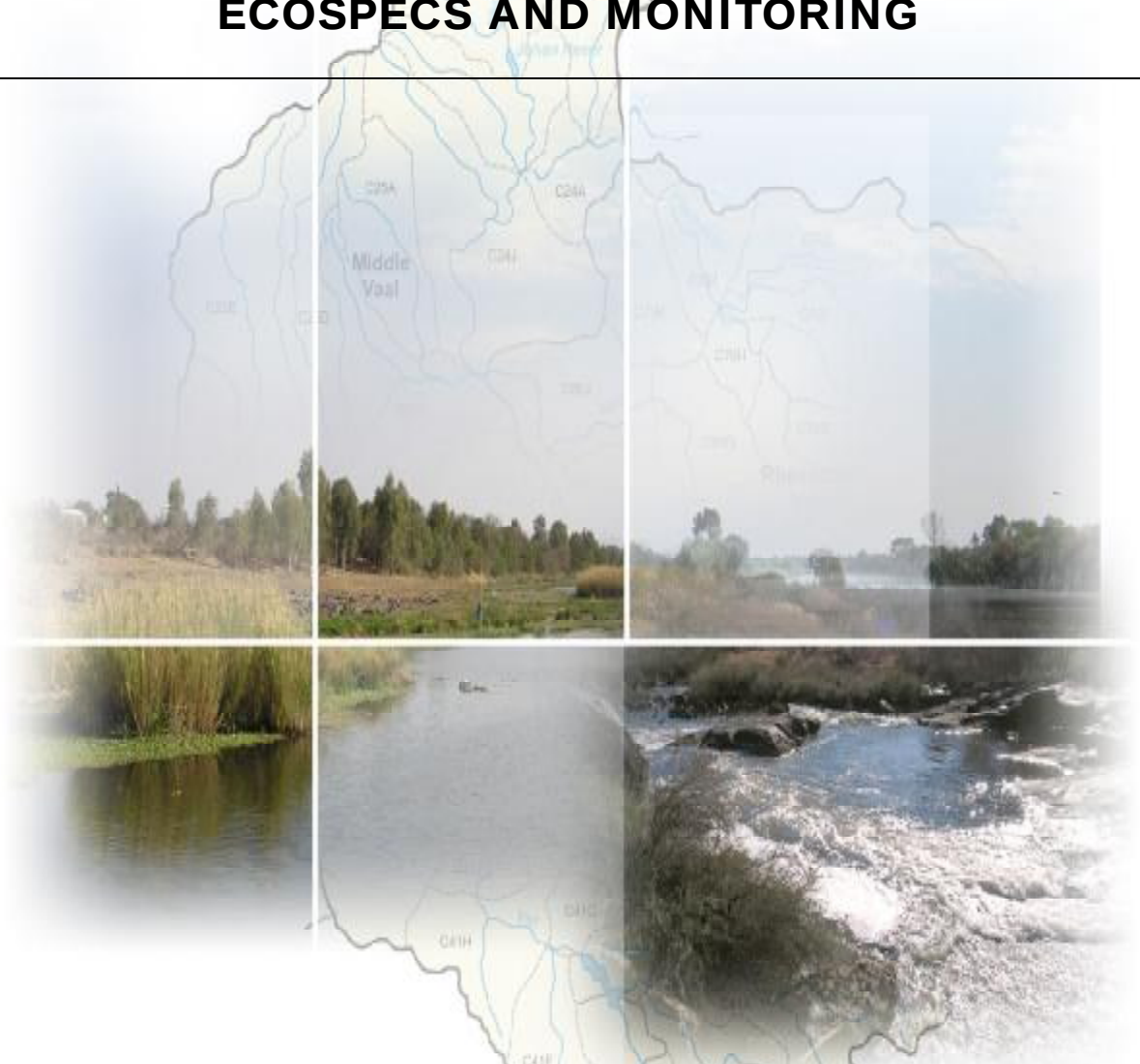
COMPREHENSIVE RESERVE DETERMINATION

INTEGRATED VAAL RIVER SYSTEM

SURFACE WATER

ECOSPECS AND MONITORING



TECHNICAL COMPONENT: MIDDLE VAAL

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EXECUTIVE SUMMARY

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for rivers, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve be determined and requirements met before other economic activities can be satisfied.

According to the Act all Reserve determinations that are currently determined and approved by the Department of Water Affairs (DWA) are preliminary Reserve determinations and the associated recommended class is a preliminary class (section 17(1)), until a system for the classifying of water resources has been prescribed.

As the Department of Water Affairs (DWA) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources. The Chief Directorate: Resources Directed Measures (CD:RDM) is the Directorate within the DWA tasked with the responsibility of ensuring that Reserve assessments take place before licensing can proceed.

The CD:RDM identified the Middle Vaal Water Management Area (WMA) as requiring a comprehensive Reserve assessment as to provide input to the Reconciliation studies and the integrated water quality management plan for the Vaal River studies undertaken by the National Water Resources Planning Directorate (D:NWRP) of the DWA. These studies require higher levels of confidence in the currently available Reserve determinations.

The CD: RDM initiated the Comprehensive Reserve Determination Study for selected water resources (rivers, wetlands and groundwater) in the Middle Vaal Water Management Area (WMA). The purpose of the Comprehensive Reserve Determination Study for the selected water resources of the Middle Vaal WMA is to determine the ecological and basic human needs water quantity and quality Reserve at a comprehensive level of confidence. This Reserve will assist the DWA to make informed decisions regarding the authorisation of future water use and assist with the implementation of the Classification System.

The Middle Vaal WMA forms part of the integrated Vaal River System, and falls within the C drainage region of South Africa. The Middle Vaal WMA is one of the three cascading WMAs in the Vaal River System catchment, which includes the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers. The Middle Vaal WMA covers a catchment area of 52 563 km^2, and includes parts of the Free State and North-West Provinces. It is situated in the north-western part of the country and forms part of the Orange River watercourse. The Vaal River flows in a westerly direction to the Lower Vaal WMA. It is the middle WMA within the Vaal River System, with water being transferred *via* the Vaal River through this WMA to Bloemhof Dam, from the Upper Vaal WMA to the Lower Vaal WMA. The WMA consists of the C24, C25, C41, C42, C43, C60 and C70 tertiary catchments.

The surface flow of the Vaal River, most of which originates in the Upper Vaal WMA, represents the bulk of the surface water in the Middle Vaal WMA. The Vaal River is fed by a number of tributaries of which the most significant are the Renoster, Schoonspruit, Vals and Vet Rivers. Vlei areas occur along the lower Vet River and in the upper Schoonspruit catchment. The surface water flows that originate within the WMA are highly seasonal and intermittent.

In this Middle Vaal Reserve study four Environmental Water Requirement (EWR) sites (EWR 12 – 15) were selected.

The final step in the Reserve process is to define the Ecological Specifications (Ecospecs) and monitoring requirements for the maintenance of the at each Ecological Water Requirement (EWR) site. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the quantity, quality and habitat and biotic integrity as they pertain to the ecological objectives for a particular water resource (in this case a particular river reach). These are the values of parameters (usually maximum concentrations) that should not be exceeded in order to meet the Ecological Category specified for the water resource.

This report details the EcoSpecifications and Thresholds of Potential Concern (TPC's) for the maintenance of the ecological Reserve for each EWR site for components consisting of the drivers (geomorphology, physico-chemical variables and hydrology) and the response (riparian vegetation, fish and macroinvertebrates).

The TPCs are "triggers" that indicate management action is required, and the monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are also described.

Monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are indicated per EWR site. These monitoring programmes should be rolled out as part of the implementation of the Vaal River catchment Reserve study.

The derived Ecospecs for the maintenance of the Reserve for each EWR sites should not be exceeded in order to maintain the water driver and response components of the Recommended Ecological Category (REC).

The following table is a summary of the proposed monitoring frequency for the Ecological Reserve for the Middle Vaal EWR sites 12 to 15.

Table A1 Summary of proposed monitoring frequency for the Ecological Reserve for the Middle Vaal.

Reserve component	**Monitoring Frequency**
Hydrology	Daily monitoring at closest DWA weir
Water Quality	Monthly, Quarterly (EC and Chlorophyll -a)
Geomorphology	• Every 2nd year: Daily hydrology and Fixed-point photography

	• Every 5 – 10 years: Bed material composition; Cross-sections and Aerial photographs
Fish	Monitoring should be conducted twice annually. If only once annually then the intermediate dry –wet season would be preferred.
Macroinvertebrates	Wet and dry season sampling
Riparian Vegetation	Monitoring should be conducted annually during the wet season (Spring to early Summer). Monitoring may be reduced to one survey every two to three years, however, any significant, change should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend

It is important to note that the proposed Rapid Habitat Monitoring Programme (RHAM) has not been tested in the Middle Vaal. If this programme is to be implement then the suggested monitoring frequency in Table A would altered and the RHAM monitoring would be used a s screening approach. If the TPC are triggered then the proposed monitoring in Table A would then be initiated.

The use of RHAM should be a cost effective screening monitoring programme that could be used in Reserve monitoring. Furthermore the development of diatoms as biotic response indicators (Rapid Diatom Riverine Assessment Method (R-DRAM)) should be closely monitored and when there is sufficient scientific evidence this documented method should be included as an assessment tool for water quality Reserve studies. The R-DRAM serves as a water quality screening tool and indicates which physico-chemical variable(s) require further monitoring and more detailed data analyses. This method could be a cost effective addition to the ongoing water quality monitoring and an early warning link to aquatic ecological impacts. It is recommended that this method be implemented in the Vaal catchment.

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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

1.1 BACKGROUND

Chapter 3 of the National Water Act (NWA) (Act No. 36, 1998) provides for the protection of water resources of the country through the implementation of Resource Directed Measures (RDM), based on the guiding principles of sustainability and equity. In terms of the Act, before any authorization to utilise a particular water resource can be granted, it is necessary to determine the Reserve for the relevant ecological component of the resource that will be impacted by the proposed water use. The Reserve can be defined as, 'the quantity, quality and reliability of water needed to sustain both basic human needs and aquatic ecosystems.

According to the Act all Reserve determinations that are currently determined and approved by the Department of Water Affairs (DWA) are preliminary Reserve determinations and the associated recommended class is a preliminary class (section 17(1)), until a system for the classifying of water resources has been prescribed.

The Chief Directorate: Resource Directed Measures (CD:RDM) is tasked with the responsibility of ensuring that the Reserve requirements, which have priority over other uses in terms of the Act, are determined before any new water uses are authorised. The Reserve requirements must be met, before the requirements for economic development or water uses are satisfied so as to ensure that the long-term integrity of ecosystems are not comprised or severely impacted upon'. As the Department of Water Affairs (DWA) is the custodian of the nation's water resources, it is their responsibility to ensure the adequate protection and effective management of these resources.

The CD: RDM initiated the Comprehensive Reserve Determination Study for selected water resources (rivers, wetlands and groundwater) in the Middle Vaal Water Management Area (WMA). The purpose of the Comprehensive Reserve Determination Study for the selected water resources of the Middle Vaal WMA is to determine the ecological and basic human needs water quantity and quality Reserve at an intermediate level of confidence. The final step in this process is to define the Ecological Specifications (Ecospecs) and monitoring requirements for the maintenance of the at each Ecological Water Requirement (EWR) site. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the quantity, quality and habitat and biotic integrity as they pertain to the ecological objectives for a particular water resource (in this case a particular river reach). These are the values of parameters (usually maximum concentrations) that should not be exceeded in order to meet the EC specified for the water resource.

The results of the Comprehensive Reserve determination study will assist the DWA to make more informed decisions regarding the authorization of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of the present and proposed developments.

This report provides the results of step 7 (Quantify Ecological Specifications and Monitoring Requirements) of the 8-step Reserve determination process (see Figure 1.1) for the rivers of the Middle Vaal catchment area. This report describes the ecological specifications and monitoring requirements for maintenance of the preliminary Reserve in the rivers in the Middle Vaal WMA as they relate to hydrology, water quality, geomorphology, vegetation, macro-invertebrates and fish.

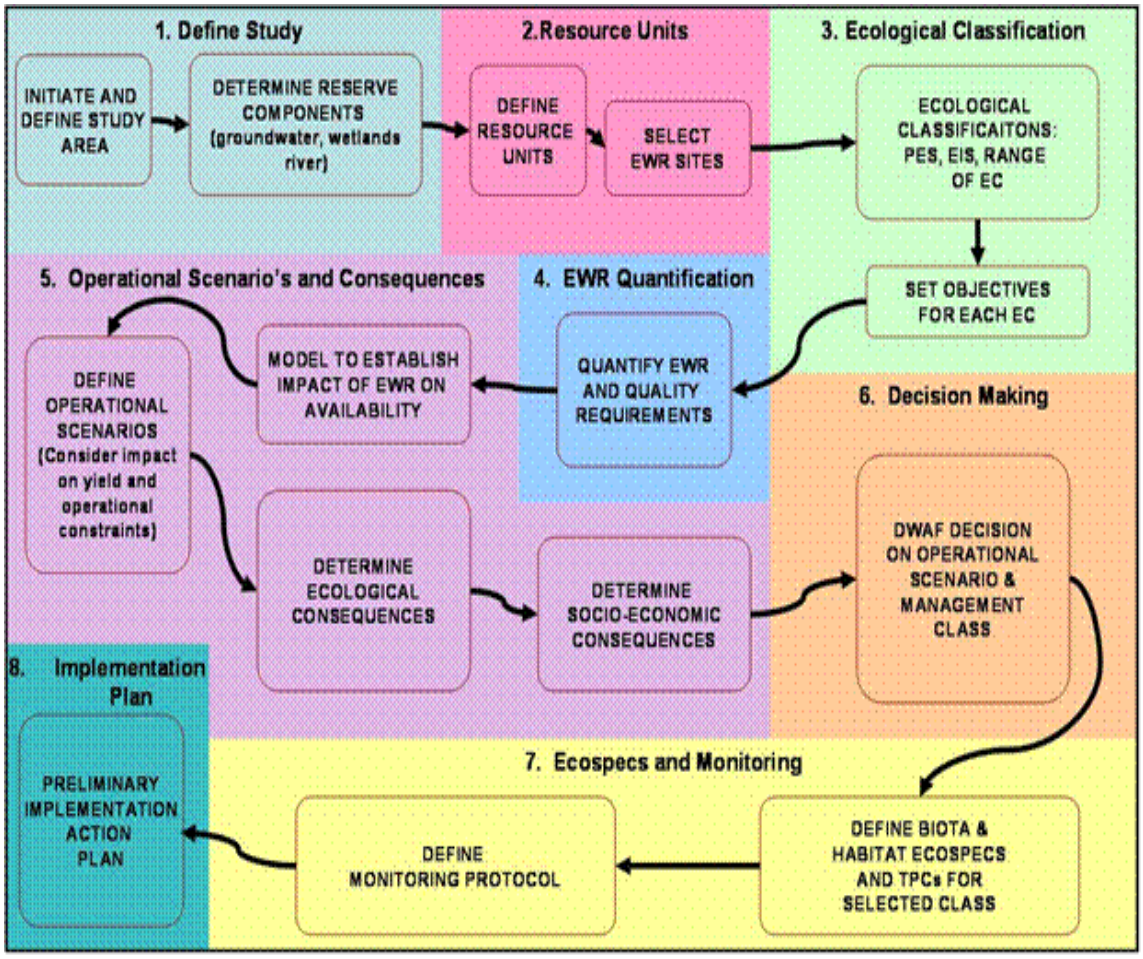

Figure 1.1: Generic procedure for the determination of the ecological Reserve

1.2 ECOLOGICAL SPECIFICATIONS AND THRESHOLDS OF POTENTIAL CONCERN

Ecological specifications (Ecospecs) are derived from the Resource Quality Objectives (RQOs) for the resource (specifically rivers, wetlands, estuaries and groundwater). RQOs are requirements for water quantity, quality and habitat and biotic integrity to be maintained in the resource. RQOs may encompass ecological, economic, social and political objectives. The Ecospecs are intended to provide the quantifiable and enforceable descriptors of the RQOs as they pertain to the ecological objectives for a particular resource (in this case a particular river reach).

