COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

OPERATIONAL SCENARIOS AND ECOLOGICAL CONSEQUENCES

TECHNICAL COMPONENT: MIDDLE VAAL

REPORT NO.: RDM/WMA9 C000/01/CON/0310

PROJECT NO.: 8829/1

water & forestry

Department:
Water Affairs & Forestry
REPUBLIC OF SOUTH AFRICA

Department of Water Affairs
Private Bag X313
PRETORIA, 0001
Republic of South Africa

Tel: (012) 336 7500/ +27 12 336 7500
Fax: (012) 336 / +27 12 336

This report should be cited as:

Department of Water Affairs (DWA), 2010. Resource Directed Measures: Comprehensive Reserve determination study for the integrated Vaal River System, Middle and Lower Vaal Water Management Areas Socio Economic consequences of operational scenarios. Report no: RDM/ WMA09/10C000/01/CON/0310. Pretoria, South Africa.

Report produced and authored by:

Golder Associates Africa (Pty) Ltd

Golder Associates Africa (Pty) Ltd
Reg. No. 2002/007104/07

PO Box 6002 Halfway House 1685
South Africa
Thandanani Park, Matuka Close
Halfway Gardens, Midrand
Tel + (27) (0)11 254-4901
Fax + (27) (0)11 805-2100

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report.

REPORT INDEX	REPORT NUMBER	REPORT TITLE
1.1	RDM/ WMA09C000/01/CON/0107	Middle Vaal Comprehensive Reserve determination: Surface Water Inception report
1.2	RDM/ WMA09C000/01/CON/ 0207	Middle Vaal Comprehensive Reserve determination: Surface Water Desktop EcoClassification report
1.3	RDM/ WMA09C000/ 01/CON/ 0108	Middle Vaal Comprehensive Reserve determination: Surface Water Basic Human Needs Reserve report
1.4	RDM/ WMA09C000/ 01/CON/ 0109	Middle Vaal Comprehensive Reserve determination: Surface Water Resource Units report
1.5	RDM/ WMA09/10C000/ 01/CON/ 0209	Middle and Lower Vaal Comprehensive Reserve determination: Surface Water Wetland/Pans Assessment report
1.6	RDM/ WMA09C000/ 01/CON/ 0110	Middle Vaal Comprehensive Reserve determination: Surface Water EcoClassification report
1.7	RDM/ WMA09C000/ 01/CON/ 0210	Middle Vaal Comprehensive Reserve determination: Surface Water Ecological Water Requirements report
1.8	RDM/ WMA09C000/ 01/CON/ 0310	Middle Vaal Comprehensive Reserve determination: Surface Water Operational scenarios and ecological consequences report
1.9	RDM/ WMA09/10C000/ 01/CON/ 0310	Middle and Lower Vaal Comprehensive Reserve determination: Surface Water Socio Economic consequences of operational scenarios report
1.10	RDM/ WMA09C000/ 01/CON/ 0510	Middle Vaal Comprehensive Reserve determination: Surface Water Ecospecs and monitoring report
1.11	RDM/ WMA09C000/ 01/CON/ 0610	Middle Vaal Comprehensive Reserve determination: Surface Water Main integration report
1.12	RDM/ WMA09C000/01/CON/ 0710	Middle Vaal Comprehensive Reserve determination: Surface Water Electronic information

APPROVAL

TITLE:	Resource Directed Measures: Comprehensive Reserve determination study for the Integrated Vaal River System, Middle and Lower Water Management Areas Socio Economic consequences of operational scenarios.
DATE:	July 2010
AUTHORS:	J du Toit and R Heath
REVIEWERS:	R Stassen
LEAD CONSULTANT:	Golder Consultants
FORMAT:	MSWord and PDF
WEB ADDRESS:	www.dwaf.gov.za

Approved for Golder Associates Africa (Pty) Ltd:

Dr Ralph Heath
Study Leader and Manager

Approved for the Department of Water Affairs by:

Ms R Stassen
Project Manager (PSP Project Management Team)

Ms B Weston
Project Manager: Resource Directed Measures.

ACKNOWLEDGEMENTS

The following individuals are thanked for their contributions to the document:

Project Management Committee

Barbara Weston	Department of Water Affairs	Project Manager
Daniel Masemola	Department of Water Affairs	Assistant Project Manager
Retha Stassen	Blue Science Consulting	PSP Management team Leader and Manager
Owen Wilson	Arcus Gibb Consulting	Assistant PSP Project Manager
Ralph Heath	Golder Associates Africa	PSP Technical Study Leader and Manager

Study Team

Ralph Heath	Golder Associates Africa	Technical Project Leader and Manager
Trevor Coleman	Golder Associates Africa	Water Quality Specialist
Danie Otto	Golder Associates Africa	Pans/Wetlands Specialist
Anton Linstom	Golder Associates Africa	Pans/Wetlands Specialist
Angelina Jordanova	Golder Associates Africa	Hydraulics engineer
Peter Kimburg	Golder Associates Africa	Fish
Alvar Koning	Golder Associates Africa	Macroinvertebrate
Adrian Hudson	Golder Associates Africa	Riparian vegetation
Anelle Odendaal	Zitholele Consulting	Stakeholder awareness
Jennifer Molwantwa	Zitholele Consulting	Water Quality trainee
Rene Ford	Zitholele Consulting	Socio-economic
Justin du Toit	Golder Associates Africa	Trainee socio-economist
Ken Haumann	PD Naidoo and Associates	Spatsim and hydrology
Mark Rountree	Private Consultant	Geomorphologist
Lindo Hlongwane	Fluvial Environmental Consultants	Trainee geomorphologist
Mushoni Makatu	PD Naidoo and Associates	Spatsim and hydrology

Members of Project Steering Committee

Harrison Pienaar	Chief Directorate: Resource Directed Measures
Barbara Weston	Chief Directorate: Resource Directed Measures
Nancy Motebe	Chief Directorate: Resource Directed Measures
Wendy Ralekoa	Chief Directorate: Resource Directed Measures
Bonani Madekezela	Directorate: Resource Quality Services
Mamogale Kadiaka	Directorate: Water Abstraction and In-stream Use (Environment & Recreation)
Seef Rademeyer	Directorate: National Water Resources Planning
Niel van Wyk	Directorate: National Water Resources Planning
Jurgo van Wyk	Directorate: Water Resource Planning Systems
Peter Pyke	Directorate: Option Analysis
Churchill Mkwalo	Directorate: Stream flow Reduction
Marius Keet	Gauteng Regional Office
Delia Mare	Gauteng Regional Office
Walther van der Westhuizen	Gauteng Regional Office
Riana Munnik	Directorate: Resource Protection and Waste
Dawie Koekemoer	Gauteng Regional Office

Hanke Du Toit	Northern Cape Regional Office
Willem Grobler	Free State Regional Office
Retha Stassen	ARCUS GIBB/ Blue Science Consulting Project Management team

EXECUTIVE SUMMARY

Water, being a scarce resource, has numerous competing uses but with the legal requirement for Ecological Water Requirements (EWR) or Ecological Reserve (ER) firmly in place in South African law, water use is viewed by many as being in direct competition for ecological requirements. As the Vaal River system is heavily populated, and supports and sustains other economic activities, altering the allocation of water to meet the requirements for the ER may have significant socio-economic impacts. These impacts are derived from changes to both water quantity and quality by applying the EWR and may affect water users directly (in terms of their future allocation of water) but may also have indirect as well as induced effects that extend further into the regional and local economies.

The socio-economic consequences presented in this report forms an important component of the Comprehensive Ecological Reserve Determination for the Middle and Lower Vaal Water Management Areas (WMAs). The Upper Vaal is subject to another study but in order to make sure that the results are comparable the same method was used for these studies. The purpose of this component of the comprehensive Ecological Reserve Study is to assess and attempt to quantify these socio-economic impacts with a view to understanding the Socio-Economic impacts of several plausible water allocation scenarios and to assess which of the scenarios is more desirable in socio-economic terms.

Based on a similar approach used for the socio-economic impact assessment for the Upper Vaal WMA, the Middle and Lower Vaal WMAs were partitioned into defined economic zones. Several EWR sites were identified along the Vaal River in the Upper, Middle and Lower Vaal WMAs within these economic zones in order to measure present day water use and to make predictions on future water use. Eight EWR sites were identified within the Middle and Lower Vaal WMAs. Present day water use for various water users was estimated. From the relevant socio-economic data collected for irrigated agriculture, mining, manufacturing and population within each WMA, baseline economic indicators such as Gross Domestic Product (GDP), employment and household income were generated for each economic zone using Water Multipliers. These baseline results were then adapted to account for water use (demand) at each of the eight EWR sites.

The baseline results indicated that irrigated agriculture had a significant economic impact in the Lower Vaal WMA providing R 546 million directly to GDP and 8,245 employment opportunities. Irrigated agriculture in the Middle Vaal provided R 372 million directly to GDP and 5,319 employment opportunities. While providing similar employment opportunities within the mining sector, the other industries within the Middle Vaal WMA provided significantly more employment opportunities and contributed more to total GDP than other industries within the Lower Vaal WMA.

The selected operational scenario 8 was compared with present day water use to understand and quantify the socio-economic impacts of meeting the EWR. Significant deviations from present day demand for Scenario 8 were found for EWR R1 (Renoster), 14 (Vals), V1 and V2 (Vet). The Vals tributary was most negatively affected by applying the EWR with direct impacts resulting in a R 26 million loss in direct GDP and a loss of 572 direct job opportunities. It is recommended that, due to the highly negative socio-economic impacts found in the Renoster, Vals and Vet tributaries, further and more detailed investigations may need to be conducted to accurately assess the socio-economic costs and benefits of implementing the EWRs in these tributaries. Irrigated agriculture is a major economic activity in these tributaries and the Renoster, Vals and Vet tributaries account for approximately 21 000ha of agricultural production within the Middle Vaal WMA. Much of the annual crop yield is also made up of cereals such as maize and wheat which may negatively affect regional and potentially national food security. Possible further research into this could entail a financial and economic analysis of irrigated agriculture along these tributaries based on water allocation or costs scenarios. The aim of such an investigation is to assess the impacts of increasing water cost to irrigators and assessing at what levels costs affect profitability. Necessary trade-offs could also be identified by such a study.

The methodology used to assess the impacts on Ecosystems Goods and Services in this study was based on that used for the Thukela Water Project: Reserve Determination Module (Mander *et al*., 2001) and was consistent with the approach used for the Upper Vaal WMA. Of the eight water allocation scenarios identified only Scenarios 4, 5, 6, 7 and 8 were evaluated per EWR site. The approach investigated the impact of each scenario on fish, riparian vegetation, recreation and water quality per EWR site. No negative impacts were found by implementing the EWRs except for scenario 5 at EWR site 14 (Vals River). These negative impacts were driven by impacts on fish species such as the, Smallmouth yellowfish (*Labeobarbus aeneus*), Orange-Vaal mudfish (*Labeo capensis*) and Moggel, (*Labeo umbratus*) and result from reduced flow levels leading to a decrease or disappearance of species from this reach. Scenario 5 cannot, therefore, be recommended as acceptable from an Ecosystems Goods and Services perspective based on these negative impacts. Scenario 6 had the highest overall score for each resource in both the Middle and Lower Vaal WMAs and on this basis must be recommended as the most acceptable Scenario from an Ecosystems Goods and Services perspective.

TABLE OF CONTENTS

DOCUMENT INDEX I
APPROVAL..... II
ACKNOWLEDGEMENTS III
EXECUTIVE SUMMARY V
TABLE OF CONTENTS..... VII
LIST OF TABLES..... VIII
LIST OF FIGURES IX
ACRYNOMS X
GLOSSARY XI
1 INTRODUCTION..... 1
2 DESCRIPTION OF THE STUDY AREA..... 3
2.1 Background..... 3
2.2 Ecosystems services in the Middle and Lower Vaal WMAs..... 6
3 METHODOLOGY AND APPROACH 8
3.1 Description of water allocation scenarios 8
3.2 Approach to socio-economic impacts..... 10
3.2.1 Background 10
3.2.2 Brief description of the SAFRIM model 11
3.2.3 Description of the Water Impact Model 12
3.2.4 Economic zones 13
3.2.5 Water multipliers..... 13
3.3 Approach to ecosystem goods and services assessment..... 14
3.4 EWR sites..... 15
3.5 Economic profile of the Middle and Lower Vaal WMAs 18
3.5.1 Middle Vaal WMA 18
3.5.2 Lower Vaal WMA..... 20
4 DATA AND DATA SOURCES..... 23
4.1 Irrigated agriculture 24
4.1.1 Crop types, areas and water use on the main-stem of the Middle and Lower Vaal WMAs 25
4.1.2 Crop types, areas and water use for the major tributaries of the Middle Vaal WMA..... 25
4.1.3 Crop types, areas and water use for the major tributaries of the Lower Vaal WMA..... 26
4.1.4 Crop water use and irrigation requirements 26

4.2 Mining and manufacturing ... 27
4.3 Domestic water usage ... 27

5 RESULTS ... 27

5.1 Baseline results ... 28
5.1.1 Irrigated agriculture ... 28
Mining and other industries ... 28
5.2 Scenario results ... 29
5.2.1 Direct impacts on surplus value ... 29
5.2.2 Direct impacts on GDP ... 33
5.2.3 Direct impacts on employment ... 33
5.2.4 Discussion of impacts per EWR site ... 34
5.2.5 Lower Vaal WMA ... 35
5.3 Evaluation of Scenario 8 ... 35
5.4 Impact on ecosystem goods and services ... 37
5.4.1 EWR site 12 (Vermaasdrift) ... 38
5.4.2 EWR site 13 (Regina Bridge) ... 38
5.4.3 EWR site 14 (Proklameersdrift) ... 39
5.4.4 EWR site 15 (Fisantkraal) ... 39
5.4.5 EWR site 16 (Downstream Bloemhof Dam) ... 40
5.4.6 EWR site 17 (Lloyds weir on Harts River) ... 40
5.4.7 EWR site 18 (Schmidtsdrift) ... 40
5.4.8 EWR site 19 (Lilydale lodge) ... 41

6 CONCLUSIONS AND RECOMMENDATIONS ... 41

7 CAPACITY BUILDING ... 44

8 LITERATURE CITED ... 45

APPENDIX A ... 47

LIST OF TABLES

Table 1: Tertiary drainage regions per WMA ... 3
Table 2: Scenario descriptions ... 9
Table 3: Generic ecosystems goods and services in the Middle and Lower Vaal WMAs ... 15
Table 4: EWR Site information – ecosystem services ... 16
Table 5: Distribution of EWR sites within each economic zone ... 16
Table 6: Crops per Irrigation Zone (2000) ... 24
Table 7: Main-stem crop type and area in the Middle and Lower Vaal WMAs ... 25
Table 8: Crop type and area in the Middle Vaal WMA tributaries ... 25
Table 9: Crop type and area in the Lower Vaal WMA tributaries ... 26
Table 10: Crop irrigation requirements for Middle and Lower Vaal WMAs ... 26
Table 11: Summary of contributions to total surplus value, direct GDP and direct employment for selected tributaries ... 28
Table 12: Population distribution within the Middle and Lower WMAs (households) ... 30

Table 13: Average annual water use within the Middle and Lower WMAs (Million m^3) 30
Table 14: Baseline scenario results for the Middle Vaal Water Management Area – Irrigated Agriculture.. 31
Table 15: Baseline scenario results for the Lower Vaal Water Management Area – Irrigated agriculture 31
Table 16: Baseline scenario results for the Middle Vaal Water Management Area - Mining and other industries 32
Table 17: Baseline scenario results for the Lower Vaal Water Management Area - Mining and other industries 32
Table 18: Comparison of the impacts on GDP and employment of Scenario 8 for Middle WMA 36
Table 19: Summary of impacts on Ecosystems services, EWR sites 12 to 19......................... 37
Table 20: Impact of water allocation scenarios on Ecosystems Services at EWR site 12......... 38
Table 21: Impact of water allocation scenarios on Ecosystems Services at EWR site 13......... 38
Table 22: Impact of water allocation scenarios on Ecosystems Services at EWR site 14......... 39
Table 23: Impact of water allocation scenarios on Ecosystems Services at EWR site 15......... 39
Table 24: Impact of water allocation scenarios on Ecosystems Services at EWR site 16......... 40
Table 25: Impact of water allocation scenarios on Ecosystems Services at EWR site 17......... 40
Table 26: Impact of water allocation scenarios on Ecosystems Services at EWR site 18......... 41
Table 27: Impact of water allocation scenarios on Ecosystems Services at EWR site 19......... 41

