Technical Report: Ecological Status for Rivers of the Overberg Region 2004/2005

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EXECUTIVE SUMMARY

BACKGROUND

Since the initiation of the River Health Program (RHP) there has been extensive progress made in terms of the establishment of sites that are monitored on a regular basis, for river systems in the Western Cape. These assessments include SASS5 (South African Scoring System, version 5) on a seasonal basis and at least one comprehensive assessment, which include all indices of the RHP. It was the intention of the RHP to successfully undertake river health assessments for all the major water management areas (WMA's), which includes the Breede, Olifants/Doring, Gourits and Berg River catchments. Subsequently, smaller river systems such as rivers in the Overberg region have not been included in these assessments to date. It was therefore decided to obtain the ecological and morphological health status for these rivers by using indices of the RHP and compiling the results in the form of a technical report.

As rivers of the Overberg Region have largely been excluded from studies and monitoring surveys to date, not much historic data exists on the state of these rivers in terms of water quality, ecology, and physical nature or anthropogenic disturbances resulting over time. Therefore, a comprehensive biomonitoring survey, using all the indices of the RHP, was undertaken.

This report forms part of a series of technical report publications for the RHP and contains meaningful site-specific monitoring information for the Overberg region.

SUMMARY OF THE MAJOR RESULTS

The results presented in this report are grouped per river system. Additionally, each river was placed into a river health category, which can be natural, good, fair or poor, with each having its own ecological and management perspectives (Table 1).

Table 1. River health categories and their ecological and management perspectives

River Health category	Ecological Perspective	Management Perspective
Natural N	No or negligible impact	Relatively little human impact
Good G	Biodiversity and integrity largely intact	Some human-related disturbance but ecosystems essentially in good state
Fair F	Sensitive species may be lost, with tolerant or opportunistic species dominating	Multiple disturbances associated with the need for socio-economic development
Poor P	Mostly only tolerant species present; alien species invasion; disrupted population dynamics; species are often diseased	High human densities or extensive resource exploitation

Results for each index-based site assessment were placed in a category as shown above. A summary of results for the rivers of the Overberg West and Overberg East are shown in the summary Tables 2 and 3.

Table 2. Summary table for all sites on the Overberg West

RHP Index	Bot			Onrus			Klein			Uilkraal			Hermanus
	Site 1	**Site 2**	**Site 3**	**Site 1**	**Site 2**	**Site 3**	**Site 1**	**Site 2**	**Site 3**	**Site 1**	**Site 2**	**Site 3**	**Site 1**
IHI Instream	Good (B)	Fair (D)	Fair (D)	Fair (C)	Poor (E)	Fair (D)	Fair (C)	Fair (C)	Fair (D)	Natural (A)	Fair (D)	Fair (D)	Natural (A)
IHI Riparian	Fair (C)	Poor (F)	Poor (F)	Poor (E)	Poor (F)	Poor (F)	Poor (F)	Poor (E)	Poor (E)	Fair (C)	Poor (F)	Poor (E)	Natural (A)
GI	Fair (C)	Poor (E)	Fair (D)	Fair (C)	Fair (C)	Fair (C)	Fair (D)	Fair (D)	Fair (C)	Good (B)	Fair (D)	Fair (D)	Good (B)
RVI	Fair (C)	Poor (E)	Poor (E)	Fair (D)	Poor (E)	Poor (E)	Fair (D)	Poor (E)	Poor (E)	Fair (C)	Poor (E)	Fair (D)	Natural (A)
SASS	Fair (C)	Fair (C)	Fair (C)	Fair (C)	Fair (C)	Fair (C)	Fair (C-D)	Fair (C)	Fair (C-D)	Good-Fair (B-D)	Good-Fair (B-C)	Fair (C-D)	Natural (A)
Fish	Poor (E)	Poor (E)	Poor (E)	Fair (D)	Fair (C)	Natural (A)	Poor (E)	Poor (E)	Fair (D)	Natural (A)	Natural (A)	Fair (C)	Natural (None)

Table 3. Summary table for all sites on the Overberg East

RHP Index	Sout	Kars			Heuningnes	Nuwejaars		Nuwejaars tributaries		Ratel
	Sites 1-7	**Site 1**	**Site 2**	**Site 3**	**Site 1**	**Site 1**	**Site 2**	**Site 1**	**Site 1**	**Site 1**
IHI Instream	Fair-Poor (C-E)	Fair (D)	Fair (D)	Fair (C)	Good (B)	Fair (C)	Good (B)	Poor (E)	Fair (D)	No data
IHI Riparian	Fair (C-D)	Poor (E)	Poor (F)	Fair (C)	Fair (C)	Poor (E)	Fair (C)	Poor (F)	Poor (E)	
GI	Fair (C-D)	Fair (C)	Fair (D)	Fair (C)	Fair (C)	Fair (D)	Fair (C)	Fair (C-D)	Fair (D)	Fair (D)
RVI	Good-Fair (B-C)	Fair (D)	Poor (E)	Fair (D)	Fair (D)	Fair (D)	Fair (D)	Poor (F)	Poor (E)	Fair (D)
SASS	Fair-Poor (D-E)	C-D Fair (C-D)	Fair-Poor (D-E)	Fair-Poor (D-E)	Natural-Good (A-B)	Good-Fair (B-D)	Fair (C-D)	Good-Fair (B-C)	Natural-Good (A-B)	Fair (D)
Fish	Good-Poor (B-F)	Natural (A)	Fair (D)	No data	Good (B)	Fair (D)	Fair (C)	Fair (D)	Fair (C)	No data

Major impacts

River channel and riverbank modifications

- Riverbanks were straightened and levees created as a means of protection against flood flows.
- Alien vegetation infestations caused in channel straightening and over-stabilization, which lead to evident channel incision and erosion.
- Construction within the channels also occurred, which resulted in habitat loss and reduced aquatic species diversity.
- Instream dams and water abstraction modified river flows and altered the downstream channels natural flow regime.

Alien species infestation

- Rivers were invaded by alien vegetation with the exception of the upper reaches of the Hermanus River, which is situated in a protected area (SAFCOL Nature Reserve); and the upper reaches of the Uilkraal River, which is also situated within a protected area (Salmonsdam Nature Reserve)
- Alien fish stocks were also prevalent in most sites surveyed. Small and largemouth bass, bluegill sunfish, rainbow trout, mosquito fish, tilapia and carp were caught during surveys. These fish have an impact on the smaller indigenous fish species by direct competition (e.g. small-mouth bass) or degrading the natural habitats (e.g. carp).

CONCLUSIONS AND RECOMMENDATIONS

Because the Overberg Region is to a large extent rural, the rivers are mostly impacted by agricultural activities. The Overberg West is dominated by irrigated agriculture and a large number of smaller off-stream and larger instream dams are found throughout the catchment. Alien vegetation has altered riparian zones at almost all sites surveyed except for those areas protected by nature reserves. Alien fish occurred at all sites and impacted on indigenous populations to a large extent in the lower reaches and were absent in some upper reaches due to natural barriers. Indigenous fish were present, however, where the larger alien species were absent. Bulldozing of the riverbed and banks, in order to contain the river flow to a confined channel, altered the physical habitat. The overall water quality however, was acceptable at most sites as was shown by the chemical water analysis and the macro invertebrates sampled. However, it should be noted that the chemical water quality results were based on samples taken on a once-off basis and remains circumspective. The water quality samples were also not coupled with SASS5 sampling as the water samples were taken after the seasonal SASS5 sampling was completed.

It was established that habitat diversity within the Eastern Overberg Rivers contained naturally low community structure diversity for invertebrates. In most cases grazing livestock, disturbance due to agriculture activities (instream bulldozing), alien vegetation and fish impacted sites. A large percentage of landuse on the Overberg East is natural and the rivers feed into numerous wetlands and vleis on the Agulhas Plain. The upper reaches of the Nuwejaars and Kars Rivers have been identified as priority rivers for conservation initiatives due to their relatively unimpacted nature and high numbers of indigenous fish species, although alien fish were present. Alien vegetation was found to be the largest threat to these river systems and limited intervention would be required to reach a desired natural state. The only habitat alteration occurring in these rivers were natural due to a flood, which occurred during the sampling season. The Sout River flows through agricultural land along its entire length but certain reaches remained largely intact for the riparian zone, as fences provided protection from cultivation and livestock disturbance pressures. Rivers draining the Agulhas Plain have obtained increased conservation interest with the establishment of the Agulhas Biodiversity Initiatives (ABI), which aims to conserve the largest habitat of lowland Fynbos and Renosterveld in the Cape Floristic hotspot.

Recommendations for river management of the Overberg Region

- Alien vegetation should be eradicated from the riparian zone and wetland areas, ensuring they remain cleared by follow-up clearing efforts.
- The re-establishment of the natural riparian zone with indigenous vegetation and the construction or extension (where possible) of existing buffer zones between agricultural lands and the river is highly recommended.
- Alien fish species should be eradicated from reaches that could be maintained free from alien fish, so as not to run the risk of re-infestation.
- The impacts of breeding or stocking of alien fish species in farm dams should be better managed and stopped where the risk of invasion is possible.
- The upper Kars River should be maintained as a priority for freshwater fish as well as the upper Nuwejaars and Uilkraals River due to the diverse aquatic life and undisturbed habitat. These rivers drain the Agulhas Plain and associated wetlands and their rehabilitation potential could form part of the Agulhas Biodiversity Initiative (ABI).

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1. INTRODUCTION

Water is indisputably our most vital resource. Yet, rivers are highly degraded systems due to both past and present human activities. More recently it has become clearer that these systems needed better protection and management. Previously water management focused only on the protection of human health and all water quality standards were set according to this. However, increasing human demands and activities have placed increasing pressure on the water resources and the aquatic ecosystems, which rivers sustain. It was also realized that the goods and services provided by the water resource depends on healthy, functioning ecosystems, which can only be achieved by actively managing and protecting the water resources. This motivated the development of the new South African National Water Act (Act No 36 of 1998), which makes provision for the supply of water for basic human needs as well as the sustainability of the aquatic environment (Hohls, 1996; Dallas, 2000).

In the past, water quality monitoring was largely focused on the analysis of physical and chemical measurements. In order to improve the quality of the information used by aquatic ecosystem management, it became necessary to include biological indicators in the assessments and the monitoring thereof. Biomonitoring therefore became an important tool in achieving this and ultimately led to the development and implementation of the River Health Programme (RHP) (Hohls, 1996).

The RHP is a biomonitoring programme that was initiated by the Department of Water Affairs and Forestry (DWAF) in 1994 in partnership with the Department of Environmental Affairs and Tourism (DEAT) and the Water Research Commission (WRC), on a national level, with the primary objective of determining the overall ecological status of river ecosystems in South Africa. On a provincial scale, partnerships have been formed between DWAF and Cape Nature, CSIR and the City of Cape Town in the Western Cape. The goal of the RHP is to serve as a source of information to water managers and users, facilitating the rational and sustainable management of freshwater resources. The rationale behind the biomonitoring programme is that the integrity or health of the biota inhabiting the river ecosystems provides a direct and integrated measure of the health of the rivers as a whole.

The biomonitoring method, specifically the South African Scoring System (SASS), has been used for a longer time period (since the early 1990’s) to assess most of the major rivers and smaller tributaries in the Western Cape. The formal large-scale implementation of the RHP came into being over the last three to five years and since then the number of monitoring sites has significantly increased. The results of these monitoring surveys – activity books, posters, popular articles and a number of State of Rivers publications – have been made available to the public and contain scientifically and managerially relevant information. In addition, a database has been developed where all data collected during monitoring surveys are housed for management of riverine reserves and priority conservation sites, amongst others.

To date, rivers of the Overberg Region have largely been excluded from studies and monitoring surveys. As a result not much data exists on the state of these river systems in terms of water quality, integrity, ecology, physical nature and anthropogenic impacts. It was therefore decided to conduct a biomonitoring survey, using indices of the RHP, on these rivers.

The surveys were conducted between October 2004 and May 2005. The indices used included the South African Scoring System version 5 (SASS5, macro-invertebrate sampling), the Riparian Vegetation Index (RVI), the Fish Index (FI)/ Fussy Index, the Geomorphological Index (GI) and the Index of Habitat Integrity (IHI). *In situ* water quality was also recorded together and a once-off analysis for water chemistry. The rivers in the Overberg West differed from those in the Overberg East due to the underlying geology, as reflected in the survey results. All major rivers and tributaries were surveyed from and including the Bot River (west) to the Sout River (east). Results for the Palmiet River catchment were included in the 2005 State of River Report and the Breede River survey will be published in a separate report in 2008, as the monitoring of this water catchment area is in progress. Therefore, these rivers systems were excluded from the present study.

2. STUDY AREA

The Overberg is situated at the southern tip of Africa and stretches from the Palmiet River in the west to the Goukou River in the east. The boundaries in the north are the Riviersonderend and Langeberg Mountains and the southern boundary is the Indian Ocean coast (Shaw *et al*., 1998; Leeuwner *et al*., 2003). The ecoregion classification provides a useful delineation into 2 sub-areas namely the Overberg West and the Overberg East and occurs in the Breede Water Management Area. Figure 1 shows the rivers occurring on the west and east Overberg. Twelve rivers (main stems and tributaries) were included in the study with a total of 31 sites.

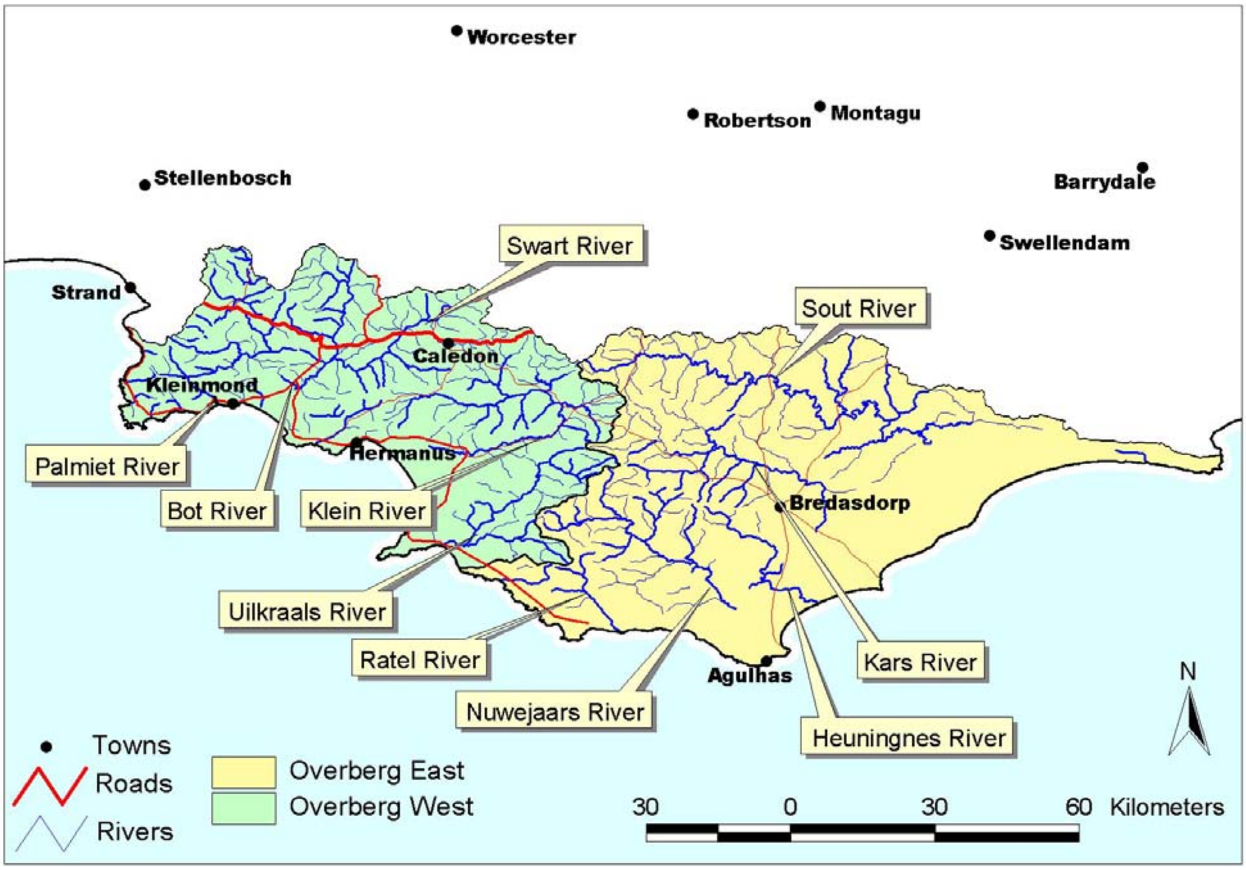


Figure 1. Map showing the study area and rivers sampled in the Overberg Region

2.1. ECOREGION CLASSIFICATION

Ecoregion classification is a relatively new development. Ecosystems and their components show spatial and regional variability with respect to causal factors such as climate, rainfall, mineral availability (geology and soils), vegetation and physiography (Kleynhans *et al*., 2004, RHP, 2003). When classifying ecoregions, regions that are ecologically similar are grouped together, based on the above-mentioned factors, which are responsible for differences among rivers. Additionally, ecoregion typing for river classification can occur at three levels.

Level I ecoregions are delineated by very broad boundaries and are therefore at the coarsest resolution. The ecoregions provided in this report were classified according to Level I and II (figure 2). Level III will provide smaller units of increasing similarity but will take a longer time to develop due to the amount of detail required (Kleynhans *et al*., 2004). The rivers of the

Overberg region occurred within two major ecoregions, namely, the Southern Folded Mountains and the Southern Coastal Belt.

2.1.1 The Southern Folded Mountains (Ecoregions 19.04, 19.05, 19.06)

The terrain morphology consists of plains of low and moderate relief, lowlands, hills and mountains that have a moderate to high relief at an altitude of 300-1900m above sea level. The vegetation types are dominated by grassy, mountain Fynbos and Little Succulent Karoo with some patches of Afromontane Forest. Mean Annual Precipitation (MAP) ranges from 200-1500mm and the mean annual temperatures (MAT) from 10-20°C (Kleynhans *et al*., 2004). Sites along the Hermanus, Swart, Bot, Onrus, Klein, Uilkraal, Ratel and Klein Pietersielieskloof Rivers occur within this ecoregion.

2.1.2 The Southern Coastal Belt (Ecoregions 22.03, 22.04, 22.05)

Plains dominate the terrain morphology with a low to moderate relief, open and closed hills, mountains (moderate to high relief) and lowlands, with an altitude of 0-700m above sea level. The dominant vegetation types are South and South West Coast Renosterveld. Patches of Afromontane Forest also occur. The MAP is 300-600mm and the MAT range between 10-20°C (Kleynhans *et al*., 2004). The rock types found are quartzitic sandstone, shale, sand and biotite granite. Shale and sand mostly underlie this region and cause a lower surface runoff of more saline and alkaline water (RHP, 2003). Sites along the upper Klein, Sout, Heuningnes, Nuwejaars, Kars and Hotnotskraal Rivers occur within this ecoregion.

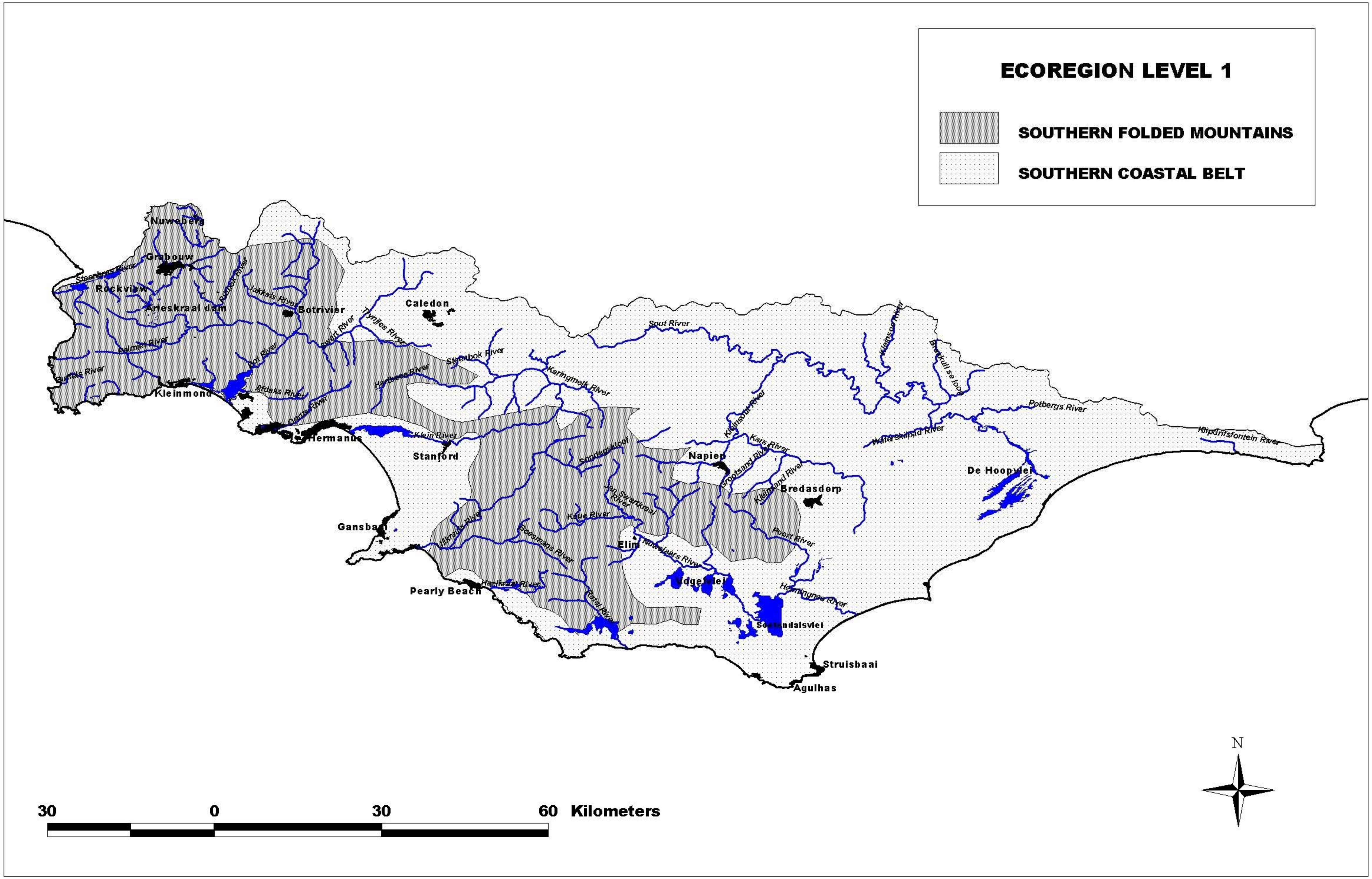


Figure 2. Ecoregions Level 1 and 11 and the monitoring sites of the Overberg

2.2. CATCHMENT CHARACTERISTICS AND LANDUSE

Agricultural activities comprise the bulk of the landuse of the Overberg region. Cereal crops such as wheat and barley are mostly grown. More recently some of these have been replaced with the oil seed crop, Canola (DEAT, 2001; Leeuwner *et al*., 2003). A wheatland-fallow system was previously practiced but was replaced by the wheatland-pasture system, where dryland pastures alternate with cereal crops. The pastures are used to graze sheep, cattle and ostriches.

On the Overberg West, commercial alien forestry is common, especially in the Bot River catchment. Mainly pine species are planted. Large-scale commercial irrigated agriculture, especially fruit cultivation, occurs in the main Bot Valley. The previously Fynbos covered landscape has been completely altered by ploughing for cereal crops or deciduous fruit cultivation, with the exception of the mountains in the north and southeast of the catchment. Approximately 1% of the Bot catchment consists of urban development and includes the towns of Hawston, Botrivier and Caledon (DEAT, 2001; Van Niekerk *et al*., 2005). Similar conditions occur in the Klein River catchment where agriculture dominates and urban development is small comprising the towns of Hermanus and Stanford (DEAT, 2001).

Privately owned farms make up much of the Onrus catchment with the higher mountain slopes covered by mountain Fynbos. The lower lying areas have been cleared for grain crop cultivation, pastures and small vineyards (Heinecken *et al*., 1983). The Onrus River therefore supports some irrigation and the De Bos Dam supplies water to the Greater Hermanus Area (DWAF, 2004). The river forms vleis in the valleys, which act as sediment traps, in the upper catchment (Heinecken *et al*., 1983). The upper reaches of the Uilkraal River originate from the Paardenberg River, which has its source in the Perdeberg Mountains. The Salmonsdam Nature Reserve protects this mountain catchment area. The middle reaches have recently been dammed by the Kraaibosch Dam (construction began in November 1998), which supplies water for irrigation and to the town of Gansbaai (DWAF, 2004). Numerous vleis and wetland areas are associated with the Uilkraal River.

Many of the rivers located on the eastern Overberg form part of the Heuningnes catchment. The total catchment area of this river system is approximately 1400km^2. Urban (residential and industrial) development comprises <1% of the catchment with the major towns being

Bredasdorp, Elim and Napier (DEAT, 2001). Orchards and vineyards cover a small percentage (1.1%) of land, which results in small-scale irrigation and recently vineyards were planted on the Agulhas Plain (Leeuwner *et al*., 2003). On the eastern Overberg a large percentage (approximately 56%) of the landuse is still natural, which includes shrubland, grassland, bushland, wetlands and waterbodies such as Zoetendalsvlei (DEAT, 2001; Leeuwner *et al*., 2003). The Sout River has no outlet to the sea (endorheic) and drains into the De Hoopvlei at De Hoop Nature Reserve (DWAF, 2004).

2.3. GEOLOGY

A map of the geology of the Overberg is shown in Figure 3 (Vegter, 1995). The Overberg forms part of the Cape Folded Belt, which consists of a parallel band of quartzitic sandstone (Table Mountain Group) separated by undulating shale valleys. The first deposits were laid down approximately 450 million years ago and the mountains were formed approximately 200 million years later. Stable geological conditions existed in the Western Cape over the past 65 million years and the Overberg landscape remained unchanged (Mustart *et al*., 1997; Bargmann, 2005). The soil found on the western Overberg is acidic, infertile and sandy as some are windblown but most are derived from the sandstone-dominated geology (Mustart *et al*., 1997, RHP, 2003). The low coastal plains of the south-eastern Overberg however, are covered by marine sands. The Bredasdorp limestone formation is the oldest coastal deposit (between 25-10 million years old). The band of alkaline windblown sands, muds and sands of the Zoetensdals Vallei and the coarse-grained sand and dune rock formations are much younger deposits. Ferricrete (koffieklip) remnants have been preserved in the shale valleys and support the unique Elim Fynbos (Mustart *et al*., 1997).

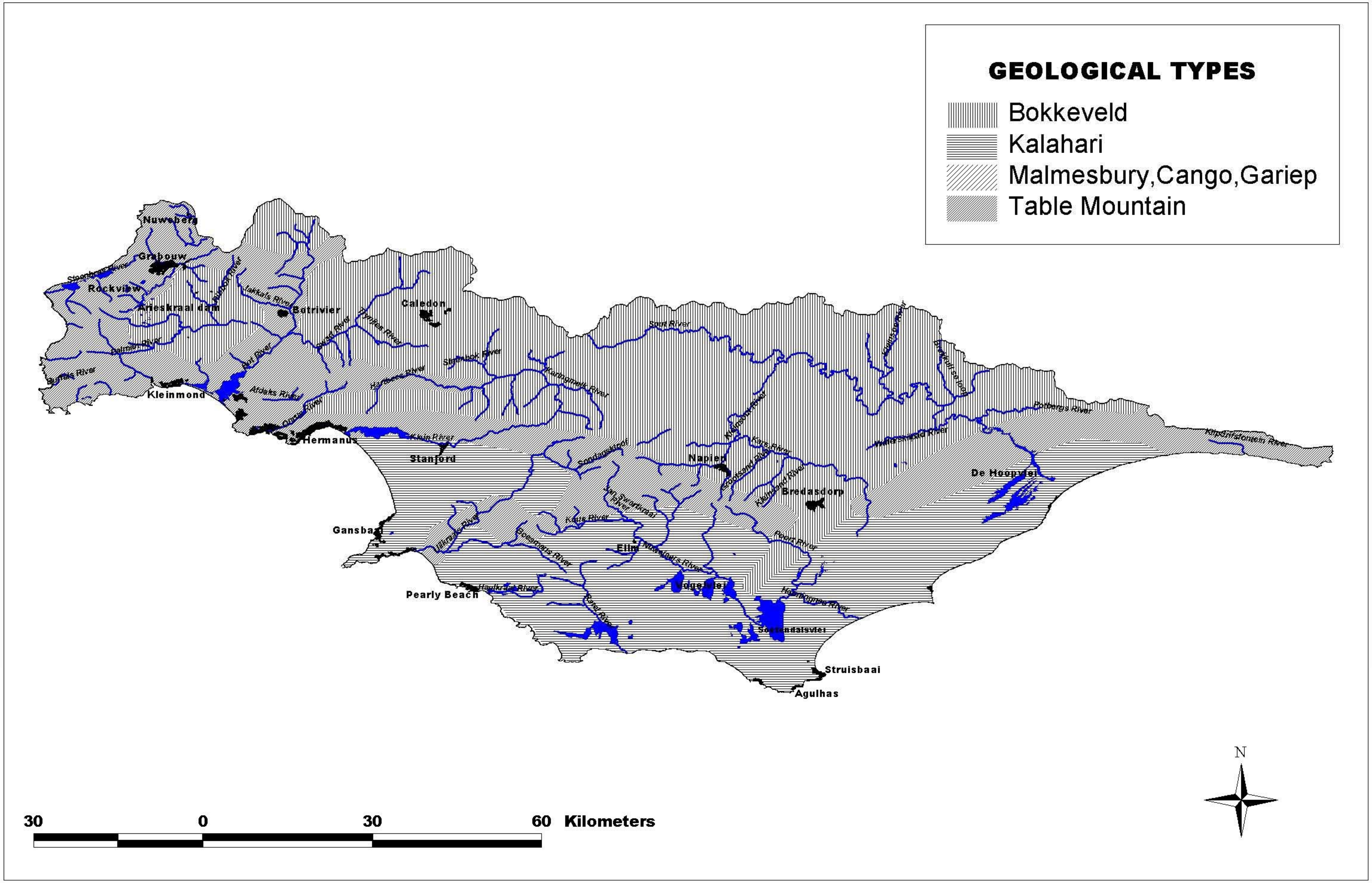


Figure 3. Map showing the geology of the Overberg Region (after Vegter, 1995)

2.4. VEGETATION

The Overberg is home to some 2 500 indigenous species of which 300 species are endemic and 32 species endangered. The vegetation types are shown in Figure 4 (Low and Rebelo, 1996). The reason for the high species richness and diversity in this region, as well as over the whole Cape Floristic Kingdom, is due to the distinctness of various habitats within it. Each habitat contains either a difference or mosaic of landscape, climate, geology, altitude or soil formulating unique environments for vegetation to colonise and diversify. However, this exclusiveness often serves as a trade-off for sensitivity, creating narrow distribution ranges for most species residence (Mustart *et al.*, 2003 and Goldblatt & Manning, 2001).

The vegetation types of the Overberg comprise of: Acid sand proteoid fynbos (Mountain regions), Limestone proteoid fynbos (Sand plains), Neutral sand proteoid fynbos (Sand plains), Ericaceous fynbos (Steep or coast facing slopes), Dune asteraceous fynbos (Coastal dune sand), Elim asteraceous fynbos (Bokkeveld shale patches), Wet restiod fynbos (South-western lowlands), Dry restiod fynbos (Bredasdorp to Cape Agulhas), Renosterveld (Bokkeveld derived soils), Forest and thicket (rocky kloofs and river valleys), and Coastal strand and rocky vegetation. The largest families in the region's flora are Asteraceae, Fabaceae, Iridaceae, Ericaceae, Aizoaceae and Campanulaceae. These families include genera that are species rich, such as, *Erica*, *Aspalathus*, *Crassula*, *Senecio*, and *Gladiolus* (Mustart *et al.*, 2003 and Leeuwner *et al., 2003*).

Several rivers and wetlands are scattered across the region, with each supporting a unique assemblage of riparian vegetation. Typical riparian vegetation forms include: sparsely distributed trees, scattered shrubs, restiod/reed patches, sedge clumps, and grass promotions. The percentage cover of these forms varies as one moves from upper regions – dominated by typical proteoid composition – to lowland regions – dominated by wetland sedge and reed communities (Kemper, 2001).

Alien invasive vegetation has become exceedingly problematic over the Southern Overberg. The vegetation is well established in most river systems, which acts as a vector for terrestrial colonization. The eradication of the invaders is essential to the long-term health of indigenous vegetation and natural riverbank stability. However, management for aliens proves to be problematic as well as costly. The major invaders of the Southern Overberg are wattles, eucalypts and hakeas from Australia, as well as the pines from the Mediterranean Basin and California. The port-jackson, long-leaved wattle, myrtle and spanish reed have also spread over large areas of the Southern Overberg will likely become major invasive threats in the future (Mustart *et al*., 2003).

2.5. CLIMATE

The Overberg is a transitional region between winter-rainfall in the west and non-seasonal rainfall in the east. The westerly winds associated with cold fronts result in rain in the west but in summer the ridging South Atlantic high, cut-off lows and southerly air brings summer showers especially to the area east of Cape Agulhas. This results in more than 70% of rainfall during winter in the west, and in the east most rainfalls occur between late spring and early autumn. Rainfall ranges from 600mm annually at the coast around Stanford to 400mm around the Breede River mouth. The mountains receive much higher levels of rainfall of up to approximately 800mm. Temperatures range from 20-30°C in summer to 12-18°C in winter (Mustart *et al*., 2003).

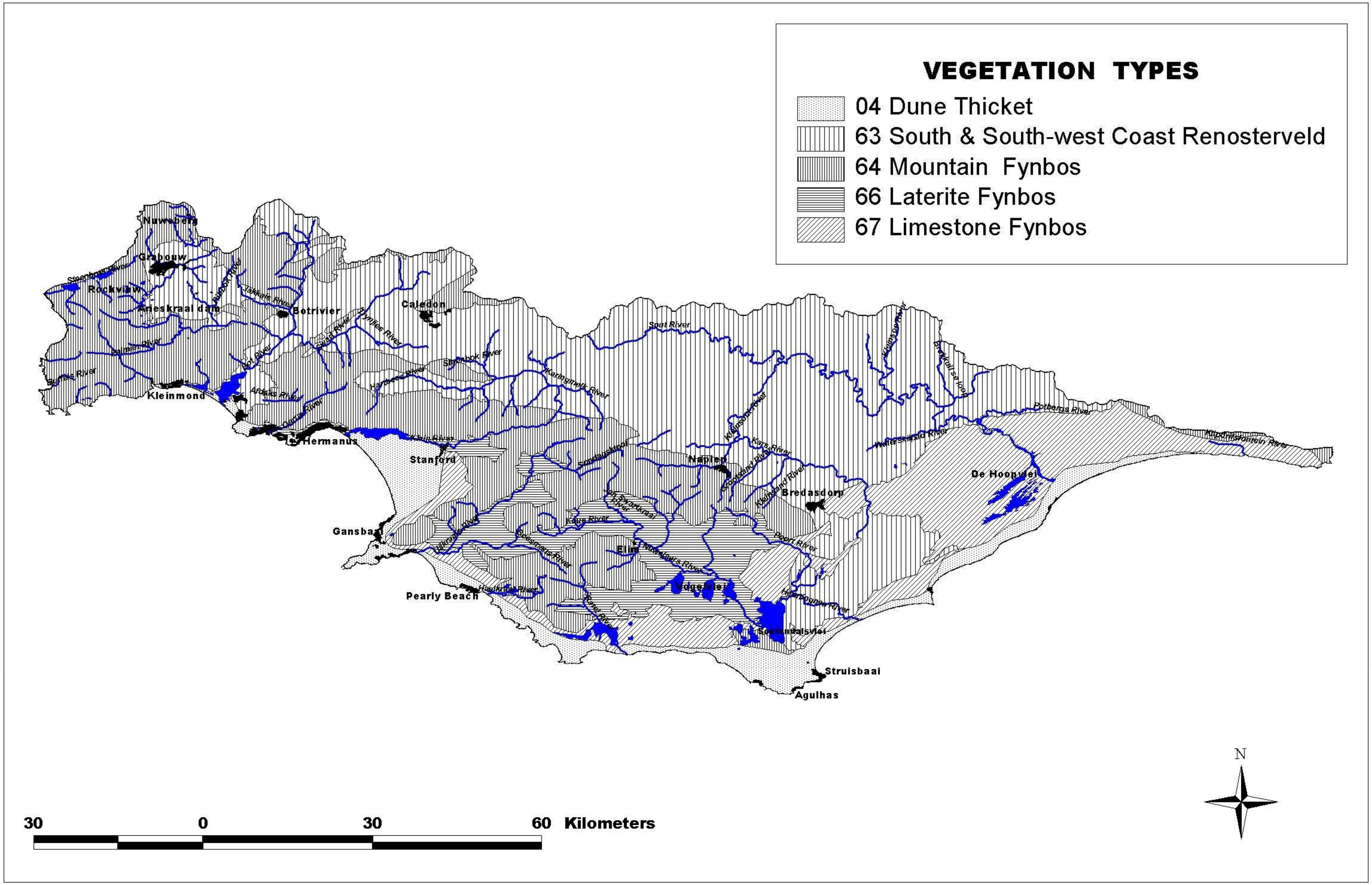


Figure 4. Map showing the vegetation types of the Overberg Region (after Low and Rebelo, 1996)

3. METHODOLOGY

All sites were monitored using the indices of the RHP, which assesses the present ecological health of a river at the time of sampling and is presented in terms of river health categories (Table 1).

Table 1. The river health categories (RHP, 2003)

Category	**Ecological Perspective**	**Management Perspective**
Natural (N)	No or negligible modification	Relatively little human impact
Good (G)	Biodiversity and integrity largely intact	Some human-related disturbance but ecosystems essentially in a good state
Fair (F)	Sensitive species may be lost, with tolerant or opportunistic species dominating	Multiple disturbances associated with the need for socio-economic development
Poor (P)	Mostly tolerant species; alien invasion, disrupted population dynamics; species are often diseased	High human densities or extensive resource exploitation

Table 2. Intermediate Habitat Integrity categories (from Kleynhans, 1996)

Category	**Description**	**Score (% of total)**
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

Sites, on each river system were selected either to illustrate reference conditions (where possible) or to monitor impacts. Reference conditions are defined as a condition represented by a group of least impacted sites of the same river type in terms of their physical, chemical and biological characteristics. This makes it possible to determine the degree of deviation from natural conditions (Dallas, 2000). Indices used include the South African Scoring System version 5 (SASS5), Riparian Vegetation Index (RVI), Geomorphological Index (GI), Index of Habitat Integrity (IHI), Fish Assessment Integrity Index and water quality. More information on the various indices are provided in Appendix A. Data sheets for SASS5 and IHI are included in Appendix B and C. SASS5, which uses macro-invertebrates as an indication of water quality, was assessed on a seasonal basis and sampling began during July 2004 until May 2005. This was done because invertebrates have a shorter life span than, for example, fish or plants and therefore would be more responsive to ecological changes. As a result, other indices were assessed only once during the 1-year monitoring period but the frequency of monitoring could also depend on local conditions (e.g. re-assessment of the biomonitoring indices due to modifications by a major flood event) (Mangold, 2001).

Table 3. List of sites assessed during the study (July 2004 - May 2005). Indices assessed included IHI, GI, RVI, SASS5/IHAS, fish and water quality. SASS5/IHAS were assessed seasonally and all other indices once during the study year. (SFM – Southern Folded Mountains; SCB – Southern Coastal Belt)

RHP Site Code	**River Name**	**Map Reference**	**Ecoregion Level I**	**Ecoregion Level II**	**Vegetation Type**	**Geology Type**
G4BOT-DORIN	Bot	3419AA	19 SFM	19.06	64 Mountain Fynbos	Db
G4BOT-KANAA	Bot	3419AA	19 SFM	19.06	63 S & SW Coast Renosterveld	Db
G4BOT-WILDE	Bot	3419AC	19 SFM	19.06	63 S & SW Coast Renosterveld	Ost
G4HERM-SAFCO	Hermanus	3419AC	19 SFM	19.04	64 Mountain Fynbos	Db
G4SWAR-CONFL	Swart	3419AC	19 SFM	19.06	63 S & SW Coast Renosterveld	Ost
G4ONRU-HAY	Onrus	3419AD	19 SFM	19.06	64 Mountain Fynbos	Ost
G4ONRU-VOLMO	Onrus	3419AC	19 SFM	19.06	64 Mountain Fynbos	Ost
G4ONRU-BRIDG	Onrus	3419AC	22 SCB	22.05	66 Laterite Fynbos	Ost

RHP Site Code	River Name	Map Reference	Ecoregion Level I	Ecoregion Level II	Vegetation Type	Geology Type
G4KLEI-GOUDI	Klein	3419BC	22 SCB	22.04	63 S & SW Coast Renosterveld	Ost
G4KLEI-BLUEG	Klein	3419BC	19 SFM	19.05	64 Mountain Fynbos	Ost
G4KLEI-WABOO	Klein	3419BC	19 SFM	19.05	64 Mountain Fynbos	Ost
G4UILK-SALMO	Uilkraal	3419BC	19 SFM	19.05	64 Mountain Fynbos	Db
G4UILK-PAARD	Uilkraal	3419DA	19 SFM	19.05	64 Mountain Fynbos	Ost
G4UILK-BAARD	Uilkraal	3419CB	19 SFM	19.05	66 Laterite Fynbos	Ost
G5KARS-KARS	Kars	3419BD	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5KARS-ROOID	Kars	3419BD	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5KARS-SOUTK	Kars	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-DWAFW	Sout	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-SOESR	Soes	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-BRAKF	Sout	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-KYKOE	Sout	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5HOTN-CONFL	Hotnotskraal	3420AC	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-SOUTK	Sout	3419BD	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-KLIPD	Sout	3419BD	22 SCB	22.04	63 S & SW Coast Renosterveld	Db
G5SOUT-WYDGE	Sout	3420AD	22 SCB	22.03	63 S & SW Coast Renosterveld	Db

RHP Site Code	River Name	Map Reference	Ecoregion Level I	Ecoregion Level II	Vegetation Type	Geology Type
G5NUWE-KERSG	Nuwejaars	3419DB	22 SCB	22.03	66 Laterite Fynbos	Db
G5NUWE-BRAKP	Nuwejaars	3419DB	22 SCB	22.03	66 Laterite Fynbos	Db
G5KLEI-BOSKL	Klein Pietersielies kloof	3419DB	19 SFM	19.05	66 Laterite Fynbos	Ost
G5PIET-BOSKL	Pietersielies kloof	3419DB	19 SFM	19.05	64 Mountain Fynbos	Ost
G5HEUNI-RIVER	Heuningnes	3420CA	22 SCB	22.03	63 S & SW Coast Renosterveld	Toc
G5RATE-DIRKU	Ratel	3419DA	19 SFM	19.05	66 Laterite Fynbos	Ost

3.1 Index of Habitat Integrity (IHI)

The habitat availability and diversity are important in determining the types of biota, which occur within an ecosystem. Therefore the quality of the habitats is important in determining overall ecosystem health. The IHI assesses impacts to both the river channel and the riparian zone, which includes river regulation, alien vegetation, water abstraction, and so on. The results are a weighted score that is also placed within the river health categories (Kleynhans, 1996).

3.2 Geomorphological Index (GI)

The GI is used to provide an indication of the overall channel condition and stability and is one of the bio-physical indices of the RHP. The geomorphological processes and hydrology of a river system form the habitats, which biota occupy and changes in stream biota must be assessed against possible changes in channel condition and morphology (Rowntree & Ziervogel, 1999). A site is placed within an impact class according to the extent to which the geomorphology of a river system has been affected by human impacts.

Sites were also classified according to the geomorphological zone in which they occurred. The zones group river reaches that have similar geomorphological features such as channel morphology, bed material and gradient, within similar ecoregions (RHP, 2003). Rowntree and Wadeson (1999) have developed a classification template describing the longitudinal zones by evaluating valley form, gradient and characteristic channel features as shown in Table 2.

Table 4. Geomorphological zonation of South African river channels (after Rowntree and Wadeson 2000).