Thresholds of Potential Concern (TPCs) are points along a continuum of change in selected Ecospecs, which prompt management action. Such action may involve attention to the causes of change or a reassessment of the validity of the Ecospecs or TPCs, as part of an adaptive management strategy.

A description of the theory behind Ecospecs, TPCs and monitoring is given in Kleynhans and Louw (2006).

1.3 STUDY AREA

The Middle Vaal WMA forms part of the integrated Vaal River System, and falls within the C drainage region of South Africa. The Middle Vaal WMA is one of the three cascading WMAs in the Vaal River System catchment, which includes the drainage area of the Vaal River from its headwaters to the confluence of the Vaal and Orange Rivers.

The Middle Vaal WMA covers a catchment area of 52 563 km^2, and includes parts of the Free State and North-West Provinces. It is situated in the north-western part of the country and forms part of the Orange River watercourse. The Vaal River flows in a westerly direction to the Lower Vaal WMA. It is the middle WMA within the Vaal River System, with water being transferred *via* the Vaal River through this WMA to Bloemhof Dam, from the Upper Vaal WMA to the Lower Vaal WMA. The WMA consists of the C24, C25, C41, C42, C43, C60 and C70 tertiary catchments.

The surface flow of the Vaal River, most of which originates in the Upper Vaal WMA, represents the bulk of the surface water in the Middle Vaal WMA. The Vaal River is fed by a number of tributaries of which the most significant are the Renoster, Schoonspruit, Vals and Vet Rivers. Vlei areas occur along the lower Vet River and in the upper Schoonspruit catchment. The surface water flows that originate within the WMA are highly seasonal and intermittent.

Selected Environmental Water Requirement (EWR) sites (EWR 12 – 15) are indicated in Table 1.1 and in Figure 1.2. A rapid Reserve Determination was also undertaken on the Klein Vet River (Table 1.1). The reason why this site was added was for potential extrapolation purposes.

Table 1-1: Selected EWR sites for the Middle Vaal catchment

EWR Site number	EWR site name	River	National RHP[1] site	Coordinates		EcoRegion (Level II)	Geomorphic zone	Altitude (m)	RU[2]	Quaternary catchment	Hydrological gauge
				Latitude	Longitude						
EWR12	Vaal River: Vermaasdrift	Vaal	C2-Vaal Orkne	S26.93615	E26.85025	11.01	E: Lower Foothills	1348	MRU Vaal F	C24A	C2H007
EWR13	Vaal River: Regina bridge	Vaal	C2-Vaal Orkne	S27.10413	E26.52185	11.08	E: Lower Foothills	1285	MRU Vaal G	C24J	C2H061
EWR14	Vals River: Proklameersdrift	Vals	C6Vals-Prokl	S27.48685	E26.81320	11.07	E: Lower Foothills	1400	MRU Vals B	C60J/C60G	C6H003
EWR15	Vet River: Fisantkraal	Vet	C4-Vet-Hoops C4-Vet-Erfen	S27.93482	E26.12569	11.08	E: Lower Foothills	1247	MRU Vet C	C43A	C4H002
Rapid EWR – RE-EWR 3	Klein-Vet, just downstream of Winburg	Klein Vet	C4GVet-V4	S28.564708	E26.943946	11.03	E: Lower Foothills	1367	MRU Vet A	C41A	

[1]: River Health Programme; [2]: Resource Unit

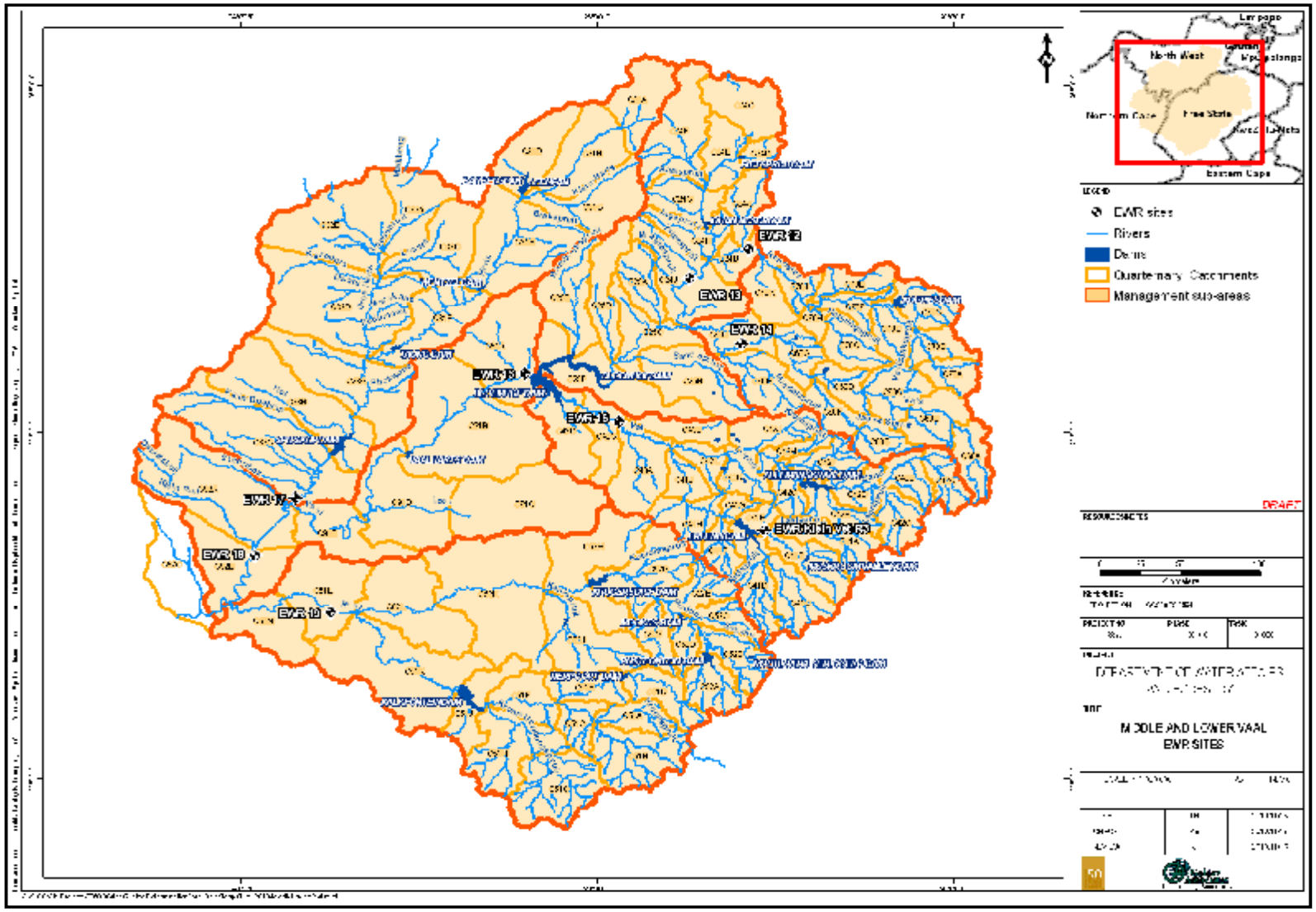

Figure 1.2: Resource Units and selected EWR sites for the Middle and Lower Vaal catchment

1.4 ECOLOGICAL CLASSIFICATION

The Present EcoStatus (PES), and the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for which Reserves were determined for each of the sites are given in Table 1.2.

Table 1-2: The Present EcoStatus (PES), the Recommended Ecological Category (REC) and Alternative Ecological Category (AEC) for the Middle Vaal EWR sites

EWR Site	River	Quaternary Catchment	PES	Importance	Ecological Category		
				EIS	REC	Alternatives	
						AEC up	AEC down
EWR 12	Vaal	C24A	D	Moderate	D	C/D	
EWR 13	Vaal	C24J	C	High	C	C	C
EWR 14	Vals	C60J/C60G	C/D	High	C/D	C	D
EWR 15	Vet	C43A	D/E	Moderate	D	D	

1.5 DESCRIPTORS OF ECOLOGICAL CONDITION FOR WHICH ECOSPECS ARE PROVIDED

In this report Ecospecs and TPCs are provided for the following disciplines:

- Hydrology
- Water Quality
- Geomorphology
- Fish
- Macroinvertebrates
- Vegetation.

1.5.1 Hydrology

The surface flow of the Vaal River, most of which originates in the Upper Vaal WMA, represents the bulk of the surface water in the Middle Vaal WMA. The surface water flows that originate within the WMA are highly seasonal and intermittent. The Vaal River is fed by a number of tributaries of which the most significant are the Renoster, Schoonspruit, Vals and Vet Rivers. Vlei areas occur along the lower Vet River and in the upper Schoonspruit catchment. The surface water occurring in the WMA has been developed to its

potential and all water is being fully utilised. There are several large dams that have been developed in the WMA :

Dam name	Quaternary catchment	River	Purpose	Full Storage Capacity million m^3
Bloemhof	C91A	Vaal	Irrigation	1 218.0
Allemanskraal	C42E	Sand	Irrigation	179.3
Bloemhoek	C60D	Jordaan Spruit	Domestic	19.6
Erfenis	C41E	Vet	Irrigation	212.3
Johan Neser	C24G	Schoonspruit	Irrigation	5.7
Klipplaatdrift	C25A	Vaal		5.7
Koppies	C70C	Renoster	Irrigation	41.1
Marquard	C41A	Laai Spruit	Domestic	2.3
Rietspruit	C24D	Schoonspruit	Irrigation	7.3
Three Sisters	C42F	Sand		1.2
Uniefees	C70C	Eland Spruit	Domestic	1.4

Most of the major tributaries of the Middle Vaal WMA support irrigation schemes. The Sand-Vet Irrigation Scheme within the Sand-Vet Government Water Scheme (GWS) is the most important in the Middle Vaal WMA. Other significant irrigation schemes in this WMA are the Schoonspruit and Rhenoster GWS.

General description of overall system operation

The Integrated Vaal River System is designed to maximise the long term water yield from the system. This is achieved by using water first from the most downstream impoundment in the system and only when depleted, water is released from upstream reservoirs to support the water requirements. The Integrated Vaal River System includes ten subsystems, seven transfer schemes and various internal supply schemes in the system, including the Vaal River Eastern Subsystem. The subsystems that form part of the Comprehensive Reserve Determination study area include the Lower Vaal Subsystem, Bloemhof Subsystem, Senqu Subsystem, Grootdraai Subsystem, Zaaihoek Subsystem, Heyshope Subsystem and Usutu subsystem. The Middle Vaal WMA forms part of the Bloemhof Subsystem of the Integrated Vaal River System, which extends from just downstream Grootdraai dam to Bloemhof Dam. The catchment area of this subsystem includes four large dams - Bloemhof, Vaal and Sterkfontein in the Vaal River catchment and Woodstock Dam in the upper part of the Thukela River catchment with a combined capacity of 6 840 million m^3.

Water stored in Bloemhof Dam is used to supply the downstream irrigation and urban users and only if Bloemhof Dam is empty will water be released from Vaal Dam to support those demands. Users along the

Middle Vaal Reach (between Vaal Barrage and Bloemhof Dam) are supplied with incremental run-off supplemented from Vaal Barrage and if required from Vaal Dam. The objective is to only release sufficient water to satisfy the requirements of the users in the reach. In addition, releases are occasionally made from Vaal Dam for blending purposed. These releases are mostly captured in Bloemhof Dam for subsequent supply to the downstream users.

Vaal River inflow from Upper Vaal WMA (C24A) – at Vermaasdrift

The Middle Vaal WMA is dependent on the Upper Vaal WMA for meeting the bulk water requirements of its mining, industrial and urban sectors in the Klerksdorp-Orkney and Welkom-Virginia areas. Large quantities of water are transferred into the WMA to augment local water resources. The North West Goldfields, therefore urban and bulk water requirements account for 40% of total requirements. The main urban centres are Klerksdorp, Orkney and Stilfontein in the NW Goldfields and Odendaalsrus in the Free State. The requirements of Stilfontein, Buffelsfontein, Vaal Reefs and Hartebeesfontein Gold Mines make up the bulk requirements in the area. Effluent returns from these towns and mines increase the water resources of the area significantly. This area also exports water from the Vaal River to a number of adjacent key areas, the most significant being Sedibeng Water export of water at Balkfontein to the Free State Goldfields in the Vet key area.

The local water resources within the WMA are used by smaller towns (Bothaville and Wolmaranstad) and for irrigation. Some small transfers also occur from Vaal Dam to Heilbron in the Middle Vaal WMA and out of Erfenis Dam to the Upper Orange WMA. Water is also transferred via the Vaal River through this WMA to Bloemhof Dam, from the Upper Vaal WMA to the Lower Vaal WMA. Management of water quality and quantity in the Middle Vaal WMA is therefore integrally linked to both the Upper and Lower Vaal WMAs. Notable abstractions in the river reach between Vaal Barrage and Bloemhof Dam include Midvaal Water, Sedibeng Water and abstractions for irrigation. These abstractions are supported with releases from Vaal Barrage (backed by Vaal Dam). The releases from Vaal Barrage are driven by either these downstream water requirements or through excess water in the Vaal Barrage (spills).

The water entering Middle Vaal WMA from the Upper Vaal WMA brings with it a large contribution of urban, industrial and mining return flows from the highly industrialised and urbanised areas within the Upper Vaal WMA. These carry with it high salinity levels and high nutrient concentrations which are “transferred” into the Middle WMA. As a consequence these high salinity levels need to be managed through dilution with fresh water from Vaal Dam to ensure water of an acceptable quality reaches the Middle Vaal WMA.

Vaal River from Vaal Barrage to downstream of the confluence with the Schoonspruit

Three conditions or events influence the flow in this reach. Firstly, releases are made from Vaal Barrage (source Vaal Dam) to supply urban and industrial demands as well as riparian irrigation. The releases to these users are dependent on the run-off from the incremental catchments and are adjusted on a short term basis. Due to the limiting storage capacity at the intakes of these users, no flexibility exists in terms of the short term release rate.

Secondly, during prolonged droughts additional releases are made from Vaal Dam for users downstream of Bloemhof Dam. These releases can be reasonably flexible with respect to the discharge rate and pattern

within a monthly period due to the buffering capacity of Bloemhof Dam. The governing rule for these releases (in terms of seasonal and annual timescales) is to only release sufficient water to satisfy the demand.

A third condition, to achieve specific water quality blending objective (the additional release of Vaal Dam water to maintain the TDS concentration in Vaal Barrage at 600 mg/l) may cause additional "spills" over Vaal Barrage. This is necessary due to the high salinity (TDS) content of the underground mine water that is pumped out of the gold mines into the river system and surface runoff from the highly urbanised areas in the incremental catchment of the Vaal Barrage. The flow rate into this reach is also flexible over the short term.

Goldfields Water and MidVaal Water Company withdraw significant amounts of water from the Vaal River within this reach.

The Pilgrims Estate weir (C2H007) which also influences flow in the Middle Vaal River is located just outside Orkney. The weir captures the inflows from the Koekemoerspruit and Vierfontein Spruit, and supports irrigation upstream of the Schoonspruit and Koekemoerspruit catchments. The MidVaal Water Company abstraction is at the Pilgrims Estate weir.

Vaal River from Schoonspruit confluence to Bloemhof Dam wall

The system operation of 'Vaal Barrage to Schoonspruit reach' applies to this reach as well with the addition of run-off from the incremental catchment. It is important to note that developments in the form of small dams and irrigation schemes along the tributaries contributing to this reach do reduce the run-off to the Vaal River.

The Klipplaatdrift weir (C2H061) is situated approximately 60 km downstream of the Pilgrims Estate weir (at Balkfontein). Sedibeng Water abstracts it water at the Klipplaatdrift weir. There is an operational problem at the Balkfontein abstraction point as storage at the Balkfontein weir is too low. Consequently releases from the Vaal Dam need to coincide with actual water requirements in this catchment to ensure that the weir does not overflow or that water shortages do not occur. Sedibeng Water also enjoys a conditional water use from Allemanskraal when the dam is overflowing, provided that the Reserve requirements are catered for. This water is cheaper and of a better quality than water from the Vaal River (DWAF, 2004).

