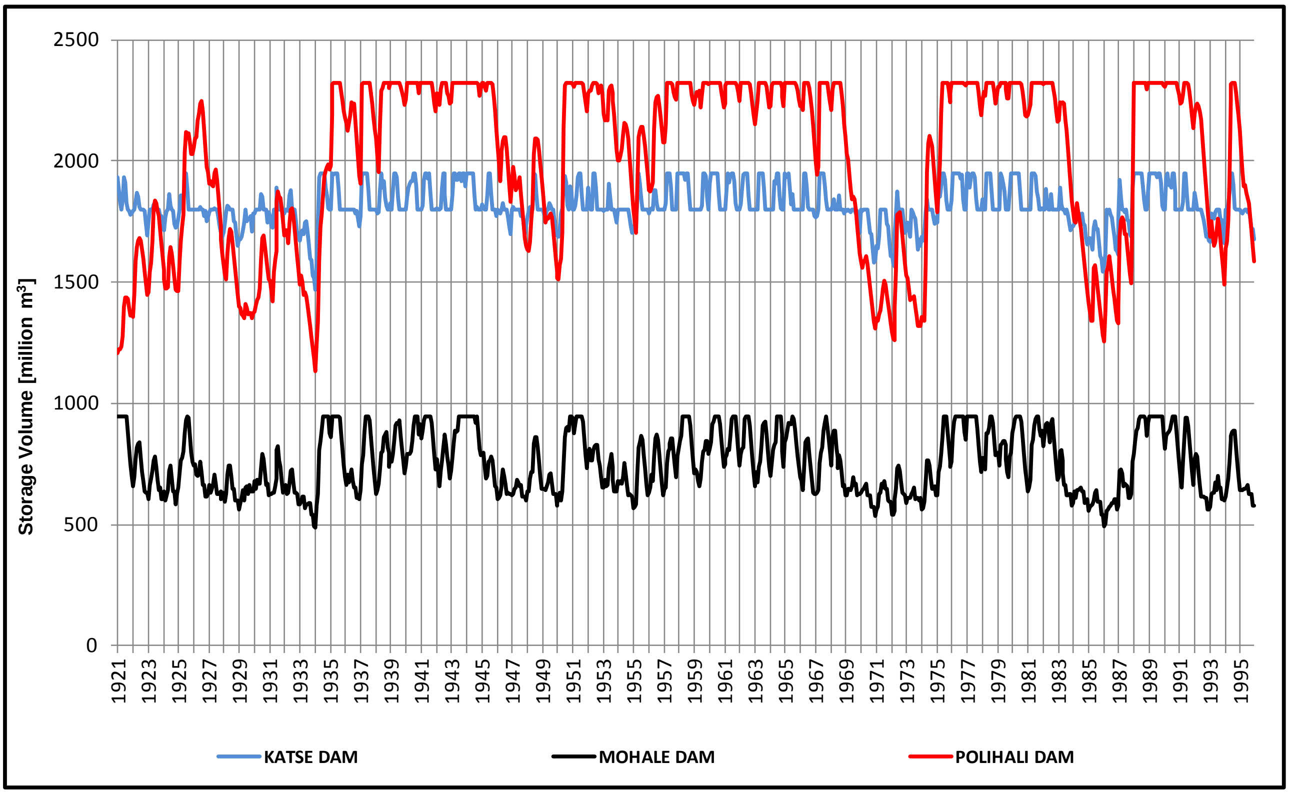


Figure K-9: Reservoir response: Senqu dams (2020 Dev Including EWRs)



Appendix L:

Scenario 5 Results

(Future Development without EWRs)

Figure L-1: Reservoir response for other VRESS dams (Future Dev Excluding EWRs)

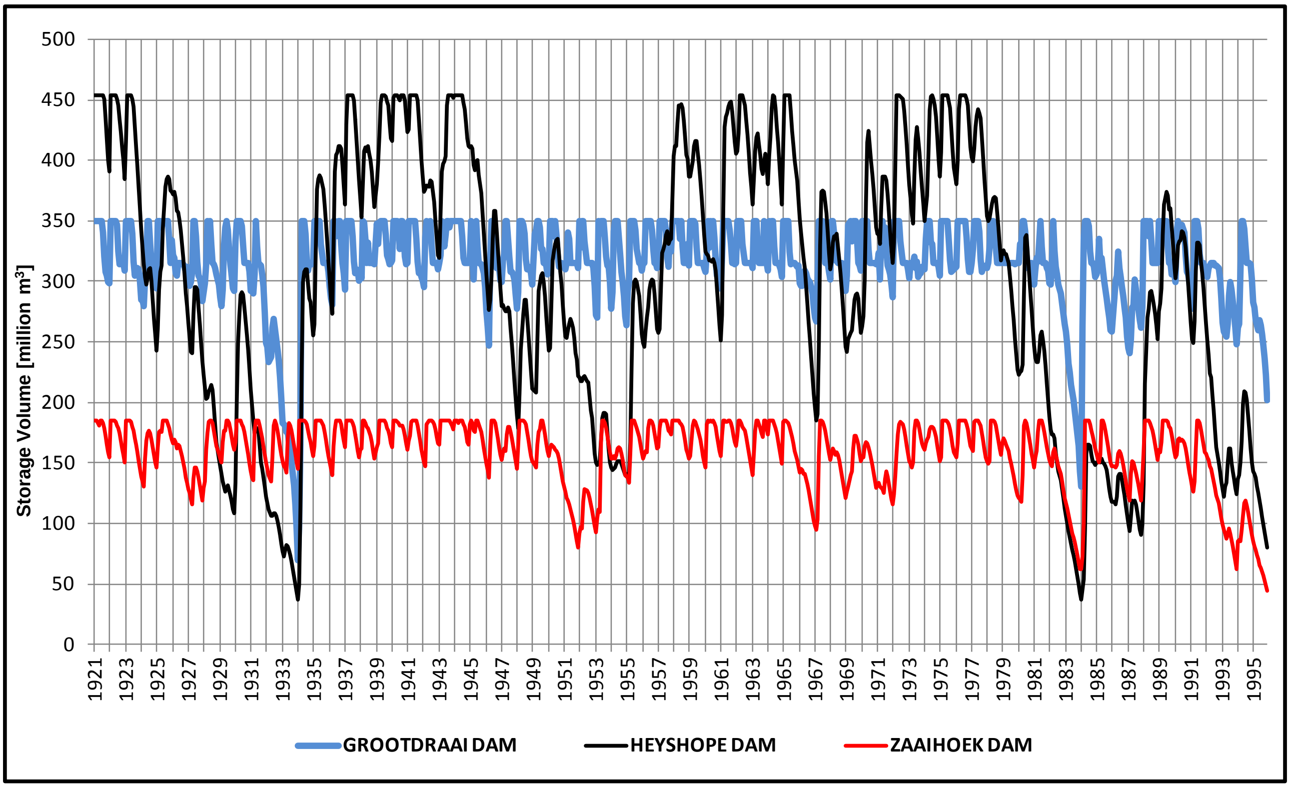


Figure L-2: Reservoir response for major dams (Future Dev Excluding EWRs)

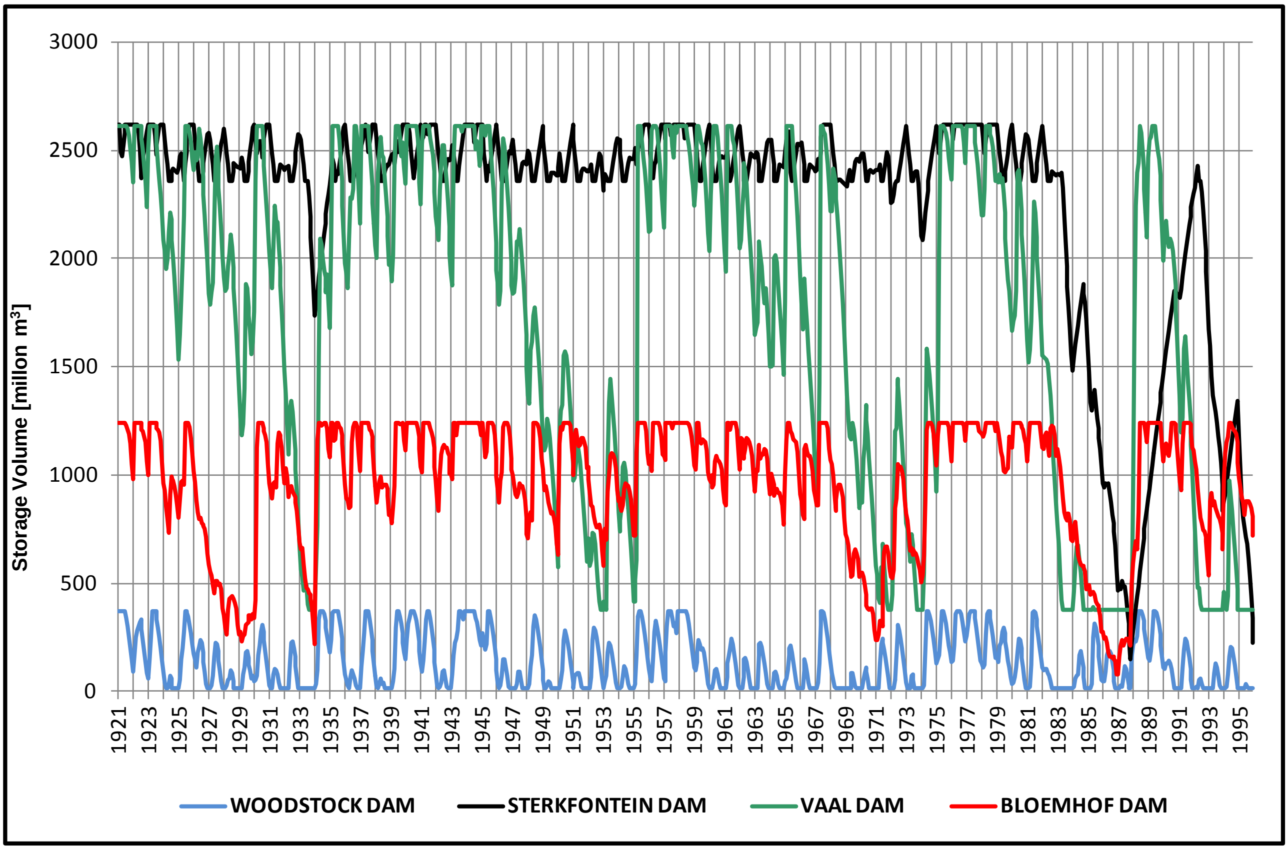
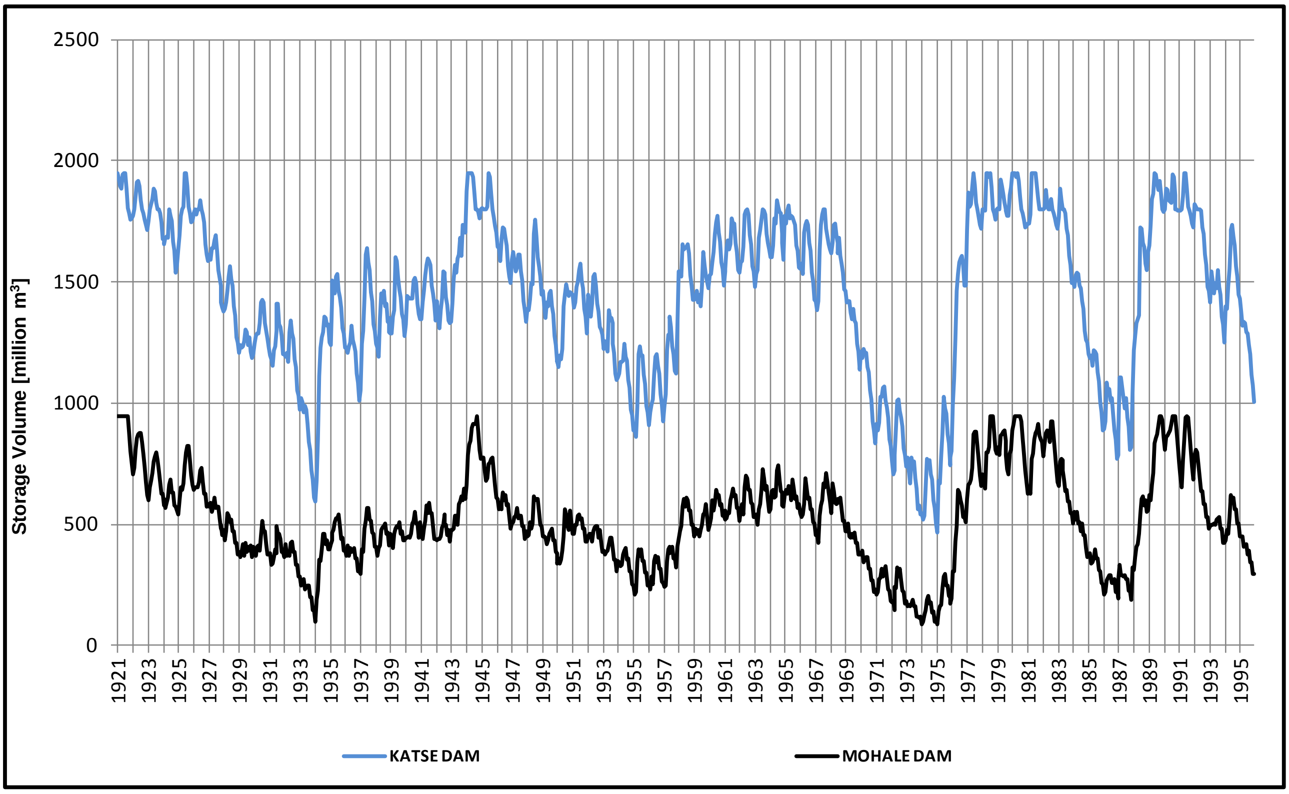


Figure L-3: Reservoir response: Senqu dams (Future Dev <u>Including EWRs</u>)



Appendix M:

Scenario 6 Results

(Future Development including EWRs)

Figure M-1: Reservoir response for other VRESS dams (Future Dev Including EWRs)