Longitudinal zone	**Gradient class**	**Characteristic channel features**
A. Zonation associated with 'normal' profiles		
Source zone		Low gradient, upland plateau or basin able to store water. Spongy or peat hydromorphic soils
Mountain headwater	>0.1	Very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally 1st or 2nd order. Reach types include bedrock fall and cascades.
Mountain stream	0.04-0.09	Steep gradient dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool. Approximate equal distribution of vertical and horizontal flow components.
Mountain stream (transitional)	0.02-0.039	Moderately steep stream dominated by bedrock or boulder. Reach types include plane-bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited floodplain development.
Upper foothills	0.005-.019	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel with plane-bed, pool-rapid or pool-riffle reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.
Lower foothills	0.001-.005	Lower gradient mixed bed alluvial channel. Sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars are common in pools. Pools of significantly greater extent than rapids or riffles. Floodplains often present.
Lowland River	0.0001-0.001	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches.
B. Additional zones associated with a rejuvenated profile		

Longitudinal zone	Gradient class	Characteristic channel features
Rejuvenated bedrock fall/cascades	>0.02	Moderate to steep gradient, gorge channel resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, usually bedrock fall, cascades and pool-rapid.
Rejuvenated foothills	0.001-0.02	Steepened section within middle reaches of a river caused by uplift, often within or downstream of a gorge. Similar to foothills (gravel/cobble bed rivers with pool-riffle/rapids) but of a higher order. Compound channels are often present with an active channel contained within a macro-channel. A limited floodplain may be present between the active and macro-channel.
Upland floodplain	<0.005	An upland low gradient channel, often associated with uplifted plateau areas, as occur beneath the eastern escarpment.

3.3 Riparian Vegetation Index (RVI)

The RVI is a qualitative site based method designed for quick assessment of the health state of the riparian vegetation. The index assessment involves a scoring system comprised of weighted scores relative to riparian vegetation quality, the extent of coverage of riparian vegetation in the zone and the structural and compositional integrity of vegetation present. The model used for assessing the riparian vegetation zone is:

$$RVI=[(EVC)+((SI \times PCIRS)+(RIRS))]$$

Where: **EVC** is the extent of vegetation cover, **SI** is structural intactness, **PCIRS** is percentage cover of indigenous riparian species and **RIRS** is recruitment of indigenous riparian species. A list of indigenous riparian species occurring along the rivers of the Overberg is shown in Appendix D.

3.4 Water quality

The water quality data was collected in conjunction with the biological assessments, where dissolved oxygen, conductivity and pH were measured *in situ* during each site visit, using portable YSI meters each time the invertebrates were sampled. Certain parameters could not be recorded during some site visits because meters were not always available at the time of sampling. Water chemistry data was also sampled at each site and analyzed at the SABS laboratories, soon after the biomonitoring assessment was completed. These data were assessed according to fitness of water quality for aquatic life as follows: free and saline ammonia, nitrate and nitrite, total phosphate and ortho-phosphate were analysed. The compliance guidelines for river health water chemistry standards are as follows: contaminants were measured in mg/l

<0.05 – Oligotrophic

0.05-2.5 – Mesotrophic

2.5-10 – Eutrophic

>10 – Hypertrophic

3.5 South African Scoring System 5 (SASS5)

The SASS method is a rapid and cost-effective biological indicator method to assess water quality and the general riverine conditions (Chutter 1994, 1998). In South Africa, macro-invertebrates are the most commonly assessed biota (Chutter, 1998, Dallas, 2000). Macro-invertebrates spend much of their lives in water and therefore the quality thereof will determine their health and survival. The rationale behind SASS as an indicator of water quality is that pollution tolerant invertebrate species will be most common in polluted water and pollution intolerant species will be most common in good quality water.

SASS5 data were collected, scored and analysed based on the macro-invertebrate assemblages found over the 4 sampling seasons. This data was captured and exported electronically to a statistical software package called Primer Version 5, for additional resolved information purposes.

Cluster analysis (Bray-Curtis Similarity) and Multi-Dimensional Scaling (MDS) were processed and by transforming data with a presence/absence biological transformation technique. The cluster analysis was used to find natural groupings of samples, where samples, which are similar was group together at the average level of similarity. In addition, hierarchical agglomerative clustering, using group-average linking, was used to produce dendrograms (Dallas, 2002).

Multi-Dimensional Scaling (MDS) produced an ordination of a number of samples, where placement of samples reflected the similarity of their biological communities. A stress value was calculated in order to assess the reliability of the ordination. SIMPER analysis was also used to display which macro-invertebrates were most responsible for the groupings, which occurred in the cluster and ordination analysis (Dallas, 2002).

3.6 Fish Index

Fish caught during the sampling period were assumed to be representative of the entire fish community for the river section monitored. Fish were caught using a 5m by 3m small mesh seine net and sampling efforts were recorded at each site. Fish habitats sampled included slow (<0.3m/s), shallow (<0.5m); slow (<0.3m/s), deep (>0.5m); fast (>0.3m/s), shallow (<0.3m); and where possible fast (>0.3m/s), deep (>0.3m). Preferences were given to features found in each flow depth class, because fish species generally prefer particular refugia. These features included thick vegetation overhanging the stream surface, undercut banks and root wads, various stream substrate, and aquatic macrophytes (Kleynhans, 1999). Fish caught were classified to species level and distribution ranges were estimated (Skelton, 2001). Fish expected but not caught were determined by use of historic data and professional judgement. Voucher specimens for each river system were retained for the South African Institute of Aquatic Diversity. The expected FAII score for a fish habitat was calculated as follows:

$$\text{FAII (Relative)} = \text{FAII(observed)}/\text{FAII(expected)} \times 100$$

$$\text{FAII (Expected)} = T\,(A(exp)+F(exp)+H(exp))/3$$

$$\text{FAII (observed)} = T(A(obs)+F(obs)+H(obs))/3$$

T = Intolerance rating
A = Abundance
F = Frequency of occurrence
H = Health rating

*Fuzzy-based logic analysis substituted the FAII where an underestimation of biotic integrity was found. The formulae for estimating overall fish assemblage integrity based on the Fuzzy logic index is as follows:

$$\text{*Fuzzy-fish Index} = \frac{\text{Observed condition of determinants considered for estimation}}{\text{Expected conditions of determinants considered for estimation}}$$

The Fuzzy-fish Index score is converted to percentage for health class estimation.

4. RESULTS

4.1 OVERBERG WEST

4.1.1 BOT, SWART AND HERMANUS RIVERS

Three sites were selected on the Bot River and one on the Swart River, which is a tributary of the Bot (Figure 5). The general site information for each site is shown in Tables 5, 6, 7 and 8). The results for all indices are also presented and discussed.

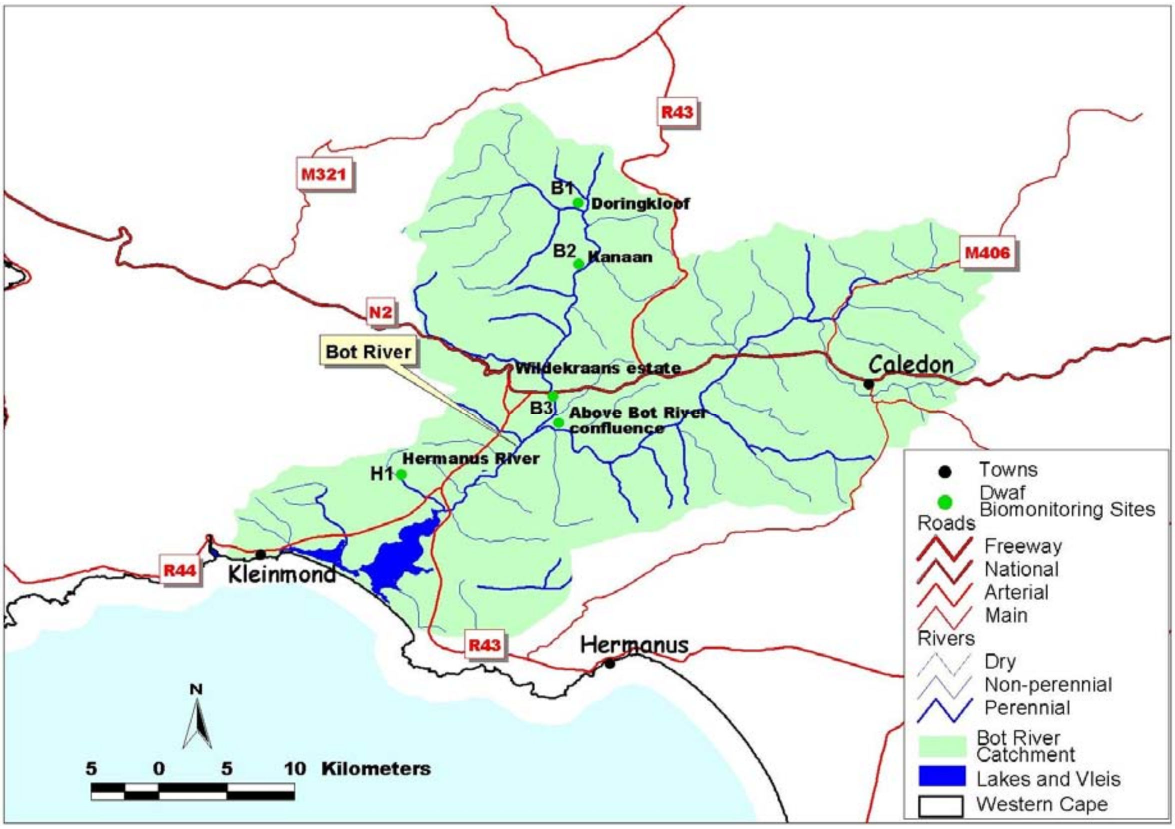


Figure 5. Map showing the monitoring sites on the Bot, Swart and Hermanus Rivers

Table 5. Summary of the general site information for Site B1

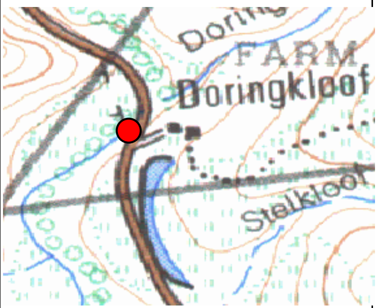
<table>
<tr><td>RHP Site code</td><td>G4BOT-DORIN</td><td>Project Site Number</td><td>B1</td></tr>
<tr><td>River</td><td colspan="3">Bot</td></tr>
<tr><td rowspan="2">Co-ordinates (Decimal Degrees)</td><td>Latitude</td><td colspan="2">Longitude</td></tr>
<tr><td>-34.11664</td><td colspan="2">19.23500</td></tr>
<tr><td>Site description</td><td colspan="3">On Doringkloof farm, Upstream site</td></tr>
<tr><td>Map Reference (1:50 000)</td><td>3419AA

</td><td>Site length (m)</td><td>20m</td></tr>
<tr><td>Longitudinal zone</td><td colspan="3">Upper foothills</td></tr>
<tr><td rowspan="2">Hydrological type</td><td>Natural</td><td colspan="2">Present</td></tr>
<tr><td>Perennial</td><td colspan="2">Perennial</td></tr>
<tr><td>Associated systems</td><td colspan="3"></td></tr>
<tr><td>Ecoregion 1</td><td>Southern Folded Mountains</td><td>Ecoregion 11</td><td>19.06</td></tr>
<tr><td>Secondary catchment</td><td>G4</td><td>Quaternary catchment</td><td>G40E</td></tr>
<tr><td>Vegetation type</td><td>Fynbos</td><td>Geological type</td><td>Db</td></tr>
<tr><td>Rainfall region</td><td colspan="3">Winter</td></tr>
</table>

Plate 1. Site B1- October 2004 (looking upstream)

Plate 2. Site B1- October 2004 (looking downstream)

Table 6. Summary of the general site information for Site B2

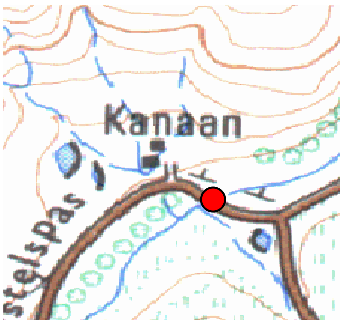
RHP Site code	G4BOT-KANAA	**Project Site Number**	B2
River	Bot	**Tributary of**	
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.16083	19.23575	
Site description	On the farm Kanaan. Located downstream of the causeway		
Map Reference (1:50 000)	3419AA 	**Site length (m)**	20m
Longitudinal zone	Lower foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.06
Secondary catchment	G4	**Quaternary catchment**	G40E
Vegetation type	South and south-west coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 3. Site B2 – October 2004 (looking upstream)

Plate 4. Site B2 – October 2004 (looking downstream)

Table 7. Summary of the general site information for Site B3

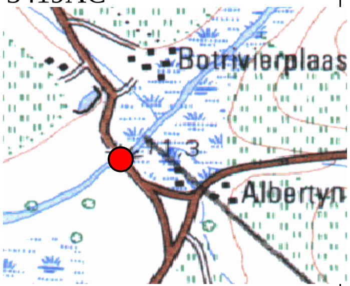
<table>
<tr><td>RHP Site code</td><td>G4BOT-WILDE</td><td>Project Site Number</td><td>B3</td></tr>
<tr><td>River</td><td colspan="3">Bot</td></tr>
<tr><td rowspan="2">Co-ordinates (Decimal Degrees)</td><td colspan="2">Latitude</td><td>Longitude</td></tr>
<tr><td colspan="2">-34.24092</td><td>19.21808</td></tr>
<tr><td>Site description</td><td colspan="3">Located at Wildekraans Wine Estate, along the R43 to Hermanus</td></tr>
<tr><td>Map Reference (1:50 000)</td><td>3419AC

</td><td>Site length (m)</td><td>20m</td></tr>
<tr><td>Longitudinal zone</td><td colspan="3">Lower foothills</td></tr>
<tr><td rowspan="2">Hydrological type</td><td colspan="2">Natural</td><td>Present</td></tr>
<tr><td colspan="2">Perennial</td><td>Perennial</td></tr>
<tr><td>Associated systems</td><td colspan="3">Marshes, wetlands and vleis</td></tr>
<tr><td>Ecoregion 1</td><td>Southern Folded Mountains</td><td>Ecoregion 11</td><td>19.06</td></tr>
<tr><td>Secondary catchment</td><td>G4</td><td>Quaternary catchment</td><td>G40G</td></tr>
<tr><td>Vegetation type</td><td>South and south-west coast Renosterveld</td><td>Geological type</td><td>Ost</td></tr>
<tr><td>Rainfall region</td><td colspan="3">Winter</td></tr>
</table>

Plate 5. Site B3 – October 2004 (looking upstream)

Plate 6. Site B3 – October 2004 (looking downstream)

Table 8. Summary of the general site information for the Swart River, site SW1

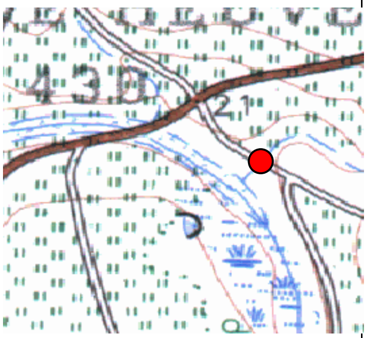
RHP Site code	G4SWAR-CONFL	**Project Site Number**	SW1
River	Swart	**Tributary of**	Bot
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.25958	19.22483	
Site description	Above Bot confluence, Avontuur rd low flow bridge		
Map Reference (1:50 000)	3419AC 	**Site length (m)**	20m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.06
Secondary catchment	G4	**Quaternary catchment**	G40F
Vegetation type	South and south-west coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 7. Site SW1- October 2004 (looking upstream)

Plate 8. Site SW1- October 2004 (looking downstream)

A. *INDEX OF HABITAT INTEGRITY: BOT RIVER SYSTEM*

The instream habitat integrity of the Bot River is generally less modified than the riparian habitat integrity (Figure 6). In the lower reaches of the Bot river system, the instream habitat integrity rapidly deteriorates from being largely natural to the currently largely modified, due to effects of the surrounding agricultural activities. The riparian habitat integrity rapidly deteriorates from being moderately modified to critically modified in the lower reaches.

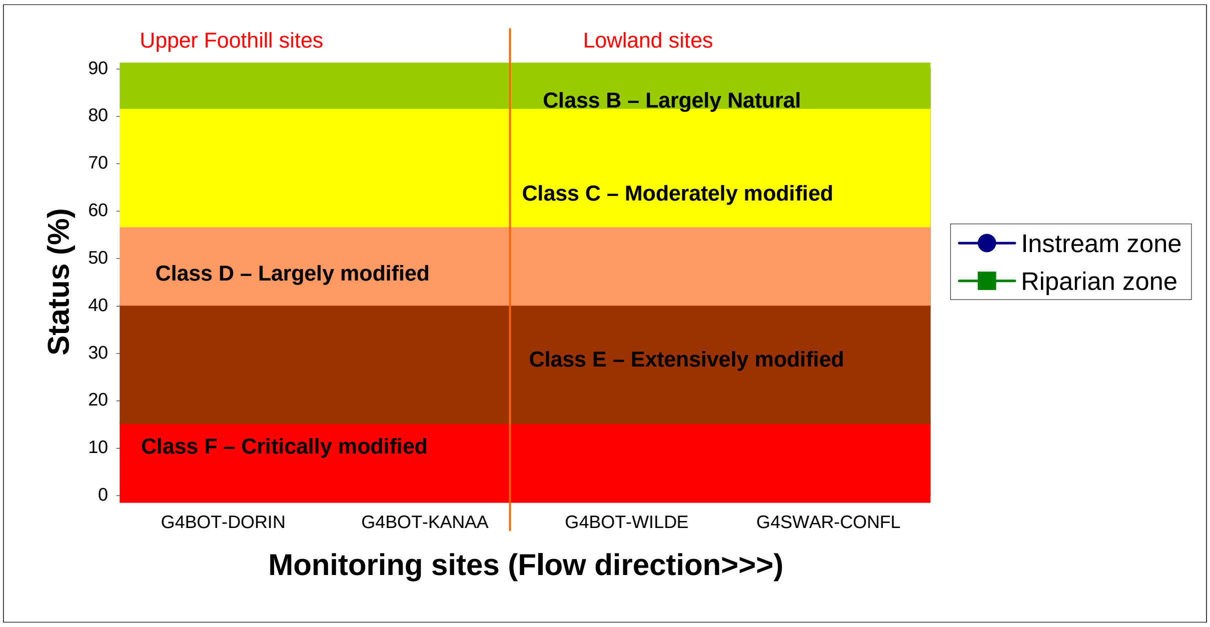


Figure 6. Summary of Index of Habitat Integrity results for the Bot River System

Site B1 – Bot (Doringkloof)

Instream – Class B

- Water abstraction and water quality (algal growth on rocks) have both moderately impacted on the instream environment.

Riparian – Class C

- Alien vegetation, and to a smaller degree, the loss of indigenous vegetation have impacted largely on the riparian zone.

B2 – Bot (Kanaan)

Instream – Class D

- Water abstraction, bed and channel modification have seriously impacted on the instream environment at this site. Flow modifications due to the many off-stream dams upstream from this site have impacted on the low flows.
- Water quality has also been moderately impacted, as a result of the surrounding cultivated fields that are fertilized and treated with pesticides.

Riparian – Class F

- Bank erosion, the loss of indigenous vegetation and an infestation of alien vegetation have critically modified the riparian zone.
- Flow modifications due to the many off-stream farm dams and abstraction pumps have seriously impacted on the riparian zone.

B3 – Bot (Wildekrans)

Instream - Class D

- Prior to the flood event in April 2005, the entire channel was overgrown and encroached by vegetation (instream sedges and reeds) indicating that the cumulative effects of water abstraction practises in the catchment have seriously modified the instream habitat availability.
- The many off-stream dams have also largely altered the low flows regimes.
- Water quality has been largely impacted by the cumulative effects of agricultural activities within the catchment (sediment inputs, nutrients, pesticides and waste).

Riparian – Class F

- The encroachment of alien vegetation in the riparian zone has critically modified the riparian zone. Additionally, the decrease in indigenous vegetation and the effects of water abstraction have seriously impacted on the riparian channel.

SW1 – Swart River (Confluence)

Instream – Class D

- Intensive water abstraction practises, for vineyard and wheat irrigation has resulted in the river drying up occasionally.
- Increased sediment, nutrients and pesticides from the surrounding catchment have largely affected water quality.

- A causeway and cattle trampling paths that are generally present have largely modified the instream channel.
- Instream low flows have been largely modified by the presence of many off-stream dams in the upper catchment. Sedimentation, cattle trampling and algal growth have also largely modified the instream bed.

Riparian – Class F

- Bank erosion, channel modification and an increase in alien vegetation have occurred within the riparian zone.
- Cattle trampling paths have largely modified the riparian channel.
- Water abstraction in off-stream dams, together with associated extended low flow, have largely affected the riparian zone.

B. GEOMORPHOLOGICAL STATUS OF THE BOT AND SWART RIVER SITES

Site B1 is located on the farm Doringkloof in the upper foothill zone. The channel type is mixed (bedrock exposed) and cobble dominated areas forms riffles. The pools showed sand deposition and the reach type was classified as a pool-rapid. The banks were well stabilized but localized erosion occurred on the outside bend of the right hand bank (RHB). The bed was moderately packed where cobble occurred and was moderately embedded, as flows were low at the time of sampling. Both banks showed a high impact by alien vegetation. The RHB was cleared and replanted with grass as the area was used for recreation. Both the habitat diversity and habitat cover was relatively high. **Impact class: C.**

Site B2 was located on the farm Kanaan in the lower foothill zone. The channel is alluvial and the dominant bed material is sand, although cobble also occurs resulting in a pool-riffle reach type. Both banks showed a moderate to low stability with sparse vegetation cover and removal of alien vegetation downstream of the bridge. Alien trees dominated the left hand bank (LHB) at the site and bank scour occurred. Upstream of the causeway the channel was very narrow (2-4m) due to dense alien vegetation on both banks and in stream as well as dense reed growth within the channel. The RHB was filled in with mostly building rubble and sand to protect the adjacent grazing land resulting in localized channel straightening. After a flood event in April 2005 a steep channel was scoured on the LHB and the instream

vegetation was removed. Causeways occur within the reach and both banks were unstable for approximately 20m downstream of the bridge. Extensive sediment is supplied to the channel and the habitat diversity and cover was moderate.
Impact class: E.

Site B3 was located on the wine farm, Wildekraans Estate, in the lower foothills. The channel is alluvial with cobble and sand being dominant. The reach type was classified as pool-riffle and lateral bars occurred. Both banks were well stabilized by alien vegetation, which had a high impact, and at the time of sampling the vegetation had encroached on the upstream channel. The initial survey showed a single narrow channel but after the flood event the channel was braided with mid channel bars. The instream vegetation was completely removed and resulted in increased channel width. Localised bed compaction also occurred where farm vehicles crossed the river. Habitat diversity and cover was moderate pre-flood and post-flood it decreased due to removal of vegetation and infilling of open substrate spaces. **Impact class: D.**

Site SW1 was located at a causeway in the lowland river zone and agriculture and livestock farming dominated the surrounding landuse. The channel type was alluvial and dominated by a sand substrate. The reach was classified as a flat bed and mid channel bars occurred within the channel. Extensive reeds grew within the riparian zone and it also dominated within the channel downstream of the causeway during low flows. Both banks were moderately stable and showed signs of trampling by livestock and fluvial erosion due to recent flooding, which had occurred at the time of sampling. Alien vegetation had a moderate impact and the local sediment sources supplied to the channel was extensive. Habitat diversity and cover were limited. **Impact class: C.**

Table 9. Summary of the geomorphological assessment of the Bot and Swart River sites

Sites	**Site B1**	**Site B2**	**Site B3**	**SW1**
Zone	Upper foothills	Lower foothills	Lower foothills	Lowland river
Channel pattern	Single	Single	Single	Multiple
Water level	Low flow	Medium flow	Low Flow	Medium flow
Valley form	Alternating slopes	Alternating slopes	Foothill floodplain	Foothill floodplain

Active channel width	5-10m	50-10m	5-10m	30-50m
Macro-channel width	None	None	None	None
Channel type	Mixed	Alluvial	Alluvial	Alluvial
Bars	None	None	Lateral bars	Mid channel
Bed material	Cobble (dominant)	Sand	Sand	Sand
Reach type	Pool-rapid	Pool-riffle	Pool-riffle	Flat bed
Bank erosion Fluvial	Slight-moderate (10-33%)	Slight-moderate (10-33%)	Slight (<10%)	Moderate both banks (10-33%)
Bank erosion Subaerial	None	Limited-active rilling	Limited rilling	Active rilling
Impact class	**C**	**E**	**D**	**C**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE BOT AND SWART RIVERS

Site B1 was a fairly acceptable upper foothill riparian habitat with some flood scour as a result of flood events prior to assessment. Riparian vegetation structural intactness was slightly modified by the presence of invasive species - *Arundo donax* (Spanish reed) populations on the wet banks; mature isolated *Populus x canescens* (Poplar) clumps on the dry banks; and *Acacia mearnsii* (Black wattle) stands, covering a moderate percentage of the riparian zone. However, recruitment of indigenous species was prevalent over the site, with plant representatives from all vegetation classes - tree *Olea europeae* subsp. *africana* (Wild olive) and *Cussonia spp.* (Common Cabbage); shrub *Rhus spp.* (Taaibos or Karee); sedge *Cyperus spp./ Phragmites spp.* and the cosmopolitan grass *Cynodon spp.*

The site was estimated as **Class C (13.0)**, which is moderately modified. A loss and change of natural habitat and biota have occurred. However, with the removal of invasive species, the site's riparian zone will return to its natural state.

Site B2 presented a moderate degree of flood scour indicating a loss of potential riparian vegetation cover. In addition, the impacts of alien invasion by *A. mearnsii, A. donax* and

Populus spp. were more pronounced than at the upper-site. Furthermore, a lack of structural intactness was evident, with no indigenous tree or shrub components represented. Impacts of stock farming were confined to this site. However, instream vegetation was satisfactory, consisting of *Phragmites australis* (common reed) and *Cyperus sp.* habitats.

The site was **Class E (7.0)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are broadly disturbed. Alien management will improve the health of this river considerably.

Site B3 presented a fairly intact vegetation cover, with little eroded soil over the riparian zone. Alien invasion was consistent with site 2, containing *A.mearnsii* and *Populus spp*. Instream vegetation cover was adequate due to indigenous reed and sedge species distribution being patchy and the alien invasive Spanish reed not presented. Human induced disturbance appeared to have played a major role in this site's modification as land-use practices was found to be extensive.

The site was **Class E (7.70)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are broadly disturbed.

Site SW1 had complete vegetation cover within the riparian zone. However, the cover component class for vegetation types was only moderately represented. The tree component present consisted of the alien invasive species *Acacia saligna* (Port Jackson) residing in low densities. Indigenous shrubs present over the riparian zone were few and sparse. However, grass and sedge species were reasonably distributed. Reed species *P. australis* density was inappropriately high. This might be related to water abstraction, compromising water flow rates.

The site was estimated as **Class D (9.90)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. Impacts are not extensive.

D. WATER QUALITY

Table 10. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Bot and Swart River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
B1	2004/10/05	50	-	6.98	17.3
B1	2005/02/23	0.518	8.7	6.86	23.7
B1	2005/05/24	-	-	7.03	13.7
B1	2005/12/06	49	69	-	20.1
B2	2005/05/24	-	-	7	14
B2	2004/07/08	23.65	11.13	7.33	9.3
B2	2004/10/04	41	-	7.06	19.4
B2	2005/02/23	0.645	8.67	7.25	22.5
B2	2005/12/06	70.6	7.1	-	21
B3	2005/05/05	-	-	6.58	18.6
B3	2004/07/07	19.09	11.77	7.05	10.7
B3	2004/10/04	43	-	7.05	18.7
B3	2005/02/23	48.52	-	8.36	23.8
B3	2005/12/06	64.1	7.6	-	20.4
SW1	2005/05/05	-	-	7.79	17.1
SW1	2005/12/03	34.66	4.45	7.90	25.5
SW1	2004/10/04	18.8	-	7.15	20.4
SW1	2004/07/07	0.989	11.56	7.86	14

Table 11. Results of water chemistry analysis

Determinants	Results			
	B1	B2	B3	SW1
Free and saline ammonia (as N in mg/l)	<0.3	<0.3	<0.3	<0.3
Nitrate and Nitrite (as N in mg/l)	<0.3	<0.3	<0.3	<0.3
Total phosphate (as P in mg/l)	<0.05	<0.05	<0.05	0.15
Ortho-phosphate (as P in mg/l)	<0.05	<0.05	<0.05	<0.05

The results for the water chemistry analysis was all considered to fall within the classes fair to good, with the exception of site SW1 containing an excessively high concentration of total phosphate ions above the recommended compliance standards, and was classed as poor for these determinants.

E. SASS5 ASSESSMENT OF THE BOT AND SWART RIVERS

The Bot River flows almost entirely through cultivated lands, mostly vineyards. The upper site had a good habitat diversity, which is reflected in the IHAS scores (73-85%) but the SASS5 and ASPT scores were still fair, indicating that deterioration in water quality has occurred. No sensitive species were found with the highest scorers being Hydracarina, Aeshnidae and Elmidae, all scoring 8. Very low scores were obtained during May 05 except at site 2 where a slight improvement was found. This result was attributed to the floods, which occurred during April 2005 causing a reduction of invertebrates, as river habitats were limited. Not much variation occurred between the SASS5 scores for the middle and lower sites on the Bot River and the ASPT scores were consistent, ranging between 4 and 5.6.

The site in the Swart River had very poor habitat availability (IHAS, 40-50%) and low scoring invertebrates were always found indicated by the low ASPT and SASS5 (also indicating few taxa found) scores. These results could be deemed fair if the river habitat proves naturally homogeneous. However, livestock farming has impacted directly to the site condition with livestock trampling and disturbances.

Table 12. Summary of the SASS5 and ASPT scores for the Bot and Swart River sites

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
B1						
05-Oct-04	98	18	5.44	C	82	SIC, SOOC, m/aqVeg, GSM
23-Feb-05	133	26	5.12	C	85	SIC, SOOC, m/aq Veg, S
24-May-05	46	12	3.83	E/F	73	SIC, SOOC, m/aqVeg, GSM
B2						
07-Jul-04	84	15	5.6	C	67	SIC, aqVeg, GS
04-Oct-04	88	17	5.17	C	70	SIC, SOOC, aqVeg, GS
23-Feb-05	87	19	4.57	D	81	SIC, SOOC, m/aqVeg, G
24-May-05	92	17	5.4	C	67	SIC, SOOC, aqVeg, GS
B3						
07-Jul-04	81	15	5.4	C	79	SIC, SOOC, m/aqVeg, GS
04-Oct-04	91	18	5.05	C	78	SIC, SOOC, m/aqVeg, GS
23-Feb-05	85	19	4.47	D	81	SIC, m/aqVeg, GM
05-May-05	58	12	4.83	D	65	SIC, m/aqVeg, GS
SW1						
07-Jul-04	14	4	3.5	E/F	53	aqVeg, GS
04-Oct-04	45	10	4.5	D	53	aq veg, G
05-May-05	44	10	4.4	D	40	m/aqVeg, GM

F. FISH ASSESSMENT FOR THE BOT AND SWART RIVERS

Site B1

This river segment has very good fish habitat and consists of pools with good depth, riffles, rapids and cascades. There is good marginal vegetation comprising reed and sedge species (*Phragmites australis* and *Prionium serratum*). Flow was good and clarity was acceptable. The expected indigenous primary freshwater fishes at site B1 are *Sandelia capensis* (Cape kurper) and *Galaxias zebratus* (Cape galaxias). However, sampling efforts yielded no indigenous freshwater fish with the seine net, but only caught the alien specie *Micropterus dolomieu* (smallmouth bass). It was predicted that the presence of the smallmouth bass has resulted in the loss of indigenous fish species.

Table 13. Numbers of fish caught and the Fish Index Score for site **B1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*M. dolomieu* (1 at 15cm)	10/35 = 28% E	No indigenous fish, bass present

Site B2

This river segment still displayed good habitat diversity with ample depth in the pools, but habitat quality was not as good as at site B1. More sediment was found in the pools, most probably as a consequence of surrounding agricultural activities. Flow was good and clarity was acceptable. Expected indigenous species were the same as for site B1 but despite intensive seining no fish were caught indicating the presence of bass, which are difficult to catch in a seine net.

Table 14. Numbers of fish caught and the Fish Index Score for the site **B2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	None	18/35 = 22% E	No indigenous fish, bass likely present

Site B3

This river segment contained good habitat diversity, with presence of riffles, deep pools and vegetated backwaters. Flow was good and clarity acceptable. Expected indigenous species are the same as site B1 but *M. dolomieu* were caught in the seine net, hence the absence of indigenous fish.

Table 15. Numbers of fish caught and the Fish Index Score for the site **B3** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*M. dolomieu* (3 between 5-25cm)	9/35 = 26% E	No indigenous fish, bass present

Site SW1

The site had good habitat for *S. capensis and G. zebratus* with wide, well vegetated pools and an adequate depth. Flow was good and water quality appeared acceptable. Seine netting below the bridge revealed no freshwater indigenous fish but very good numbers of *Myxus capensis* (freshwater mullet) was found. This can be viewed as a positive feature for this river section in terms of fish migration. *Lepomis macrochirus (*Bluegill sunfish) was unfortunately present in large numbers and may explain why the two expected indigenous species were absent from the samples.

Table 16. Numbers of fish caught and the Fish Index Score for the site **SW1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*M. capensis* (15-20 at 6-8cm) *L. macrochirus* (10-15 at 4-8cm)	21/35 = 60% C	No Galaxias, mullet present, bluegill sunfish

4.1.2 HERMANUS RIVER

Only one site was selected on the Hermanus River (Figure 7). This site was in a natural condition and located on SAFCOL property. The surrounding landuse activities occurring in the vicinity of the Fynbos reserve were some forestry plantations upstream. This river ultimately flows down to meet the Bot River just before the estuary. The general site information is shown (Table 17).

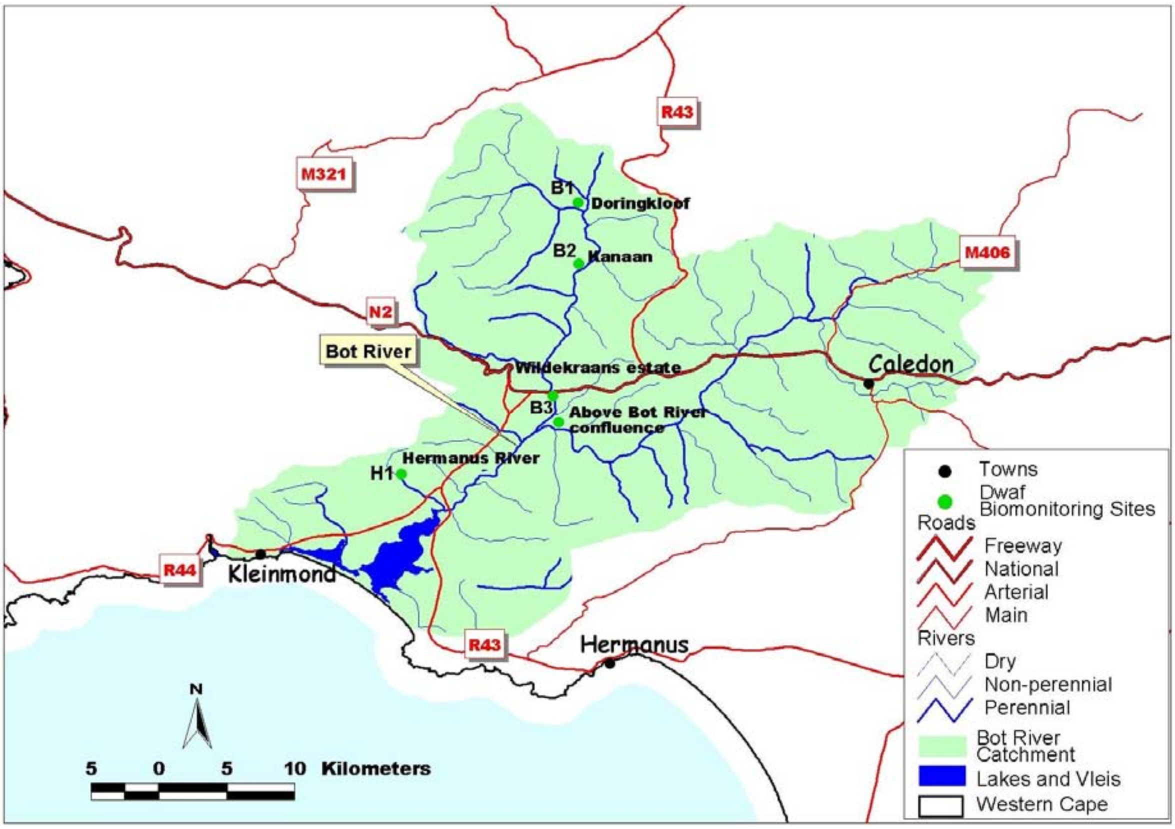


Figure 7. Map showing the monitoring sites on the Bot, Swart and Hermanus Rivers

Table 17. Summary of the general site information for Site **H1.**

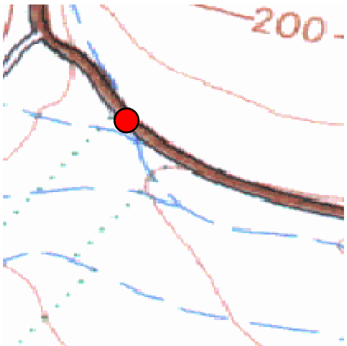
RHP Site code	G4HERM-SAFCO	**Project Site Number**	H
River	Hermanus		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.29403	19.11781	
Site description	Within SAFCOL owned property		
Map Reference (1:50 000)	3419AC 	**Site length (m)**	25m
Longitudinal zone	Upper foothill		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis in lower reaches		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	10.04
Secondary catchment	G4	**Quaternary catchment**	G40G
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 9. Site H- October 2004 (looking upstream)

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Plate 10. Site H- October 2004 (looking downstream)

A. INDEX OF HABITAT INTEGRITY: HERMANUS RIVER

The Hermanus River, site **H1**, habitat integrity for both the instream and riparian zones fall within Class A (natural and unmodified).

Instream – Class A

- The presence of pine plantations in the upper catchment might cause slightly reduced flow for the instream habitat, particularly during the low flow period.

Riparian – Class A

- The pine plantations in the upper catchment may have had a very small effect on the riparian zone in terms of flow modifications.

B. GEOMORPHOLOGICAL STATUS OF THE SITE ON THE HERMANUS RIVER

This site was largely natural and located in the upper foothills zone. The channel was narrow and alluvial with cobble as the dominant substrate. The reach type was pool-riffle and both banks were stable with only limited rilling (miniature stream channels that develop when water flows over a bare or sparsely vegetated area/slope) occurring in the vicinity of the bridge. The habitat diversity and cover were both high. The only channel impacts were limited erosion and a bridge with side supports but geomorphologically this was not significant. **Impact class: B.**

Table 18. Summary of the geomorphological assessment of site **H1.**

Site	**Site H1**
Zone	Upper foothills
Channel pattern	Single
Water level	Medium flow
Valley form	Foothill floodplain
Active channel width	05-1.5m
Macro-channel width	None
Channel type	Alluvial
Bars	None
Bed material	Cobble
Reach type	Pool-riffle
Bank erosion fluvial	Slight (LHB) (<10%)
Bank erosion sub-aerial	Active rilling (LHB)
Impact class	**B**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE HERMANUS RIVER

This site was situated amidst a close to pristine mountain fynbos habitat within the vicinity of Kogelberg Biosphere Reserve. As expected, the extent of vegetation cover of the riparian zone was entirely natural; the structural intactness of the riparian vegetation's density and distribution components was also natural; and the regeneration of indigenous species was extensive. Flora present included no tree species (typical of some mountain fynbos habitats) but rather contained an upper canopy class shrub mosaic of *Berzelia lanuginose, Protea spp.* and *Brunia spp.* Other riparian vegetation included *Restio dispar* (reed), *Erica macowanii* (shrub), *Blechnum capensis* (fern), *Agathosma spp.* (shrub), *Cliffortia spp.* (shrub), including instream sedge, amongst others.

This site was estimated as **Class A (19.0),** which is unmodified or natural. The only disturbance to this site is a small gravel road, which has an insignificant impact.

D. WATER QUALITY

Table 19. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Hermanus River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
H1	2005/05/05	-	16.55	5.2	17.1
H1	2004/07/07	13.52	10.04	5.18	14.5
H1	2004/10/04	-	-	4.99	17.3
H1	2005/02/23	18.69	16.46	5.33	20.4
H1	2005/12/06	23	8.1	-	17.8

Table 20. Results of water chemistry analysis

Determinands	Results
	H1
Free and saline ammonia (as N in mg/l)	<0.03
Nitrate and Nitrite (as N in mg/l)	0.6
Total phosphate (as P in mg/l)	<0.05
Ortho-phosphate (as P in mg/l)	<0.05

The results of the water chemistry analysis all displayed acceptable concentrations of nitrogen and phosphate ions and was classed as good.

E. SASS5 ASSESSMENT OF THE HERMANUS RIVER

Only one site was located on this river, upstream of any impacts. The site was as close to pristine as can be considered typical of a natural fynbos mountain stream and high scoring invertebrates were found, indicating natural water quality.

Table 21. Summary of the SASS5 and ASPT scores for the Hermanus River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
SAFCOL						
07-Jul-05	92	14	7.66	A	76	SIC, SOOC, m/aqVeg, GSM
04-Oct-04	138	10	7.66	A	78	SIC, mVeg, S
23-Feb-05	156	11	7.43	A	90	SIC, SOOC, mVeg, GSM
05-May-05	113	15	7.53	A	77	SIC, mVeg, GSM

4.1.3 ONRUS RIVER

Three sites were selected on the Onrus River (Figure 8). Site O1 was located on the farm Haygrove Heaven, site O2 below an instream dam and site O3 below residential development. The general site information for each site is shown below (Tables 22, 23, 24).

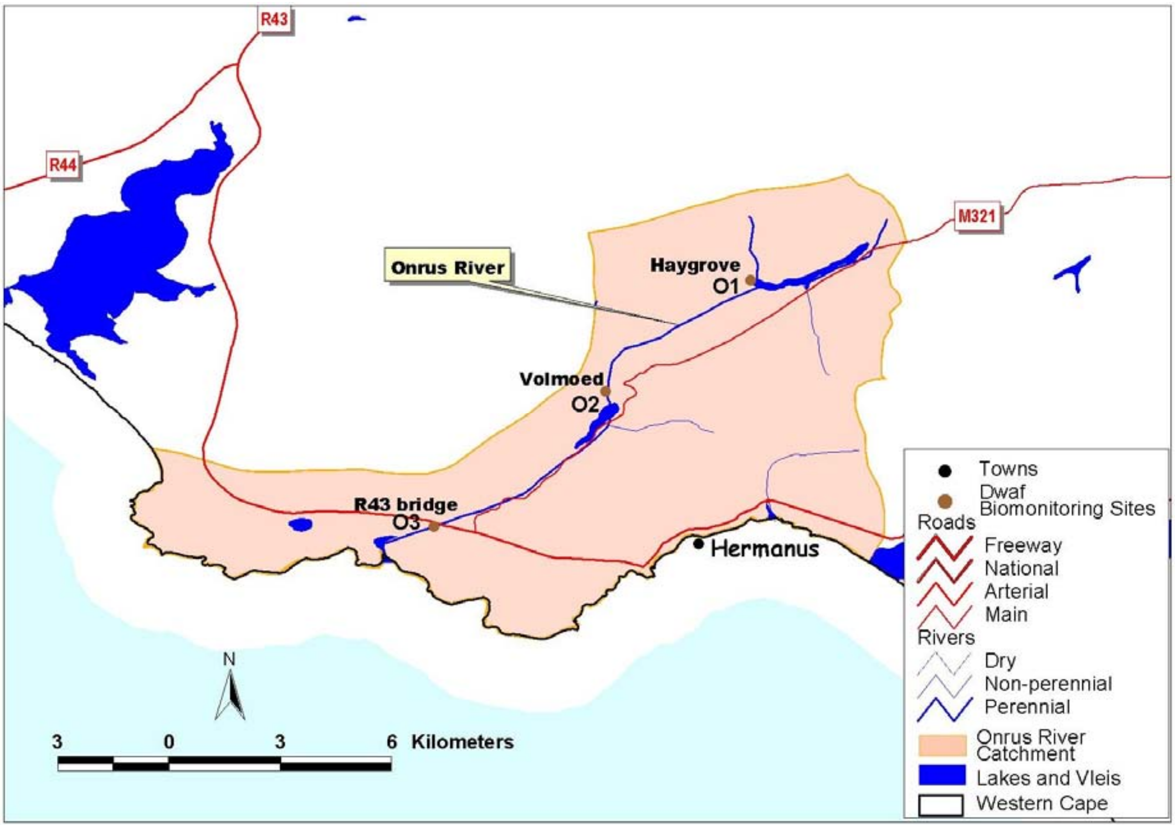


Figure 8. Map showing the monitoring sites on the Onrus River

Table 22. Summary of the general site information for Site O1

RHP Site code	G4ONRU-HAYGR	**Project Site Number**	O1
River	Onrus		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.35192	19.26836	
Site description	On the farm Haygrove Heaven at low flow bridge		
Map Reference (1:50 000)	3419AD 	**Site length (m)**	20m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.06
Secondary catchment	G4	**Quaternary catchment**	G40G
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 11. Site O1- October 2004 (looking upstream)

Plate 12. Site O1 – October 2004 (looking downstream)

Table 23. Summary of the general site information for Site O2

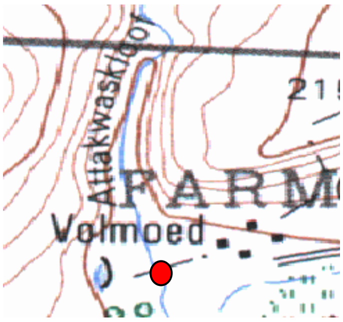
RHP Site code	G4ONRU-VOLMO	**Project Site Number**	O2
River	Onrus		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.37836	19.23261	
Site description	Located at the holiday resort, Volmoed		
Map Reference (1:50 000)	3419AC 	**Site length (m)**	10m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.06
Secondary catchment	G4	**Quaternary catchment**	G40G
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 13. Site O2 – October 2004 (looking upstream)

Plate 14. Site O2 – October 2004 (looking downstream)

Table 24. Summary of the general site information for Site O3

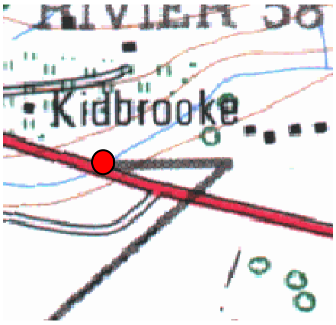
RHP Site code	G4ONRU-BRIDG	**Project Site Number**	O3
River	Onrus		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.41067	19.19300	
Site description	Located at the R43 road bridge at the residential area Kidbrooke		
Map Reference (1:50 000)	3419AC 	**Site length (m)**	20m
Longitudinal zone	Lower foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.05
Secondary catchment	G4	**Quaternary catchment**	G40G
Vegetation type	Laterite Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 15. Site O3– October 2004 (looking upstream)

Plate 16. Site O3– October 2004 (looking downstream)

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The Onrus Rivers' instream zone habitat integrity is less modified than that of the riparian zone (Figure 9). The instream habitat integrity deteriorates from being moderately modified at the uppermost site to being extensively modified at the second site as the effects of agriculture and urban developments become evident. Subsequently the instream habitat recovers slightly to largely modified at the lower site. The riparian habitat integrity rapidly deteriorates from extensively modified at the uppermost site to being critically modified at both the lower two sites.