Renoster (C70): The Renoster River has its origin south of Petrus Steyn in the South Eastern Free State. It includes the C70 tertiary catchment (C70A to C70K). The major town influencing the Renoster River is Petrus Steyn. The Rhenoster catchment is rural in nature and has significant controlled irrigation and rural requirements (87 % of total requirements). Heilbron and Viljoenskroon are the most significant urban centers in the area. Water is imported from the Upper Vaal WMA (Vaal Dam) to supply the needs of Heilbron. This catchment area does not contribute to the yield of the Vaal River. The potential for water resources development within the key area is mostly limited to the exploitation of groundwater.

Only one dam exists, namely Koppies Dam, which was constructed mainly for irrigation purposes and completed in 1912. The height of the dam wall was increased to 5.94m in the late 1970's. Water is released through a channel system back into the original river channel. The presence of a large number of weirs (61), road bridges and roads has resulted in a large to serious impact on the Renoster River. Koppies Dam also adds to this impact. Koppies Dam provides flow regulating capability. The yield balance situation is such

that the water available from the dam is fully utilised. There is also significant water use from the river downstream of the dam to the extent that there is not excess water available. The Voorspoed Mine has recently purchased water rights from irrigators that were supplied from Koppies Dam as part of the Koppies Government Water Scheme.

Large areas of the river are inundated and this has a serious impact on the flow, bed and channel of the river. The riparian zone is also impacted on by these obstructions in the river as the wetted and dry riparian zones of the river are altered. The many abstraction pumps present also indicate that there is a large volume of water abstracted from the river although not many irrigated lands were visible.

Koekemoerspruit (C24B)

The Koekemoerspruit catchment is highly altered by catchment development. The river falls within the C24B quartenary catchment. The Koekemoerspruit flows through the Hartebeesfontein and Stilfontein mines and is upstream of Klerksdorp and the Midvaal Water Company. Catchment development has led to severe deterioration in water quality. Major impacts on water quality include mining pollution, urban run-off, sewage effluent and irrigation return flows. The water quality issues in the catchment have an impact on the water abstracted by MidVaal Water. Flow in the Koekemoerspruit is measured at the Buffelsfontein weir (C2H139), however the gauging station is totally unreliable for gauging due to serious submergence problems (DWAF, 2007). There have been concerns that water is disappearing from the Koekemoerspruit however this has been difficult to prove due to rapidly changing flows in the river.

The Buffelsfontein weir is also used to monitor the water quality of the discharges from the goldmines in the area, and whether the Margaret shaft water is entering the Vaal River. However this has not yet been proven.

Schoonspruit (C24)

As with the Koekemoerspruit, the Schoonspruit catchment is also characterised by intensive development. The Schoonspruit catchment comprises of six quaternary catchments C24C, C24D, C24E, C24F, C24G and C24H. Quaternary C24C and parts of C24E and C24F are considered as endoreic areas, as the surface runoff generated in these areas flow to localised pans in the area and therefore do not contribute to the stream flow in the Shoonspruit and its tributaries. The Schoonspruit Eye forms the origin of the Schoonspruit in the southern part of quaternary catchment C24C. Just downstream of the Schoonspruit Eye a diversion weir was constructed to divert water into the Schoonspruit Canal. The diversion weir (C2H064) is also used as a gauging weir to measure excess water that is not diverted into the canal but spills over the weir back into the mainstream of the Schoonspruit. The Schoonspruit canal supplies water to Ventersdorp as well as to the whole Schoonspruit Irrigation Scheme. The Right Bank Canal conveys the water to the Ventersdorp Municipality off take and further along the canal at Kalk Dam, the Municipality also abstracts water for agriculture use in the town.

At the Kalk Dam, there is a structure that can reject excess water into the Schoonspruit as well as allowing water to flow underneath the Schoonspruit by means of a siphon to a canal. This canal supplies water for irrigation up to the Rietspruit Dam as well as supplies water by means of the Elandskuil siphon to the Elandskuil Dam and canal on the Right Bank of the Schoonspruit. All the excess water flows into the Rietspruit Dam. The Elandskuil Dam supplies water for irrigation and is considered more as a balancing

dam. The Rietspruit Dam captures runoff from the Rietspruit catchment and is used to supply water for irrigation by means of a canal system (DWAF, 2006).

Significant irrigation developments started on the dolomitic aquifer recharge areas in the late nineteen eighties. Irrigation water for these new developments was obtained from the dolomitic aquifers through boreholes. To be able to protect the resource the minister proclaimed the Ventersdorp Eye subterranean Government Water Control Area (G.W.C.A) in June 1995.

The Klerksdorp Irrigation Scheme is located downstream of the Schoonspruit Irrigation Scheme and originates on the farm Witpoort and stretches to the Vaal River. Abstraction of water takes place at five points in and around Johan Neser Dam. The irrigation scheme includes weirs, directing pumping from the dam and river, a canal system and a 400 mm pipeline from the Johan Neser Dam to supply irrigation developments.

Informal or diffuse irrigation also takes place within the tributary sub-catchments of the Schoonspruit. Water is abstracted directly from the streams or from farm dams located in the tributary sub-catchment. Urban/Industrial return flows from Klerksdorp, Hartbeesfontein and Orkney enter the lower Schoonspruit catchment downstream of Johan Neser Dam. Return flows from Ventersdorp is relatively small and enters the Schoonspruit downstream of Kalk Dam.

Vals River (C60)

The Vals River which includes the C60 tertiary drainage region of the Vaal River catchment has its origin in the vicinity of Bethlehem from where it flows past Lindley in the north-westerly direction to Kroonstad and on to Bothaville from where it flows into the Vaal River. Various tributaries enter the Vals River of which the Elandspruit is the largest. While the Vals River catchment is rural in nature, it has significant urban requirements (73 % of total water requirements). The urban requirements are dominated by the requirement of Kroonstad Municipality. Water is imported from the Vaal River by Sedibeng Water to supply the needs of the Bothaville local municipality. Treated sewage and storm water returns from Kroonstad in particular contribute significantly (33 % of total resource) to the water resources of the Vals key area. All irrigation in the Vals catchment is regarded as diffuse and is not significant. The catchment does not contribute to the yield of the Vaal River. This river system does not have storage regulation capability with release capabilities, with the result that high flow control and management is not possible.

Serfontein Dam is the only large Dam in the catchment on the Vals River and it is located near Kroonstad. It has a small storage relative to the runoff. The Serfontein Dam has a capacity of 4.200million m^3 and a surface area of 1.58 km^2. Seasonal water releases are made from the dam. The yield balance situation is such that there are deficits in supply as was recently experienced in restrictions to the town of Kroonstad.

Water quality deterioration as a result of Kroonstad, Lindley and Bothaville Sewage Works runoff as well as runoff from irrigated and dry lands has a serious to critical impact on the Vals River. Prolific growth of algae in the lower reach of the river has been observed.

The overall modification to bed, channel and flow in the Vals River is moderate to large due to the presence of several weirs, roads through the river and road bridges over the river, as well as Serfontein Dam. Some sand mining occurs in the river and these lead to bank erosion and siltation of the river.

Sandspruit (C25B)

The Sandspruit is located in quaternary catchment C25B of the Vaal River System. It is an ephemeral river that flows only during certain times during the year. There are no structures, weirs or dams.

Makwassie (C25D)

As with the Sandspruit the Makwassie is also an ephemeral river, with no flow regulation in the catchment.

Vet River (C40)

The Vet River catchment includes the secondary drainage (C4) of the Vaal River catchment. The Sand River is a major tributary of the Vet River. The river system includes two major dams, Erfenis on the Vet River and Allemanskraal Dam on the Sand River. The available water resources in this river system are fully utilised. Allemanskraal Dam (located in quaternary C42E) on the Sand River and Erfenis Dam (located in quaternary C41E) on the Vet River have flow release regulating capabilities.

The water resources of this catchment area are augmented by transfers from Vaal River by Sedibeng Water for urban and bulk use in the Free State Goldfields and by the upstream yields of Erfenis and Allemanskraal catchment areas. The mining and urban water requirements of the Free State Goldfields dominate the water requirements of this catchment. The main urban centres are Welkom and Virginia and the main mines are Harmony, President Steyn, African Rainbow Minerals and Bambanani Gold Mines. Returns flows from these users contribute about 10 % to the water resources of the catchment.

Irrigation water requirements for controlled irrigation are significant in the Vet River catchment and are the most important in the Middle WMA as a whole. Approximately 122 km^2 is scheduled for irrigation in three areas, namely Sand-Vet GWS (Sand), Sand-Vet GWS (Vet) and Vet River GWS. Actual irrigation requirements are significant therefore Vet River catchment does not contribute to the yield of the Lower Vaal WMA.

The Allemanskraal Dam and Erfenis Dam catchments are rural in nature. In the Allemanskraal catchment area consumptive requirements by urban and rural users make up the rest of the requirements, with irrigation water requirements not being significant. Senekal is the most important urban centre in the area. The upper reaches of this catchment do contribute to the downstream yield of the Sand River.

There is an export of water from Erfenis Dam to Brandfort local municipality in the Upper Orange WMA. Irrigation water requirements are also not significant in the Erfenis Dam catchment. Winburg and Marquard are the most important urban centres in the catchment area.

Bloemhof Dam (C25, C43)

Bloemhof Dam was built in 1970 and helped to relieve Vaal Dam of part of the downstream water demands. Bloemhof Dam is the most downstream regulating storage in the subsystem with the function of supplying the water requirements in the Low Vaal Subsystem as their primary resource. The releases from the dam are made in accordance with a daily schedule of water requirements that are updated on a weekly basis. Since the water requirements supplied from Bloemhof Dam is more than the supply capability (incremental yield) of the dam, releases are made from Vaal Dam (via Vaal Barrage) once the water level in Bloemhof Dam reaches its minimum operating level.

Various sub-catchments contribute to the flow into Bloemhof Dam with each having various dams and water abstractions all impacting on the supply capability of the dam. There are no release obligations from these sub-catchments with the result that only spills from these dams and unused runoff flows into Bloemhof Dam.

The requirements of this catchment area are dominated by non-consumptive requirements. Consumptive requirements by urban and rural users are small in comparison, approximately, 3% . Wolmaransstad and Wesselsbron are the most important urban centres in the catchment area. There is no significant irrigation in this area. The potential for water resources development in this area is controlled by requirements in the Upper Vaal WMA and the upstream Middle Vaal River catchment area and by the scheduled irrigation requirements of the downstream Lower Vaal WMA.

Hydrological Ecospecs

The hydrological Ecospecs are encompassed in the water quantity aspects of the Ecological Reserve (Riverine RDM Report). The following descriptors of the hydrological characteristics are used:

- Total Mean Annual Maintenance volume
- Monthly Mean Maintenance flow
- Monthly exceedance curves for the low flows
- Monthly exceedance curves for the complete flow regime
- Duration, magnitude (in daily average peak), volume and timing of intra-annual floods.

The Reserve information for the various rivers in the study area is provided in detail elsewhere. It is not repeated in this report.

1.5.2 Water quality

The water quality Ecospecs are encompassed in the water quality aspects of the Ecological Reserve. The following water quality variables are included in the water quality Ecospecs either quantitatively or qualitatively:

- $MgSO_4$ (mg/L)
- Na_2SO_4 (mg/L)
- $MgCl_2$ (mg/L)
- $CaCl_2$ (mg/L)
- NaCl (mg/L)
- Total inorganic nitrogen (TIN) in mg/L
- Soluble Reactive Phosphorus (SRP) in mg/L
- pH
- Water temperature (°C)
- Dissolved oxygen (DO) in mg/L
- Turbidity (NTU)
- Electrical conductivity (mS/m)
- Chlorophyll a (Chl a) as periphyton algae (mg/m^2)
- Chlorophyll a as phytoplankton algae (µg/L)
- Toxic substances.

The Ecological Specifications (Ecospecs) for the maintenance of the Water Quality Reserve for each EWR site are the values of water quality parameters (usually maximum concentrations) that should not be exceeded in order to meet the water quality component of the Recommended Ecological Category (REC).

The Thresholds of Potential Concern (TPCs) which are "triggers" that indicate management action (further investigation into the cause of a potentially problematic water quality constituent) is required, and the monitoring activities that should be undertaken in order to measure the Ecospecs and TPCs are also described.

The water quality Ecospecs and TPCs were derived using methods from DWAF (2006); DWAF (2006b) and Muller and Scherman (2007).

The Present Ecological State for water quality (WQ PES), the Overall PES, the Ecological Importance and Sensitivity (EIS), and the Recommended Ecological Category (REC) for EWR sites at which an Intermediate Reserve determination was done are given in Table 1.3. EIS is high for all the EWR sites and thus the overall REC is equal to the overall PES *i.e.* the recommendation is that all sites be maintained in the current EcoStatus. In order to achieve this, it is necessary for water quality also to be maintained at the current (or better) level of impacts.

Table 1-3: Summary of the Middle Vaal EWR sites and the REC for water quality

Site (River)	EWR no.	EWR site and WQSU	Overall PES	WQ PES	EIS	Overall REC	REC for water quality
Vaal	EWR 12	Vaal River: Vermaasdrift WQSU 41	D	D	Moderate	D	D

Site (River)	EWR no.	EWR site and WQSU	Overall PES	WQ PES	EIS	Overall REC	REC for water quality
Vaal	EWR 13	Vaal River: Regina bridge WQSU 48	C	D	High	C	D
Vals	EWR 14	Vals River: Proklameersdrift WQSU 52	C/D	C/D	High	C/D	C/D
Vet	EWR 15	Vet River: Fisantkraal WQSU X	D/E	C	Moderate	D	C

The approach followed in specifying the Ecospecs for the REC was to use the boundary value as given in the Riverine RDM Report for the current PES category for each variable. In cases where there was a negative trend for a water quality variable or where the variable was currently in a lower category than the REC, the Ecospecs was to improve by half or one category.

Since the hydrological regime under the REC is designed to maintain PES, major changes in water quality as a consequence of altered flow are not expected. Changes in water quality in the future are more likely to be a consequence of changes in land use (diffuse pollutants) or new point-sources of pollutants. Nevertheless it is important to keep in mind the following general relationships between flow and water quality:

- A decrease in flow is likely to result in increased concentrations of chemical constituents as a consequence of the reduced dilution capacity of the system.
- The range in daily in stream temperature is likely to increase if flow is reduced due a reduction in the buffering capacity. Thus during the summer, hotter day temperatures can be expected and during the winter, colder temperatures can be expected during the night.
- Dissolved oxygen (DO) concentrations will decrease as water temperature increases.
- Dissolved oxygen concentrations may also be lowered if flow is reduced due to reduction of aeration, a consequence of fewer riffle areas.
- pH is unlikely to show a marked change in response to changes in flow.

There are few data for the catchments under consideration for DO, temperature, turbidity or Chlorophyll *a*, and monitoring of these variables is highly recommended (possibly by installing data loggers for DO and temperature). As such, they have been included in the monitoring programme.

There was an incompatibility between water quality data obtained from the DWAF WMS database and the data format required to run the model "TEACHA." As a result, the theoretical concentrations of the salts

that are normally examined during a water quality Reserve study ($MgSO_4$, Na_2SO_4, $MgCl_2$, $CaCl_2$, and NaCl) could not be calculated. TPCs are also set for physico-chemical parameters for the site, i.e. to monitor a deterioration from present state. TPCs are presented as 95th percentiles, i.e. values not to be exceeded more than 5% of the time, for inorganic salts, physical variables and toxics; and 50th percentiles for nutrients, i.e. Total Inorganic Nitrogen (TIN), Soluble Reactive Phosphorous (SRP) or ortho-phosphate and Chlorophyll-*a* (Chl-a). The TPC ranges are defined by the upper boundary of the PES category and 80% thereof for the lower boundary, e.g. if a B category for a PES EcoSpec is < 15 mg/L, the associated TPC would be 12 – 15 mg/L.

Percentiles should be calculated within the framework of the current assessment method (DWAF, 2008), i.e. using the PES monitoring point as shown on the table for the relevant EWR site, and the most recent 3 to 5 years of data, equivalent to a minimum of 60 data points. Data used from the DWA gauging weir must be requested from DWA's Water Management System's (WMS) database.