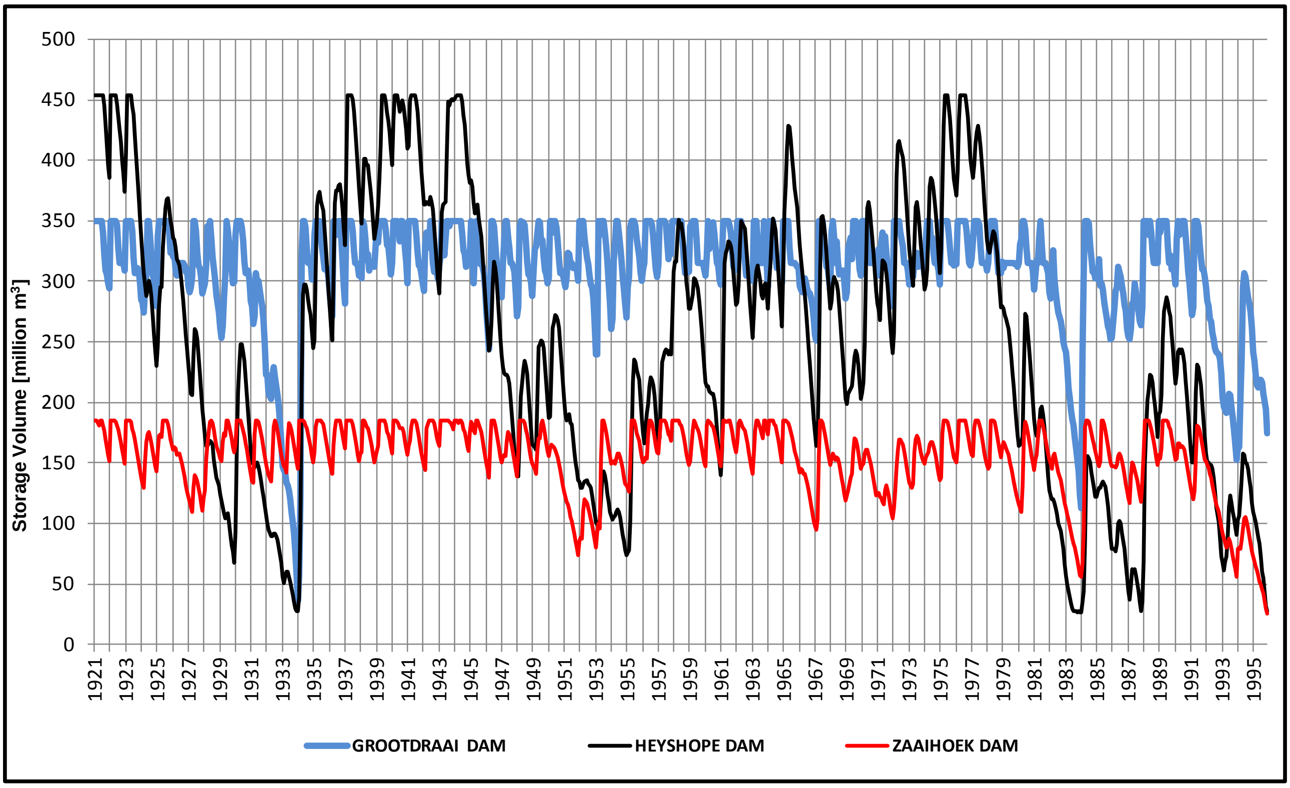


Figure M-2: Reservoir response for major dams (Future Dev Including EWRs)

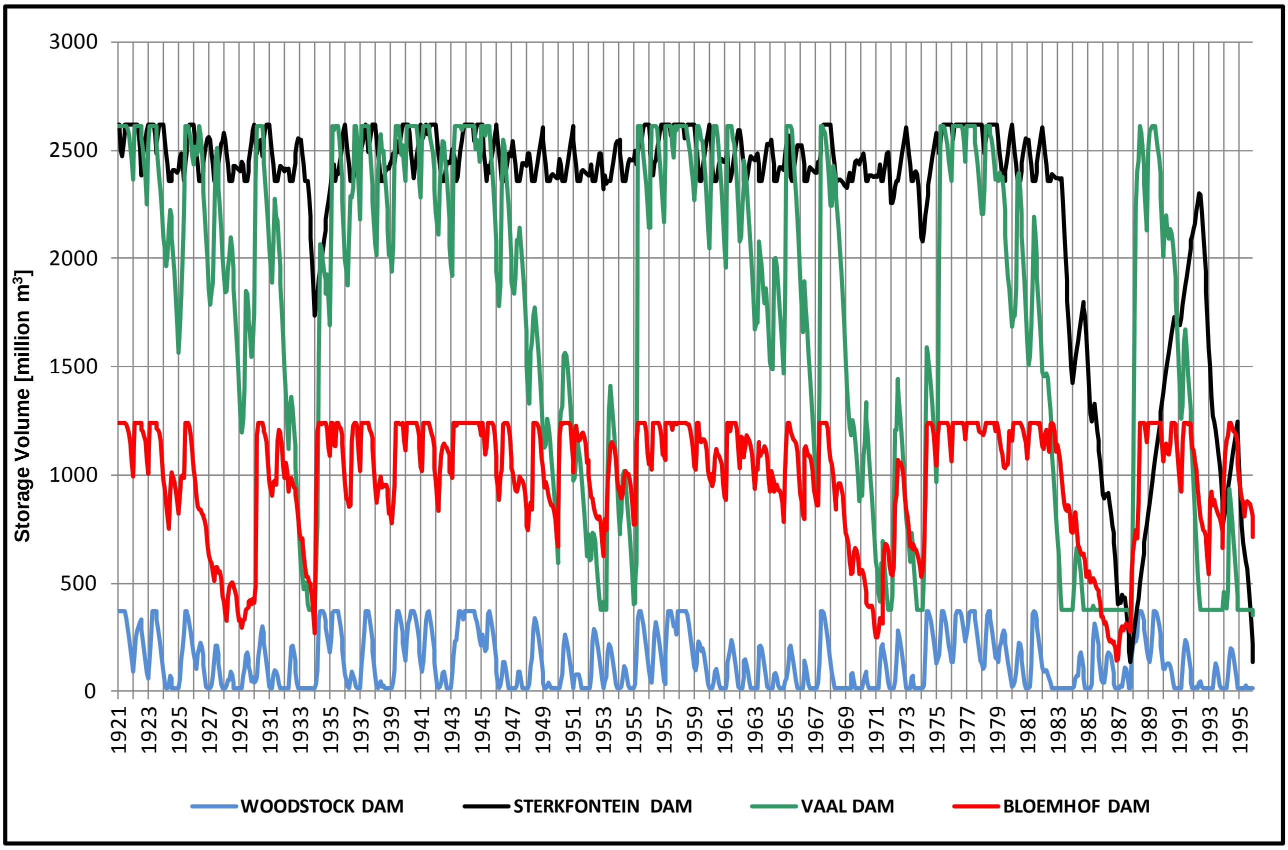
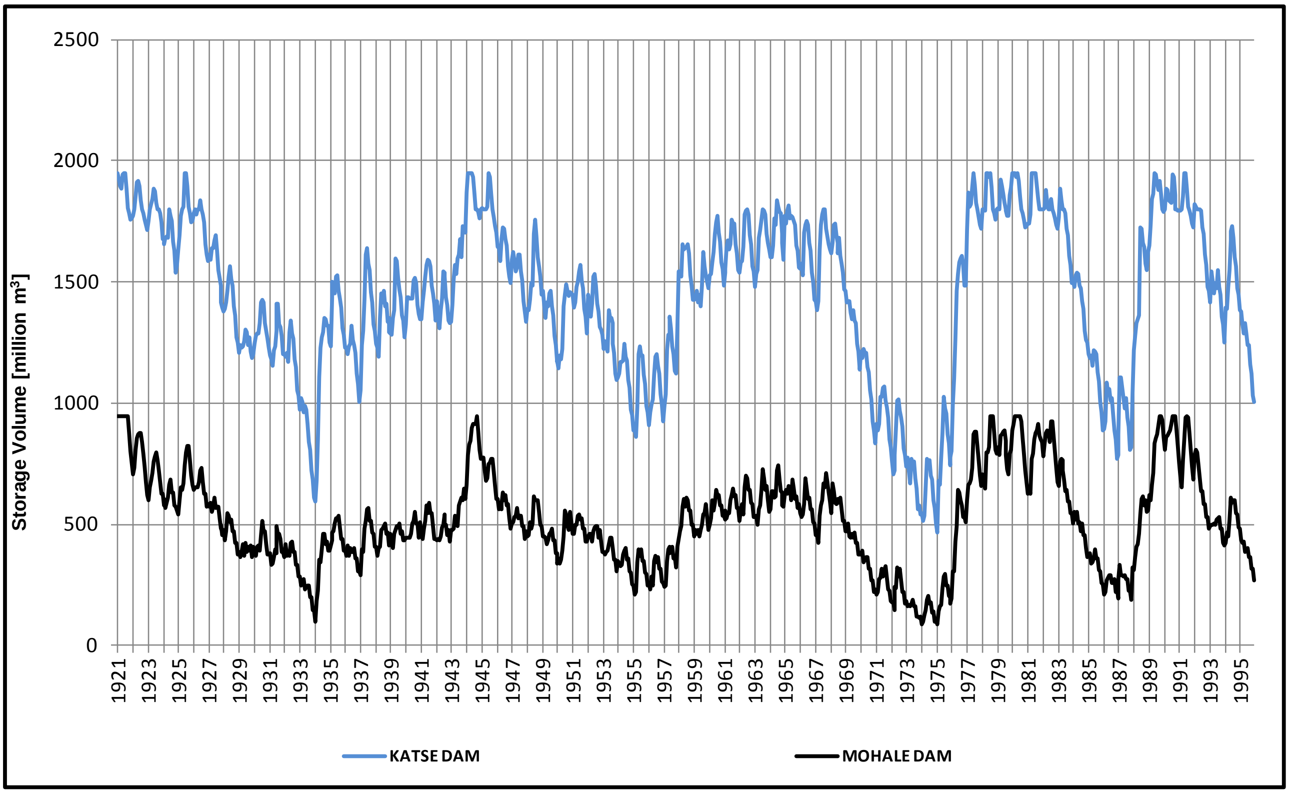


Figure M-3: Reservoir response: Senqu dams (Future Dev Including EWRs)



Appendix N:

Scenario 7 Results

(Present Day including EWRs and Grootdraai compensation releases)

Figure N-1: Reservoir response for other VRESS dams (Present Day Including EWRs)

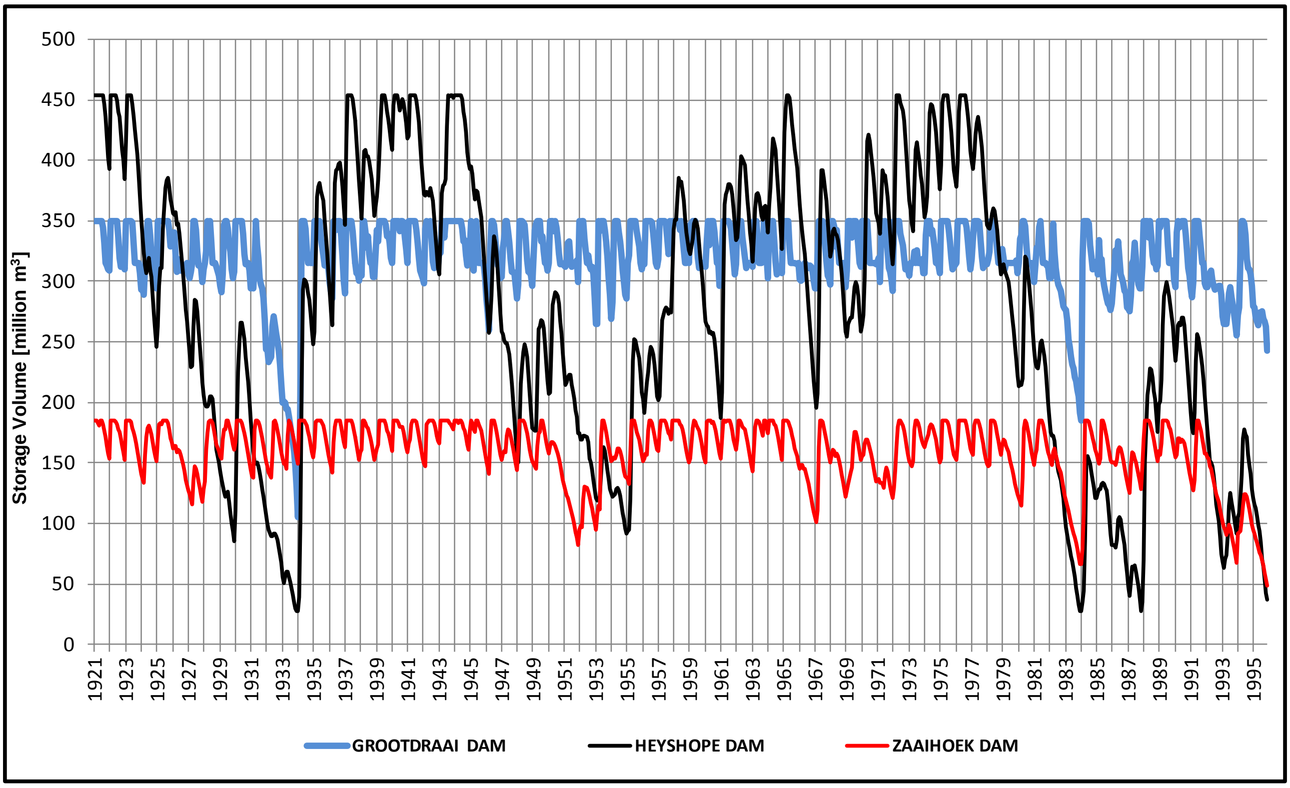
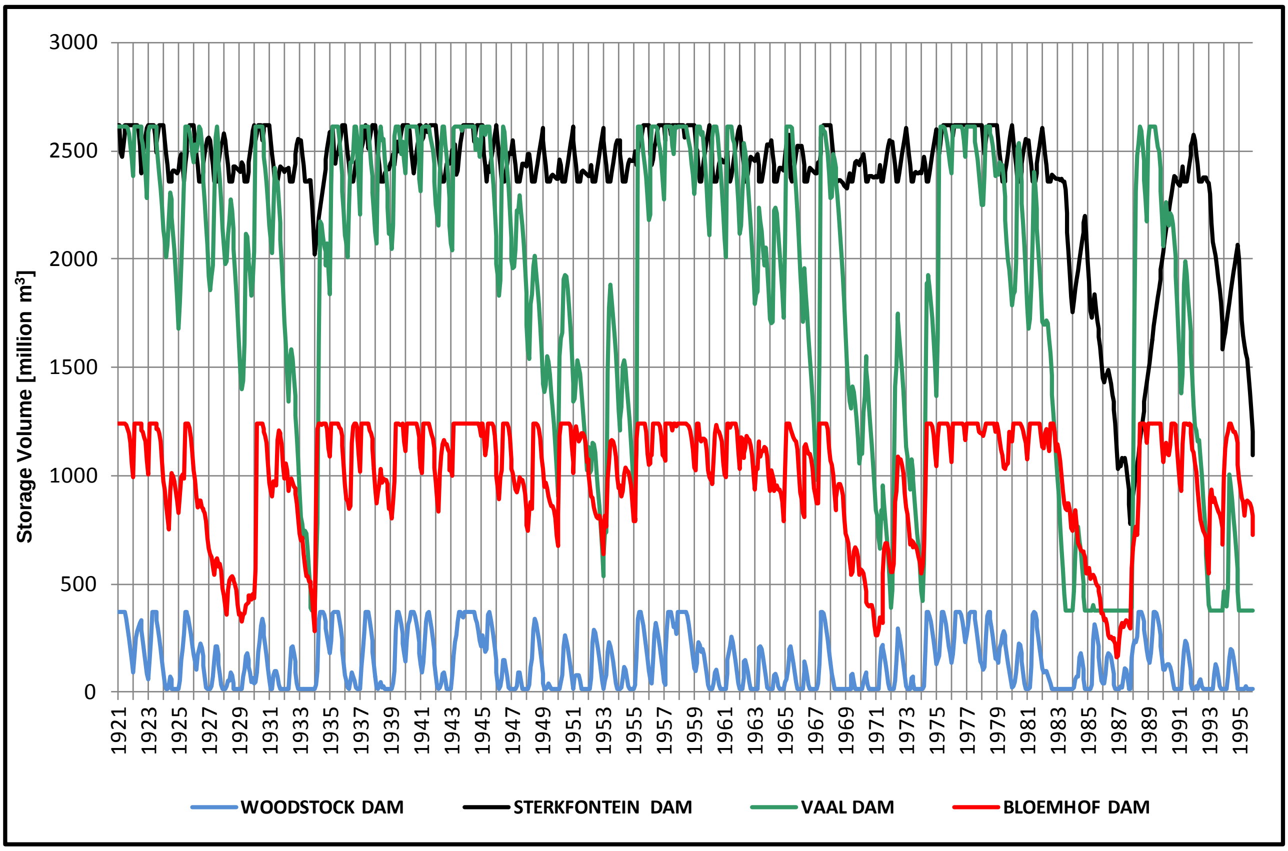