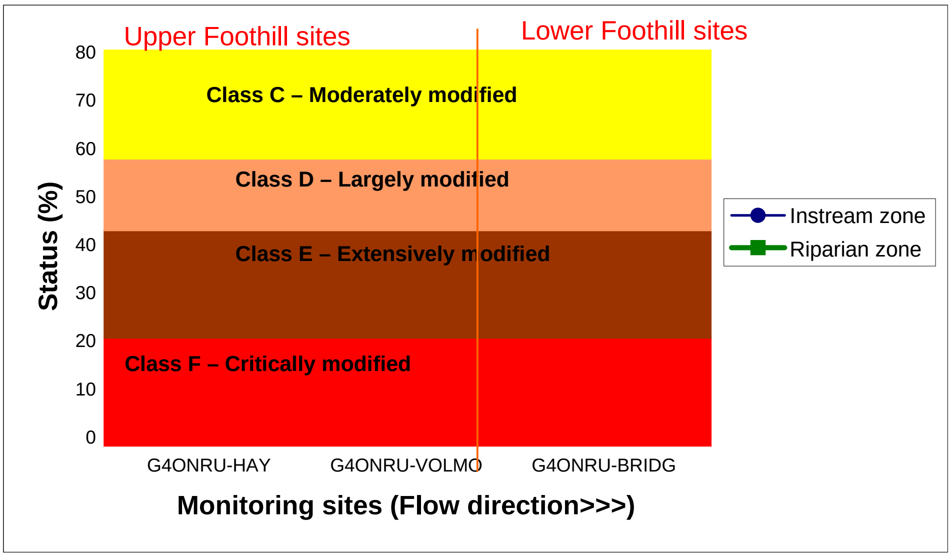


Figure 9. Summary of Index of Habitat Integrity results for the Onrus River System

Site O1 – Haygrove Heaven

Instream - Class C

- The effects of agricultural activities in the catchment have largely impacted on water quality (turbidity) and water abstraction in the instream environment.

Riparian - Class E

- The effects of alien vegetation encroachment, together with the associated decrease in indigenous vegetation have critically modified the riparian zone.

Site O2 – Volmoed

This site is situated directly below a small instream dam.

Instream – Class E

- The most serious impact for the instream habitat is the effect of water abstraction above the site.

- Flow modifications, as a result of the instream dam, have largely impacted on the instream habitat. The instream bed and channel have also been seriously modified at the site due to the presence of the instream dam and its associated structures.

Riparian – Class F

- The most critical impact in the riparian zone is the removal of indigenous vegetation and the associated increase in alien vegetation.
- The presence of the instream dam has resulted in slower flows downstream, which resulted in serious encroachment by reed species
- The riparian zone has also been moderately inundated as a result of the dam.
- The riparian channel has been moderately modified by the presence of horse paddocks and grazing areas alongside the dam.

Site O3 – Kidbrooke

Instream – Class D

- The instream habitat has been seriously modified by the cumulative effects of water abstraction from agricultural activities in the catchment, as well as the presence of extensive *Eucalyptus spp.* infestation along the banks of the river.
- These impacts have also seriously modified the low flows. The instream channel has been largely modified due to the presence of *Eucalyptus spp*, overstabilising the wetbanks and increased sediment input from surrounding urban developments (evident algal growth).

Riparian – Class F

- The riparian zone has been critically modified by an intensive *Eucalyptus spp.* infestation. As a result the impact on indigenous vegetation is critical as well, with the removal thereof being extensive.

B. GEOMORPHOLOGICAL STATUS OF THE ONRUS RIVER SITES

Site O1 was located on the farm Haygrove Heaven in the upper foothill zone. This site was located above the De Bos Dam, which supplies the Greater Hermanus Area. The channel was alluvial and dominated by a cobble substrate. The reach type was a pool-riffle. Both banks were very stable and dominated by dense alien trees causing some degree of channel straightening. Slight to moderate fluvial erosion occurred in the vicinity of the causeway. The bed was loosely packed and cobbles were moderately to well embedded in the pool and riffle areas. Run-off from a newly cultivated vineyard supplied a considerable amount of sediment to the channel. **Impact class: C.**

Site O2 was located at Volmoed, a recreational farm in the lower foothills. The site was located below an instream dam created for recreational purposes and below the bigger De Bos dam. The channel was very narrow and overgrown with vegetation downstream of the dam due to the decreased flow. The channel was alluvial and dominated by gravel although cobble also occurred. Lateral and mid channel bars occurred. The banks were well stabilized and slight fluvial erosion occurred on the LHB in the vicinity of the causeway. Banks upstream of the site were cleared and replanted with grass for recreation. Habitat diversity was decreased but the habitat cover was relatively high. Together with dams and causeways impacting on this reach, alien vegetation also had a high impact. Moreover, storage weirs and a shortage of sediment supply also impacted on the geomorphology of this site. **Impact class: D.**

Site O3 was located below the residential area, Kidbrooke, in Onrus. The channel was alluvial and gravel dominated in the lower foothills. The reach type was classified as pool-riffle. Both banks had a moderate stability and showed bank scour and active rilling and were dominated by alien trees. No bars occurred and the bed was loosely packed and moderately embedded. Some local source of woody debris occurred upstream of the site as a large amount of the alien trees had been cleared from the LHB. Other impacts which occurred, were bridges with in-channel supports and extensive sediment was supplied to the channel. The habitat diversity and habitat cover were relatively high. **Impact class: D.**

Table 25. Summary of the geomorphological assessment of the Onrus River sites

Sites	**Site O1**	**Site O2**	**Site O3**
Zone	Upper foothills	Lower foothills	Lower foothills
Channel pattern	Single	Single	Single
Water level	Low flow	Low flow	Low Flow
Valley form	Foothill floodplain	Alternating slopes	Foothill floodplain
Active channel width	5-10m	1.5-5m	10-15m
Macro-channel width	None	None	None
Channel type	Alluvial	Alluvial	Alluvial
Bars	None	Lateral and mid channel	None
Bed material	Cobble (dominant)	Gravel	Gravel
Reach type	Pool-riffle	Pool-riffle	Pool-riffle
Bank erosion Fluvial	Slight-moderate (10-33%)	Slight (<10%)	Slight-moderate (10-33%)
Bank erosion Subaerial	None	None	Active rilling
Impact class	**C**	**D**	**D**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE ONRUS RIVER

Site O1 presented a highly impacted riparian zone. This is primarily due to a high invasion by alien tree species: *A. mearnsii, A. saligna* and *Eucalyptus spp.* (river gum). Structural intactness, determined by vegetation class cover distribution, was adversely affected, with imbalances for tree-shrub-sedge-grass ratios. However, representatives and recruitment of indigenous riparian species were somewhat prevalent. Also, instream vegetation appeared reasonable with *Prionium spp.* (palmiet), *Typha capensis* (bull-rush) and *Phragmites australis* having patchy distributions.

The site was estimated as **Class D (9.0)**. This implies that natural habitat has been modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. Clearing of invasive species was observed and requires effective management for long-term improvement of river health.

Site O2 was more impacted than the upstream locality. The riparian zone continued to display the alien tree species, but with *A. mearnsii* dominating *Eucalyptus spp.* in density.

Grass forms predominated, covering some 50% of the riparian zone, and indigenous riparian individuals' recruitment rate was lower. Instream vegetation was consistent with O1, but somewhat denser and in good health.

The site was estimated as **Class E (8.30)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are broadly disturbed, excluding the instream habitat. Impacts of surrounding land-use practices were prevalent, but noticeably localised.

Site O3 was a significantly impacted riparian zone with a very high intensity of alien invasion and removal of the zone's topsoil. In addition, all the riparian vegetation classes were underrepresented, except for the grass component, which covered most of the riparian zone. Instream vegetation included *P. australis* and *Prionium spp.* in low density, but providing good faunal habitat.

The site was estimated as **Class E (7.0)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are broadly disturbed. Clearing of alien invasives and rehabilitation of the eroded topsoil is essential for the improvement of riparian zone integrity. The instream habitat requires less attention.

D. WATER QUALITY

Table 26. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Onrus River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
O1	2005/05/04	-	-	5.46	15.8
O1	2005/02/22	26.37	12.42	6.16	19.9
O1	2004/07/07	11.96	10.72	5.77	11.7
O1	2004/10/05	22	-	6.04	16.9
O1	2005/11/29	25.5	7.1	-	21.9
O2	2005/05/04	-	-	4.04	19.1
O2	2004/07/08	18.24	10.04	6.37	-
O2	2004/10/05	30	-	6.1	19.7
O2	2005/02/22	29.28	13.5	6.09	22.3
O2	2005/11/29	27.7	7.1	-	21.9
O3	2005/05/05	-	10.84	5.74	15.7
O3	2005/02/22	0.609	13.41	5.9	21.5
O3	2004/10/05	73	-	5.44	18.1
O3	2004/07/07	30.59	9.92	5.77	11.7
O3	2005/11/29	68.3	6.7	-	21.4

Table 27. Results of water chemistry analysis

Determinants	Results		
	O1	**O2**	**O3**
Free and saline ammonia (as N in mg/l)	<0.3	<0.3	<0.3
Nitrate and Nitrite (as N in mg/l)	<0.3	<0.3	<0.3
Total phosphate (as P in mg/l)	1.02	0.305	<0.05
Ortho-phosphate (as P in mg/l)	<0.05	<0.05	<0.05

The results for the water chemistry analysis was all considered to fall within the classes fair to good, with the exception of sites O1 and O2, containing an excessively high concentration of total phosphate ions above the recommended compliance standards, and was classed as poor for these determinants.

E. SASS5 ASSESSMENT OF THE ONRUS RIVER

Although the habitat availability was good (IHAS, 60-80%) vineyards had a large impact at the upper site. During the sampling period the LHB was cleared to cultivate with vineyards, which resulted in increased sediment loads at the site. The highest ASPT of 6.15 occurred during July 2004, where high scoring Helodidae (12) and Hydropsychidae > 2 species (12) occurred, probably due to flushing by higher flows. The middle site was located immediately below an instream dam so flows were always low during sampling times and habitats were reduced. Low scorers were always found and the ASPT scores (< 5) also reflected this. The same trend was observed at the lowest site, which was impacted mostly by residential areas.

Table 28. Summary of the SASS5 and ASPT scores for the Onrus River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
			O1			
07-Jul-04	80	13	6.15	B	73	SIC, SOOC, m Veg, GS
05-Oct-04	72	16	4.5	D	80	SIC, SOOC, m/aqVeg, GS
22-Feb-05	92	18	5.11	C	69	SIC, m/aqVeg, SM
04-May-05	35	7	5	C	74	SIC, SOOC, aqVeg, GS
			O2			
08-Jul-05	58	12	4.83	D	67	SIC, SOOC, m/aqVeg
05-Oct-04	71	16	4.44	D	64	SIC, SOOC, m/aqVeg
22-Feb-05	46	10	4.6	D	61	SIC, SOOC, m/aqVeg, M
04-May-05	56	13	4.31	D	64	aqVeg, GSM
			O3			
07-Jul-05	65	12	5.14	C	67	SIC, m/aqVeg, S
05-Oct-04	42	9	4.67	D	69	SIC, mVeg, GS
22-Feb-05	54	13	4.15	D	57	SIC, aqVeg, GS
05-May-05	50	11	4.54	D	59	SIC, m/aqVeg, GSM

*F. **FISH ASSESSMENT FOR THE ONRUS RIVER***

Site O1: Haygrove Heaven

This river segment contained small and fast flowing habitats, with adequate depth for *G. zebratus* in pools. The riparian zone is extensively invaded by invading vegetation species *A. mearnsii* and requires rehabilitation. The incised river, and near absence of instream plants e.g. *Prionium serratum,* makes the river less suitable for *G. zebratus*.

No fish were caught using the SASS net and the presence of rainbow trout in De Bos Dam downstream may result in trout moving upstream and preying on *G. zebratus*. Results remain inconclusive.

Table 29. Numbers of fish caught and the Fish Index Score for the site **O1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
G. zebratus		13/30 = 43% D	No fish caught –trout or under-sampling

Site O2: Volmoed

A small ornamental instream dam on the farm, which is stocked with *Micropterus salmoides* (largemouth bass), has compromised the rivers integrity. The river up and downstream of the dam is small and shallow with excellent *Galaxias* habitat. The relatively steep gradient between sites 2 and 3 may result in several waterfalls being present below this site and these may be the reason why *S. capensis* was not caught. The river is probably too shallow to support bass. Scoring the site was difficult, as without the dam the river scores highly but with the dam the score drops because of the presence of *M. salmoides*. Good numbers of *G. zebratus* were caught using the SASS net and bass were caught in the dam using a small seine net.

Table 30. Numbers of fish caught and the Fish Index Score for the site **O2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
G. zebratus	*G. zebratus* in river below dam (3 at 3cm) *M. salmoides* (3 at 6 cm)	26/35 = 74% C	*Galaxias* common in river, Bass in instream dam

Site O3: Kidbrooke

The river here has good habitat despite the severe *Eucalyptus spp.* infestation, which is in the process of being cleared. There is good depth and cover in pools and riffles and rapids are common. Flow was good. The two indigenous fishes expected were caught in good numbers and in a healthy condition using a small seine net. A bridge crossing caused a substantial drop in the river level preventing the upward migration of estuarine fish species.

Table 31. Numbers of fish caught and the Fish Index Score for the site **O3** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*S. capensis* (10-15 all sizes) *G. zebratus* (5 at 4-6cm)	32/35 = 91% A	Both expected species present in good numbers, good habitat

9.1.4 UILKRAAL RIVER

Initially four sites were selected on the Uilkraal River but one was discarded from the assessment because of construction of a new causeway across the site Plate (17 and 18). The first site was located within the Salmonsdam Nature Reserve, site 2 at a causeway below farming and site 3 below the newly constructed Kraaibosch Dam (Figure 10). The general site information for each site is shown below Tables 32, 33, 34.

Plate 17. Site 3 Uilkraal River before construction – October 2004 (upstream)

Plate 18. Site 3 Uilkraal River after construction – May 2005 (upstream)

Plate 19. Site 3 Uilkraal River before construction – October 2004 (downstream)

Plate 20. Site 3 Uilkraal River after construction – May 2005 (downstream)

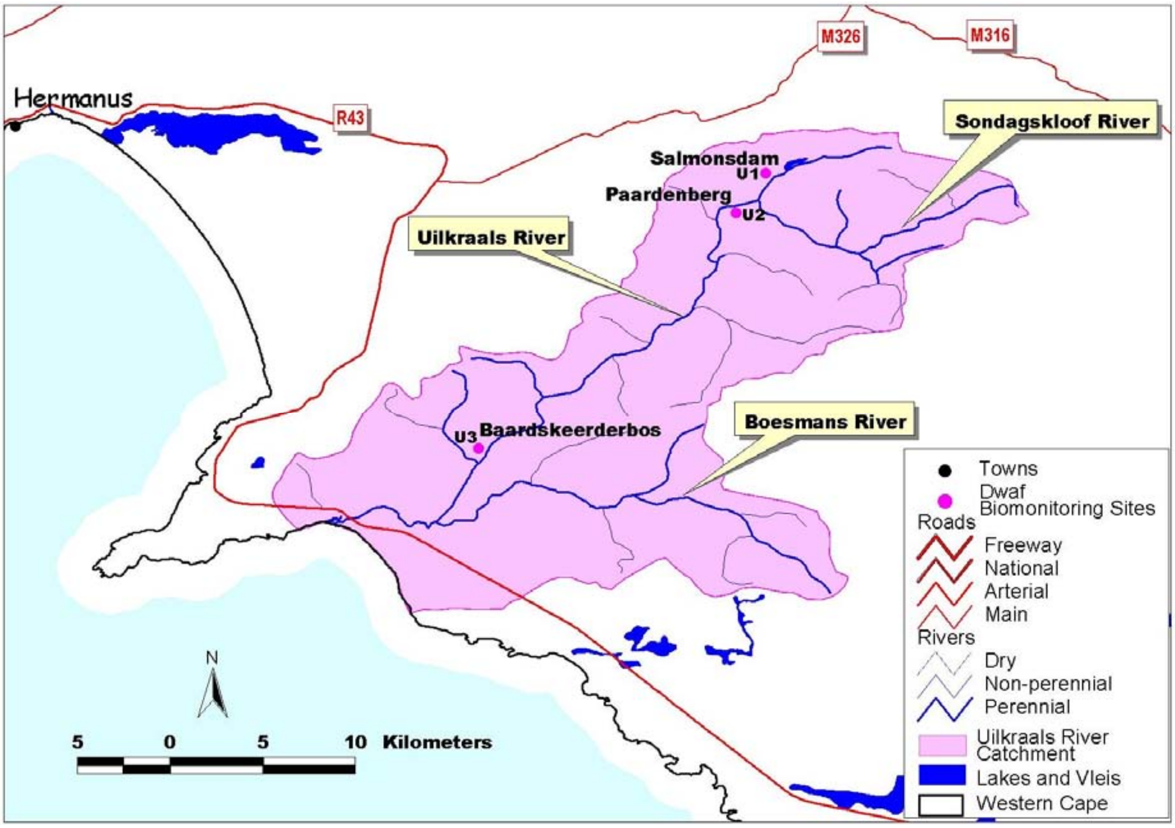


Figure 10. Map showing the monitoring sites on the Uilkraal River

Table 32. Summary of the general site information for Site U1

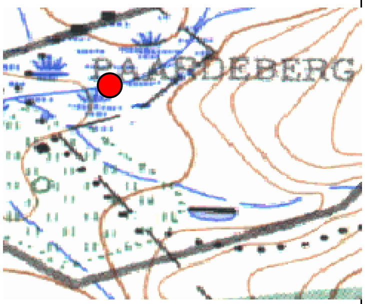
RHP Site code	G4UILK-SALMO	**Project Site Number**	U1
River	Paardenberg		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.44019	19.61956	
Site description	In Salmonsdam Nature Reserve		
Map Reference (1:50 000)	3419BC 	**Site length (m)**	15m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Numerous wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G4	**Quaternary catchment**	G40M
Vegetation type	Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 21. Site U1– October 2004 (looking upstream)

Plate 22. Site U1– October 2004 (looking downstream)

Table 33. Summary of the general site information for Site U2

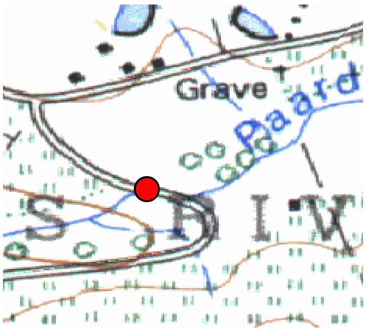
RHP Site code	G4UILK-PAARD	**Project Site Number**	U2
River	Uilkraal		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.45197	19.60453	
Site description	Located at a causeway in the vicinity of Paardenberg Farm		
Map Reference (1:50 000)	3419DA 	**Site length (m)**	20m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Numerous wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G4	**Quaternary catchment**	G40M
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 23. Site U2 – October 2004 (looking upstream)

Plate 24. Site U2– October 2004 (looking downstream)

Table 34. Summary of the general site information for Site U3

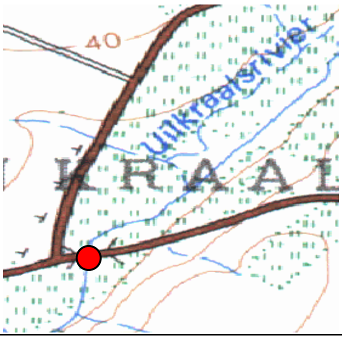
RHP Site code	G4UILK-BAARD		**Project Site Number**	U3
River	Uilkraal			
Co-ordinates (Decimal Degrees)	**Latitude**		**Longitude**	
	-34.57366		19.47933	
Site description	Located at bridge on the road to Baardskeerdersbos			
Map Reference (1:50 000)	3419CB 	**Site length (m)**	20m	
Longitudinal zone	Lowland			
Hydrological type	**Natural**		**Present**	
	Perennial		Perennial	
Associated systems	Numerous wetlands and vleis			
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05	
Secondary catchment	G4	**Quaternary catchment**	G40M	
Vegetation type	Laterite Fynbos	**Geological type**	Ost	
Rainfall region	Winter			

Plate 25. Site U3– October 2004 (looking upstream)

Plate 26. Site U3– October 2004 (looking downstream)

A. INDEX OF HABITAT INTEGRITY: UILKRAAL RIVER SYSTEM

The instream habitat integrity starts off as natural and unmodified in the Salmonsdam Nature Reserve. Unfortunately this deteriorates rapidly to being largely modified as the river leaves the confines of the nature reserve and becomes subjected to agricultural activities and the subsequent effects thereof (water abstraction, flow modifications, poor water quality (Figure11). The riparian zone also tends to show similar deterioration. Unfortunately though, the riparian zone in the nature reserve has already been moderately modified by alien vegetation encroachment, and quickly deteriorates to being critically modified at the next site. The riparian zone 'recovers' slightly to being extensively modified at the lower site.

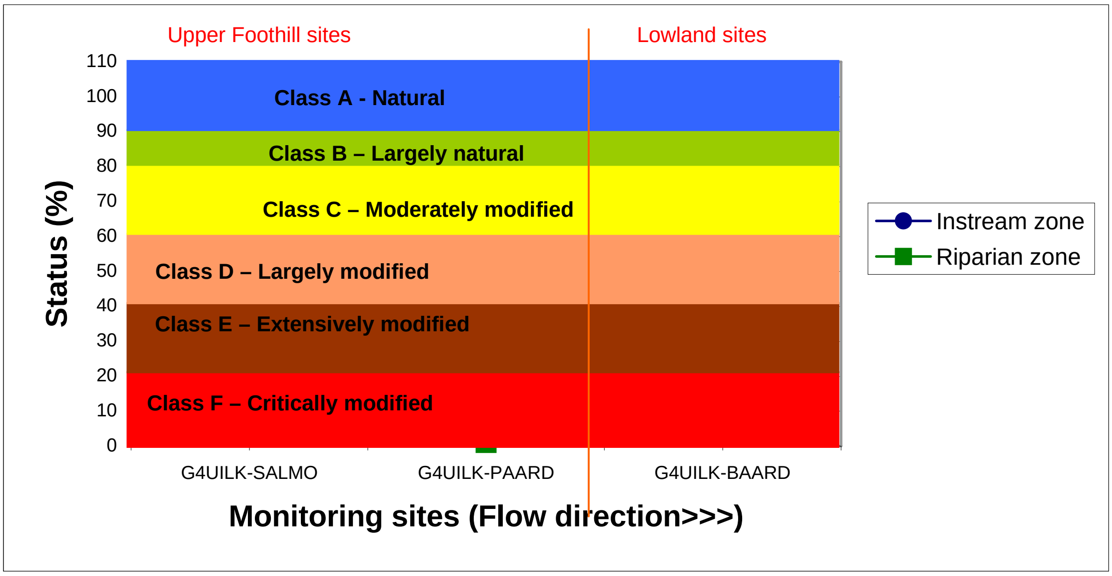


Figure 11. Summary of Index of Habitat Integrity results for the Uilkraal River System

Site U1 – Salmonsdam

This site is situated just below Salmonsdam Nature reserve.

Instream – Class A

- Water abstraction for Salmonsdam Nature Reserve facilities had a low impact on the instream habitat.

Riparian – Class C

- Alien vegetation encroachment has largely modified the riparian zone.

Site U2 – Paardenberg

This site is approximately 3km downstream from the previous site.

Instream – Class D

- The instream channel has been critically modified by severe alien (*Eucalyptus spp.*) infestation along the riverbank.
- Water abstraction for irrigation of surrounding agricultural land together with the presence of the *Eucalyptus spp.* infestation has largely modified the instream habitat.
- The presence of irrigated pastures for livestock has impacted on the instream water quality.

Riparian – Class F

- Indigenous riparian vegetation has been totally replaced by alien species (*Eucalyptus spp.*), critically modifying the riparian zone.
- Critical channel modification has occurred in the riparian zone as a result of alien infestation, paths and fences.
- The extensive alien infestation has contributed to the effects of flow modification for the riparian zone.

Site U3 – Baardskeerdersbos; below dam

This site is situated approximately 1-2km downstream of a large instream dam. The dam is required to make environmental flow releases but this may not be complied with.

Instream – Class D

- The presence of the instream dam has seriously modified flow at this site.
- Water quality has been modified by the presence of livestock pastures (cattle) and some irrigated vineyards.

Riparian – Class E

- The riparian zone has been seriously affected by flow modifications from the instream dam.
- Encroachment of alien vegetation, together with associated loss of indigenous vegetation has largely modified sections of the riparian zone.
- Water abstraction also affects the riparian zone resulting in increased periods of low flow.

B. GEOMORPHOLOGICAL STATUS OF THE UILKRAAL RIVER

Site U1 channel was very narrow and alluvial dominated by cobble. The reach type was classified as pool-riffle and a mid channel bar was present. The banks were well stabilized with mostly indigenous vegetation. Some livestock trampling did result in limited rilling on the LHB. The habitat diversity was relatively low but habitat cover was good. The alien vegetation had a moderate impact and sediment sources were few. **Impact class: B.**

Site U2 was located in the upper foothills. The channel was alluvial and cobble dominated downstream of the causeway. The upstream pool was filled with sand. The reach type was classified as pool-riffle. Alien vegetation dominated on both banks resulting in some degree of channel incision, especially upstream of the causeway. Bank scour occurred on the RHB, on an outside meander bend upstream of the causeway, resulting in moderate to extensive bank erosion. Limited rilling was observed on both banks due to trampling by livestock. Sediment supplied to the channel was extensive but the habitat diversity and cover was relatively high. **Impact class: D.**

Site U3 was located below the Kraaibosch Dam and is a lowland river. The channel is alluvial and the dominant substrate is sand and mud. The reach type is a flat bed. The banks are well stabilized and patchy vegetation cover occurs in the vicinity of the bridge where limited rilling also occurs. The channel impacts are the upstream dam (severe impact), alien vegetation (high impact), bridge (in-channel supports) and moderate supply of sediment to the channel. Extensive reed growth also encroaches on the channel as a result of the reduced flows. **Impact class: D.**

Table 35. Summary of the geomorphological assessment of the Uilkraal River sites

Sites	**Site U1**	**Site U2**	**Site U3**
Zone	Upper foothills	Upper foothills	Lowland
Channel pattern	Single	Single	Single
Water level	Low flow	Low flow	Medium flow
Valley form	Foothill floodplain	Alternating slopes	Foothill floodplain
Active channel width	1.5-5m	10-15m	15-30m
Macro-channel width	15-30m	None	None
Channel type	Alluvial	Alluvial	Alluvial
Bars	Mid channel	None	None

Bed material	Cobble	Cobble	Sand
Reach type	Pool-riffle	Pool-riffle	Flat bed
Bank erosion Fluvial	None	Moderate –extensive (33-75%)	None
Bank erosion Subaerial	Limited (RHB)	Limited rilling	Limited rilling
Impact class	**B**	**D**	**D**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE UILKRAAL RIVER

Site U1. As expected, the extent of vegetation cover of the riparian zone was natural; the structural intactness of the riparian vegetation's density and distribution components were also natural; and the regeneration of indigenous species was high. Flora present included Acid sand proteoid fynbos species: *Brunia spp., Helichrysum spp., Senecio, Geranium spp.*, etc. on the dry banks, with natural riparian species: *Rhus spp., Calopsis spp., Prionium spp., Juncus spp., Asparagus spp.* etc., over the zone. However, invasive species *Acacia cyclops* (Rooikraans), *Eucalyptus spp.* and *Solanum elaeagnifolium* (Satanbos) were present in low numbers, compromising indigenous tree and shrub components of the riparian zone.

The site was analysed as **Class C (14.97)**, which is modified. Localized loss of natural habitat, biota and basic ecosystem functions has occurred but most ecosystem functions are still predominantly unchanged.

Site U2 displayed a riparian zone that underwent extensive flood scour prior to assessment. In addition, this zone was severely impacted with alien invasion by *Eucalyptus spp., Acacia mearnsii* and *Populus spp*. As a result of the extensive loss of the zone's topsoil, and alien vegetation invasion, the natural riparian vegetation was erratically distributed and underrepresented.

The site was estimated as **Class E (5.50)**. This implies that natural habitat and biotic or basic ecosystem functions have been lost. Clearing of alien invasives with the rehabilitation of the eroded topsoil is essential for the improvement of the riparian zone integrity.

Site U3 displayed only moderate flood scour over the riparian zone because this locality received a measure of protection from the flood event by the dam upstream. All natural riparian vegetation structural classes were present. However, invasion by the terrestrial alien plant species *Populus spp.* and *A. cyclops* occurred within the riparian zone. Additionally, the riparian channel is overgrown by *P. australis* monostands, which serves as an indicator of severe abstraction or constant slow, low flows.

The site was estimated as **Class D (9.05)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred, but are not extensive.

D. WATER QUALITY

Table 36. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Uilkraal River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
U1	2005/05/10	28.05	12.61	4.83	13.5
U1	2005/03/08	31.22	12.42	4.71	19.2
U1	2005/12/02	38.3	8.5	5.77	14.8
U1	2004/10/12	31	-	4.22	13.8
U1	2004/07/09	21.92	11.48	4.82	9.4
U2	2005/05/10	27.74	13.28	5.28	13.9
U2	2005/03/08	43.48	12.68	5.55	19.9
U2	2005/12/02	86.9	8.5	5.93	1.8
U2	2004/10/12	44	-	4.99	14.7
U2	2004/07/09	26.27	10.62	5.47	9.6
U3	2005/05/10	46.42	10.26	6.86	17.8
U3	2005/03/08	1.16	4.65	6.84	21.2
U3	2005/12/02	77.5	5.2	6.71	18.5
U3	2004/10/12	78	-	7.03	19.2
U3	2004/07/09	34.59	10.42	6.44	13.3

Table 37. Results of water chemistry analysis

Determinants	Results		
	G4UILK-SALMO	G4UILK-PAARD	G4UILK-BAARD
Free and saline ammonia (as N in mg/l)	<0.3	<0.3	<0.3
Nitrate and Nitrite (as N in mg/l)	<0.3	<0.3	<0.3
Total phosphate (as P in mg/l)	<0.05	<0.05	<0.05
Ortho-phosphate (as P in mg/l)	<0.05	<0.05	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of nitrogen and phosphate ions and was classed as good.

E. SASS5 ASSESSMENT OF THE UILKRAAL RIVER

The upper site contained high scoring invertebrates for all sampling seasons, with the exception of March 2005 sample (ASPT=5.38). The middle site displayed variable water quality being good during July 2004 and May 2005, where high scoring invertebrates resulted in ASPT scores of 7.09 and 7.12 respectively, and fair scores occurred during October ‘04 and March ‘05 where low invertebrate scorers were abundant. The lower site was located below the instream dam, Kraaibosch. The sampling habitat was drastically reduced and a deep pool provided the only habitat. Only low scoring invertebrates were found and although the SASS5 scores were variable the ASPTs were consistently below 5.5 for all sampling periods.

Table 38. Summary of the SASS5 and ASPT scores for the Uilkraal River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
U1						
09-Jul-04	76	10	7.6	A	69	SIC, m/aqVeg, S
12-Oct-04	103	16	6.44	B	77	SIC, SOOC, m/aqVeg, SM
08-Mar-05	43	8	5.38	D	73	SIC, SOOC, m/aqVeg, S
10-May-05	82	11	7.45	A	70	SIC, m/aqVeg, GS
U2						
09-Jul-04	78	11	7.09	A	64	SIC, m Veg, SM
12-Oct-04	32	6	5.33	C	71	SIC, SOOC, aqVeg, G
08-Mar-05	73	15	4.87	D	65	SIC, m/aqVeg, GM
10-May-05	57	8	7.12	A	70	SIC, m/aqVeg, GS
U3						
09-Jul-04	89	16	5.56	C	72	SIC, m Veg, S
12-Oct-04	28	7	4	D	43	m/aqVeg
08-Mar-05	59	13	4.54	D	43	AqVeg, M
10-May-05	21	5	4.2	D	36	m/aqVeg, M

F. FISH ASSESSMENT FOR THE UILKRAAL RIVER

Site U1: Salmonsdam Nature Reserve

The river segment’s active channel was very small, shallow and well vegetated. Flow was good and water quality appeared excellent. However, immediately below the reserve, *Acacia saligna* and other alien trees become serious invaders of the riparian zone and might impact on aquatic faunal health, which includes freshwater fish.

The river consists of narrow pools and riffles that provide excellent *G. zebratus* habitat and these are common in the river (a SASS net was used to catch fish, with the assumption that the river was too shallow and fast flowing to support *S. capensis* populations).

Table 39. Numbers of fish caught and the Fish Index Score for the site **U1** are shown in the table below.

Species expected	Species caught	Score	Reason for score

G. zebratus	*G. zebratus* (5 at 3-4cm)	29/30 = 97% A	Very close to natural

Site U2: Paardenberg

This river segment contained very good fish habitat. This is despite a moderate invasion by invasive alien trees (*A. saligna*, *A. melanoxylon* and *Eucalyptus spp.*). The site was situated about 3 km below site U1, yet flow was almost double the quantity and habitat diversity was much better. Pools and riffles had good depth and *Prionium serratum* (palmiet) and marginal vegetation was common, especially above the bridge. The water was peat stained.

A small seine was used very successfully and the catch consisted of large numbers and contained broad size classes for *S. capensis* and *G. zebratus*. A significant *in situ* observation was that the upper catchment of the river is home to some of the largest *G. zebratus* ever caught.

Table 40. Numbers of fish caught and the Fish Index Score for the site **U2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*S. capensis* (40-50 all sizes) *G. zebratus* (10 at 2-6cm)	28/30 = 93% A	Excellent numbers of both expected species, good fish habitat

Site U3: Road Bridge below Uilkraal Dam

The river segment contained good fish habitat for the expected species with large deep well vegetated pools. Water lilies were abundant.

Micropterus salmoides (Bass) was present in the dam. *Lepomis macrochirus* (bluegill sunfish) was common in the river. This alien species may be the reason why *S. capensis* were not caught despite intensive seining with a small seine net. A positive aspect was that very large numbers of *G. zebratus* were caught and *Myxus capensis* (freshwater mullet) were common. The dam obviously prevents further upstream migration by mullet.

Table 41. Numbers of fish caught and the Fish Index Score for the site **U3** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*G. zebratus* (100+ all sizes) *M. capensis* (8 at 5-7 cm) *L. macrochirus* (3 at 6-7cm)	23/35 = 66% C	Good numbers *Galaxias* and mullet present, good habitat but also presence of alien fish

4.1.5 KLEIN RIVER

Three sites were selected for the Klein River (Figure 12). The general site information for each site is shown in (Tables 42, 43, 44).

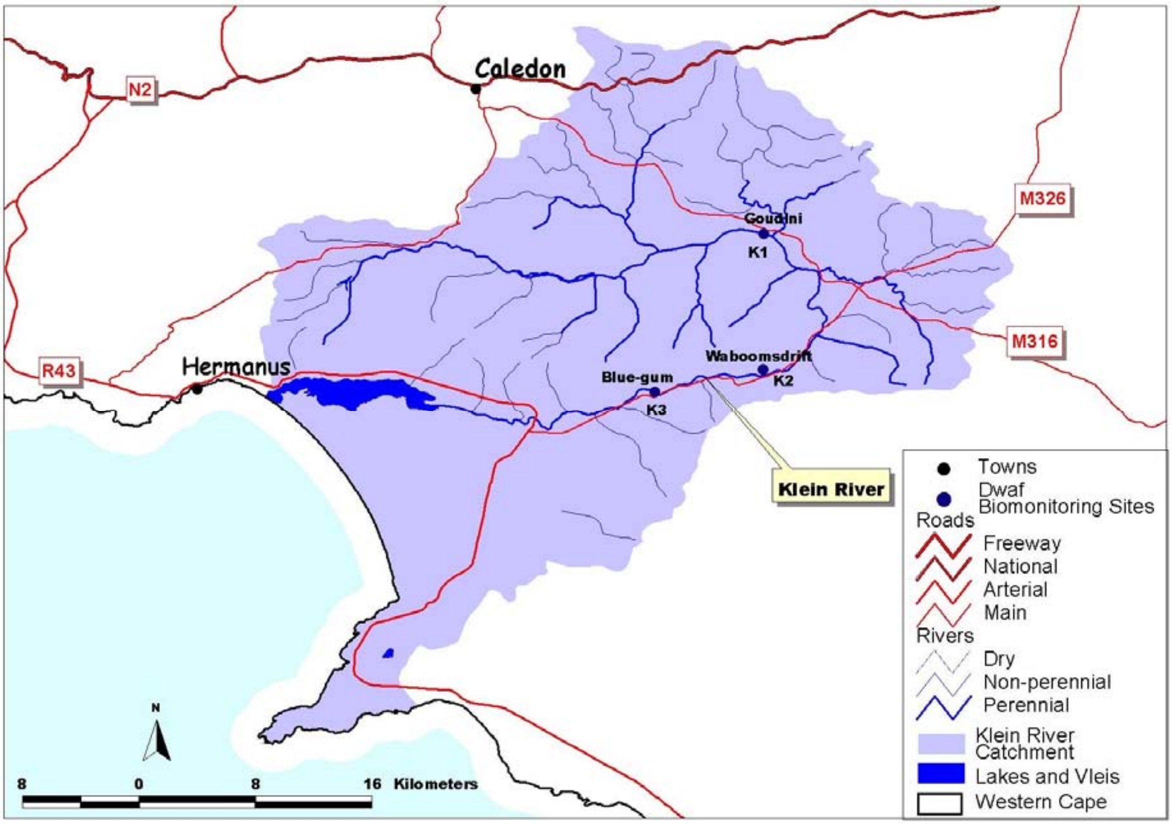


Figure 12. Map showing the monitoring sites on the Klein River

Table 42. Summary of the general site information for Site K1

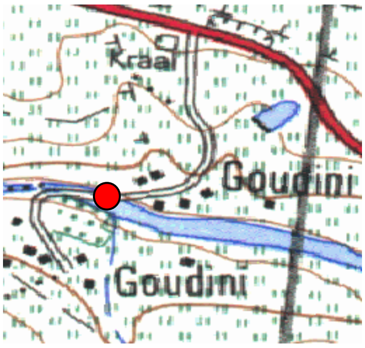
RHP Site code	G4KLEI-GOUDI	**Project Site Number**	K1
River	Klein		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.37839	19.23261	
Site description	Located on the farm Goudini along R316 toward Bredasdorp		
Map Reference (1:50 000)	3419BC 	**Site length (m)**	25m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	22.04
Secondary catchment	G4	**Quaternary catchment**	G40K
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 27. Site K1– October 2004 (looking upstream)

Plate 28 Site K1– October 2004 (looking downstream)

Table 43. Summary of the general site information for Site K2

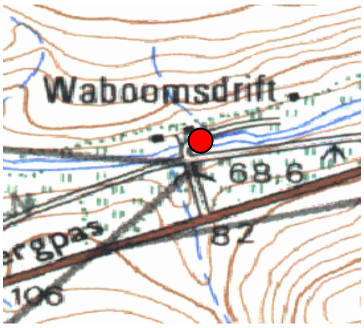
RHP Site code	G4KLEI-WABOO	**Project Site Number**	K2
River	Klein		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.40461	19.60658	
Site description	Located on the farm Waboomsdrift		
Map Reference (1:50 000)	3419BC 	**Site length (m)**	30m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G4	**Quaternary catchment**	G40K
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 29. Site K2 – October 2004 (looking upstream)

Plate 30. Site K2 – October 2004 (looking downstream)

Table 44. Summary of the general site information for Site K3

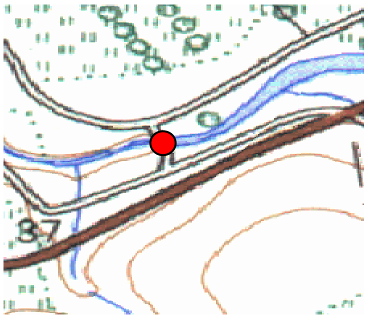
RHP Site code	G4KLEI-BLUEG	**Project Site Number**	K3
River	Klein		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.41672	19.53972	
Site description	Blue-gum turnoff from Riviersonderend rd from Stanford		
Map Reference (1:50 000)	3419BC 	**Site length (m)**	30m
Longitudinal zone	Upper foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G4	**Quaternary catchment**	G40K
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 31. Site K3 – October 2004 (looking upstream)

Plate 32. Site K3 – October 2004 (looking downstream)

The instream habitat integrity of the Klein River varies between moderately modified and largely modified, as opposed to the riparian habitat integrity that has been extensively and critically modified (Figure 13). As the river flows downstream the instream habitat integrity deteriorates slightly as the effects of water abstraction, flow modifications and poor water quality become more pronounced. The riparian zone at the upper site has been critically modified by alien vegetation encroachment and subsequent channel modification. The riparian zone does, however, change to being extensively modified at the last two sites.

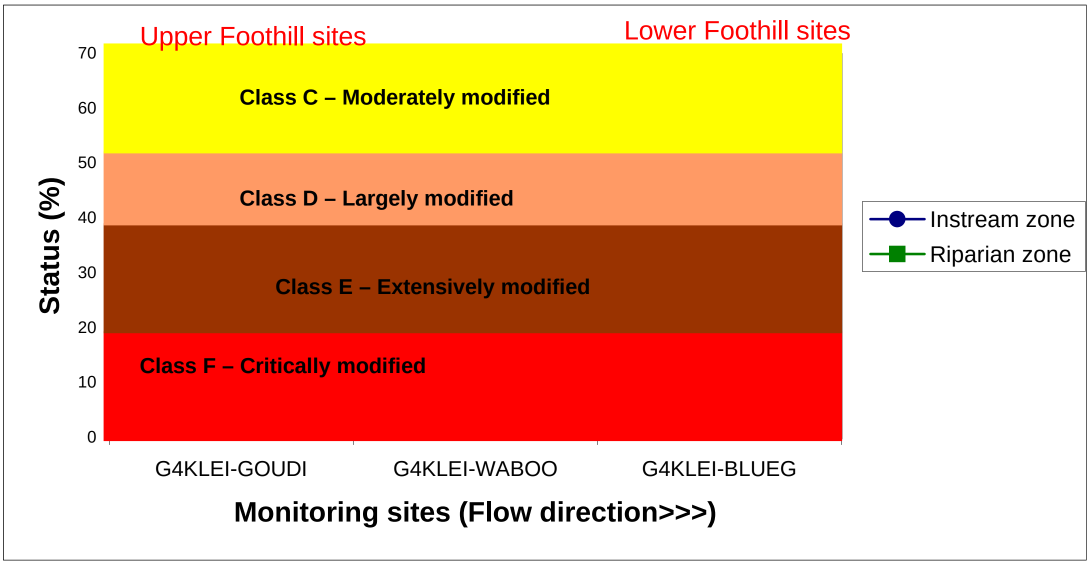


Figure 13. Summary of Index of Habitat Integrity results for the Klein River System

Site K1 – (Goudini)

Instream – Class C

- Alien vegetation has modified the instream channel (over-stabilisation).
- The presence of many off-stream dams (abstraction) in the catchment has largely modified low flows in the instream environment.