- EcoSpecs, i.e. water quality specifications or objectives for the Recommended Ecological Category (REC), are set for physico-chemical parameters only, i.e. quantifiable measurable parameters.

- EcoSpecs, i.e. water quality specifications or objectives for the Present Ecological State (PES), are set for physico-chemical parameters only, i.e. quantifiable measurable parameters.

Quality EcoSpecs are therefore related to attaining the water quality category of the overall REC or PES, and are presented as the range that each variable should be in to maintain the required category for that variable. The category specified per variable, and the composition of categories for all variables, will depend on the drivers of water quality per site.

1.5.3 Geomorphology

Reserve monitoring is required to assess the efficacy of the requested flows for the environment. Monitoring should thus be focussed on those descriptors of the system that are sensitive to flow alterations. However, the geomorphological condition at a monitoring or EWR site can be affected by both the upstream flow alterations as well as adjacent landuse activities. Thus there may not always be simple cause-effect relationships between geomorphological descriptors and flow conditions, and one should be aware of possible changes to river geomorphology that are not directly flow related. Additionally, antecedent events such as large natural flood events may temporarily create apparently undesirable changes that are not directly related to the provision of EWR flows at a site. Monitoring of the geomorphological conditions must therefore take into account the number and size of recent floods and the impacts of catchment and riparian landuse in addition to the flow record and provision (or lack) of the requested EWR flows.

The descriptors that were selected for geomorphology were chosen based on their assumed potential to indicate responses to flow changes. Three categories of descriptors were identified:

- Hydrology;

- Low flow season bed material composition, and;

- Channel form and gross morphology.

Once the descriptors were identified, the ranges of conditions expected for the Recommended Ecological Category were determined. The objectives or desired condition for the descriptor is described as an EcoSpec – a quantifiable and enforceable descriptor of the Resource Quality Objectives (RQOs) as they pertain to the ecological objectives for a river reach or site.

Thresholds of Probable Concern (TPCs) are provided to act as "red flags" which represent a level of concern of a particular Ecospecs whereby further change of that descriptor is likely to result in a new condition that does not satisfy the Resource Quality Objectives for that site or river reach. This approach is used to minimise monitoring costs, since only if the TPC's are exceeded will more detailed discipline-specific assessments be required for the sites. It is assumed that if the TPC's are not exceeded, then the Ecospecs are achieved and thus the desired state (REC) of the reach is being achieved.

The Ecospecs for geomorphology, described below for each of the EWR sites, are based on expert assumptions of the likely acceptable range of change for a variety of metrics. The expected critical, relatively rapid responding metrics or variables were selected for the generation of Ecospecs and TPC's. These needed to be

- Relevant for assessing and monitoring the condition of the river geomorphology, and/or represent critical habitats for instream biota, and

- Feasible and cost-effective to collect as part of a monitoring programme.

No RHAM monitoring baseline data are available for the Middle Vaal EWR sites, so no metrics related to this proposed Reserve monitoring approach could be identified or monitoring guidelines for this proposed. Ecospecs and TPC's were thus determined from the EWR data collected in 2008. The Geomorphological TPC's provided thus relate to the baseline conditions observed at the time of the EWR site visits (the low flow season of August 2008).

In general, the Vaal River and associated tributaries in the Middle Vaal WMAs can be described as supply (sediment) limited systems, in that there is much more streampower available to erode than there is sediment available to be moved. Mobile sediment is composed predominantly of fines and suspended materials; with larger cobble and boulder components tending to be derived ***in situ*** rather than be representative of the general load of the system. Channel beds often have at least some bedrock component, indicating that the rivers have eroded down to base level (the underlying bedrock) and are not flowing across deposited alluvial material.

The bedrock influence and limited sediment storage and availability mean that the morphologies of these rivers are relatively resilient to moderate increases or decreases in overall flow. This is evident in the stable morphologies observed from the historical aerial photographs, and from the general absence of large-scale sedimentary features within the channels and along the banks.

Where relevant descriptors (such as hydrology, bed material composition and channel morphology) were identified, Ecospecs and where appropriate TPC's have been generated for each EWR site. These are

presented in the tables below. These specifications were set based on a field and desktop assessment of the site undertaken during August (the low flow season) 2008.

Monitoring frequency is recommended at 2 (for hydrology/EWR flow verification) to 5 (for bed material, cross-sections and aerial photography assessments) year intervals. However, in the event of a 1:10-year or greater return period flood, it is recommended that the following dry season that the cross-section and bed material is resurveyed and fixed point photography is updated for the site.

It must be stressed however that rates and ranges of morphological adjustment that can be expected from the normal morphological descriptors for geomorphological monitoring (bed material composition and channel morphology) are likely to be relatively small due to the low slopes and resistant (often bedrock-controlled) nature of the river. In essence, the geomorphology of the rivers is extremely stable and thus cannot easily be monitored for the minor adjustments than can be expected. Some reduction in sediment load has occurred due to the trapping of sediment in upstream dams, but this cannot be ameliorated by flows. If funds or resources are limited, monitoring should be focussed on water quality and baseflow indicators (such as diatoms, invertebrates and fish) rather than riparian vegetation and geomorphology as these systems are relatively insensitive to large flows and floods and thus not likely to yield largescale changes in the geomorphology or riparian vegetation. Additionally, given the widespread encroachment of infrastructure into the riparian zone, it would be difficult to provide the larger floods required to improve riparian vegetation.

1.5.4 Fish

The fish communities will be affected in several ways by flow regulation. These include both beneficial and adverse effects. Some species may increase in abundance in the rivers whereas others may be lost from a specific reach. In particular, flow plays a critical role in mediating relative abundances of native and non-native species, with low, constant flows benefiting invasive alien species. The species used include:

- *Barbus anoplus* (Chubbyhead barb);
- *Labeobarbus aeneus* (Smallmouth yellowfish);
- *Labeobarbus kimberleyensis* (Largemouth yellowfish);
- *Labeo capensis* (Orange Vaal mudfish);
- *Labeo umbratus* (Moggel);
- *Clarias gariepinus* (Sharptooth catfish);
- *Tilapia sparrmanii* (Banded tilapia);
- *Pseudocrenilabrus philander* (Southern mouthbrooder);
- *Cyprinus carpio* (Carp) (exotic);

- *Gambusia affinis* (Mosquitofish) (exotic).

1.5.5 Macroinvertebrates

The descriptors for the invertebrates were derived from DWAF (2007, 2008) and Kleyhans and Louw (2006), and are based on a combination of target SASS5 scores and site-specific requirements for the presence of individual taxa. This approach was chosen because of the practicality of using existing biomonitoring practices, as well as the greater precision afforded by focusing on taxa with fairly well known habitat requirements.

The descriptors of the macroinvertebrates are given below:

- SASS5 Scores
- Average score per taxon (ASPT)
- Biotopes/habitats
- Taxa
    - *Elmidae*
    - *Hydrosychidae* 2spp
    - *Baetidae*
    - *Leptophlebiidae*
    - *Simulidae*
    - *Coenagrioenidae*
    - *Atyidae*
    - *Leptoceridae*.

1.5.6 Riparian Vegetation

The plant communities will respond to habitat changes related to changes in water level as follows:

- Changes in distribution of species along the vertical axis (*i.e.*, laterally up the banks), and along the rivers (*i.e.*, longitudinal zones);
- Changes in relative species abundance; and
- The loss of existing species or the gain of new species.

For this reason, descriptors of change consist of (1) a lateral zone and (2) species within the lateral zone. Details of the zonation of the riparian vegetation at the EWR sites are provided in the Riverine RDM Report.

The descriptors can usefully be divided into three main response groups, *viz.* those that are expected to decrease in response to adverse flow changes, and those that are expected to increase in response to adverse flow changes.

Change in response to flow change is also time dependent. The longer the period plus degree of change from natural, the greater the degree of the negative effect or the greater the likelihood of the change response occurring.

Function and timing of different flow classes

The periodicity of the different flood size classes is causal to the formation and maintenance of the different lateral vegetation zones. Floods size classes, by definition, have different periodicities and different lateral wetting heights (e.g., Class 1, 2, 3 and 4, which have an intra-annual occurrence, and the 1:2, 1:5, 1:10 and 1:20 year floods).

The physical environment shaping functions of each flow type is as important as the shaping of the vegetation by the flow. Certain smaller herbaceous plants would be reduced in size or numbers by smaller floods than trees, while large floods are clearly very important to clear channels of larger trees. The movement of depositional materials in floods is well known from debris lines left after floods.

Of lesser realized importance is the role played by different flow sizes to transport and bury reproductive material (seeds and portions of plants) through the different parts of the system. Similarly the regularity of wetting different parts of the riparian zone facilitates the growth and indeed survival of different species in each zone. The effects of these factors over the longer term are considered in the ratings given to the effects of flow reductions as assessed in a study of this nature.

1.6 PURPOSE OF THIS REPORT

The activities and tasks for step 7 (Ecological Specifications and Monitoring) of the 8 step Reserve determination process were undertaken in accordance with the appropriate approaches and methodologies for rivers as prescribed by the CD: RDM of DWA, namely:

- The methodology as set out in DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 3: River Ecosystems Version 1.0 (Revised water quality methodology, 2002).
- EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2) of Kleynhans and Louw (2007).

This report serves to document the results of the Ecological Specification and Monitoring process and the determination of the ecological specification and monitoring requirements for the rivers in the Middle Vaal Water Management Area which were finalised at several specialist meetings held during July 2010.

The specialist components consist of the drivers (geomorphology, physico-chemical variables and hydrology) and the response (riparian vegetation, fish and macroinvertebrates).

1.7 REPORT STRUCTURE

This report is structured into the following sections:

Section 1: Introduction

This section.

Section 2: Determination of Ecological Specifications and Monitoring Requirements

This chapter provide results of different Ecospecs and monitoring requirements of the drivers and responses per EWR site.

Section 3: Conclusions and Recommendations

The results are summarised and recommendations are made.

Section 4: References

2 DETERMINATION OF ECOLOGICAL SPECIFICATIONS AND MONITORING REQUIREMENTS

2.1 EWR 12 UPSTREAM VERMAASDRIFT (VAAL RIVER)

2.1.1 Hydrology

Three conditions or events influence the flow in this reach.

- Releases are made from Vaal Barrage (source Vaal Dam) to supply urban and industrial demands as well as riparian irrigation. The releases to these users are dependent on the run-off from the incremental catchments and are adjusted on a short term basis. Due to the limiting storage capacity at the intakes of these users, no flexibility exists in terms of the short term release rate.

- During prolonged droughts additional releases are made from Vaal Dam for users downstream of Bloemhof Dam. These releases can be reasonably flexible with respect to the discharge rate and pattern within a monthly period due to the buffering capacity of Bloemhof Dam. The governing rule for these releases (in terms of seasonal and annual timescales) is to only release sufficient water to satisfy the demand.

- To achieve specific water quality blending objective (the additional release of Vaal Dam water to maintain the TDS concentration in Vaal Barrage at 600 mg/l) may cause additional "spills" over Vaal Barrage. This is necessary due to the high salinity (TDS) content of the underground mine water that is pumped out of the gold mines into the river system and surface runoff from the highly urbanised areas in the incremental catchment of the Vaal Barrage. The flow rate into this reach is also flexible over the short term.

Goldfields Water and MidVaal Water Company withdraw significant amounts of water from the Vaal River within this reach.

The Pilgrims Estate weir (C2H007) which also influences flow in the Middle Vaal River is located just outside Orkney. The weir captures the inflows from the Koekemoerspruit and Vierfontein Spruit, and supports irrigation upstream of the Schoonspruit and Koekemoerspruit catchments. The MidVaal Water Company abstraction is at the Pilgrims Estate weir.

In general the flows in this reach of the river have been regulated since 1919. The base flow in winter has been raised and the smaller summer floods reduced by upstream impoundments and industrial water use.

The hydrology Ecospecs for site EWR 12 are given in Table 2.1

Table 2-1: Hydrology Ecospecs for site EWR 12 (PES D, REC D)

nMAR (present day)	Maintenance Low Flows (% nMAR)	Drought Low Flows (% nMAR)	High Flows (% nMAR)	MCM Excluding Floods	Long Term Mean (% nMAR) Excluding Floods	MCM Including Floods	Long Term Mean (% nMAR) Including Floods
1574.64	12.4	9.6	15.88	332.15	21.09	510.49	32.42

2.1.2 Water quality

There are many point and diffuse sources of pollution into the Vaal River at the upper reaches of the Middle Vaal WMA and water quality is highly impacted (D/E category). This assessment was made using data from the nearest weir is C2H018Q01. The Free State DWA regional office also does monthly monitoring. Data was available from the MidVaal Water Company which does a limited selection of water quality variables on a daily basis.

Extra water is released from the Vaal Dam in winter and this is used for the dilution of salts in the middle and lower Vaal. Increased summer and winter flows are present as a result of the Vaal Barrage. The salinity and nutrient impacts from the Klip, Riet and Suikerbosrand Rivers are combined in the Vaal Barrage and released downstream to this EWR site. High salinity due to mine water decants from Witwatersrand and Mooi River (Wonderfonteinspruit). High ammonia values due to waste water (treated and untreated) being released from the Vaal Barrage and Mooi River. Diffuse runoff from un-sewered areas leads to seasonally high microbiological contamination. Occasional low dissolved oxygen values that result in fish kills as a result from treated and untreated sewage effluent entering and being released from the Vaal Barrage.

There is a masking of the floods due to the dams (loss of floods) and a decreased turbidity from trapped (sedimentation) of suspended solids.

The water quality Ecospecs and TPCs for EWR 12 are given in Table 2.2 as is the recommended frequency for monitoring. The PES WQ at EWR 12 is a D/E category (high confidence) and the REC is a D (Table 2.1). It is recommended that the REC for water quality improves to a D category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Free State DWA and University of the Free State should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently at the EWR site and main stem of the Vaal River. This should include Chlorophyll – a and algal identification.

Table 2-2: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 12

RIVER		Vaal River	**WATER QUALITY MONITORING POINTS**			
WQSU		41	**DWAF WQ WMS**	C2H018Q01 1972 – 2008 (n = 1209); V2a Midvaal 1996 – 2008 (n = 143); DWA Regional Office		
EWR SITE		EWR 12	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	Yes to C	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	A	0 - 15 mg/L		95^{th} percentile to be <15 mg/L	
	$CaCl_2$	C	57 - 69 mg/L		95^{th} percentile to be <69 mg/L	
	NaCl	B	45 - 191 mg/L		95^{th} percentile to be <191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	Category = D	0.025 – 0.125 mg/L	Yes to C	50^{th} percentile to be <0.125 mg/L	Monthly
	TIN	Category = B	0.70 – 1.0 mg/L	No	50^{th} percentile to be <1.0 mg/L	Monthly
Physical Variables	pH	C	6.5 – 9.2	Yes to B	5^{th} percentile to be >6.5 and <9.2	Monthly
	Temperature	Limited data. Highly impacted by waste water treatment works, urbanisation and industrial discharges.	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		7 - 8 mg/L	N/A	5^{th} percentile to be >7 mg/L	Monthly
	Turbidity (NTU)	High seasonal variability	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	Category = C	55.1 - 85 mS/m	No	95^{th} percentile to be <85 mS/m	Quarterly
Response variables	Chl a: periphyton	Category = D. Visual inspection indicates high algal concentrations in river	21 - 84 mg/m^2	No	50^{th} percentile to be <84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 - 30 µg/L		50^{th} percentile to be <30 µg/L	
	Macroinvertebrates (ASPT)	C	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Some toxicity from industry, mining and waste water treatment works	An impact is expected if the 95th percentile of the data exceeds the Target Water Quality Range (TWQR) as stated in the SA WQ guidelines (DWAF, 1996). Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	B	≤ 43 ug/L		95^{th} percentile to be < 43 ug/L	Monthly

- Metals should be monitored at least monthly to determine the potential impacts of the Gold mining industry

- Water use authorisations should be reviewed to ensure stricter phosphate standard as well as general compliance.

- The Free State Regional Office's monitoring data needs to be entered into the DWA's Water Management System (WMS).

2.1.3 Geomorphology

The recommended geomorphology Ecospeces for EWR 12 are indicated in Table 2.3.