Figure N-2: Reservoir response for major dams (Present Day Including EWRs)



Appendix O:

Scenario 8 Results

(Present Day and optimized Sterkfontein release rule)

Figure O-1: Reservoir response for other VRESS dams (Present Day Excluding EWRs, Optimised Sterkfontein Release Rule)

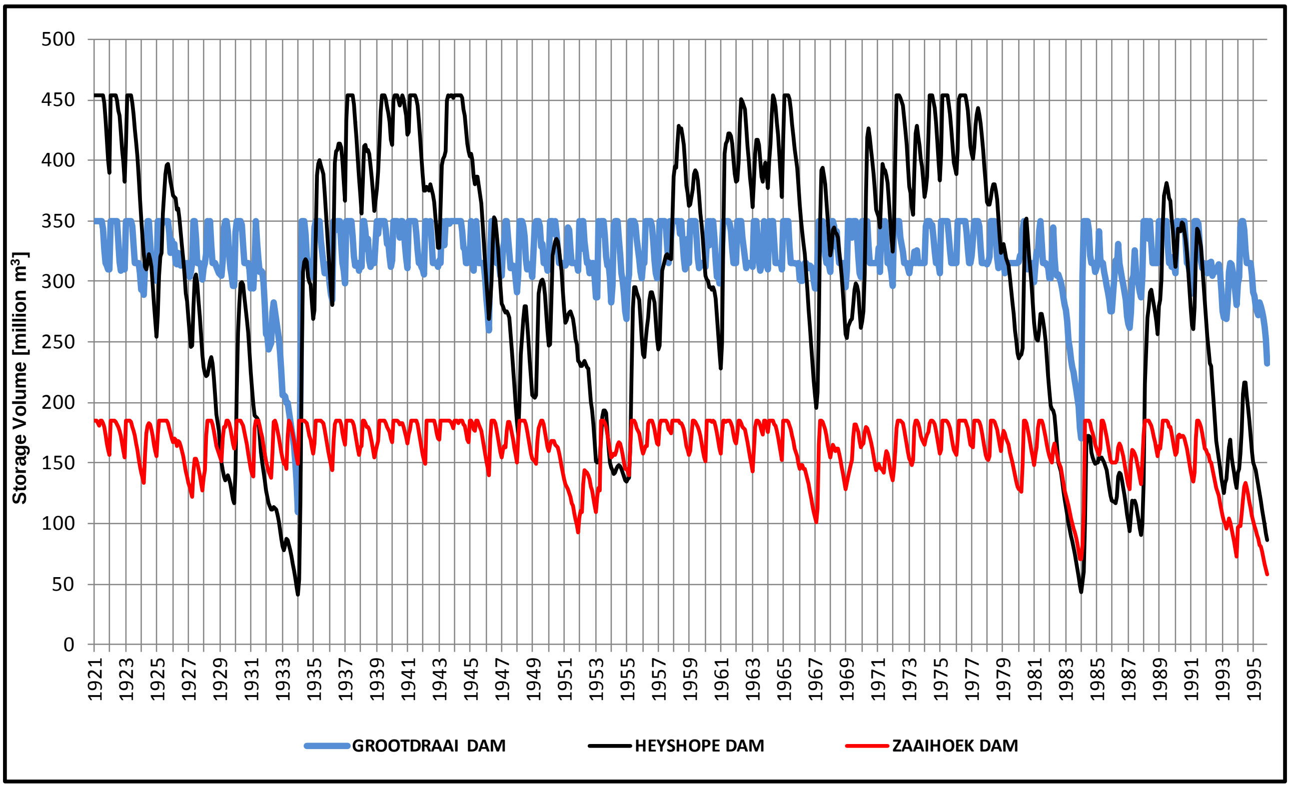
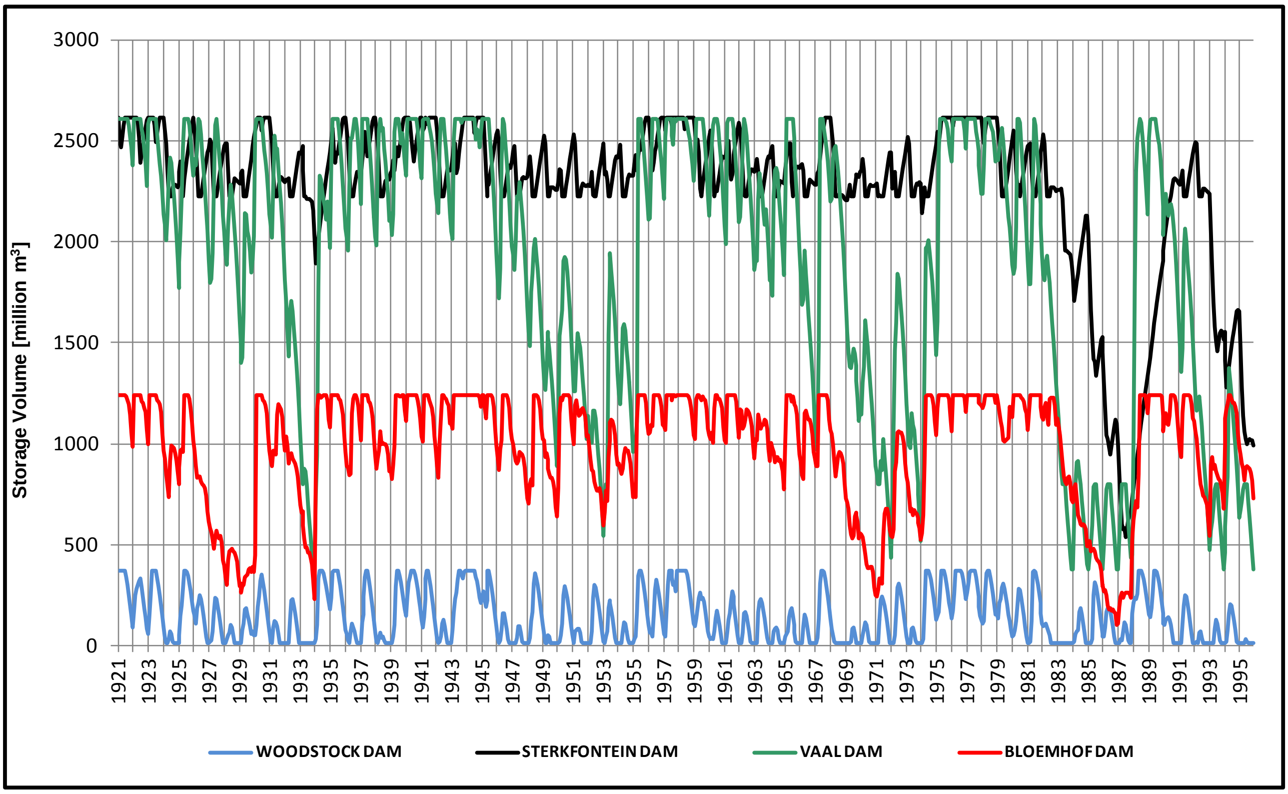


Figure O-2: Reservoir response for major dams (Present Day Excluding EWRs, Optimised Sterkfontein Release Rule)



Appendix P:

Scenario 9a Results

(Douglas EWR assessments for Future Development)

Figure P-1: Reservoir response for major dams (Future Development Excluding Douglas EWR)

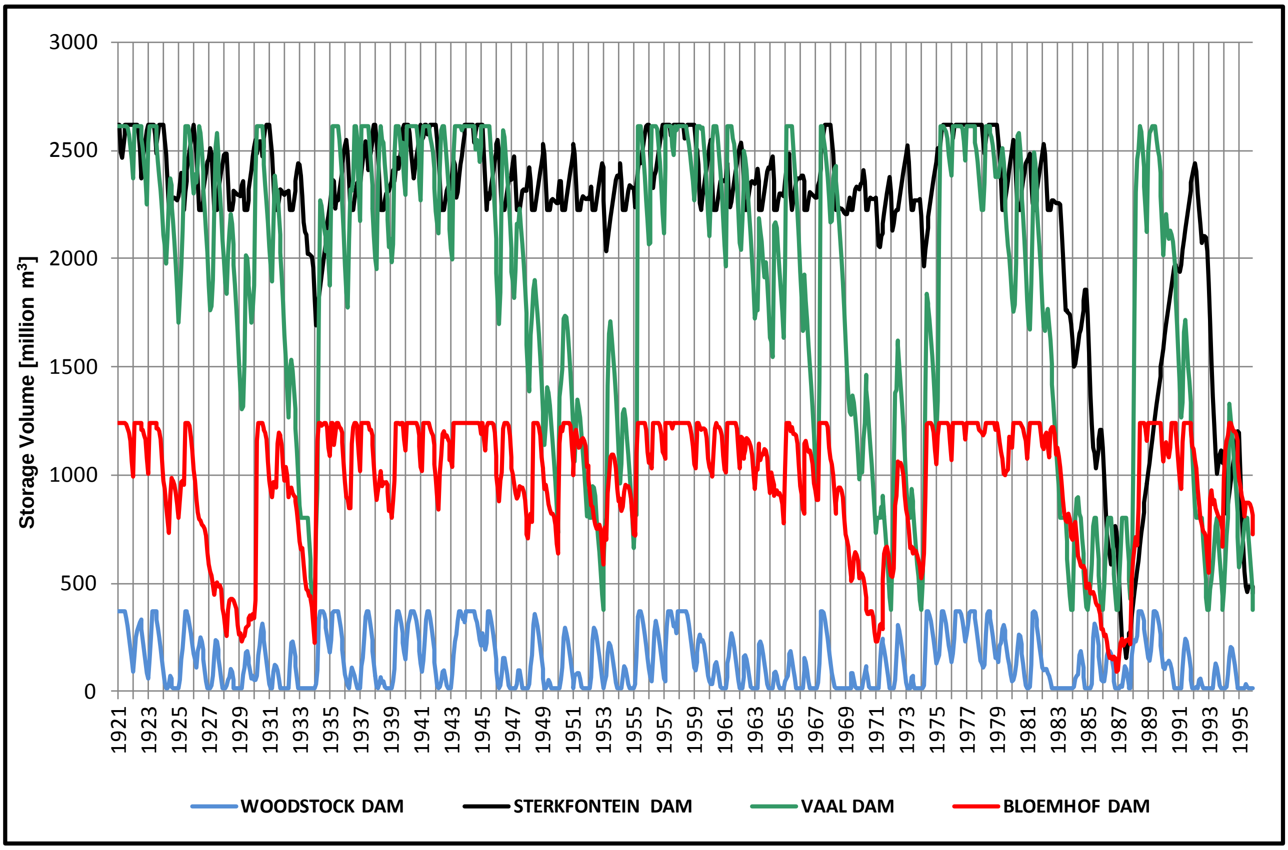
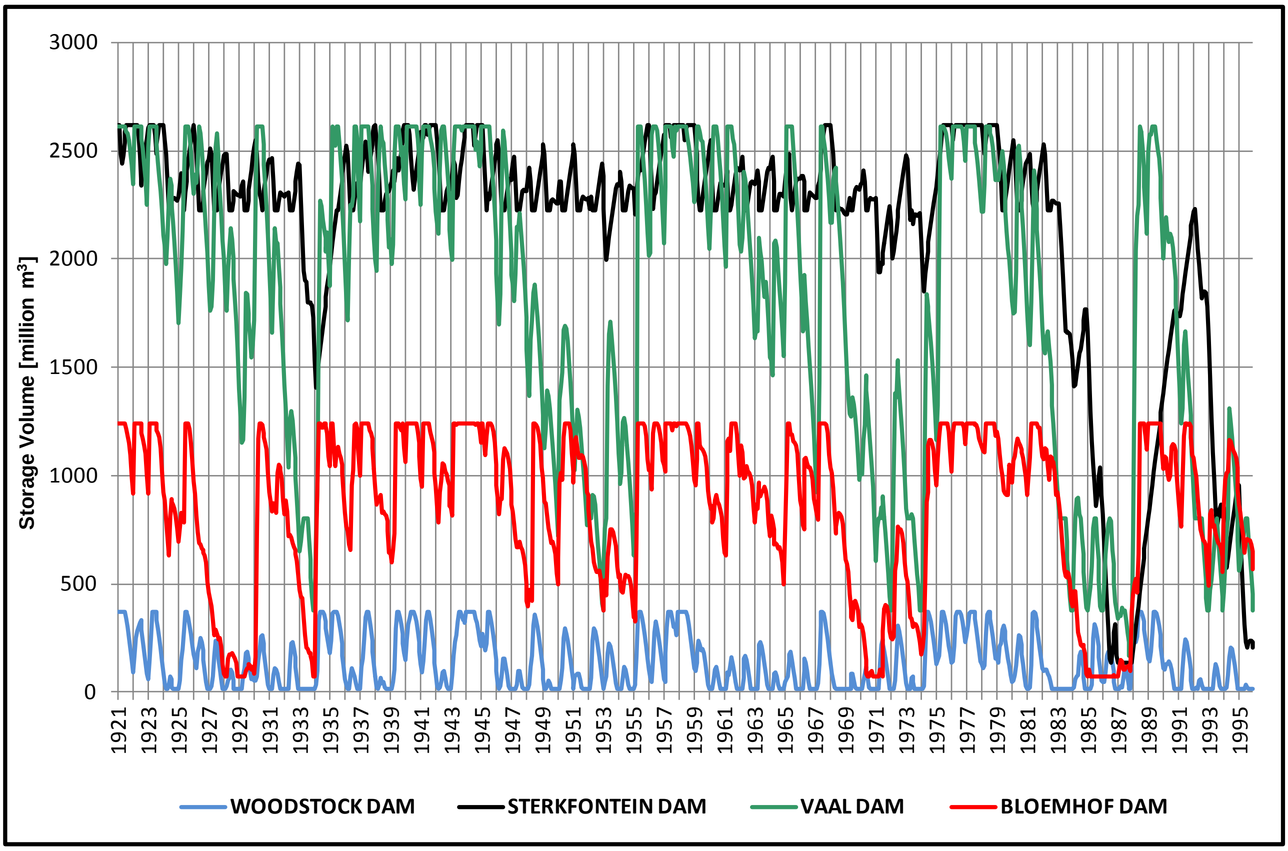


Figure P-2: Reservoir response for major dams (Future Development Including Douglas EWR)



Appendix Q:

Scenario 9b Results

(Douglas EWR assessment for 2020 Full Utilization)

Figure Q-1: Reservoir response for major dams (2020 Full Utilization Excluding Douglas EWR)