LIST OF FIGURES

Figure 1: Integrated Vaal River System indicating the major interbasin transfers via arrows(DWAF, 2010) 5
Figure 2: The division of the estimated total average annual economic value for fishermen of Yellowfish on the Vaal River.. 7
Figure 3: Approach to the socio-economic assessment for the Middle and Lower Vaal WMAs 11
Figure 4: Ecological Water Requirements (EWR) sites for the Middle and Lower Vaal Water Management Areas.. 17
Figure 5: GGP contributions for important magisterial districts in the Middle Vaal Water Management Area (Source: Quantec, 2010).. 18
Figure 6: Tertiary Catchments and Major towns in the Middle Vaal Water Management Area.. 19
Figure 7: Major economic sectors in the Middle Vaal Water Management Area ((Source: Quantec, 2010) 20
Figure 8: GGP contributions for important magisterial districts in the Lower Vaal Water Management Area (Source: Quantec, 2010).. 21
Figure 9: Lower Vaal and Upper Orange Water Management Areas)...................................... 22
Figure 10: Major economic sectors in the Lower Vaal Water Management Area (DWAF, 2002) 23
Figure 11: Macroeconomic impacts of Scenario 8 on Surplus value.. 29
Figure 12: Macroeconomic impacts of Scenario 8 on direct GDP.. 33
Figure 13: Macroeconomic impacts of Scenario 8 on employment.. 33
Figure 14: Traffic diagram of overall socio-economic impacts of Scenarios 7 and 8 for Middle and Lower Vaal WMAs.. 43

Figure 15: Traffic diagram of overall Ecosystems Goods and Services impacts of Scenarios 4, 5, 6, 7 and 8 for the Middle and Lower Vaal WMAs.. 44

Appendix A: Comprehensive list of Ecosystems Services for the Middle and Lower Vaal WMAs

ACRYNOMS

CD: RDM	Chief Directorate: Resource Directed Measures
D: NWRP	Directorate: National Water Resource Planning
D: RQS	Directorate: Resource Quality Services
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GGP	Gross Geographic Product
IHI	Index of Habitat Integrity
NWA	National Water Act
PES	Present Ecological State
QHI	Quick Habitat Integrity
REC	Recommended Ecological Category
RU	Resource Unit
SCI	Socio Cultural Importance
ToR	Terms of Reference
WMA	Water Management Area

GLOSSARY

DROUGHT FLOW	The minimum flow required facilitating the survival of the riverine ecosystem in a particular condition and over short, infrequent periods, when users are subject to water restrictions. Drought flows in the Vaal River will be defined as low-flows that occur less than x % of the time under natural conditions for each month.
ECOLOGICAL CATEGORY	A category indicating the potential management target for a river. Values range from Category A (unmodified, natural) to Category D (largely modified). This term replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC). The reasons for these changes are explained in the proceedings of a workshop to clarify the terminology used in Reserve determinations (DWAF 2003). It should be noted that a distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
ECOSPECS	Clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that defines the Ecological Category. The purpose of ecospecs is to establish clear goals relating to resource quality (Kleynhans 2003).
ECOSTATUS	An overall assessment of the Ecological Category (A-F), based on rule-based integration of specialist indices (water quality, fish, etc). Ecostatus refers to the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services" (Iversen *et al.* 2000, *In* IWR Environmental 2003).
ECOLOGICAL WATER	

REQUIREMENTS (EWR) — 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.

INSTREAM FLOW

REQUIREMENTS (IFR) — The flow patterns (magnitude, timing and duration) needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to the quantity component only of Ecological Water Requirements.

MAINTENANCE FLOW — The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition during "normal" climatic years. The distinction between "normal" and "drought" was based on an examination of monthly flow duration curves

PRESENT ECOLOGICAL STATE (PES) — The degree to which ecological conditions of an area have been modified from natural (reference) conditions. The measure is based on water quality variables, biotic indicators and habitat information collected 1 to 3 years prior to the assessment. Results are classified on a 6-poin scale, from Category A (*Largely Natural*) to Category F (*Critically Modified*).

REFERENCE CONDITION — Natural ecological conditions, prior to human development.

RESERVE — The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems under the National Water Act, 1998 (Act No. 36 of 1998) in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve refers to the modified

	Ecological Water Requirement, where operational limitations, and stakeholder consultation are taken into account.
RESOURCE QUALITY OBJECTIVE	Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection. This term takes into account the management *classes* and the requirements of other users. These components are not addressed in this project
RESOURCE UNIT	Stretches of river that are sufficiently ecologically distinct to warrant their own specification of Ecological Water Requirements, and that can be practically managed as a single unit.

1 INTRODUCTION

The Vaal River has been described as "Africa's hardest working river" and is one of South Africa's most developed and regulated river systems supporting a significant amount of economic activity in the Gauteng, Free State and North West Provinces. Originating on the plateau west of the Drakensberg escarpment, the Vaal River is the main tributary of the Orange River and drains a large proportion of the central Highveld. Extending over four countries, the Orange/Vaal River basin covers an area of approximately 964 000km^2. Five of the total of 19 WMAs falls within the Orange/Vaal River basin. These are the Upper, Middle and Lower Vaal and Upper and Lower Orange WMAs (Figure 1).

The Upper Vaal WMA has a significant water requirement due to the size of its population (Johannesburg and surrounds), manufacturing and industry and the Witwatersrand Gold mining activities. Major water users in the Middle and Lower Vaal WMAs include the following:

- Irrigated agriculture;
- Mining and manufacturing; and
- Domestic and/or household consumption.

In addition to the abovementioned water users, the recreational angling industry also makes a significant contribution to the local and regional economies of the Middle and Lower Vaal WMAs. According to a study by Brand *et al.* (2009), the Yellowfish angling industry[1] in the Vaal River has an estimated total annual average economic use value of R133 million. This total economic use value is derived from expenditure on equipment, travel and accommodation spent by recreational fisherman who target Yellowfish. Other important ecosystems services such as thatching, grazing, recreation, waste assimilation and waste dilution are also provided by the river systems in the Middle and Lower Vaal.

DWAF (1999:1) note that the demand for water from the Vaal River exceeds the exploitable potential of the river and that inter-basin transfers have been developed out of necessity to meet the demands of a sophisticated and growing economy. Transfers from the Komati, uThukela and uSuthu into the Orange/Vaal River Basin are examples of such schemes. Ramoejane *et al.* (2009) note that, in general, the construction and operation of these inter-basin transfer schemes have only considered economic factors and have not fully considered social and ecological factors. DWAF (1999) stress that given the growing demand and unit costs for water, it is necessary to ensure that water is used wisely, efficiently and equitably. Under water legislation that is regarded globally as being enabling and progressive. Van Wyk *et al.* (2006) note that an equitable, efficient and sustainable allocation and use of river resources in South Africa is possible. Water, being a scarce resource, has numerous competing uses but with the legal requirement for Ecological Water Requirements (EWR) or Ecological Reserve firmly in place in South African law, human requirements are viewed by many as being in direct competition for ecological requirements.

---

[1] The Yellowfish angling industry consists of costs spent on equipment, travel, accommodation, memberships and other activities related to recreational Yellowfish angling (Brand *et al.,* 2009).

The purpose of an Ecological Reserve is to preserve the integrity and proper functioning of river ecosystems and is defined by van Wyk *et al.* (2006) as, "an allocation of water specified as a volume and quality underpinned by flow and duration requirements to sustain the specified river ecosystem". Van Wyk *et al.* (2006) note further that due to the Ecological Reserve being an allocation of water, more consideration is often given to water as the resource rather than the river being the resource. This also creates a perception that water could potentially be utilised more equitably, efficiently and sustainably towards other uses.

As the Vaal River system is heavily populated, and supports and sustains other economic activities, altering the allocation of water to meet the requirements for the Ecological Reserve may have significant socio-economic impacts. These impacts are derived from changes to both water quantity and quality by applying the EWR and may affect water users directly (in terms of their future allocation of water) but may also have indirect as well as induced effects that extend further into the regional and local economies. In particular, irrigated agriculture in the Lower Vaal WMA may be affected by reduced flows and increasing salinity from these lower flows. The socio-economic and ecosystems services consequences presented in this report form an important component of the Comprehensive Ecological Reserve Determination for the Middle and Lower Vaal Water Management Areas (WMAs). The purpose of this component of the comprehensive Ecological Reserve Study is to assess and attempt to quantify these socio-economic and ecosystem services impacts with a view to understanding the Socio-Economic impacts of several plausible water allocation scenarios and to assess which of the scenarios is more desirable to society.

Based on a similar approach used for the socio-economic consequences for the Upper Vaal WMA (as undertaken by Connningarth), the Middle and Lower Vaal WMAs were partitioned into defined economic zones. Several EWR sites were identified along the Vaal River in the Upper, Middle and Lower Vaal WMAs within these economic zones in order to measure present day water use and to make predictions on future water use. These EWR sites were evaluated and identified according to criteria which included hydraulics, land use, regulation and accessibility. Eight EWR sites were identified within the Middle and Lower Vaal WMAs and present day water use for various water users estimated. From the relevant socio-economic data collected for irrigated agriculture, mining and manufacturing and population within each WMA, baseline economic indicators such as Gross Domestic Product (GDP), employment and household income were generated for each economic zone using Water Multipliers. These baseline results were then adapted to account for water use (demand) at each of the eight EWR sites.

To assess the socio-economic consequences of either providing or not providing the Ecological Reserve, eight plausible water allocation scenarios were identified. Although all eight scenarios were analysed as part of the overall study, Scenario 8 (which included the EWR) was assessed relative to Scenario 7 specifically for the socio-economic component of the study. The remaining scenarios were used to assess the impact of alternative options for the inclusion of the EWRs.

For the ecosystems services assessment, 5 water allocation scenarios were assessed according to impacts on the following river resources:

- Fish;
- Riparian vegetation;

- Recreation; and
- Water quality.

Each resource was scored per scenario according to whether utilization of the resource remained at current/present day levels or either increased or declined at each EWR site.

The report is structured as follows:

- Section 2 presents a brief background to socio-economic consequences assessment and explains what is meant by direct, indirect and induced effects.
- A description of the study area and an economic profile for the Middle and Lower Vaal WMAs is presented in Section 3.
- The methodology followed for the socio-economic component of the study is presented in Section 4. This section also presents a brief description of the water allocation scenarios used for the study.
- The relevant data and data sources used for the purposes of this study are presented in Section 5 and the results of the study are presented in Section 6. The report ends with some conclusions and recommendations.

2 DESCRIPTION OF THE STUDY AREA

2.1 Background

The Vaal River System is part of the larger Integrated Vaal River System (as shown in Figure 1) and is divided into three Water Management Areas (WMA); the Upper, Middle and Lower WMAs. The Vaal River system is further partitioned into secondary, tertiary and quaternary catchments. The distribution and division of tertiary catchments per WMA is shown in Table 1.

Table 1: Tertiary drainage regions per WMA

WMA	Tertiary Catchment
Upper Vaal	C11 – C13 C81 – C83
Middle Vaal	C21 – C25 C41 – C43 C60 C70
Lower Vaal	C31 – C33 C51 – C52 C91 – C92

Source: DWAF (1999)

It has been noted that noticeable climatic variations occur along the Vaal river system. Mean annual precipitation (MAP) declines from approximately 500mm in the Middle Vaal to 100mm in the Lower Vaal WMA. The potential annual evaporation, however, increases from approximately 1300mm in the Middle Vaal to 2800mm in the Lower Vaal (DWAF, 2010). These prevailing climatic conditions have influenced the land use patterns as well as economic activities within each WMA.

The Upper Vaal WMA is the most populous and industrialised WMA in the Orange/Vaal River basin, is pivotal to the country (DWAF, 2002) and is characterised by sprawling urban and industrial areas in its northern and western portions. Water quality for the remainder of the Vaal River is strongly influenced by usage and management practices in this WMA. Also, due to its high demand for water, the Upper Vaal WMA derives much of its water through transfers from other sub-systems such as the uSuthu, uThukela and Senqu (Lesotho). Although not as prominent as the Upper Vaal WMA in terms of population and major economic activities, the Middle and Lower Vaal WMAs still play an important role in the context of the Orange/Vaal River basin.

The Middle Vaal WMA is located downstream of the confluence of the Vaal and the Rietspruit Rivers and upstream of Bloemhof Dam. It extends to the Schoonspruit River in the north and the Vet River in the south, and covers a total catchment area of 52 563 km^2. The Middle Vaal WMA incorporates portions of the Free State and North-West Provinces and is, therefore, important to the regional economies of these provinces. Major rivers in the Middle Vaal Water Management Area include the Schoonspruit, Rhenoster, Vals, Vet and Vaal rivers.

Settlement patterns within the Middle Vaal WMA are dispersed and extensive dryland agricultural practices take place throughout this WMA. Major towns and urban areas in the Middle Vaal WMA include Klerksdorp, Kroonstad, Welkom and Virginia.

Primary sector activities such as mining and agriculture accounted for approximately 55% of the areas total GDP in 1997 (DWAF, 2002). Of this total, mining activities accounted for approximately 46%. Major mines in the area include Anglogold’s Great Noligwa, Kopanang, Tau Lekoa and Moab Khotsong mines and Harmony’s Tshepong and Virginia mines. According to Van Vuuren (2008), few of the gold mines within the Middle Vaal WMA have a secure future beyond 2010, although the resource base could potentially support mining up to 2030. Mine dewatering and the discharge into the river systems have a negative impact on water quality within this WMA.

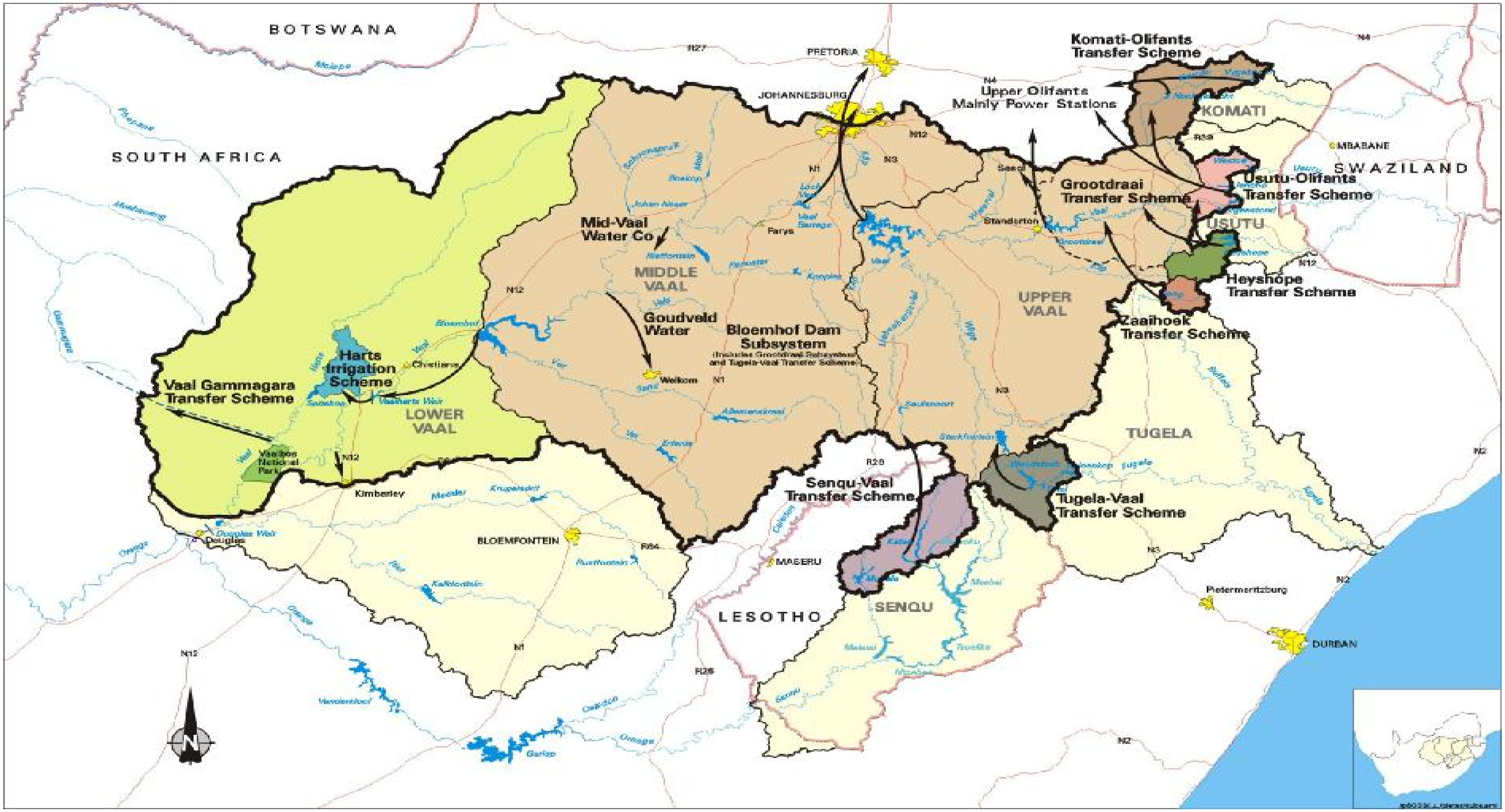

Figure 1: Integrated Vaal River System indicating the major interbasin transfers via arrows(DWAF, 2010)

The Lower Vaal WMA is located downstream of Bloemhof Dam and upstream of Douglas Weir. It extends to the headwaters of the Harts, Molopo and Kuruman River in the north and the Vaal River Downstream of Bloemhof in the south. It covers a catchment area of 51,543 km^2 and lies in the North West and Northern Cape Provinces, with the south-eastern corner in the Free State, and borders on Botswana in the north, as well as on the Crocodile (West) and Marico, Middle Vaal, Upper Orange and Lower Orange water management areas.