Table 2-3: Geomorphology Ecospecs for site EWR 12

Geomorphology PES = C/D	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 50 m^3/s – at least 4 events per year 800 m^3/s – at least a 1:3 year return interval	
Dry season bed material composition must be maintained The channel here has a bed of angular (i.e locally derived) cobbles and boulders and some bedrock exposures. In places mobile sands overly this. The flows set for this site are to maintain the movement of sand through the reach and prevent excessive sedimentation, with large floods to occasionally turn over the cobbles to prevent embeddedness. To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. At this site any fining of the bed – an increase in the percentage of fines in particular - would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.	
• Maintenance of channel form and gross morphology • Maintain the channel form and associated processes and habitats.	

Aerial photos	At this site, upstream dams have reduced sediment delivery to the site. This may be playing a role in reducing the number and extent of islands in the reach. The elevated baseflows may also cause erosion of these features. To maintain the PES, the diversity of habitat types should be maintained and thus the area of islands within the reach should be maintained. The area of islands can be monitored using aerial photography or high resolution satellite imagery. TPCs: - Progressive loss of island area over a period of 10 years or more. ***(Ignore if attributed entirely to a single large flood event).***
Cross-section scale	The gross cross-section shape/profile is not expected to be very sensitive to flow changes. Therefore monitoring of the cross-section at this site is not required.

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.4.

Table 2-4: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*Not applicable*	*Not applicable*
BED MATERIAL	*Not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*Not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.1.4 Fish

Eight fish species would historically have occurred at the site at moderate abundances. A 9th species *Austroglanis sclateri* (Rock catfish) would historically have occurred at the site at low densities (Kleynhans CJ, *et al.* 2007). The expected fish assemblage has a wide range of velocity depth preferences. This is indicative of the wide range of flow levels and habitats that would naturally have occurred at the site in historical times. Five of the eight expected species are either moderately tolerant or tolerant of no flow conditions indicating the seasonal nature of the river under reference conditions. Three of the expected species namely *Labeobarbus aeneus*, *L. kimberleyensis* and *L. umbratus* are moderately intolerant of no flow conditions indicating that these species require flowing water for completion of their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Seven of the 8 expected fish species are either moderately tolerant or tolerant of modified water quality indicating that the water quality in the river fluctuates naturally along with the seasonal change in flow levels. Three of the expected fish species namely *Barbus anoplus* (Chubbyhead barb), *Clarias gariepinus* (Sharptooth catfish) and *Tilapia sparrmanii* (Banded tilapia) have a requirement for movement between between reaches/ fish habitat segments. These species are likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Only four of the expected indigenous fish species were recorded at the site during the Reserve Determination surveys (PES Class D). In addition 2 exotic fish species: *Gambusia affinis* (Mosquitofish) and *Cyprinus carpio* (Carp) were recorded at the site.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease any further. Table 2.5 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2-5: Fish Ecospecs and TPC for site EWR 12

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 60 minutes. Gillnets should be left for at least 4 hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the

intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.1.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 101 with an ASPT of 4.59. The Recommended Ecological Category (REC) is C/B. The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 125 with an ASPT of 5.6.

The PES for this site is a C/D (65.57%). The REC is a C/B (75%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.6).

Table 2-6: The habitat preferences for the indicator taxa groups for site EWR 12

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.7 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2-7: Macroinvertebrate Ecospecs and TPCs for site EWR 12

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 30 cm.	The maximum depth over the riffle area is less than 33cm.
To ensure that the average depth over the riffle area is greater than 20cm.	The average depth over the riffle area is less than 22cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >100; ASPT value: > 5.0.	SASS5 scores below 105 and ASPT below 5.1.
To ensure that the MIRAI score remains within the range of a C category (> 70), using the same reference data used in this study	A MIRAI score of 72 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae* • *Atyidae* • *Coenagrionidae* • *Simuliidae*	Presence of less than three of the five key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 110 and 118, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 75% and 78%.	

2.1.6 Riparian Vegetation

The riparian vegetation composition at EWR 12 should not differ significantly from that recorded during the study (Table 2.8), with the possible reduction in exotic species.

Table 2-8: Riparian vegetation recorded at site EWR 12

Recorded species : 46	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
42 indigenous species	0	13	8	14	8	13
20 exotic species	0	7	1	8	2	6
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata			√			
Ziziphus mucronata			√		√	
Rhus lancea			√		√	
Gymnosporia buxifolia			√			
Rhus pyroides			√		√	
Grewia flava					√	
Asparagus sauveolens					√	
Sertaria verticillata			√			√
Themeda triandra				√		√
Gomphocarpus fruticosus						√
Andropogon eucomus				√		
Cynodon dactylon		√		√		
Phragmites australis		√				
Eragrostis plana				√		√
Imperata cylindrica		√				
Cyperus denudatus		√				
Cyperus longus		√				
Eragrostis obtusa				√		√
Eragrostis porosa						√
Panicum coloratum		√				
Sporobulus africanus				√		√
Eucalyptus spp.			√		√	
Melia azedarach					√	
Opuntia ficus-indica				√		√
Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium		√		√		
Arundo donax				√		√
Pennisetum clandestinum		√		√		
Cirsium vulgare		√		√		√
Azolla filiculoides		√				
Eichhornia crassipes		√				

Recorded species : 46	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
42 indigenous species	0	13	8	14	8	13
20 exotic species	0	7	1	8	2	6
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Myriophyllum spicatum		√				
Verbena bonariensis		√		√		√

Current status: The area is currently considerably degraded due to the introduction of a number of exotic species. The exotic species in the area, in fact, contribute to a total of almost 50% of the total number of species identified during the surveys. Furthermore, the lack of stochastic events, such as fire and flooding, are causing homogenization of the riparian vegetation at site EWR 12.

Trajectory of change: Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

The Vaal River system (particularly the section falling within the Highveld Alluvial vegetation type) is highly degraded, due to the introduction of exotic species and other anthropogenic impacts, a hypothetical reference position was determined using existing historical data, as well as the data collected from all the sites within the study area. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience.

The area is currently considerably degraded due to the introduction of a number of exotic species. The exotic species in the area, in fact, contribute to a total of almost 50% of the total number of species identified during the surveys. Furthermore, the lack of stochastic events, such as fire and flooding, are causing homogenization of the riparian vegetation at site EWR 12.

Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

This section combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site (Table 2.9).

Table 2-9: Riparian Vegetation Ecospecs and TPCs for site EWR 12

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	• Maintain marginal vegetation cover at greater than 40% • Maintain Cyperoid species density at 20 - 25% • Maintain *Arundo donax* instream cover at 0%	• Marginal vegetation cover reduced to less than 40% • Cyperoid density greater than 45% or less than 20% • *Arundo donax* instream cover greater than 0%
	Species Richness	Maintain species richness at 20 or more	Species richness drops below 20
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 30 - 35% • Maintain *Panicum maximum* cover at 20 - 25% • Maintain terrestrial species cover at 30 - 35%	• woody species cover greater than 25% or less than 55% • *Panicum maximum* cover greater than 75% or less than 50% • Terrestrial species cover greater than 30% or less than 35%
	Species Richness	Maintain species richness at 31 or more	Species richness drops below 31
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 10 - 15% • Maintain indigenous grass cover at 60 - 70%	Indigenous Acacia species cover less than 10% Indigenous grass cover greater than 70% or less than 60%
	Species Richness	• Maintain species richness at 20 or more • Maintain terrestrial species at 60% or less	Species richness drops below 20 Terrestrial species increase above 60%
	Vegetation Structure	Maintain woody cover between 60 and 70 %	Woody cover greater 70 than or less than 60%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the Ecostatus table for each site. Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.10, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2-10: Interpretation of Riparian Vegetation results for site EWR 12

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 40% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 25 – 30%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Marginal Zone	*Arundo donax**	Lining parts of river and stream floodplains, Currently 0% cover in the instream area but may encroach on this area.	Increase	Reduction of indigenous species and denudation of the banks leads to areas that can be colonised by *Arundo donax*. Canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks, *Arundo donax* is able to colonise these areas better than the indigenous species leading to the increase in cover of this species.	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal
Lower Non Marginal	Woody species cover	Moderate densities, Currently 30 – 35% cover	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones. Many of the terrestrial species in this area are woody species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Panicum maximum*	Moderate densities. Currently 10 – 15%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of indigenous terrestrial species	Currently 30-35%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Upper Non-marginal	Indigenous *Acacia,*	Currently 10 – 15%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Upper Non - marginal	% indigenous grass cover	Currently 60 – 70%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

2.2 EWR 13 VAAL RIVER AT REGINA BRIDGE

2.2.1 Hydrology

The system operation of 'Vaal Barrage to Schoonspruit reach' applies to this reach as well with the addition of run-off from the incremental catchment. It is important to note that developments in the form of small dams and irrigation schemes along the tributaries contributing to this reach do reduce the run-off to the Vaal River.

The Klipplaatdrift weir (C2H061) is situated approximately 60 km downstream of the Pilgrims Estate weir (at Balkfontein). Sedibeng Water abstracts it water at the Klipplaatdrift weir. There is an operational problem at the Balkfontein abstraction point as storage at the Balkfontein weir is too low. Consequently releases from the Vaal Dam need to coincide with actual water requirements in this catchment to ensure that the weir does not overflow or that water shortages do not occur. Sedibeng Water also enjoys a conditional water use from Allemanskraal when the dam is overflowing, provided that the Reserve requirements are catered for. This water is cheaper and of a better quality than water from the Vaal River (DWAF, 2004).

In general the flows in this reach of the river have been regulated since 1919. The base flow in winter has been raised and the smaller summer floods reduced by upstream impoundments and industrial water use.

The hydrology Ecospecs for site EWR 13 are given in Table 2.12

Table 2-11: Hydrology Ecospecs for site EWR 13 (PES and REC=C)

nMAR (present day)	Maintenance Low Flows (% nMAR)	Drought Low Flows (% nMAR)	High Flows (% nMAR)	MCM Excluding Floods	Long Term Mean (% nMAR) Excluding Floods	MCM Including Floods	Long Term Mean (% nMAR) Including Floods
1638.37	11.6	0.05	5.05	460.1	17.33	619.87	22.34

2.2.2 Water quality

There are many point and diffuse sources of pollution into the Vaal River at the upper reaches of the Middle Vaal WMA and water quality is moderately impacted (D category). This assessment was made using data from the nearest weir is C2H073Q01. The Free State DWA regional office also takes Ad Hoc samples.

Extra water is released from the Vaal Dam in winter and this is used for the dilution of salts in the middle and lower Vaal. Increased summer and winter flows are present as a result of the Vaal Barrage. The salinity and nutrient impacts from the Klip, Riet and Suikerbosrand River Waterval are combined in the Vaal Barrage and released downstream to this EWR site. High salinity due to mine water decants from Witwatersrand and Mooi River (Wonderfonteinspruit). High ammonia values due to waste water (treated and untreated) being released from the Vaal Barrage and Mooi River. Diffuse runoff from un-sewered

areas leads to seasonally high microbiological contamination. Occasional low dissolved oxygen values that result in fish kills as a result from treated and untreated sewage effluent entering and being released from the Vaal Barrage. Masking of the floods due to the dams (loss of floods) thus there's decreased turbidity from trapped (sedimentation) of suspended solids.

Furthermore gold mining around the KOSH area results in increased inputs into the Koekermoerspruit and Schoonspruit catchments. The winter increased salt load is due to diffuse salts from the mines in the Witwatersrand, Mooi River (Wonderfonteinspruit) and Koekermoerspruit and Schoonspruit catchments. There is an increasing trend in phosphate concentrations, as well as high ammonia values due to waste water (treated and untreated) being released from the Vaal Barrage, Mooi River (Potchefstroom) and Schoonspruit (Klerksdorp, Orkney and Stilfontein).

The system is driven by steady salts (reduced mining and management, although high) and increasing nutrients particularly ammonia (from the degradation of organic algal matter and possible diffuse pollution from irrigation.

The water quality Ecospecs and TPCs for EWR 13 are given in Table 2.13 as is the recommended frequency for monitoring. The PES WQ at EWR 13 is a D category (high confidence) and the REC is a D (Table 2.12). It is recommended that the REC for water quality is maintained at a D category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Free State DWA and University of the Free State should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently at the EWR site and main stem of the Vaal River. This should include Chlorophyll – a and algal identification.

- Metals should be monitored at least monthly to determine the potential impacts of the Gold mining industry

- Water use authorisations should be reviewed to ensure stricter phosphate standard as awell as general compliance.

- The Free State Regional Office's monitoring data needs to be entered into the DWA's Water Management System (WMS).

Table 2-12: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 13

RIVER		Vaal River	**WATER QUALITY MONITORING POINTS**			
WQSU		48	**DWAF WQ WMS**	C2H073Q01 1980 – 2008 (*n* = 1107)		
EWR SITE		EWR 13	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	No	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	C	38 - 51 mg/L		95th percentile to be < 51 mg/L	
	$CaCl_2$	D	105 – 141 mg/L		95th percentile to be < 141 mg/L	
	NaCl	B	45 - 191 mg/L		95th percentile to be < 191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	F	The PES: F currently exceeds 0.125 mg/L	Yes to D	The PES: F currently exceeds 0.125 mg/L	Monthly
	TIN	F	The PES: F currently exceeds 4.0 mg/L	Yes to D	The PES: F currently exceeds 4.0 mg/L	Monthly
Physical Variables	pH	B	6.5 - 8.8 mg/L	No	5th percentile to be > 6.5 and < 8.8	Monthly
	Temperature	Higher temperature due to the high algae trapping heat. DO cannot penetrate and is being used by algae. High diurnal fluctuations due to algal growth.	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen (DO)		5 - 8 mg/L	N/A	5th percentile to be > 5 mg/L	Monthly
	Turbidity (NTU)	Very turbid due to high algal matter diversity.	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	D	The PES: F currently exceeds 85 mS/m	No	The PES: F currently exceeds 85 mS/m	Quarterly
Response variables	Chl a: periphyton	Category = E. Visual inspection indicates high algal concentrations on rocks and in pools	The PES: F currently exceeds 84 mg/ m^2	Yes to D	The PES: F currently exceeds 84 mg/ m^2	Quarterly
	Chl a: phytoplankton		The PES: F currently exceeds 30 µg/L		The PES: F currently exceeds 30 µg/L	
	Macroinvertebrates (ASPT)	C	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Degradation of algae and impacts of upstream sewage works are causing an increase in ammonia concentrations. Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	F – Currently extremely high concentrations present	The PES: F currently exceeds 129 ug/L	Yes to D/E	The PES: F currently exceeds 129 ug/L	Monthly

2.2.3 Geomorphology

The recommended geomorphology Ecospeces for EWR 13 is indicated in Table 2.13.

Table 2-13: Geomorphology Ecospecs for site EWR 13

Geomorphology PES = C	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 520 m^3/s – at least a 1:2 year return interval 1500 m^3/s – at least a 1:10 year return interval	
Dry season bed material composition must be maintained The cross-section is located between two bedrock riffles. The channel here has a fixed boulder bed of primarily locally derived boulders and cobbles and bedrock exposures. Some mobile cobbles and fine sands occur on the bed. The flows set for this site are to maintain the movement of sand through the reach and prevent excessive sedimentation, with large floods to occasionally turn over the cobbles. To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. As with the upstream EWR 12, at this site any fining of the bed – an increase in the percentage of fines in particular - would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.	
Maintenance of channel form and gross morphology Maintain the channel form and associated processes and habitats.	
Cross-section scale	The gross cross-section shape/profile is not expected to be very sensitive to flow changes. Therefore monitoring of the cross-section at this site is not required.
Fixed point photos and Aerial photos	Analysis of the bars to be undertaken to monitor the area of bars and islands in this reach. The area of bars can be monitored using fixed point photographs (at the site) or aerial photography/high resolution satellite imagery (for the reach scale). TPCs: - Increases or decreases by more than 10% from the current levels would indicate undesirable changes. *(Ignore if attributed entirely to a single large flood event).*

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.15.