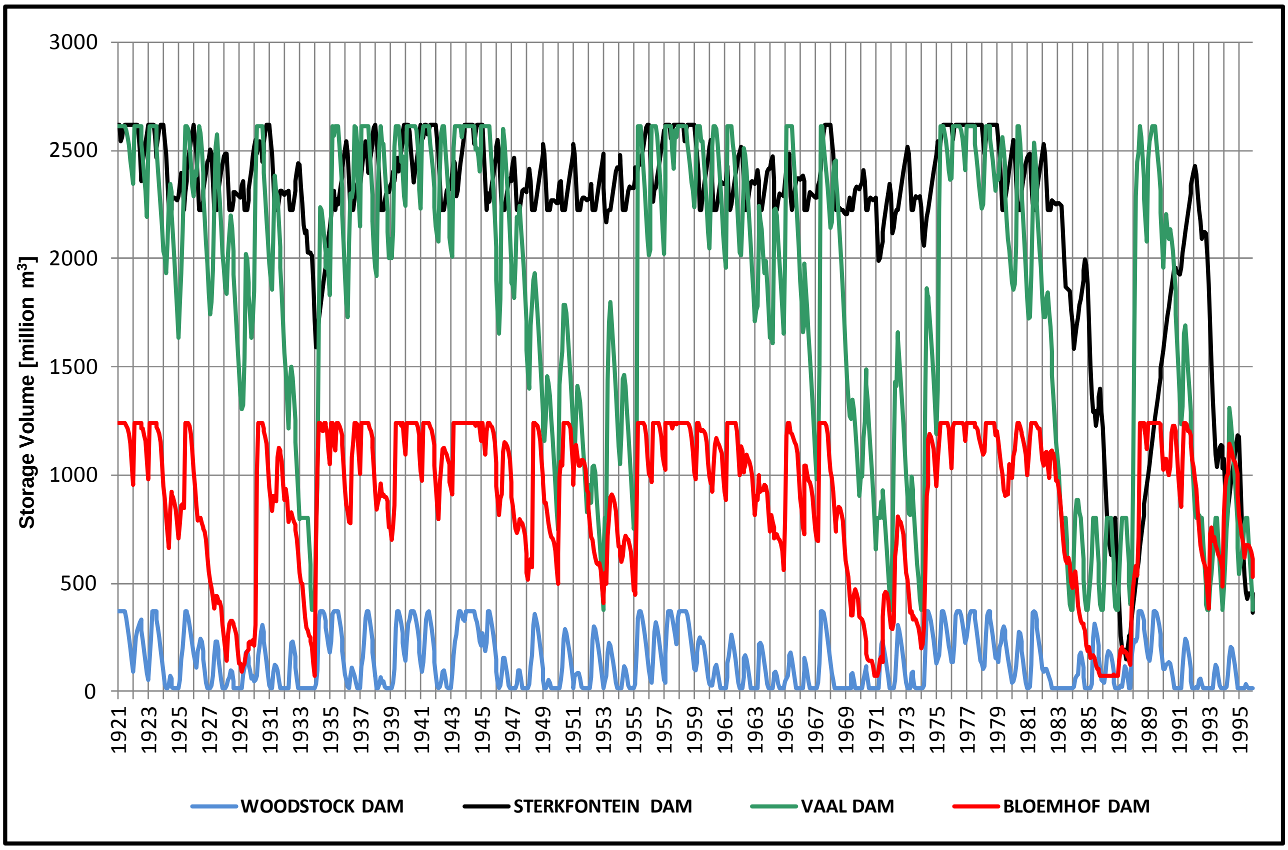
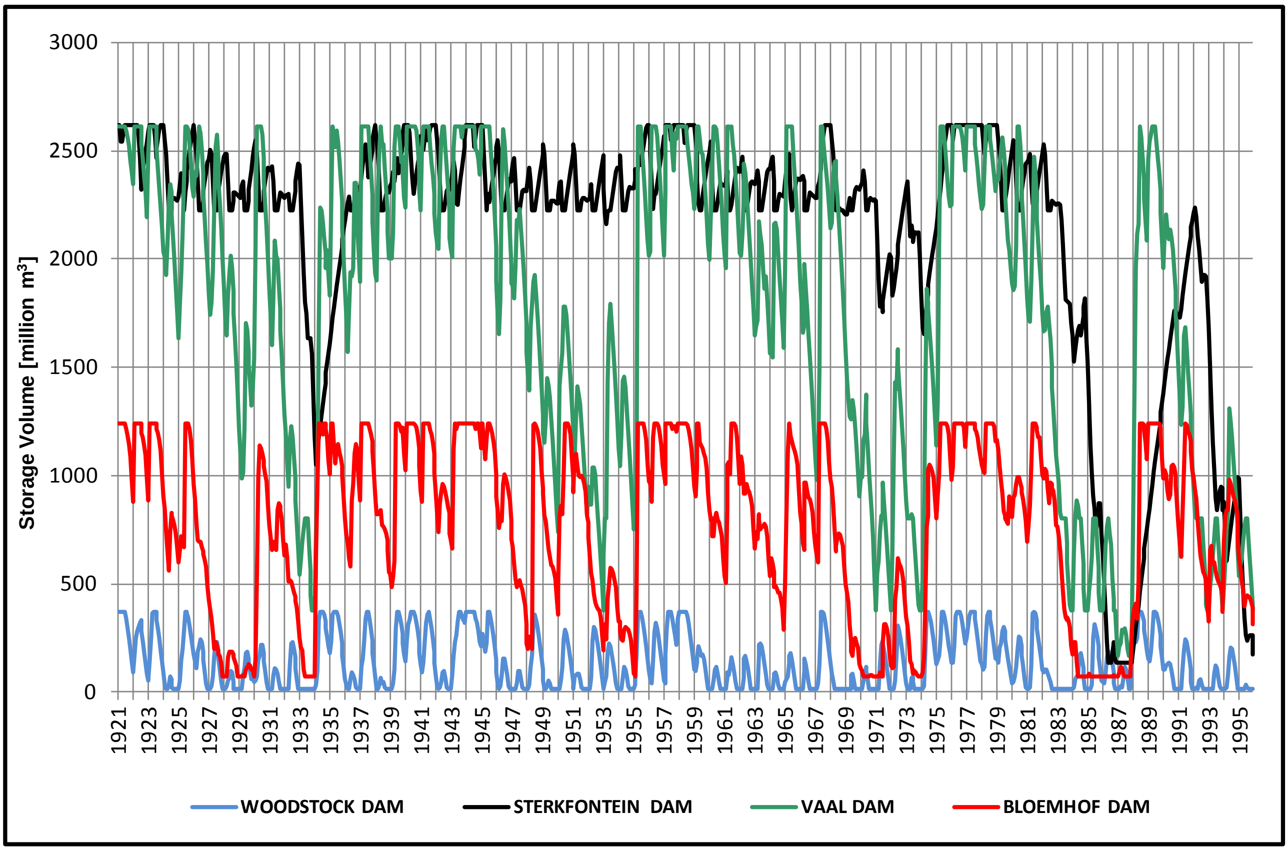


Figure Q-2: Reservoir response for major dams (2020 Full Utilization Including Douglas EWR)



Appendix R:

Summarised WRPM Scenario

Results for EWR Sites

Table R-1: Summarised information for EWR Sites in the Upper, Middle and Lower Vaal WMAs

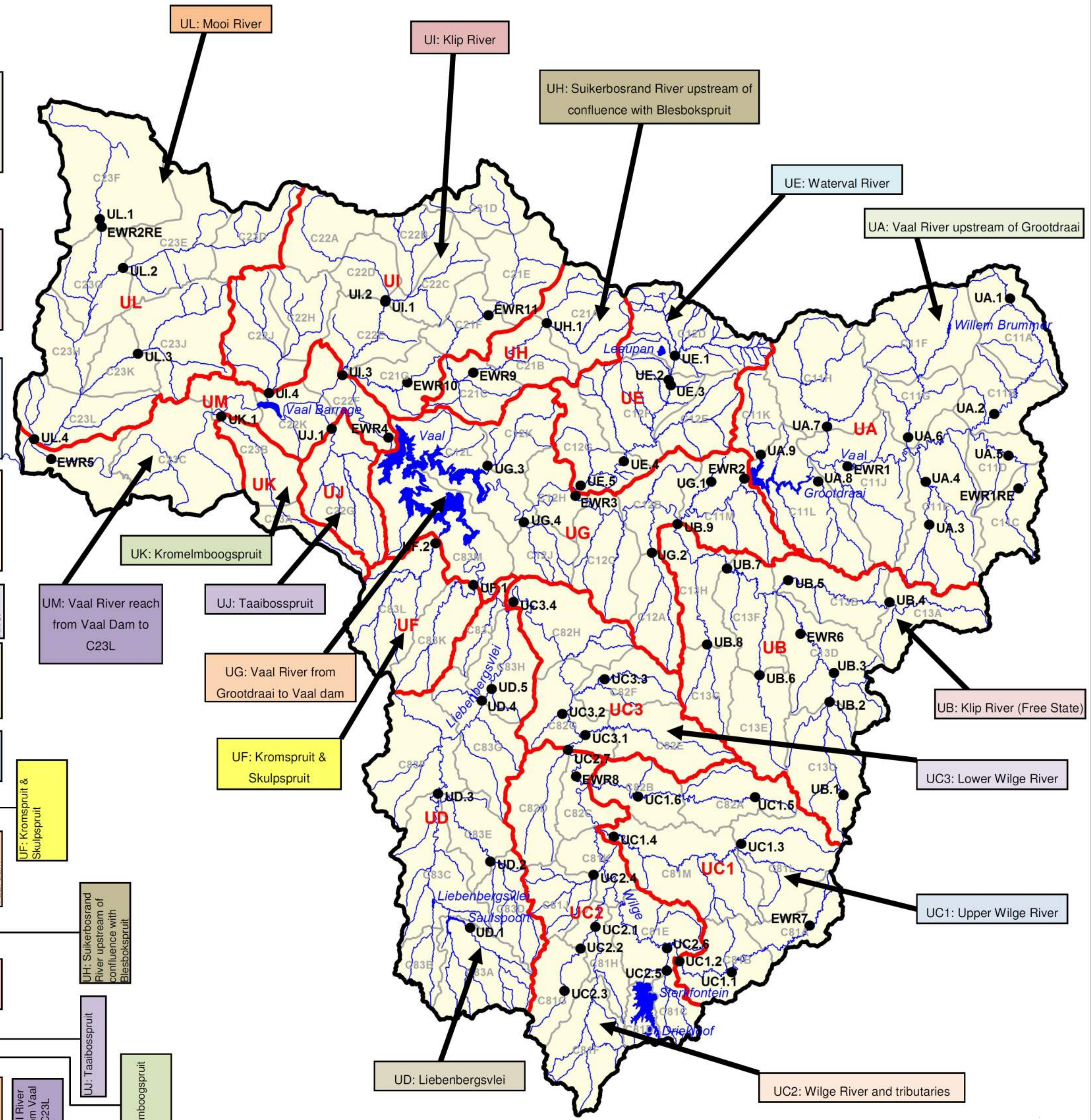
No.	EWR Site Reference	Description	WRPM Channel for EWR Site Flows	Simulated average annual flow (in million m^3/a) at EWR Sites for identified scenarios							
				Scenario 1 Present Day (2011) Conditions excluding EWRs	Scenario 2 Present Day (2011) Conditions including EWRs	Scenario 3 2020 Development Conditions excluding EWRs	Scenario 4 2020 Development Conditions including EWRs	Scenario 5 Full Utilisation (future development conditions) excluding EWRs	Scenario 6 Full Utilisation (future development conditions) including EWRs	Scenario 7 Present Day (2011) Conditions including EWRs with compenastion releases as alternative to EWR2 and EWR3 ds of Grootdraai	Scenario 8 Present Day (2011) Conditions excluding EWRs. Base on optimised Sterkfontein release rule.
1	RE-EWR1	Klein Vaal	1427	23.50	23.74	25.63	25.64	23.50	23.75	23.74	23.5
2	EWR1	Vaal - Uitkoms	1433+30+549	301.27	310.85	311.55	321.90	301.63	312.95	308.47	301.35
3	EWR2	Vaal - Grootdraai	1453	321.92	331.57	303.93	311.55	310.19	321.20	321.32	322.06
4	EWR3	Vaal - Gladdedrift	1358	654.92	664.68	666.76	674.66	643.26	654.37	654.42	655.07
5	WA1	Upper Waterval (C1H004)	1703	88.45	88.45	97.69	97.69	88.45	88.45	88.45	88.45
6	WA2	Lower Waterval (C1H008)	1717	149.89	149.91	163.73	163.73	149.89	149.91	149.91	149.89
7	EWR4	Vaal - Deneysville	757	1178.91	1184.01	1296.05	1299.40	1122.30	1128.14	1182.10	1180.7
8	EWR5	Vaal - Scandinavia	1741	1518.98	1524.10	1707.17	1710.57	1458.73	1464.59	1522.20	1520.79
9	EWR6	Klip River	1458	84.53	84.55	88.80	88.88	84.53	84.55	84.55	84.53
10	EWR8	Wilge - Bavaria	1640+703	772.58	767.24	778.55	771.23	771.63	783.17	767.98	778.59
11	EWR9	Upper Suikerbosrant	2061	28.23	28.24	29.47	29.47	28.23	28.24	28.24	28.23
12	EWR10	Lower Suikerbosrant	2049	158.30	158.33	152.91	152.94	158.31	158.33	158.33	158.3
13	EWR11	Blesbokspruit	834	113.17	113.17	99.42	99.43	113.17	113.17	113.17	113.17
14	RE-EWR2	Mooi (Klerkskraal)	103	27.35	27.35	27.35	27.35	27.35	27.35	27.35	27.35
15	R1	Renoster (Koppies Dam)	2515	32.75	32.84						
16	R2	Renoster (outlet of C70H)	783	71.55	72.01						
17	EWR12	Vaal: Vermaasdrift	1873	1715.38	1722.14	1904.64	1909.66	1655.13	1662.62	1720.23	1717.19
18	S1	Schoonspruit IFR1	1673	12.41	13.43	12.41	13.43	12.41	13.43	13.43	12.41
19	S3	Schoonspruit IFR3	1712	59.97	69.09	59.97	69.08	59.97	69.09	69.09	59.97
20	S4	Schoonspruit IFR4	1731	69.19	78.62	69.24	78.65	69.19	78.62	78.62	69.19
21	EWR13	Vaal: Regina Bridge	1835	1777.04	1793.21	1966.55	1981.03	1715.82	1732.73	1791.31	1778.84
22	EWR14	Vals: Proklameerdrift	1887	115.87	115.87	116.34	116.35	115.87	115.87	115.87	115.87
23	EWR15	Vet: Fisantkraal	1907	254.81	254.81	254.66	254.66	254.81	254.81	254.81	254.81
24	EWR16	Vaal: d/s of Bloemhof	96	1796.05	1809.44	1990.74	2002.83	1736.73	1750.69	1807.60	1797.5
25	H1	Harts River (Taung Dam)	628	35.34	35.64	31.49	31.79	31.71	32.16	35.64	35.34
26	EWR17	Harts: Lloyds Weir	1945	117.64	117.64	113.90	113.98	114.11	114.18	117.64	117.64
27	EWR18	Vaal: Schmidtsdrift	676	1308.57	1321.97	1500.79	1512.96	1245.75	1259.78	1320.13	1310.02

Appendix S:

Summary of Information Relative to Desktop Nodes)