Riparian – Class F

- Severe alien vegetation encroachment together with associated removal of indigenous vegetation has critically modified the riparian zone.
- The severe alien vegetation infestation has contributed to bank erosion.
- The presence of paths, fences and alien vegetation has largely modified the riparian channel.

Site K2 – (Waboomsdrift)

Instream – Class C

- Large-scale water abstraction for surrounding irrigation has largely influenced the low flows and seriously modified the instream habitat.
- Increased sediment, pesticides and nutrients from the surrounding catchment have largely impacted on instream water quality.

Riparian – Class E

- Water abstraction and associated flow modifications have largely impacted on the riparian zone.
- Alien vegetation has largely modified the riparian zone.

Site K3 – (White Water Lodge)

Instream – Class D

- The cumulative effects of water abstraction in the catchment have modified the instream habitat, while the associated effects on flow have largely impacted on the instream environment.
- Cumulative effects on water quality from surrounding agricultural land use (vineyards, wheat fields) have largely modified the instream habitat.

Riparian – Class E

- Alien vegetation encroachment together with the associated removal of indigenous vegetation has modified the riparian zone.
- The cumulative effects of water abstraction and flow modification have largely impacted on the riparian zone.

B. GEOMORPHOLOGICAL STATUS OF THE KLEIN RIVER SITES

Site K1 was located on the farm, Goudini, in the lower foothills. The channel type was mixed substrate and the reach type was pool-riffle. Both banks were dominated by alien vegetation and had moderate stability with extensive fluvial erosion and active rilling/livestock trampling. The bed was moderately packed and stones were embedded. After flooding in April 2005, fluvial erosion of the banks increased and resulted in bank scour. An extensive amount of woody debris was added to the channel and blocked the channel upstream of the bridge. The habitat diversity and cover was relatively low and extensive amounts of sediment were supplied to the channel. **Impact class: D.**

Site K2 was located on the farm, Waboomsdrift, in the lower foothills. The channel type was alluvial and dominated by sand. The reach type was classified as pool-riffle. The LHB was a steep hillslope abutting the channel and at the time of sampling no fluvial erosion occurred although limited rilling occurred on both banks. After flooding in April extensive fluvial erosion occurred on the RHB and scouring formed a lateral channel. Lee bars also occurred below the causeway as well as upstream (formed due to woody debris within the channel). The habitat diversity and cover were both low. Impacts which occurred, were localized channel straightening, occasional causeways, high impact by alien vegetation, recent indigenous vegetation removal and extensive sediment supply to the channel. **Impact class: D.**

Site K3 was located at the Whitewater Lodge guesthouse, in the lower foothills. The banks were dominated by alien vegetation but were relatively stable. The channel type was alluvial and the dominant substrate, cobble. The reach type was pool-riffle. Impacts at the site included a moderate sediment supply to the channel, high impact by alien vegetation and a causeway. **Impact class: C.**

Table 45. Summary of the geomorphological assessment of the Klein River sites

Sites	**Site K1**	**Site K2**	**Site K3**
Zone	Lower foothills	Lower foothills	Lower foothills
Channel pattern	Single	Single	Single
Water level	Low flow	Isolated pool	Low Flow
Valley form	Foothill floodplain	Alternating slopes	Foothill floodplain
Active channel width	10-15m	15-30m	5-10m
Macro-channel width	None	30-50m	None
Channel type	Mixed	Alluvial	Alluvial
Bars	None	Lee bar	Lateral bars
Bed material	Gravel (dominant)	Sand	Sand
Reach type	Pool-riffle	Pool-riffle	Pool-riffle
Bank erosion Fluvial	Extensive (Both banks (10-33%)	None	Slight (<10%)
Bank erosion Subaerial	Active rilling	Limited-active rilling	Limited rilling
Impact class	**D**	**D**	**D**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE KLEIN RIVER

Site K1 displayed a moderate impact (high grass density), which was further intensified by a flood event prior to assessment. The riparian zone was infested with alien invasive species: *A. mearnsii* (black wattle) *Populus spp.* (Poplar), *Eucalyptus spp.* and *A. saligna* occurring in high densities and size classes. In addition, garden escapees *Nasturtium officinale* and *Agapanthus spp.* were prevalent. Recruitment of indigenous riparian trees (*Olea spp.*) and shrubs (*Rhus spp.*) was low and sparse. However instream habitat was satisfactory with sedge species densely distributed.

The site was estimated as **Class D (9.0)**. This implies that natural habitat has been modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. Structural intactness and representatives of plant forms – trees and shrubs – need to be improved in order to secure long-term health for this locality.

Site K2 displayed a higher degree of structural intactness for the riparian zone when comparing indigenous vegetation to representatives from the site previously described. However, flood scour was more evident in this locality, limiting the distribution of riparian vegetation cover. Additional impacts on the riparian zone include both alien – as in previous site – and indigenous terrestrial species invasion – *Elytropappus rhinocerotis* (renosterbos). Sedge species were prominent as in the upstream locality, but comprised *Juncus spp.* and *Prionium spp.* (palmiet) clumps rather than *P. australis* reed beds. Recruitment of indigenous riparian vegetation was low.

The site was estimated as **Class E (7.0)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are disturbed.

Site K3 has a very disturbed riparian zone, with flood scour and high-density monostands of *A. saligna* and *Eucalyptus spp*. The natural structural intactness of the zone was altered to such a degree that riparian shrub and tree representatives were limited to a few sparse distributed individuals. The instream vegetation consisted of an overgrowth of *P. serratum* sedge occupying most of the channel with sparsely distributed *P. australis* clumps. As a result, the impact of flooding disturbances resulted in predominance of grass and sedge turf.

The site was estimated as **Class E (6.50)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are extensively altered over the zone. However instream health display good faunal habitat.

D. WATER QUALITY

Table 46. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Klein River sites

Site Code	**Sampling Date**	**COND (mS/m)**	**DO (mg/l)**	**pH (pH unit)**	**TEMP (^{0}C)**
K1	2005/02/24	1.342	4.71	7.18	22.2
K1	2004/07/09	0.807	6.56	7.08	6
K1	2004/10/11	64	-	6.41	14.4
K1	2005/05/11	0.582	10.24	7.32	15.2
K1	2005/11/29	71.2	3.8	-	22.8
K2	2005/02/24	1.606	3.94	7.27	25.3
K2	2004/07/09	0.931	8.95	6.93	11.4
K2	2004/10/11	11.1	0	6.73	16.1
K2	2005/05/11	0.961	12.45	7.87	16.7
K2	2005/11/29	13.52	4.81	-	27.1
K3	2004/07/09	35.89	3.5	6.85	11.4
K3	2004/10/11	10.8	-	6.9	25
K3	2005/05/11	1.038	10.6	7.87	16.3
K3	2005/11/29	11.80	6.2	-	26.7

Table 47. Results of water chemistry analysis

Determinands	**Results**		
	G4KLEI-GOUDI	**G4KLEI-WABOO**	**G4KLEI-BLUEG**
Free and saline ammonia (as N in mg/l)	<0.3	<0.3	<0.3
Nitrate and Nitrite (as N in mg/l)	<0.3	<0.3	<0.03
Total phosphate (as P in mg/l)	0.81	2.46	5.57
Ortho-phosphate (as P in mg/l)	<0.05	<0.05	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of nitrogen and Ortho-phosphate ions and was classed as good. However, the concentrations for Total phosphates (as P in mg/l) analysis were classed as very poor. This result indicates excessive salts concentrations (possibly farming activity) and therefore conductivity increasing at a rapid pace as one move downstream along the three sites. Alternatively, the estuarine water influence may also have provided high salt concentrations and therefore the results remain suggestive.

E. SASS5 ASSESSMENT OF THE KLEIN RIVER

All sites had low ASPT scores, which ranged from 4 to 5.3. The sampling habitat was very limited at the upper site with only GSM and marginal vegetation occurring. This site was also affected by the April floods and the channel was blocked with coarse woody debris during the May '05 sampling period. Even though the habitats improved at the middle and lower sites both the SASS5 and ASPT scores did not, with only low scoring invertebrates found. No summer sample was collected at the lower site due to no flow, probably as a result of over-abstraction.

Table 48. Summary of the SASS5 and ASPT scores for the Klein River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
K1						
09-Jul-04	8	2	4	D	47	SIC, SOOC, m Veg
11-Oct-04	50	12	4.17	D	52	SIC, SOOC, m Veg
24-Feb-05	73	18	4.06	D	49	m/aqVeg, GSM
11-May-05	54	13	4.15	D	82	SOOC, m/aqVeg, GSM
K2						
09-Jul-04	75	15	5	C	63	SIC, SOOC, m Veg, G
11-Oct-04	37	7	5.29	C	67	SIC, m/aqVeg, S
24-Feb-05	111	24	4.63	D	61	SIC, m Veg, S
11-May-05	23	5	4.6	D	65	aqVeg, GS
K3						
09-Jul-04	73	14	5.21	C	78	SIC, SOOC, mVeg, GS
11-Oct-04	44	9	4.88	D	76	SIC, SOOC, mVeg, GS
Dry during summer						
11-May-05	51	10	5.1	C	66	SIC, aqVeg, GS

F. FISH ASSESSMENT FOR THE KLEIN RIVER

Site K1: Goudini

The river segment contained large deep pools, with occasional riffles. Flow was acceptable and the water quite turbid, possibly due to farming and sediment input from unstable banks. The riparian zone was seriously invaded by *A. mearnsii*, *Populus spp.*, *Eucalyptus spp.* and *Acacia saligna*, beyond which are wheat-fields. Seine netting yielded *Micropterus puctulatus* (spotted bass) and low numbers of *S. capensis*. No *Galaxias spp.* were caught but are very likely to be present.

Table 49. Numbers of fish caught and the Fish Index Score for the site **K1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*S. capensis* (5 at 3-5cm) *M. punctalatus* (2 at 5cm)	12/35 = 34% E	No *Galaxias*, low numbers *S. capensis*, bass present

Site K2: Waboomsdrift

The river was characterized by good fish habitats including some deep (>2m) pools, which contained abundant *Cyperus spp.* and palmiet (instream sedge) growth. However, the deep pools were very difficult to seine net and probably required some other sampling methods (e.g. electroshocker).

The instream habitat was totally dominated by alien fish species, notably *Lepomis macrochirus* (bluegill sunfish), *Micropterus salmoides* (largemouth bass) and *Gambusia affinis* (mosquito fish). It is possible that *Myxus capensis* (freshwater mullet) was present, but required some gill netting for confirmation.

Table 50. Numbers of fish caught and the Fish Index Score for the site **K2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*L macrochirus* *M. salmoides* *G. affinis*	9/35 = 26% E	No indigenous fish, bass, bluegills present

Site K3: Whitewater Lodge

The river is characterized by good habitat with pools, riffles and rapids. Pools contained abundant growth of *Cyperus spp.* and palmiet (instream sedge). Flow was good, but had a higher velocity that is anticipated for the sampling period. The riparian zone was moderately invaded by *A. saligna* and *Eucalyptus spp*. Pools were seine netted and yielded two invasive alien fishes – *M. salmoides* and *L. macrochirus* – and a freshwater dependent estuarine species *M. capensis* (freshwater mullet). The catch of mullet is positive as it shows that estuarine fish can migrate to this point in the river.

Table 51. Numbers of fish caught and the Fish Index Score for the site **K3** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*M. capensis* (1 at 5cm) *L macrochirus* (6 at 5-6cm) *M. salmoides* (3 at 5-6cm)	15/35 = 43% D	No indigenous freshwater fish, mullet, bass present

4.2 OVERBERG EAST

4.2.1 SOUT RIVER

A total of 8 sites were selected on the Sout River, where 6 occurred on the main stem and 2 on main tributaries (Figure 14). The landuse was completely dominated by agriculture (cereal crops, canola) and livestock farming. The general information for each site is shown in Tables 52-59.

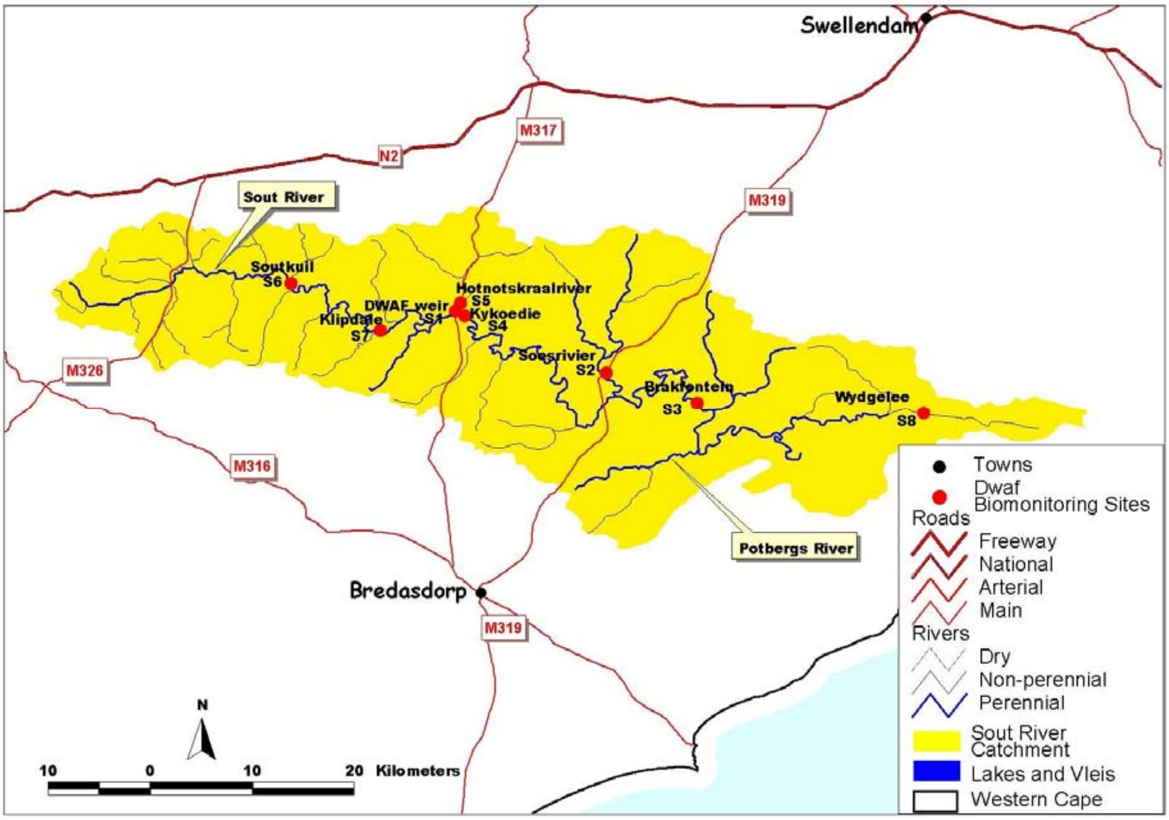


Figure 14. Map showing the monitoring sites on the Sout River

Table 52. Summary of the general site information for Site S1

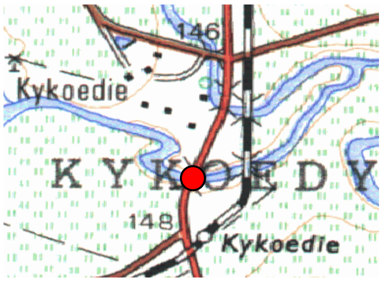
RHP Site code	G5SOUT-DWAFW	**Project Site Number**	S1
River	Sout		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.29197	20.02336	
Site description	Above confluence with Hotnotskraal River at road bridge toward Bredasdorp		
Map Reference (1:50 000)	3420AC 	**Site length (m)**	20m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50H
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		
DWAF gauging weir	Yes	**Distance: up-downstream**	10m (up)

Plate 33. DWAF weir – October 2004 (looking upstream)

Plate 34. DWAF weir – October 2004 (looking downstream)

Table 53. Summary of the general site information for Site S2

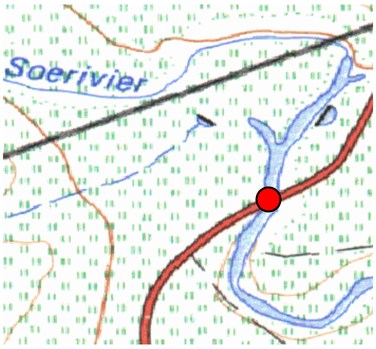
RHP Site code	G5SOE-SOESR	**Project Site Number**	S2
River	Soes	**Tributary of**	Sout
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.34342	20.15356	
Site description	Located at the Soesrivier bridge, road to Bredasdorp		
Map Reference (1:50 000)	3420AC 	**Site length (m)**	20m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Seasonal	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50H
Vegetation type	Fynbos	**Geological type**	Db
Rainfall region	Winter		

Plate 35. Soes – October 2004 (looking upstream)

Plate 36. Soes – October 2004 (looking downstream)

Table 54. Summary of the general site information for Site S3

RHP Site code	G5SOUT-BRAK	**Project Site Number**	S3
River	Sout		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.36858	20.23775	
Site description	Located on a farm along the road to Bredasdorp at Brakfontein close to Twee Driwwe		
Map Reference (1:50 000)	3420AC 	**Site length (m)**	15m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50H
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 37. Brakfontein – October 2004
(looking upstream)

Plate 38. Brakfontein – October 2004
(looking downstream)

Table 55. Summary of the general site information for Site S4

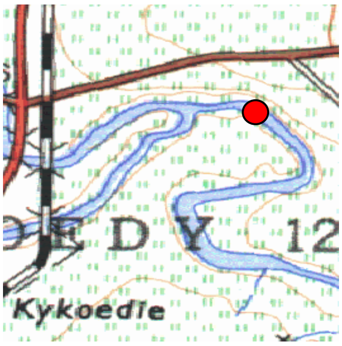
RHP Site code	G5SOUT-KYKOE	**Project Site Number**	S4
River	Sout		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.34331	20.15336	
Site description	Located on the farm Kykoedy		
Map Reference (1:50 000)	3420AC 	**Site length (m)**	15m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Seasonal	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50H
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 39. Kykoedy site – October 2004 (looking upstream)

Plate 40. Kykoedy site – October 2004 (looking downstream)

Table 56. Summary of the general site information for Site S5

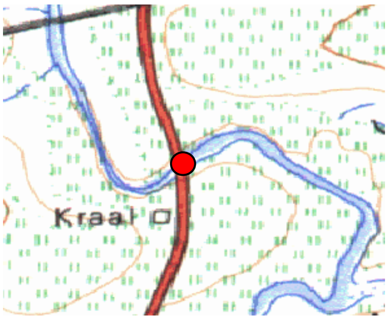
RHP Site code	G5HOTN-CONF	**Project Site Number**	S5
River	Hotnotskraal	**Tributary of**	Sout
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.34331	20.15336	
Site description	Located upstream of the confluence with the Sout River		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	15m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50G
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 41. Hotnotskraal – October 2004 (looking upstream)

Plate 42. Hotnotskraal – October 2004 (looking downstream)

Table 57. Summary of the general site information for Site S6

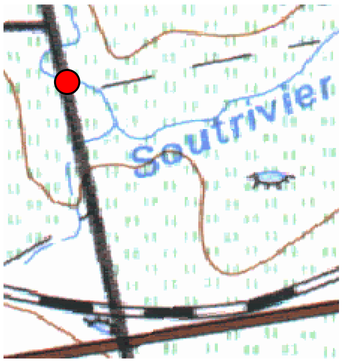
RHP Site code	G5SOUT-SOUTK	**Project Site Number**	S6
River	Sout		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.26928	19.87472	
Site description	Located on the farm Sout Kuil on route to Riviersonderend		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	15m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Seasonal	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50H
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 43. Soutkuil – October 2004 (looking upstream)

Plate 44. Soutkuil – October 2004 (looking downstream)

Table 58. Summary of the general site information for Site S7

RHP Site code	G5SOUT-KLIPD	**Project Site Number**	S7
River	Sout		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.54731	19.80733	
Site description	Located at the town Klipdale		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	25m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Seasonal	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50G
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 45. Klipdale – October 2004 (looking upstream)

Plate 46. Klipdale – October 2004 (looking downstream)

Table 59. Summary of the general site information for Site S8

<table>
<tr><td>RHP Site code</td><td colspan="2">G5SOUT-WYDGE</td><td colspan="2">Project Site Number</td><td>S8</td></tr>
<tr><td>River</td><td colspan="2">Sout</td><td colspan="2">Tributary of</td><td></td></tr>
<tr><td rowspan="2">Co-ordinates (Decimal Degrees)</td><td colspan="3">Latitude</td><td colspan="2">Longitude</td></tr>
<tr><td colspan="3">-34.39636</td><td colspan="2">20.29050</td></tr>
<tr><td>Site description</td><td colspan="5">Site located at bridge toward Wydgeleë</td></tr>
<tr><td>Map Reference (1:50 000)</td><td>3420AD

</td><td colspan="2">Site length (m)</td><td colspan="2">10m</td></tr>
<tr><td>Longitudinal zone</td><td colspan="5">Lowland</td></tr>
<tr><td rowspan="2">Hydrological type</td><td colspan="3">Natural</td><td colspan="2">Present</td></tr>
<tr><td colspan="3">Perennial</td><td colspan="2">Seasonal</td></tr>
<tr><td>Ecoregion 1</td><td>Southern Coastal Belt</td><td colspan="2">Ecoregion 11</td><td colspan="2">22.03</td></tr>
<tr><td>Secondary catchment</td><td>G5</td><td colspan="2">Quaternary catchment</td><td colspan="2">G50H</td></tr>
<tr><td>Vegetation type</td><td>South & South-West Coast Renosterveld</td><td colspan="2">Geological type</td><td colspan="2">Db</td></tr>
<tr><td>Rainfall region</td><td colspan="5">Winter</td></tr>
</table>

Plate 47. Wydgelee – October 2004 (looking upstream)

Plate 48. Wydgelee – October 2004 (looking downstream)

A. INDEX OF HABITAT INTEGRITY: SOUT RIVER SYSTEM

The instream habitat integrity of most sites in the Sout River system are classed as being largely modified, mostly due to the effects of water abstraction and poor water quality resulting from the surrounding agricultural landuse (Figure 15). The riparian habitat varies slightly more with several sites being critically modified and a few being either largely or extensively modified. One particular site only showed moderate modifications to the riparian zone.

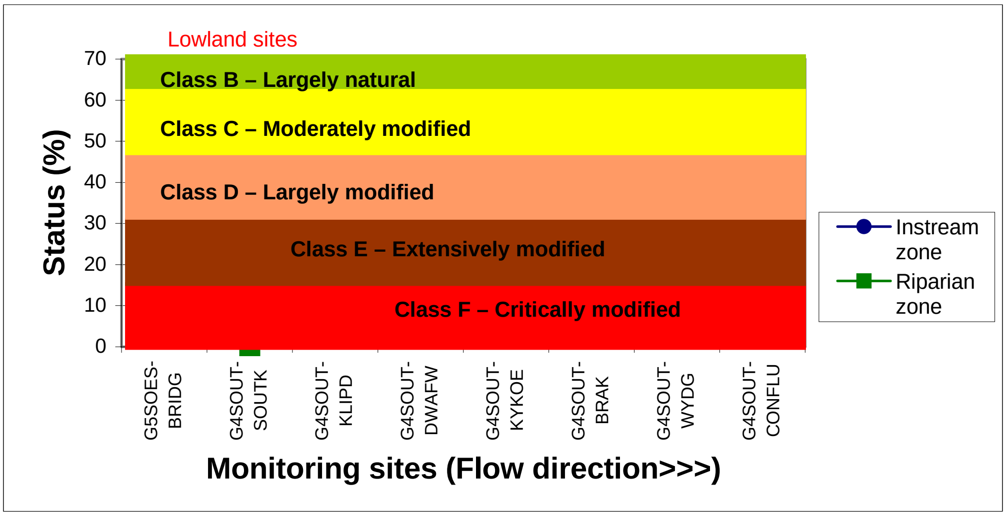


Figure 15. Summary of Index of Habitat Integrity results for the Sout River System

Site S1 – DWAF weir

Instream – Class D

- Water quality at this site has critically modified the instream habitat by extensive algal blooms, reed beds and sediment input.
- Instream flow has also been largely modified by the presence of the upstream DWAF weir as well as off-stream dams in the catchment.

Riparian – Class F

- Severe bank erosion has critically modified the riparian zone.
- Agricultural fields and pastures extend to the rivers edge, and have subsequently impacted on the indigenous vegetation and have also largely modified the riparian channel.

- Extensive reed beds reflect the large impact that water abstraction; water quality and flow modifications have had on the riparian zone.

Site S2 – Soes

Instream - D

- Water abstraction and associated flow modifications from surrounding off-stream dams have impacted on the instream habitat.
- The instream bed has been largely modified due to increased sediment inputs and quite severe algal blooms resulting from agricultural activities in the surrounding catchment, which impacts on water quality.

Riparian – Class E

- The riparian zone has been seriously impacted by bank erosion, which has been exacerbated by the large effects of water abstraction and a decrease in indigenous vegetation.

Site S3 – Brakfontein

Instream – Class D

- Water abstraction has seriously modified the instream habitat.
- Poor water quality as a result of increased nutrients, pesticides and sediment input together with flow modifications by the many off-stream dams in the catchment has largely impacted on the instream habitat.
- The instream bed has also been modified due to algal blooms, reed encroachment and sediment inputs.

Riparian – Class C

- Water abstraction and flow modifications have largely impacted on the riparian zone.

Site S4 – Kykoedy

Instream – Class E

- The combined effects of water abstraction, flow modifications and poor water quality have critically modified the instream habitat availability. Extensive reed infestation on the upstream side of the causeway and algal blooms downstream have seriously modified the instream bed.

Riparian – Class F

- Bank erosion has critically modified the riparian zone. The riparian channel has also been seriously modified by agricultural activities extending to the rivers edge. Water abstraction, flow modifications and a decrease in indigenous vegetation have largely impacted on the riparian zone.

Site S5 – Hotnotskraal

Instream – Class D

- Water abstraction and water quality impacts have seriously modified the instream habitat availability. As a result, the presence of algae and increased sediment has largely modified the instream bed.
- Flow modifications associated with the presence of off-stream dams largely impact the low flows.

Riparian – Class E

- The riparian channel has been largely modified by agricultural activities mostly as a result of a removal of indigenous vegetation.

Site S6 – Soutkuil

Instream – Class E

- Water quality has critically impacted on the instream habitat. Associated with this is the serious bed modification resulting from extensive algal blooms. Both these impacts are exacerbated by the serious water abstraction and flow modifications from the many off-stream dams in the catchment.

Riparian – Class F

- The removal of indigenous vegetation and subsequent alien infestation has critically altered the riparian zone.
- Water abstraction, quality and flow modifications have moderately impacted the riparian zone.

Site S7 – Klipdale

Instream – Class E

- Run-off from surrounding agricultural activities has critically impacted the water quality in the instream environment.

- The effects of water quality impacts are worsened by serious water abstraction and flow modifications as a result of the many off-stream dams and irrigation systems in the catchment.
- The instream bed has also largely been modified by the presence of algal and reed beds encroaching into the river as a result of the high nutrient levels.

Riparian – Class F

- Extensive erosion has critically modified the riparian zone, with the riparian channel seriously impacted as a result thereof (trampling, loss of vegetation, run-off etc).
- The indigenous vegetation has been largely removed, with subsequent encroachment of alien vegetation occurring to a lesser extent.
- Encroachment of reeds into the river channel indicates that water abstraction and water quality largely impact the riparian zone and reduced flows.

Site S8 – Wydgeleë

Instream – Class E

- Water quality has critically modified the instream habitat with intense algal blooms largely modifying the instream bed.
- Water abstraction and associated flow modifications resulting from the presence of many off-stream dams and water pumps in the catchment have seriously impacted on the instream habitat, exacerbating the poor water quality.

Riparian – Class E

- The presence of extensive reed beds encroaching, both the instream and riparian channels, indicate that water abstraction and flow modifications have had serious effects on the riparian zone.
- The encroaching reed beds also indicate that water quality has had a moderate impact on the riparian zone.
- The riparian channel has also been moderately modified by surrounding agricultural activities, including a large path cleared for access to the river.

B. GEOMORPHOLOGICAL STATUS OF THE SOUT RIVER SITES

The Sout River is an endorheic (it has no outlet to the sea) river and drains into the De Hoop Vlei. The entire river occurs in the lowland zone and all the sites had a single channel pattern. Certain sites had a medium flow and others a low flow, depending on the sampling time. Certain sites were dry during the summer sampling assessment. The channel types were alluvial with the exception of the Hotnotskraal tributary (site S5), which had a mixed channel. Either sand dominated channels or silt and clay with small percentages of gravel present, resulting in flat bed reach types at all sites.

Bank erosion featured prominently at all the sites except at the Hotnotskraal site due to bedrock stabilization on the LHB and dominant reed growth on the RHB. In most cases the cultivated areas occurred up until the riverbanks and therefore not much of the riparian zones remained intact. Limited and active rilling was a result of livestock trampling. Alien vegetation had a negligible to moderate impact but reed growth dominated at most sites. Other impacts, included bridges with in-channel supports, gauging weirs, causeways, localized channel straightening and extensive sediment supply to the channels (see table 59 for assessment of each site). **Impact class range: C-E.**

Table 60. Summary of the geomorphological assessment of the Sout River sites

Sites	S1	S2	S3	S4	S5	S6	S7	S8
Zone	Lowland	Lowland	Lowland	Lowland	Lowland	Lowland	Lowland	Lowland
Channel pattern	Single	Single	Single	Single	Single	Single	Single	Single
Water level	Medium flow	Medium flow	Medium flow	Medium flow	Medium flow	Low flow	Low flow	Medium flow
Valley form	Foothill floodplain	Foothill floodplain	Alternating slopes	Alternating slopes	Foothill floodplain	Foothill floodplain	Foothill floodplain	Foothill floodplain
Active channel width	10-15m	5-10m	10-15m	10-15m	10-15m	1.5-5m	15-30m	15-30m
Macro-channel width	30-50mm	None	15-30m	None	None	None	None	30-50m
Channel type	Alluvial	Alluvial	Alluvial	Alluvial	Mixed	Alluvial	Alluvial	Alluvial
Bars	None	None	Lateral	Lateral and mid channel	None	None	None	None
Bed material	Gravel	Silt and clay	Silt and clay	Gravel	Silt and clay	Silt and clay	Sand	Silt and clay
Reach type	Flat bed	Flat bed	Flat bed	Flat bed	Flat bed	Flat bed	Flat bed	Flat bed
Bank erosion Fluvial	Moderate (RHB)	Slight (Both Banks)	Slight (LHB)	Slight-moderate (Both banks	None	Moderate-extensive (Both banks)	Moderate-extensive (RHB)	Slight (Both banks)
Bank erosion subaerial	Limited rilling (LHB)	Limited rilling (Both banks)	Limited rilling (RHB)	Limited rilling (Both banks)	None	Limited rilling (Both banks)	Limited-active rilling (Both banks)	Limited rilling (RHB)
Impact class	**D**	**D**	**C-D**	**D**	**C**	**E**	**C-D**	**D**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE SOUT RIVER

Site S1 was a fairly intact riparian locality with its banks completely covered by natural vegetation. The vegetation classes cover component indicated trees, shrubs and sedge species have a natural distribution (*Olea spp., Lycium spp.* and *Juncus spp.*). As with most lowland rivers, the cosmopolitan reed *P. australis* was distributed densely within the channel. Grass species *Cynodon spp.* covered a moderate extent of the site, while terrestrial species *A. karoo* was characteristic of the robust proportions of the riparian zone. Disturbances impacting on all sites include stock and other subsistence farming related impacts.

The site was analysed as **Class C (13.11)**, which is modified. A loss of natural habitat, biota and basic ecosystem functions has occurred, but the site is still in a relatively intact condition.

Site S2 was another fairly intact locality. The distribution and extent of vegetation cover for this site was reasonable with representatives of all vegetation classes. *A. karoo* (doringboom) was also occupying this site. "Reed" and sedge species were prominent, providing good habitat for faunal diversity. Grass species continued to dominate indicating consistent disturbance patterns.

The site was analysed as **Class C (13.01)**, which is modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. Impacts include localized erosion and abstraction points.

Site S3 was very intact from a vegetation cover component perspective, with representatives from all vegetation classes and having a reasonable distribution (as found in previous sites described). The terrestrial tree *A. karoo,* as well as shrub *Atriplex spp.* (salt bush), covered a moderate extent of the riparian zone. Recruitment of *Rhus spp.* and *Lycium spp.* shrubs were found. This serves as desirable support for riparian zone stability. Furthermore, instream reed species *P. australis* provided desirable habitat for fish and invertebrates.

The site was analysed as **Class B (17.0)**, which is largely natural with some modifications. Ecosystem functions remain essentially unchanged.

Site S4 was fairly intact and fully covered by riparian vegetation. The densities of sedge species (*P.* australis) were high upstream and shrub species (*Rhus spp.* And *A. karoo*) were recruiting downstream of the sampling point. Grass species found were well distributed over the riparian zone.

The site was analysed as **Class C (13.46)**, which is modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. Impacts seem localised.

Site S5 displayed little difference to the previous sites described with regards to habitat intactness. Sedge and shrub densities were slightly low. Instream reed densities were continuous and the cover of grass species was moderate. However, *A. karoo* was not as prominent as the upstream riparian sites sampled. Some encroachment impacts by cultivation activities were evident over the site.

The site was analysed as **Class C (13.01)**, which is modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. Recruitment of riparian shrubs is required.

Site S6 displayed a moderately impacted riparian zone due to absence of long-term bank stability plant forms i.e. trees and shrubs. However, vegetation cover by sedge and grass representatives was entire, adding stability against the erosion of the riparian zone. Reeds present were natural restiod species, covering some 50% of instream and wet bank components. Pampas grass and other weedy aliens served as an indication of impacts.

The site was estimated as **Class D (12.18)**, which is largely modified. A loss of natural habitat, biota and basic ecosystem functions has occurred.

Site S7 presented a robust cover distribution of vegetation present over the riparian zone, as all plant types were represented. Indigenous riparian shrubs included *Rhus sp.* and *Metrosideros sp.* (typical riparian) and *A. karoo* (typical terrestrial tree). Other trees present were alien invader species namely: *Acacia saligna, A. cyclops* and *Eucalyptus spp.* Succulents included *Sarcocornia sp* and herbs included *Helichrysum sp.*

The site was estimated as **Class C (13.0)**, which is modified. A loss of natural habitat, biota and basic ecosystem functions has occurred. However the site's health was deemed fair.

Site S8 displayed another robust cover distribution for vegetation classes present over the riparian zone. Riparian shrubs were represented in this site namely: *Rhus spp.* and *Lycium spp.* The instream vegetation was also adequate for riparian faunal health, offering a range of habitat between reed and sedge clumps. However, invasion by indigenous shrubs and alien invading tree species were consistent with the upstream sites.

The site was estimated as **Class C (13.50)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. Alien clearance will improve the riparian zone considerably.

D. WATER QUALITY

Table 61. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Sout River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
S1	2004/07/13	14.29	9.8	8.41	11.1
S1	2004/10/13	18.8	-	8.19	21.5
S1	2005/03/09	6.22	5.77	8.24	23.6
S1	2005/05/25	6.65	-	8.35	13.7
S1	2005/12/03	17.83	8.65	8.98	18.2
S2	2004/07/13	13.47	5.73	8.17	11.8
S2	2004/10/14	-	-	8.55	20.1
S2	2005/03/09	17.72	1.66	8.24	23.6
S2	2005/05/25	13.64	-	8.09	16.1
S2	2005/12/03	17.65	8.77	8.16	27.7
S3	2005/05/25	8.7	-	8.89	16.1
S3	2004/10/14	-	-	7.65	19.6
S3	2005/03/10	15.6	-	8.08	23.3
S3	2005/12/03	16.43	8.77	8.16	27.7
S4	2004/07/13	2.865	9.76	8.2	12.4
S4	2004/10/13	19.9	-	8.23	22
S4	2005/05/25	7.33	-	8.51	13.7
S4	2005/03/09	8.75	1.31	8.24	23.6
S4	2005/12/03	14.78	2.58	8.13	23.7
S5	2005/03/09	10.5	1.34	8.24	21
S5	2004/10/13	18.8	-	7.31	21
S5	2005/05/25	9.19	13.9	8.52	-
S5	2005/12/03	12.91	9.84	8.33	24.4

S5	2004/07/13	7.82	2.33	7.41	14.6
S6	2004/07/13	8.1	12.68	7.34	15
S6	2004/10/13	18.8	-	8.51	25
S6	2005/03/09	12.7	5.54	8.4	20.5
S6	2005/05/24	9.32	-	8.89	16.1
S6	2005/12/03	11.99	-	8.60	28.4
S7	2004/10/13	19.9	-	8.47	22.7
S7	2005/03/09	11.27	1.54	8.76	23.7
S7	2004/05/24	9.68	-	8.18	15.3
S7	2004/10/13	19.9	-	8.47	22.7
S7	2005/12/03	24.93	7.18	8.60	19.1
S8	2004/10/14	18.8	-	7.26	20
S8	2004/07/13	15.33	11.66	8.01	8.2
S8	2005/03/10	29.51	3.04	7.5	24.8
S8	2005/05/25	9.02	-	8.89	12.3
S8	2005/12/03	17.51	3.09	7.76	29.7

Table 62. Results of water chemistry analysis

Determinands	**Results**							
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Free and saline ammonia (N mg/l)	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.9
Nitrate and Nitrite (N mg/l)	<0.3	<0.3	<0.3	<0.3	<0.3	6.2	<0.3	0.9
Total phosphate (P mg/l)	0.38	0.21	0.13	0.14	0.11	0.11	0.17	0.51
Ortho-phosphate (P mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of nitrogen and Ortho-phosphate ions and was classed as good. However, the concentrations for Total phosphates (as P in mg/l) analysis were inconsistent over the catchment and may be due to farming related activities or it may be natural. This result indicates excessive salts concentrations (possibly farming activity), but result remains inconclusive.

E. SASS5 ASSESSMENT OF THE SOUT RIVER

All the sites had low SASS5 scores ranging between 15 and 66 and low ASPT scores all below 5. The invertebrates found were primarily low scorers, which would indicate a major deterioration in water quality. All sites only had the GSM and marginal/aquatic vegetation sampling habitats. Low flows always occurred even during July with certain sites being dry during summer months. The site located closest to the Vlei (Site S8) was excavated to create a small instream dam to aid abstraction due to the low flows during the March 2005 sampling period. This resulted in further habitat destruction and fewer invertebrates. Excavation also occurred in a dry section of the Soes River bed.

The sites sampled showed a major deterioration in water quality with mostly non-sensitive invertebrates found. This is also reflected in the ASPT scores. The invertebrate habitat diversity of these lowland rivers contained only GSM and marginal vegetation sampling areas at most of the sites. However, habitat availability may be naturally poor based on a lack of reference sites to which the results could be compared. For these reasons, the interpretation of the results for water quality class scores was difficult.

Table 63. Summary of the SASS5 and ASPT scores for the Sout River and associated tributaries

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
S1						
13-Jul-04	40	10	4	D	54	SIC, SOOC, aqVeg, M
13-Oct-04	35	9	3.88	E	49	m/aqVeg, GS
9-Mar-05	37	10	3.7	E	54	SIC, SOOC, mVeg, M
25-May-05	32	9	3.55	E	63	aqVeg, GSM
S2						
13-Jul-04	40	9	4.44	D	47	aqVeg, M
14-Oct-04	48	10	4.8	D	45	aqVeg, M
9-Mar-05	22	6	3.67	E	38	aqVeg, M
25-May-05	29	8	3.62	E	44	m/aqVeg, GM
S3						
14-Oct-04	39	9	4.33	D	52	SIC, SOOC, m/aqVeg, M
10-Mar-05	17	4	4.25	D	46	mVeg, M
Dry during summer						
25-May-05	26	8	3.25	E	55	mVeg, GM
S4						
13-Jul-04	37	10	3.7	E	65	SIC, SOOC, aqVeg, GM
13-Oct-04	56	12	4.67	D	42	SIC, aqVeg, M

9-Mar-05	35	10	3.5	E	55	SIC, aqVeg, GS
25-May-05	21	7	3	E	58	m/aqVeg, GS
S5						
13-Jul-04	31	7	4.43	D	52	SIC, SOOC, aqVeg, M
13-Oct-04	58	13	4.46	D	56	SOOC, m/aqVeg
9-Mar-05	48	12	4	D	39	aqVeg, M
25-May-05	32	8	4	D	48	m/aqVeg, M
S6						
13-Jul-04	24	7	3.43	E	43	aqVeg, M
13-Oct-04	42	10	4.2	D	35	SOOC, aqVeg, M
9-Mar-05	52	13	4	D	41	m Veg, M
25-May-05	66	15	4.4	D	45	SOOC, m/aqVeg, SM
S7						
13-Oct-04	26	6	4.33	D	40	SOOC, aqVeg, M
9-Mar-05	64	14	4.57	D	62	SIC, SOOC, m/aqVeg, M
Dry during summer						
24-May-05	61	14	4.36	D	58	SOOC, m/aqVeg, M
S8						
13-Jul-04	47	10	4.7	D	53	aqVeg, SM
14-Oct-04	36	9	4	D	43	aqVeg, M
9-Mar-05	15	4	3.75	E	32	aqVeg, M
25-May-05	20	6	3.33	E	44	aq Veg, M

F. SASS5 ASSESSMENT OF THE SOUT RIVER

Site S1 – DWAF weir

The river consisted of pools and runs with good depth. *P. australis* reed growth was abundant providing good habitat for a fish species such as *S. capensis*. Flow was moderate (gauging weir) and water quality appeared acceptable. Several seines at the weir and pool below yielded no fish samples. This begs the question whether possible presence of *M. salmoides* and *Oreochromis mossambicus* (Mozambique tilapia) are taking up *G. zebratus* and *S. capensis* river habitat. Sampling for these fish could determine the reasons for not finding the indigenous fish are in the sample, as water salinity appears acceptable for their survival.

Table 64. Numbers of fish caught and the Fish Index Score for the site **S1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis ***G. zebratus***	None	9/35 = 26% E	No indigenous fish, bass?

Site S2 – Soes River

Only 1 site was sampled. It was a large pool of acceptable depth with a heavy growth of papyrus on the margins. The habitat was very suitable for *S. capensis*. However, seine netting yielded large numbers of small Mozambique tilapia.

Table 65. Numbers of fish caught and the Fish Index Score for the site **S2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis	*O. mossambicus* (40-50 at 4cm)	11/30 = 37% E	No indigenous fish, large numbers of tilapia

Site S3 – Brakfontein

This river segment contained good ecological conditions for fish, with wide-deep pools and a near natural riparian zone. The expected species, *S. capensis* was caught in reasonable numbers using a small seine. However, some *O. mossambicus* were also caught but in very low numbers.

Table 66. Numbers of fish caught and the Fish Index Score for the site **S3** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis	*S. capensis* (10 at 3-5cm) *O. mossambicus* (1 at 3cm)	25/30 = 83% B	Expected species present, excellent habitat, low numbers of Mozambique tilapia

Site S4 – Kykoedy

This site contained some fish habitat with *P. australis* densities in the upstream sampling locality. However, no fish were caught using a SASS net. The reasons for this may be due to inappropriate sampling methods or bad water quality.

Table 67. Numbers of fish caught and the Fish Index Score for the site **S4** are shown in the table below.

Species expected	Species caught	Score	Reason for score
G. zebratus	None	1/25 = 4% F	Very poor and polluted habitat, no fish

Site S5 – Hotnotskraal River

The river is small and the abundant growth of algae indicates excess nutrients in the water. Adequate habitat is present for *S. capensis*. Extra sampling may have yielded fish, but if present, the abundance would be low. Flow was low and clarity was moderate.

Table 68. Numbers of fish caught and the Fish Index Score for the site **S5** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis	None	2/15 = 13% F	No fish, pollution

Site S6 – Soutkuil

This site contained limited fish habitat and yielded no fish when using a SASS net. The reason for this may be due to inappropriate sampling methods. However, the water quality was very turbid and shallow. Thus it was speculated that the fish couldn't tolerate the water quality of this site.