Table 2-14: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*not applicable*	*not applicable*
BED MATERIAL	*not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.2.4 Fish

Eight fish species would historically have occurred at the site at moderate abundances. A 9th species *Austroglanis sclateri* (Rock catfish) would historically have occurred at the site at low densities (Kleynhans CJ, *et al.* 2007). The expected fish assemblage has a wide range of velocity depth preferences. This is indicative of the wide range of flow levels and habitats that would naturally have occurred at the site in historical times. Five of the eight expected species are either moderately tolerant or tolerant of no flow conditions indicating the seasonal nature of the river under reference conditions. Three of the expected species namely *Labeobarbus aeneus*, *L. kimberleyensis* and *L. umbratus* are moderately intolerant of no flow conditions indicating that these species require flowing water for completion of their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Seven of the 8 expected fish species are either moderately tolerant or tolerant of modified water quality indicating that the water quality in the river fluctuates naturally along with the seasonal change in flow levels. Three of the expected fish species namely *Barbus anoplus* (Chubbyhead barb), *Clarias gariepinus* (Sharptooth catfish) and *Tilapia sparrmanii* (Banded tilapia) have a requirement for movement between reaches/ fish habitat segments. These species will be impacted upon by the construction of dams and weirs that impede fish migration.

Five of the nine species expected to occur at the site in moderate to high densities were recorded at the site during the Reserve Determination surveys (PES Class D). In addition 2 exotic fish species: *Gambusia affinis* (Mosquitofish) and *Cyprinus carpio* (Carp) were recorded at the site in moderate to high abundances.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease any further. Table 2.16 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2-15: Fish Ecospecs and TPC for site EWR13

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 60 minutes. Gillnets should be left for at least 4hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season

(spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.2.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 117 with an ASPT of 4.68. The Recommended Ecological Category (REC) is a C/B. The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 135 with an ASPT of 5.6. The PES for this site is a C (66.89). The REC is a C/B (>70%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.16).

Table 2-16: The habitat preferences for the indicator taxa groups for site EWR 13

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.17 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2-17: Macroinvertebrate Ecospecs and TPCs for site EWR 13

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 30 cm.	The maximum depth over the riffle area is less than 33cm.
To ensure that the average depth over the riffle area is greater than 20cm.	The average depth over the riffle area is less than 22cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >100; ASPT value: > 5.0.	SASS5 scores below 105 and ASPT below 5.1.
To ensure that the MIRAI score remains within the range of a C category (> 70), using the same reference data used in this study	A MIRAI score of 72 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae* • *Atyidae* • *Coenagrionidae* • *Simuliidae*	Presence of less than three of the five key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 110 and 118, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 75% and 78%.	

2.2.6 Riparian Vegetation

The vegetation composition at EWR 13 should not differ significantly from that recorded during the study (Table 2.18), with the possible reduction in exotic species.

Table 2-18: Riparian vegetation recorded at site EWR 13

Recorded species : 46	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
26 indigenous species	0	13	8	13	7	12
20 exotic species	0	7	1	7	1	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata			√			
Ziziphus mucronata			√		√	
Rhus lancea			√		√	
Gymnosporia buxifolia			√			
Rhus pyroides			√		√	
Grewia flava					√	
Asparagus sauveolens					√	
Sertaria verticillata			√			√
Themeda triandra				√		√
Gomphocarpus fruticosus						√
Andropogon eucomus				√		
Cynodon dactylon		√		√		
Phragmites australis		√				
Eragrostis plana				√		√
Imperata cylindrica		√				
Cyperus denudatus		√				
Cyperus longus		√				
Eragrostis obtusa				√		√
Eragrostis porosa						√
Panicum coloratum		√				
Sporobulus africanus				√		√
Eucalyptus spp.			√		√	
Opuntia ficus-indica				√		√
Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium		√		√		
Arundo donax				√		√
Pennisetum clandestinum		√		√		
Cirsium vulgare		√		√		√
Azolla filiculoides		√				
Eichhornia crassipes		√				
Myriophyllum spicatum		√				
Verbena bonariensis		√				

Current status: The area is currently considerably degraded due to the introduction of a number of exotic species. The exotic species in the area, in fact, contribute to a total of almost 50% of the total number of species identified during the surveys. Furthermore, the lack of stochastic events, such as fire and flooding, are causing homogenization of the riparian vegetation at site EWR 13.

Trajectory of change: Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

The Vaal river system (particularly the section falling within the Highveld Alluvial vegetation type) is highly degraded, due to the introduction of exotic species and other anthropogenic impacts, a hypothetical reference position was determined using existing historical data, as well as the data collected from all the sites within the study area. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience.

The area is currently considerably degraded due to the introduction of a number of exotic species. Although Site EWR 13 is not as degraded as Site EWR 13, there are still a certain number of invasive species and there is a considerable amount of the cover that is dominated by exotic species.

Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

This section combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site (Table 2.19).

Table 2-19: Riparian Vegetation Ecospecs and TPCs for site EWR 13

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	Maintain marginal vegetation cover at greater than 80% Maintain Cyperoid species density at 50 - 75% Maintain *Arundo donax* instream cover at 0%	Marginal vegetation cover reduced to less than 80% Cyperoid density greater than 75% or less than 50% *Arundo donax* instream cover greater than 0%
	Species Richness	Maintain species richness at 21 or more	Species richness drops below 21
Lower Non-	Vegetation abundance	• Maintain woody	• woody species cover

Metric Group	Metric	ECOSPECs	TCPs
marginal zone		species cover at 60 - 65% • Maintain *Panicum maximum* cover at 10 - 15% • Maintain terrestrial species cover at 40 - 50%	greater than 60% or less than 65% • *Panicum maximum* cover greater than 10% or less than 15% • Terrestrial species cover greater than 40% or less than 50%
	Species Richness	Maintain species richness at 32 or more	• Species richness drops below 32
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 30 - 40% • Maintain indigenous grass cover at 60 - 70%	• Indigenous Acacia species cover less than 10% • Indigenous grass cover greater than 70% or less than 60%
	Species Richness	• Maintain species richness at 25 or more • Maintain terrestrial species at 85% or less	• Species richness drops below 25 • Terrestrial species increase above 85%
	Vegetation Structure	Maintain woody cover between 60 and 70 %	Woody cover greater 70 than or less than 60%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans ***et al.*** 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site.

Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to

and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.20, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2-20: Interpretation of Riparian Vegetation results for site EWR 13

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 80% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 50 – 75%	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.
Marginal Zone	*Arundo donax**	Lining parts of river and stream floodplains, Currently 0% cover in the instream area but may encroach on this area.	Increase	Reduction of indigenous species and denudation of the banks leads to areas that can be colonised by *Arundo donax*. Canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
				the banks to drop of steeply and reducing shallow substrate adjacent to the banks, *Arundo donax* is able to colonise these areas better than the indigenous species leading to the increase in cover of this species.	
Lower Non Marginal	Woody species cover	High densities, Currently 60 – 65% cover	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones. Many of the terrestrial species in this area are woody species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Panicum maximum*	Low densities. Currently 10 – 15%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of indigenous terrestrial species	Currently 40-50%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events
Upper Non-marginal	Indigenous *Acacia,*	Currently 30 – 40%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
					effect on the lower and upper non-marginal zone.
Upper Non - marginal	% indigenous grass cover	Currently 60 – 70%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

2.3 EWR 14 VALS RIVER PROKLAMEERSDRIFT

2.3.1 Hydrology

The Vals River which includes the C60 tertiary drainage region of the Vaal River catchment has its origin in the vicinity of Bethlehem from where it flows past Lindley in the north-westerly direction to Kroonstad and on to Bothaville from where it flows into the Vaal River. Various tributaries enter the Vals River of which the Elandspruit is the largest. While the Vals River catchment is rural in nature, it has significant urban requirements (73 % of total water requirements). The urban requirements are dominated by the requirement of Kroonstad Municipality. Water is imported from the Vaal River by Sedibeng Water to supply the needs of the Bothaville local municipality. Treated sewage and storm water returns from Kroonstad in particular contribute significantly (33 % of total resource) to the water resources of the Vals key area. All irrigation in the Vals catchment is regarded as diffuse and is not significant. The catchment does not contribute to the yield of the Vaal River. This river system does not have storage regulation capability with release capabilities, with the result that high flow control and management is not possible.

Serfontein Dam is the only large Dam in the catchment on the Vals River and it is located near Kroonstad. It has a small storage relative to the runoff. The Serfontein Dam has a capacity of 4.200million m^3 and a surface area of 1.58 km^2. Seasonal water releases are made from the dam. The yield balance situation is such that there are deficits in supply as was recently experienced in restrictions to the town of Kroonstad.

The overall modification to bed, channel and flow in the Vals River is moderate to large due to the presence of several weirs, roads through the river and road bridges over the river, as well as Serfontein Dam. Some sand mining occurs in the river and these lead to bank erosion and siltation of the river.

The hydrology Ecospecs for site EWR 14 are given in Table 2.21

Table 2-21: Hydrology Ecospecs for site EWR 14 (PES and REC=C/D)

nMAR (present day)	Maintenance Low Flows (% nMAR)	Drought Low Flows (% nMAR)	High Flows (% nMAR)	MCM Excluding Floods	Long Term Mean (% nMAR) Excluding Floods	MCM Including Floods	Long Term Mean (% nMAR) Including Floods
118.04	5.41	0.08	2.37	7.58	5.2	23.37	16.03

2.3.2 Water quality

This assessment was made using data from the nearest weir is C6H001Q01. The Free State DWA regional office also does monthly monitoring. Data was available from the MidVaal Water Company which does a limited selection of water quality variables on a daily basis.

High salts in winter due to low flows and return flows from irrigation. There are low nutrients present in the system, but a high growth of aquatic macrophytes, hence the ammonia is higher than the nutrients.

Summer salts are less than half the winter concentrations and the flows are 15 times higher than the winter flows. Thus, nutrient levels are diluted in summer and the potential for algal blooms increases due to summer temperatures. This is masked by the higher turbidity during the summer. The system is driven by fairly low salinity (EC and SO_4); not as much algal diversity but spirogyra and nutrients are low due to sedimentation but some eutrophication (high ammonia).

Water quality deterioration as a result of Kroonstad, Lindley and Bothaville Sewage Works runoff as well as runoff from irrigated and drylands has a serious to critical impact on the Vals River. Prolific growth of algae in the lower reach of the river has been observed.

The water quality Ecospecs and TPCs for EWR 14 are given in Table 2.22 as is the recommended frequency for monitoring. The PES WQ at EWR 14 is a C/D category (high confidence) and the REC is a C/D (Table 2.21). It is recommended that the REC for water quality is maintained at a C/D category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Free State DWA and University of the Free State should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Vals River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2-22: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 14

RIVER		Vals River	**WATER QUALITY MONITORING POINTS**			
WQSU		52	**DWAF WQ WMS**	C6H001Q01 1980 – 2008 (*n* = 597)		
EWR SITE		EWR 14	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	N/A	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	B	20 - 33 mg/L		95th percentile to be < 33 mg/L	
	$MgCl_2$	B	15 - 30 mg/L		95th percentile to be < 30 mg/L	
	$CaCl_2$	B	21 - 57 mg/L		95th percentile to be < 57 mg/L	
	NaCl	B	45 - 191 mg/L		95th percentile to be < 191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	F	The PES: F currently exceeds 0.125 mg/L	Yes to D	The PES: F currently exceeds 0.125 mg/L	Monthly
	TIN	B	0.25 – 0.7 mg/L	N/A	50th percentile to be < 0.7 mg/L	Monthly
Physical Variables	pH	D	6.5 – 10.0	No	5th percentile to be > 6.5 and < 10.0	Monthly
	Temperature	Limited data.	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		8 - 11 mg/L	N/A	5th percentile to be > 8.0 mg/L	Monthly
	Turbidity (NTU)	Very turbid	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	C	55.1 - 85 mS/m	No	95th percentile to be < 85 mS/m	Quarterly
Response variables	Chl a: periphyton	Limited data.	0 – 1.7 mg/m^2	N/A	50th percentile to be < 1.7 mg/ m^2	Quarterly
	Chl a: phytoplankton		0 - 10 µg/L		50th percentile to be < 10 µg/L	
	Macroinvertebrates (ASPT)	C/D	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	F - Currently extremely high concentrations present	The PES: F currently exceeds 129 ug/L	Yes to D/E	The PES: F currently exceeds 129 ug/L	Monthly

2.3.3 Geomorphology

The Geomorphology Ecospecs for site EWR 14 is indicated in Table 2.23.

Table 2-23: Geomorphology Ecospecs for site EWR 14

Geomorphology PES = B/C	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 3 m^3/s – at least 5 events per year 35 m^3/s – at least a 1:1 year return interval 200 m^3/s – at least a 1:10 year return interval	
Dry season bed material composition must be maintained The cross-section is located in an incised section of river. The channel has incised into the sandy banks, with a channel bed composed of gravels and cobbles (possibly from localised rock exposure or an old drift crossing). Immediately downstream of the cross-section the reach is stable with sandy banks and beds and a meandering active channel. No monitoring of the channel bed material at the cross-section is recommended, since the material here is not representative of the reach.	
Maintenance of channel form and gross morphology Maintain the channel form and associated processes and habitats.	
Cross-section scale	The Reference condition at this site would have had fewer cut banks. To maintain the PES, no further channel incision can occur. . Incision and the extent of cut banks can be monitored through resurveyed cross-sections and fixed point photography. TPCs**:** - Any deepening of the channel or - Increased erosion (steepening and/or widening) of the banks.

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.24.

Table 2-24: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*not applicable*	*not applicable*
BED MATERIAL	*not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.3.4 Fish

Seven fish species would historically have occurred at this site at low to moderate abundances. A further 2 species *L. kimberleyensis* and *A. sclateri* may occasionally have occurred at the site at low abundances. Six of the expected species have a preference for either slow deep or slow shallow habitats suggesting that these are the predominant velocity depth classes that occur at this site. Two species: *L. aeneus* and *A. sclateri* have a preference for fast shallow habitat and *L. kimberleyensis* for fast deep habitats. Five of the expected fish species are either moderately tolerant or tolerant of reduced flow. Four fish species have a requirement for flowing water at some stage in their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Eight of the expected fish species are either moderately tolerant or tolerant of modified water quality indicating that water quality in the Vals River would fluctuate naturally along with seasonal flow patterns. Three species have a requirement for movement between reaches/ fish habitat segments. These species are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Six of the expected fish species were recorded at the site during the 2 Reserve Determination surveys. The Present Ecological State (PES) of the site was rated as a Class C.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease any further. Table 2.25 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2-25: Fish Ecospecs and TPC for site for site EWR14

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Barbus anoplus - Present in moderate abundance and present at most sites (> 50 - 75%)	*B. anoplus* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 30 minutes. Gillnets should be left for at least 4 hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.3.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 126 with an ASPT of 5.04. The Recommended Ecological Category (REC) is a C.

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Freshwater Conservation Plan. The reference total SASS5 score for the site is 140 with an ASPT of 6.0.

The PES for this site is a C/D (64.02%). The REC is C (66-70%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES. A short description of the REC is given.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.26).

Table 2-26: The habitat preferences for the indicator taxa groups at site EWR 14

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	Tricorythidae, Simuliidae	>0.6	Cobbles	Moderate/Low
2	Belostomatidae, Coenagrionidae, Atyidae	<0.1	Vegetation	Moderate/Low
3	Physidae, Lymnaeidae	<0.1	Vegetation	None

Table 2.27 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2-27: Macroinvertebrate Ecospecs and TPCs for site EWR 14

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 20 cm.	The maximum depth over the riffle area is less than 23cm.
To ensure that the average depth over the riffle area is greater than 10cm.	The average depth over the riffle area is less than 12cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >120; ASPT value: > 5.0.	SASS5 scores below 125 and ASPT below 5.2.
To ensure that the MIRAI score remains within the range of a C/D category (>60), using the same reference data used in this study	A MIRAI score of 62 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae* • *Atyidae* • *Coenagrionidae* • *Simuliidae*	Presence of less than three of the five key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 110 and 118, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 66% and 77.	

2.3.6 Riparian Vegetation

The vegetation composition at EWR 14 should not differ significantly from that recorded during the study (Table 2.28), with the possible reduction in exotic species.