Node name	PES	REC	EIS	EI	Gross catchment area (km^2)	MAR (mill m^3/a)	Irrigation Demand (mill m^3/a)	Irrigation % MAR	Other Demand (mill m^3/a)	Storage Volume (mill m^3)	Storage % MAR
UA.1	B/C	B	moderate	high	197	13.27	0.00	0.00	0.00	1.23	9.30
UA.2	C	C	moderate	moderate	1073	69.33	1.30	1.88	0.18	5.94	8.57
UA.3	C	C	low	low	215	12.03	0.00	0.00	0.50	0.26	2.18
UA.4	C	C	low	moderate	746	41.73	0.87	2.08	0.50	0.67	1.59
UA.5	C/D	C/D	moderate	low	533	41.66	1.77	4.25	0.00	0.74	1.78
UA.6	C/D	C/D	low	low	1331	66.07	3.16	4.78	0.06	14.02	0.06
UA.7	C/D	C/D	moderate	low	1084	70.66	0.38	0.54	0.02	2.09	2.96
UA.8	B/C	B/C	moderate	moderate	355	18.62	0.42	2.24	0.00	0.92	4.95
UA.9	C	C	moderate	moderate	340	18.07	0.13	0.70	0.02	0.35	1.93
EWR1RE	C	C	moderate	moderate	318	26.09	Simulated as part of larger Vaal system				
EWR1	B/C	B/C	high	high	4984	288.8	Simulated as part of larger Vaal system				
UB.1	B	B	high	high	88	5.67	0.00	0.00	0.00	0.00	0.00
UB.2	B/C	B	high	high	837	54.00	2.05	3.79	0.45	1.46	2.71
UB.3	B/C	B	moderate	high	1090	68.04	2.05	3.01	0.45	1.89	2.77
UB.4	C	C	moderate	moderate	595	51.37	1.14	2.22	0.01	0.46	0.90
UB.5	C	C	moderate	moderate	1139	78.84	1.14	1.45	0.01	0.48	0.61
UB.6	B/C	B	moderate	high	603	33.60	0.95	2.83	0.00	0.73	2.17
UB.7	C/D	C/D	moderate	moderate	4129	248.05	7.52	3.03	0.46	5.03	2.03
UB.8	C	C	moderate	moderate	435	20.80	0.69	3.30	1.10	3.79	18.23
UB.9	C/D	C/D	moderate	moderate	589	19.22	7.52	39.14	2.66	8.98	46.72
EWR6	B/C	B/C	moderate	moderate	1583	95.31	Simulated as part of larger Vaal system				
UC1.1	B	B	moderate	high	591	69.03	0.32	0.46	0.01	0.44	0.63
UC1.2	C	C	moderate	low	932	81.11	0.73	0.90	0.08	1.89	2.33
UC1.3	B	B	moderate	high	364	26.49	0.95	3.60	0.00	0.24	0.90
UC1.4	C	C	moderate	moderate	1831	104.03	3.16	3.04	0.03	3.31	3.18
UC1.5	C	C	moderate	moderate	156	7.82	0.15	1.89	0.00	0.71	9.03
UC1.6	C	C	moderate	low	812	39.63	2.73	6.88	0.00	3.03	7.65
EWR7	A/B	A/B	high	high	170	23.47	Simulated as part of larger Vaal system				
UC2.1	C/D	C/D	low	moderate	1405	114.76	0.26	0.23	16.04	33.98	29.61
UC2.2	C	C	moderate	moderate	435	22.13	0.26	1.19	0.00	0.02	0.08
UC2.3	B	B	moderate	high	115	5.85	0.00	0.00	0.00	0.00	0.00
UC2.4	C	C	low	low	392	12.00	0.12	1.01	0.00	0.31	2.60
UC2.5	B/C	B/C	moderate	moderate	250	18.41	0.83	4.50	0.01	1.15	6.26
UC2.6	C	C	low	low	527	39.87	0.97	2.43	0.01	3.90	9.78
UC2.7	C	C	low	moderate	572	19.60	4.23	21.56	0.00	3.21	16.37
EWR8	C	C	moderate	moderate	7503	474.25	Simulated as part of larger Vaal system				
UC3.1	C	C	moderate	moderate	729	32.90	3.94	11.98	0.00	0.74	2.26
UC3.2	B/C	B/C	low	moderate	152	6.34	0.00	0.00	0.00	0.01	0.17
UC3.3	C	C	moderate	moderate	296	11.08	0.00	0.00	0.00	0.08	0.76
UC3.4	C/D	C/D	moderate	low	10633	591.39	50.48	8.54	16.51	22.28	3.77
UD.1	C	C	moderate	low	375	14.36	0.14	0.95	0.00	0.31	2.13
UD.2	C	C	moderate	moderate	465	12.42	0.11	0.86	0.00	0.56	4.52
UD.3	C	C	moderate	moderate	891	23.31	3.15	13.51	0.00	5.37	23.02
UD.4	B/C	B	moderate	high	139	4.74	0.08	1.73	0.00	0.03	0.61
UD.5	B/C	B	moderate	high	76	2.66	0.00	0.00	0.00	0.01	0.34
UE.1	C	C	low	low	695	59.33	0.39	0.66	0.00	0.20	0.34
UE.2	D	D	low	low	970	80.37	1.64	2.04	0.11	2.55	3.17
UE.3	C	C	low	moderate	41	2.12	0.00	0.00	0.00	0.00	0.00
UE.4	D	D	low	low	2278	149.84	0.00	0.00	0.00	0.00	0.00
UE.5	D	D	moderate	moderate	2787	177.67	12.51	7.04	0.14	5.75	3.24
UF.1	C	C	moderate	moderate	546	25.70	1.84	7.17	0.00	0.98	3.82
UF.2	C	C	moderate	moderate	765	35.59	0.20	0.56	0.00	0.76	2.14
UG.1	C	C	low	low	75	3.36	1.45	43.21	0.00	1.02	30.24
UG.2	C	C	moderate	moderate	485	21.00	0.00	0.00	0.00	0.13	0.62
UG.3	C	C	moderate	low	479	22.00	0.31	1.40	0.00	0.35	1.57
UG.4	C	C	moderate	moderate	344	12.43	0.16	1.30	0.00	0.21	1.69
EWR2	C	C	moderate	moderate	7995	457.68	Simulated as part of larger Vaal system				
EWR3	C	C	moderate	moderate	15638	852.13	Simulated as part of larger Vaal system				
UH.1	B/C	B	moderate	high	707	28.65	0.22	0.75	0.01	0.86	2.99
EWR9	C	B/C	high	high	1175	31.31	Simulated as part of larger Vaal system				
UI.1	E	D1	low	low	857	36.60	3.87	10.56	1.31	0.19	0.53
UI.2	E	D1	low	moderate	893	39.21	6.29	16.04	0.19	0.13	0.33
UI.3	E	D1	low	low	2309	96.98	22.44	23.14	1.60	0.68	0.71
UI.4	D/E	D1	low	moderate	926	22.10	3.21	14.51	0.00	0.19	0.85
EWR10	C/D	C/D	moderate	moderate	3271	86.97	Simulated as part of larger Vaal system				
EWR11	D	D	low	low	1098	29.14	Simulated as part of larger Vaal system				
UJ.1	D	D	low	low	831	18.40	0.26	1.42	0.00	0.19	1.02
UK.1	C	C	moderate	low	724	14.30	0.59	4.15	0.00	0.29	2.00
UL.1	C/D	C/D	low	low	1324	37.69	0.50	1.33	0.00	0.44	1.16
UL.2	E	D	low	low	1360	25.96	2.25	8.67	23.81	0.25	0.96
UL.3	E	D	low	low	890	20.26	0.00	0.00	0.00	0.00	0.00
UL.4	D	D	low	low	5535	132.21	Simulated as part of larger Vaal system				
EWR2RE	D	D	low	low	1324	37.69					
EWR4	C	B/C	high	high	38638	1977.2	Simulated as part of larger Vaal system				
EWR5	C/D	C	high	high	49739	2288.0	Simulated as part of larger Vaal system				

UA: Vaal River upstream of Grootdraai Dam
UB: Klip River (Free State)
UC1: Upper Wilge River
UC2: Wilge River and tributaries
UC3: Lower Wilge River
UD: Liebenbergsvlei
UE: Waterval
UF: Kromspruit & Skulpspruit
UG: Vaal River from Grootdraai to Vaal dam
UH: Suikerbosrand River upstream of confluence with Blesbokspruit
UI: Klip River
UJ: Taaibosspruit
UK: Kromelmboogspruit
UL: Mooi River
UM: Vaal River reach from Vaal Dam to C23L



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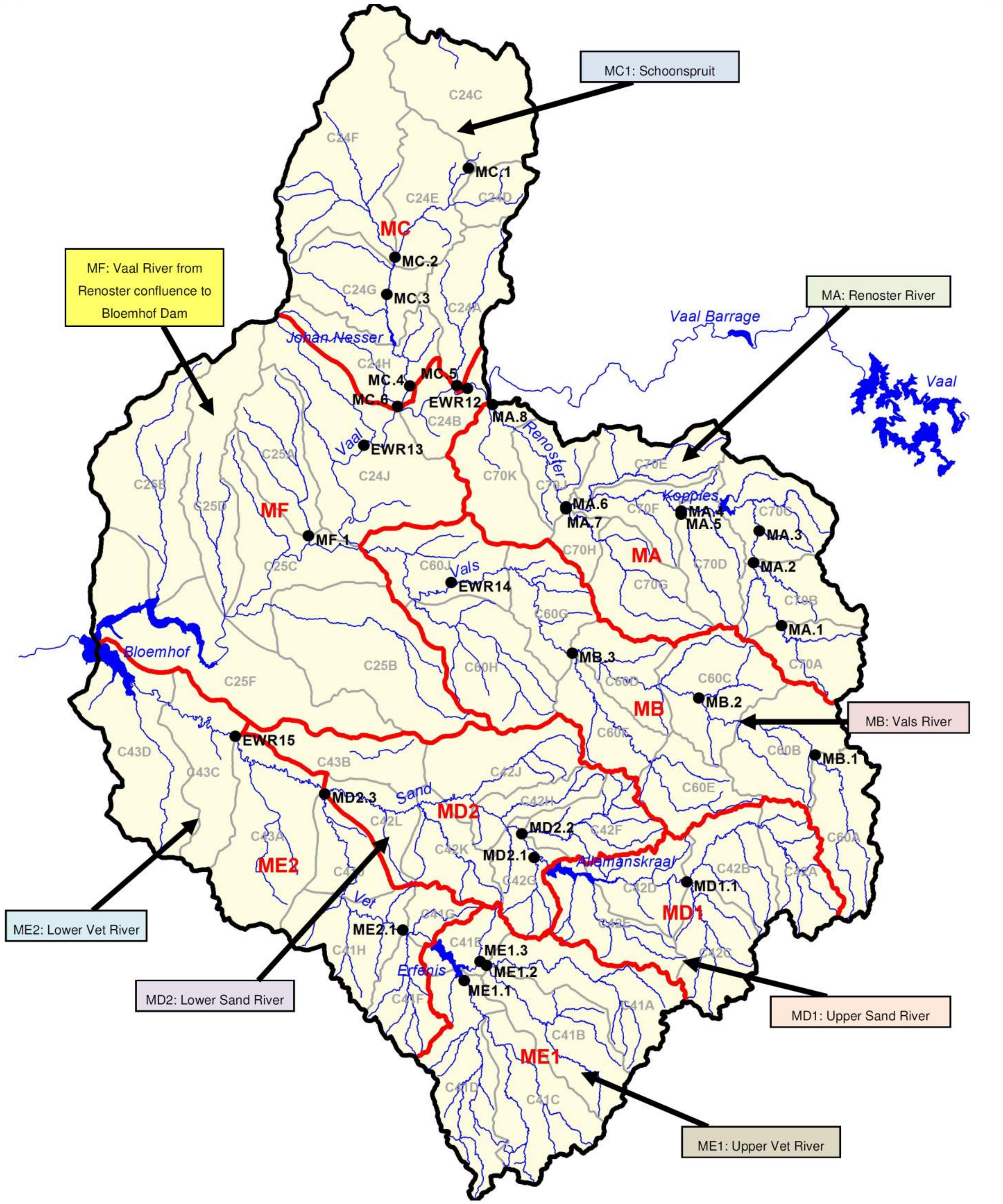
Upper Vaal Integrated Units of Analysis (IUA)