Primary agriculture is the major economic activity in the Lower Vaal WMA. Water is supplied from the Vaal River main stem via the Vaal-Harts Weir to the Taung and Vaalharts Irrigation schemes under which 6 000ha and 32 000ha of irrigated land are cultivated, respectively. Commonly produced crops include a mix of high and low value crops such as maize, wheat, lucerne, table grapes, citrus and peaches. DWAF (2002) note that approximately 80% of the water released from the Upper Vaal WMA is used for irrigation purposes and that only irrigation return flows and flood flows reach the confluence with the Orange River. In terms of provincial context, the Middle and Lower Vaal WMAs also have an important role to play in the provincial economies. The Middle Vaal WMA extends from the Gauteng, North West and Free State Provinces whereas the Lower Vaal WMA extends over the North West and Northern Cape Provinces.

2.2 Ecosystems services in the Middle and Lower Vaal WMAs

The Vaal River System, because of its extent, plays an important role in maintaining important Ecosystems goods and services to both on-site as well as other users. According to Boyd and Banzhaf (2006:8), "ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being". An ecosystem service is a product that emerges from processes or features within largely natural environments, which enhances human wellbeing and is directly used by people. Natural capital and associated ecosystem services are now becoming scarce and the Millennium Ecosystems Assessment (MEA) partitions ecosystems services into four broad categories:

- Provisioning services are the most familiar category of benefit, often referred to as ecosystem 'goods', such as foods, fuels, fibres, biochemicals, medicine, and genetic material, that are in many cases: directly consumed; subject to reasonably well-defined property rights (even in the case of genetic or biochemical material where patent rights protect novel products drawn from ecosystems); and are priced in the market.

- Cultural services are the less familiar services such as religious, spiritual, inspirational and aesthetic well-being derived from ecosystems, recreation, and traditional and scientific knowledge that are: mainly passive or non-use values of ecological resources (non-consumptive uses); that have poorly-developed markets (with the exception of ecotourism); and poorly-defined property rights (most cultural services are regulated by traditional customs, rights and obligations); but are still used directly by people and are therefore open to valuation.

- Regulating services are services, such as water purification, air quality regulation, climate regulation, disease regulation, or natural hazard regulation, that affect the impact of shocks and stresses to socio-ecological systems and are: public goods (globally in the case of disease or climate regulation) meaning that they "offer non-exclusive and non-rival benefits to particular communities" (Perrings 2006); and are thus frequently undervalued in economic markets; many of these are indirectly used being intermediate in the provision of cultural or provisioning services.

- Supporting services are an additional set of ecosystem services referred to in the MEA, such as nutrient and water cycling, soil formation and primary production, that capture the basic ecosystem functions and processes that underpin all other services and thus: are embedded in those other services (indirectly used); and are not evaluated separately (Mander *et al*., 2007).

Recreational angling is an important ecosystem service supplied by the Vaal River System. Yellowfish (***Labeobarbus spp.)*** are one of South Africa's most important angling and sport fishing species (De Villiers, 2007a; 2007b) and are an indigenous South African fish species, widely distributed throughout the Orange-Vaal River system.

The two most common species of Yellowfish are the Orange-Vaal Small-mouth (***Labeobarbus aeneus***) and the Orange-Vaal Large-mouth (***Labeobarbus kimberleyensis***). According to Brand *et al.* (2009) Yellowfish are attractive, reach a large size, and are considered to be an excellent game fish. Their study on the economic and social use value of Yellowfish in the Vaal River found that Yellowfish were a targeted angling species for approximately 5,000 anglers. They estimated the total value of the Yellowfish dependent fishing industry in the Vaal River at R133 million per annum. This total value comprised the equipment sector (estimated expenditure of anglers on fishing and associated equipment) with R14.6 million, the travel sector (estimated expenditure of anglers on travel to and from fishing areas along the Vaal River) with R41.4 million, the accommodation sector (estimated expenditure of anglers on angling related accommodation) with R75.5 million. The division of the total average annual economic value for fisherman of Yellowfish is shown in Figure 2.

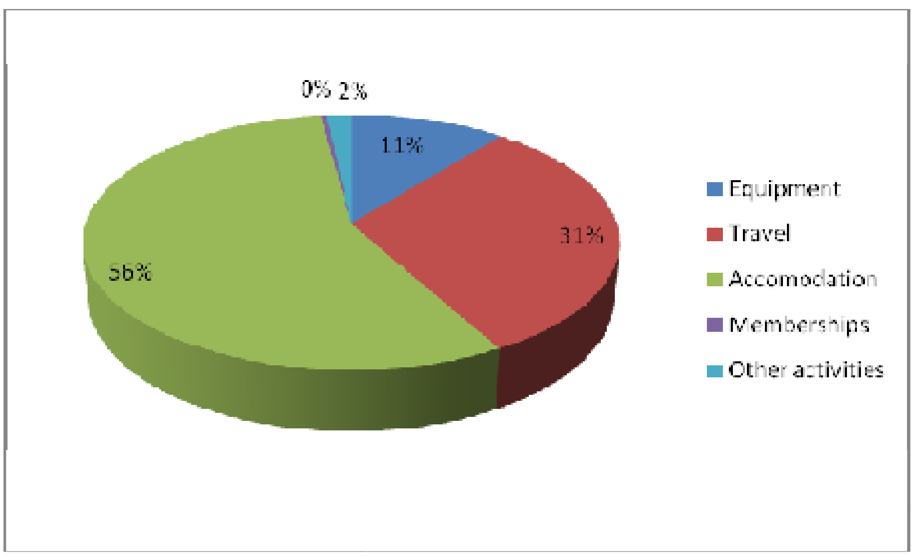

Figure 2: The division of the estimated total average annual economic value for fishermen of Yellowfish on the Vaal River

The results of the study on the total economic value of Yellowfish in the Vaal River by Brand *et al.* (2009) showed that much of the total expenditure by anglers are on accommodation, equipment and travel. Little of the total cost is spent on memberships and other activities. The study also suggested that a link between the social and economic benefits of Yellowfish conservation in terms of improved livelihoods and local economies from Yellowfish angling and related activities exists. The social benefits of Yellowfish identified as part of the study were (Brand *et al.*, 2009:27):

- Yellowfish as an indicator species;
- Yellowfish as a food source;
- Yellowfish promotes social cohesion in families;
- Yellowfish conservation can improve quality of life; and
- Yellowfish conservation promotes stewardship and community engagement.

3 METHODOLOGY AND APPROACH

As mentioned in the Introduction, water is a scarce resource and has numerous competing uses. South Africa has a legal requirement to meet Ecological Water Requirements (EWR) and as the Vaal River system is heavily populated, and supports and sustains other economic activities, altering the allocation of water to meet the requirements for the Ecological Reserve for this river could have significant socio-economic and ecosystem services impacts. In order to assess these impacts, due to either providing or not providing the Ecological Reserve, eight plausible water allocation scenarios were identified during the study. The methodology used for the socio-economic assessment was developed in conjunction with Conningarth Economists and is based on a similar approach used for the Upper Vaal WMA. This approach is based on the Water Impact Model (WIM) and SAFRIM model which uses water multipliers to quantify direct, indirect and induced economic impacts based on a change in water usage.

The methodology used to assess the impacts on Ecosystems Services is similar to the approach used in the Thukela Water Project: Reserve Determination Module (Mander *et al.*, 2007). These are described in greater detail in the following section.

3.1 Description of water allocation scenarios

A description of the 8 water allocation scenarios used for the purposes of this study is provided in Table 2. Although all eight scenarios were analyzed as part of the overall study, scenarios 7 (which excluded the EWRs) and 8 (which included the EWR) were assessed specifically for the socio-economic component of the study as the ecological water requirements were met for the other scenarios. The remaining scenarios were used to assess the impact of alternative options for the inclusion of the EWRs. For the ecosystems services assessment, impacts for scenarios 4, 5, 6, 7 and 8 were analyzed against the base Scenario (Scenario 1).

Table 2: Scenario descriptions

Scenario No.	WRPM Reference	Development Level	EWR Status	Comments
1	V8RES05	2008	Excluded	• Base scenario representing the status quo.
2	V8RES06	2008	Included	• Based on Scenario 1. • EWR Scenario: All EWRs included with JMRBS EWRs adopted for Usutu.
3	V8RES07	2008	Included	• Based on Scenario 1. • EWR Scenario: Including all EWRs in Vaal but with sub-system EWRs excluded.
4	V8RES08	2008	Included	• Based on Scenario 1. • EWR Scenario: With exception of EWR4 and EWR5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.
5	V8RES09	2020	Excluded	• Base scenario representing the future 2020 development conditions excluding the EWRs. • Includes VRESSAP 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.
6	V8RES10	2020	Included	• Based on Scenario 5. • EWR Scenario: With exception of EWR4 and EWR5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.
7	V8RES13	Full utilization (Future development scenario)	Excluded	• Scenario representing the full utilization of available water. • Based on current infrastructure. • Includes VRESSAP pipeline from Vaal Dam to Eastern Sub-system.

Scenario No.	WRPM Reference	Development Level	EWR Status	Comments
8	V8RES14	Full utilization (Future development scenario)	Included	• Based on Scenario 7. • EWR Scenario: With exception of EWR4 and EWR5, all EWRs in Vaal and one EWR in Thukela downstream of Driel Barrage were included.

Source: WRP (2010)

3.2 Approach to socio-economic impacts

3.2.1 Background

The evaluation of economic impacts takes into consideration the potential impacts of a particular development on the economic environment of a study area (which can be delineated according to impact intensity). More specifically, the way in which the direct benefits and costs of an intervention could affect the local, regional, or national economy can be assessed. The intervention can be in the form of new investment in infrastructure, new development, and adoption of a new policy or services or expansion of current operations. The types of economic impacts stimulated by an intervention are generally positive (in an economic sense) and include creation of additional jobs, generation of business sales and value-added, improved quality of life, an increase in disposable income, and growth of government revenue. For the purposes of this study, the economic intervention arises as a result of different water allocation scenarios, the economic impacts of which can be assessed per water allocation scenario. Three types of economic impacts are generally assessed:

- The **direct** economic effects are generated when the new business creates new jobs and purchases goods and services to operate the new facility. Direct impact results in an increase in job creation, production, business sales, and household income;

- The **indirect** economic effects occur when the suppliers of goods and services to the new businesses experience larger markets and potential to expand. Indirect impacts result in an increase in job creation, Gross Geographic Product (GGP), and household income; and

- The **induced** economic effects represent further shifts in spending on food, clothing, shelter and other consumer goods and services as a consequence of the change in workers and payroll of directly and indirectly affected businesses. This leads to further business growth/decline throughout the local economy.

The approach to the socio-economic impact assessment component of the project is shown in Figure 3 below. The work consisted of defining the relevant economics zones per WMA, collecting data for major water users per WMA, inputting these data into the relevant macro-economic models and finally interpreting and assessing the results.

Two models were used to calculate the macro-economic impacts of water use in the different economic zones. This was necessitated by the difference in water sources in the two main economic zone types. In the tributaries the irrigation water is drawn from local sources with a large percentage, if not all, of the required demand for the mining and other urban requirements pumped from the main stem. The broad approach for this component of the study is shown below in Figure 3. The approach for this study was based on a similar approach used for the Upper Vaal WMA study where a particular WMA is partitioned into various economic zones. For this study, the economic zones were only used to calculate the baseline or present day economic impacts.

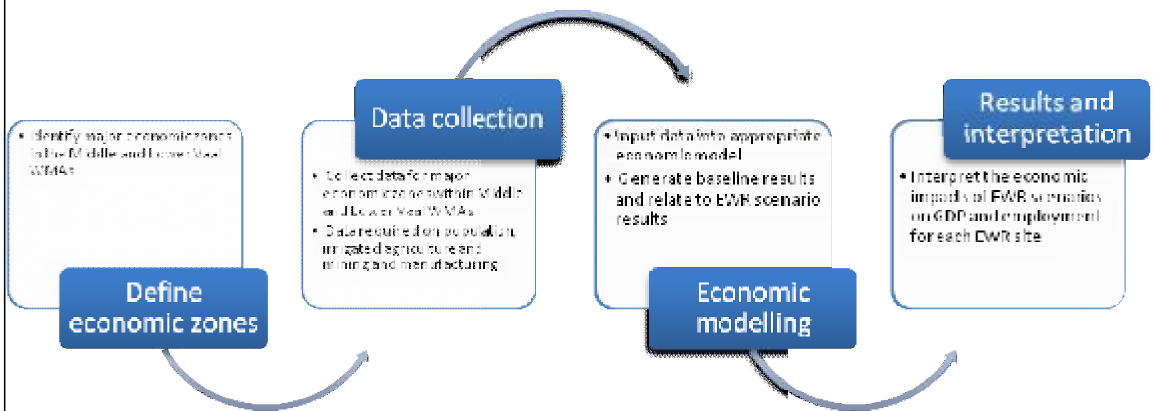

Figure 3: Approach to the socio-economic assessment for the Middle and Lower Vaal WMAs

On the main stem the irrigation water, together with the rest of the demands, is sourced from the river. A decision was taken that water demand quantities drawn from the main stem will be supplied by external sources if needed (transfers in).

On the main stem of the river and for the urban, mining and industrial requirements on the tributaries, the South African Inter-Industry Model (SAFRIM) was used to calculate the impact on the introduction of the EWR. For the irrigation from the tributaries the WIM was used to calculate the impact on the introduction of the EWR.

3.2.2 Brief description of the SAFRIM model

In line with the Australian approach (i.e. to link a sectoral based macro-econometric model with a regionally based water demand/supply structure), SAFRIM was linked to a so-called Water Satellite Model (WSM).

The following steps were followed in preparing the model for the calculation of water multipliers (Conningarth Economists, 2010):

- Step 1: The SAFRIM produces, inter alia, 46 sectoral production figures as the endogenous outcomes of an exogenous change originating from any part of the model's configurations, e.g., changes in government expenditure, exports, etc.

- A change in water demand per sector was proportionately aligned with a production increase/decrease. This ratio is directly based on the average water consumption per unit of production, or average water coefficients. For the purpose of this calculation, it is assumed that each sector in turn receives an additional one million m^3 of water, whilst keeping water demand of the other sectors in the economy constant.

- Step 2: Having established the production value equivalent of one million m^3 of water consumed per sector, it is now possible to increase the final demand of each sector with this calculated amount. This demand vector is then fed into SAFRIM, which then in turn estimates the total increase in production per sector flowing from this increase in water input per sector. It is important to emphasise again that the increase in production estimated by the model encompasses the total (i.e. direct, indirect and induced) impact of an increase in water consumption.

- Step 3: The third and crucial step is to use these resultant production impact figures to "shock" the WSM. As is well-known by now, this WSM consists of 65 sectors, and that agriculture is "driven" by the number of hectares irrigated. As such, the production figure derived at in Step 2 has to be converted into hectares in order to activate that part of the model. Ultimately, the WSM provides the total water consumption per sector which is associated with a one million m^3 increase in water consumption per sector.

- Step 4: Lastly, the results of Steps 2 and 3 are divided by one another to provide a Water Multiplier as such – i.e. the amount of GDP, employment, investment and household income per (additional) cubic meter of water consumed (this can, to some extent, be construed as a crude measure of water's marginal productivity).