Table 69. Numbers of fish caught and the Fish Index Score for the site **S6** are shown in the table below.

Species expected	Species caught	Score	Reason for score
G. zebratus	None	1/25 = 4% F	Very poor and polluted habitat, no fish

Site S7 – Klipdale

This river segment contained a larger active channel than the upstream site, with deeper pools and some growth of instream sedge, which includes *P. australis* and aquatic macrophytes. Flow was low and water clarity was high. Intensive seine netting yielded no fish. *M. salmoides* may be present, but the abundance of aquatic macrophytes should have provided sufficient refugia for *G. zebratus*. Results remain inconclusive.

Table 70. Numbers of fish caught and the Fish Index Score for the site **S7** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	None	3/25 = 12% F	No indigenous fish, acceptable habitat

Site S8 – Wydgeleë

The river here consists of heavily reeded pools with abundant algal growth. The riparian zone is more impacted with a small buffer between the river and adjacent farmland. Seine-netting was thus very difficult and only small numbers of O. mossambicus were caught. However, it was presumed that *S. capensis* should be present but were not caught because of the difficult sampling conditions.

Table 71. Numbers of fish caught and the Fish Index Score for the site **S8** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis	*O. mossambicus* (6 at 3-4cm)	10/30 = 33% E	No indigenous fish, tilapia, excess plant growth

4.2.2 Kars River

Three sites were selected on the Kars River. All sites were located in the lower foothills and lowland river zones (Figure 16). The general site information for each site is shown below (Tables 72, 73, 74).

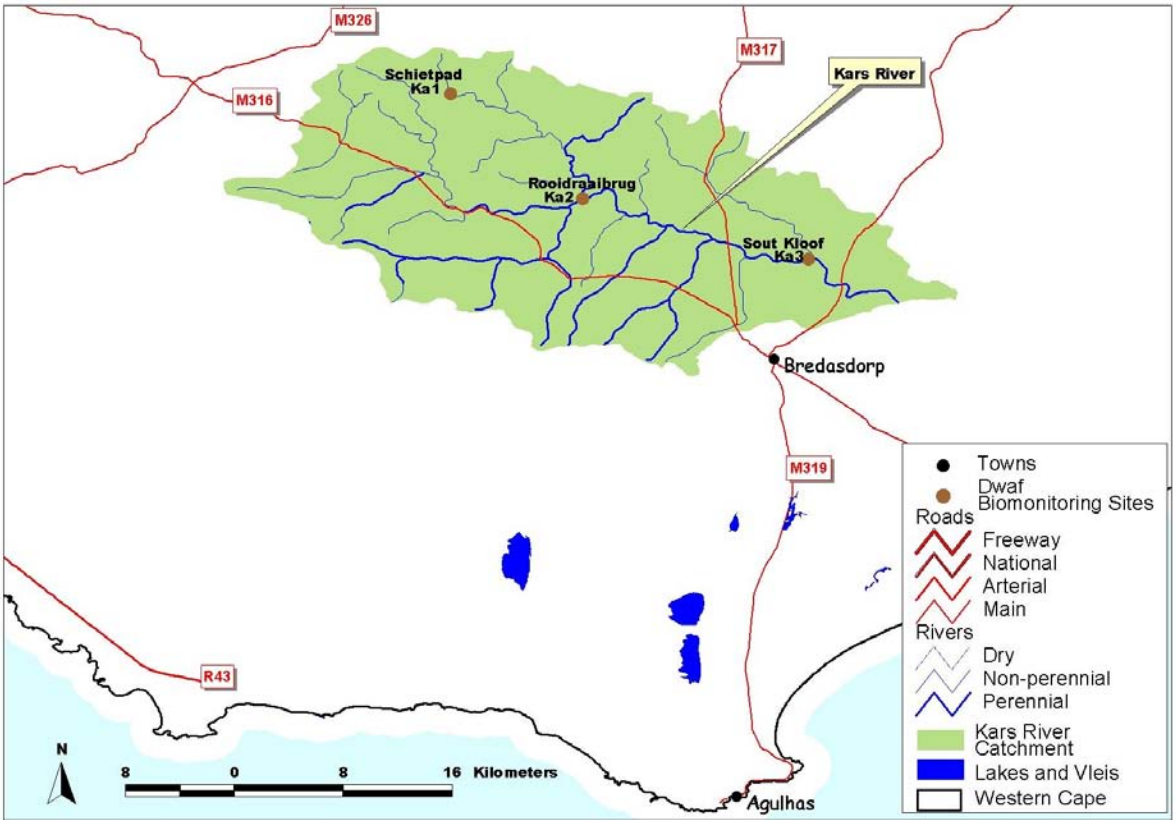


Figure 16. Map showing the monitoring sites on the Kars River

Table 72. Summary of the general site information for Site Ka1

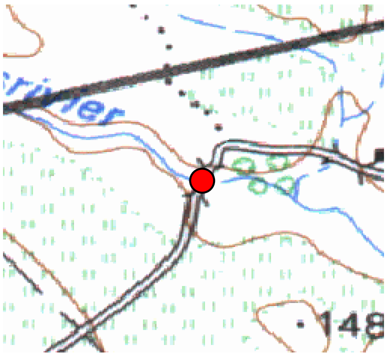
RHP Site code	G5KARS-KARSR	**Project Site Number**	Ka1
River	Kars		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.41331	19.82058	
Site description	At Karsrivier farm using Schietpad		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	15
Longitudinal zone	Lower foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50D
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 49. Site Ka1– October 2004 (looking upstream)

Plate 50. Site Ka1 – October 2004 (looking downstream)

Table 73. Summary of the general site information for Site Ka2

RHP Site code	G5KARS-ROOID	**Project Site Number**	Ka2
River	Kars		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.42972	19.91531	
Site description	Located at the Rooidraaibrug toward Klipdale		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	20
Longitudinal zone	Lower foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50D
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 51. Site Ka2 – October 2004 (looking upstream)

Plate 52. Site Ka2 – October 2004 (looking upstream)

Table 74. Summary of the general site information for Site Ka3

RHP Site code	G5KARS-SOUTK	**Project Site Number**	Ka3
River	Kars		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.47253	20.05753	
Site description	Sout Kloof rd to Stormsvlei, then Nooitgedacht		
Map Reference (1:50 000)	3420AC 	**Site length (m)**	15m
Longitudinal zone	Lower foothills		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.04
Secondary catchment	G5	**Quaternary catchment**	G50D
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	Db
Rainfall region	Winter		

Plate 53. Site Ka3 – October 2004 (looking upstream)

Plate 54. Site Ka3 – October 2004 (looking upstream)

A. INDEX OF HABITAT INTEGRITY: KARS RIVER

The instream and riparian habitat integrity of the Kars River improves in the lower reaches of the river (Figure 17). The instream zone changes from largely modified at the uppermost site to moderately modified at the lowermost site. Similarly the riparian zone changes from extensively modified at the first two sites to moderately modified at the lower-most site.

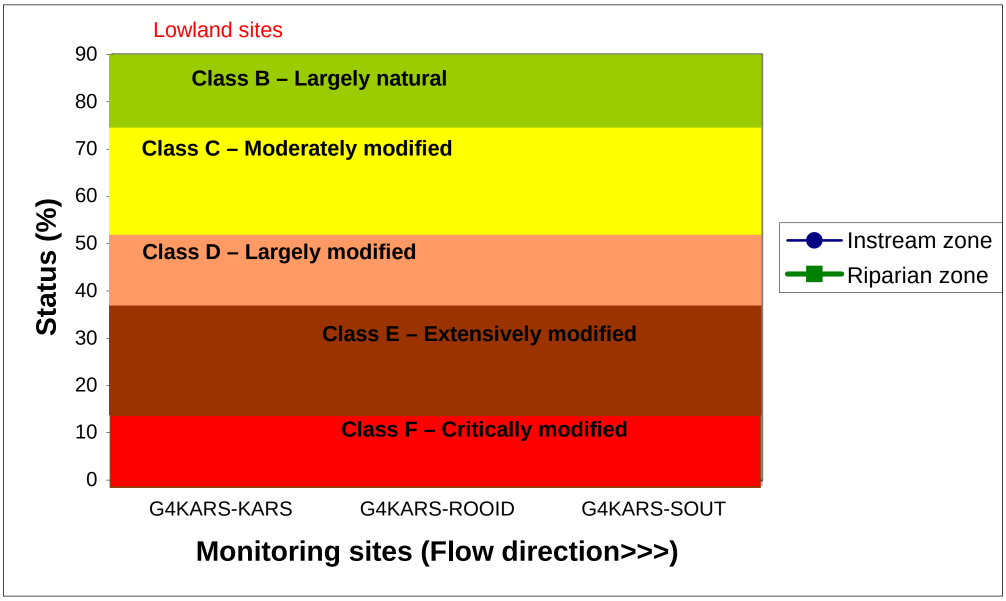


Figure 17. Summary of Index of Habitat Integrity results for the Kars River System

Site Ka 1 – Schietpad

Instream – Class D

- Water quality has been seriously modified by the extensive agricultural activities in the catchment that contribute to increased nutrients, algae and sediment inputs into the instream environment.
- The effects of poor water quality have largely modified the instream bed.
- Water abstraction and associated flow modifications have also largely impacted on the instream habitat.

Riparian – Class E

- Bank erosion and alien vegetation encroachment have seriously modified the riparian zone.

- Water abstraction and removal of indigenous vegetation have largely impacted on the riparian zone.
- Water quality and flow have had moderate impacts on the riparian zone.

Site Ka 2 – Rooidraaibrug

Instream – Class D

- Water abstraction has critically impacted on instream habitat as it dries up entirely in late summer.
- Water quality has also seriously affected the instream habitat, where agricultural activities in the catchment result in increased sediment input, nutrients, algal blooms and pesticides.
- Flow modifications have largely affected the instream habitat as a result of the many off-stream dams in the catchment.
- The instream channel has been modified by the encroachment of alien vegetation.

Riparian – Class F

- Water abstraction and flow modifications have seriously impacted on the riparian zone and are reflected in the extensive encroachment of aliens.
- Decrease in indigenous vegetation, channel modification and water quality have had serious impacts on the riparian zone.

Site Ka 3 – Soutkloof

Instream – Class C

- Water abstraction and water quality probably have had moderate to large effects on the instream habitat.

Riparian – Class C

- Encroachments of alien vegetation and associated decrease in indigenous vegetation have had a moderate to large impact on the riparian zone.

B. GEOMORPHOLOGICAL STATUS OF THE KARS RIVER SITES

Site Ka1 was located in the lower foothills. The channel type was single, alluvial and the dominant bed material was sand. A causeway occurred at the site and caused inundation upstream and created an artificial riffle area immediately downstream, whereas the reach type remained a flat bed. Lateral bars were also present. Both banks were stable upstream of the causeway and well vegetated. Most of the erosion occurred downstream as a result of flooding on the RHB (outside meander bend) in the form of bank scour, creating a steep bank. Channel impacts included infrequent causeways, high impact of alien vegetation, few abstraction weirs in the reach and a moderate sediment supply to the channel. The habitat cover and diversity was relatively high. **Impact class: C.**

Site Ka2 was located in a lowland river zone. The channel type was single, alluvial and the dominant bed material was sand. The reach type was classed as a flat bed. Slight erosion occurred on both banks and limited rilling due to livestock tracks occurred. Both the fluvial and sub-aerial erosion was limited to the vicinity closest to the bridge. Lateral and mid channel bars occurred and the habitat diversity and cover was high. Channel impacts included few abstraction weirs in the reach, a bridge with in-channel supports, high impact by alien vegetation and an extensive supply of sediment to the channel. **Impact class: D.**

Site Ka3 was located on the farm Soutkloof, in the lower foothills. The channel type was single, mixed and the dominant bed material was sand, silt and clay. The reach type was flat bed and lateral bars were present. Both banks were stable and only the LHB showed slight (<10%) bank erosion where the bedrock did not dominate. The channel margins on both banks were reed dominated and the banks were well covered with continuous vegetation. The habitat diversity and cover were good. Alien vegetation had a high impact and sediment sources supplied to the channel were moderate. **Impact class: C.**

Table 75. Summary of the geomorphological assessment of the Kars River sites

Sites	**Site Ka1**	**Site Ka2**	**Site Ka3**
Zone	Lower foothills	Lowland	Lower foothills
Channel pattern	Single	Single	Single
Water level	Medium flow	Medium flow	Medium flow
Valley form	Foothill floodplain	Foothill floodplain	Foothill floodplain
Active channel width	10-15m	5-10m	15-30m
Macro-channel width	None	None	None
Channel type	Alluvial	Alluvial	Mixed
Bars	Lateral	Lateral, mid channel	Lateral
Bed material	Sand	Sand	Sand, silt and clay
Reach type	Flat bed	Flat bed	Flat bed
Fluvial erosion	Slight (RHB) Moderate (LHB)	Slight (Both banks)	Slight (LHB)
Subaerial erosion	Limited	Limited	None
Impact class	**C**	**D**	**C**

C. RIPARIAN VEGETATION ASSESSMENT FOR THE KARS RIVER

Site Ka1 presented a disturbed riparian zone with organic deposits indicating a recent flood event prior to assessment. Vegetation invasion by *Eucalyptus spp* and *Acacia saligna* was high. The instream vegetation consisted of sedge, primarily *Cyperus spp.* with *Juncus spp.* occupying the river channel and margin. Indigenous riparian trees and shrubs species were few. As a result of cumulative disturbances over time, grass and sedge turf predominated.

The site was estimated as **Class D (9.0)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. Instream habitat was satisfactory.

Site Ka2 displayed an unstable riparian zone with no indigenous shrub or tree components verifying habitat intactness. Vegetation invasion was consistent with the upstream site, but with the *A. saligna* densities progressing with the absence of *Eucalyptus spp.* competition. Reed representatives from *P. australis* were prolific instream, indicating profound water abstraction practice. In general, sedge species predominated, providing habitat for fauna instream.

The site was estimated as **Class E (8.21)**. This implies that natural habitat has been lost and biotic or basic ecosystem functions are broadly disturbed.

Site Ka3 displayed rather robust habitat intactness for indigenous vegetation classes represented over the riparian zone. Riparian tree *Olea africana* (wild olive) and shrubs *Rhus spp.* and *Lycium spp.*, were sufficiently represented. Alien invading tree species – *A. saligna* and *A. cyclops* – were present, but in moderate density compared to the upstream localities. Instream reed densities were distributed in patchy clumps, as preferred - sedge and grass species being adequate.

The site was estimated as **Class D (10.56)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred, but not extensive. The flood event prior to assessment did not impact significantly at this downstream locality.

D. WATER QUALITY

Table 76. *In situ* water chemistry data for the conductivity, dissolved oxygen, pH and temperature for the Kars River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
Ka 1	2004/07/12	0.928	8.82	5.72	11.5
Ka 1	2004/10/13	62	-	5.75	16.6
Ka 1	2005/12/03	71.4	7.80	7.85	27.7
Ka 2	2004/10/14	18.80	-	6.65	20
Ka 2	2005/12/03	10.04	7.44	7.31	24.4
Ka 3	2004/07/12	2.219	12.13	8.57	11.9
Ka 3	2004/10/14	1880	-	6.76	22.4
Ka 3	2005/12/03	5.18	6.8	7.59	25.7

Table 77. Results of water chemistry analysis

Determinands	Results		
	Ka 1	Ka 2	Ka 3
Free and saline ammonia (N mg/l)	<0.3	<0.3	<0.3
Nitrate and Nitrite (N mg/l)	<0.3	<0.3	<0.3
Total phosphate (P mg/l)	<0.05	0.21	0.13
Ortho-phosphate (P mg/l)	<0.05	<0.05	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of nitrogen and Ortho-phosphate ions. The concentrations for Total phosphates (as P in mg/l) analysis were slightly high in site Ka 2 (poor to fair class rating). However, the overall quality for the river system was very good.

E. SASS5 ASSESSMENT OF THE KARS RIVER

All the sites along the Kars River were located in the lowland zones and therefore GSM and instream and marginal vegetation provided the only sampling habitats. The SASS5 and ASPT scores were low being below 50 and 5.1 at all sites respectively indicating deterioration in water quality. It can also be reasoned that due to the limiting habitat availability, these sites would score naturally low.

Table 78. Summary of the SASS5 and ASPT scores for the Kars River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
Ka 1						
12-Jul-04	16	5	3.2	E	69	SIC, SOOC, mVeg
13-Oct-04	44	11	4	D	81	SIC, SOOC, m/aqVeg
Dry during summer						
24-May-05	37	7	5.27	C	71	SIC, m/aqVeg, GS
Ka 2						
14-Oct-04	47	10	4.7	D	39	aqVeg, M
09-Mar-05	27	7	3.86	E	49	mVeg, SM
Dry during summer						
24-May-05	34	7	4.86	D	44	aqVeg, M
Ka 3						
12-Jul-04	47	10	4.7	D	51	SIC, SOOC, mVeg, GS
14-Oct-04	42	9	4.67	D	48	SOOC, aqVeg
09-Mar-05	46	9	5.11	C	52	SIC, aqVeg, GS
25-May-05	15	4	3.75	E	42	m/aqVeg, S (Bedrock)

F. FISH ASSESSMENT OF THE KARS RIVER

Site Ka 1 – Schietpad

This site was slow flowing and pools and runs were well vegetated. The water and stream substrate was peat stained and water flow and quality were good at the time of sampling. The riparian zone was in an acceptable condition with *Cyperus spp.* and *Juncus spp.* providing good instream fish habitat.

Seine netting yielded excellent numbers of all expected fish species, and this site was noted as having a significant range extension for the *Pseudobarbus burchelli* (Heuningnes redfin). For these reasons, the upper Kars River was considered a priority site for freshwater fish conservation.

Table 79. Numbers of fish caught and the Fish Index Score for the site **Ka 1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis ***G. zebratus***	*S. capensis* 7 (3-4 cm) *G. zebratus* (15-20 all sizes) *P. "burchelli"* (in excess of 100, mainly juvs.)	29/30 = 97% A	Near pristine community

Site Ka 2 – Rooidraaibrug

This site contained some pools with runs that provided well-vegetated habitats. However, marginal vegetation was inadequately tall and dense at some sections of the stream. Instream vegetation was characterized by *Cyperus spp.* and *P. australis* occupying the channel bed and margins.

The presence of *M. punctalatus* and *L. macrochirus* has resulted in the localized extinction of redfins and probably *G. zebratus* as well. However, habitat proved favourable for *S. capensis* populations regardless of competition from the alien fish species. It should be noted that the eradication of alien fish species would support thousands of *P. burchelli*, *G. zebratus* and *S. capensis* fish recruitment, as the current instream habitat was in a most desired state.

Table 80. Numbers of fish caught and the Fish Index Score for the site **Ka 2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis ***G. zebratus*** *P. "burchelli"*, based on previous site	*S. capensis* (7-10 at 5-10cm) *L. macrochirus* (7-10 at 4-5cm) *M. punctalatus* (1 at 5cm)	14/35 = 40% D	Alien fish dominate fauna, few Cape kurper present

4.2.3 NUWEJAARS, HEUNINGNES AND RATEL RIVER SYSTEM

One site was selected on the Heuningnes River as its flows from various wetlands and vleis including the Zoetendalsvlei and two sites were selected on the Nuwejaars River. Another two sites were selected on upper tributaries (Pietersielieskloof and Klein Pietersielieskloof) of the Nuwejaars River (Figure 18). The general site information for each site is displayed in Tables 81-85.

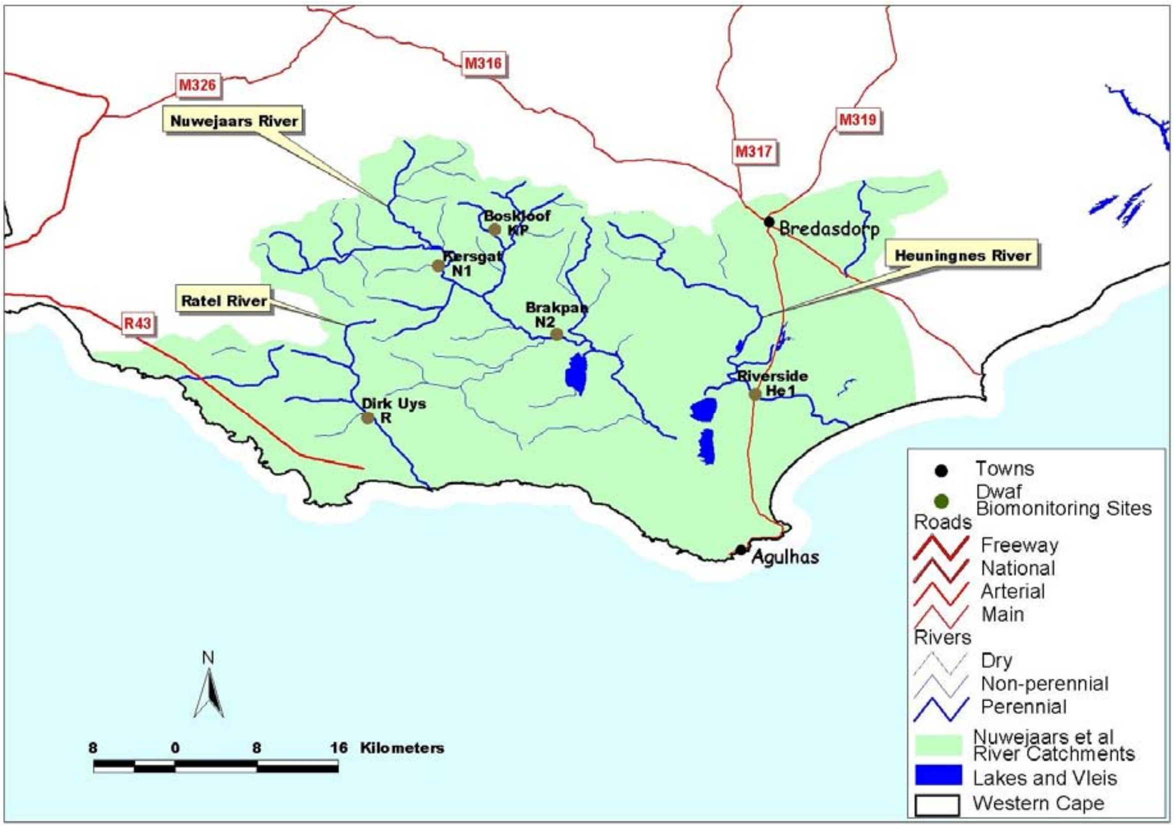


Figure 18. Map showing the monitoring sites on the Nuwejaars, Heuningnes and Ratel River systems.

Table 81. Summary of the general site information for Site N1

RHP Site code	G5NUWE-KERSG	**Project Site Number**	N1
River	Nuwejaars		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.57858	19.70792	
Site description	Located at a causeway on the road to Kersgat, just outside Elim		
Map Reference (1:50 000)	3419DB 	**Site length (m)**	15m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.03
Secondary catchment	G5	**Quaternary catchment**	G50B
Vegetation type	Laterite Fynbos	**Geological type**	Db
Rainfall region	Winter		

Plate 55. Site N1 – October 2004 (looking upstream)

Plate 56. Site N1 – October 2004 (looking downstream)

Table 82. Summary of the general site information for Site N2

RHP Site code	G5NUWE-BRAKP	**Project Site Number**	N2
River	Nuwejaars		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.63403	19.86500	
Site description	Located on the Farm Brakpan		
Map Reference (1:50 000)	3419DB 	**Site length (m)**	40m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.03
Secondary catchment	G5	**Quaternary catchment**	G50C
Vegetation type	Laterite Fynbos	**Geological type**	Db
Rainfall region	Winter		

Plate 57. Site N2– October 2004 (looking upstream)

Plate 58. Site N2 – October 2004 (looking downstream)

Table 83. Summary of the general site information for Site 3 (KP)

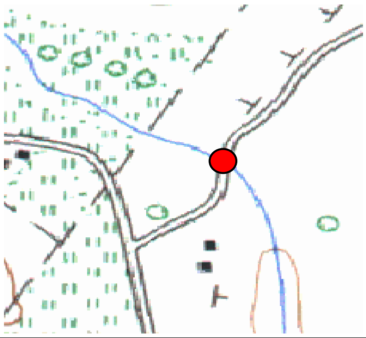
RHP Site code	G5KLEI-BOSKL	**Project Site Number**	KP
River	Klein Pietersielieskloof	**Tributary of**	Nuwejaars
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.5473055555556	19.8073333	
Site description	Located at the causeway at Klein Pietersieliesrivier		
Map Reference (1:50 000)	3419BD 	**Site length (m)**	15m
Longitudinal zone	Lower foothill		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G5	**Quaternary catchment**	G50B
Vegetation type	Laterite Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 59. Site KP– October 2004 (looking upstream)

Plate 60. Site KP – October 2004 (looking downstream)

Table 84. Summary of the general site information for Site 4 (P)

RHP Site code	G5PIET-BOSKL	**Project Site Number**	P
River	Pietersielieskloof	**Tributary of**	Nuwejaars
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.54233	19.81867	
Site description	Located at a causeway on route to Boskloof farm		
Map Reference (1:50 000)	3419DB 	**Site length (m)**	20m
Longitudinal zone	Lower foothill		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, wetlands and vleis		
Ecoregion 1	Southern Folded Mountains	**Ecoregion 11**	19.05
Secondary catchment	G5	**Quaternary catchment**	G50B
Vegetation type	Mountain Fynbos	**Geological type**	Ost
Rainfall region	Winter		

Plate 61. Site P – October 2004 (looking upstream)

Plate 62. Site P – October 2004 (looking downstream)

Table 85. Summary of the general site information for Site 5 (He1)

RHP Site code	G5HEUN-RIVER	**Project Site Number**	He1
River	Heuningnes		
Co-ordinates (Decimal Degrees)	**Latitude**	**Longitude**	
	-34.68861	20.03361	
Site description	Located on the farm Riverside on road to Struisbaai		
Map Reference (1:50 000)	3420CA 	**Site length (m)**	30m
Longitudinal zone	Lowland		
Hydrological type	**Natural**	**Present**	
	Perennial	Perennial	
Associated systems	Marshes, vleis and wetlands		
Ecoregion 1	Southern Coastal Belt	**Ecoregion 11**	22.03
Secondary catchment	G5	**Quaternary catchment**	G50F
Vegetation type	South & South-West Coast Renosterveld	**Geological type**	TQc
Rainfall region	Winter		

Plate 63. Site He1 – October 2004 (looking upstream)

Plate 64. Site He1 – October 2004 (looking downstream)

A. INDEX OF HABITAT INTEGRITY: HEUNINGNES/NUWEJAARS RIVER SYSTEM

The Heuningnes/Nuwejaars system dramatically improves in habitat integrity as the rivers flow towards the sea. The instream habitat integrity was less modified than the riparian habitat integrity, which was largely due to the effects of agricultural activities in the riparian zones (Figure 19). The instream and riparian zones of the two uppermost sites were seriously modified after a flood event in April 2005 (Appendix F). The lowermost site on the Heuningnes River boasts a largely natural instream habitat and an only moderately modified riparian habitat. The presence of *Cyprinus carpis* (carp) in the system was the only major concern for the instream habitat integrity. The catchments lower reaches seemed to recover well after passing through the many wetlands spread throughout the entire system.

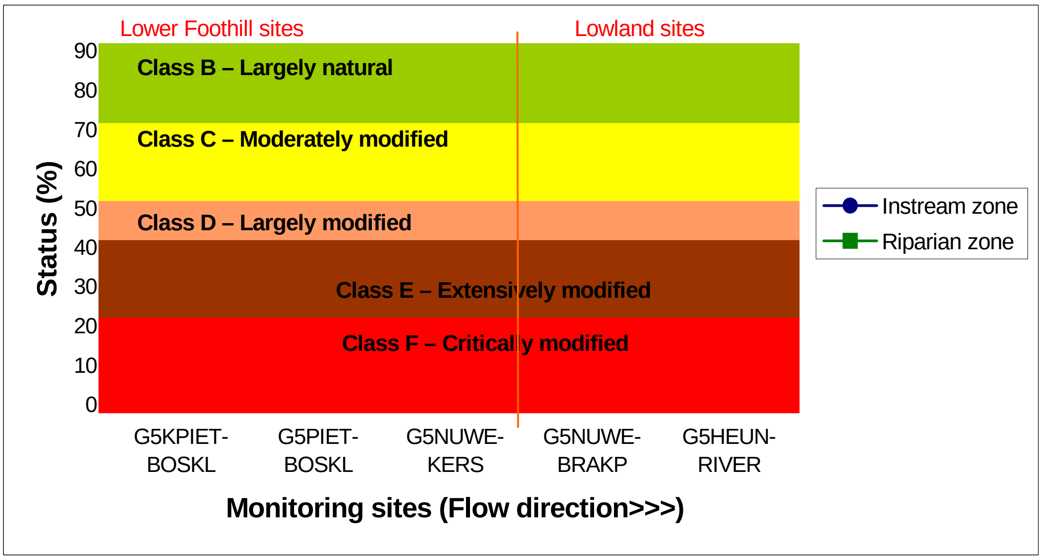


Figure 19. Summary of Index of Habitat Integrity results for the Heuningnes/Nuwejaars River System

Site N1 – Nuwejaars (Kersgat)

Instream – Class B

- Water abstraction has moderately impacted on the instream habitat.

Riparian – Class C

- Alien vegetation encroachment has seriously modified the riparian zone.

Site N2 – Nuwejaars (Brakpan)

Instream – Class C

- Water abstraction and water quality have both largely modified the instream habitat.

Riparian – Class E

- Alien vegetation encroachment has seriously impacted on the riparian zone. Associated bank erosion and channel modification has also impacted largely on the riparian zone.

Site KP – Klein Pietersielieskloof

A major flood event caused severe instream and riparian habitat destruction.

Instream – Class E

- The instream bed was critically modified during the above-mentioned flood event. Furthermore the instream bed was almost totally destroyed as a result of serious bulldozing subsequent to the flood event.
- Water quality was seriously modified by severe sedimentation subsequent to the flood event.
- The instream channel was seriously modified from the severe bulldozing.

Riparian – Class F

- Critical encroachment of alien vegetation dominated the riparian zone with a subsequent total loss of any indigenous vegetation.
- Critical bank erosion subsequent to the flood event and severe bulldozing have impacted on the riparian zone.

Site P – Pietersielieskloof

A major flood event during April 2005 caused severe instream and riparian modifications.

Instream – Class D

- Recent extensive bulldozing of the channel across the instream bed has caused direct habitat disturbance. Subsequently, concerns exist about the impacts the channel bulldozing may have on the large *Prionium spp.* bed, which supports much of the instream habitat and natural flow processes and patterns of this river segment.
- Severe sedimentation has largely modified water quality subsequent to the flood event, which was further exacerbated by the recent bulldozing of the instream bed.

- The presence of extensive alien infestation in the entire area has largely modified the instream flow.
- The low water bridge/causeway has largely modified the instream channel in its immediate vicinity.

Riparian – Class E

- The riparian zone has been critically modified by intensive alien infestation. Associated with the alien infestation is the critical removal of indigenous vegetation from the riparian zone.

Site He1 – Heuningnes

Instream – Class B

- The presence of *Cyprinus carpis* (carp) impacted moderately on the instream habitat.

Riparian – Class C

- Decrease in indigenous vegetation and associated channel modifications largely impacted on the riparian zone.

B. GEOMORPHOLOGICAL STATUS OF THE NUWEJAARS AND HEUNINGNES RIVER SITES

Site N1 was located in the lowland zone. The channel was single, alluvial and the dominant bed material was sand. The reach type was classed as flat bed and extensive aquatic vegetation occurred within the channel. Both banks were stable and consisted of mostly alien vegetation and reeds. Only slight erosion processes occurred in the vicinity of the causeway on both banks. Habitat diversity and cover was relatively high. **Impact class: C.**

Site N2 at Brakpan was situated in the lowland zone and the surrounding landuse was irrigation farming. The channel was single, mixed and the dominant bed material was silt and clay. The reach type was flat bed and lateral bars were present. The LHB showed slumping and was undercut in the vicinity of the bridge. Farm vehicle tracks were found on the LHB close to the point of where water abstraction occurred. The habitat diversity was low and the habitat cover was moderate. Localised channel straightening, dense alien vegetation, extensive sediment supply and bridges with in-channel supports occurred. **Impact class: D.**

Site P was located in the lower foothills. Both channels were alluvial, single and gravel dominated. The channel banks were dominated by alien vegetation and the Pietersieliekloof channel was completely overgrown upstream of the causeway. The dense alien trees confined the channels. These two rivers were mostly impacted by the flood event of April 2005 (Appendix F).

The Pietersieliekloof channels were filled with sediment and all instream vegetation was removed resulting in a much wider channel, which revealed islands of Palmiet reed in the Pietersieliekloof. The channel was braided after flooding with numerous mid channel bars and islands. Moderate fluvial erosion occurred and limited rilling on both banks. The habitat diversity and cover was still high. **Impact class: C-D.**

The floodwater of **Site KP** removed most of the alien vegetation in the vicinity of the causeway and deposited large amounts of sediment in the channel. The bed material changed from gravel to sand and all the vegetation habitats were removed resulting in a low habitat diversity and cover. Due to the over stabilization by the alien vegetation the floodwater scoured around the trees on the banks resulting in deep gully formation which occurred mostly on the RHB. **Impact class: D.**

Site He1 was located on the farm called "Riverside", which was situated in the lowland zone. The channel was alluvial, single and the dominant bed material was gravel and sand. The reach type was classified as a flat bed. Both banks were stable and showed no sign of erosion even after the flood in April 2005. The habitat diversity and cover were moderate. Channel impacts, which occurred, were a negligible impact by alien vegetation, bridges with in-channel supports and a moderate sediment supply. **Impact class: C.**

Table 86. Summary of the geomorphological assessment of the Nuwejaars/Heuningnes River sites

Sites	**N1**	**N2**	**KP**	**P**	**He1**
Zone	Lowland	Lowland	Lower foothills	Lower foothills	Lowland
Channel pattern	Single	Single	Multiple	Single	Single
Water level	Medium flow	Low flow	Medium flow	Low flow	Medium flow
Valley form	Foothill floodplain	Foothill floodplain	Foothill floodplain	Foothill floodplain	Foothill floodplain
Active channel width	10-15m	15-30m	15-30m	30-50m	15-30m
Macro-channel width	None	None	None	None	None
Channel type	Alluvial	Mixed	Alluvial	Alluvial	Alluvial
Bars	None	Lateral	None	Mid channel and islands	None
Bed material	Sand	Silt and clay	Sand	Sand	Gravel
Reach type	Flat bed	Flat bed	Flat bed	Flat bed	Flat bed
Fluvial erosion	Slight (Both banks)	Slight-moderate	Extreme (both banks)	Moderate (both banks)	None
Subaerial erosion	None	Limited and active riling	Limited rilling (Both banks)	Limited rilling (Both banks)	None
Impact class	**C**	**D**	**D**	**D**	**C**

C. RIPARIAN VEGETATION ASSESSMENT OF THE NUWEJAARS RIVERS AND HEUNINGNES RIVER SYSTEM

Site N1 riparian zone had complete vegetation cover. The indigenous cover component vegetation classes were not desirable as alien species *A. saligna* covered a large section of the zone and indigenous shrub densities were low. The channel margin and stream bed vegetation cover was satisfactory, with sedge densities from *P. serratum*, *Cyperus spp*. and *Calopsis spp*. distributed in suitable densities.

The site was estimated as **Class D (10.0)**, which is modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. However, instream vegetation functionality was satisfactory as habitat diversity was high.

Site N2 had a riparian zone with complete vegetation cover. Indigenous cover component vegetation classes were consistent with the upstream site, having *A. saligna* covering a large part of the riparian zone. However, indigenous shrub densities improved slightly when compared to the upstream site. The instream habitat was consistent to upstream site, providing good habitat for fish and invertebrates. Sedge densities from *P. serratum, Cyperus spp*. and *Juncus spp*. had a patchy distribution.

The site was estimated as **Class D (12.0)**, which is largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.

Site KP was severely disturbed by a flood event prior to assessment. Most of the sites topsoil had been eroded. The invasive species *Eucalyptus spp., A. saligna, A. cyclops, Leptospermum laevigatum* (Australian myrtle) and *Pinus spp.* proliferated over the riparian zone. *P. australis* and *P. serratum* individuals were sparsely distributed and were the only indigenous riparian vegetation on the site.

The site was estimated as **Class F (4.0)**. This implies that disturbance has caused an almost complete loss of natural habitat. Modifications have reached a critical level and clearing of aliens as part of a rehabilitation program is strongly recommended.

Site P was severely disturbed by a flood event prior to assessment. The invasive species *Eucalyptus spp., A. saligna, A. longifolia* (long-leaf wattle) and *L. laevigatum* was well established over the riparian zone. Most of the indigenous riparian vegetation was removed by the flood or alien vegetation occupation. However, the sedge occupying the channel was significantly improving this river segment's health, with *P. serratum, Calopsis spp.,* common fern and *Juncus spp.* occupying desired instream densities.

The site was estimated as **Class E (5.0)**. This implies that disturbance has caused an almost complete loss of natural habitat. Implications from ongoing disturbances are serious and clearing of aliens as part of a rehabilitation program is strongly recommended.

Site He1 had a riparian zone that displayed a rather robust habitat intactness and a high percentage coverage of indigenous vegetation classes. Riparian tree *Olea africana* (wild olive) and shrubs *Rhus spp.* and *Asparagus spp.,* were sufficiently represented. Alien invading tree species – *A. cyclops, A. saligna* and *Eucalyptus spp.* – were evident, but only recruiting at low densities. Sedge and grass species were particularly high as a result of some flood disturbance previously. However, reed densities (*P. australis*) provided some aspect of instream health.

The site was estimated as **Class D (12)**, which is largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.

D. WATER QUALITY

Table 87. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Bot and Swart River sites

Site Code	Sampling Date	COND (mS/m)	DO (mg/l)	pH (pH unit)	TEMP (^{0}C)
N1	2005/05/12	48.54	-	6.85	16.2
N1	2005/03/10	1.322	-	6.79	19.6
N1	2005/12/03	60.6	4.8	7.13	25.2
N1	2004/10/22	59	5.73	6.16	19.8
N1	2004/07/29	70.4	8.36	-	11.6
N2	2004/07/29	88.8	3.86	-	11.9
N2	2004/10/22	85.4	2.05	5.87	22.4
N2	2005/05/12	0.657	-	7.23	16.1
N2	2005/03/10	0.89	-	7.07	21.7
N2	2005/12/03	98.0	3.1	6.46	24.0
KP	2005/03/10	35.15	11.55	5.53	20.5
KP	2005/07/04	42.79	8.09	-	14.9
KP	2005/12/03	50.4	6.8	6.7	27.7
P	2005/05/12	37.3	-	5.51	17.7
P	2005/12/03	43.3	7.8	5.93	26.0
P	2005/03/10	4.98	4.43	5.16	17.6
P	2004/10/22	29.7	6.36	4.52	15
P	2004/07/29	42.79	8.09	-	14.9
He1	2005/05/12	1.026	8.78	7.87	17.3
He1	2005/03/05	26.95	0.31	8.13	20.4
He1	2005/12/03	8.71	5.4	7.59	24.2
He1	2004/10/15	18.8	-	7.62	21.8
He1	2004/07/12	12.76	9.32	8.18	15.6

Table 88. Results of water chemistry analysis

Determinants	Results				
	N1	N2	KP	P	He1
Free and saline ammonia (N mg/l)	<0.3	<0.3	0.9	<0.3	<0.3
Nitrate and Nitrite (N mg/l)	<0.3	<0.3	<0.3	<0.3	<0.3
Total phosphate (P mg/l)	0.16	0.13	<0.05	<0.05	0.11
Ortho-phosphate (P mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of nitrogen and Ortho-phosphate ions. The concentrations for Total phosphates (as P in mg/l) analysis were slightly high in sites N1, N2 and He1 (poor to fair class). These high salt concentrations could possibly be consequent to farming activities in the catchment. However, the overall quality for the river system as a whole was very good.

E. SASS5 ASSESSMENT OF THE NUWEJAARS AND HEUNINGNES RIVER SYSTEM

The upper site located on the Nuwejaars River (**N1**) had variable SASS5 scores but the middle site (**N2**) had a consistent score of 54 except during March when the score was 47. The ASPT scores ranged between 4 and 5.7 at Kersgat and at Brakpan all scores were below 5 except during July when a score of 6 occurred, which was the highest obtained on the Nuwejaars mainstream. This was possibly due to the presence of high scoring Amphipoda, which was the only site showing a high SASS5 score (142) indicating high habitat diversity (July 2004 sample of the Klein Pietersielieskloof River tributary of the Nuwejaars). The river substrate was comprised of a gravel/cobble-bed and the water quality could also be interpreted as being good/natural as high scoring invertebrates were present, such as Notonemouridae (stoneflies-14) and Amphipoda (13). The IHAS score was relatively high (77%). The March 2005 sample showed a lower ASPT and SASS5 score and an absence of the high scorers, showing some deterioration in water quality, as the habitat scores were still very high (81%). The Pietersielieskloof River (**Site P**) displayed higher SASS5 scores during March 2005 than October 2004, which corresponded to an increased habitat diversity (81%).

The tributaries contained a more defined channel and therefore their habitats were most altered by the flooding in April 2005 (Appendix F). The Klein Pietersielieskloof (**site** KP) had a completely altered substrate from a cobble/gravel to a sand bed and therefore no sample was collected after the flood. The SASS5 and ASPT scores displayed an improvement in the Pietersielieskloof River after flooding.

The site on the Heuningnes River (**Site He1**) displayed poor SASS5 scores (ranging from 15-42), possibly due to low habitat diversity (49-59%), but the ASPT values were relatively high and ranged between 6 and 7.5 indicating good water quality. The taxa found were high scoring and included Amphipods (13) and Atytidae (8).

Table 89. Summary of the SASS5 and ASPT scores for the Nuwejaars and Heuningnes River system

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
N1						
29-Jul-04	46	10	4.6	D	55	m/aqVeg, S
22-Oct-04	69	12	5.75	C	47	aqVeg, M
10-Mar-05	49	9	5.44	C	41	m/aqVeg, M
12-May-05	30	7	4.28	D	46	m/aqVeg, S
N2						
29-Jul-04	54	9	6	B	51	m/aqVeg, GSM
22-Oct-04	54	13	4.15	D	45	aqVeg, GSM
10-Mar-05	47	11	4.27	D	59	SIC, SOOC, m/aqVeg, M
May-05	54	12	4.5	D	33	m/aqVeg, M
KP						
29-Jul-04	142	23	6.17	B	77	SIC, SOOC, aqVeg, S
10-Mar-05	82	15	5.67	C	81	SIC, m/aqVeg, GS
P						
22-Oct-04	38	6	6.33	B	74	SIC, SOOC, m/aqVeg, G
10-Mar-04	88	16	5.5	C	81	SIC, m/aqVeg, GS
12-May-05	20	2	10	A	57	SIC, G
He1						
12-Jul-04	15	2	7.5	A	49	SIC, aqVeg, S
15-Oct-04	18	3	6	B	52	SIC, aqVeg, SM
10-Mar-05	43	7	6.14	B	59	SIC, m/aqVeg, GM
12-May-05	42	8	5.25	C	44	mVeg, GS

F. FISH ASSESSMENT OF THE HEUNINGNES/NUWEJAARS RIVERS

Site N1: Nuwejaars River (Kersgat)

The river was characteristic to that of a wetland with a tremendous diversity of indigenous aquatic instream sedge. The water was peat stained and contained pools of good depth and vegetation habitats. Alien fish species *L. macrochirus* was found in the river segment and *M. puctulatus* may also be present (seine-netting in the larger pools below the bridge was not done effectively due to its depth and very soft bottom). Both spotted and non-spotted *Galaxias spp.* were abundant in the shallow weeded runs. *S. capensis* is less common. This part of the river is also a **priority for river conservation initiatives** due to the diverse aquatic life. The absence of redfins may be due to the bluegill and possible presence of bass species.

Table 90. Numbers of fish caught and the Fish Index Score for the site **N1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis ***G. zebratus*** *P. "burchelli"*, possibly present	*S. capensis* (3 at 4-5cm) *G. zebratus* non-spotted (40-50 all sizes) *G. zebratus* spotted (6-8 all sizes) *L. macrochirus* (7-10 at 4-5cm)	25/35 = 71% C	Excellent habitat, *S. capensis* and *G. zebratus* present, However, *L. macrochirus* was also present

Site N2: Nuwejaars (Brakpan)

The river was wider than the upper site and contained more pools. Instream and marginal vegetation was abundant. The river was flowing well and the water was turbid. Seine netting of pools yielded *L. macrochirus* in open waters and *Galaxias zebratus* in the heavily weeded margins. Pools were generally too deep and big to seine net effectively and it is highly likely that pools contain *M. puctulatus* and possibly *Cyprinus carpis*. This would explain the evident lack of *S. capensis* and redfin species.