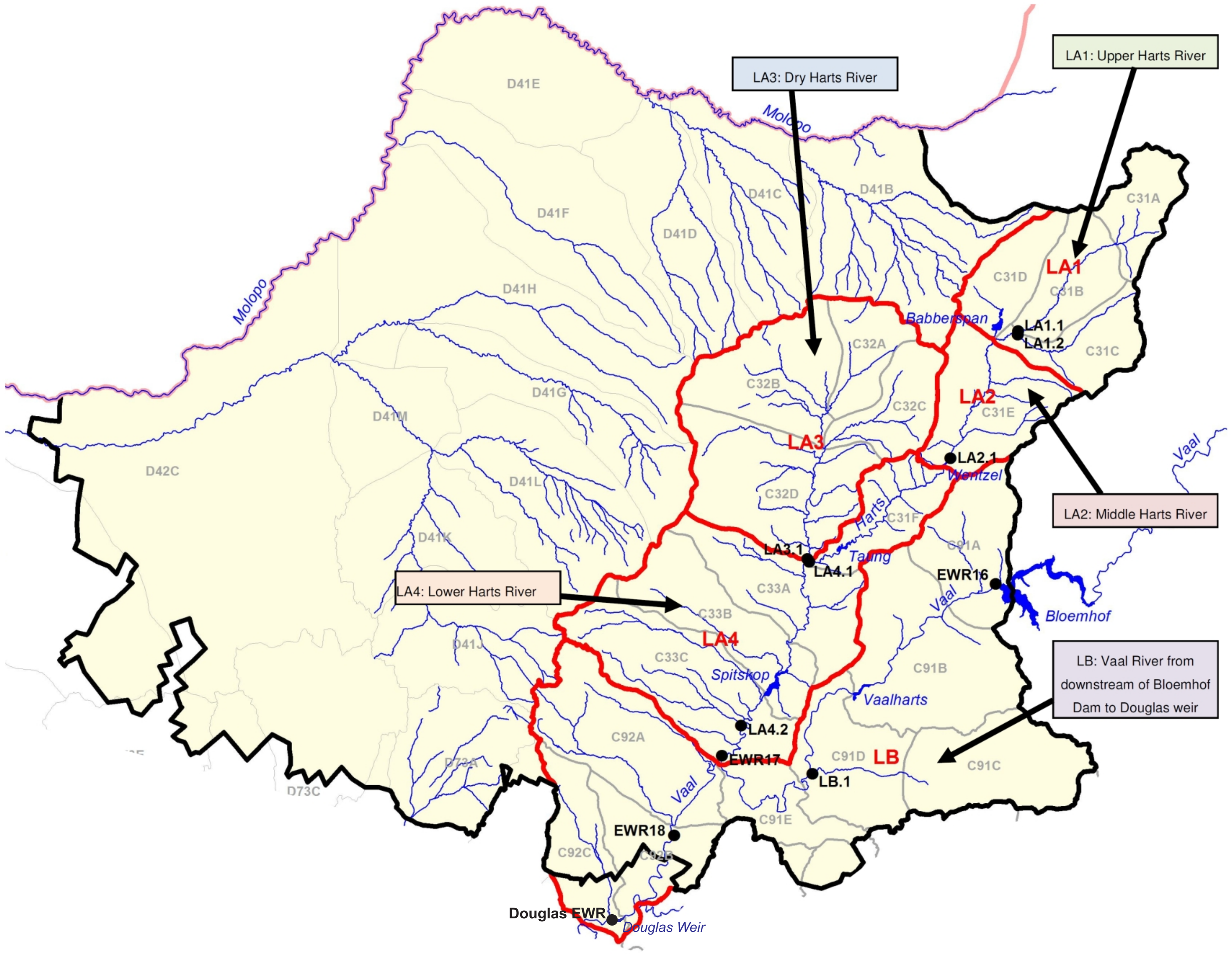
S-1

Node name	PES	REC	EIS	EI	Gross catchment area (km^2)	MAR (mill m^3/a)	Irrigation		Other	Storage	
							Demand (mill m^3/a)	% MAR	Demand (mill m^3/a)	Volume (mill m^3)	% MAR
MA: Renoster River											
MA.1	C	C	moderate	moderate	613	18.46	2.23	12.05	0.00	4.94	26.76
MA.2	B/C	B/C	moderate	moderate	881	25.55	2.60	10.17	0.00	5.32	20.84
MA.3	C	C	moderate	moderate	81	2.11	0.00	0.00	0.00	0.33	15.83
MA.4	C	C	low	low	2413	63.86	4.31	6.76	0.45	39.87	62.43
MA.5	C/D	C/D	low	low	422	7.86	0.75	9.53	0.00	2.92	37.20
MA.6	C	C	low	low	4092	93.14	7.90	8.48	1.11	56.49	60.65
MA.7	C	C	low	moderate	1152	17.94	0.91	5.04	5.28	13.67	76.20
MA.8	C	C	low	low	5868	120.92	9.67	7.99	8.78	82.78	68.46
MB: Vals River											
MB.1	C	C	low	low	860	31.24	0.65	2.08	0.00	2.92	9.36
MB.2	C	C	low	moderate	349	8.2	1.24	15.06	0.00	1.54	18.83
MB.3	C	C	low	low	4898	131.7	10.27	7.79	12.57	37.54	28.50
EWR14	C/D	C/D	moderate	moderate	5930	145.79	Simulated as part of larger Vaal system				
MC1: Schoonspruit											
MC.1	C/D	C/D	Note 1	Note 1	1350	60.6	0.00	0.00	0.00	0.00	0.00
MC.2	C	C	low	moderate	2020	19.5	0.11	0.58	0.00	3.99	20.45
MC.3	C/D	C/D	Note 1	Note 1	2694	105.52	0.00	0.00	0.00	0.00	0.00
MC.4	C/D	C/D	Note 1	Note 1	3503	117.31	0.00	0.00	0.00	0.00	0.00
MC.5	D/E	D	low	low	839	26.19	0.23	0.88	0.00	3.63	13.86
MC.6	D	D	low	low	499	5.24	0.00	0.00	0.00	2.70	51.45
MD1: Upper Sand River											
MD1.1	C	C	low	low	2215	66.4	0.85	1.28	0.00	9.50	14.31
MD2: Lower Sand River											
MD2.1	C	C	moderate	low	3974	104.16	4.02	3.86	0.75	72.44	69.54
MD2.2	C	C	moderate	low	734	19.26	0.78	4.07	0.00	2.33	12.08
MD2.3	C	C	moderate	low	7555	180.27	5.34	2.96	3.95	47.81	26.52
ME1: Upper Vet River											
ME1.1	C	C	low	moderate	2113	72.01	1.20	1.66	0.18	15.57	21.62
ME1.2	C	C	low	low	2083	81.86	1.53	1.87	1.95	17.50	21.38
ME1.3	B/C	B/C	low	moderate	159	3.87	0.00	0.00	0.00	0.86	22.22
ME2: Lower Vet River											
ME2.1	C	C	low	moderate	5551	190.94	3.33	1.74	3.95	44.09	23.09
EWR15	C/D	C/D	moderate	moderate	16040	413.55	Simulated as part of larger Vaal system				
MF: Vaal river from Renoster confluence to Bloemhof Dam											
MF.1	C	C	low	moderate	864	4.75	0.00				
EWR12	D	D	moderate	moderate	62305	2546.42	Simulated as part of larger Vaal system				
EWR13	C/D	C/D	moderate	moderate	70809	2714.89	Simulated as part of larger Vaal system				

Note 1: Not determined as part of the comprehensive EWR study



Node name	PES	REC	EIS	EI	Gross catchment area (km^2)	MAR (mill m^3/a)	Irrigation Demand (mill m^3/a)	Irrigation % MAR	Other Demand (mill m^3/a)	Storage Volume (mill m^3)	Storage % MAR
LA1: Upper Harts River											
LA1.1	C	C	low	low	3145	17.06	0.05	0.30	0.00	2.99	17.52
LA1.2	C	C	low	moderate	1554	12.18	1.16	9.54	0.00	1.55	12.76
LA2: Lower Harts River											
LA2.1	C	C	low	moderate	9109	45.33	0.00	0.00	1.02	NA	NA
LA3: Dry Harts River											
LA3.1	D	D	low	low	10205	48.70	0.87	1.78	0.37	1.38	2.83
LA4: Lower Harts River											
LA4.2	A/B	A/B	moderate	high	1167	3.29	0.00	0.00	0.00	NA	NA
EWR17	D	D	moderate	moderate	31029	147.85	Simulated as part of larger Vaal system				
LB: Vaal river from downstream of Bloemhof Dam to Douglas weir											
LB.1	A/B	A/B	moderate	high	4743	11.62	0.32	2.78	0.00	NA	NA
EWR16	D	D	moderate	moderate	108474	3303.10	Simulated as part of larger Vaal system				
EWR18	C	C	moderate	moderate	157685	3407.79	Simulated as part of larger Vaal system				
Douglas EWR	C/D	C	high	high	194479	3759	Simulated as part of larger Vaal system				



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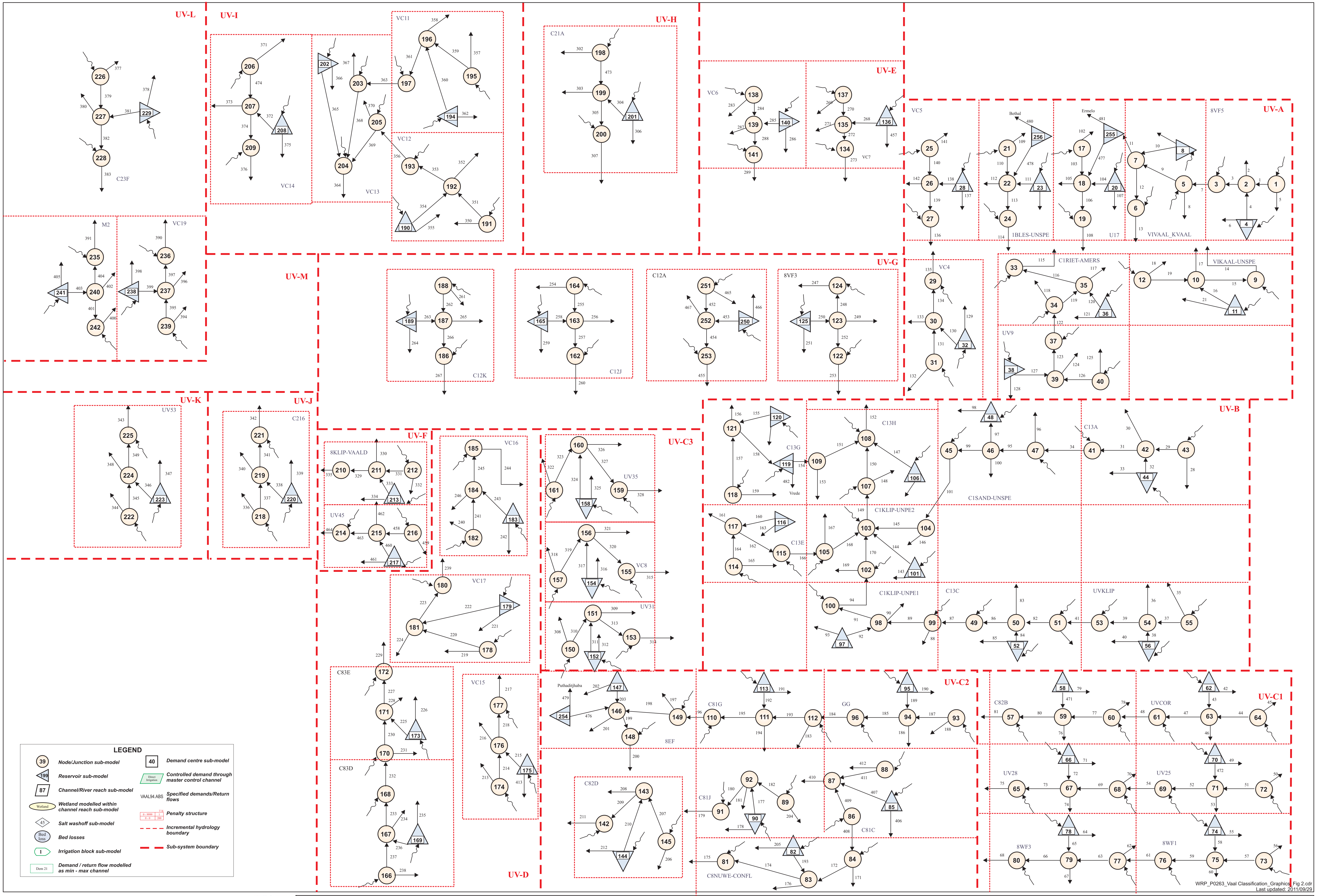
Lower Vaal Integrated Units of Analysis (IUA)

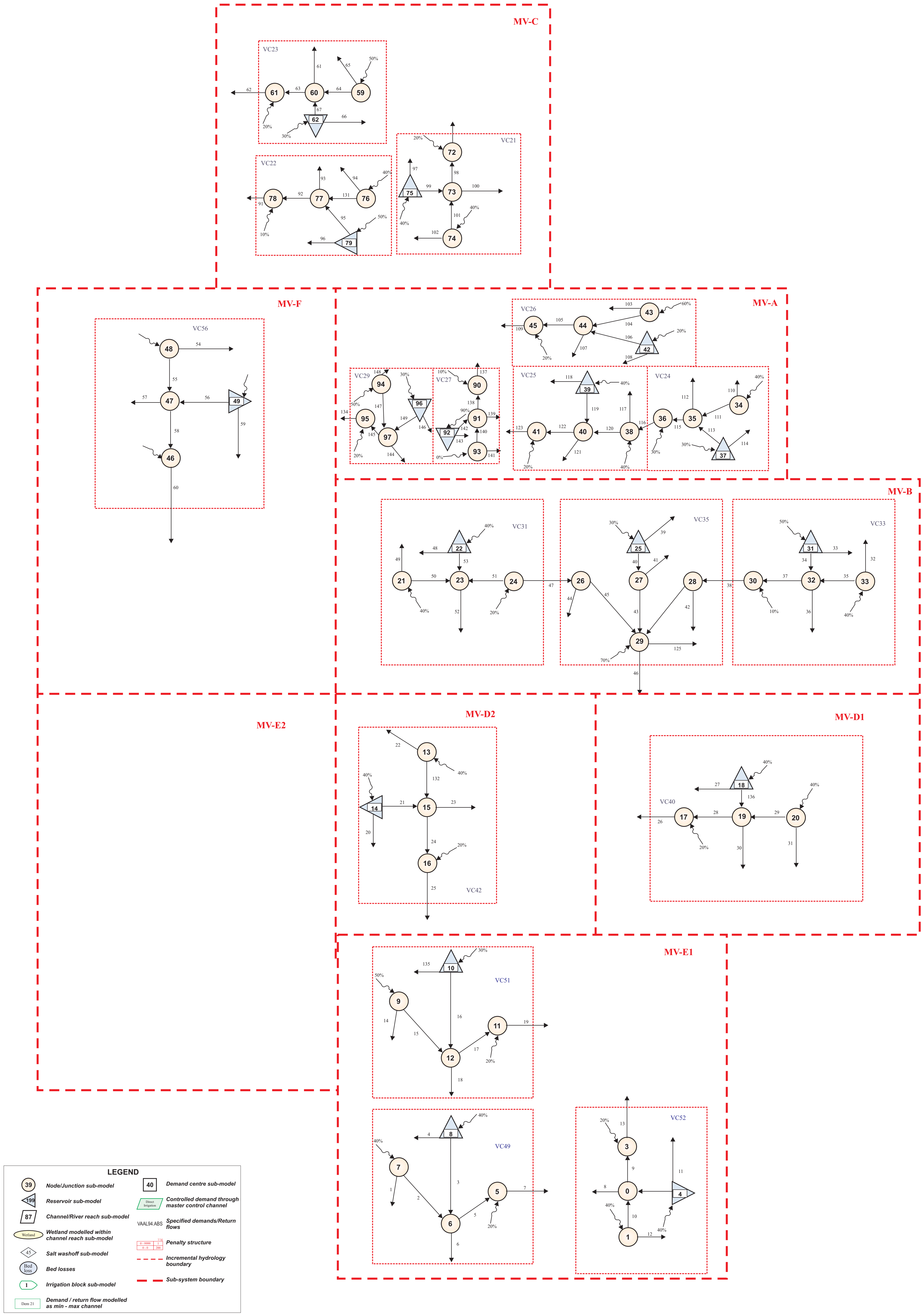


WRP_P0263_Vaal Classification_Graphics Fig 2.cdr
Last updated: 2011/09/29

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRYM Schematic Diagram:
Upper Vaal Sub-system

S-4



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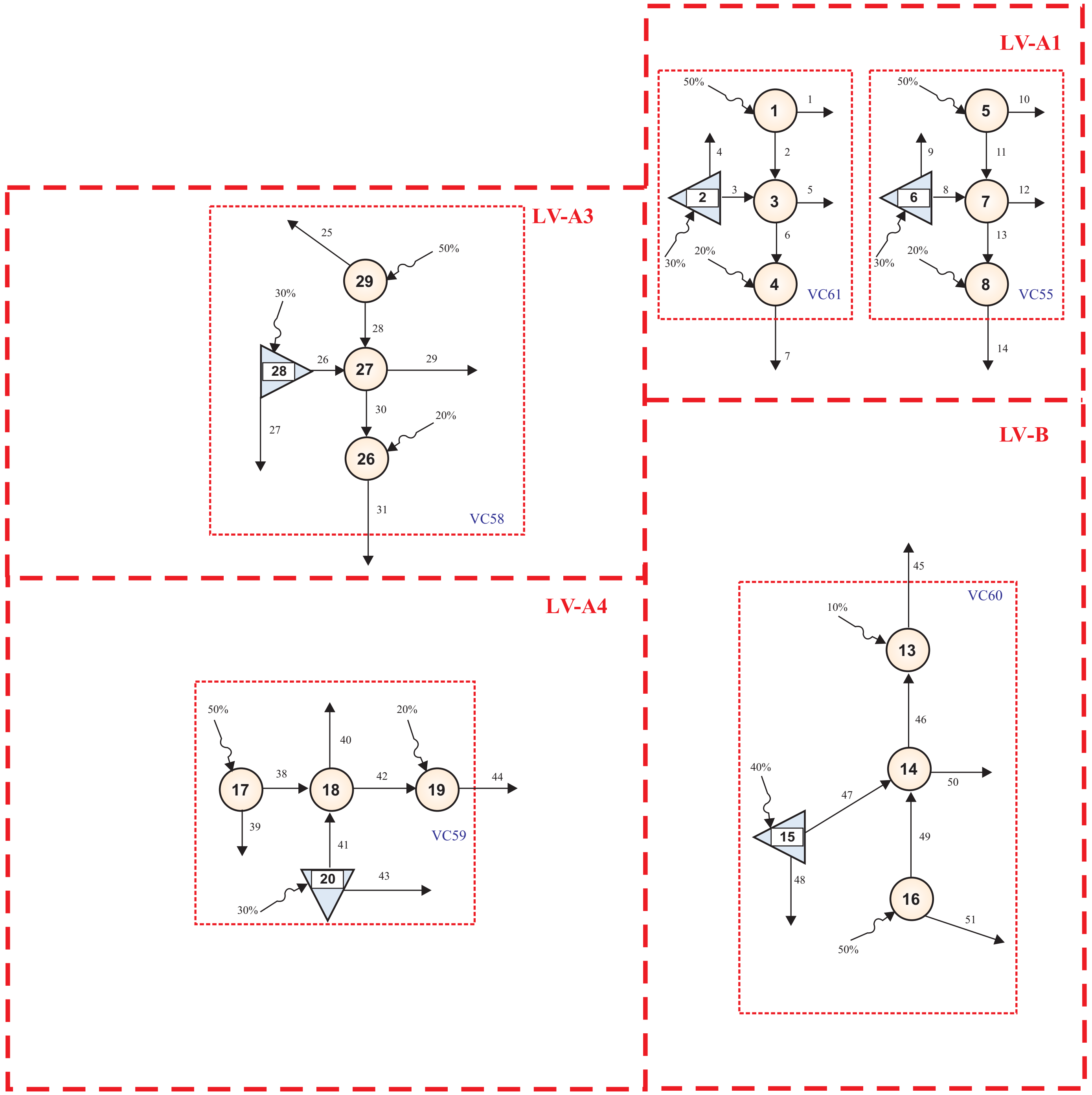
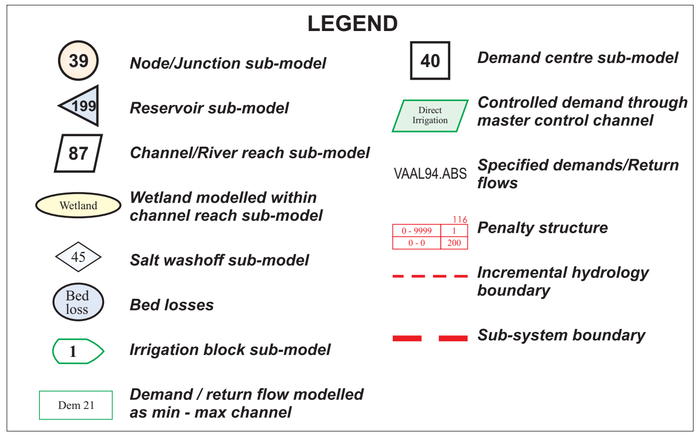
CLASSIFICATION OF SIGNIFICANT WATER RESOURCES (RIVER, WETLANDS GROUNDWATER AND LAKES) IN THE UPPER, MIDDLE AND LOWER VAAL WATER MANAGEMENT AREAS (WMA) 8,9,10