3.2.3 Description of the Water Impact Model

Although reduced water allocation and/or lowering assurances of supply will directly impact on water users, there are also broader macro-economic implications at a regional level. In order to assess the indirect impacts of re-allocation of water a Water Impact Model (WIM) developed by the project team was constructed for each tributary. This model is based on the Input-Output Model. The economic model is based on a steady state social (i.e. low income household, employment and levels of income) and financial contribution made by water users with a water allocation. Gross revenue, gross margins, cash returns and net profits calculated for the base case will be used to compare with the gross revenues and margins of the other allocation scenarios. One of the key inputs is the water allocation to each sector which is provided from the Water Resource Planning Model (WRPM) as basis.

The WIM was structured by economic zones which comprises the quaternary catchment in a specific tributary. It is structured to determine the implications of sectoral changes in water allocations to the social and economic well-being of the communities in the economic zone. In doing so, the impact of changes in water use patterns can be uniquely measured for each water user sector in the economic zone and comparative analyses between various user sectors can be performed in terms of the economic impacts emanating from each water re-allocation scenario (Conningarth Economists, 2010).

3.2.4 Economic zones

The economic zones used for the purposes of the socio-economic study for the Middle and Lower Vaal WMAs were the following rivers:

Middle Vaal WMA

- Vaal River main-stem;
- Rhenoster;
- Schoonspruit;
- Sand;
- Vet; and
- Vals.

Lower Vaal WMA

- Vaal River main-stem;
- Harts;
- Modder; and
- Riet.

3.2.5 Water multipliers

By using the multiplier concept, the following macro-economic variables were determined for each economic zone:

- Economic growth (i.e. the impact on Gross Domestic Product [GDP]).
- Employment creation (i.e. the impact on labour requirements).
- Impact on capital formation.
- Income distribution (i.e. the impact on low-income, poor households and the total income households).

The multipliers for each economic zone are calculated using data from the Gauteng Provincial SAM, the National South African SAM and data obtained from both the Reserve Bank of South Africa and Statistics South Africa.

Direct GDP, labour and capital multipliers for each sector are calculated using the following six equations:

$$\text{GDP multiplier} = \frac{\text{Value Added}}{\text{Production}} \quad (1)$$

$$\text{Labour multiplier} = \frac{\text{Employment}}{\text{Production}} \quad (2)$$

$$\text{Capital multiplier} = \frac{\text{Capital stock}}{\text{Production}} \quad (3)$$

With the use of the Water Impact Model (WIM-model), these multipliers were further developed to be applied as water multipliers. These multipliers are, for example, expressed as:

$$\text{GDP water multiplier} = \frac{\text{GDP (R Million)}}{\text{Water Volume (Mm3)}} \quad (4)$$

$$\text{Labour water multiplier} = \frac{\text{Employment (numbers)}}{\text{Water Volume (Mm3)}} \quad (5)$$

The following example demonstrates the mechanism of how the macro-economic impacts were determined for this Scenario report:

$$\text{Water volume } (\text{Mm}^3) \ \text{X} \ \text{GDP (R Million)} = \frac{\text{GDP (R Million)}}{\text{Water Volume (Mm3)}} \quad (6)$$

Once the economic multipliers (equations 1 to 6) for each economic zone had been determined, the impacts of applying the ER (Scenario 7 versus 8) could be determined. An EWR site was then selected for each economic zone and water use or demand and supply were calculated per EWR site. The economic multipliers were then modified (using adjusted water demand figures) for each EWR site per economic zone (Conningarth Economists, 2010).

3.3 Approach to ecosystem goods and services assessment

Ecosystem services are the outputs of ecological systems that generate quality of life or wellbeing for people. An ecosystem service is a product that emerges from processes or features within largely natural environments, which enhances human wellbeing and is directly used by people. No longer is capital, skills or labour major constraints to human development - environmental quality is often the limiting factor. Natural capital and associated ecosystem services are now becoming scarce. This study also investigated the anticipated impacts of the various water allocation scenarios on several ecosystem goods and services. These goods and services were partitioned into several resources categories: fish, riparian vegetation, recreation and water quality. A generic and abbreviated list of selected services is presented in Table 3.

Table 3: Generic ecosystems goods and services in the Middle and Lower Vaal WMAs

Resources	**Common Name**
Fish	Rock catfish
	Smallmouth yellowfish
	Largemouth yellowfish
Riparian vegetation	
Thatching	Thatching grass
Grazing	Guinea grass
	Red Grass
Recreation	
Cultivated floodplains	
Rafting	
Canoeing	
Recreational Fishing	
Water quality	
Water treatment costs	
Waste assimilation	
Waste dilution	

Note: This table shows selected Ecosystems Goods and Services for illustrative purposes. A full list of ecosystems services is shown in Appendix A.

The following scoring system was used in order to assess the impact of the water allocation scenarios on ecosystems services:

- 1 represents current level of utilization per good/service;
- Any increase in utilization per good/service is represented by an increase between 1 and 2; and
- A decrease in utilization would be represented by a decrease from 1.

The impacts of Scenarios 7 and 8 on ecosystems goods and services were evaluated for EWR sites 12 to 19. A description of the EWR sites used in the socio-economic and ecosystems services assessment is discussed separately in the following section.

3.4 EWR sites

The specific locations of the EWR Sites for the Middle and Lower Vaal WMAs are shown in Figure 4. For the socio-economic assessment, it was found in preliminary water demand and supply modelling that the demand for water would likely be met for each water allocation scenario on the Vaal River main-stem. Socio-economic impacts were then only derived and assessed for tributaries in the Middle and Lower Vaal WMAs. For the ecosystems services assessment, however, sites 12 to 19 were used. These EWR sites are described in more detail in Table 4.

Table 4: EWR Site information – ecosystem services

EWR site no.	EWR site name	River	Vaal WMA
12	Vermaasdrift	Vaal	Middle
13	Regina Bridge	Vaal	Middle
14	Proklameerdrift	Vals	Middle
15	Fisantkraal	Vet	Middle
16	Downstream Bloemhof Dam	Vaal	Lower
17	Lloyds weir on Harts River	Harts	Lower
18	Schmidtsdrift	Vaal	Lower
19	Lilydale lodge	Riet	Lower

For the purposes of the socio-economic assessment two additional sites were identified for the Renoster and Sand/Vet tributaries in order to account for the contribution of these tributaries to the main-stem of the Vaal River. Data from the Voorspoed Mine Study undertaken by WRP in 2005 were used for the Renoster River and the two EWR sites (referred to as EWR R1 and R2) were included in the assessment. For the Sand/Vet tributary additional EWR sites V1 and V2 were identified. Data for these EWR sites were obtained by extrapolating data from EWR 15. A description of each EWR site used in the socio-economic assessment and the site's location within both the Middle and Lower Vaal is presented in Table 5.

Table 5: Distribution of EWR sites within each economic zone

EWR site no.	Tributary-Catchment	Economic Zones	Vaal WMA	Comment
R1	Renoster River (Koppies Dam)	Renoster	Middle	Additional EWR sites
R2	Renoster River	Renoster	Middle	
14	Vals (Proklameerdrift)	Vals	Middle	
none	Schoonspruit	Schoonspruit	Middle	
V1	Vet River (Fisantkraal - Allemanskraal Dam)	Vet	Middle	Additional EWR sites
V2	Vet River (Fisantkraal - Erfenis Dam)	Vet	Middle	
15	Vet River	Vet	Middle	
17	Harts River at Loyds Weir	Harts	Lower	
19	Riet River at Lilydale Lodge	Riet	Lower	

Source: Conningarth Economists (2010)

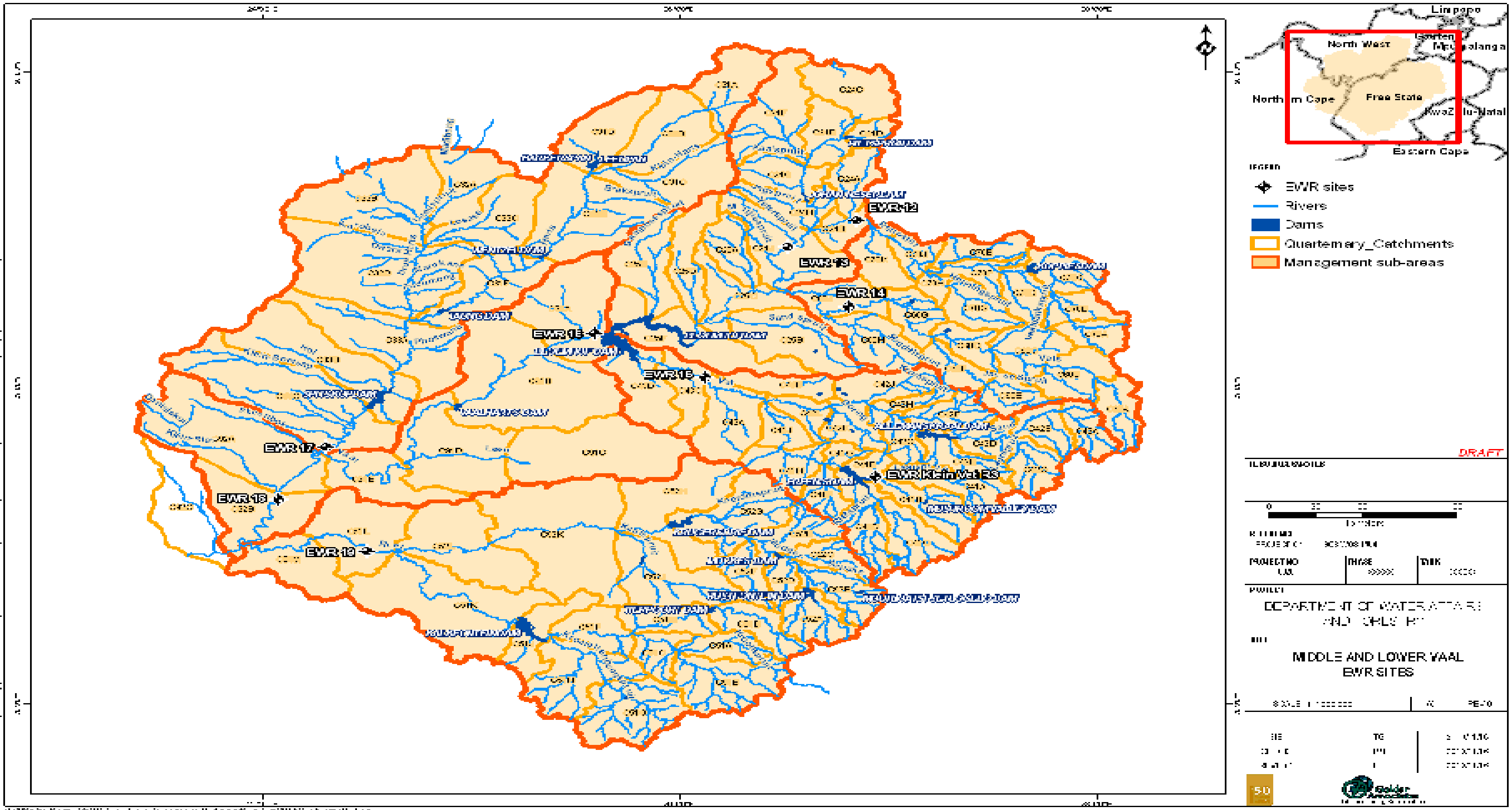

Figure 4: Ecological Water Requirements (EWR) sites for the Middle and Lower Vaal Water Management Areas

3.5 Economic profile of the Middle and Lower Vaal WMAs

3.5.1 Middle Vaal WMA

The major towns and urban areas (in terms of their contribution to the total GDP) found within the Middle Vaal WMA are shown in Figure 5**.** These areas are mainly concentrated in the North West and Free State Goldfields areas. The Middle Vaal WMA exhibits relatively little urbanisation with the largest urban area being Klerksdorp. Other urban areas include Welkom, Stilfontein, Kroonstad, Winburg, Marquard, Senekal, Lindley, Bothaville, Viljoenskroon, Heilbron, Virginia, Makwassie, Wolmaranstad, Leeudoringstad, Ventersdorp and Orkney. The Midvaal Water Company and Sedibeng Water are major suppliers of bulk water to the North West and Free State Goldfield areas, respectively. The large urban users are heavily dependent on water released into this WMA from the Upper Vaal WMA.

The Gross Geographic Product (GGP) of the Middle Vaal WMA was approximately R20.1 billion in 2009. The contribution to GGP for important magisterial districts is shown in Figure 6 (Quantec, 2010).

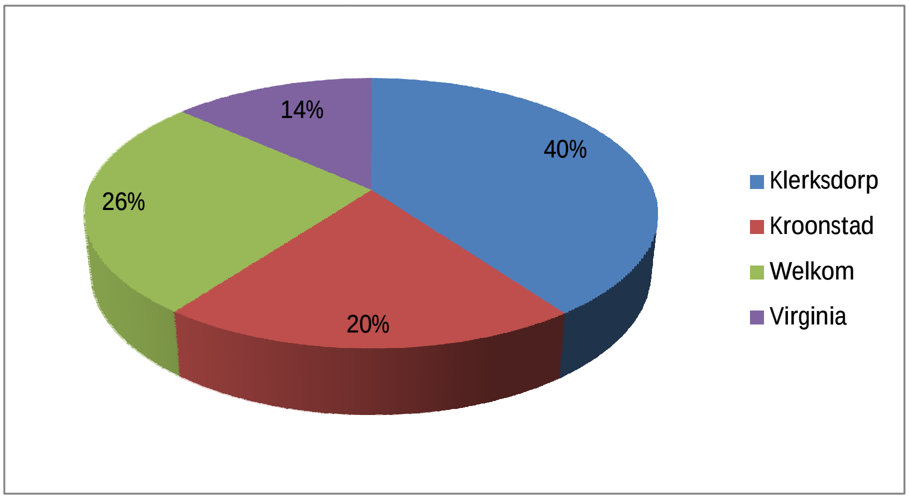

Figure 6: GGP contributions for important magisterial districts in the Middle Vaal Water Management Area (Source: Quantec, 2010)

The contribution of various economic sectors to the GGP of the Middle Vaal WMA economy is illustrated in Figure 5. Mining makes up nearly half (46%) of the total GGP within the Middle Vaal.

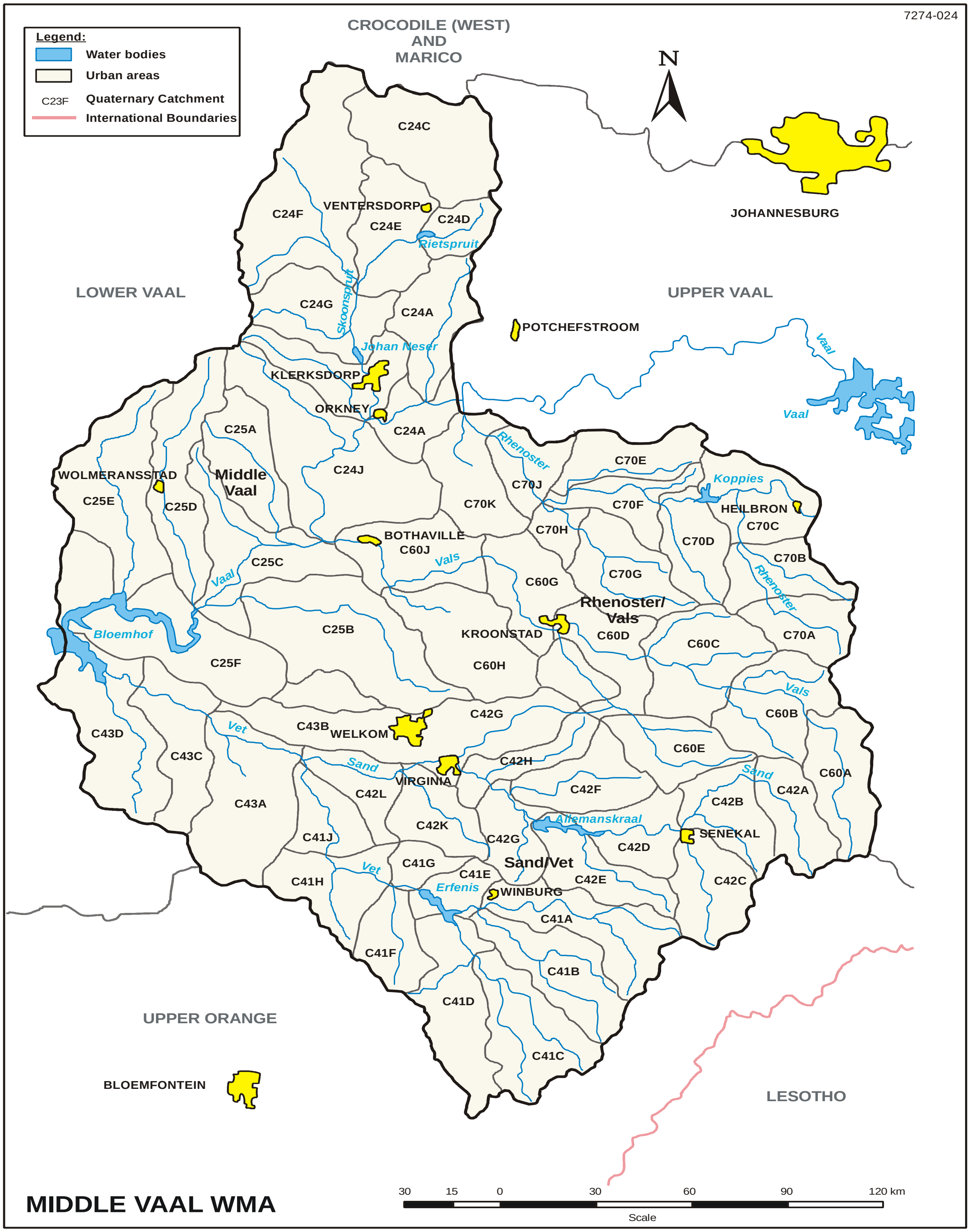

Figure 5: Tertiary Catchments and Major towns in the Middle Vaal Water Management Area