Table 91. Numbers of fish caught and the Fish Index Score for the site **N2** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus* *P. "burchelli"*, possibly present	*G. zebratus* (10-12 at 2-3cm) *L. macrochirus* (10 at 4-5cm)	20/35 = 57% D	Only *G. zebratus, L. macrochirus* abundant

Site KP – Klein Pietersielieskloof

Major flooding has destroyed the riparian and instream habitat, leaving shallow cobble bed riffles and shallow sandy pools. Flow and water quality was good at the time of sampling. These habitats were sampled using a SASS net for several minutes and both non spotted and spotted *Galaxias spp.* were caught which is a positive sign in terms of future rehabilitation of the river. The river segment may have had *S. capensis* previously and it is possible that the lack of cover during flooding could have washed fish species downstream.

Table 92. Numbers of fish caught and the Fish Index Score for the site **KP** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*G. zebratus* spotted (2 at 3cm) *G. zebratus* non spotted (3 at 3cm)	17/30 = 56% D	Low numbers *Galaxias*, degraded habitat

Site P – Pietersielieskloof

Major floods have destroyed huge areas of instream palmiet beds and associated peatlands. Small pockets of palmiet remained and the river was braided in many areas. Flow and water clarity was good at the time of sampling. These habitats were sampled using a SASS net for several minutes and both non spotted and spotted *Galaxias spp.* were caught which is a positive sign in terms of future rehabilitation of the river. The river may have had *S. capensis* previously and it is possible that the lack of cover during flooding could have washed indigenous fish species downstream.

Table 93. Numbers of fish caught and the Fish Index Score for the site **P** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus*	*G. zebratus* (10-15 at 3-4cm)	18/30 = 60% C	Bass present

Site He1 – Heuningnes River at Riverside farm

The river was flowing strongly at the time of sampling. Habitat appeared excellent with deep pools and abundant instream macrophytes (Potamogeton). The riparian zone was in acceptable condition with good instream sedge communities. A small seine net was used several times and yielded a remarkable catch of fish. *Gilchristella aestuaria* (estuarine round herring), *Awaous aeneofuscus* (freshwater goby), *S. capensis*, *Monodactylus falciformis* (Cape moonies) and *Solea bleekeri* (Sole) were common. *Cyprinus carpio* (Carp) was unfortunately also present. Surprisingly, no mullet were caught – perhaps it was the wrong time of the year for recruitment.

Table 94. Numbers of fish caught and the Fish Index Score for the site **He1** are shown in the table below.

Species expected	Species caught	Score	Reason for score
S. capensis *G. zebratus* Various estuarine species, depending on time of year	*S. capensis* (6 at 5-6cm) *Gilchristella aestuaria* (40-60 all sizes) *Monodactylus falciformus* (10-15 all sizes) *Awaous aeneofuscus* *Solea Bleekeri* *C. carpio*	31/35 = 88% B	Abundant indigenous fishes, *Cyprinus carpio* present

4.2.4 RATEL RIVER

Only 1 site was selected on the Ratel River, which was located in the lowland river zone (Figure 18). The general site information for this site is shown below.

Table 95. Summary of the general site information for Site 1 (R)

<table>
<tr><td>RHP Site code</td><td>G5RATE-DIRKU</td><td>Project Site Number</td><td>R</td></tr>
<tr><td>River</td><td colspan="3">Ratel</td></tr>
<tr><td rowspan="2">Co-ordinates (Decimal Degrees)</td><td>Latitude</td><td colspan="2">Longitude</td></tr>
<tr><td>-34.7127</td><td colspan="2">19.69803</td></tr>
<tr><td>Site description</td><td colspan="3">Rd to Gansbaai/Buffelsjacht after Wolwengat (Viljoenshof, from Elim)</td></tr>
<tr><td>Map Reference (1:50 000)</td><td>3419DA

</td><td>Site length (m)</td><td>15m</td></tr>
<tr><td>Longitudinal zone</td><td colspan="3">Lowland</td></tr>
<tr><td rowspan="2">Hydrological type</td><td>Natural</td><td colspan="2">Present</td></tr>
<tr><td>Perennial</td><td colspan="2">Perennial</td></tr>
<tr><td>Associated systems</td><td colspan="3">Marshes, wetlands and vleis</td></tr>
<tr><td>Ecoregion 1</td><td>Southern Folded Mountains</td><td>Ecoregion 11</td><td>19.05</td></tr>
<tr><td>Secondary catchment</td><td>G5</td><td>Quaternary catchment</td><td>G50B</td></tr>
<tr><td>Vegetation type</td><td>Laterite Fynbos</td><td>Geological type</td><td>Ost</td></tr>
<tr><td>Rainfall region</td><td colspan="3">Winter</td></tr>
</table>

Plate 65. Site R – October 2004 (looking upstream)

Plate 66. Site R – October 2004 (looking downstream)

A. INDEX OF HABITAT INTEGRITY: RATEL RIVER

No data available

B. GEOMORPHOLOGICAL STATUS OF THE SITE ON THE RATEL RIVER

The site was located on the farm, Dirk Uys in the lowland zone. Although the water level was low at the time of sampling, the site was dry for most of the year. As a result much of the channel was overgrown with grass upstream of the road bridge. The riparian zone contained limited indigenous vegetation and dense alien trees dominated the banks (mostly Black wattle) downstream, which resulted in channel straightening. The gravel road also supplied sediment to the channel. The channel was alluvial and sand dominated. The reach was classified as a flat bed. Both banks showed no signs of erosion and the habitat diversity and cover was good. **Impact class: D.**

Table 96. Summary of the geomorphological assessment of the Ratel River site

Site	**Site 1 (R)**
Zone	Lowland river
Channel pattern	Single
Water level	Medium flow
Valley form	Foothill floodplain
Active channel width	1.5-5m
Macro-channel width	15-30m
Channel type	Alluvial
Bars	None
Bed material	Sand
Reach type	Flat bed
Bank erosion fluvial	None
Bank erosion sub-aerial	None
Impact class	**D**

C. RIPARIAN VEGETATION ASSESSMENT OF THE RATEL RIVER

This site was moderately disturbed, indicated by the dominance of grass over the riparian zone. Alien invasion also occupied a significant extent of the riparian zone. However, these disturbance densities were not consistent as natural vegetation recruitments were evident. Overall, the riparian zone was somewhat acceptable due to complete vegetation cover. However, structural intactness of natural vegetation over the zone was compromised by the invasion of *Acacia mearnsii.*, *Eucalyptus spp.* and weedy grass species. Indigenous vegetation *O. africana* (tree) and *Agathosma* (shrub) was underrepresented. Instream sedge vegetation was scattered across the channel, comprising of *Prionium spp.*, *Ischyrolepis spp.* and *Aponogeton spp.* (waterblommetjie).

The site was estimated as **Class D (9.0)**. This implies that natural habitat has been modified. A loss of natural habitat, biota and basic ecosystem functions has occurred.

D. WATER QUALITY

Table 97. *In situ* water quality data for the conductivity, dissolved oxygen, pH and temperature for the Bot and Swart River sites

Site Code	**Sampling Date**	**COND (mS/m)**	**DO (mg/l)**	**pH (pH unit)**	**TEMP (^{0}C)**
R	2005/05/12	0.548	-	6.17	15.3
R	2005/05/12	10.59	2.78	6.97	19.8
R	2004/10/15	8.4	-	5.96	17.3
R	2004/07/29	11.97	8.23	-	10.1

Table 98. Results of water chemistry analysis

Determinants	**Results**
	R
Free and saline ammonia (N mg/l)	<0.3
Nitrate and Nitrite (N mg/l)	<0.3
Total phosphate (P mg/l)	0.05
Ortho-phosphate (P mg/l)	<0.05

The results of the water chemistry analysis all displays acceptable concentrations of determinants.

E. SASS5 ASSESSMENT OF THE RATEL RIVER

Very low SASS5 and ASPT scores were obtained for the Ratel River during all sampling seasons. No sample possible in summer since the river was dry. The channel was overgrown with vegetation (grass) at the site and access to the channel was restricted downstream of the bridge due to dense vegetation growth. As a result the only habitat available to sample was vegetation, which resulted in the sampling of very few low scoring invertebrates, which explains the low SASS5 and ASPT scores.

Table 99. Summary of the SASS5 and ASPT scores for the Ratel River

Date	SASS5 score	No. of taxa	ASPT	Class	IHAS (%)	Biotopes sampled
Site R (Dirk Uys)						
29-Jul-04	32	8	4	D	52	m/aqVeg
15-Oct-04	25	6	4.17	D	35	aqVeg
Dry during summer						
12-May-05	21	5	4.2	D	50	aqVeg

F. FISH ASSESSMENT OF THE RATEL RIVER

No data available

SYNTHESIS

5.1 INDEX OF HABITAT INTEGRITY: OVERBERG RIVERS

Index of Habitat Integrity assessments were conducted on river systems in the Overberg region of the Western Cape during October 2005. The results indicated that the instream habitat integrity of the rivers was generally less modified than the riparian habitat integrity (Table 100). In most cases extensive agricultural activities resulted in the deterioration or destruction of the riparian zone. The loss of indigenous vegetation along many of the river courses has been replaced by severe alien vegetation encroachment. The instream habitat integrity was mostly affected by water abstraction and poor water quality, both of which are associated with agricultural activities in the area. The topography of the land allows agricultural activities to take place right up to the river courses and only in areas where steep sloped river banks occurred, did the riparian zone remain less modified.

Table 100. Summary of Index of Habitat Integrity results for the Overberg Rivers (Only modifications with large to critical impacts are listed).

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Upper foothill	B1	B	• Water abstraction	C	• Alien vegetation encroachment •Decrease in indigenous vegetation
Upper foothill	B2	D	• Bed modification • Water abstraction • Channel modification • Flow modification • Water quality	F	• Bank erosion • Decrease in indigenous vegetation • Alien vegetation encroachment • Water abstraction • Water quality • Channel modification
Lowland	B3	D	• Water abstraction • Water quality • Flow modification	F	• Alien vegetation encroachment • Decrease in indigenous vegetation • Channel modification • Water abstraction • Flow modification • Water quality
Lowland	SW	D	• Water abstraction • Water quality • Bed modification • Channel modification • Flow modification	F	• Channel modification • Decrease in indigenous vegetation • Bank erosion • Water abstraction • Flow modification • Water quality
Upper foothill	H1	A	-	A	-

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Upper foothill	O1	C	• Water quality • Water abstraction	E	• Exotic vegetation encroachment • Decrease in indigenous vegetation • Bank erosion
Upper foothill	O2	E	• Water abstraction • Flow modification • Bed modification • Channel modification • Inundation • Water quality	F	• Alien vegetation encroachment • Decrease in indigenous vegetation • Flow modifications • Inundation • Channel modification • Water abstraction • Water quality
Lower foothill	O3	D	• Water abstraction • Flow modification • Channel modification • Water quality	F	• Alien vegetation encroachment • Decrease in indigenous vegetation • Bank erosion • Channel modification • Water abstraction
Upper foothill	U1	A		C	• Alien vegetation encroachment
Upper foothill	U2	D	• Channel modification • Water abstraction • Water quality	F	• Decrease of indigenous vegetation • Serious alien encroachment • Channel modification • Water abstraction

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Lowland	U3	D	• Flow modification • Water quality • Water abstraction • Bed modification	E	• Flow modification • Alien vegetation encroachment • Decrease of indigenous vegetation • Water abstraction
Lower foothill	K1	C	• Channel modification • Water abstraction • Flow modification	F	• Alien vegetation encroachment • Decrease in indigenous vegetation • Bank erosion • Channel modification • Water abstraction
Lower foothill	K2	C	• Water abstraction • Water quality • Flow modification	E	• Water abstraction • Flow modification • Alien vegetation encroachment
Lower foothill	K3	D	• Water abstraction • Water quality • Flow modification	E	• Alien vegetation encroachment • Decrease in indigenous vegetation • Water abstraction • Flow modification
Lowland	S6	E	• Bed modification • Water quality • Water abstraction • Flow modification • Channel modification	F	• Bank erosion • Alien vegetation encroachment • Decrease in indigenous vegetation • Water abstraction • Flow modification • Channel modification • Water quality

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Lowland	S1	D	• Water quality • Water abstraction • Flow modification • Bed modification • Channel modification	F	• Bank erosion • Channel modification • Water abstraction • Water quality • Decrease in indigenous vegetation • Flow modification • Inundation
Lowland	S2	D	• Water abstraction • Flow modification • Bed modification • Water quality • Channel modification	E	• Bank erosion • Water abstraction • Channel modification • Water quality • Flow modification
Lowland	S4	E	• Water quality • Water abstraction • Bed modification • Flow modification • Solid waste	F	• Bank erosion • Channel modification • Water abstraction • Flow modification • Decrease in indigenous vegetation
Lowland	S3	D	• Water abstraction • Water quality • Flow modification • Bed modification	C	• Water abstraction • Flow modification
Lowland	S7	E	• Water quality • Water abstraction • Flow modification • Bed modification • Channel modification	F	• Bank erosion • Channel modification • Decrease in indigenous vegetation • Water abstraction • Flow modification • Alien vegetation encroachment • Water quality

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Lowland	S8	E	• Water quality • Water abstraction • Flow modification • Bed modification • Channel modification	E	• Water abstraction • Flow modification • Water quality • Channel modification
Lowland	S5	D	• Water abstraction • Water quality • Flow modification • Bed modification • Channel modification	E	• Channel modification • Decrease in indigenous vegetation • Water abstraction • Flow modification
Lowland	Ka1	D	• Water quality • Water abstraction • Bed modification • Flow modification	E	• Bank erosion • Alien vegetation encroachment • Water abstraction • Decrease in indigenous vegetation • Water quality • Flow modification
Lowland	Ka2	D	• Water abstraction • Water quality • Flow modification • Channel modification	F	• Water abstraction • Flow modification • Alien vegetation encroachment • Decrease in indigenous vegetation • Channel modification • Water quality
Lowland	Ka3	C	• Water abstraction • Water quality	C	• Alien vegetation encroachment • Decrease in indigenous vegetation
Lowland	N1	B	• Water abstraction	C	• Alien vegetation encroachment

Longitudinal zone	Site No	Instream IHI	Main modifications	Riparian IHI	Main modifications
Lowland	N2	C	• Water abstraction • Water quality	E	• Alien vegetation encroachment • Decrease in indigenous vegetation • Bank erosion • Channel modification
Lower foothill	KP	E	• Bed modification • Water quality • Water abstraction • Channel modification	F	• Bank erosion • Alien vegetation encroachment • Decrease in indigenous vegetation • Channel modification
Lower foothill	P	D	• Bed modification • Water quality • Flow modification • Channel modification	E	• Alien vegetation encroachment • Decrease in indigenous vegetation
Lowland	He1	B	• Water abstraction • Exotic fauna	C	• Decrease in indigenous vegetation • Channel modification
Lowland	R	No data available			

5.2 GEOMORPHOLOGICAL INDEX

The Overberg regions river geomorphology was comprised of two general valley forms namely: the Foothill floodplain characterised by moderately steep slopes with some unconfined incised channels (Overberg West) and Lowland floodplain characterised by lower gradient slopes and widened valley floors (Overberg East). However, long runs and plain-bed types were found in both instances where the rivers were in their lower courses in the vicinity of their respective estuaries. Cobble-bed or mixed bedrock-cobble bed channels, and pool-rapid or pool-riffle reach types were more frequent in the Overberg West. Mixed bed alluvial channel, sand and gravel, and long pool-runs dominating the beds of the Overberg East reach types. Low gradient alluvial fine bed channels and floodplains were often present over the whole study area, thus providing a reason for the high pressures that agricultural activities place on the plough able Overberg floodplains (Table 101).

Table 101. Summary of Geomorphological Index results for the Overberg Rivers (main channel impacts are listed).

River	**Site**	**Channel type**	**Channel impacts**	**Class**
Bot	B1	Mixed	• Alien vegetation - moderate • Sediment - few	C
	B2	Alluvial	• Bridge – in-channel supports • Local channel straightening • Few storage weirs • Alien vegetation - high • Sediment - extensive • Recent alien vegetation removal	E
	B3	Alluvial	• Infrequent causeways • Alien vegetation - high • Sediment - moderate	D
Swart	SW1	Alluvial	• Many storage weirs • Infrequent causeways • Alien vegetation - moderate • Sediment - extensive	C
Hermanus	H1	Alluvial	• Bridge – side supports • Sediment - few	B
Onrus	O1	Alluvial	• Infrequent causeways • Alien vegetation-high • Sediment - moderate	C

River	Site	Channel type	Channel impacts	Class
	O2	Alluvial	• Few storage weirs • Upstream dam-high • Infrequent causeways • Alien vegetation - high • Sediment - few	D
	O3	Alluvial	• Upstream dam-low • Bridge – in-channel supports • Alien vegetation - high • Recent alien vegetation removal • Sediment - few	D
Uilkraal	U1	Alluvial	• Sediment - few • Alien vegetation - moderate	B
	U2	Alluvial	• Infrequent causeways • Alien vegetation - high • Sediment-extensive	D
	U3	Alluvial	• Bridge – side supports • Alien vegetation - high • Sediment - moderate	D
Klein	K1	Mixed	• Bridge – side supports • Alien vegetation - high • Sediment - extensive	D
	K2	Alluvial	• Local channel straightening • Infrequent causeways • Alien vegetation - high • Sediment - extensive	D
	K3	Alluvial	• Few storage weirs • Infrequent causeways • Alien vegetation-high • Sediment-moderate	C
Sout	S1	Alluvial	• Gauging weir-low • Bridge – in-channel supports • Alien vegetation - moderate • Sediment - extensive	D
	S2	Alluvial	• Bridge – in-channel supports • Sediment-extensive • Low sediment extraction	D
	S3	Alluvial	• Bridge – in-channel • Sediment - extensive	C-D
	S4	Alluvial	• Infrequent causeways • Alien vegetation - moderate • Sediment - extensive	D
	S5	Mixed	• Bridge – side supports • Sediment-extensive	C
	S6	Alluvial	• Bridge – side supports • Sediment-extensive	E

River	Site	Channel type	Channel impacts	Class
	S7	Alluvial	• Bridge – in-channel supports • Alien vegetation-moderate • Sediment - high	C-D
	S8	Alluvial	• Few storage weirs • Bridge – in-channel supports • Alien vegetation-high • Sediment - moderate • Low sediment extraction	D
Kars	Ka1	Alluvial	• Few storage weirs • Infrequent causeways • Alien vegetation - high • Sediment - moderate	C
	Ka2	Alluvial	• Bridge – in-channel supports • Few storage weirs • Alien vegetation - high • Sediment - extensive • Recent alien vegetation removal	D
	Ka3	Mixed	• Alien vegetation - high • Sediment - moderate	C
Nuwejaars	N1	Alluvial	• Infrequent causeways • Alien vegetation-high • Sediment-moderate	C
	N2	Mixed	• Local channel straightening • Bridge – in-channel supports • Alien vegetation - high • Sediment - extensive	D
Klein Pietersielies kloof	KP	Alluvial	• Alien vegetation - high • Sediment – high (after flood)	D
Pietersielies Kloof	P	Alluvial	• Alien vegetation - high • Sediment – high (after flood)	C-D
Heuningnes	He1	Alluvial	• Bridge – in-channel supports • Alien vegetation - negligible • Sediment - moderate	C
Ratel	R	Alluvial	• Bridge – in-channel supports • Alien vegetation - high • Sediment - moderate extraction	D

5.3 RIPARIAN VEGETATION INDEX

Indigenous Vegetation

In general, the riparian vegetation evaluation for the Overberg region was classified as being relatively fair (C/D). This estimation was based on the fact that most riparian zones retained an adequate amount of indigenous vegetation amongst various disturbance stresses. The evidence of disturbances was indicated by the presence of alien invasive species, modest indigenous diversity, and the abundance of grassy sedge weeds – *Conondon dicotylon* – in particular (Table 102 and 103).

Further analysis for the Overberg regions riparian vegetation displayed a considerable difference in vegetation community structure in the western catchments (Uilkraal to Onrus river systems) – composed of mesic mountain fynbos and renosterveld – and the eastern catchment (Nuwejaars to Sout river systems) – composed of transitional succulent karoo vegetation (*A.* karoo) in the midst of mesic mountain fynbos. Additionally, the western catchment's instream vegetation was dominated by the "palmiet" species *Prionium serratum,* where the eastern catchment was dominated by the "common reed" species *Phragmites australis.* Furthermore, the eastern catchments' were dominated by scrub and grassy-sedge species, where the western catchments' were more tree or shrub dominated. Thus, an impacted zone on the Overberg-West region displays a shortage of tree and shrub species, which requires 3-5 years growth for rehabilitation. Alternatively, the Overberg-East region displays a shrubby-sedge/restio vegetation composition, where indication of impacts does not include absence of tree or tall-shrub species, but a proliferation of sedge, weeds and open spaces, amongst others (Table 102 and 103).

Invasive vegetation

Vegetation invasion was an active theme of the riparian zone for the Overberg. However, the extent, impact and implication of invasion by alien species are catchment specific. The rivers of the western catchments were more extensively impacted by alien invasion than the east. This resulted from a higher degree of human induced disturbance pressures indicated by the higher density of human settlements and forestry in the western region; where the eastern region is dominated by extensive stock and commercial farming practices.

Prevailing alien invasive vegetation included tree species *Populus spp., Acacia cyclops, A. longifolia, A. mearnsii, A. melanoxylon, A. saligna* and *Eucalyptus spp.*, with the invasion by the alien genus's *Eucalyptus spp., A. saligna* and *A. mearnsii* bearing the most management implications for the Overberg region. The most impacted rivers surveyed included: the Uilkraal, Klein, middle and lower Bot, and the lower Onrus River in the Overberg west; and the Klein Pietersielieskloof and Pietersielieskloof river tributaries flowing into the Nuwejaars River (Table 103).

Land-use

Land-use practices are the greatest factor to consider in relation to river health and management. It provides the gateway for rehabilitation possibilities, via conservation stewardship programs and has the potential to cause the highest long-term impact on river systems for this region. Impacts related to agricultural practice include farming encroachment, over abstraction, water quality modification and physical habitat modification. Evidence of these impacts includes unstable riparian zones with an under-representation of trees and shrub components. It is thus highly recommended that the riparian zone stability be rehabilitated in these instances by extending the natural buffer zone, replanting appropriate shrubs and trees, and/or reducing direct farming encroachment onto the zone.

Priority regions

Managing rivers for conservation purposes not only serve the purpose of conserving the natural heritage of unique environments, but more importantly maintains the health of water resources, and ensures a realised supply of goods and services including various attributes from them. Priority regions for conservation management, from a riparian vegetation zone aspect, include segments of the Hermanus, Sout, Kars, Nuwejaars, Bot and Uilkraal rivers. These rivers have the highest potential for conservation, and require the least amount of rehabilitation time and costs.

The Hermanus River can be considered as an example of a river as close to pristine as any fynbos river surveyed in this study and is actively managed in a natural protected area. The Sout, Kars and Nuwejaars river systems contain good diversity, vegetation class distribution and habitat across the riparian zone, particularly the in-stream vegetation of these areas, and require some rehabilitation practises to maintain active sustainable utilisation of its resources. The upper Bot and upper Uilkraal rivers have retained a moderate degree of indigenous riparian vegetation, and could be considered for rehabilitation practise as part of its management scope.

Table 102. Summary of the indigenous vegetation sampled for the Riparian Vegetation Index assessment.

	Sites	Uilkraal			Klein			Hermanus	Swart	Bot			Onrus			Soes	Sout			Hotnotskraal	Sout			Kars			Heuningnes	Nuwejaars		Piet	Ratel
Species name	**Growth form**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**3**	**4**	**1**	**6**	**7**	**8**	**1**	**2**	**3**	**1**	**1**	**3**	**1**	**1**
Acacia karoo	t															5	1	5	3	2			3				1				
Agapanthus africana	a	3	1																												
Agathosma spp.	s			30%	1	1	2%		1				2	2	1																20%
Aloe ferox	suc															2															
Asparagus sp.	s		1		2					1																	1%	5%	2%		
Atriplex lindleyi	s	2		1														4				1	3								
Berzilia lanuginose	s							1																							
Brunia allepeceriodes	s	4						1																							
Calopsis sp.	g	50%	2%				5%														10%						10%	15%		2%	5%
Carpobrotus aciniformes	suc					3%																						5%			
Campanulaceae	a							1%																							
Chrysanthemoides monilifera	s	1						1		1						1							2				2				
Cliffortia strobilifera	s							2																							
Common fern	p	10%						2					10%	5%														10%		2%	
Compositae	s	2%		2				2										2				2									
Conondon dicotylon	g	20%	30%	20%	50%	50%	5%		10%	5%	10%	30%	30%	20%	20%	10%	10%	10%	10%	15%	20%	15%	15%	10%	10%	15%	10%	5%	5%		40%
Cunonia capensis	t			1						1																					
Cussonia spp.	t																														
Cyperus spicata	g				5%	20%	15%	1%	25%	5%	5%	20%									10%			50%	30%	20%		5%	10%		5%
Ehrata ramose	g							1																							
Eletropappus rhinocerocus	s					2																						3	5		
Erica sessiliflora	s							2																							
Erica spp.	s							2																							
Ficinia oligantha	g																				10%	5%		5%				5%	5%		
Ficus spp.	t									1																					
Geraniaceae	s	2						1%							1																
Grassy sedge	g								10%				20%	20%	30%	10%	10%	30%	10%	15%		5%	10%		2%	5%	40%	20%	10%	10%	35%
Grewia sp.	t																														
Helichrysum crispum	p			2		3									1	2						2		2							
Ischerolepis capensis	g							15%																				5%	2%		10%
Juncus capensis	g	5%	5%										1%	10%			2				30%		1	2%				5%	5%		
Leonotis leonurus	s																														
Leucodendron xanthoconus	s							2																							
Lycium cinereum	s															2	3	2		2			3			2	1				
Meleanthus major	s				4	1	3																								
Metalasia muricata	s																														1
Metrosiderous angustifolia	s																					1									
Olea europa subs. Africana	t					1				2						1	2	1	1	1						2	1				
Phragmites australis	r		5%	70%		15%	2		90%	40%	25%	5%		10%	2%	70%	75%	50%	50%	65%		50%	70%		50%	40%	40%				
Podocarpus latifolius	t																														
Prionium serratum	g	10%	10%			20%	50%						5%	5%	2%													15%	40%	20%	
Protea spp.	s							1																							
Restio spp.	r					2%		2							1						1%							10%			
Rhus augustiflora	s									2						1		1		1			1			1	2		2		
Rhus dentate	s			3																								1			
Rhus lancea	t	2					1			1																	1				
Rhus undulate	s	2	1	1	1		1						1		1	1		1	1	1			1	1		1	2	1			
Sarcocornia xerophila	p															5%											2				
Salvia Africana	s																										2				
Salix mucronata	t											1																			
Typha capensis	g									15%		2%															1				
Virgilia Capensis	t	1																													
Wachendorfia thyrsiflora	h												2%															1	1		
Zantedeschia aethiopica	h	3		2	2					1		1	1	2															1		

#The growth forms listed are either (t) tree, (s) shrub, (suc) succulent, (p) perennial, (a) annual, (r) reed, or (g) for sedge and grass
*Density values were ranked according to the following classes: 0=absent; 1=<9; 2=<20; 3=<30; 4=<50; 5=>50 and 6=>100
' Percentage= the degree of surface cover (non-quantifiable individuals)

[redacted]		Sites	Uilkraal			Klein			Hermanus	Swart	Bot			Onrus			Sout								Kars			Heuningnes	Nuwejaars		Piet	Kleinpiet	Ratel
Species name	**Growth form**	**Weed Status**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**1**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	**3**	**1**	**1**	**3**	**1**	**1**	**1**
Acacia cyclops	t	2	1		1												1		1				1	1			2	1					
Acacia longifolia	t	1																							2						6	6	
Acacia mearnsii	t	1		2		6	2					3	3	4	3	4																	
Acacia melanoxylon	t	2		4																													
Acacia saligna	t	2		1						2		2							2				2	2	2	4	3		4	4	6	6	
Arundo donax	r	1									5%	15%																					
Cortaderia selloana	g	1										5%							2%														5%
Eucalyptus spp.	t	2	5	6		4	6	6		1			2	5	1	5			1				1		3			1			5	4	6
Leptospermum laevigatum	s	1																													4	5	
Nasturtium officinale	h	2				1																											
Nerium oleander	s	1		1																													
Optunia spp.	suc - s	1									1			1									1										
Paraserianthes lopantha	t	1					1																										
Pennisetum setaceum	p	1																									1%						
Pinus spp.	t	2													1																		
Populus spp.	t	1		2	4	2						1	4																				
Rubus spp.	s	1			2%																												
Salix babylonica	t	2									1																						
Sesbania punicea	t	1																															
Solanum spp	s	1	1																											1			
Stenotaphrum secundatum	g	3						2%						20%																			

The growth forms are either (t) tree, (s) shrub, (suc) succulent, (p) perennial, (r) reed, or (g) for sedges and grass.
* Weed status as declared = 1 (high threat), 2 (moderate threat) and 3 (low threat).
' Density values were ranked using the following classes: 0=absent; 1=<9; 2=<20; 3=<30; 4=<50; 5=>50 and 6=>100
" Percentage=percentage cover of surface

5.4 WATER QUALITY

Nutrients are naturally supplied to river systems and are relatively constant depending on the particular catchment. These include climatic factors, catchment characteristics (surface geology) and anthropogenic sources of which agricultural and urban activities are considered to be the major sources of phosphorus (as phosphate ions) and nitrogen (as nitrite and nitrate) to aquatic ecosystems. These nutrients also contribute to eutrophication (Dallas & Day, 2004). Water quality samples were collected during the study and analysed for nitrite, nitrate, ammonia, total phosphorus and ortho-phosphate.

Most of the Overberg Rivers flow through rural/agricultural areas with very few being affected by urban activities. Sites that did not comply with the total phosphorus guidelines, according to DWAF, were the sites on the Nuwejaars, Swart, Klein and both the upper and middle sites on the Onrus Rivers, as well as all the sites on the Sout River. These were also the sites where extensive agricultural activities occurred (wheat and vineyards) and eutrophication was often observed at these sites.

Waters that receive sewage or where leaching or runoff from cultivated land occurs, normally have increased concentrations of phosphorus. Sediments also act as a sink for phosphorus, especially during low flows and are released into the water when flows increase (Dallas and Day, 2004). Samples were taken during summer low flows and the habitats were slow flowing pools at all sites. Alien trees formed the riparian zone at the Klein and Nuwejaars sites often resulting in high concentrations of instream leaf litter and aquatic reeds dominated at all the Sout River sites.

All other nutrients considered in analysis were within the acceptable guidelines (Table 104). It should be noted that the results shown below are from a once-off sampling event and therefore is not necessarily a true reflection of the water quality. A longer time series of samples would improve the analysis and interpretation.

Table 104. Summary table of the results (all sites) of the water quality analysis according to the DWAF compliance guidelines and standards. A – Pristine, B – Good, C – Fair, D – Poor, E – Very Poor.

RHP Site codes	**Category**			
	Free/saline ammonia (N mg/l)	**Nitrate/Nitrite (N mg/l)**	**Total phosphate (P mg/l)**	**Ortho-phosphate (P mg/l)**
B1	A	B	B	B
B2	A	B	B	B
B3	A	B	B	B
H1	A	B	B	B
SW1	A	B	B	B
O1	A	B	E	B
O2	A	B	E	B
O3	A	B	B	B
U1	A	B	B	B
U2	A	B	B	B
U3	A	B	B	B
K1	A	B	E	B
K2	A	B	E	B
K3	A	B	E	B
S1	A	B	C	B
S2	A	B	D	B
S3	A	B	C	B
S4	A	B	D	B
S5	A	B	C	B
S6	A	D	C	B
S7	A	B	D	B
S8	A	B	E	B
Ka1	A	B	B	B
Ka2	A	B	D	B
Ka3	A	B	D	B
N1	A	B	D	B
N2	A	B	D	B
KP	A	B	B	B
P	A	B	B	B
He1	A	B	C	B
R	A	B	C	B

5.5 SASS5

Using PRIMER 5, multivariate analysis for similarity was carried out for the SASS5 sampling results at all sites considered. The application of a multivariate approach considers each taxonomic group/family to be a variable and the presence/absence or abundance of each group/family to be an attribute of a site or time. Thus, subtle changes in the composition of taxa or in the abundance between sites were not inherently masked by the need to summarize the combined characteristics of a site into a single value, but to detect spatial and temporal trends in these biotic assemblages (Dallas, 2002). The data presented in the results display combined biotopes. Table 105 summarises the characterizing taxa within all groups formed during spring, summer, autumn and winter. The sites were coded as follows:

B1-B3	Bot River sites	N1-N2	Nuwejaars River sites
SW1	Swart River	O1-O3	Onrus River sites
H1	Heuningnes River	P	Pietersielieskloof River
H	Hermanus River	KP	Klein Pietersielieskloof River
Ka1-Ka3	Kars River sites	U1-U3	Uilkraal River sites
K1-K3	Klein River sites	S1-S8	Sout River sites
R	Ratel River		

A. SPRING

Three main groups were formed. Group 3 sub-divided into 3a and 3b (Figure 20). Within-group similarity of macroinvertebrate assemblages at sites in Group 1, 2 and 3 was 29%, 38% and 30% respectively. The average similarity increased to between 46% and 51% at the sub-group level. Group 3b included all sites on the Overberg West (OW) (Bot, Uilkraal, lower-Klein, Onrus, Hermanus) with the distinguishing taxa being, Chironomidae, Simulidae, Corixidae and Caenidae. Group 3a included the Sout, Kars and Nuwejaars as well as the Swart and Upper Klein sites with the distinguishing taxa being Corixidae, Dytiscidae and Chironomidae. Group 2 had a similarity of 38% and included the Heuningnes, upper Uilkraal, middle Klein and upper Nuwejaars tributary with Chironomidae and Amphipoda dominating the group. The distinguishing taxa in Group 1 for middle Uilkraal and Ratel rivers were Baetidae (2 sp).

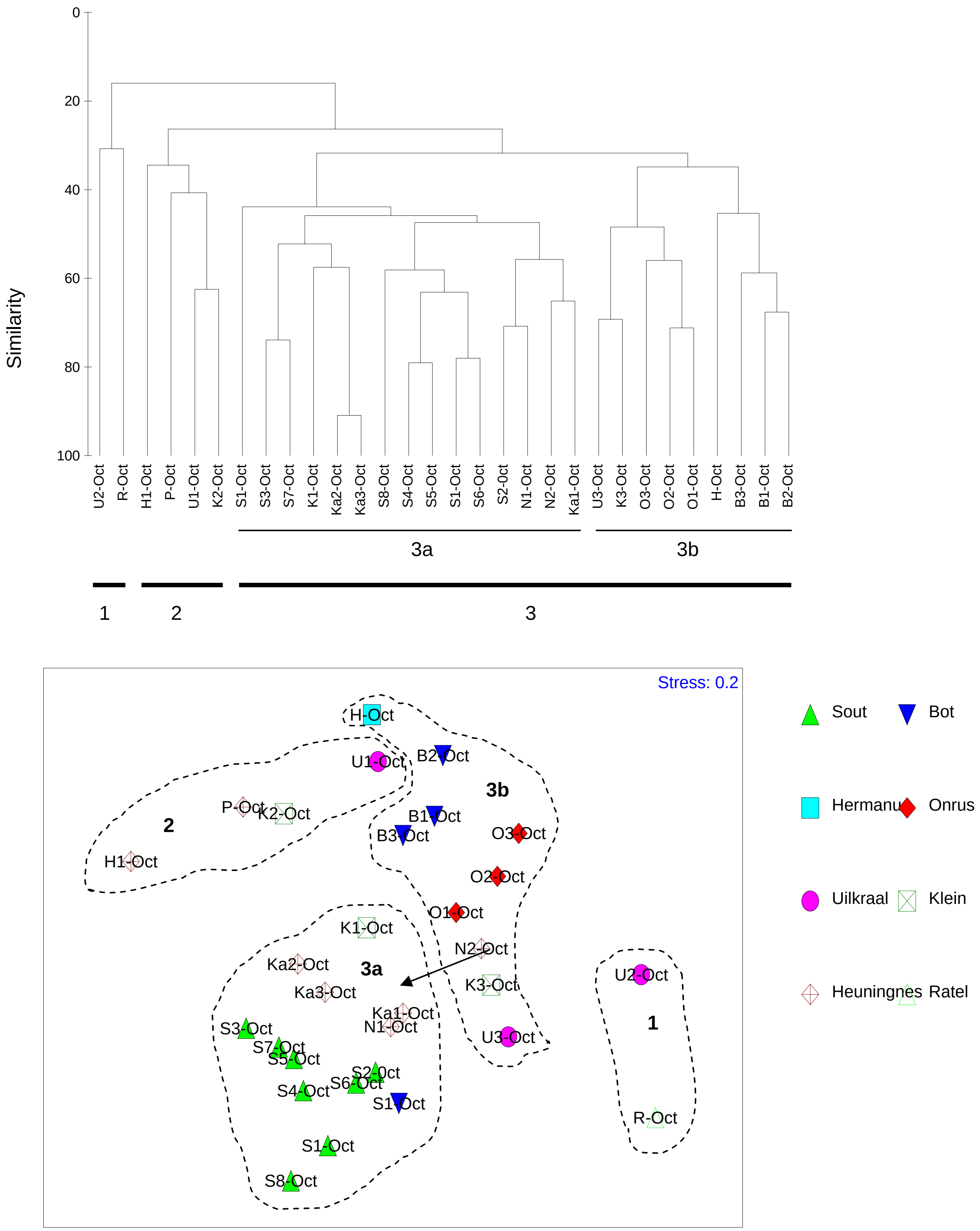


Figure 20. Dendrogram and MDS ordination showing the classification of Overberg sites based on taxa recorded in spring (October)

B. SUMMER

The sites clustered into 2 main groups. Group 2 further sub-divided into group's 2a and 2b (Figure 21). The upper site on the Uilkraal and the site on the Heuningnes River formed Group 1 on the ordination plot (stress value: 0.16) and dendrogram. The similarity of macroinvertebrate assemblages for Group 1 was 54%. Both sites had amphipods present but those of the Uilkraal River were characteristic of a mountain stream and those of the Heuningnes characteristic of estuarine environments. Other characterizing taxa included Potamonautidae and Chironomidae. Sites in Group 2 were 37% similar and at the sub-group level the average similarity increased to between 45% and 47%. Group 2a included all the sites on the (OW)(Bot, Uilkraal, Klein, Onrus, Hermanus Rivers) as well as the site on the upper Nuwejaars tributary (KP). The Hermanus site (H) and the Klein Pietersielieskloof (KP) site further sub-divided to form a group within Group 2a probably due to the presence of Notonemouridae. The taxa characterizing Group 2a were Chironomidae, Corixidae, Veliidae, Caenidae and Libellulidae. Group 2b included the sites on the Sout, Kars and the upper site on the Nuwejaars Rivers. The species distinguishing the group were Corixidae and Hydrophilidae.

C. AUTUMN

This sampling period occurred after a major flood event during April 2005. The middle Uilkraal site (U2) and the upper Nuwejaars tributary (P) formed outliers in the ordination plot (stress value: 0.19) and dendrogram (Figure 22). Within-group similarity of macroinvertebrate assemblages at sites in Group 1 and 2 was 38% and 32% respectively. Group 1 sub-divided into 1a, 1b and 1c and the average similarity increased to between 50% and 56%. Taxa characterizing Group1 were Chironomidae and Corixidae but the taxa distinguishing the sub-groups could be related to the habitats, which occurred at the sites. For example, Baetidae (2sp) and Simulidae dominating in Group 1b, which included all the sites at which a stony habitat occurred. Taxa characterizing Group 2 included Simulidae and Chironomidae. The average dissimilarity between Groups 1 and 2 was 69%. The Klein Pietersielieskloof (KP) site exhibited a completely different habitat after flooding and was therefore excluded from the sampling season.