WRYM Schematic Diagram: Middle Vaal Sub-system

S-5





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Last updated: 2011/09/29

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WRYM Schematic Diagram:
Lower Vaal Sub-system

S-6

Table S-1: Summarised results for desktop nodes

WMA	IUA	Node Name	Upstream Nodes	EWR Supply Assessment Comments (2009 Irrigation)	EWR Supply Assesment Comments (ELU Irrigation)	Change in EWR Supply from 2009 to ELU	MAR (mcm/a)	EI	PES	REC	Irrigation (2009) (mcm/a)	Irrigation (ELU) (mcm/a)	Δ	Farm Dam Storage (mcm)	Storage as % of MAR
Upper Vaal	UA	UA.1		EWR is met	EWR is met	→	13.27	HIGH	B/C	B	0.00	0.00	→	1.23	○ 9.3%
		UA.3		EWR is met	EWR is met	→	12.03	LOW	C	C	0.00	0.22	↑	0.26	○ 2.2%
		UA.4	UA.3	EWR is met	EWR is met	→	41.73	MODERATE	C	C	0.87	0.48	↓	0.67	○ 1.6%
		UA.6	UA.1	EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR is met	↑	66.07	LOW	C/D	C/D	3.16	2.68	↓	14.02	◔ 21.2%
		UA.7		EWR is met	EWR is met	→	70.66	LOW	C/D	C/D	0.38	0.31	↓	2.09	○ 3.0%
		UA.8		EWR is met	EWR is met	→	18.62	MODERATE	B/C	B/C	0.42	0.39	↓	0.92	○ 5.0%
		UA.9		EWR is met	EWR is met	→	18.07	MODERATE	C	C	0.13	0.13	→	0.35	○ 1.9%
	UB	UB.1		EWR is met	EWR is met	→	5.67	HIGH	B	B	0.00	0.00	→	0.00	○ 0.0%
		UB.2	UB.1	EWR not met	EWR is met	↑	54.00	HIGH	B/C	B	2.05	0.64	↓	1.46	○ 2.7%
		UB.3	UB.1,UB.2	EWR not met	EWR not met	→	68.04	HIGH	B/C	B	2.05	0.64	↓	1.89	○ 2.8%
		UB.4		EWR is met	EWR is met	→	51.37	MODERATE	C	C	1.14	1.03	↓	0.46	○ 0.9%
		UB.5		EWR is met	EWR is met	→	78.84	MODERATE	C	C	1.14	1.03	↓	0.48	○ 0.6%
		UB.6		EWR not met	EWR not met	→	33.60	HIGH	B/C	B	0.95	0.38	↓	0.73	○ 2.2%
		UB.7	UB.1,UB.2,UB.3,UB.6	EWR is met	EWR is met	→	248.05	MODERATE	C/D	C/D	7.52	3.26	↓	5.03	○ 2.0%
		UB.8		EWR distribution reasonable, sporadic failures.	EWR distribution r	→	20.80	MODERATE	C	C	0.69	0.69	→	3.79	◔ 18.2%
		UB.9	UB.1,UB.2,UB.3,UB.6,UB.8	EWR largely met	EWR largely met	→	19.22	MODERATE	C/D	C/D	7.52	3.26	↓	5.23	◔ 27.2%
	UC1	UC1.1		EWR is met	EWR is met	→	69.03	HIGH	B	B	0.32	0.39	↑	0.44	○ 0.6%
		UC1.2	UC1.1	EWR is met	EWR is met	→	81.11	LOW	C	C	0.73	0.86	↑	1.89	○ 2.3%
		UC1.3		EWR distribution reasonable, failures Sep.	EWR is met	↑	26.49	HIGH	B	B	0.95	0.00	↓	0.24	○ 0.9%
		UC1.4	UC1.3	EWR is met	EWR is met	→	104.03	MODERATE	C	C	3.16	1.08	↓	3.31	○ 3.2%
		UC1.5		EWR distribution reasonable, failures Sep and Oct.	EWR not met	↓	7.82	MODERATE	C	C	0.15	0.78	↑	0.71	○ 9.0%
		UC1.6	UC1.5	EWR is met	EWR not met	↓	39.63	LOW	C	C	2.73	4.21	↑	3.03	○ 7.7%
	UC2	UC2.1	UC2.3,UC2.2	EWR is met	EWR is met	→	114.76	MODERATE	C/D	C/D	0.26	1.83	↑	34.00	◔ 29.6%
		UC2.2	UC2.3	EWR is met	EWR is met	→	22.13	MODERATE	C	C	0.26	0.31	↑	0.02	○ 0.1%
		UC2.3		EWR is met	EWR is met	→	5.85	HIGH	B	B	0.00	0.00	→	0.00	○ 0.0%
		UC2.4		EWR is met	EWR not met	↓	12.00	LOW	C	C	0.12	0.19	↑	0.31	○ 2.6%
		UC2.5		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR is met	↑	18.41	MODERATE	B/C	B/C	0.83	0.02	↓	1.15	○ 6.3%
		UC2.6	UC2.5	EWR distribution reasonable, sporadic failures.	EWR is met	↑	39.87	LOW	C	C	0.97	0.02	↓	3.90	○ 9.8%
		UC2.7		EWR Distribution reasonable, deficites for %tiles .lt. 50% just in September.	EWR is met	↑	19.60	MODERATE	C	C	4.23	2.45	↓	3.21	◔ 16.4%
	UC3	UC3.1		EWR distribution reasonable.	EWR is met	↑	32.90	MODERATE	C	C	3.94	1.01	↓	0.74	○ 2.3%
		UC3.2		EWR is met	EWR is met	→	6.34	MODERATE	B/C	B/C	0.00	0.00	→	0.01	○ 0.2%
		UC3.3		EWR is met	EWR is met	→	11.08	MODERATE	C	C	0.00	0.00	→	0.08	○ 0.8%
	UD	UD.1		EWR is met	EWR is met	→	14.36	LOW	C	C	0.14	0.01	↓	0.31	○ 2.1%
		UD.2		EWR is met	EWR not met	↓	12.42	MODERATE	C	C	0.11	0.82	↑	0.56	○ 4.5%
		UD.3	UD.2	EWR distribution reasonable, sporadic failures.	EWR not met	↓	23.31	MODERATE	C	C	3.15	3.62	↑	5.37	◔ 23.0%
		UD.4		EWR is met	EWR is met	→	4.74	HIGH	B/C	B	0.08	0.08	→	0.03	○ 0.6%
		UD.5		EWR is met	EWR is met	→	2.66	HIGH	B/C	B	0.00	0.00	→	0.01	○ 0.3%
	UE	UE.3		EWR is met	EWR is met	→	2.12	MODERATE	C	C	0.00	0.00	→	0.00	○ 0.0%
	UF	UF.2		EWR is met	EWR is met	→	35.59	MODERATE	C	C	0.20	0.42	↑	0.76	○ 2.1%
		UF.1		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR is met	↑	25.70	MODERATE	C	C	1.84	1.26	↓	0.98	○ 3.8%
	UG	UG.1		EWR distribution reasonable.	EWR is met	↑	3.36	LOW	C	C	1.45	0.64	↓	1.02	◔ 30.2%
		UG.2		EWR is met	EWR is met	→	21.00	MODERATE	C	C	0.00	0.00	→	0.13	○ 0.6%
		UG.3		EWR is met	EWR is met	→	22.00	LOW	C	C	0.31	0.20	↓	0.35	○ 1.6%
		UG.4		EWR is met	EWR not met	↓	12.43	MODERATE	C	C	0.16	0.28	↑	0.21	○ 1.7%
	UH	UH.1		EWR is met	EWR is met	→	28.65	HIGH	B/C	B	0.22	0.11	↓	0.86	○ 3.0%
	UJ	UJ.1		EWR is met	EWR is met	→	18.40	LOW	D	D	0.26	0.05	↓	0.19	○ 1.0%
	UK	UK.1		EWR distribution reasonable.	EWR is met	→	14.30	LOW	C	C	0.59	0.17	↓	0.29	○ 2.0%
	UL	UL.1		EWR is met	EWR is met	→	37.69	LOW	C/D	C/D	0.50	0.48	↓	0.44	○ 1.2%
Middle Vaal	MA	MA.1		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR is met	↑	18.46	MODERATE	C	C	2.23	0.25	↓	4.94	◔ 26.8%
		MA.2	MA.1	EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR is met	↑	25.55	MODERATE	B/C	B/C	2.60	0.80	↓	5.32	◔ 20.8%
		MA.3		EWR is met	EWR is met	→	2.11	MODERATE	C	C	0.00	0.00	→	0.33	◔ 15.8%
		MA.5		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR distribution r	→	7.86	LOW	C/D	C/D	0.75	0.13	↓	2.92	◑ 37.2%
		MA.7		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR Distribution	→	17.94	MODERATE	C	C	0.91	0.27	↓	13.67	● 76.2%
	MB	MB.1		EWR is met	EWR is met	→	31.24	LOW	C	C	0.65	0.80	↑	2.92	○ 9.4%
		MB.2		EWR Distribution reasonable, deficites for %tiles .lt. 50%	EWR Distribution	→	8.20	MODERATE	C	C	1.24	1.05	↓	1.54	◔ 18.8%
		MB.3	MB.2,MB.1	EWR distribution reasonable.	EWR distribution r	→	131.70	LOW	C	C	10.27	8.80	↓	37.54	◔ 28.5%
	MC	MC.2		EWR is met	EWR is met	→	19.50	MODERATE	C	C	0.11	0.11	→	3.99	◔ 20.4%
		MC.5		EWR is met	EWR distribution r	↓	26.19	LOW	D/E	D	0.23	0.28	↑	3.63	○ 13.9%
		MC.6		EWR is met	EWR is met	→	5.24	LOW	D	D	0.00	0.00	→	2.70	◕ 51.5%
	MD1	MD1.1		EWR is met	EWR not met	↓	66.40	LOW	C	C	0.85	1.32	↑	9.50	○ 14.3%
	MD2	MD2.2		EWR is met	EWR is met	→	19.26	LOW	C	C	0.78	0.87	↑	2.33	○ 12.1%
	ME1	ME1.1		EWR distribution reasonable.	EWR not met	↓	72.01	MODERATE	C	C	1.20	1.41	↑	15.57	◔ 21.6%
		ME1.2		EWR is met	EWR is met	→	81.86	LOW	C	C	1.53	1.16	↓	17.50	◔ 21.4%
		ME1.3		EWR is met	EWR is met	→	3.87	MODERATE	B/C	B/C	0.00	0.00	→	0.86	◔ 22.2%
	MF	MF.1		EWR is met	EWR is met	→	4.75	MODERATE	C	C	0.00	0.00	→	2.28	◕ 48.1%
Lower Vaal	LA1	LA1.1		EWR is met	EWR is met	→	17.06	LOW	C	C	0.00	0.00	→	2.99	◔ 17.5%
		LA1.2		EWR is met	EWR is met	→	12.18	MODERATE	C	C	0.00	0.00	→	1.55	○ 12.8%
	LA3	LA3.1		EWR is met	EWR is met	→	48.70	LOW	D	D	0.87	0.87	→	1.38	○ 2.8%
										TOTALS:	79.86	54.47			

EWR not met

EWR supply is unacceptable due to EWR determination and modeling issue.