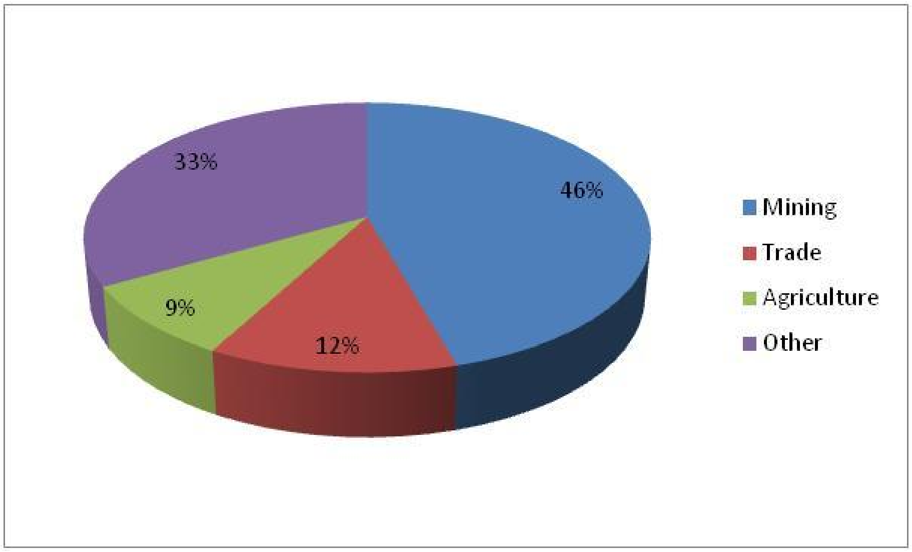

Figure 5: Major economic sectors in the Middle Vaal Water Management Area (Source: Quantec, 2010)

3.5.2 Lower Vaal WMA

The major towns and urban areas (in terms of their contribution to the total GDP) found within the Lower Vaal WMA are shown in Figure 6. The Lower Vaal WMA is not heavily developed or urbanised with the significant urban areas being Kimberly in the South, Lichtenburg in the north-east and Kuruman in the central part of the WMA. Other towns include Schweizer Reineke, Jan Kempdorp, Pampierstad, Christiana, Warrenton, Riverton, Delportshoop, Olifantshoek and Postmasburg. The Kalahari East Water Board and the North West Supply Authority are two water boards responsible for supplying bulk water to the areas in the users in the WMA. According to the Lower Vaal Water Management Area: Overview of Water Resources Availability and Utilisation Report, the GGP of the Lower Vaal WMA was R9.8bn in 1997. The most important magisterial districts in terms of contribution to GGP in this WMA are shown in Figure 6.

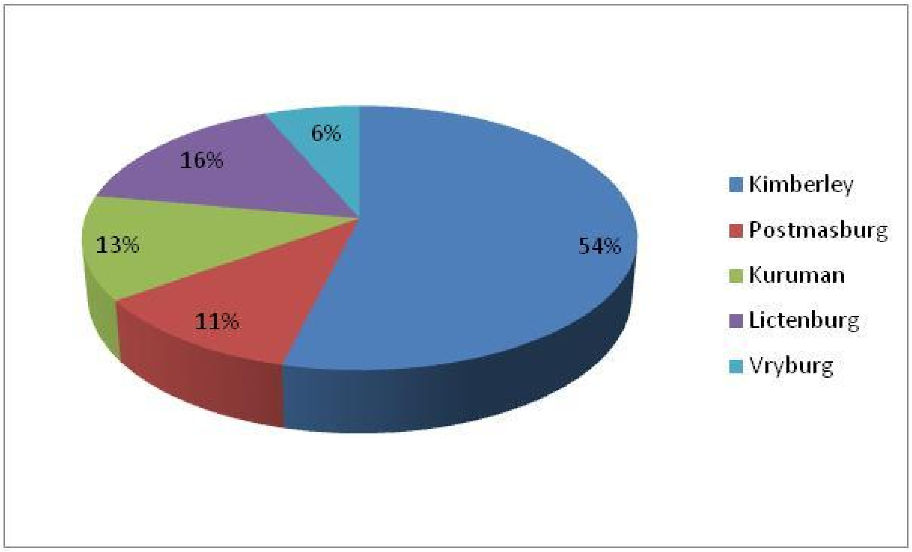

Figure 6: GGP contributions for important magisterial districts in the Lower Vaal Water Management Area (Source: Quantec, 2010)

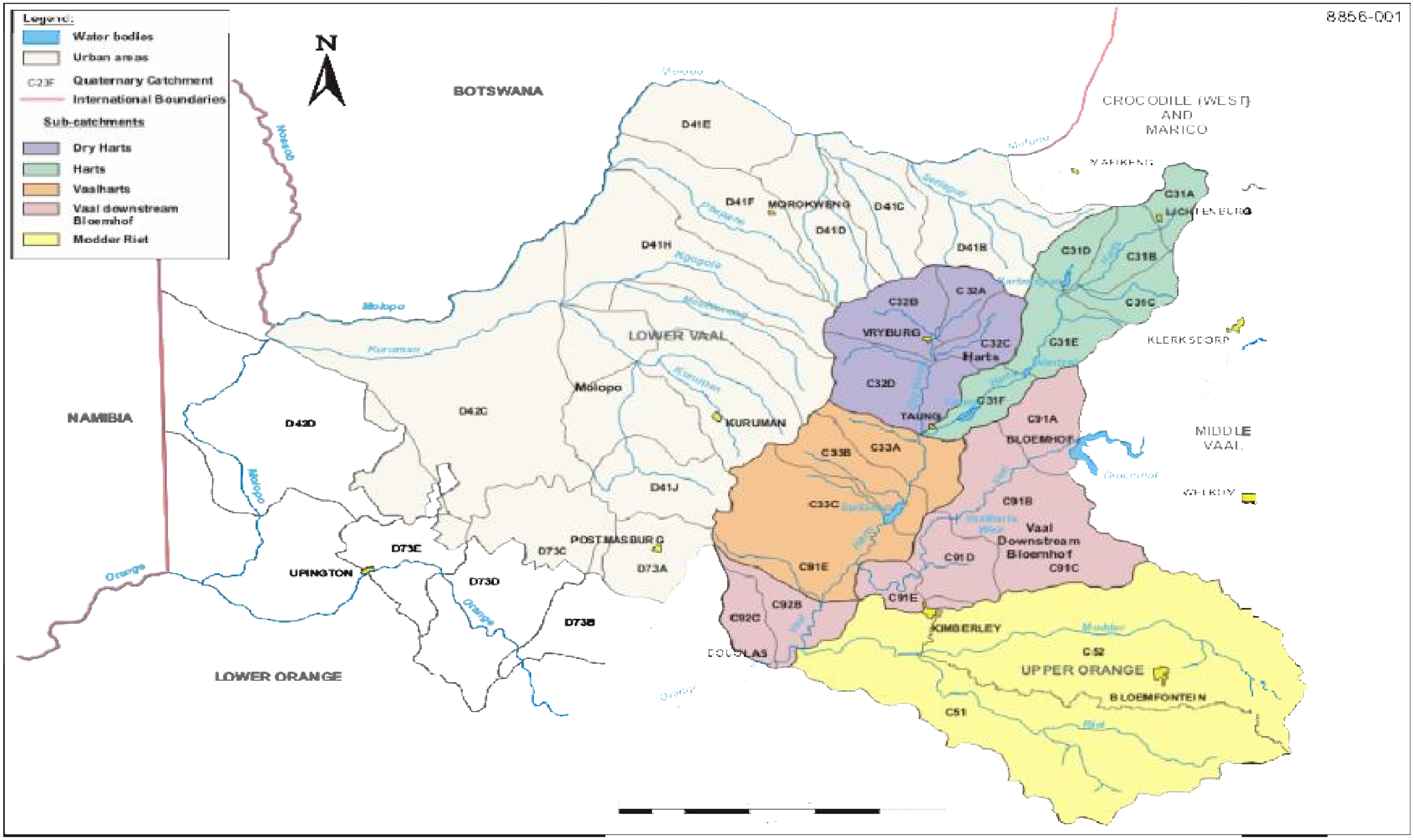

Figure 7: Lower Vaal and Upper Orange Water Management Areas

Major mining activities in this WMA include diamonds, iron ore, manganese and other minerals such as limestone, dolomite and asbestos. Kimberlite diamonds are mined at the Finsch Mine at Lime Acres, one of the most important diamond producing mines for the De Beers Company. The Sishen Mine, a major supplier of iron ore in the country, is located in the Lower Vaal WMA and the mine has a mineable depth of 30 metres and was opened in 1953 as part of Iscor's expansion strategy. In 1997, it produced approximately 2 400 million ton iron ore per year. Other important mining areas include Kudumane (iron, manganese and asbestos etc), Ganyesa (diamonds, mica group clay and salt) and Taung (diamonds, limestone, dolomite and salt (DWAF, 2002).

The contribution of each major economic sector to the GGP of the Lower Vaal WMA is shown in Figure 10. The most important economic activities of the WMA are mining, government services and trade. The main agricultural activities identified include livestock and dryland cropping. Livestock includes beef and dairy cattle, goats, sheep, pigs and ostriches. Crops grown include maize, sunflower, cotton, groundnuts and vegetables (DWAF, 2002).

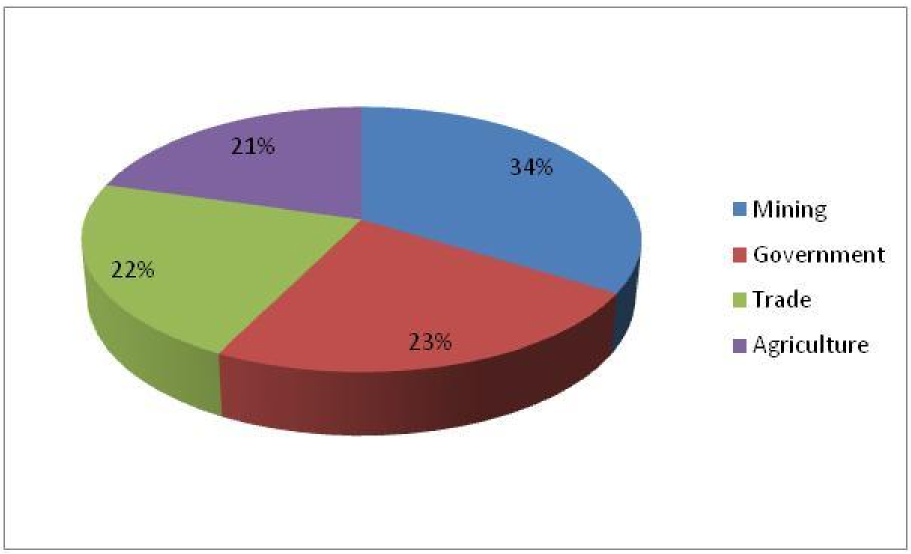

Figure 8: Major economic sectors in the Lower Vaal Water Management Area (DWAF, 2002)

4 DATA AND DATA SOURCES

The major economic activities within the Middle and Lower Vaal WMAs are the following:

- Irrigated agriculture (DWAF, 1999);
- Mining and manufacturing (various sources); and
- Domestic and/or household consumption (Statistics South Africa, 2001).

Although extensive large-scale mining takes place within the Middle and Lower Vaal WMAs, the manufacturing sector is not significant. The two major economic sectors are, therefore, irrigated agriculture, mining and domestic or household consumption. This section presents a summary of the data collected for the purposes of the socio-economic assessment.

4.1 Irrigated agriculture

Although irrigated agriculture occurs along the length of the Orange-Vaal River System, large-scale irrigated agriculture occurs primarily within the Lower Vaal WMA. Significant and well established irrigation schemes within the Lower Vaal WMA include the Vaalharts and Taung irrigation schemes. DWAF (1999) in their "Vaal River Irrigation Study[2]" partitioned the entire Vaal River System into ten discrete irrigation zones. Crop types, and estimates of areas grown per irrigation zone for the year 2000, identified as part of that study, are shown in Table 6. Irrigation zones 5 and 6 account for the largest areas of agricultural production for the Vaal River System. Irrigation zone 5 includes the Sand/Vet catchment and irrigation zone 6 includes the Lower Vaal Government Water Scheme and the Vaalharts/Taung Irrigation Schemes. The Vaalharts and Taung irrigation schemes when combined distribute water to roughly 38,000ha of irrigated cropland. Low value annual field crops such as maize and soya beans account for approximately 72.5% of the total cropped area within the Vaal River System.

The DWAF (1999) study is the most recent and comprehensive study which verified on-farm crop production and water use. A verification validation process has been completed for only the Upper Vaal WMA. At the time of writing this report, the verification validation processes for the Middle and Lower Vaal WMAs had not yet started and similar data for these WMAs were unfortunately not available. The data presented in Table 6 were partitioned into crop types and areas for both the main-stem and tributaries of the Middle and Lower Vaal WMAs.

Table 6: Crops per Irrigation Zone (DWAF 1999)

Irrigation zone	Total crop area (ha)	Crop category (ha)				Crop category (%)			
		Fodder	Annual field (lower value)	Annual field (higher value)	Orchard/Vine	Fodder	Annual field (lower value)	Annual field (higher value)	Orchard/ Vine
1	8 178	2 871	4 396	910	0	35.1	53.8	11.1	0.0
2	5 627	70	3 002	1 905	650	1.2	53.4	33.9	11.6
3	9 542	0	7 904	1 413	226	0.0	82.8	14.8	2.4
4	16 308	6 460	8 694	1 133	21	39.6	53.3	7.0	0.1
5	21 782	1 087	17 856	2 839	0	5.0	82.0	13.0	0.0
6	57 180	9 816	43 279	1 635	2 450	17.2	75.7	2.9	4.3
7	2 110	531	1 303	171	105	25.2	61.8	8.1	5.0
8	9 406	2 945	6 189	173	99	31.3	65.8	1.8	1.1
9	6 914	2 131	4 483	240	60	30.8	64.8	3.5	0.9
10	30 604	4 213	24 509	1 370	512	13.8	80.1	4.5	1.7
TOTAL	167 652	30 125	121 615	11 790	4 122	18.0	72.5	7.0	2.5

Source: DWAF (1999)

[2] This is also known as the Loxton Venn Study.

4.1.1 Crop types, areas and water use on the main-stem of the Middle and Lower Vaal WMAs

The total crop area, composition and water use for crops produced from the Vaal River main-stem in the Middle and Lower Vaal WMAs is shown in Table 7, respectively.

Table 7: Main-stem crop type and area in the Middle and Lower Vaal WMAs

Crop types	Middle Vaal (ha)	Lower Vaal (ha)	Total (ha)
- Maize	1,714	8,767	**10,481**
- Wheat	2,767	17,222	**19,989**
- Lucerne	146	9,350	**9,496**
- Pastures	-	320	**320**
- Nuts	396	8,873	**9,269**
- Grape	22	320	**342**
- Deciduous Fruit	8	80	**88**
- Potatoes	865	330	**1,195**
- Cotton	-	3,540	**3,540**
Total	**5,918.0**	**48,802.0**	**54,720**

Source: DWAF (1999)

4.1.2 Crop types, areas and water use for the major tributaries of the Middle Vaal WMA

The crop types and areas produced per major tributary in the Middle Vaal WMA are shown in Table 8.