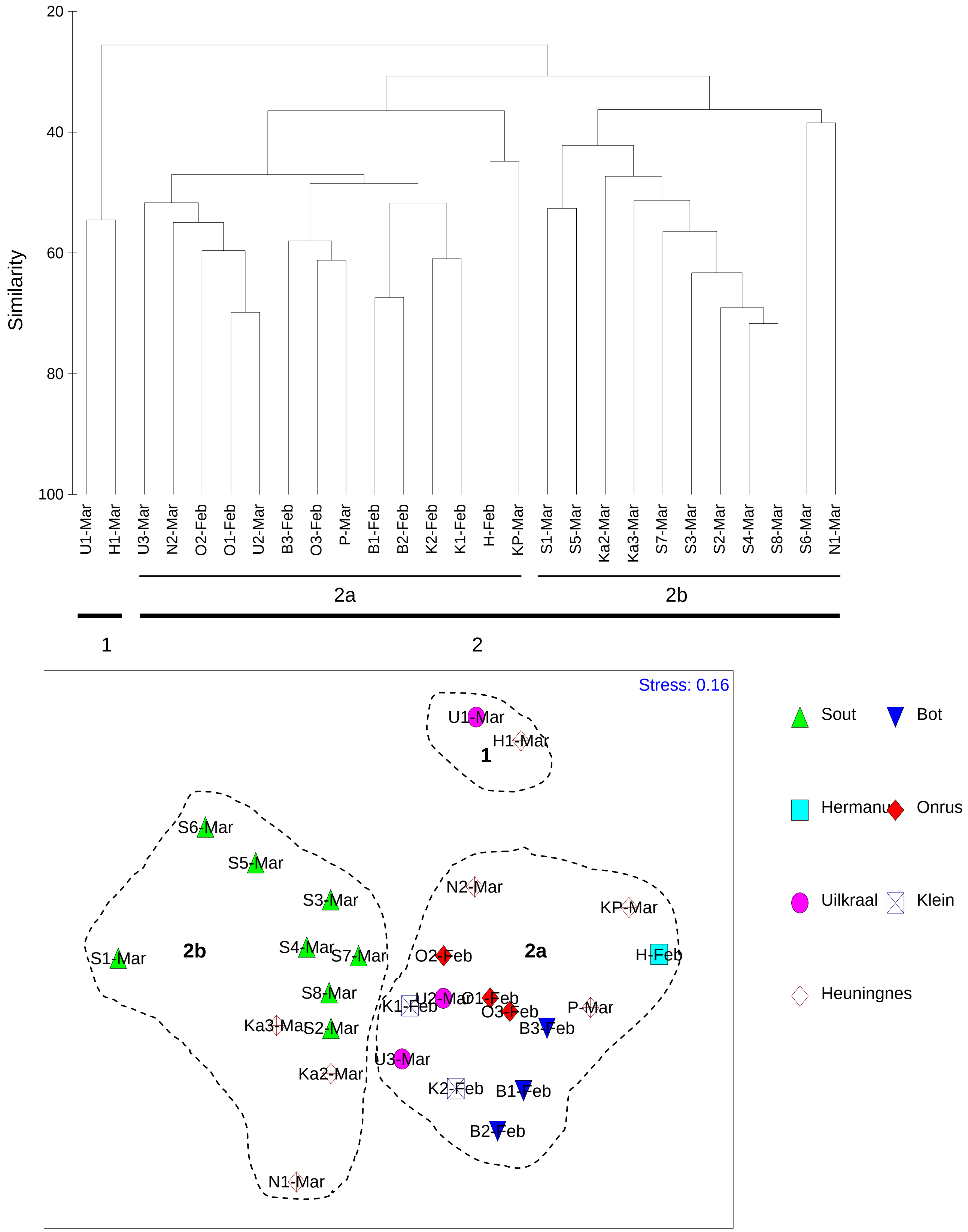


Figure 21. Dendrogram and MDS ordination showing the classification of Overberg sites based on taxa recorded in summer

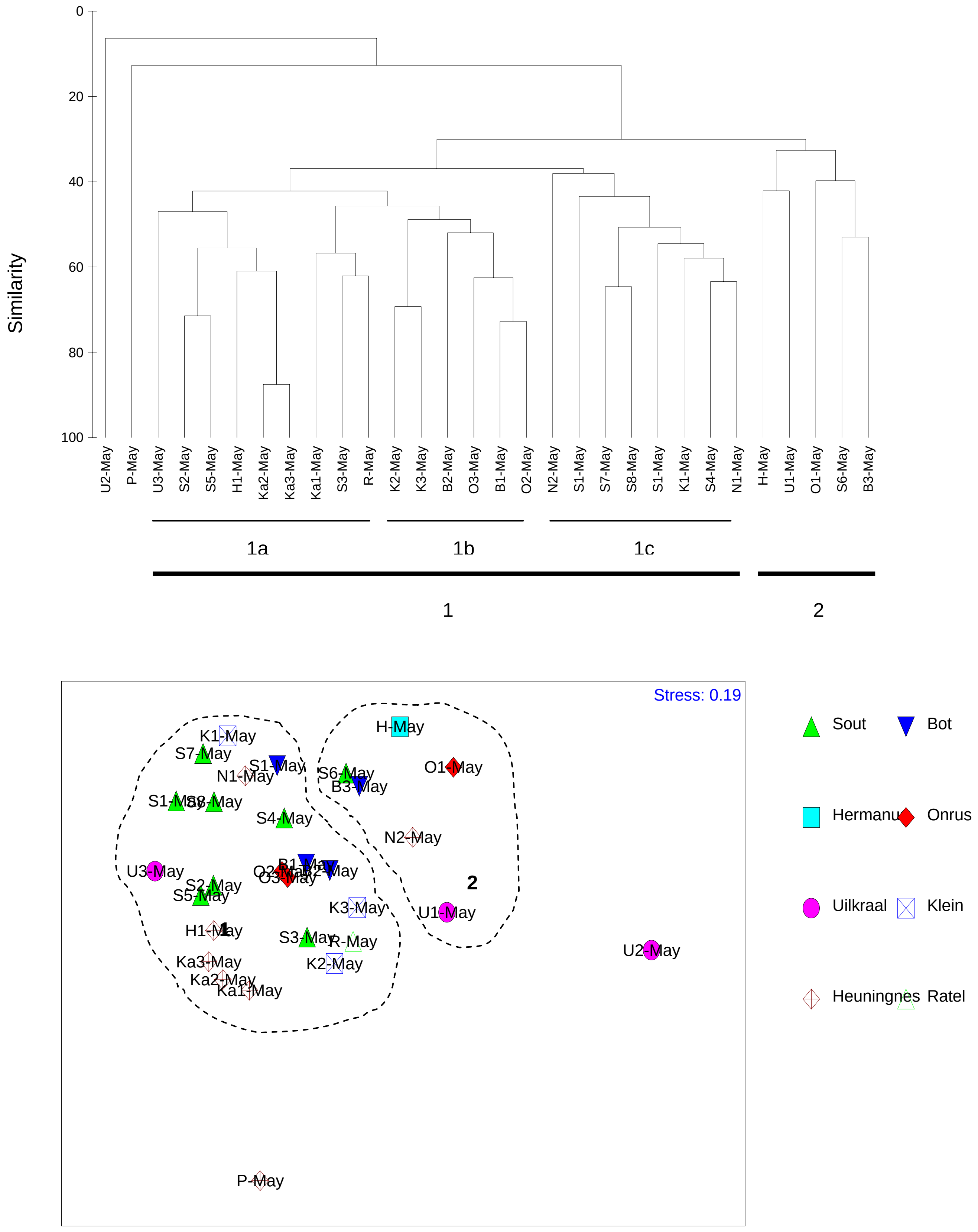
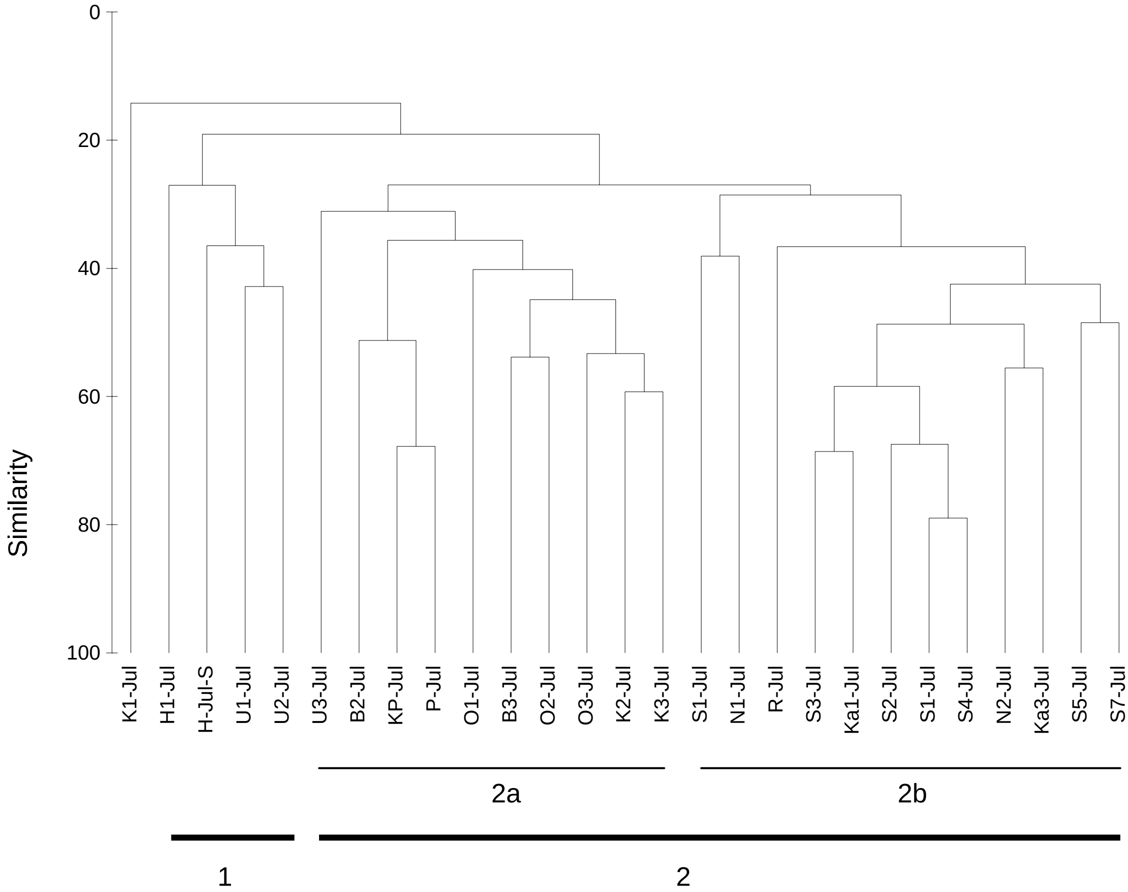


Figure 22. Dendrogram and MDS ordination showing the classification of Overberg sites based on taxa recorded in autumn

D. WINTER

The same grouping formed with the Sout, Kars and Nuwejaars systems as well as the Swart River (Bot tributary)(Group 2b), which was dry during the summer sampling (Figure 23). Site K1 (upper Klein River) was an outlier in both the dendrogram and ordination plot (stress value: 0.21). During the sampling season 2 major groupings were again formed with Group 2 forming sub-groups 2a and 2b. Group 1 included the Hermanus River and site 2 on the Uilkraal River as well as the Heuningnes and upper Uilkraal site but in the ordination plot (stress value: 0.22) these 2 sites grouped separately. The lower site on the Uilkraal River (U3) clustered with Group 2 sites in the dendrogram but grouped with Group 1 sites in the ordination plot. Group 1 sites were 28% similar and the distinguishing taxa were Amphipoda. Group 2 had a similarity of 26% and the sub-groups increased the average similarity to between 40% and 41%. Group 2a consisted mostly of sites on the OW and the distinguishing taxa were Simulidae, Caenidae, Leptoceridae and Chironomidae. Group 2a further sub-divided and grouped together the lower sites on the Bot (B2) and Uilkraal (U3) Rivers and the 2 sites on the upper Nuwejaars River (KP, P). A gravel bed dominated these sites. The other sub-group within 2a was dominated by a stony substrate (O1, O2, O3; K2; K3). The distinguishing taxa in Group 2b were Corixidae, Chironomidae and Culicidae.



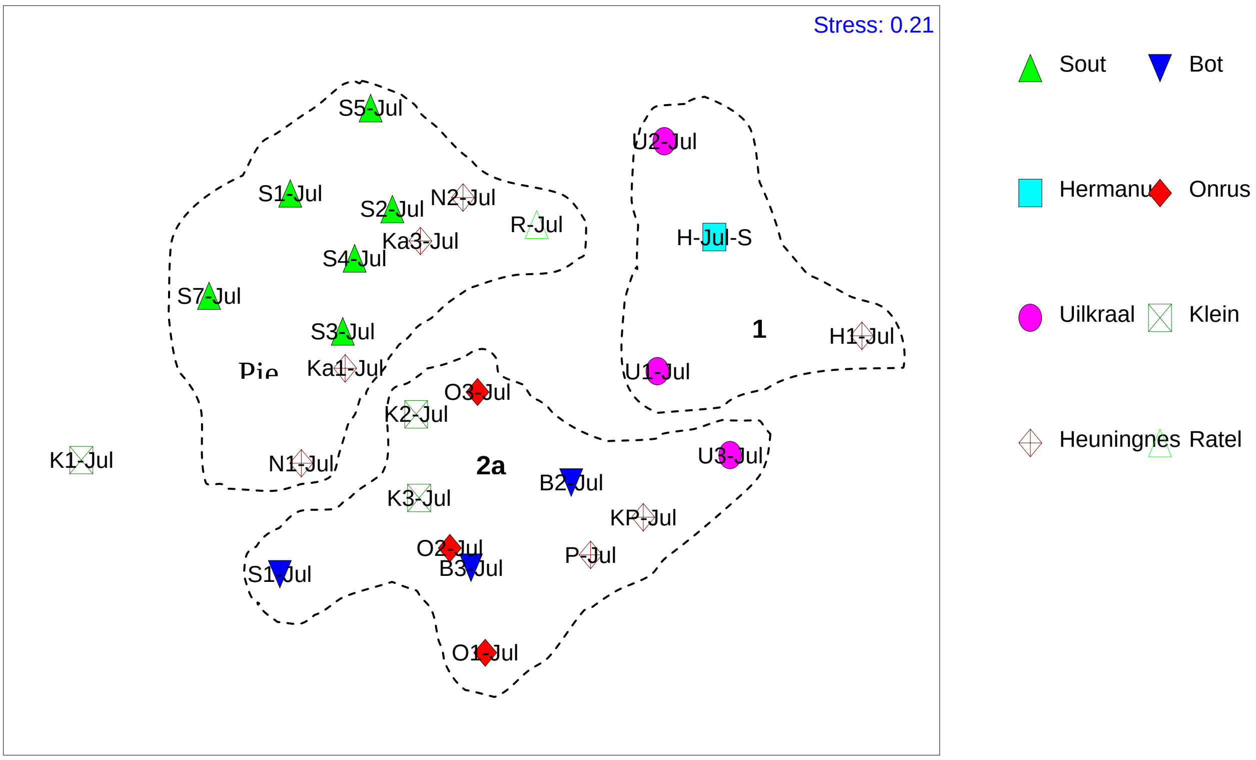


Figure 23. Dendrogram and MDS ordination showing the classification of Overberg sites based on taxa recorded in winter

Table 105. Taxa contributing the within-group similarity of groups identified in the seasonal analysis of the Overberg River systems. Those taxa contributing to the first 50% of the similarity are indicated by ▲; the remaining taxa contributing to the next 40% (i.e. 90% in total) of the similarity are indicated by □.

	Spring					**Summer**				**Autumn**					**Winter**			
Group	**1**	**2**	**3**	**3a**	**3b**	**1**	**2**	**2a**	**2b**	**1**	**2**	**1a**	**1b**	**1c**	**1**	**2**	**2a**	**2b**
Average similarity (%)	30.7	36.3	41.2	51.7	46.2	54.5	38.2	47.01	45.4	43.2	36.26	56.6	50.3	51.1	32.8	33.6	39.6	41.7
No. of distinguishing taxa	1	6	14	9	15	5	17	18	6	9	7	4	8	11	5	15	17	9
Corixidae			▲		▲		▲	▲		▲		▲	□	▲		▲	□	▲
Chironomidae		▲	▲		▲	▲	▲	▲	□	▲	□	□	□	▲	□	▲	▲	▲
Caenidae		□	□		▲		□	▲		□			□	□		□	▲	
Culicidae			□	□	□		□	□								▲		▲
Pleidae														□				
Dytiscidae			▲				□	□	□	□				□		▲	□	□
Baetidae (1sp)				□	□		□		□		□			□				
Baetidae (2sp)	▲		□		□		□	□		□		▲	▲		□	□	□	□
Baetidae (>2sp)																	□	
Hydracarina			□	□	□		□	□						□		□		□
Hydrophilidae			□	□			▲							□		□		□
Thiriadae			□	□			□		□							□		□
Veliidae / Mesoveliidae					□	□	□	▲			□			□		□		
Coenagrionidae		□	□	□	□	□	▲	□	□	□	□	□	□	▲		□	□	□
Libellulidae			□		□		□	▲		□				□				
Potamonautidae		□			□	▲	□	□										
Turbellaria					□													
Gyrinidae					□			□									□	
Amphipoda		□				□									▲		□	
Simulidae			□		▲		□	□		□	▲		▲			□	▲	
Oligochaeta		□	□							□	□		□			□	□	
Ceraptogonidae			□														□	
Ancylidae								□										
Hydropsychidae (1sp)								□					□					
Hydropsychidae (2sp)																	□	
Gomphidae								□			□					□	□	
Elmidae/Dryopidae																		
Leptoceridae					□			□							□	□	▲	
Notonectidae							□		□						□			
Aeshnidae							□	□									□	
Naucoridae																	□	

DISCUSSION OF SASS5 SYNTHESIS

Catchment scale variables, especially geology played a role in distinguishing sites from one another. This is seen by the clear distinction between rivers of the Overberg West (OW) and Overberg East (OE), where the geological characteristics of the catchment and at the sites influenced the macroinvertebrate assemblages. The geology not only influenced the intrinsic water chemistry (e.g. pH) but also the longitudinal zonation in which the sites occurred (e.g. the entire Sout River - lowland zone). This also influences other variables such as geomorphology, temperature and discharge.

The same sites grouped together throughout the seasonal sampling with the same invertebrates driving the groupings. Autumn was the only season where a notable change was observed in the groupings, which formed due to major habitat disturbance as a result of flooding. Sites on the Sout, Kars and the lower Nuwejaars Rivers always grouped together (OE). These sites occurred within the lowland river zone and the Gravel Sand Mud (GSM) and marginal vegetation biotopes dominated most sites. It would appear that when sites in the OW grouped with the OE sites it was due to similar habitat occurrences and therefore the same invertebrates were present. This was observed when the Swart River (OW), which only had GSM and marginal vegetation habitats present grouped with the lowland sites of the OE (in spring and winter, dry in summer).

The upper reaches of the rivers on the OW were dominated by Table Mountain Sandstone and therefore the mountain stream zones, upper and lower foothills and lowland zones were apparent in most river systems and sites were present in most zones if they were easily accessible. As a result the biotopes included Stones in and out of current (SIC/SOOC), marginal/aquatic vegetation and GSM (when available). The upper Nuwejaars tributaries (Klein Pietersielieskloof and Pietersielieskloof, OE) often grouped with the OW sites due to their stony/gravel habitat resulting in similar invertebrates present during sampling.

The floods definitely influenced the macroinvertebrate assemblages causing river systems to form groups that were always separated during the other seasons. This was observed when all the sites located on the Bot, Onrus, Uilkraal, Klein and Heuningnes Rivers, grouped with the lowland Sout and Kars River sites. The 3 sub groups, which formed within Group 2, were more characteristic groupings, which occurred during previous sampling seasons. After the flooding fewer invertebrates were found at most sites and changes to the biotope availability also influenced the samples. This was observed for the lower Bot, Pietersielieskloof, Klein Pietersielieskloof and Klein River sites.

The seasonal sampling showed very little variation in the type of invertebrates present at the various sites. The same invertebrates occurred at the same sites during all seasons. The results did however show that when a site exhibited the same or similar sampling habitats that the same invertebrate assemblages were always present. The general trend seen is that SASS5 and ASPT scores are low with the exception of the two upper sites on the OW (Hermanus and Uilkraal Rivers). Reasons for this are that most rivers in the Overberg have very limited habitats, primarily a lack of stones. Water quality impairment also played a role in certain streams and fewer invertebrates were expected in others that are naturally saline (e.g. Sout River).

5.6 FISH ASSEMBLAGE INTEGRITY INDEX

Indigenous freshwater fish found in the Overberg Rivers include the *G. zebratus* (Cape galaxias), *S. capensis* (Cape kurpers) and the unique *P. burchelli* (Heuningnes Redfin minnow). Estuarine fish were found at the lower reaches of the Overberg Rivers (in particular the Heuningnes River), where instream dams or low water bridges did not prevent the migration of estuarine fish and included *Gilchristella aestuaria* (estuarine round herring), *Awaous aeneofuscus* (freshwater goby), *Monodactylus falciformis* (Cape moonie) and *Solea Bleekeri* (sole).

The major impact on indigenous fish is introduced alien fish species - Smallmouth and Spotted bass, Bluegill sunfish, Rainbow trout, Mosquito fish, Tilapia and Carp - because these species directly compete and in most instances outcompete indigenous fish species for space. Consequences of alien fish presence include amongst others, indigenous fish predation, indigenous fish stock shortage and poor water quality. Table 106 and Appendix E show a summary list of all fish species caught in the Overberg region.

Table 106. Summary of fish species caught using the FAII/Fuzzy Fish Index and scores obtained at all sites in the Overberg Region

Site	Species expected	Species caught	Score	Reason for score
G4BOT-DORIN	*S. capensis* *G. zebratus*	*M. dolomieu* (1 at 15cm)	10/35 = 28% **E**	No indigenous fish, bass present
G4BOT-KANAA	*S. capensis* *G. zebratus*	None	18/35 = 22% **E**	No indigenous fish, bass likely present
G4BOT-WILDE	*S. capensis* *G. zebratus*	*M. dolomieu* (3 between 5-25cm)	9/35 = 26% **E**	No indigenous fish, bass
G4SWAR-CONFL	*S. capensis* *G. zebratus*	*M. capensis* (15-20 at 6-8cm) *L. macrochirus* (10-15 at 4-8cm)	21/35 = 60% **C**	No *Galaxias*, mullet present, bluegill sunfish
G4HERM-SAFCO	No assessment completed			
G4ONRU-HAYGR	*G. zebratus*	None	13/30 = 43% **D**	No fish caught –trout or under-sampling
G4ONRU-VOLMO	*G. zebratus*	*G. zebratus* in river below dam (3 at 3cm) *M. salmoides* (3 at 6 cm)	26/35 = 74% **C**	*Galaxias* common in river, Bass in instream dam
G4ONRU-BRIDG	*S. capensis* *G. zebratus*	*S. capensis* (10-15 all sizes) *G. zebratus* (5 at 4-6cm)	32/35 = 91% **A**	Both expected species present in good numbers, good habitat
G4UILK-SALMO	*G. zebratus*	*G. zebratus* (5 at 3-4cm)	29/30 = 97% **A**	Very close to natural
G4UILK-PAARD	*S. capensis* *G. zebratus*	*S. capensis* (40-50 all sizes) *G. zebratus* (10 at 2-6cm)	28/30 = 93% **A**	Excellent numbers of both expected species, good fish habitat
G4UILK-BAARD	*S. capensis* *G. zebratus*	*G. zebratus* (100+ all sizes) *M. capensis* (8 at 5-7 cm) *L. macrochirus* (3 at 6-7cm)	23/35 = 66% **C**	Good numbers *Galaxias* and mullet present, good habitat but also alien fishes
G4KLEI-GOUDI	*S. capensis* *G. zebratus*	*S. capensis* (5 at 3-5cm) M. punctalatus (2 at 5cm)	12/35 = 34% **E**	No *Galaxias*, low numbers of Cape kurper bass present

Site	Species expected	Species caught	Score	Reason for score
G4KLEI-WABOO	*S. capensis* *G. zebratus*	*L macrochirus* *M. salmoides* G. affinis	9/35 = 26% **E**	No indigenous fish, bass, bluegills present
G4KLEI-BLUEG	*S. capensis* *G. zebratus*	*M. capensis* (1 at 5cm) *L macrochirus* (6 at 5-6cm) *M. salmoides* (3 at 5-6cm)	15/35 = 43% **D**	No indigenous freshwater fish, mullet, bass present
G5SOUT-DWAFW	*S. capensis* *G. zebratus*	None	9/35 = 26% **E**	No indigenous fish, bass?
G5SOE-SOESR	*S. capensis*	*O. mossambicus* (40-50 at 4cm)	11/30 = 37% **E**	No indigenous fish, large numbers of tilapia
G5SOUT-BRAKF	*S. capensis*	*S. capensis* (10 at 3-5cm) *O. mossambicus* (1 at 3cm)	25/30 = 83% **B**	Expected species present, excellent habitat, low numbers Mozambique tilapia
G5SOUT-KYKOE	No assessment completed as the site was not suitable (human impact)			
G5HOTN-CONF	*S. capensis*	None	2/15 = 13% **F**	No fish, pollution
G5SOUT-SOUTK	*G. zebratus*	None	1/25 = 4% **F**	Very poor and polluted habitat, no fish
G5SOUT-KLIPD	*S. capensis* *G. zebratus*	None	3/25 = 12% **F**	No indigenous fish, acceptable habitat
G5SOUT-WYDGE	*S. capensis*	*O. mossambicus* (6 at 3-4cm)	10/30 = 33% **E**	No indigenous fish, tilapia, excess plant growth
G5KARS-KARSR	*S. capensis* *G. zebratus*	*S. capensis* 7 (3-4 cm) *G. zebratus* (15-20 all sizes) *P. "burchelli"* (in excess of 100, mainly juvs.)	29/30 = 97% **A**	Near pristine community
G5KARS-ROOID	*S. capensis* *G. zebratus* *P. "burchelli"*, based on previous site	*S. capensis* (7-10 at 5-10cm) *L. macrochirus* (7-10 at 4-5cm) *M. punctalatus* (1 at 5cm)	14/35 = 40% **D**	Alien fish dominate fauna, few Cape kurper present

Site	Species expected	Species caught	Score	Reason for score
G5NUWE-KERSG	*S. capensis* *G. zebratus* *P. "burchelli"*, possibly present	*S. capensis* (3 at 4-5cm) *G. zebratus* non-spotted (40-50 all sizes) *G. zebratus* spotted (6-8 all sizes) *L. macrochirus* (7-10 at 4-5cm)	25/35 = 71% **C**	Excellent habitat, Cape kurper and Cape galaxias present, bluegill also present
G5NUWE-BRAKP	*S. capensis* *G. zebratus* *P. "burchelli"*, possibly present	*G. zebratus* (10-12 at 2-3cm) *L. macrochirus* (10 at 4-5cm)	20/35 = 57% **D**	Only Cape galaxias, bluegill abundant
G5KLEI-BOSKL	*S. capensis* *G. zebratus*	*G. zebratus* spotted (2 at 3cm) *G. zebratus* non spotted (3 at 3cm)	17/30 = 56% **D**	Low numbers *Galaxias*, degraded habitat
G5PIET-BOSKL	*S. capensis* *G. zebratus*	*G. zebratus* (10-15 at 3-4cm)	18/30 = 60% C	Bass present
G5HEUN-RIVER	*S. capensis* *G. zebratus* Various estuarine species, depending on time of year	*S. capensis* (6 at 5-6cm) *Gilchristella aestuaria* (40-60 all sizes) *Monodactylus falciformus* (10-15 all sizes) *Awaous aeneofuscus* *Solea Bleekeri* *C. carpio*	31/35 = 88% **B**	Abundant indigenous fishes, carp present
G5RATE-DIRKU	No assessment completed			

6. CONCLUSIONS AND RECOMMENDATIONS

The Overberg Region is to a large extent rural, therefore rivers are mostly impacted by agricultural activities. The Overberg West region is dominated by irrigated agriculture and a large number of smaller off-stream farm and larger instream dams occur. Alien vegetation has altered riparian zones at almost all sites surveyed except for those areas protected by nature reserves. Alien fish occurred at all sites and have impacted on indigenous populations to a large extent, particularly in the lower reaches because of their absence in some upper reaches due to natural barriers. Indigenous fish were present, however, where the larger alien species were absent or lower density.

A large percentage of landuse on the Overberg East is natural and the rivers feed into numerous wetlands and vleis on the Agulhas Plain. The upper reaches of the Nuwejaars and Kars Rivers have been identified as priority rivers for conservation initiatives due to their relatively unimpacted nature and high numbers of indigenous fish species, although some alien fish were present. Alien vegetation was found to be the largest threat to these river systems. However, only a limited intervention would be required to reach a desired natural state. The only habitat alteration occurring in these rivers were natural due to a flood, which occurred during the sampling season.

The Sout River flows through agricultural land along its entire length but certain reaches remained largely intact due to some protection provided by fences against the impacts of cultivation and/or grazing animals. Consequently, this created a natural buffer zone, which is essential to ecological river functioning. Certain sites along the Sout River were, however, bulldozed or the riverbeds were excavated. Rivers draining the Agulhas Plain have recently received increased conservation initiatives with the establishment of the Agulhas Biodiversity Initiative (ABI), which aims to conserve the largest habitat of lowland Fynbos and Renosterveld in the Cape Floristic hotspot.

Agricultural activities have also influenced the water quality of the Overberg Rivers. Natural water quality occurred where upper reaches were protected in nature reserves (e.g. Uilkraal River) and sensitive invertebrates typical of a mountain and upper foothill stream were still found. Water quality analysis indicated that good water quality occurred at most sites sampled. However, SASS5 and ASPT scores did not always reflect this due to influences such as habitat disturbances resulting from livestock trampling, bulldozing and flood scour. The scores for the eastern Overberg were naturally low due to the geology of the area resulting in lowland rivers and low invertebrate diversity. However, natural water quality did occur at certain sites, despite poor habitat, which was indicated by the sensitive invertebrates found (e.g. Heuningnes River).

Primer 5 analyses were used to distinguish between the macroinvertebrate assemblages that occurred for the four seasons. No temporal changes were evident as the same families occurred throughout all the seasons. What was evident is that habitat played a significant role in the groupings of invertebrates. Differences between the dominant families in the Overberg West and Overberg East rivers were seen due to the habitat type present at a particular site. Where similar habitats occurred the same invertebrates dominated irrespective of whether sites occurred on the east or west Overberg.

Recommendations for river management of the Overberg Region

- Remove alien vegetation from the riparian zone and wetland areas, ensuring they remain cleared by follow-up clearing.
- Re-establish the natural riparian zone with indigenous vegetation and create or extend (where possible) existing buffer zones between agricultural lands and the river.
- Eradicate alien fish species from selected reaches that could be maintained alien free so as not to run the risk of re-infestation.
- Discourage the breeding or keeping of alien fish species in farm dams.
- The upper Kars River should be maintained as a priority for freshwater fish as well as the upper Nuwejaars River due to the diverse aquatic life and undisturbed habitat. These rivers drain the Agulhas Plain and associated wetlands and their rehabilitation could form part of the Agulhas Biodiversity Initiative (ABI).

7. APPENDICES

APPENDIX A (*INDEX* ***METHODOLOGY***)

Index of Habitat Integrity

Assessment of habitat integrity of a river can be seen as a precursor of the assessment of biotic integrity and is a measure of the degree to which a river has been modified from its natural state. Habitat and biotic integrity together constitute ecological integrity (Kleynhans, 1996). A site-based approach was carried out at all sites, where observations were conducted at ground level at each monitoring site, but also makes use of other sources of information (maps, local knowledge etc.). The objectives of the Index of Habitat Integrity (IHI) assessment are to put into perspective the significance of various factors in the degradation of the habitat integrity of a specific river (Kleynhans, 1996).

The methodology (Kleynhans, 1996) involves an assessment of the number and severity of anthropogenic impacts on a river and the damage they potentially inflict upon the system. These disturbances include both abiotic and biotic factors, which are regarded as the primary causes of degradation of a river. The severity of each impact is ranked using a six-point scale with 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact).

Criteria evaluated in the Index for Habitat Integrity

Instream Criteria	***Weight***	**Riparian Zone Criteria**	***Weight***
Water abstraction	14	Water abstraction	13
Flow modification	13	Inundation	11
Bed modification	13	Flow modification	12
Channel modification	13	Water quality	13
Water quality	14	Indigenous vegetation removal	13
Inundation	10	Exotic vegetation encroachment	12
Exotic macrophytes	9	Bank erosion	14
Exotic fauna	8	Channel modification	12
Solid waste disposal	6		
Total	**100**	**Total**	**100**
Score (% of total)		**Score (% of total)**	
Category		***Category***	

Intermediate Habitat Integrity categories (from Kleynhans, 1996)

Category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

Geomorphological Index (GI)

Geomorphology forms the physical template in which stream biota live and has therefore become an integral part of assessing ecological integrity (river health). Changes to stream biota could occur as a response to changes in water quality but it could also be due to changes in channel morphology or channel condition. The GI consists of two main components, namely, channel classification and stability and channel condition. The data collected classifies the channel in terms of channel type so as to allow similar sites to be grouped. It also provides reference data to which later surveys could be compared. The channel stability index is used to classify sites according to their potential for morphological change. Changes to channels can occur as a result of natural events such as flooding or due to anthropogenic impacts (locally, e. g. bulldozing in-channel or in the catchment, e. g. impoundments) (Rowntree and Ziervogel, 1999).

The index of channel condition is based on the bed and bank conditions. Certain channels are inherently less stable than others, e.g. lowland sand channels versus mountain stream bedrock channels. Another important component is the assessment of anthropogenic impacts to the channels and how it affects channel conditions. These impacts are placed classes ranging from A (natural state) to F (critically modified), depending on the degree of modification (Rowntree and Ziervogel, 1999), where: A – Natural; B – Largely natural; C – Moderately modified; D – Largely modified; E – Severely modified; and F – Critically modified.

<u>Riparian Vegetation Index (RVI) description (Kemper, 2001)</u>

The RVI evaluates two areas of riparian vegetation quality at a site, namely the extent of coverage of the riparian zone by vegetation, and the structural or compositional integrity of the vegetation present. The procedures determining the RVI consist of 4 sub-indices and are described as sections A, B, C and D (Section E assists with the interpretation process of the RVI method).

A. Extent of vegetation coverage of the riparian zone (EVC)

The EVC addresses the whole sampling area, in the context of the percentage vegetation present, the relevance of vegetation discontinuity, and the extent of anthropogenic or other disturbances phenomena.

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The EVC is determined by calculating the average score of EVC1 and EVC2, where:

- EVC1 = Combined vegetation cover score out of 10 for the left and right banks, including islands (if present).
- EVC2 = 10 minus the average site disturbance intensity

Percentage score	0%	1-5%	6-25%	26-50%	51-75%	76-100%
EVC1	0	2	4	6	8	10
EVC2	0	1	2	4	6	10

EVC (score out of 10) = [(EVC1 + EVC2)/2]

B. Structural Intactness (SI)

The SI addresses the relevance of vegetation class density and distribution over the riparian zone. This enables a holistic view of the riparian vegetation responses to disturbance. The SI is determined with reference to the following scoring table of vegetation distribution for Present versus Perceived Reference State, where:

- The score is determined for each of the cover classes, namely trees(SI1), shrubs(SI2), reeds(SI3), sedges(SI4) and grasses(SI5)

	PRESENT STATE (P/S)			
Perceived Reference State (PRS)	Continuous	Clumped	Scattered	Sparse

Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

SI (score out of 1) = [((SI1+SI2+SI3+SI4+SI5)/5)*0.33]

C. Percentage cover of indigenous riparian species (PCIRS)

The PCIRS is assessed against a perceived reference state, where no alien invasion is found, terrestrialisation is very low, and reed populations are not extensive. The percentage cover of indigenous species is assumed to be 100 percent in a natural site, thus exotic, terrestrial and reed components are assessed against the reference of 100%, as follows:

Exotic invasion:

Species	Invasive/Recruitments (tick)		Extent of invasion VL L M H VH				
	I	R	1	2	3	4	5
Total extent of invasion			1	2	3	4	5

Terrestrial invasion:

Species	Extent of invasion VL	L	M	H	VH
	1	2	3	4	5
Total extent of invasion	1	2	3	4	5

Reeds:

Species	Extent of Problem VL	L	M	H	VH
	1	2	3	4	5
Total extent					

The PCIRS is thus determined by the sum of the weighted cover scores for “problematic” species (exotic, terrestrial indigenous and reed species), and are subtracted from the adjusted EVC score.

PCIRS (score our of 5)=[(EVC/2)-((exotics x 0.7)+(terrestrial x 0.1)+(reeds x 0.2))]

*The site will score 0 (min) for PCIRS if no indigenous riparian species are present.

D. Regeneration of indigenous species (RIRS)

The positive significance of indigenous species recruitment is taken into account in this section. The assessment only considers indigenous riparian vegetation, specifically that which comprises the dominant species within the site. However, homogeneity is not regarded as a positive feature for RIRS, but special references are given to desired species recruitment.

The RIRS is determined by the application of the following scoring system, with a maximum weight of 5.

Recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

E. Final analysis and interpretation

The final formulae calculating the riparian zone health from the vegetation perspective is:

$$RVI=[(EVC)+((SI \times PCIRS)+(RIRS))]$$

The RVI provides a final score out of 20 that is associated with the six assessment classes and can be interpreted as follows:

RVI Score	Assessment class	Description
19-20	A	Unmodified, natural.
17-18	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the ecosystem functions remain unchanged.
13-16	C	Modified. A loss and change of natural habitat, biota and basic ecosystem functions have occurred.
9-12	D	Largely modified. A moderate to large loss of natural habitat, biota and basic ecosystem functions have occurred.
5-8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive.
0-4	F	Modifications have reached a critical level and the system has been modified completely with complete loss of habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed to the extent that changes are irreversible.

South African Scoring System (SASS5)

The SASS method has progressed through different versions, the latest being version 5 (SASS5). The most significant changes from SASS4 to SASS5 are:

- The splitting of biotopes into 3 categories but still achieving one SASS and ASPT score. An advantage of these separate biotopes are that sampling points can now be assessed and compared based on habitats, which occur at a site because all biotopes (i.e. stones –in-and-out-of-current, grave/sand/mud, marginal/aquatic vegetation) are always present (Chutter, 1998). This also allows for more accurate interpretations of SASS scores whether it increases or decreases as a result of habitat changes (natural or anthropogenic) or whether there is a potential water quality problem. Example, a decrease in the amount of invertebrates, which is normally due to a loss of habitat as a result of flooding.
- The cased caddis flies (Trichoptera) are assessed by including the actual families that are present.
- Changes have been made to the scoring sheet to include additional families and some sensitivity ratings have been changed (Dickens and Graham, 2001). The common names have also been included as in SASS5 and IHAS data sheets.

The SASS5 method uses a kick-sampling technique whereby the invertebrates are dislodged by disturbing the streambed and retained in a 1mm mesh size net. The sample is placed in a sorting tray where each taxon is recorded and identified to family level and returned to the river alive. Each invertebrate found is assigned a score ranging from 1 (pollution tolerant) – 15 (pollution intolerant), depending on its sensitivity to pollution (Dickens and Graham, 2001). The scores for all sites are totalled and yield a SASS5 score. The Average Score per Taxon (ASPT) of all the families present is obtained and this provides an indication of the number of sensitive, high scoring species presented in the total score. The Invertebrate Habitat Assessment System (IHAS) (McMillan, 1998) was also assessed at each site. An example of the IHAS assessment sheet is shown in Appendix A. This methodology still requires considerable revision but it does provide a relatively good indication of the type of habitats available to invertebrates. Abundances of invertebrates found do not feature in the SASS5 score but it was recorded and is shown in Appendix A together with all invertebrates found at each site. Samples were collected from 4 biotopes, namely stones-in-current (SIC), stones-out-of-current (SOOC), marginal/aquatic vegetation (m/aqVeg) and gravel-sand-and-mud (G/S/M) at each site or where the biotopes were available.

The Fish Assemblage Integrity Index (FAII) (Kleynhans, 1999)

The FAII is a site-specific index, which aims to provide an indication of the overall long-term biological integrity of a river – "the ability of an ecosystem to support and maintain a balanced, integrated, adaptive community of organisms, having a species composition, diversity functional organisation comparable to that of the natural habitat of the region" (Karr, 1981). The FAII measures the biological integrity of a river by estimating the population status of samples in fish habitat segments' to relevant relationships between indigenous and alien fish occupation in selected sections of rivers, and in turn, extrapolating these results to be representatively interpreted as a measure of the whole system under investigation. These relationships include refugia preferences against available refugia; indigenous fish density and diversity; and alien fish impacts with regard to density, diversity and competition. Therefore, measures of species richness, composition, trophic structure, abundance and general health or health conditions are established. However, the FAII may provide an underestimation of biological integrity when fish and habitat diversity are naturally low, and should be interpreted with experienced professional scrutiny.

Calculation of the FAII score

The FAII (Fish Assemblage Integrity Index) is a function that applies sensitivity values 1-5 (SVs) to compare expected FAII scores to the observed scores, where observed scores are expressed as a percentage of the expected. SVs range between 1 and 5, where a SV of 1 would imply a low or heavily impacted rating and a SV of 5 would be interpreted as high or natural. The formulae for determining FAII is as follows:

FAII (Relative) = FAII(observed)/FAII(expected) x 100

FAII (Expected) = T (A(exp)+F(exp)+H(exp))/3
FAII (observed) = T(A(obs)+F(obs)+H(obs))/3

T = Intolerance rating; A = Abundance; F = Frequency of occurrence;
H = Health rating

The intolerance ratings are a combined assessment of the trophic specialisation of a species, its habitat specialisation, its sensitivity to changes in water quality, and its dependence upon flowing water. Abundance refers to the density of fish; frequency refers to how often the fish is recaught and health refers to the fish's physical appearance (no parasites, unscathed and round bellies would be healthy).

Representation of the FAII score

River segments contain various fish habitats and fish assemblages. This is evident as one samples' from river sources (low indigenous fish diversity and density), to foothill river sections (high fish diversity and density), to lowland river sections (containing a variety of both estuarine and indigenous fresh water fish). However, natural characteristics of fish habitat segments undergo modification by anthropogenic influences, including recreational alien fish stocking. As a result the interpretation of FAII scores indicates both short-term and long-term cumulative upstream disturbances.

FAII Assessment categories

Class	**Description of General Expected Conditions**	**FAII Score**
A	Unmodified, or approximates natural conditions closely.	90-100
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicated modification.	80-89
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower end of this scale.	60-79
D	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. Impairment of health may become evident at the lower end of this class.	40-59
E	Seriously modified. A strikingly lowered than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become very evident.	20-39
F	Seriously modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower end of the class. Impairment of health may become very evident.	0-19

Guidelines for the assessment of the fish integrity according to the fuzzy fish index (FFI).