Appendix T:

Members of Project Steering Committee

Last Name	First Name	Company
Aaron	Nontsikelelo	Lejweleputswa District Municipality
Abrahams	Abe	Department of Water Affairs (DWA)
Ah Shene Verdoorn	Carolyn	Birdlife South Africa
Armour	Jack	Free State Agriculture
Atwaru	Yakeen	Department of Water Affairs (DWA)
Augoustinos	Mario	Vaaldam Catchment Executive Committee
Bakane-Tuoane	Manana Anne	Emfuleni Local Municipality
Barnard	Hendrik	Ga-Segonyana Local Municipality
Basson	Noeline	Sedibeng Water
Batchelor	Garth	Department of Economic Development Environment and Tourism
Bezuidenhout	P J	Overberg District Council
Bierman	Bertus	Joint Water Forum and Anglo American Platinum
Blair	Vernon	Department of Water Affairs (DWA)
Boden	Denis	National Petroleum Refiners of S A (Pty) Ltd (NATREF)
Bosch	Gert	Sishen Iron Ore Mine
Bosman	Lourie	Agri Mpumalanga (Plaas Uitgezogt)
Botha	Hannes	Mpumalanga Tourism and Parks Agency
Bothes	Elizabeth	Department of Tourism, Environment and Conservation
Brink	Fanie	Grain South Africa
Broderick	Maylene	Economic Development, Environment and Tourism
Burger	Alwyn	City of Tshwane Metropolitan Municipality
Chamda	Yunus	Sedibeng District Municipality
Chauke	Lucia	Eskom
Chauke	Sydney	Emfuleni Municipality
Chewe	Victor	City of Tshwane Metropolitan Municipality
Claassens	Johan	TCTA
Cloete	Riekie	Conningworth Economists
Cogho	Vik	Optimum Coal Holdings
Collins	Nacelle	Free State Department of Tourism, Environmental and Economi
Cornelius	Steven	Gauteng Department of Agriculture and Rural Development
Critchley	John	Rand Water
Cronje	Barry	Rural Foundation
de Fontaine	Marc	Rand Water Rietspruit Blesbokspruit Forum
de Jager	Steyn	Greater Taung Municipality
de Klerk	Albert	Midvaal Local Municipality
De Kock	Abe	Farm: Mooidraai
de Villiers	D W	Koppieskraal Irrigation Board
Dhluwayo	Boy	Sol Plaatjie Municipality (Kimberley)
Dini	John	South African National Biodiversity Institute
Diniza	Maria	Gamagara Local Municipality
Dippenaar	Gideon	Sedibeng Water
Dippenaar	Gideon	Sedibeng Water
Dlabantu	Mpumelelo	Working for Water
Dlamini	Mavela	City of Johannesburg Metropolitan Municipality
Dlamini	Thami	Msukwaligwa Local Municipality
Donaldson	R	Manganese Mines
Driver	Mandy	SANBI
du Plessis	Rickus	Department of Agriculture and RuraL Development
du Toit	Hanke	Department of Water Affairs (DWA)
Du Toit	Tienie	Renoster River Water Users Association
Eilard	J	Dikgatlong Local Municipality
Eilerd	Johannes	Dikgatlong Local Municipality
Els	Nic	City Council of Klerksdorp
Erasmus	Coenie	Department of Tourism, Environment and Economic Affairs
Erasmus	Frik	Durban Roodepoort Deep Limited
Florence	Achmat	Frances Baard District Municipality
Fourie	A J	Griqualand Exploration & Finance Co Ltd
Fourie	Wynand	Department of Environmental Affairs (DEA)
Gabriel	Mary-Jean	Department of Agriculture, Forestry and Fisheries (DAFF)
Galane	Malesela	Environmental Justice Networking Forum (EJNF)

Last Name	First Name	Company
Gamede	Andries	Gert Sibande District Municipality
Gaobusiwe	Benjamin	Kgalagadi District Municipality
Gincane	Ruben	Mamusa Local Municipality
Ginster	Martin	Sasol
Gondo	Joe	National African Farmers Union (NAFU)
Gopane	Ruth	Dikgatlong Local Municipality
Gosani	Ntsikelelo	TCTA
Greeff	Henry	Kgalagadi District Municipality
Greyling	Jan	Matjhabeng Local Municipality
Greyling	S P J	Schoonspruit Irrigation Scheme
Grobler	Willem	Department of Water Affairs (DWA)
Gungubele	Mondli	Ekurhuleni Metropolitan Municipality
Hadebe	Slindokuhle	Ekurhuleni Metropolitan Municipality
Hall	Peter	Sasol Infrachem (Leeu Spruit, Taaibosch Spruit Forum)
Hanekom	Dirk	Eskom
Harrison	Pienaar	Department of Water Affairs (DWA)
Hauman	Louis	Kuruman Agricultural Union
Hendriksz	Johan	East Rand Water Company (ERWAT)
Itholeng	Kebalepile	Gauteng Department of Agriculture and Rural Development
Itumeleng	Clement	Gamagara Local Municipality
Izaaks	Saul	Siyanda Water and Sanitation District
Jacobs	Gideon	Distrik Boere Unie
Jooste	Sebastian	Department of Water Affairs (DWA)
Joubert	Andre	Zitholele Consulting (Pty) Ltd
Kadiaka	Mamogala	Department of Water Affairs (DWA)
Keet	Marius	Department of Water Affairs (DWA)
Kekesi	Albert	Bophirima District Municipality
Khan	Rafat	Midvaal Water Company
Kleynhans	Neels	Department of Water Affairs (DWA)
Kokobela	Mosimanegape	House of Traditional Leaders
Komape	Martha	Department of Water Affairs (DWA)
Kruger	Marina	Midvaal Water Company
Leeto	Nokwanje	Lejweleputswa District Municipality
Leeuw	David	Sol Plaatjie Local Municipality
Lekoko	Simon	Directorate of Traditional and Corporate Affairs
Lethoko	Itumeleng	Ditsobotla Local Municipality
Letlhogile	Tshiamo	Ditsobotla Local Municipality
Letsoalo	Mokopane	Waterberg District Municipality
Leuschner	Andries	Gold Fields South Africa Ltd
Liefferink	Mariette	Federation for a Sustainable Environment (FSE)
Liphadzi	Stanley	Water Research Commission
Lobelo	Govan	Dr Ruth Segomotisi Mompati District Municipality
Lodewijks	Henk	Anglo Coal Environmental Services
Louw	Delana	Rivers for Africa
Louw	Lonnox	Tosca Dolomite Water User Association
Mabalane	Itumeleng	Chamber of Mines
Maboe	Paul	Sasolburg Transitional Local Council
Mabuda	Solly	Department of Water Affairs (DWA)
Mafejane	Ariel	Johannesburg Water
Magodi	Omphemetse	Kgalagadi District Municipality
Mahonde	Kay	Birdlife South frica
Mahusi	Christopher	Molopo Local Municipality
Makape	G G	Tsantsabane Municipality
Makena	Gladys	Magareng Local Municipality
Makgalemane	Itumeleng	Greater Taung District Municipality
Makodi	Rebecca	Leekwa Teemane Local Municipality
Makuapane	Andrew	Leekwa Teemane Local Municipality
Malaka	Tebogo	Department of Water Affairs (DWA)
Malebye	Patrick	Dipaliseng / Balfour Local Municipality
Manamela	Sadimo	Department of Water Affairs (DWA)
Manele	Sorrious	Sedibeng District Municipality
Mapholi	Masindi	Maquassi Hills Local Municipality
Maposa		Delportshoop TLC

Last Name	First Name	Company
Marx	Karin	Wildlife and Environment Society of South Africa (WESSA)
Maseng	Benardo	Kgatelopele Local Municipality
Masondo	Amos	City of Johannesburg Metropolitan Municipality
Maswuma	Zacharia	Department of Water Affairs (DWA)
Matseba	Mogale	Department of Water Affairs (DWA)
Mazwi	Nosie	Department of Water Affairs (DWA)
McCourt	Liz	Department of Environmental Affairs (DEA)
Meintjes	Louis	Transvaal Agricultural Union South Africa (TAUSA)
Mere	Shedrick	Magareng Local Municipality
Midgley	Ian	Eskom
Mlambo-Izquierdo-	Poppy	Kgatelopele Local Municipality
Mmarete	Charles	Department of Water Affairs (DWA)
Mmoiemang	Kenneth	Kgalagadi District Municipality
Mngomezulu	Willy	Pixley Ka Seme Local Municipality
Mnisi	Jones	Johannesburg Water (Pty) Ltd
Mochware	Ontlametse	Kagisano Local Municipality
Modisakeng	Busisiwe	Lesedi Local Municipality
Mofokeng	Mahole	Sedibeng District Municipality
Mofokeng	Mpho	Greater Taung District Municipality
Mofokeng	Puleng	Department of Agriculture, Forestry and Fisheries
Mogotlhe	Paul	North West Department of Agriculture, Conservation, Environment and Tourism
Mohapi	Ndileka	Department of Water Affairs (DWA)
Mokadi	Andrew	Vaal University of Technology
Mokgosi	Mantebo	Moqhaka Local Municipality
Mokgosi	Mantebu	Moqhaka Local Municipality
Molema	Kemonna	Tribal Authority
Molema	Shelley	Bophirima District Council
Mompati	Rose	Naledi Local Municipality
Mongake	Monty	Fezile Dabi District Municipality
Mongolola	Gift	Ga-Segonyane Municipality
Moraka	William	South African Local Government Association (SALGA)
Mosai	Sipho	Rand Water
Mothibi	Dimakatso	Department of Agriculture and Land Reform
Motlhale	Kelehile	Tswelopele Local Municipality
Motoko	Phihadu	Ratlou Local Municipality
Mshudulu	S A	Emfuleni Local Municipality
Mthimunye	George	Naledi Local Municipality
Mtsuku	Samuel	Department of Tourism, Environment and Economic Affairs
Mudau	Stephinah	Chamber of Mines South Africa
Mulangaphuma	Lawrence	Department of Water Affairs (DWA)
Muller	Anton	Bloemhofdam Kom
Mutyorauta	J J	Department of Agriculture
Mutyorauta	Julius	Department of Tourism, Environment and Conservation (DTEC)
Mvula	Obed	Department of Land Affairs
Mwaka	Beason	Department of Water Affairs (DWA)
Mweli	Zandisile	Maquassi Hills Local Municipality
Nagel	Marius	Government Communication and Information Systems (GCIS)
Naidoo	Shane	Department of Water Affairs (DWA)
Nakana	Lesego	Greater Taung Local Municipality
Namusi	Sedirilwe	Molopo Local Municipality
Nast	Timothy	Midvaal Local Municipality
Naude	Piet	Free State Agricultural Water Committee
Nengovhela	Rufus	Department of Water Affairs (DWA)
Ngamole	G	Masilonyana Municipality
Ngangelizwe	Sebenzile	Matjhabeng Local Municipality
Ngcobo	Mbuleleni	Gert Sibande District Municipality
Ngcobo	Sonwabo	Tswaing Local Municipality
Ngema	Khaya	Ekurhuleni Metropolitan Municipality
Ngila	Zelna	Siyanda District Municipality
Ngomane	Lulu	Gauteng Water Sector Forum
Ngxanga	Eric	Siyanda District Municipality
Nkonyane	Martha	
Nkwane	Oupa	City of Tshwane Metropolitan Municipality

Last Name	First Name	Company
Nosi	Thabo	Frances Baard District Municipality
Ntili	Tseliso	Department of Water Affairs (DWA)
Ntsepe	Sello	Mantsopa Local Municipality
Ntsizi	Thembile	Wes Vaal Chamber of Commerce
Ntwe	Francisco	Ratlou Local Municipality
Nyamande	Tovhowani	Department of Water Affairs (DWA)
Oagile	Mothus	Kagisano Local Municipality
Oosthuizen	Christo	Louwna/Coetzerdam Water User Association
Opperman	Dirk	Land Affairs
Opperman	Nic	Agri SA
Peek	Bobby	GroundWork - Friends of the Earth South Africa
Petersen	Thabo	Matjhabeng Local Municipality
Phukuntsi	Rosy	Tswelopele Local Municipality
Pienaar	Harrison	Department of Water Affairs (DWA)
Pienaar	P G	Vyf Hoek South Management Board
Pillay	Nava	Metsweding District Municipality
Potgieter	Ampie	Sasol Mining Rights Department (SMRD)
Potgieter	Jan	Department of Agriculture, Forestry and Fisheries
Potgieter	Sandra	Dow Plastics
Pretorius	Theuns	Kaalfontein Boerevereniging Distriks Landbou Unie
Pyke	Peter	Department of Water Affairs (DWA)
Radebe	Khulu	Male Development Agency
Rademeyer	Seef	Department of Water Affairs (DWA)
Ramaema	Lowrence	Department of Tourism, Enviroment and Economic Affairs
Ramokgopa	Kgosientsho	City of Tshwane Metropolitan Municipality
Ramokhoase	Jonas	Fezile Dabi District Municipality
Rampai	Constance	Mantsopa Local Municipality
Rampine	M K	South African National Civic Organisation (SANCO) Boikhotsong
Reinecke	C J	Potchefstroom Univ for CHE
Reitz	J J C	Kalahari East Water User Association
Rossouw	Lourens	Tokologo Local Municipality
Rust	Nelia	Matjhabeng Local Municipality
Sales	Malcolm	Lebalelo Water User Association
Samson	Paballo	Moshaweng Local Municipality
Sebusho	Sipho	Kgalagadi District Municipality
Seikaneng	Tefo	Moshaweng Local Municipality
Shabalala	Sam	Emfuleni Local Municipality
Shone	Steve	Grain SA
Sindane	Jabulani	Lekwa Local Municipality
Slabbert	Nadene	Department of Water Affairs
Smit	Hennie	Department of Water Affairs (DWA)
Snyders	Louis	Department of Water Affairs (DWA)
Stoch	Leslie	Geotech (Lower Wonderfonteinspruit Forum)
Stoltz	Gert	Molopo Farmers Union
Surendra	Anesh	Eskom
Sutton	Malcolm	Anglogold
Swart	Susan	WRP Consulting Engineers (Pty) Ltd
Takalo	Mmabatho	City of Tshwane Metropolitan Municipality
Terrè-Blanche	Riana	Namaqualand Water and Sanitation Support Group (NAWASAN)
Thakurdin	Manisha	Department of Water Affairs (DWA)
Theron	Danie	Christiana Farmers Association
Theron	J H	Vaalharts Water Users Association
Theron	Piet	Munisipaliteit van Delportshoop
Thirion	Christa	Department of Water Affairs
Thompson	Isa	Department of Water Affairs (DWA)
Tlhape	Manketse	Tswaing Local Municipality
Tshipelo	Kenneth	Mamusa Local Municipality
Tsotetsi	Mabalone	Dipaliseng Local Municipality
Ubisi	Makumu	Sedibeng Water
van Aswegen	Johann	Department of Water Affairs (DWA)
van den Berg	J W	Saamstaan Agricultural Union
van den Berg	Ockie	Department of Water Affairs (DWA)

Last Name	First Name	Company
van den Bon	Patrick	Vadex Consulting cc
van der Heever	Piet	Lesedi Local Municipality
van der Merwe	Ben	Emfuleni Local Municipality
van der Merwe	Danie	Ekurhuleni Metropolitan Municipality
van der Merwe	Johan	Rand Water
van der Walt	Philip	City of Tshwane Metropolitan Municipality
van der Westhuizen	Walther	Department of Water Affairs (DWA)
van Rooyen	Johan	Department of Water Affairs (DWA)
van Rooyen	Pieter	WRP Consulting Engineers (Pty) Ltd
van Schalkwyk	V	South African Rivers Association
van Tonder	Dean	Sasol Mining
van Vuuren	Hennie	Regina Farmers Union
van Vuuren	J L	Frankfort TLC
van Wyk	Francois	Rand Water
van Wyk	Jurgo	Department of Water Affairs (DWA)
van Wyk	Niel	Department of Water Affairs (DWA)
van Zyl	Andre	Fezile Dabi District Municipality
Van Zyl	Chris	TAU SA Agricultural Union
van Zyl	J F C	Bloemhof TLC
Venter	Gerda	Department of Water Affairs (DWA)
Venter	Petrus	Department of Water Affairs (DWA)
Vilakazi	Bheki	Msukwaligwa Local Municipality
Viljoen	Peter	Vereeniging Refractories Ltd
Vorster	Albert	Kimberley Agricultural Union
Watson	Marie	Centre for Environmental Management
Wepener	Lotter	River Property Owners' Association - Save the Vaal
Williams	Bruce	Klerksdorp Irrigation Board
Woodhouse	Philip	Goldfields (West Driefontein Gold Mine)
Yawitch	Joanne	Department of Environmental Affairs (DEA)

Appendix U:

Comments and Responses

COMMENTS RECEIVED	ADDRESSED IN REPORT?	COMMENT
Comments from Ms T Nyamande (received on 8 May 2012)		
1. A table indicating the names and description of the IUAs must be included.	Yes	Refer to Table 7.1 on Page 40 of report.
2. Consideration of Freshwater Conservation targets in the establishment of the ESBC and the RDM Configuration Scenarios (Step 4C). NFEPAs determined for the Vaal WMA should have been considered.	Yes (see comments)	Due cognisance was taken of the NFEPAs. The process of how NFEPAS was considered is stipulated in the status quo report. Each NFEPA was identified and a preliminary node placed in the relevant area. They were then evaluated to determine their consistency with specialist knowledge and data available to the study team.