Table 8: Crop type and area in the Middle Vaal WMA tributaries

Crop types	Rhenoster (ha)	Schoonspruit (ha)	Sand (ha)	Vet (ha)	Sand/Vet incremental	Vals (ha)	Total (ha)
- Maize	667	2,029	2,021	3,323	1,127	2,448	**9,371**
- Wheat	667	652	3,071	4,088	1,387	1 224	**9,967**
- Lucerne	445	472	362	124	42	516	**1,479**
- Pastures	467	574	402	117	40	440	**1,600**
- Sorghum	167	36	-	-	-		**203**
- Sunflower	222	324	461	305	104		**1,416**
- Potatoes	222	83	996	1,144	388		**2,833**
- Vegetables	-	643	525		-		**1,168**
- Deciduous fruit	-	15	-	-	-		**15**
- Nuts	-	-	477	832	282		**1,591**
- Soyabean				124	42		**166**
Total	**2,858**	**4,834**	**8,315**	**10,057**	**3,412**	**4,628**	**29,809**

Source: DWAF (1999)

4.1.3 Crop types, areas and water use for the major tributaries of the Lower Vaal WMA

The crop types and areas produced per major tributary in the Middle Vaal WMA are shown in Table 9.

Table 9: Crop type and area in the Lower Vaal WMA tributaries

Irrigation Crops	Harts Ha	Modder Ha	Riet Ha	Total Ha
- *Maize*	544	1,348	2,864	**4,756**
- *Wheat*	604	2,435	2,992	**6,031**
- *Lucerne*	415	2,019	2,511	**4,945**
- *Pastures*	116	113	434	**663**
- *Sunflower*	10	480	74	**564**
- *Potatoes*	71	90	148	**309**
- *Nuts*	95	20	74	**189**
- *Fruit*	-	-	-	**0**
- *Vegetables*	140	350	25	**515**
- *Deciduous fruit*	25			**25**
- *Cotton*	10	-	185	**195**
- *Grapes*	80	-	99	**179**
Total	**2,110**	**6,855.0**	**9,406.0**	**18,371**

Source: DWAF (1999)

4.1.4 Crop water use and irrigation requirements

Irrigation water requirements were, initially, taken from the "Vaal River Irrigation Study" (DWAF, 1999). These data were, however, based on theoretical crop water use calculations and may not, therefore, reflect present day water use. Due to uncertainties regarding the present day crop types and areas within the Middle and Lower Vaal WMAs, water demand data from WRP were used as an alternative with the assumption that the crop basket would be similar between 1999 and present day. The water use figures from the "Vaal River Irrigation Study" (DWAF, 1999) as well as present day demand data as supplied by WRP Consulting Engineers (Susan Swart 2010) for the Middle and Lower Vaal WMAs are shown in Table 10.

Table 10: Crop irrigation requirements for Middle and Lower Vaal WMAs

Water management area	Vaal River Irrigation Study (theoretical water use)[a] (Million m^3/annum)	WRP[b] (Million m^3/annum)
Middle Vaal		
Main stem	35.25	46.76
Renoster	16.94	16.54
Schoonspruit	26.09	30.18
Sand-Vet (Allemanskraal)	39.67	43.10
Sand-Vet (Erfenis)	46.40	59.61
Sand-Vet (incremental)	15.74	-
Vals	1.83	30.10
Total	**181.92**	**226.29**

Lower Vaal		
Main stem (Vaalharts)	446.11	461.27
Harts	13.16	19.14
Modder	44.31	77.11
Riet	60.94	226.54
Total	**564.52**	**784.06**

Source: a. Source: DWAF (1999); WRP Consulting Engineers (2010)

The WRP (2010) water volume data were used to derive the baseline results for each economic zone. The estimated total water usage for irrigated agricultural production is 1348.58 million m^3 per annum. Of this total, 481.36 (48%) is used for irrigation along the Middle and Lower Vaal main-stem. It is, therefore, anticipated that much of the economic impact could be experienced in these irrigation areas.

4.2 Mining and manufacturing

Data is required for the mining and manufacturing sectors related to the sectors annual water use, employment and turnover (production). Large water users in these sectors were identified and relevant data were collected. Water use data for each user was largely sourced from previous studies such as DWAF (2002). Employment and turnover figures (where available) were obtained from mining websites and other secondary data sources. Where these data were not available, reasonable assumptions were made using the methodology described in Section 3.2.

4.3 Domestic water usage

The population distribution and domestic, or urban water use, for the Lower and Middle Vaal WMAs is shown in Table 12 and Table 12 respectively. Population data for the Middle and Lower Vaal WMA were collected from Statistics South Africa and were the latest Census (2001) data. The population data were partitioned into high, middle and low income (for households who receive an income of R1 or greater). These percentile categories are as follows:

- Low income (R1 – R307 200);
- Middle income (R307 201 – R1 228 800); and
- High income (greater than R1 228 801).

Water use per person per day was estimated to be 25 litres for the purposes of this study.

5 RESULTS

The results of the socio-economic assessment have been separated into baseline or “present day” and scenario results. The baseline results represent the current economic impact of the present day water use levels per economic zone whereas the scenario results present deviations from present day demand per EWR site as a consequence of either applying or not applying the Ecological Reserve (Scenarios 7 and 8 in Table 3). The results for the impacts of Scenarios 7 and 8 on ecosystems services per EWR site are presented in section 6.4.

5.1 Baseline results

5.1.1 Irrigated agriculture

The baseline total economic impact results for irrigated agriculture for the Middle and Lower Vaal WMAs are presented in Table 14 and Table 15, respectively. From the baseline results for irrigated agriculture it can be seen that in the Lower Vaal WMA, irrigated agriculture has a much larger economic impact than in the Middle Vaal WMA. Irrigated agriculture within the Lower Vaal WMA contributes approximately R28.3 million per annum more in terms of surplus value[3], R174 million per annum more to GDP and directly employs 2 534 more individuals than in the Middle Vaal WMA. Table 11 below provides a summary of the contribution of various tributaries in the Middle and Lower Vaal WMAs to surplus value, direct GDP and direct employment. The impacts of implementing the Ecological Reserve are, therefore, expected to be the highest in these tributaries and portions of the Middle and Lower Vaal WMAs.

As shown in Table 11, the Sand/Vet tributaries make the highest contribution (collectively) to total surplus value (net income) and employment in the Middle Vaal WMA. In terms of contribution to direct GDP, however, irrigation on the main-stem of the Middle Vaal WMA makes the highest contribution. Maize and wheat are major irrigated crops produced in the Sand/Vet catchments. In the Lower Vaal WMA, irrigation along the main-stem of the Vaal makes the most significant contribution to total surplus value (net income), direct GDP and direct employment for irrigated agriculture in this WMA. Major irrigated crops contributing to this significant contribution are irrigated maize, wheat, lucerne and nuts.

Table 11: Summary of contributions to total surplus value, direct GDP and direct employment for selected tributaries

WMA	Surplus Value	Direct GDP	Direct employment
Middle Vaal	**% of total**		
Middle Vaal – main-stem	29	21	3
Sand	21	6	35
Vet	32	8	47
Lower Vaal			
Lower Vaal WMA – main-stem	67	71	70

Mining and other industries

The baseline total economic impact results for mining and manufacturing for the Middle and Lower Vaal WMAs are presented in Table 16 and Table 17, respectively.

[3] Note: a. Surplus value represents the contribution of each crop type to regional net income (Mullins, 2010: pers comm).

5.2 Scenario results

The results of Scenario 8 are presented per EWR site (described in Table 5). It should be noted that water allocated to industries as well as for domestic usage makes up a relatively small proportion of the total water use within the Middle and Lower Vaal WMAs. Water used for irrigated agriculture is, therefore, most likely to be affected. The results for Scenario 8 are presented in Table 18 and are interpreted as the difference between Scenario 7 and 8. Water supply to the Lower Vaal main-stem and tributaries was found to be affected by the implementation of Scenario 8 and therefore no economic impact modelling was done for the EWR sites in the Lower Vaal WMA. This is discussed in greater detail in section 5.2.4.

5.2.1 Direct impacts on surplus value

Figure 11 illustrates the comparative impact on surplus value (net income) of implementing the Ecological Reserve at the relevant EWR sites. As this Figure shows, the greatest negative impacts as a result of Scenario 8 on surplus value were found for EWR V1 and V2 and EWR 14.

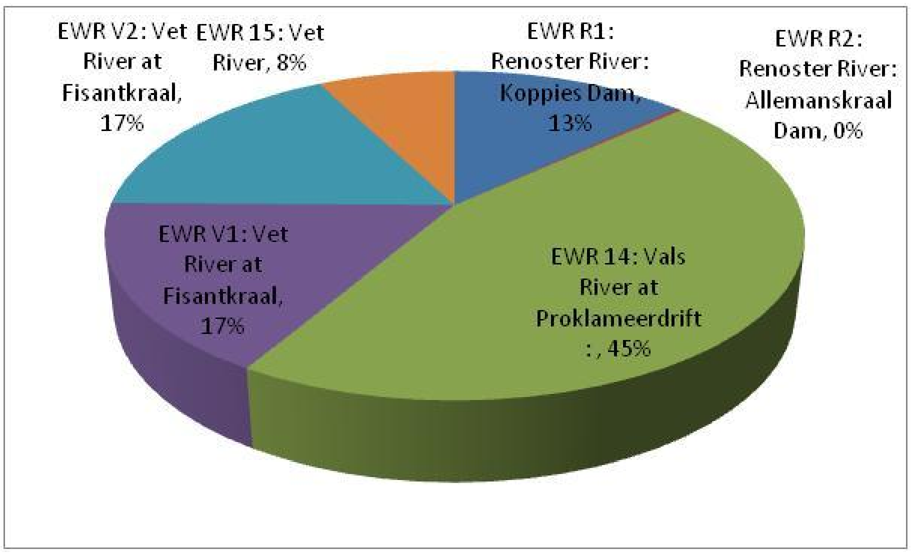

Figure 9: Macroeconomic impacts of Scenario 8 on Surplus value

Table 12: Population distribution within the Middle and Lower WMAs (households)

	Main Stem Middle Vaal	Renoster	Schoonspruit	Sand	Vet	Vals	Main stem Lower Vaal	Harts	Total
High Income	298	68	103	120	0	99	244	28	**960**
Middle Income	1,508	124	741	498	18	275	909	24	**4,097**
Low Income	169,280	10,872	10,684	30,243	4,910	21,525	55,288	5,489	**308,291**
No Income	24,696	1,866	408	5,119	720	3,661	10,065	362	**46,897**
Total	**195,782**	**12,930**	**11,936**	**35,980**	**5,648**	**25,560**	**66,506**	**5,903**	**360,245**

Source: Statistics South Africa (2001)

Table 13: Average annual water use within the Middle and Lower WMAs (Million m^3)

	Main Stem Middle	Renoster	Schoonspruit	Sand	Vet	Vals	Main stem Lower	Harts	Total
High Income	0.003	0.001	0.001	0.001	0.000	0.005	0.002	0.000	**0.013**
Middle Income	0.138	0.001	0.007	0.005	0.002	0.009	0.008	0.000	**0.169**
Low Income	1.545	0.099	0.097	0.276	0.046	1.461	0.449	0.050	**4.025**
No Income	0.225	0.017	0.004	0.047	0.007	0.033	0.235	0.003	**0.571**
Total	**1.910**	**0.118**	**0.109**	**0.328**	**0.054**	**1.508**	**0.695**	**0.054**	**4.777**

Note: For the purposes of this study, it was assumed that the average person consumes 25 litres of water per day

Table 14: Baseline scenario results for the Middle Vaal Water Management Area – Irrigated Agriculture

	Surplus Value[a] (R Mil)	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
	Direct	**Direct**	**Indirect & Induced**	**Total**	**Direct**	**Indirect & Induced**	**Total**	**Total**	**Total**	**Medium & High**	**Low**
Middle Vaal – main-stem	22.92	76.66	38.88	115.53	192	920	1120	1045.84	2157.81	1671.82	485.99
Renoster	4.82	22.23	31.22	53.46	372	324	696	126.12	62.09	44.29	17.8
Schoonspruit	5.22	30.52	45.2	75.72	211	470	681	181.7	88.08	63.64	24.44
Sand	16.96	89.1	124.4	213.6	2008	1292	3300	498.1	248.8	176	72.8
Vet	25.67	122.53	174.55	297.08	2706	1817	4523	694.76	347.06	245.7	101.36
Vals	4.46	30.7	47.37	78.07	222	496	718	187.78	91.39	66.02	25.37
Total	**80.05**	**371.74**	**461.62**	**833.46**	**5711**	**5319**	**11038**	**2734.3**	**2995.23**	**2267.47**	**727.76**

Note: a. Surplus value represents the contribution of each crop type to regional net income (Mullins, 2010: pers comm).

Table 15: Baseline scenario results for the Lower Vaal Water Management Area – Irrigated agriculture

	Surplus Value (R Mil)	GDP (R Mil)			Employment (Numbers)			Capital (R Mil)	Household Income (R Mil)		
	Direct	**Direct**	**Indirect & Induced**	**Total**	**Direct**	**Indirect & Induced**	**Total**	**Total**	**Total**	**Medium & High**	**Low**
Lower Vaal WMA – main-stem	72.34	385.6	516.29	902.16	5811	5213	11024	2060.47	1029.3	732.11	297.2
Harts	6.55	23.71	28.67	52.38	517	291	808	113.43	60.19	42.09	18.1
Modder	12.67	58.49	76.83	135.32	882	807	1689	303.82	157.01	111.88	45.13
Riet	16.82	77.92	102.32	180.24	1035	1079	2115	402.5	209.62	149.41	60.21
Total	**108.38**	**545.72**	**724.11**	**1270.1**	**8245**	**7390**	**15636**	**2880.22**	**1456.12**	**1035.49**	**420.64**

Table 16: Baseline scenario results for the Middle Vaal Water Management Area - Mining and other industries

	Mining		Other Industries		Households			
Allocation Zones	**Employment (Numbers)**	**GDP (R Million)**	**Employment (Numbers)**	**GDP (R Million)**	**High (R Million)**	**Middle (R Million)**	**Low (R Million)**	**Total (R Million)**
Renoster Tributary	0	0.0	15 544	1 692.1	25	115	25 717	25 857
Schoonspruit Tributary	11 487	750.5	11 103	1 208.6	18	82	18 369	18 469
Sand Tributary	12 031	786.0	71 057	7 735.2	112	527	117 563	118 202
Vet Tributary	-	0.0	13 323	1 450.3	21	99	22 043	22 163
Vals	-	0.0	28 867	3 142.4	46	214	47 760	48 020
Mainstem	1 440	94.1	66 616	7 251.7	105	494	110 215	110 815
Total	**24 958**	**1 630.6**	**206 511**	**22 480.4**	**326**	**1 532**	**341 668**	**343 526**

Table 17: Baseline scenario results for the Lower Vaal Water Management Area - Mining and other industries

	Mining		Other Industries		Households			
Allocation Zones	**Employment (Numbers)**	**GDP (R Million)**	**Employment (Numbers)**	**GDP (R Million)**	**High (R Million)**	**Middle (R Million)**	**Low (R Million)**	**Total (R Million)**
Harts River Tributary	-	0.0	196	196.3	103	415	65 523	66 041
Modder Tributary	-	0.0	5 290	5 299.8	353	1 427	225 058	226 837
Riet Tributary	4 804	515.3	392	392.6	36	145	22 791	22 971
Mainstem	20 817	2232.8	3 396	3 402.3	143	578	91 163	91 883
Total	**25 621**	**2 748.0**	**9 274**	**9 291.0**	**634**	**2 565**	**404 534**	**407 733**

5.2.2 Direct impacts on GDP

Figure 10 illustrates the comparative impact on surplus value (net income) of implementing the Ecological Reserve at the relevant EWR sites. As this Figure shows, the greatest negative impacts as a result of Scenario 8 on surplus value were found for EWR V1 and V2 and EWR 14.