DETERMINANTS CONSIDERED FOR ESTIMATION	**RIVER ZONE OR DEFINED RESOURCE UNIT** (scoring/assessment criteria; provide comments for each score)	*SITE AND COMMENTS*
Native Species Richness	Number of species expected: number of species currently present (most recent). Score according to: None of expected present=0; Only few of expected present=1-2; Majority of expected species present=3-4 All/almost all of expected present=5	
Presence of Native intolerant Species	No intolerant species present=0; Few intolerant species =1-2; Majority of intolerant species present =3-4 All/almost all intolerant species present (OR no intolerants naturally present)=5	
Abundance of native species	No fish=0; Only few individuals=1-2; Moderate abundance=3-4; Abundance as expected for natural conditions=5	
Native species Occurrence Frequency	Fish absent at all sites=0; Fish present at only very few sites=1-2; Fish present at most sites=3-4;Fish present at all sites=5	
Health/condition; native & introduced species	All fish seriously affected/fish absent=0;Most fish affected=1-2;Most fish unaffected=3-4 Only single/few individuals affected=5	
Presence of introduced fish Species	Predaceous species and/or habitat modifying species with a critical impact on native species=0 Predaceous species and/or habitat modifying species with a serious impact on native species=1-2 Predaceous species and/or habitat modifying species with a moderate impact on native species=3-4 Predaceous species and/or habitat modifying species no impact on native species=5	
Instream habitat modification	Water quality/Flow/Stream bed substrate, critically modified, no suitable conditions for expected species=0 Water quality/Flow/Stream bed substrate, seriously modified, little suitable conditions for expected species=1-2 Water quality/Flow/Stream bed substrate, moderately modified, moderately suitable conditions for expected species=3-4 Water quality/Flow/Stream bed substrate, little/no modification, abundant suitable conditions for expected species=5	
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	TAKING INTO ACCOUNT THE ABOVE INFORMATION: RATE FISH ASSEMBLAGE INDEX CATEGORY A – F (GENERAL SCORING GUIDELINES): Category — % of total expected score A: 90 – 100 B: 80 – 90 C: 60 – 80 D: 40 – 60 E: 20 – 40 F: 0 – 20	

APPENDIX B (*SASS5 RESULTS*)

INVERTEBRATES PRESENT DURING SAMPLING TIMES AT ALL SITES

	Site B1 (Doringkloof)		
Invertebrates	**Spring**	**Summer**	**Autumn**
TURBELLARIA	A	A	-
Oligochaeta	1	1	-
Leeches	1	1	-
Potamonautidae*	1	A	1
HYDRACARINA	1	A	-
Baetidae 2sp	-	-	A
Baetidae >2sp	B	B	-
Caenidae	A	A	A
Leptophlebidae	-	-	A
Coenagrionidae	-	-	A
Aeshnidae	-	A	A
Gomphidae	A	A	1
Corduliidae	-	-	1
Libellulidae	A	-	-
Corixidae		-	A
Gerridae	A	A	-
Naucoridae	A	A	1
Nepidae	-	1	-
Notonectidae	-	A	-
Veliidae/Mesoveliidae	-	A	-
Hydropsychidae 1sp	-		1
Hydropsychidae 2 sp	-	A	-
Hydroptilidae	-	1	-
Leptoceridae	A	1	-
Dytiscidae	A	A	-
Elmidae/Dryopidae		A	-
Gyrinidae	B	A	B
Athericidae		1	1
Ceratopogonidae	1	A	1
Chironomidae	A	B	B
Culicidae	-	-	1
Simulidae	-	-	B
Ancylidae	-	-	-

Site 2 (Kanaan)

Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
TURBELLARIA	A	A	-	-
Oligochaeta	1	1	-	-
Potamonautidae*	1	A	-	1
Leeches	1	1	-	-
HYDRACARINA	1	A	-	-
Baetidae 2sp	-	-	B	A
Baetidae >2sp	B	B	-	-
Caenidae	A	A	1	A
Leptophlebiidae	-	-	-	A
Coenagrionidae	-	-	-	A
Aeshnidae	-	A	A	A
Corduliidae	-		-	1
Gomphidae	A	A	A	1
Libellulidae	A	A	A	-
Corixidae	-	B	-	A
Gerridae	A	A	-	-
Naucoridae	A	A	A	1
Nepidae	-	1	-	-
Notonectidae	-	A	A	-
Veliidae/Mesoveliidae	-	A	-	-
Hydropsychidae 1sp	-		-	1
Hydropsychidae 2sp	-	A	-	-
Hydroptilidae	-	1	-	-
Leptoceridae	A	1	1	-
Dytiscidae	A	A	A	-
Elmidae/Dryopidae	-	A	1	-
Gyrinidae	B	A	B	A
Hydraenidae	-	-	A	-
Athericidae	-	-	-	1
Ceratopogonidae	1	A	A	1
Chironomidae	A	B	A	B
Culicidae	-	-	-	1
Simulidae	B	B	A	B
Syrphidae	-	-	-	-
Ancylidae	1	1	-	-

Site 3 (Wildekraans)				
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
TURBELLARIA	A	A	1	-
Oligochaeta	A	1	A	A
Potamonautidae*	1	A	-	-
HYDRACARINA	A	-	1	-
Baetidae 2sp	-	B		-
Baetidae >2sp	B	-	B	A
Caenidae	1	A	-	-
Coenagrionidae	A	B	A	1
Aeshnidae	1	1	-	A
Corduliidae	-	-	-	-
Gomphidae	A	B	1	A
Libellulidae	-	A	1	1
Corixidae	A	A	1	1
Naucoridae	1	A	1	B
Hydrometridae	-	1	-	-
Veliidae/Mesoveliidae	A	B	1	-
Hydropsychidae 1sp	A	A	-	-
Dytiscidae	A	-	-	-
Elmidae/Dryopidae	-	-	A	-
Gyrinidae	-	B	A	-
Hydrophilidae	-	-	-	A
Chironomidae	A	B	A	A
Culicidae	-	A	-	1
Simulidae	B	A	B	B
Ancylidae	A	A	1	-
Physidae	A	-	A	-

		Swart River		
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	-	-	1	-
HYDRACARINA	A	-	-	-
Notonemouridae	-	-	-	1
Baetidae 1sp	-	-	-	A
Baetidae >2sp	A	-	-	-
Caenidae	-	-	-	A
Coenagrionidae	-	-	-	1
Libellulidae	A	-	-	A
Corixidae	A	-	A	A
Naucoridae	-	-	-	1
Pleidae	1	-	-	-
Veliidae/Mesoveliidae	-	-	-	A
Dytiscidae	A	-	-	-
Hydraenidae	-	-	A	-
Hydrophilidae	-	-	-	A
Chironomidae	A	-	A	A
Culicidae	1	-	-	-
Simulidae	-	-	-	1
Planorbinae	1	-	-	-
Physidae	B	-	-	-

Hermanus (SAFCOL)

Invertebrates	Spring	Summer	Winter	Autumn
Amphipoda	B	B	B	A
Potamonautidae*	-	A	1	-
HYDRACARINA	-	A	-	-
Notonemouridae	1	B	B	A
Baetidae 1sp	-	-	-	1
Baetidae 2sp	A	-	A	-
Baetidae >2sp	-	B	-	-
Leptophlebiidae	A	-	B	-
Teloganodidae	B	A	A	A
Chlorestidae	-	-	-	1
Coenagrionidae	A	1	1	A
Aeshnidae	-	1	-	1
Gomphidae	A	A	1	A
Veliidae/Mesoveliidae	1	B	1	A
Hydropsychidae 1sp	A	A	-	1
Philopotamidae	A	A	-	1
Barbarochthonidae	B	-	A	A
Leptoceridae	A	A	-	-
Petrothrincidae	-	A	-	-
Dytiscidae	A	1	-	-
Elmidae/Dryopidae	A	A	-	-
Gyrinidae	A	-	A	A
Helodidae	-	A	-	-
Ceratopogonidae	1	-	-	-
Chironomidae	A	A	1	A
Simulidae	1	A	-	A
Ancylidae		1	-	-

ONRUS RIVER SYSTEM

Onrus Site 1 (Haygrove)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	1	-	-	A
Potamonautidae*	1	A	A	-
HYDRACARINA	1	A	-	-
Baetidae 2sp	C	B	-	-
Baetidae >2sp	-	-	A	-
Caenidae	B	C	A	-
Coenagrionidae	A	1	1	A
Aeshnidae	1	A	A	1
Gomphidae	-	-	A	-
Libellulidae	-	A	A	-
Corixidae	A	B	A	-
Notonectidae	-	1	-	-
Veliidae/Mesoveliidae	A	A	-	A
Hydropsychidae 1sp	A	A	-	B
Hydropsychidae >2sp	-	-	B	-
Leptoceridae	B	A	A	-
Dytiscidae	A	A	A	-
Elmidae/Dryopidae	A	-	-	A
Gyrinidae	-	A	-	-
Helodidae	-	-	A	-
Ceratopogonidae	A	A	-	-
Chironomidae	A	A	-	-
Culicidae	A	-	-	-
Simulidae	A	A	A	A

Onrus Site 2 (Volmoed)

Invertebrates	Spring	Summer	Winter	Autumn
TURBELLARIA	A	-	A	1
Potamonautidae*	1	A	1	A
HYDRACARINA	-	A	1	1
Baetidae 2sp	A	-	-	A
Caenidae	A	1	1	-
Coenagrionidae	A	A	A	A
Libellulidae	A	1	1	A
Corixidae	A	A	A	A
Hydrometridae	1	-	-	-
Veliidae/Mesoveliidae	A	A	-	A
Hydropsychidae 1sp	A	-	-	1
Hydropsychidae 2sp	-	-	A	-
Hydroptilidae	-	-	-	1
Leptoceridae	A	-	A	1
Dytiscidae	-	A	-	1
Elmidae/Dryopidae	1	-	-	-
Gyrinidae	1	-	A	-
Hydraenidae	-	1	-	-
Ceratopogonidae	-	1	-	-
Chironomidae	B	A	A	A
Culicidae	1	-	-	-
Simulidae	B	B	C	B
Ancylidae	-	-	A	-

Onrus site 3 (Kidbrooke)

Invertebrates	Spring	Summer	Winter	Autumn
TURBELLARIA	-	-	-	1
Oligochaeta	-	1	-	-
Potamonautidae*	-	A	-	-
Baetidae 2sp	-	A	A	A
Caenidae	A	A	A	1
Corduliidae	-	-	1	-
Gomphidae	-	1	-	-
Libellulidae	A	A	-	1
Corixidae	A	B	A	A
Gerridae	-	-	1	-
Naucoridae	-	-	-	1
Nepidae	-	1	-	-
Veliidae/Mesoveliidae	1	A	1	A
Hydropsychidae 1sp	-	-	1	A
Leptoceridae	B	1	A	-
Dytiscidae	-	-	-	A
Elmidae/Dryopidae	-	-	1	-
Gyrinidae	1	A	-	-
Hydrophilidae	-	1	-	-
Athericidae	1	-	-	-
Chironomidae	A	A	A	A
Culicidae	-	-	1	-
Simulidae	A	-	A	A
Ancylidae	1	-	-	-

UILKRAAL RIVER SYSTEM

Uilkraal site 1 (Salmonsdam)

Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	A	-	-	-
Amphipoda	B	A	A	B
Potamonautidae*	A	A	-	-
HYDRACARINA	A	-	-	-
Notonemouridae	A	-	B	A
Baetidae 1sp	-	1	A	-
Baetidae 2sp	A	-	-	A
Caenidae	B	-	-	-
Coenagrionidae	A	A	A	A
Corduliidae	1	-	-	-
Libellulidae	A	-	-	-
Hydrometridae	-	1	-	-
Veliidae/Mesoveliidae	-	-	-	A
Corydalidae	-	-	A	-
Barbarochthonidae	-	-	-	1
Leptoceridae	A	1	B	-
Elmidae/Dryopidae	A	-	A	-
Helodidae	-	-	1	1
Athericidae	1	-	-	-
Ceratopogonidae	A	-	1	-
Chironomidae	C	1	B	1
Simulidae	B	-	A	C
Tipulidae	-	-	-	1

Uilkraal site 2 (Paardenberg)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	-	-	1	-
Amphipoda	-	-	A	-
Potamonautidae*	-	1	-	-
HYDRACARINA	-	A	-	-
Notonemouridae	-	-	-	A
Baetidae 2sp	A	A	A	A
Caenidae	1	-	-	-
Coenagrionidae	-	A	-	A
Aeshnidae	-	1	1	-
Libellulidae	-	A	-	-
Corixidae	-	B	-	-
Gerridae	-	A	-	-
Hydrometridae	-	1	-	-
Notonectidae	-	1	-	-
Veliidae/Mesoveliidae	-	B	-	-
Leptoceridae	-	A	A	A
Dytiscidae	-	1	-	-
Elmidae/Dryopidae	1	-	-	A
Helodidae	-	-	A	A
Hydrophilidae	1	-	A	-
Ceratopogonidae	-	B	-	-
Chironomidae	A	B	A	A
Simulidae	B	-	-	A

	Uilkraal site 3 (Baardskeerdersbos)			
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	-	-	A	-
Amphipoda	-	-	A	-
HYDRACARINA	-	A	-	1
Baetidae 1sp	-	A	-	-
Baetidae 2sp	A	-	A	-
Caenidae	-	-	A	-
Coenagrionidae	-	1	A	1
Aeshnidae	-	-	A	-
Libellulidae	-	A	A	1
Corixidae	B	B	B	B
Gerridae	-	A	1	-
Hydrometridae	-	-	1	-
Notonectidae	-	A	-	-
Veliidae/Mesoveliidae	A	A	A	-
Hydroptilidae	1	1	-	-
Leptoceridae	-	-	A	-
Dytiscidae	-	-	A	-
Elmidae/Dryopidae	-	-	1	-
Athericidae	-	-	1	-
Chironomidae	A	A	A	A
Culicidae	A	-	-	-
Simulidae	1	-	-	-
Ancylidae	-	1	-	-
Physidae	-	1	-	-

Klein site 1 (Goudini)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	B	1	-	-
Potamonautidae*	-	A	-	-
HYDRACARINA	1	A	-	-
Baetidae 1sp	-		-	-A
Baetidae 2sp	-	A	-	-
Caenidae	A	A	-	B
Coenagrionidae	-	A	-	B
Libellulidae	1		-	1
Corixidae	A	B	1	B
Gerridae	1	A	-	-
Hydrometridae	-	A	-	-
Nepidae	-	1	-	-
Pleidae	-	A	-	B
Veliidae/Mesoveliidae	A	A	-	1
Dytiscidae	A	B	A	A
Hydrophilidae	-	A	-	-
Ceratopogonidae	A		-	1
Chironomidae	A	B	-	A
Culicidae	1	A	-	-
Ancylidae	-	-	-	A
Physidae	-	A	-	A
Planorbidae	1	A	-	1

KLEIN RIVER SYSTEM

Klein site 2 (Waboomsdrift)

Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	A	1	A	-
Potamonautidae*	A	A	-	-
Amphipoda	A		-	-
HYDRACARINA	-	B	A	-
Baetidae 1sp	-	A	-	-
Baetidae 2sp	-		-	A
Caenidae	B	A	A	C
Leptophlebiidae	1	1	-	-
Coenagrionidae	-	A	-	A
Aeshnidae	-	A	-	-
Gomphidae	-	B	1	-
Libellulidae	-	A	-	-
Corixidae	A	A	A	-
Naucoridae	-	A	A	-
Naucoridae	-	A	-	-
Notonectidae	-	1	-	-
Pleidae	-	A	-	-
Veliidae/Mesoveliidae	-	1	A	-
Leptoceridae	-	1	A	-
Dytiscidae	-	A	A	-
Elmidae/Dryopidae	-	-	A	-
Hydraenidae	-	-	1	-
Hydrophilidae	-	1	A	-
Ceratopogonidae	-	-	A	-
Chironomidae	A	A	A	1
Culicidae	-	A	A	-
Simulidae	-	-	1	A
Ancylidae	-	B	-	-
Physidae	-	A	-	-
Corbiculidae	-	1	-	-

Klein site 3 (Whitewater)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	-		A	-
HYDRACARINA	-		1	-
Baetidae 2sp	A		-	A
Baetidae >2sp	-		B	-
Caenidae	A		B	B
Leptophlebiidae	1		-	-
Gomphidae	-		-	1
Libellulidae	-		1	-
Corixidae	A		A	-
Hydropsychidae 1sp	-		-	1
Hydroptilidae	1		-	-
Leptoceridae	1		A	-
Dytiscidae	-		A	-
Gyrinidae	-		A	-
Ceratopogonidae	-		1	-
Chironomidae	A		A	1
Culicidae	A		1	-
Dixidae	-		A	-
Simulidae	1		B	B

SOUT RIVER SYSTEM

Sout Site 1 (DWAF weir)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	-	-	1	-
HYDRACARINA	C	-	B	-
Potamonautidae	-	1	-	A
Baetidae 1sp	A	A	-	A
Baetidae 2sp	-	-	B	-
Coenagrionidae	B	B	1	A
Corixidae	A	C	A	A
Notonectidae	-	A	A	-
Veliidae/Mesoveliidae	-	1	-	-
Dytiscidae	1	A	A	A
Hydraenidae	-	-	-	-
Hydrophilidae	B	B	B	-
Ceratopogonidae	-	-	-	-
Chironomidae	A	A	A	B
Culicidae	A	-	A	-
Simulidae	-	-	-	A
Thiaridae	B	A	B	1

Sout Site 2 (Soes tributary)				
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Amphipoda	A	-	-	-
HYDRACARINA	1	-	1	-
Baetidae 1sp	B	-	-	-
Baetidae 2sp	-	-	A	A
Coenagrionidae	A	1	A	1
Corixidae	B	1	B	A
Veliidae/Mesoveliidae	-	-	A	-
Dytiscidae	A	A	-	A
Hydrophilidae	A	A	A	1
Ceratopogonidae	-	-	A	-
Chironomidae	A	A	-	A
Culicidae	1	-	A	1
Thiaridae	B	B	A	A

Sout Site 3 (Brakpan)				
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
TURBELLARIA	-	-	DRY	-
Oligochaeta	-	-		1
HYDRACARINA	A	-		-
Baetidae >2sp	B	-		-
Coenagrionidae	B	A		1
Corixidae	B	A		-
Veliidae/Mesoveliidae	1	-		A
Hydrophilidae	A	A		A
Chironomidae	A	A		A
Culicidae	A	-		1
Simulidae	-	-		A
Thiaridae	-	-		1

Sout Site 4 (Kykoedy)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	A	-	B	A
HYDRACARINA	B	-	C	-
Baetidae 1sp	-	A	A	-
Baetidae 2sp	-	-	-	A
Coenagrionidae	A	A	1	-
Corixidae	A	A	-	A
Notonectidae	-	-	-	1
Veliidae/Mesoveliidae	-	A	-	-
Dytiscidae	B	A	A	-
Hydraenidae	-	-	1	-
Hydrophilidae	-	A	1	-
Ceratopogonidae	-	-	1	-
Chironomidae	B	C	A	B
Culicidae	A	A	1	1
Muscidae	-	1	-	-
Dixidae	-	-	1	-
Simulidae	A	A	-	B
Thiaridae	A	A	A	-

Sout Site 5 (Hotnotskraal tributary)

Invertebrates	Spring	Summer	Winter	Autumn
Potamonautidae*	1		-	-
HYDRACARINA	A	A	A	-
Baetidae 1sp	-	A	-	-
Baetidae 2sp	A	-	A	A
Coenagrionidae	1	A	A	A
Libellulidae	-	A	-	A
Corixidae	A	B	-	A
Notonectidae	A	C	-	A
Pleidae	-	1	-	-
Dytiscidae	A	A	A	A
Gyrinidae	1	-	-	-
Hydrophilidae	A	A	A	A
Chironomidae	A	C	-	A
Culicidae	A	1	C	-
Dixidae	1	-	A	-
Thiaridae	A	-	-	-

Sout Site 8 (Wydgeleë)

Invertebrates	Spring	Summer	Winter	Autumn
Potamonautidae*	-	-	1	-
HYDRACARINA	A	-	A	-
Notonemouridae	-	-	-	-
Baetidae 1sp	-	A	A	A
Baetidae 2sp	B	-	-	-
Coenagrionidae	A	-	-	-
Corixidae	B	A	A	1
Notonectidae	-	-	-1	-
Dytiscidae	B	-	A	1
Hydrophilidae	B	1	B	-
Chironomidae	-	-	-	A
Culicidae	B	-	A	A
Psychodidae	1	-	-	-
Thiaridae	A	B	B	B

Sout Site 6 (Soutkuil)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	B	-	-	-
HYDRACARINA	A	-	-	A
Potamonautidae	-	1	-	A
Baetidae 1sp	A	-	A	-
Baetidae 2sp	-	B	-	B
Caenidae	-	-	-	A
Coenagrionidae	-	A	A	A
Libellulidae	-	1	1	-
Corixidae	B	C	B	B
Naucoridae	-	A	-	A
Notonectidae	-	A	-	1
Pleidae	-	1	-	1
Veliidae/Mesoveliidae	-	A	-	A
Dytiscidae	A	1	A	A
Hydraenidae	A	-	-	-
Hydrophilidae	1	A	-	A
Ceratopogonidae	A	-	-	-
Chironomidae	A	1	-	B
Culicidae	A	1	1	B
Thiaridae	B	-	B	-

Kars site 1 (Schietpad)

Invertebrates	Spring	Summer	Winter	Autumn
TURBELLARIA	-	DRY	-	-
Oligochaeta	A		-	A
HYDRACARINA	B		-	-
Baetidae 2sp	A		-	A
Coenagrionidae	A		-	-
Libellulidae	A		-	-
Corixidae	B		A	A
Naucoridae	-		-	A
Leptoceridae	-		-	1
Dytiscidae	A		A	-
Helodidae	-		-	1
Hydrophilidae	A		A	-
Chironomidae	A		A	A
Culicidae	1		A	-
Simulidae	A		-	-

KARS RIVER SYSTEM

Kars site 3 (Soutkloof)

Invertebrates	Spring	Summer	Winter	Autumn
Amphipoda	1	-	-	-
HYDRACARINA	-	1	A	-
Baetidae 1sp	A	A	-	-
Baetidae 2sp	-	-	A	A
Caenidae	A	1	-	-
Coenagrionidae	-	-	A	A
Belostomatidae	1	-	-	-
Corixidae	B	-	A	A
Gerridae	-	A	-	-
Naucoridae	-	A	1	-
Pleidae	-	1	-	-
Veliidae/Mesoveliidae	-	-	A	-
Dytiscidae	A	A	-	-
Gyrinidae	-	-	1	-
Hydrophilidae	-	A	-	-
Ceratopogonidae	1	-	-	-
Chironomidae	A	A	A	1
Culicidae	1	-	A	-
Ancylidae	-	-	A	-

Kars site 2 (Rooidraaibrug)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	1	A	No sample	-
Amphipoda	A	-		-
HYDRACARINA	A	1		-
Baetidae 1sp	A	-		-
Caenidae	A	-		-
Coenagrionidae	1	-		1
Aeshnidae	-	-		1
Corduliidae	-	-		1
Corixidae	B	C		A
Gerridae	-	A		-
Notonectidae	=	A		-
Pleidae	-	-		A
Veliidae/Mesoveliidae	-	-		1
Hydrophilidae	-	1		-
Ceratopogonidae	1	-		-
Chironomidae	B	A		1
Culicidae	A	-		

HEUNINGNES AND NUWEJAARS SYSTEM

		Klein Pietersielieskloof River		
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	-	1	-	-
Amphipoda	-	1	A	-
Notonemouridae	-	-	1	-
Baetidae >2sp	-	A	A	-
Caenidae	-	A	A	-
Coenagrionidae	-	A	A	-
Aeshnidae	-	A	A	-
Gomphidae	-	A	A	-
Corduliidae	-	-	A	-
Libellulidae	-	A	-	-
Corixidae	-	-	1	-
Gerridae	-	-	1	-
Naucoridae	-	-	A	-
Veliidae/Mesoveliidae	-	A	1	-
Hydropsychidae 1sp	-	1	-	-
Hydropsychidae 2sp	-	-	B	-
Hydroptilidae	-	-	A	-
Leptoceridae	-	1	1	-
Dytiscidae	-	-	1	-
Gyrinidae	-	1	-	-
Hydraenidae	-	-	A	-
Hydrophilidae	-	-	1	-
Chironomidae	-	A	1	-
Culicidae	-	1	1	-
Muscidae	-	-	A	-
Simulidae	-	A	A	-
Ancylidae	-	-	1	-

Site 1 Nuwejaars (Kersgat)

Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	-	-	1	A
Potamonautidae*	1	1	-	-
HYDRACARINA	B	1	A	-
Baetidae 1sp	-	-	-	A
Baetidae 2sp	-	A	A	-
Baetidae >2sp	A	-	-	-
Caenidae	1	1	B	A
Coenagrionidae	A	1	A	-
Aeshnidae	-	1	-	-
Gomphidae	-	-	-	1
Libellulidae	1	-	-	-
Corixidae	A	-	-	-
Pleidae	-	-	-	1
Philopotamidae	1	-	-	-
Hydroptilidae	A	-	-	-
Leptoceridae	1	A	-	A
Helodidae	-	-	1	-
Ceratopogonidae	-	-	1	-
Chironomidae	A	A	C	A
Culicidae	-	-	A	-
Psychodidae	-	-	1	-
Simulidae	A	-	-	A
Ancylidae	-	1	-	--

Site 2 Nuwejaars (Brakfontein)

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	A	A	-	A
Potamonautidae*	1	1	1	-
Amphipoda	-	-	A	-
HYDRACARINA	A	A	A	B
Baetidae 1sp	-	1	A	-
Baetidae 2sp	B	-	-	A
Caenidae	-	-	-	A
Coenagrionidae	A	-	-	A
Libellulidae	-	1	-	-
Belostomatidae	-	1	-	-
Corixidae	-	B	A	A
Gerridae	C	-	-	-
Notonectidae	A	B	-	-
Pleidae	-	-	-	1
Veliidae/Mesoveliidae	-	-	-	A
Dytiscidae	A	-	A	A
Elmidae/Dryopidae	-	-	1	-
Hydraenidae	-	A	1	-
Hydrophilidae	-	1	-	1
Ceratopogonidae	1	A	-	1
Chironomidae	A	-	1	A
Culicidae	A	-	-	-
Dixidae	1	-	-	-
Physidae	1	-	-	-

Pietersielieskloof River

Invertebrates	Spring	Summer	Winter	Autumn
Oligochaeta	A	A	-	-
Potamonautidae*	-	1	-	-
Amphipoda	1	1	A	-
Atyidae	-	A	-	-
HYDRACARINA	-		-	-
Notonemouridae	-	A	1	A
Baetidae 1sp	-		-	-
Baetidae 2sp	-	A	-	A
Baetidae >2sp	A		A	-
Caenidae	-	A	A	-
Coenagrionidae	A		A	-
Aeshnidae	-	1	A	-
Gomphidae	-		A	-
Corduliidae	-		A	-
Libellulidae	-	A	-	-
Corixidae	-	1	1	-
Gerridae	-		1	-
Naucoridae	-		A	-
Veliidae/Mesoveliidae	-	A	1	-
Hydropsychidae 1sp	-	1	-	-
Hydropsychidae 2sp	-		B	-
Hydroptilidae	A		A	-
Leptoceridae	-		1	-
Dytiscidae	-		1	-
Gyrinidae	-	1	-	-
Helodidae	-		-	-
Hydraenidae	-	1	A	-
Hydrophilidae	[		1	-
Chironomidae	A	A	1	-
Culicidae	-	1	1	-
Muscidae	-		A	-
Simulidae	-	A	A	-

RATEL RIVER

Ratel (Dirk Uys)				
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Oligochaeta	-	DRY	-	A
Baetidae 2sp	B		A	A
Coenagrionidae	1		A	1
Libellulidae	-		-	1
Veliidae/Mesoveliidae	A		-1	-
Leptoceridae	-		-	A
Hydroptilidae	-		A	-
Ceratopogonidae	-		-	-
Chironomidae	A		A	-
Simulidae	-		1	-
Syrphidae	B		-	-
Planorbidae	A		-	-

Heuningnes (Riverside)				
Invertebrates	**Spring**	**Summer**	**Winter**	**Autumn**
Amphipoda	B	1	B	B
Atyidae	-	A	-	-
Baetidae 2sp	-	-	-	A
Coenagrionidae	-	1	-	B
Corixidae	-	-	-	A
Veliidae/Mesoveliidae	-	A	-	A
Chironomidae	A	A	1	1
Ancylidae	-	1	-	-
Thiaridae	A	A	-	1

APPENDIX C (*IHI RESULTS*)

OVERBERG IHI DATA SHEETS

Bot Site 1 (Doringkloof))

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**10**	Water abstraction	13	**5**
Flow modification	13	**8**	Inundation	11	**0**
Bed modification	13	**1**	Flow modification	12	**5**
Channel modification	13	**0**	Water quality	13	**0**
Water quality	14	**8**	Indigenous vegetation removal	13	**11**
Inundation	10	**10**	Exotic vegetation encroachment	12	**14**
Exotic macrophytes	9	**0**	Bank erosion	14	**7**
Exotic fauna	8	**5**	Channel modification	12	**7**
Solid waste disposal	6	**0**			
Category		**B**	***Category***		**C**

Bot Site 2 (Kanaan)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**17**	Water abstraction	13	**17**
Flow modification	13	**14**	Inundation	11	**0**
Bed modification	13	**17**	Flow modification	12	**8**
Channel modification	13	**17**	Water quality	13	**10**
Water quality	14	**10**	Indigenous vegetation removal	13	**22**
Inundation	10	**0**	Exotic vegetation encroachment	12	**21**
Exotic macrophytes	9	**0**	Bank erosion	14	**23**
Exotic fauna	8	**1**	Channel modification	12	**10**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**F**

Bot Site 3 (Wildekraans Estate)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***

Water abstraction	14	**17**	Water abstraction	13	**17**
Flow modification	13	**15**	Inundation	11	**1**
Bed modification	13	**6**	Flow modification	12	**15**
Channel modification	13	**6**	Water quality	13	**10**
Water quality	14	**15**	Indigenous vegetation removal	13	**18**
Inundation	10	**2**	Exotic vegetation encroachment	12	**19**
Exotic macrophytes	9	**0**	Bank erosion	14	**6**
Exotic fauna	8	**1**	Channel modification	12	**17**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**F**

Swart

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**20**	Water abstraction	13	**15**
Flow modification	13	**12**	Inundation	11	**5**
Bed modification	13	**15**	Flow modification	12	**14**
Channel modification	13	**15**	Water quality	13	**12**
Water quality	14	**15**	Indigenous vegetation removal	13	**18**
Inundation	10	**5**	Exotic vegetation encroachment	12	**15**
Exotic macrophytes	9	**0**	Bank erosion	14	**18**
Exotic fauna	8	**1**	Channel modification	12	**18**
Solid waste disposal	6	**2**			
Category		**D**	***Category***		**F**

Hermanus (Safcol)

Instream Criteria	*Weight*	*Score*	Riparian Zone Criteria	*Weight*	*Score*
Water abstraction	14	**1**	Water abstraction	13	**1**
Flow modification	13	**1**	Inundation	11	**0**
Bed modification	13	**0**	Flow modification	12	**1**
Channel modification	13	**1**	Water quality	13	**0**
Water quality	14	**0**	Indigenous vegetation removal	13	**0**
Inundation	10	**0**	Exotic vegetation encroachment	12	**0**
Exotic macrophytes	9	**0**	Bank erosion	14	**0**
Exotic fauna	8	**0**	Channel modification	12	**1**
Solid waste disposal	6	**0**			
Category		**A**	***Category***		**A**

Onrus Site 1 (Haygrove Heaven)

Instream Criteria	*Weight*	*Score*	Riparian Zone Criteria	*Weight*	*Score*
Water abstraction	14	**13**	Water abstraction	13	**6**
Flow modification	13	**8**	Inundation	11	**0**
Bed modification	13	**3**	Flow modification	12	**6**
Channel modification	13	**8**	Water quality	13	**2**
Water quality	14	**15**	Indigenous vegetation removal	13	**20**
Inundation	10	**0**	Exotic vegetation encroachment	12	**22**
Exotic macrophytes	9	**0**	Bank erosion	14	**10**
Exotic fauna	8	**0**	Channel modification	12	**3**
Solid waste disposal	6	**0**			
Category		**C**	***Category***		**E**

Onrus Site 2 (Volmoed)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**19**	Water abstraction	13	**12**
Flow modification	13	**16**	Inundation	11	**13**
Bed modification	13	**16**	Flow modification	12	**16**
Channel modification	13	**16**	Water quality	13	**10**
Water quality	14	**13**	Indigenous vegetation removal	13	**20**
Inundation	10	**13**	Exotic vegetation encroachment	12	**20**
Exotic macrophytes	9	**0**	Bank erosion	14	**1**
Exotic fauna	8	**1**	Channel modification	12	**13**
Solid waste disposal	6	**0**			
Category		**E**	***Category***		**F**

Onrus Site 3 (Kidbrooke)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**10**
Flow modification	13	**17**	Inundation	11	**0**
Bed modification	13	**7**	Flow modification	12	**5**
Channel modification	13	**15**	Water quality	13	**4**
Water quality	14	**10**	Indigenous vegetation removal	13	**24**
Inundation	10	**0**	Exotic vegetation encroachment	12	**24**
Exotic macrophytes	9	**0**	Bank erosion	14	**23**
Exotic fauna	8	**0**	Channel modification	12	**11**
Solid waste disposal	6	**8**			
Category		**D**	***Category***		**F**

Uilkraal Site 1 (Salmonsdam)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***

Water abstraction	14	**6**	Water abstraction	13	**0**
Flow modification	13	**1**	Inundation	11	**0**
Bed modification	13	**1**	Flow modification	12	**1**
Channel modification	13	**0**	Water quality	13	**4**
Water quality	14	**0**	Indigenous vegetation removal	13	**3**
Inundation	10	**0**	Exotic vegetation encroachment	12	**14**
Exotic macrophytes	9	**0**	Bank erosion	14	**5**
Exotic fauna	8	**0**	Channel modification	12	**4**
Solid waste disposal	6	**0**			
Category		**A**	***Category***		**C**

Uilkraal Site 2 (Paardenberg)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**15**	Water abstraction	13	**15**
Flow modification	13	**8**	Inundation	11	**0**
Bed modification	13	**8**	Flow modification	12	**0**
Channel modification	13	**23**	Water quality	13	**3**
Water quality	14	**14**	Indigenous vegetation removal	13	**24**
Inundation	10	**2**	Exotic vegetation encroachment	12	**23**
Exotic macrophytes	9	**0**	Bank erosion	14	**23**
Exotic fauna	8	**0**	Channel modification	12	**20**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**F**

Uilkraal Site 3 (Baardskeerdersbos)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**14**	Water abstraction	13	**11**
Flow modification	13	**17**	Inundation	11	**5**
Bed modification	13	**10**	Flow modification	12	**18**
Channel modification	13	**8**	Water quality	13	**8**
Water quality	14	**15**	Indigenous vegetation removal	13	**12**
Inundation	10	**5**	Exotic vegetation encroachment	12	**15**
Exotic macrophytes	9	**0**	Bank erosion	14	**5**
Exotic fauna	8	**1**	Channel modification	12	**8**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**E**

Klein Site 1 (Goudini)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**11**	Water abstraction	13	**10**
Flow modification	13	**10**	Inundation	11	**0**
Bed modification	13	**4**	Flow modification	12	**8**
Channel modification	13	**17**	Water quality	13	**6**
Water quality	14	**6**	Indigenous vegetation removal	13	**21**
Inundation	10	**0**	Exotic vegetation encroachment	12	**21**
Exotic macrophytes	9	**0**	Bank erosion	14	**19**
Exotic fauna	8	**1**	Channel modification	12	**16**
Solid waste disposal	6	**1**			
Category		**C**	***Category***		**F**

Klein Site 2 (Waboomsdrift)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**15**
Flow modification	13	**11**	Inundation	11	**1**
Bed modification	13	**4**	Flow modification	12	**15**
Channel modification	13	**4**	Water quality	13	**8**
Water quality	14	**12**	Indigenous vegetation removal	13	**10**
Inundation	10	**1**	Exotic vegetation encroachment	12	**15**
Exotic macrophytes	9	**0**	Bank erosion	14	**10**
Exotic fauna	8	**1**	Channel modification	12	**8**
Solid waste disposal	6	**0**			
Category		**C**	***Category***		**E**

Klein Site 3 (Bluegum Estate)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**19**	Water abstraction	13	**15**
Flow modification	13	**14**	Inundation	11	**1**
Bed modification	13	**5**	Flow modification	12	**10**
Channel modification	13	**5**	Water quality	13	**3**
Water quality	14	**14**	Indigenous vegetation removal	13	**18**
Inundation	10	**3**	Exotic vegetation encroachment	12	**20**
Exotic macrophytes	9	**0**	Bank erosion	14	**6**
Exotic fauna	8	**0**	Channel modification	12	**8**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**E**

Sout Site 1 (DWAF weir)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**14**
Flow modification	13	**15**	Inundation	11	**10**
Bed modification	13	**12**	Flow modification	12	**11**
Channel modification	13	**10**	Water quality	13	**14**
Water quality	14	**20**	Indigenous vegetation removal	13	**13**
Inundation	10	**7**	Exotic vegetation encroachment	12	**10**
Exotic macrophytes	9	**0**	Bank erosion	14	**20**
Exotic fauna	8	**0**	Channel modification	12	**15**
Solid waste disposal	6	**5**			
Category		**D**	***Category***		**F**

Sout Site 2 (Soes tributary)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**13**
Flow modification	13	**15**	Inundation	11	**1**
Bed modification	13	**15**	Flow modification	12	**11**
Channel modification	13	**11**	Water quality	13	**11**
Water quality	14	**12**	Indigenous vegetation removal	13	**10**
Inundation	10	**0**	Exotic vegetation encroachment	12	**0**
Exotic macrophytes	9	**0**	Bank erosion	14	**16**
Exotic fauna	8	**1**	Channel modification	12	**12**
Solid waste disposal	6	**2**			
Category		**D**	***Category***		**E**

Sout Site 3 (Brakfontein)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**13**
Flow modification	13	**14**	Inundation	11	**0**
Bed modification	13	**13**	Flow modification	12	**12**
Channel modification	13	**7**	Water quality	13	**8**
Water quality	14	**15**	Indigenous vegetation removal	13	**1**
Inundation	10	**2**	Exotic vegetation encroachment	12	**0**
Exotic macrophytes	9	**0**	Bank erosion	14	**7**
Exotic fauna	8	**1**	Channel modification	12	**5**
Solid waste disposal	6	**3**			
Category		**D**	***Category***		**C**

Sout Site 4 (Kykoedie)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**15**
Flow modification	13	**15**	Inundation	11	**2**
Bed modification	13	**16**	Flow modification	12	**12**
Channel modification	13	**8**	Water quality	13	**18**
Water quality	14	**23**	Indigenous vegetation removal	13	**12**
Inundation	10	**3**	Exotic vegetation encroachment	12	**2**
Exotic macrophytes	9	**0**	Bank erosion	14	**23**
Exotic fauna	8	**0**	Channel modification	12	**18**
Solid waste disposal	6	**10**			
Category		**E**	***Category***		**F**

Sout Site 5 (Hotnotskraal tributary)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**20**	Water abstraction	13	**14**
Flow modification	13	**13**	Inundation	11	**1**
Bed modification	13	**13**	Flow modification	12	**13**
Channel modification	13	**10**	Water quality	13	**8**
Water quality	14	**18**	Indigenous vegetation removal	13	**15**
Inundation	10	**1**	Exotic vegetation encroachment	12	**2**
Exotic macrophytes	9	**0**	Bank erosion	14	**6**
Exotic fauna	8	**0**	Channel modification	12	**15**
Solid waste disposal	6	**3**			
Category		**D**	***Category***		**E**

Sout Site 6 (Soutkuil)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**20**	Water abstraction	13	**13**
Flow modification	13	**18**	Inundation	11	**0**
Bed modification	13	**23**	Flow modification	12	**13**
Channel modification	13	**13**	Water quality	13	**10**
Water quality	14	**23**	Indigenous vegetation removal	13	**23**
Inundation	10	**3**	Exotic vegetation encroachment	12	**23**
Exotic macrophytes	9	**0**	Bank erosion	14	**20**
Exotic fauna	8	**0**	Channel modification	12	**13**
Solid waste disposal	6	**0**			
Category		**E**	***Category***		**F**

Sout Site 7 (Klipdale)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**15**
Flow modification	13	**16**	Inundation	11	**0**
Bed modification	13	**15**	Flow modification	12	**11**
Channel modification	13	**12**	Water quality	13	**10**
Water quality	14	**20**	Indigenous vegetation removal	13	**15**
Inundation	10	**5**	Exotic vegetation encroachment	12	**11**
Exotic macrophytes	9	**0**	Bank erosion	14	**20**
Exotic fauna	8	**0**	Channel modification	12	**18**
Solid waste disposal	6	**0**			
Category		**E**	***Category***		**F**

Sout Site 8 (Wydgeleë)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**18**
Flow modification	13	**17**	Inundation	11	**1**
Bed modification	13	**15**	Flow modification	12	**17**
Channel modification	13	**12**	Water quality	13	**15**
Water quality	14	**21**	Indigenous vegetation removal	13	**5**
Inundation	10	**2**	Exotic vegetation encroachment	12	**5**
Exotic macrophytes	9	**0**	Bank erosion	14	**3**
Exotic fauna	8	**1**	Channel modification	12	**13**
Solid waste disposal	6	**0**			
Category		**E**	***Category***		**E**

Kars Site 1 (Schietpad)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**12**	Water abstraction	13	**12**
Flow modification	13	**10**	Inundation	11	**8**
Bed modification	13	**11**	Flow modification	12	**10**
Channel modification	13	**8**	Water quality	13	**10**
Water quality	14	**18**	Indigenous vegetation removal	13	**11**
Inundation	10	**8**	Exotic vegetation encroachment	12	**17**
Exotic macrophytes	9	**0**	Bank erosion	14	**17**
Exotic fauna	8	**0**	Channel modification	12	**8**
Solid waste disposal	6	**1**			
Category		**D**	***Category***		**E**

Kars Site 2 (Rooidraaibrug))

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**20**	Water abstraction	13	**19**
Flow modification	13	**15**	Inundation	11	**3**
Bed modification	13	**8**	Flow modification	12	**17**
Channel modification	13	**12**	Water quality	13	**16**
Water quality	14	**18**	Indigenous vegetation removal	13	**16**
Inundation	10	**3**	Exotic vegetation encroachment	12	**17**
Exotic macrophytes	9	**0**	Bank erosion	14	**4**
Exotic fauna	8	**0**	Channel modification	12	**16**
Solid waste disposal	6	**0**			
Category		**D**	***Category***		**F**

Kars Site 3 (Soutkloof)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**13**	Water abstraction	13	**4**
Flow modification	13	**6**	Inundation	11	**0**
Bed modification	13	**3**	Flow modification	12	**3**
Channel modification	13	**3**	Water quality	13	**3**
Water quality	14	**10**	Indigenous vegetation removal	13	**11**
Inundation	10	**0**	Exotic vegetation encroachment	12	**15**
Exotic macrophytes	9	**0**	Bank erosion	14	**5**
Exotic fauna	8	**1**	Channel modification	12	**3**
Solid waste disposal	6	**0**			
Category		**C**	***Category***		**C**

Nuwejaars Site 1 (Kersgat)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**10**	Water abstraction	13	**1**
Flow modification	13	**5**	Inundation	11	**0**
Bed modification	13	**5**	Flow modification	12	**0**
Channel modification	13	**5**	Water quality	13	**1**
Water quality	14	**7**	Indigenous vegetation removal	13	**5**
Inundation	10	**5**	Exotic vegetation encroachment	12	**18**
Exotic macrophytes	9	**0**	Bank erosion	14	**2**
Exotic fauna	8	**0**	Channel modification	12	**4**
Solid waste disposal	6	**1**			
Category		**B**	***Category***		**C**

Nuwejaars Site 2 (Brakpan)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**15**	Water abstraction	13	**5**
Flow modification	13	**7**	Inundation	11	**0**
Bed modification	13	**3**	Flow modification	12	**2**
Channel modification	13	**8**	Water quality	13	**5**
Water quality	14	**12**	Indigenous vegetation removal	13	**15**
Inundation	10	**0**	Exotic vegetation encroachment	12	**18**
Exotic macrophytes	9	**0**	Bank erosion	14	**11**
Exotic fauna	8	**1**	Channel modification	12	**11**
Solid waste disposal	6	**0**			
Category		**C**	***Category***		**E**

Pietersielieskloof

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**4**	Water abstraction	13	**5**
Flow modification	13	**13**	Inundation	11	**1**
Bed modification	13	**20**	Flow modification	12	**5**
Channel modification	13	**13**	Water quality	13	**1**
Water quality	14	**15**	Indigenous vegetation removal	13	**20**
Inundation	10	**2**	Exotic vegetation encroachment	12	**24**
Exotic macrophytes	9	**0**	Bank erosion	14	**7**
Exotic fauna	8	**0**	Channel modification	12	**7**
Solid waste disposal	6	**0**			
Category		*D*	***Category***		**E**

Klein Pietersielieskloof

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**18**	Water abstraction	13	**5**
Flow modification	13	**8**	Inundation	11	**0**
Bed modification	13	**25**	Flow modification	12	**5**
Channel modification	13	**18**	Water quality	13	**0**
Water quality	14	**20**	Indigenous vegetation removal	13	**25**
Inundation	10	**1**	Exotic vegetation encroachment	12	**25**
Exotic macrophytes	9	**0**	Bank erosion	14	**25**
Exotic fauna	8	**0**	Channel modification	12	**20**
Solid waste disposal	6	**0**			
Category		**E**	***Category***		**F**

Heuningnes (Riverside)

Instream Criteria	***Weight***	***Score***	**Riparian Zone Criteria**	***Weight***	***Score***
Water abstraction	14	**7**	Water abstraction	13	**5**
Flow modification	13	**3**	Inundation	11	**0**
Bed modification	13	**2**	Flow modification	12	**2**
Channel modification	13	**3**	Water quality	13	**5**
Water quality	14	**5**	Indigenous vegetation removal	13	**15**
Inundation	10	**0**	Exotic vegetation encroachment	12	**5**
Exotic macrophytes	9	**0**	Bank erosion	14	**4**
Exotic fauna	8	**10**	Channel modification	12	**3**
Solid waste disposal	6	**0**			
Category		**B**	**Category**		**C**

APPENDIX D

Indigenous riparian species list

Species name	Growth form	Species name	Growth form
Acacia karoo	T	*Ischerolepis capensis*	g
Agapanthus africana	A	*Juncus kraussii*	g
Agathosma spp.	S	*Leonotis leonurus*	s
Aloe ferox	Suc	*Leucodendron xanthoconus*	s
Aponogeton distachyos	Aq	*Leucospermum cordifolium*	s
Asparagus sp.	S	*Lycium cinereum*	s
Athanasia dentate	S	*Meleanthus major*	s
Atriplex lindleyi	S	*Metalasia muricata*	s
Avena fatua	G	*Metrosiderous*	s
Berzilia lanuginose	S	*Olea europa subs. Africana*	t
Brunia allepeceriodes	S	*Phragmites australis*	r
Calopsis sp.	G	*Podocarpus latifolius*	t
Carpobrotus aciniformes	Suc	*Prionium serratum*	g
Chrysanthemoides monilifera	S	*Protea spp.*	s
Cliffortia strobilifera	S	*Psoralea pinnata*	t
Common fern	H	*Restio spp.*	g
Cynodon dicotylon	G	*Rhus augustiflora*	s
Cunnunia capensis	T	*Rhus dentata*	s
Cussonia spicata	T	*Rhus lancea*	t
Cyperus spp.	G	*Rhus lucida*	s
Diplachne fusca	G	*Rhus undulata*	s
Ehrata ramose	G	*Salix mucronata*	t
Eletropappus rhinocerocus	S	*Salvia africana-lutea*	s
Erica spp	S	*Sarcocornia xerophila*	s
Erica sessiliflora	S	*Stenotaphrum secundatum*	g
Ficinia oligantha	G	*Typha capensis*	g
Grewia sp.	T	*Wachendorfia thyrsiflora*	h
Helichrysum crispum	H	*Zantedeschia aethiopica*	h

*The species list contains plants that are significant to the intactness of the riparian zone as surveyed. The growth forms listed are either (t) tree, (s) shrub, (suc) succulent, (a) annual, (p) perennial, (h) herb, (aq) aquatic plant or (g) for sedges and grasses.

Alien species names and invasion index

Species name	Weed status	Growth form	Species name	Weed status	Growth form
Acacia cyclops	2	T	*Nerium oleander*	1	s
Acacia longifolia	1	T	*Optunia spp.*	1	suc - s
Acacia mearnsii	2	T	*Paraserianthes lopantha*	1	t
Acacia melanoxylon	2	T	*Pennisetum setaceum*	1	p
Acacia pycnantha	1	T	*Pinus spp.*	2	t
Acacia saligna	2	T	*Populus spp.*	1	t
Arundo donax	1	R	*Rubus spp.*	1	s
Cortaderia selloana	1	G	*Salix babylonica*	2	t
Eucalyptus spp.	2	T	*Sesbania punicea*	1	t
Leptospermum laevigatum	1	S	*Solanum elaeagnifolium*	1	s
Nasturtium officinale	*2*	*H*			

*Weed status as declared = 1 (high threat), 2 (moderate threat), 3 (low threat). The growth forms listed are either (t) tree, (s) shrub, (suc) succulent, (p) perennial, (r) reed, (h) herb, or (g) for sedges and grasses.

Appendix E

Species list of indigenous fish found in the Overberg Monitoring Surveys

Scientific name	Common name	Conservation status
Galaxias zebratus	Cape galaxias	Near threatened
Sandelia capensis	Cape kurper	Near threatened
Gilchristella aestuaria	Estuarine round-herring	Near threatened
Monodactylus falciformis	Cape moony	Near threatened
Myxus capensis	Freshwater mullet	Vulnerable
Pseudobarbus burchelli	Burchell's redfin	Endangered
Awaous aeneofuscus	Freshwater goby	Not threatened
Solea Bleekeri	Sole	Not threatened

Species list of alien fish found in the Overberg Monitoring Surveys

Scientific name	Common name	Impact on indigenous biota
Cyprinus carpio	Carp	Competitor, habitat degrader
Gambusia affinis	Mosquito fish	Competitor
Lepomis macrochirus	Bluegill sunfish	Predator and competitor
Micropterus dolomieu	Small-mouth bass	Predator
M. punctalatus	Spotted bass	Predator
M. salmoides	Large-mouth bass	Predator
Oreochromis mossambicus	Mozambique tilapia	Primary competitor
Oncorhynchus mykiss	Rainbow trout	Predator

APPENDIX F

CHANNEL CHANGES DUE TO FLOODING DURING APRIL 2005

Klein Pietersielieskloof River pre-flood (looking upstream)

Klein Pietersielieskloof River post-flood

Pietersielieskloof River pre-flood (Feb 2005)

Pietersielieskloof post-flood

Lower Bot River pre-flood (looking downstream)

Lower Bot River post-flood

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