Table 2-28: Riparian vegetation recorded at site EWR 14

Recorded species : 46	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
25 indigenous species	1	6	6	8	8	8
21 exotic species	1	2	2	6	2	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata			√			
Ziziphus mucronata			√		√	
Rhus lancea			√		√	
Rhus pyroides					√	
Grewia flava					√	
Asparagus sauveolens					√	
Cynodon dactylon		√		√		√
Eragrostis plana						√
Cyperus denudatus		√				
Cyperus longus		√				
Panicum coloratum		√				
Sporobulus africanus				√		√
Salix babylonica	√		√			
Populus X canescens					√	
Eucalyptus spp.			√		√	
Opuntia ficus-indica				√		√
Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium		√		√		
Arundo donax				√		√
Cirsium vulgare		√		√		√

Current status: The area is currently degraded due to the introduction of a number of exotic species. Although not as degraded as the sites along the Vaal River, the Vals River has been impacted upon by surrounding agricultural practices and burning regimes. For this reason, combined with the lack of

significant historical data, it was difficult not only to determine the correct reference site conditions, but also the actual current status of this site

Trajectory of change: Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, which the trajectory of change is

Reasons for PES

Little literature is available concerning the vegetation of the Vals River. The vegetation is not highly degraded due to the introduction of exotic species and other anthropogenic impacts, but some impacts are visible throughout the reach. As historical data for this site was not found a hypothetical reference position was determined using the data collected from the sites itself and reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site. Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience. The area is currently degraded due to the introduction of a number of exotic species. Although not as degraded as the sites along the Vaal River, the Vals River has been impacted upon by surrounding agricultural practices and burning regimes. For this reason, combined with the lack of significant historical data, it was difficult not only to determine the correct reference site conditions, but also the actual current status of this site**.** Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

This section combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site (Table 2.29).

Table 2-29: Riparian Vegetation Ecospecs and TPCs for site EWR 14

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	• Maintain marginal vegetation cover at greater than 80% • Maintain Cyperoid species density at 50 - 80% • Maintain exotic vegetation cover at 20-30%	• Marginal vegetation cover reduced to less than 80% • Cyperoid density greater than 75% or less than 50% • Exotic vegetation cover greater than 30-35%
	Species Richness	Maintain species richness at 10 or more	Species richness drops below 10
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 0 -	• woody species cover greater than 5%

Metric Group	Metric	ECOSPECs	TCPs
		5% • Maintain *Panicum maximum* cover at 20 - 25% • Maintain indigenous terrestrial species cover at 50 - 70%	• *Panicum maximum* cover greater than 25% or less than 10% • Terrestrial indigenous species cover greater than 70% or less than 50%
	Species Richness	Maintain species richness at 22 or more	• Species richness drops below 22
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 5- 10% • Maintain indigenous grass cover at 50 - 70%	• Indigenous Acacia species cover less than 5% • Indigenous grass cover greater than 70% or less than 50%
	Species Richness	• Maintain species richness at 23 or more • Maintain exotic species at 45% or less	• Species richness drops below 23 • exotic species increase above 45%
	Vegetation Structure	Maintain woody cover between 5 and 10 %	Woody cover greater 10 than or less than 5%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored. Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site. Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.30, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2-30: Interpretation of Riparian Vegetation results for site EWR 14

Lateral River Zone	Metric	PES condition	Reaction (movement denoting change in ES)	Explanation	Action
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 80% of marginal zone is covered by indigenous marginal vegetation	Decrease	Water levels and flow speeds vary greatly. Very little canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow. Banks do not drop off steeply and are easily colonised by vegetation. Marginal vegetation has not been significantly reduced due to flow. Invasion of this zone by exotic woody species may affect the marginal vegetation cover as they may be outcompeted by very competitive exotic species.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics
Marginal Zone	Cyperoid species	Density 50 – 80%	Decrease	Water levels and flow speeds vary greatly. Very little canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow. Banks do not drop off steeply and are easily colonised by vegetation. Marginal vegetation has not been significantly reduced due to flow. Invasion of this zone by exotic species may affect the density of these species as they may be outcompeted by very competitive exotic species.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Marginal Zone	Exotic species abundance	Currently 20 - 30% cover in the area but may encroach on this area.	Increase	The main threat to this zone is the invasion of this area by exotic species. It is unlikely that any anthropogenic changes in flow are likely to occur in this area and thereby have any effect on riparian vegetation.	Reduce possible introduction of exotic species. Physical removal of exotics
Lower Non Marginal	Woody species cover	Low densities, Currently 0 –5% cover	Increase	Invasion of this zone by exotic species may affect the density of these species as they may be outcompeted by very competitive exotic species.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics
Lower Non Marginal	*Panicum maximum*	Moderate densities. Currently 20 – 25%	Decrease	Invasion of this zone by exotic species may affect the density of these species as they may be outcompeted by very competitive exotic species.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics
Lower Non Marginal	Percentage cover of indigenous species	Currently 50 - 70%	Decrease	The main threat to this zone is the invasion of this area by exotic species. It is unlikely that any anthropogenic changes in flow are likely to occur in this area and thereby have any effect on riparian vegetation.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics
Upper Non-marginal	Indigenous *Acacia,*	Currently 5 – 10%	Decrease	The main threat to this zone is the invasion of this area by exotic species. It is unlikely that any anthropogenic changes in flow are likely to occur in this area and thereby have	Maintain current flow regime. Reduce possible introduction of exotic species.

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
				any effect on riparian vegetation. Invasion of this zone by exotic species may affect the density of these species as they may be outcompeted by very competitive exotic species.	Physical removal of exotics
Upper Non - marginal	% indigenous grass cover	Currently 50 – 70%	Decrease	The main threat to this zone is the invasion of this area by exotic species. It is unlikely that any anthropogenic changes in flow are likely to occur in this area and thereby have any effect on riparian vegetation. Invasion of this zone by exotic species may affect the density of these species as they may be outcompeted by very competitive exotic species.	Maintain current flow regime. Reduce possible introduction of exotic species. Physical removal of exotics

2.4 EWR 15 VET RIVER AT FISANTKRAAL

2.4.1 Hydrology

The Vet River catchment includes the secondary drainage (C4) of the Vaal River catchment. The Sand River is a major tributary of the Vet River. The river system includes two major dams, Erfenis on the Vet River and Allemanskraal Dam on the Sand River. The available water resources in this river system are fully utilised. Allemanskraal Dam (located in quaternary C42E) on the Sand River and Erfenis Dam (located in quaternary C41E) on the Vet River have flow release regulating capabilities.

The water resources of this catchment area are augmented by transfers from Vaal River by Sedibeng Water for urban and bulk use in the Free State Goldfields and by the upstream yields of Erfenis and Allemanskraal catchment areas. The mining and urban water requirements of the Free State Goldfields dominate the water requirements of this catchment. The main urban centres are Welkom and Virginia and the main mines are Harmony, President Steyn, African Rainbow Minerals and Bambanani Gold Mines. Returns flows from these users contribute about 10 % to the water resources of the catchment.

Irrigation water requirements for controlled irrigation are significant in the Vet River catchment and are the most important in the Middle WMA as a whole. Approximately 122 km^2 is scheduled for irrigation in three areas, namely Sand-Vet GWS (Sand), Sand-Vet GWS (Vet) and Vet River GWS. Actual irrigation requirements are significant therefore Vet River catchment does not contribute to the yield of the Lower Vaal WMA.

The Allemanskraal Dam and Erfenis Dam catchments are rural in nature. In the Allemanskraal catchment area consumptive requirements by urban and rural users make up the rest of the requirements, with irrigation water requirements not being significant. Senekal is the most important urban centre in the area. The upper reaches of this catchment do contribute to the downstream yield of the Sand River.

There is an export of water from Erfenis Dam to Brandfort local municipality in the Upper Orange WMA. Irrigation water requirements are also not significant in the Erfenis Dam catchment. Winburg and Marquard are the most important urban centres in the catchment area.

The Vet River's flows have been reduced in winter due to upstream use and dams.

The hydrology Ecospecs for site EWR 15 are given in Table 2.31.

Table 2-31: Hydrology Ecospecs for site EWR 15 (PES and REC = C)

nMAR (present day)	Maintenance Low Flows (% nMAR)	Drought Low Flows (% nMAR)	High Flows (% nMAR)	MCM Excluding Floods	Long Term Mean (% nMAR) Excluding Floods	MCM Including Floods	Long Term Mean (% nMAR) Including Floods
253.15	5.44	2.37	12.76	32.80	12.96	56.87	22.47

2.4.2 Water quality

This assessment was made using data from the nearest weir is C4H004Q01.

Water from Allemanskraal Dam is used for agricultural irrigation as well as to meet the urban water requirements of Virginia Town. Erfenis Dam supplies water to irrigation as well as urban water users. However, since the urban water users comprising of Brandfort, Theunissen, Bultfontein and Hoopstad, do not have access to water from alternative water resources, the supply to these towns have priority over the irrigation water use. High salts in winter are present as a result of the low flows. Winter salt concentrations are double those of the summer despite the flows being 20 times less. Point sources of nutrients relate to the waste water treatment works associated with the many small towns, as well as return flows from irrigation. There are low nutrients present in the system, but a high growth of aquatic macrophytes, hence the ammonia is higher than the nutrients. The high turbidity at this site reduces the algal growth opportunities in winter.

The water quality Ecospecs and TPCs for EWR 14 are given in Table 2.32 as is the recommended frequency for monitoring. Additional recommendations with respect to monitoring are given below.

The PES WQ at EWR 12 is a C category (high confidence) and the REC is a C (Table 2.31). It is recommended that the REC for water quality is maintained at a C category. Special attention should be paid to monitoring nutrient levels (Soluble reactive Phosphorus), which can be improved due to more stringent discharge standards. Furthermore:

- The River Health Programme (RHP) network of sites managed by the Free State DWA and University of the Free State should be continued. On-site water quality data should be collected as per standard RHP protocol (electrical conductivity (EC), temperature, dissolved oxygen (DO), turbidity if possible and a visual assessment (RHAM, 2009) should be done.

- Nutrient monitoring should be undertaken more frequently on the Vet River.

- Water use authorisations should be reviewed to ensure stricter phosphate standard compliance.

Table 2-32: Water Quality Ecospecs, TPCs and monitoring frequency for site EWR 15

RIVER		Vet River	**WATER QUALITY MONITORING POINTS**			
WQSU		61	**DWAF WQ WMS**	C4H004Q01 1972 – 2008 (*n* = 668)		
EWR SITE		EWR 15	**RHP**	Currently several monitoring sites		
Confidence in PES assessment		High				
Water Quality constituents		**PES Category**	**WQ Ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Inorganic salts (mg/L)	$MgSO_4$	F	The PES: F currently exceeds 45 mg/L	N/A	The PES: F currently exceeds 45 mg/L	Monthly
	Na_2SO_4	F	The PES: F currently exceeds 64 mg/L		The PES: F currently exceeds 64 mg/L	
	$MgCl_2$	A	0 - 15 mg/L		95^{th} percentile to be < 15 mg/L	
	$CaCl_2$	C	69 - 105 mg/L		95^{th} percentile to be < 105 mg/L	
	NaCl	B	45 - 191 mg/L		95^{th} percentile to be < 191 mg/L	
Nutrients (mg/L)	PO_4-P (SRP)	D	0.025 – 0.125 mg/L		50^{th} percentile to be < 0.125 mg/L	Monthly
	TIN	C	0.7 – 1.0 mg/L		50^{th} percentile to be < 1.0 mg/L	Monthly
Physical Variables	pH	C	6.5 – 9.2	No	5^{th} percentile to be > 6.5 and < 9.2	Monthly
	Temperature	Limited data.	Maintain range	N/A	Maintain natural range	Monthly
	Dissolved oxygen		7 - 8 mg/L	N/A	5^{th} percentile to be >7.0 mg/L	Monthly
	Turbidity (NTU)	High turbidity	Moderate change allowed	N/A	Moderate change allowed	Monthly
	Electrical conductivity (mS/m)	C	55.1 - 85 mS/m	No	95^{th} percentile to be <85 mS/m	Quarterly
Response variables	Chl a: periphyton	Limited data.	21 - 84 mg/m^2	N/A	50^{th} percentile to be <84 mg/ m^2	Quarterly
	Chl a: phytoplankton		20 30 µg/L		50^{th} percentile to be <30 µg/L	
	Macroinvertebrates (ASPT)	D	See Ecospecs for fish and invertebrates respectively			
	Fish community score	D				
	Instream toxicity	Once off instream toxicity results indicated no toxicity	Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics	Ammonia	B	15 – 43.75 ug/L	No	95^{th} percentile to be < 43 ug/L	Monthly

2.4.3 Geomorphology

The Geomorphology Ecospecs for site EWR 15 are indicated in Table 2.33

Table 2-33: Geomorphology Ecospecs for site EWR 15

Geomorphology PES = C	
Ecospecs	**Motivation and TPCs**
Daily Hydrology: requested flows must be provided To ensure that the requested flows (specifically floods) are delivered to the site: 70 m^3/s – at least a 1:1 year return interval 300 m^3/s – at least a 1:5 year return interval	
Dry season bed material composition must be maintained The channel is deeply incised and dominated by very fine sands. Very infrequent dolerite dykes form occasional riffles across the active channel. Underlying shales also introduce some locally derived angular gravels. The flows set for this site are to flush fines and maintain the movement of sand through the reach, with large floods to sort the bed sediments and clean gravels. To ensure that the bed composition and thus physical habitat diversity is maintained, sampling of the dry season bed material at the EWR site (using a sample size of not less than 500 points) should be undertaken at the prescribed intervals (every 5 years) to assess impacts of flow on the bed sediment and therefore as an indication of the change of available habitat for instream biota. At this site any fining of the bed – a decrease in the percentage of the gravel component in particular - would indicate insufficient flows being delivered to the site to maintain the geomorphological condition.	
Maintenance of channel form and gross morphology Maintain the channel form and associated processes and habitats.	
Cross-section scale	The Reference condition at this site would have had fewer cut banks. To maintain the PES, no further channel incision can occur. Incision and the extent of cut banks can be monitored through resurveyed cross-sections and fixed point photography. TPCs: - Any deepening of the channel or - Increased erosion (steepening and/or widening) of the banks.

Geomorphology monitoring frequencies and interpretation

The monitoring frequencies and interpretation of for geomorphology are shown in Table 2.34.

Table 2-34: Geomorphology monitoring frequencies and interpretation

	Short-term monitoring (every 2nd year)	Interpretation (every 2nd year)	Long-term monitoring (every 5 to 10 years)	Interpretation (every 5 to 10 years)
HYDROLOGY	Daily hydrology: Update of the daily hydrological time series	Hydrological time series must be analysed to verify that the requested flood flows have been provided at the sites.	*not applicable*	*not applicable*
BED MATERIAL	*not applicable* After any 1:10-year or greater return period flood: - re-survey cross-section - re-survey bed material distribution, and - take fixed point photographs.	*not applicable*	Bed material composition: Resurvey the bed material (sediment in the active channel) after 5 years along the cross-section/s.	Analyse bed material distribution data and compare to previous and to TPCs provided for each site.
CHANNEL FORM	Fixed-point photography	Fixed point photography should be analysed for changes in channel geometry, islands and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret in line with the site-specific guidelines provided in tables above.	Cross-section: Re-survey of fixed cross-sections Aerial photographs: Analysis of aerial photographs or high resolution satellite imagery (if available)	Assess the re-surveyed cross-sections and aerial photographs for any significant planform changes. Interpret these in terms of short- medium- changes in hydrology and land use Assess both for signs of net aggradation (increase in the bed level) or net erosion/incision. Some EWR sites have narrowed channels, and further such reductions in available habitat are undesirable.