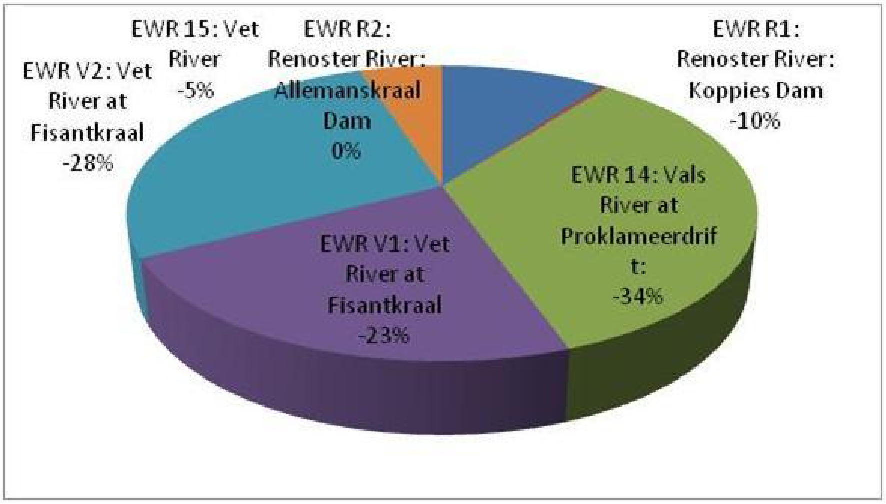

Figure 10: Macroeconomic impacts of Scenario 8 on direct GDP

5.2.3 Direct impacts on employment

Figure 11 below illustrates the comparative impact on surplus value (net income) of implementing the Ecological Reserve at the relevant EWR sites. As this Figure shows, the greatest negative impacts as a result of Scenario 8 on surplus value were found for EWR V1 and V2 and EWR 14. EWR 14 showed the greatest loss in employment opportunities with a loss of 572 job opportunities as a result of Scenario 8.

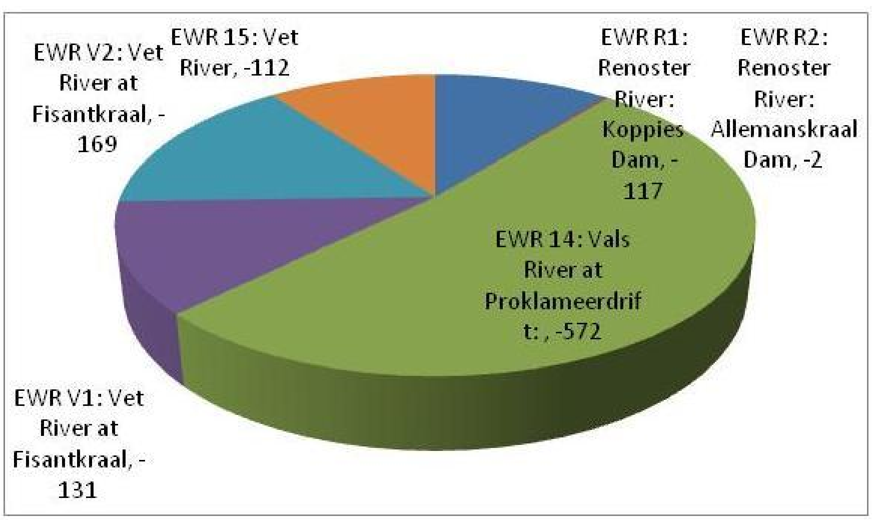

Figure 11: Macroeconomic impacts of Scenario 8 on employment

5.2.4 Discussion of impacts per EWR site

EWR R1 and R2: Renoster River, Koppies Dam

The overall macroeconomic impacts at these additional EWR sites were relatively small. The flow of the Renoster River is regulated by the Koppies Dam which supplies three major water users. These are the Koppies Government Water Scheme (GWS), the town of Koppies and the Voorspoed Diamond mine (WRP, 2010). Much of the water abstracted at EWR R1 is used for irrigation purposes.

The direct macro economic impacts for Scenario 8 at EWR R1 are a loss of R7.73 million GDP and 117 total employment opportunities. In terms of total economic impact at EWR R1, implementation of the Ecological Reserve will result in a loss of R18.7million in GDP and 231 job opportunities. The water abstracted at EWR R2 is used primarily for irrigation purposes. The impact on irrigators due to the implementation of the EWR (Scenario 8) at EWR R2 will be a loss of R0.7million in GDP and 6 employment opportunities in the immediate vicinity of EWR R2 (Table 18).

EWR14: Vals River at Proklameerdrift:

The water abstracted at EWR 14 is used primarily for irrigation purposes. The macro-economic impacts for the present day demand at EWR 14 are a direct loss of R26 million in GDP and 572 direct employment opportunities. The net impact of implementing the Ecological Reserve at EWR 14 will be a total loss of approximately R63 million in GDP and 953 employment opportunities in the immediate vicinity of EWR 14. This EWR site is the most negatively affected of all EWR sites in the Middle Vaal WMA (Table 18).

Schoonspruit Catchment

As the Schoonspruit was analysed in a previous study, the supply was monitored in this study and no water data were made available for economic modelling.

EWR V1: Vet River

EWR V1 is situated below the Allemanskraal Dam which provides water to irrigators as well as to the town of Virginia in the Free State. The net impact of Scenario 8 will be a loss of R44.7 million in GDP and 431 employment opportunities in the immediate vicinity of EWR V1. The Virginia urban water use is reduced by 40% for Scenario 8 (Table 18).

EWR V2: Vet River:

EWR V2 is situated below the Erfenis Dam which provides water to urban users as well as to irrigators. It must be noted, however, the urban areas supplied by the dam (Brandfort, Theunissen, Bultfontein and Hoopstad) have no alternative water source and supply to these urban areas, therefore takes preference over irrigation requirements. When the economic impacts for the Scenario 8 are assessed, GDP and employment decline by R55.5 million and 542 job opportunities, respectively. Urban water users are not likely to be impacted upon negatively by the implementation of the Ecological Reserve (Table 18).

EWR 15: Vet River at Fisantkraal

When the economic impacts for Scenario 8 (EWR included) were modelled, the total GDP and employment in the vicinity of this EWR site decline by R3.9 million and 167 employment opportunities, respectively (Table 18).

5.2.5 Lower Vaal WMA

EWR 17: Harts River at Lloyds Weir

Although the problem identified in terms of the maximum discharge constraints at Spitskop Dam should be addressed when implementing the EWR, EWR17 was assessed in the WRPM Scenario Analysis. Due to that qualitative analysis no economic modelling was done (Conningarth *personal communication*).

EWR 19: Riet River at Lilydale Lodge

In the WRPM Scenario Analysis the conclusion was made that the EWR cannot be imposed on the available water resources as they are already in deficit and it is uncertain as to how the deficit should be allocated to the individual water resources. Therefore no economic modelling was performed for this tributary.

Main Stem of the Vaal River (EWR 12, 13, 18, 16)

The effect of the Scenarios 8 was modelled by the WRPM model. The main conclusion is that Scenario 8 has a 3.1% lower average storage level that Scenario 7 in the Sterkfontein Dam. The assurance of supply to users were, however, not jeopardised by implementing the EWRs (Swart, 2010: pers comm).

5.3 Evaluation of Scenario 8

According to Conningarth Economists (2010), in evaluating the impact of the scenarios the following assumptions (as per the Upper Vaal WMA) must be taken into consideration (Conningarth Economists, 2010):

- The present day water demands at a specific EWR site does not reflect the total irrigation water use per economic zone;
- The multipliers used to calculate the impact at the specific point is calculated using the total irrigation activity in the zone, there is therefore a chance that the crop mix at the EWR site will differ from that of the total zone;
- The base EWR scenario is based on the 2008 water demand, while Scenario 8 is based on the projections up to 2010. It was assumed that the present crop mix would remain unchanged in future; and
- The impacts are based on the use of the total water per zone without making a distinction between lawful and unlawful use.

Table 18: Comparison of the impacts on GDP and employment of Scenario 8 for Middle WMA

Middle Vaal WMA	Surplus Value (R Mil)	GDP (R mil.)			Employment (numbers)			Capital (R Mil)	Household Income (R.mil.)		
	Direct	**Direct**	**Indirect & Induced**	**Total**	**Direct**	**Indirect & Induced**	**Total**	**Total**	**Total**	**Medium & High**	**Low**
EWR R1: Renoster River: Koppies Dam	R -1.63	R -7.73	R -10.92	R -18.65	-117	-114	-231	R -44.07	R -21.64	R -15.47	R -6.17
EWR R2: Renoster River: Allemanskraal Dam	R -0.03	R -0.26	R -0.41	R -0.66	-2	-4	-6	R -1.61	R -0.78	R -0.57	R -0.22
EWR 14: Vals River at Proklameerdrift: EWR14	R -5.67	R -26.03	R -36.55	R -62.58	-572	-381	-953	R -146.10	R -72.92	R -51.62	R -21.30
EWR V1: Vet River at Fisantkraal	R -2.10	R -17.42	R -27.31	R -44.73	-131	-299	-431	R -106.42	R -52.22	R -37.66	R -14.56
EWR V2: Vet River at Fisantkraal	R -2.16	R -21.09	R -34.38	R -55.47	-169	-373	-542	R -133.36	R -65.24	R -47.08	R -18.16
EWR 15: Vet River	R -0.95	R -3.88	R -5.33	R -9.21	-112	-56	-167	R -21.34	R -10.72	R -7.52	R -3.20
Total (cumulative impact)	**R -12.54**	**R -76.41**	**R -114.90**	**R -191.30**	**-1,103**	**-1,227**	**-2,330**	**R -452.90**	**R -223.52**	**R -159.92**	**R -63.61**

Significant deviations from present day demand for Scenario 8 were found for EWR R1 (Renoster), EWR 14 (Vals), EWR V1 (Sand) and EWR V2 (Vet). The results for the main stem showed that Scenario 8 caused more water to be pumped through the VRESAP pipeline and Sterkfontein Dam was operated at lower storage levels. The assurance of supply to users were, however, not jeopardised by implementing the EWRs (Swart, 2010: pers comm).

5.4 Impact on ecosystem goods and services

The impacts of Scenarios 4, 5, 7 and 8 on ecosystem goods and services in the Middle and Lower Vaal WMAs per EWR site are presented in Table 19. The impact results are applicable for all EWR sites in the Middle and Lower Vaal WMAs. Impacts on ecosystems goods and services were measured using a scale of 0 to 2. One represents current level of utilization. Any increase in utilization is represented by an increase between 1 and 2. A decrease in utilization would be represented by a decrease from 1.

Table 19: Summary of impacts on Ecosystems services, EWR sites 12 to 19

	Scenario					
EWR site	1 (base)	4	5	6	7	8
Middle Vaal						
12	32	32	33.1	32.6	32	32
13	33	33	37	36	33	33
14	31	31	29.4	32	31	31
15	31	32.8	31.6	32.8	31	32.8
16	35	35	35.4	35	35	35
Total	**162**	**163.8**	**166.5**	**168.4**	**162**	**163.8**
Lower Vaal						
17	32	33.6	33.2	33.4	33	33.3
18	36	38.9	37	40.3	36	38.9
19	35	36.7	35.4	36.7	35	36.7
Total	**103**	**109.2**	**105.6**	**110.4**	**104**	**108.9**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

Scenarios 4, 7 and 8 were either found to have no effect or an improvement in the current utilization levels for EWR sites 12 to 19. Scenario 5 was found to have a negative impact at EWR site 14 (Proklameersdrift) in the Middle Vaal WMA. The negative impacts were driven by impacts on fish species such as the, Smallmouth yellowfish (*Labeobarbus aeneus*), Orange-Vaal mudfish (*Labeo capensis*) and Moggel, (*Labeo umbratus*) and result from reduced flow levels leading to a decrease or disappearance of species from this reach and low levels of catches in recreational and subsistence fisheries.

The Smallmouth yellowfish is an important angling species and Scenario 5 is, therefore, not an acceptable water allocation scenario from an ecosystems services perspective. Scenarios 4, 6 and 8 resulted in the greatest net improvement in terms of impacts on ecosystems services for both the Middle and Lower Vaal WMAs. Scenario 6 was found to have the highest positive impact in both the Middle and Lower Vaal WMAs and can be seen from an ecosystem services perspective as being an acceptable water allocation scenario.

Impacts on ecosystems services are discussed in more detail per EWR site in the following sections.

5.4.1 EWR site 12 (Vermaasdrift)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 12 are shown in Table 20. As shown in Table 20, the impacts of the various water allocation scenarios on ecosystems resources at EWR site 12 have no affect on the current utilisation levels of these resources. Scenarios 5 and 6 resulted in a positive impact on water quality at EWR site 12 through improvements in terms of water treatment costs and waste assimilation. Scenario 5, with a score of 33.1 at EWR site 12, had the highest positive impact on ecosystem services.

Table 20: Impact of water allocation scenarios on Ecosystems Services at EWR site 12

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	4	4	4	4	4	4
Riparian Vegetation	10	10	10	10	10	10
Recreation	5	5	5	5	5	5
Water quality	13	13	14.1	13.6	13	13
Total for EWR site	**32**	**32**	**33.1**	**32.6**	**32**	**32**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.2 EWR site 13 (Regina Bridge)

The impact results of Scenarios 4, 5, 6, 7 and 8 on ecosystems services at EWR site 13 are shown in Table 21. As shown in Table 21, the impacts of the various water allocation scenarios on the resources at EWR site 13 shows that Scenarios 4, 7 and 8 have no effect whilst Scenarios 5 and 6 result in an increased utilization of fish, recreation and water quality resources. Important angling and recreational fishing species such as Smallmouth Yellowfish would be impacted to a greater extent than Largemouth Yellowfish. Scenario 5 had the greatest positive impact at EWR site 13 with a total score of 37 relative to the base scenario (Scenario 1) score of 33.

Table 21: Impact of water allocation scenarios on Ecosystems Services at EWR site 13

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	6	6	8.2	8.2	6	6
Riparian Vegetation	9	9	9	9	9	9
Recreation	5	5	5.5	5	5	5
Water quality	13	13	14.3	13.8	13	13
Total for EWR site	**33**	**33**	**37**	**36**	**33**	**33**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.3 EWR site 14 (Proklameersdrift)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 14 are shown in Table 22. As shown in Table 22, the impacts of the various water allocation scenarios on fish resources at EWR site 13 shows that Scenarios 4, 7 and 8 have no effect whilst Scenario 6 results in an increased utilization of resources such as fish, recreation and water quality. Scenario 5 was found to have a negative impact at EWR site 14 in the Middle Vaal WMA. The negative impacts were driven by impacts on fish species such as the Smallmouth yellowfish (*Labeobarbus aeneus*), Orange-Vaal mudfish (*Labeo capensis*) and Moggel, (*Labeo umbratus*) as a result of reduced flow levels leading to a decrease or disappearance of species from this reach and low levels of catches in recreational and subsistence fisheries. Scenario 6 had the greatest positive impact at EWR site 14 with a total score of 32 relative to the base scenario (Scenario 1) score of 31.

Table 22: Impact of water allocation scenarios on Ecosystems Services at EWR site 14

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	4	4	2.4	4.5	4	4
Riparian Vegetation	9	9	9	9	9	9
Recreation	6	6	6	6.5	6	6
Water quality	12	12	12	12	12	12
Total for EWR site	31	31	29.4	32	31	31

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.4 EWR site 15 (Fisantkraal)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 15 are shown in Table 23. As shown in Table 23, the impacts of the various water allocation scenarios on fish resources at EWR site 15 shows that Scenarios 5 and 7 had no effect whilst Scenarios 4, 6 and 8 resulted in an increased utilization of all fish resources including important angling and recreational fishing species such as Yellowfish. This is due to increased base flows during wet and dry season that may result in increased abundance of target species (Yellowfish) in both recreational and subsistence fisheries.

Table 23: Impact of water allocation scenarios on Ecosystems Services at EWR site 15

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	5	6.6	5	6.6	5	6.6
Riparian Vegetation	9	9	9	9	9	9
Recreation	4	4.2	4	4.2	4	4.2
Water quality	13	13	13.6	13	13	13
Total for EWR Site	**31**	**32.8**	**31.6**	**32.8**	**31**	**32.8**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.5 EWR site 16 (Downstream Bloemhof Dam)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 16 are shown in Table 24. As shown in Table 24, the impacts of the various water allocation scenarios on fish resources at EWR site 16 shows that Scenarios 4, 6, 7 and 8 have no effect on ecosystems services whilst Scenario 5 resulted in an improvement in water quality. The improved water quality was driven by positive impacts on water treatment costs, waste assimilation and waste dilution. It must be noted, however, that although Scenario 5 resulted in a net improvement in water quality relative to Scenario 1, poorer in water quality occurred in terms of increases in soil salinity and radioactive health risks.

Table 24: Impact of water allocation scenarios on Ecosystems Services at EWR site 16

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	6	6	6	6	6	6
Riparian Vegetation	10	10	10	10	10	10
Recreation	6	6	6	6	6	6
Water quality	13	13	13.4	13	13	13
Total for EWR site	**35**	**35**	**35.4**	**35**	**35**	**35**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.6 EWR site 17 (Lloyds weir on Harts River)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 17 are shown in Table 25. As shown in Table 25, the impacts of the various water allocation scenarios on fish resources at EWR site 17 shows that all scenarios have a positive impact on ecosystems services at the site. Scenario 4 had the highest net increase with a score of 33.6 relative to a score of 32 for Scenario 1.