All information must be interpreted in terms of medium- to long-term trends and trajectories and the impact of flood(s)

2.4.4 Fish

Seven fish species would historically have occurred at this site at low to moderate abundances. A further 2 species *L. kimberleyensis* and *A. sclateri* may occasionally have been recorded at the site at low abundances. Seven of the expected species have a preference for either slow deep or slow shallow habitats suggesting that these are the predominant velocity depth classes that occur at this site. Two species: *L. aeneus* and *A. sclateri* have a preference for fast shallow habitat and *L. kimberleyensis* for fast deep habitats. Six of the expected fish species are either moderately tolerant or tolerant of reduced flow. Four of the expected fish species are moderately intolerant of reduced flow levels. These species would therefore have a requirement for flow at some stage of their lifecycle. The expected fish assemblage show high levels of preference for a wide range of cover types. Nine of the expected fish species are either moderately tolerant or tolerant of modified water quality. *L. kimberleyensis* is moderately intolerant of modified water quality. Four species have a requirement for movement between reaches/ fish habitat segments. These species are most likely to be impacted upon by the construction of dams and weirs that impede fish migration.

Seven of the expected fish species were recorded in the project area during the 2 Reserve Determination survey. The PES of the site was rated as a Class C. One exotic species *G. affinis* was recorded at the site. A further exotic species *C. carpio* has previously been recorded at the site but was not captured during the reserve surveys.

It is recommended that the site be managed so that the current PES is maintained and doesn't decrease any further. Table 2.35 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the PES Class and Threshold of Potential Concern (TPC).

Table 2-35: Fish Ecospecs and TPC for site for site EWR15

Biota Ecospecs	**Biota TPC**
Labeobarbus aeneus - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. aeneus* - absent from the site for a single survey
Labeo capensis - Present in moderate to high abundance and present at most sites (> 50 – 75%)	*L. capensis* - absent from the site for a single survey
Barbus paludinosus - Present in moderate abundance and present at most sites (> 50 - 75%)	*B. paludinosus* - absent from the site for a single survey
Habitat Ecospecs	**Habitat TPC**
Maintenance of fast shallow and slow deep habitats	40% reduction in fast shallow habitats
Provision of adequate flow during the spawning season	Reduction in flow during the spawning season

Fish monitoring

Fish should be sampled by means of combined electrofishing and gillnetting. Electrofishing should be conducted for at least 30 minutes. Gillnets should be left for at least 4hours either around sunrise or sunset. Monitoring should be conducted twice annually, once during the intermediate dry – wet season (spring) and once during the intermediate wet – dry season (autumn). If only once annually then the

intermediate dry –wet season would be preferred. This would provide an indication of any spawning or recruitment events that tend to peak at that time of year.

All fish caught should be counted and identified. Depending on the size of the catch, all fish or a subsample should be measured. Length frequency sampling will provide an indication of spawning periods, longevity and the number of cohorts in the system. Indigenous species should be returned to the water as soon as possible whereas introduced species should be destroyed. All results and samples should be lodged with the appropriate national databases.

Any observations of *L. kimberleyensis* should be considered significant due to the widespread decline in the abundance of this species.

2.4.5 Macroinvertebrates

Two surveys were conducted (during October 2007 and April 2008) in order to gather information regarding the macro-invertebrate communities at the various EWR sites and to apply the MIRAI (Macro-invertebrate Response Assessment Index) in order to determine the PES (Present Ecological State) of the macro-invertebrate component of the EcoStatus.

The results obtained from RHP and DACE database, together with the data obtained during the two field surveys was interpreted using the above mentioned methods. The original SASS5 total score for the site was 93 with an ASPT of 4.89. The Recommended Ecological Category (REC) is a C and the PES is a C/D.

The reference conditions used to derive the EcoStatus (MIRAI) were based on the Invertebrate Frequency of occurrence (Roux & Thirion *pers comm*). The reference total SASS5 score for the site is 140 with an ASPT of 6.0.

The PES for this site is a C/D (55.45%). The REC is a C (66-70%). The TPCs are set to alert managers that the PES of a C/D is in danger of not being maintained. The Ecospecs are described for the PES. A short description of the REC (C category) is given.

Suitable habitat (> 0.6 m/s over coarse substrate) is required to ensure that all the selected taxa can overwinter without significant detrimental impacts on the overall population. *Tricorythidae* and *Simuliidae* require velocities of > 0.6 m/s, but may persist at lower velocities (> 0.1 m/s). *Belostomatidae, Coenagrionidae* and *Atyidae* require velocities of <0.1 m/s. All three taxa occur on vegetation. The *Tricorythidae* and *Atyidae* are moderately sensitive to water quality conditions. These taxa are not expected to tolerate wide fluctuations in flow and water quality. *Physidae* and *Lymnaeidae* must be monitored so that their numbers does not increase significantly.

Although a variety of flow-dependent taxa were collected at this site there are basically 3 groups of indicator taxa (Table 2.36).

Table 2-36: The habitat preferences for the indicator taxa groups at site EWR 15

Indicator group	Families	Velocity (m/s)	Substratum	Water Quality
1	*Tricorythidae, Simuliidae*	>0.6	Cobbles	Moderate/Low
2	*Belostomatidae, Coenagrionidae, Atyidae*	<0.1	Vegetation	Moderate/Low
3	*Physidae, Lymnaeidae*	<0.1	Vegetation	None

Table 2.37 indicates the Abundance and Frequency of Occurrence of selected indicator species for maintenance of the Ecospecs and Threshold of Potential Concern (TPC).

Table 2-37: Macroinvertebrate Ecospecs and TPCs for site EWR 15

HABITAT ECOSPECS	**HABITAT TPC**
To ensure that the maximum depth over the riffle area is greater than 15 cm.	The maximum depth over the riffle area is less than 18cm.
To ensure that the average depth over the riffle area is greater than 10cm.	The average depth over the riffle area is less than 14cm.
To ensure that the maximum velocity over the riffle area is greater than 0.6m/s.	The maximum velocity over the riffle area is less than 0.62m/s.
BIOTA ECOSPECS	**BIOTA TPC**
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >90; ASPT value: > 4.8.	SASS5 scores below 93 and ASPT below 4.9.
To ensure that the MIRAI score remains within the range of a C/D category (>55), using the same reference data used in this study.	A MIRAI score of 57 or less.
To maintain suitable flow velocity(maximum > 0.6m/s) and clean, unembedded surface area (cobbles) to support the following flow-dependent taxa in the VFCS (Very fast flow over coarse sediment) biotope: • *Tricorythidae* (Abundance A) • *Simuliidae* (Abundance B)	Any one of these taxa missing or present as a single individual in any two consecutive surveys.
To maintain suitable water quality, shading, temperature and habitat conditions for the following five key taxa: • *Belostomatidae* • *Tricorythidae* • *Atyidae*	Presence of less than three of the five key taxa listed in any survey.

• *Coenagrionidae* • *Simuliidae*	
To ensure that no group consistently dominates the fauna, defined as D abundance (>1000).	Any taxon occurring in an abundance of >500 for two consecutive surveys
The REC: SASS5 scores ranging between 110 and 118, ASPT scores ranging between 5.2 and 6.0; MIRAI scores ranging between 66% and 70%.	

2.4.6 Riparian Vegetation

The vegetation composition at EWR 15 should not differ significantly from that recorded during the study (Table 2.38).

Table 2-38: Riparian vegetation recorded at site EWR 15

Recorded species : 24	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
12 indigenous species	1	9	7	9	9	8
12 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Acacia karroo			√		√	
Salix mucronata			√			
Ziziphus mucronata			√		√	
Rhus lancea			√		√	
Rhus pyroides					√	
Grewia flava					√	
Asparagus sauveolens					√	
Cynodon dactylon		√		√		√
Eragrostis plana						√
Cyperus denudatus		√				
Cyperus longus		√				
Panicum coloratum		√		√		
Sporobulus africanus				√		√
Salix babylonica	√		√		√	
Populus X canescens			√		√	
Eucalyptus spp.			√		√	
Opuntia ficus-indica				√		√
Cirsium vulgare				√		√
Datura ferox				√		√
Xanthium strumarium		√		√		
Arundo donax				√		√
Pennisetum clandestinum		√		√		
Cirsium vulgare		√		√		√
Myriophyllum spicatum		√				

Recorded species : 24	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
12 indigenous species	1	9	7	9	9	8
12 exotic species	1	5	3	7	3	5
Species	**Marginal**		**Lower**		**Upper**	
	W	**NW**	**W**	**NW**	**W**	**NW**
Verbena bonariensis		√				

Current status: The area is currently considerably degraded mainly due to the introduction of a number of exotic species. The exotic species in the area, in fact, contribute to a total of over 50% of the total number of species identified during the surveys. Furthermore, the lack of stochastic events, such as fire and flooding, are causing homogenization of the riparian vegetation at site EWR 15. The marginal and lower non-marginal zones are dominated by *Cynodon dactylon* and the exotic *Xanthium strumarium* (Burweed), *Acacia karoo* (which tends to encroach on watercourses in more arid areas) and *Salix mucronata* (a riparian obligate). *Themeda triandra* (which is a good indicator of terrestrialisation of riparian zones) is very sparse in the area due to overgrazing of the veld in general. Furthermore, the homogenous sward of *Cynodon dactylon* within the riparian zone makes it difficult to determine the boundaries between the various riparian zones.

Trajectory of change: Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Reasons for PES

As the Vaal river system (particularly the system falling within the Highveld Alluvial vegetation type) is highly degraded, due to the introduction of exotic species and other anthropogenic impacts, a hypothetical reference position was determined using existing historical data, as well as the data collected from all the sites within the study area. Due to the lack of historical vegetation data for the Vet River and the highly degraded nature of this area the construction of a reference site for this site was particularly difficult. Reductions in exotic species diversity and abundance, as well as exotic species cover, were utilised in order to obtain a hypothetical reference site.

Many of the decisions made in order to determine the hypothetical reference site were subjective decisions based on existing literature and field experience. The area is currently considerably degraded mainly due to the introduction of a number of exotic species. The exotic species in the area, in fact, contribute to a total of over 50% of the total number of species identified during the surveys. Furthermore, the lack of stochastic events, such as fire and flooding, are causing homogenisation of the riparian vegetation at site EWR 15. Due to the factors mentioned above under the section "Current Status" and the fact that these factors are not being remedied or arrested it must be assumed, in order to comply with cautionary principles, that the trajectory of change is negative.

Ecospecs and TPCs

This section combines and summarises the information from previous sections, which was presented per discipline, and presents the information per river reach, each of which is represented by one EWR site (Table 2.39).

Table 2-39: Riparian Vegetation Ecospecs and TPCs for site EWR 15

Metric Group	Metric	ECOSPECs	TCPs
Marginal zone	Vegetation abundance	Maintain marginal vegetation cover at greater than 50% Maintain Cyperoid species density at 15 - 20% Maintain *Cynodon dactylon* cover at 40%	Marginal vegetation cover reduced to less than 50% Cyperoid density greater than 15% or less than 20% *Cynodon dactylon* cover greater than 40%
	Species Richness	Maintain species richness at 10 or more	Species richness drops below 10
Lower Non-marginal zone	Vegetation abundance	• Maintain woody species cover at 30 - 35% • Maintain *Panicum coloratum* cover at 5 - 10% • Maintain terrestrial species cover at 10 - 15%	• woody species cover greater than 35% or less than 30% • *Panicum coloratum* cover less than 5% • Terrestrial species cover greater than 10% or less than 15%
	Species Richness	Maintain species richness at 16 or more	• Species richness drops below 16
Upper Non-marginal zone	Vegetation abundance	• Maintain Indigenous Acacia species cover at 10 - 15% • Maintain indigenous grass cover at 60 - 70%	• Indigenous Acacia species cover less than 10% • Indigenous grass cover greater than 70% or less than 60%
	Species Richness	• Maintain species richness at 17 or more • Maintain terrestrial species at 60% or less	• Species richness drops below 17 • Terrestrial species increase above 60%
	Vegetation Structure	Maintain woody cover between 30 and 35 %	Woody cover greater 35 than or less than 30%

Riparian Vegetation Monitoring

Monitoring should be conducted annually during the wet season (Spring to early Summer) following the national VEGRAI (Vegetation Response Assessment Index) riparian vegetation monitoring system (Kleynhans *et al.* 2006) to identify and quantify changes in the vegetation in respect of abundance and cover of the selected zones or species being monitored.

Vegetation zones should be identified along two fixed transects through the river at each of the EWR sites. The boundaries of the zones should be recorded on profiles, noting the distances between each zone margin with density counts of shrubs and trees within them done every second year.

Vertical (or as near vertical as possible) photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the EcoStatus table for each site.

Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded. Sampling vegetation is best during Spring to early Summer as this makes access to and sampling of all vegetation zones better as although water levels are high, aquatic zone temporal species are still abundant (built up under low flow conditions), temperatures are high thus plants grow and more species are in flower (this later aspect assists with their identification) under the longer day length. Geophytic species are present and flowering during this time.

Monitoring may be reduced to one survey every two to three years at this site if necessary, however, any significant, change as explained in Table 2.40, should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend.

Table 2-40: Interpretation of Riparian Vegetation results for site EWR 15

Lateral River Zone	Metric	PES condition	Reaction (movement denoting change in ES)	Explanation	Action
Alien species marked with *					
Marginal Zone	Marginal vegetation cover	More than 50% of marginal zone is covered by marginal vegetation	Decrease	Water levels and flow speeds constant. Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks. Undercutting of the banks has reduced the marginal vegetation.	Increase density by introducing variability in flow. Introduce lower flows during dry months
Marginal Zone	Cyperoid species	Density 15 – 20%	Decrease	Causes canalisation of the river and the reduction of substrate in which marginal and instream vegetation can grow also causing the banks to drop of steeply and reducing shallow substrate adjacent to the banks.	Increase density by introducing variability in flow. Introduce lower flows during dry months.
Marginal Zone	*Cynodon dactylon*	Dominant species in all three zones. Currently 40% cover at the marginal zone but may encroach on the site area.	Increase	*Cynodon dactylon* is a very efficient coloniser and is able to colonise areas better than other species, with the lack of stochastic events, leading to the increase in cover of this species.	Decrease density by introducing variability in flow. Introduce lower flows during dry months. Physical removal

Lateral River Zone	**Metric**	**PES condition**	**Reaction** (movement denoting change in ES)	**Explanation**	**Action**
Lower Non Marginal	Woody species cover	Moderate densities, Currently 40 – 45% cover	Increase		Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	*Panicum coloratum*	Moderate densities. Currently 5 – 10%	Decrease	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Lower Non Marginal	Percentage cover of Terrestrial species	Currently 30-35%	Increase	Due to the incision of the river, desiccation and subsequent terrestrialisation have occurred in the vegetation of lower and upper non-marginal zones	Increase flow rate and moderate flood events
Upper Non-marginal	Indigenous *Acacia,*	Currently 10 – 15%	Decrease	An increase in exotic tree species will cause a decrease in percentage of indigenous species.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.
Upper Non - marginal	% indigenous grass cover	Currently 50 – 60%	Decrease	Increase in exotic trees cause a reduction of indigenous grass species due to increased crown cover.	Other than reducing the number of exotics in the riparian zone, change in the flow regime is unlikely to have much effect on the lower and upper non-marginal zone.

3 CONCLUSIONS

The following table is a summary of the proposed monitoring frequency for the Ecological Reserve for the Middle Vaal EWR sites 12 to 15 (Table 3.1).

Table 3-1 Summary of proposed monitoring frequency for the Ecological Reserve for the Middle Vaal.

Reserve component	**Monitoring Frequency**
Hydrology	Daily monitoring at closest DWA weir
Water Quality	Monthly, Quarterly (EC and Chlorophyll -a)
Geomorphology	• Every 2nd year: Daily hydrology and Fixed-point photography • Every 5 – 10 years: Bed material composition; Cross-sections and Aerial photographs
Fish	Monitoring should be conducted twice annually. If only once annually then the intermediate dry –wet season would be preferred.
Macroinvertebrates	Wet and dry season sampling
Riparian Vegetation	Monitoring should be conducted annually during the wet season (Spring to early Summer). Monitoring may be reduced to one survey every two to three years, however, any significant, change should precipitate immediate surveys which should be conducted annually for at least three years in order to monitor the change and determine whether it was a stochastic event or the beginning of a trend

It is important to note that the proposed Rapid Habitat Monitoring Programme (RHAM) has not be tested in the Middle Vaal.

If this programme is to be implement then the suggested monitoring frequency in Table 3.1 would altered and the RHAM monitoring would be used a s screening approach. If the TPC are triggered then the proposed monitoring would click in.

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