Table 25: Impact of water allocation scenarios on Ecosystems Services at EWR site 17

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	4	5.1	5	5.1	5	5.1
Riparian Vegetation	10	10	10	10	10	10
Recreation	5	5.5	5	5.3	5	5.2
Water quality	13	13	13.2	13	13	13
Total for EWR site	**32**	**33.6**	**33.2**	**33.4**	**33**	**33.3**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.7 EWR site 18 (Schmidtsdrift)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 18 are shown in Table 26. As shown in Table 26, the impacts of the various water allocation scenarios on fish resources at the EWR site shows that Scenario 7 had no impact whilst Scenarios 4, 5, 6 and 8 all had positive impacts on ecosystems services. Increases in utilization of fish resources (Smallmouth yellowfish, Largemouth yellowfish, Sharptooth catfish, Orange-Vaal mudfish and Moggel) at this site could be due to increased flows. A 20 – 30% reduction in salt and nutrient levels from Scenario 6 could result in increased abundance and utilization of Yellowfish species. Scenario 6 had the highest net increase in ecosystem services with a score of 40.3 relative to a score of 36 for Scenario 1.

Table 26: Impact of water allocation scenarios on Ecosystems Services at EWR site 18

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	7	9.4	7	10.7	7	9.4
Riparian Vegetation	11	11	11	11	11	11
Recreation	6	6.5	6	6.6	6	6.5
Water quality	12	12	13	12	12	12
Total for EWR site	**36**	**38.9**	**37**	**40.3**	**36**	**38.9**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

5.4.8 EWR site 19 (Lilydale lodge)

The impact results of Scenarios 4, 5, 6, 7 and 8 on fish resources at EWR site 19 are shown in Table 27. As shown in Table 27, the impacts of the various water allocation scenarios on fish resources at the EWR site shows that Scenarios 5 and 7 have no effect whilst Scenarios 4, 6 and 8 results in increased utilization of ecosystems services at this site. Increases in the utilization of fish resources at this site may be due to increased base flows and improved water quality which may result in a small increase in the abundance and utilization of target fish species. Scenarios 4, 6 and 8 had the highest net increase in ecosystem services with scores of 36.7 relative to a score of 35 for Scenario 1 at this site.

Table 27: Impact of water allocation scenarios on Ecosystems Services at EWR site 19

Resources	Scenario					
	1 (base)	4	5	6	7	8
Fish	5	6.5	5	6.5	5	6.5
Riparian Vegetation	12	12	12	12	12	12
Recreation	6	6.2	6	6.2	6	6.2
Water quality	12	12	12.4	12	12	12
Total for EWR site	**35**	**36.7**	**35.4**	**36.7**	**35**	**36.7**

Note: Green indicates an increase in the utilisation; yellow indicates no change in the current utilisation; red indicates a decrease in utilisation.

6 CONCLUSIONS AND RECOMMENDATIONS

Of the initial eight water allocation scenarios identified for the study, the economic impacts of Scenarios 7 and 8 were modelled for several tributaries of the Vaal. Present day GDP and employment figures per EWR site were calculated using present day water abstraction at each EWR site and economic water multiplier for each economic zone within the Middle and Lower Vaal WMAs. The relevant economic zones were:

Middle Vaal WMA

- Vaal River main-stem;
- Rhenoster;
- Schoonspruit;
- Sand;
- Vet; and
- Vals.

Lower Vaal WMA

- Vaal River main-stem;
- Harts;
- Modder; and
- Riet.

Water use data were collected for various water users within the Middle and Lower Vaal WMAs. Major water users within these WMAs are:

- Irrigated agriculture;
- Mining and manufacturing; and
- Domestic and/or household consumption

Relevant data were collected for each user category and used to estimate water use. The data were then modelled using the SAFRIM and WIM methodology (consistent with the Upper Vaal study) producing baseline economic impacts based on the economic zones identified. The baseline results indicated that irrigated agriculture had a significant economic impact in the Lower Vaal WMA providing R524 million directly to GDP and 7,403 employment opportunities. Irrigated agriculture in the Middle Vaal provided R315 million directly to GDP and 6,027 employment opportunities.

While providing similar employment opportunities within the mining sector, the other industries within the Middle Vaal WMA provided significantly more employment opportunities and contributed more to total GDP than other industries within the Lower Vaal WMA.

The results of the socio-economic assessment indicated that significant deviations from present day demand for Scenario 8 were found for EWR R1 (Renoster), EWR 14 (Vals), EWR V1 (Vet) and EWR V2 (Vet). This implies that potentially significant economic impacts may occur as a consequence of providing the Ecological Reserve in the Renoster, Vals and Vet Rivers which are tributaries of the Vaal River.

The results for the main stem Vaal River showed that Scenario 8 caused more water to be pumped through the VRESAP pipeline and Sterkfontein Dam was operated at lower storage levels. The assurance of supply to users will, however, is not likely to be jeopardised by implementing the EWRs.

In terms of evaluating which Scenario is acceptable from a socio-economic perspective, Scenario 8 was the only Scenario evaluated against present day water use. It is recommended that, due to the highly negative socio-economic impacts found in the Renoster, Vals and Vet tributaries, further and more detailed investigations need to be conducted to more accurately assess the socio-economic costs and benefits of implementing the EWRs in these tributaries.

Irrigated agriculture is a major economic activity in these tributaries and the Renoster, Vals and Vet tributaries account for approximately 21 000ha of agricultural production within the Middle Vaal WMA (see Table 8). Much of the annual crop yield is also made up of cereals such as maize and wheat which may negatively affect regional and potentially national food security. Possible further research into this could entail a financial and economic analysis of irrigated agriculture along these tributaries based on water allocation or costs scenarios. The aim of the study should be to assess the impacts of increasing water cost to irrigators and assessing at what levels costs affect profitability. Necessary trade-offs that could be made should also be identified by such a study. The traffic diagram below (Figure 14) provides a graphic representation of the overall socio-economic impacts of Scenario 8 in the Middle and Lower Vaal WMAs.

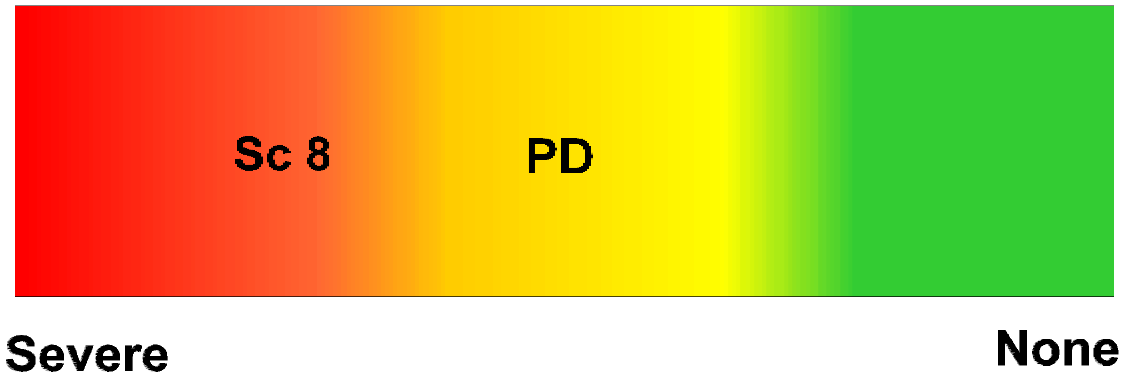

Figure 12: Traffic diagram of overall socio-economic impacts of Scenarios 7 and 8 for Middle and Lower Vaal WMAs

The methodology used to assess the impacts on Ecosystems Goods and Services in this study was based on that used for the Thukela study and was consistent with the approach used for the Upper Vaal WMA. Of the eight water allocation scenarios identified, Scenarios 4, 5, 6, 7 and 8 (described in Table 2) were evaluated per EWR site (shown in Figure 4). The approach investigated the impact of each scenario on Fish, Riparian Vegetation, Recreation and Water Quality resources per EWR site.

Overall, implementing the EWR at each EWR site showed no negative impacts except for Scenario 5 at EWR site 14. These negative impacts were driven by impacts on fish species such as the, Smallmouth yellowfish (*Labeobarbus aeneus*), Orange-Vaal mudfish (*Labeo capensis*) and Moggel, (*Labeo umbratus*) and result from reduced flow levels leading to a decrease or disappearance of species from this reach. Scenario 5 cannot, therefore, be recommended as acceptable from an Ecosystems Goods and Services perspective based on these negative impacts. Scenario 6 had the highest overall score for each resource in both the Middle and Lower Vaal WMAs and on this basis must be recommended as the most acceptable Scenario from an Ecosystems Goods and Services perspective. The traffic diagram below (Figure 15) provides a graphic representation of the overall impacts of each Scenario on Ecosystems Goods and Services in the Middle and Lower Vaal WMAs.

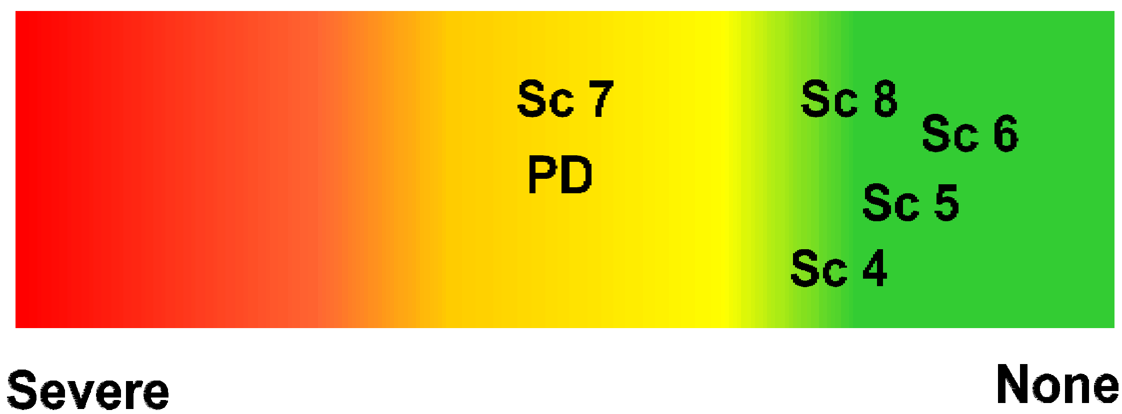

Figure 13: Traffic diagram of overall Ecosystems Goods and Services impacts of Scenarios 4, 5, 6, 7 and 8 for the Middle and Lower Vaal WMAs

7 CAPACITY BUILDING

The following are some learning's from members of the Golder Project Team whilst working on this interesting and challenging component of the Vaal Reserve Determination Study.

The socio-economic and ecosystems services components of the Comprehensive Reserve Determination Study for the Vaal WMAs are relatively small but important components of the overall Reserve Determination Study in terms of their role in quantifying the broader social and ecosystems impacts. The project team were multidisciplinary and professionals in each of their respective fields. Important lessons learnt from being included in the team are:

- Communication amongst project team members: Given the scale and scope of the Reserve Determination Study, effective communication amongst members of the project team has been vital to completing this work to an acceptably high standard. When the project team is large, however, communication becomes even more essential and on numerous occasions during this project, difficulties in communicating had to be overcome.

- Interdependence of project components: Understanding how project components are linked and how each component relates to one another is an important lesson learnt during this study. It is essential to understand the broader objectives of the project and how one component is responsible for or may affect or influence the component of another project team member.

- Professional conduct and presentation: Interacting with project team members gives one an opportunity to learn about how to conduct and present oneself professionally and appropriately at project team meetings and workshops.

8 LITERATURE CITED

Boyd J, and Banzhaf, S. (2006). What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units. Discussion Paper. Resources for the Future. Washington, DC.

Brand M, Maina J, Mander M and O'Brien G. (2009) Characterisation of the Social and Economic Value of the Use and Associated Conservation of the Yellowfishes in the Vaal River. WRC Report No. KV 226/09.

Conningarth Economists (2010). Personal Communications with Mr. William Mullins, Senior Economist at Conningarth Economists. CSIR Premises, Pretoria, South Africa.

De Villiers and Ellender (2007a). Status of the Orange-Vaal Smallmouth Yellowfish ***Labeobarbus Aeneus*** (Burchell, 1822), in *Technical Report on the State Of Yellowfishes in South Africa*. Report to the Water Research Commission by The Yellowfish Working Group, Edited by Impson ND, Bills IR and Wolhuter L.

De Villiers and Ellender (2007b). Status of the Orange-Vaal Largemouth Yellowfish, Labeobarbus Kimberleyensis (Gilchrist & Thompson, 1913) in Technical Report on the State Of Yellowfishes in South Africa. Report to the Water Research Commission by The Yellowfish Working Group, Edited by Impson ND, Bills IR and Wolhuter L.

Department of Water Affairs and Forestry, (1999). Vaal River Irrigation Study. DWAF Directorate Water Resources Report No. PC000/00/21599.

Department of Water Affairs and Forestry (DWAF). (2003). Middle Vaal Water Management Area: Water Resources Situation Assessment – Main Report – Volume 1 of 3. DWAF Report number P09000/00/0101.

Department of Water Affairs and Forestry (DWAF). (2003). Lower Vaal Water Management Area: Overview of Water Resources and Availability. DWAF Report number P WMA10/000/00/0203

Department of Water Affairs and Forestry (DWAF). (2009). Directorate National Water Resource Planning. Department of Water Affairs and Forestry, South Africa, September 2009. INTEGRATED WATER QUALITY Management Plan for The Vaal River System: Task 5: Water Quality Economic Impact Modelling. Report No. P RSA C000/00/2305/4.

Department of Water Affairs and Forestry (DWAF). (2010). http://www.dwa.gov.za/Projects/VaalWRMS/area.aspx. Accessed 3 March 2010.

Mander, M., Cox, D., Stipcich, D., Ngubane, S., Lewis, F. and Wiseman, B. (2007). Thukela Water Project: Reserve Determination Module Part 1 & 2. Institute of Natural Resources, Pietermaritzburg, South Africa.

Ramoejane M, Swartz E and Weyl O. (2010). The Genetic Integrity of ***Labeo*** Species (Cyprinidae) In South Africa In Relation To Inter-Basin Water Transfer Schemes. Proceedings of the 14^{th} Yellowfish Working Group Conference, Free State Province 16 – 17 April 2010. RSA C000/00/2305/4

Swart, S. (2010). Consultant. WRP Consulting Engineers. Personal Communication.

Van Wyk E, Breen CM, Roux DJ, Rogers KH, Sherwill T, and van Wilgen BW. (2006). The Ecological Reserve: Towards a common understanding for river management in South Africa. *Water SA* Vol 32 No 3. 403 – 409.

APPENDIX A

Comprehensive list of Ecosystems Services for the Middle and Lower Vaal WMAs

Resources	**Common Name**	***Scientific***
Fish	Rock catfish	*Austroglanis sclateri*
	Smallmouth yellowfish	*Labeobarbus aeneus*
	Chubbyhead barb	*Barbus anoplus*
	Sharptooth catfish	*Clarias gariepinus*
	Orange-Vaal mudfish	*Labeo capensis*
	Moggel	*Labeo umbratus*
	Southern mouthbrooder	*Pseudocrenilabrus philander*
	Banded tilapia	*Tilapia sparrmanii*
	Largemouth yellowfish	*Labeobarbus kimberleyensis*
Riparian vegetation		
Thatching	Thatching grass	*Hypparhenia hirta*
	Thatching grass	*Hypparhenia tamba*
Grazing	Guinea grass	*Panicum spp*
	Red Grass	*Themeda triandra*
	Eragrostis	*Eragrostis* spp.
	Couch grass	*Cynodon dactylon*
Trees (Fuel)	Sweet thorn	*Acacia karroo*
	Bluegum	*Eucalyptus spp.*
Trees (Medicinal)	Buffalo thorn	*Ziziphus mucronata*
	Cape Willow	*Salix mucronata*
	Karee	*Rhus spp.*
	Touch-me-not	*Melianthus comosus*
Trees (Traditional)	Raisin bush	*Grewia flava*
Recreation	Scenario Impact	Current Factor
Cultivated floodplains		
Rafting		
Canoeing		
Recreational Fishing'		
Recreational river use		
Ritual Use		
Water quality		
Water treatment costs		
Waste assimilation		
Waste dilution		
Pathogens treatments		
Pathogens productivity loss		
Cholera treatment		

Resources	**Common Name**	***Scientific***
Cholera productivity loss		
Water hyancinth		
Harmful algal blooms		
Soil salinity		
Aquatic macrophytes		
Radio-activity health risk		
Black fly		