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DEPARTMENT OF WATER AFFAIRS
AND FORESTRY
DIRECTORATE OF WATER RESOURCES PLANNING

BREEDE RIVER BASIN STUDY

ECOLOGICAL RESERVE DETERMINATION (WATER QUALITY)

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DEPARTMENT OF
WATER AFFAIRS AND FORESTRY

BREEDE RIVER BASIN STUDY

ECOLOGICAL RESERVE DETERMINATION
(WATER QUALITY)

Final

MAY 2003

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BREEDE RIVER BASIN STUDY

ECOLOGICAL RESERVE DETERMINATION (WATER QUALITY)

EXECUTIVE SUMMARY

RESERVE DETERMINATIONS UNDERTAKEN FOR THE BREEDE RIVER BASIN STUDY

Environmental sustainability forms one of the cornerstones of the National Water Act. In recognition of this, and to provide the information that would be required to ascertain the availability of water at particular locations in the Breede River catchments and to set a Preliminary Reserve in the Breede Water Management Area, a considerable portion of Study resources was directed toward determining the ecological water requirements of the aquatic ecosystems in the catchments of the Breede River.

Reserve determinations were carried out for the following components of the Reserve :

- Groundwater, documented in Report PH 00/00/1202 *Groundwater Reserve Determination.*
- The Papenkuils Wetland, documented in Report PH 00/00/1402 *Papenkuils Wetland Intermediate (Ecological) Reserve Determination (Low Confidence).*
- Riverine water quantity, documented in Report PH 00/00/1302 *Ecological Reserve Determination for Six Representative Sites using the Building Block Methodology*.
- Riverine water quality, documented in Reports PH 00/00/3402 *Ecological Reserve Determination (Water Quality)*, and PH 00/00/3602 *Ecological Reserve Determination (Water Quality) – Recalculation of the Water Quality Reserve*.
- The Breede River Estuary, documented in Report PH 00/00/1102 *Intermediate Determination of Resource Directed Measures for the Breede River Estuary.*

The geographical spread and confidence levels of the determinations were planned to deliver, as far as present knowledge and available resources permitted, Reserve determinations commensurate with the management needs of the Breede River catchments. The Study findings represent scientific estimates of the ecological water requirements of the aquatic ecosystems in the Breede River catchments. The socio-economic implications of the implementation of Reserves at the recommended levels (Ecological Management Categories) should therefore be carefully considered prior to the setting of a preliminary Reserve. Before a comprehensive Reserve can be set, a separate stakeholder consultation process must first take place.

Numerous interrelations exist between the different components of the Reserve in the Breede River Basin. These had to be taken into account to provide an accurate reflection of current and future water availability. This information will also be required when setting a Preliminary Reserve, and to manage

the system accordingly. Relatively simple integration procedures were therefore developed during the course of the Study, and the findings of this work are reported on in the *Main Report* of the Study (Report PH 00/00/3102)

Very little experience has thus far been gained in the implementation and management of Reserves in South Africa, and little is known about the effectiveness of the ecological water requirements (EWRs) in achieving the recommended ecological management categories. In recognition of the limited experience available, further study work was approved to explore the implications that the system-wide implementation of recommended EWRs may have on water availability in the Basin. This work is also documented in the *Main Report*.

WATER QUALITY RESERVE DETERMINATION

Background to Water Quality in the Breede River Basin

Most of the runoff in the Breede River and its tributaries originates in relatively pristine high rainfall source areas underlain by sandstone rocks of the Table Mountain Group (TMG). Consequently, the natural quality of most of the streamflow is excellent. Historically, the dominant water quality issue in the Breede River catchment has been progressively rising salinities in the middle and lower reaches of the main stem, as well as in certain tributaries, such as the Kogmanskloof and the Poesjenels, due to increasing irrigation return flows.

Eutrophication is the increase in plants nutrients, phosphorus and nitrogen, in rivers and streams and the resultant proliferation of rooted and free floating aquatic plants in the watercourses. Dissolved or ortho-phosphate concentrations are generally low in rivers and streams that are unimpacted by manmade activities. The ortho-phosphate concentrations in the headwaters of the Breede River and its tributaries are generally low. However, elevated concentrations occur in the lower reaches of the Hex, Kogmanskloof and Buffeljags Rivers. These are generally associated with manmade activities such as leaching from fertilised agricultural areas or the discharge of treated effluents into river courses. The main source is probably treated effluents being discharged into the river and its tributaries.

Dissolved nitrogen concentrations in the Breede River Basin show similar spatial trends to those observed in the phosphate concentrations. Elevated dissolved nitrogen concentrations have been observed in the downstream reaches of the Hex and Kogmanskloof Rivers, and these are mostly associated with agriculture in the area.

Concerns have also been expressed about suspended sediment loads as a result of inappropriate farming practises such as not adhering to guidelines for establishing buffer strips next to watercourses or changing watercourses. Concerns have also been expressed about the bacteriological quality of the water in the Breede River and its tributaries.

Lastly, concerns have also been expressed about the presence of agrochemicals in surface and ground waters in the Breede River catchment. A Water Research Commission project, which was completed recently, investigated the quality of surface and ground water supplies in the rural Western Cape with

regard to agrochemicals (London *et al*. 2000). Initial findings indicate that even though endosulfan and chlorpyrifos levels were low, elevated levels of these pesticides have been recorded in the Hex River study area. It is assumed that the pesticide situation would probably be similar in other areas in the Breede River catchment where pesticides are used for intensive agriculture.

The Water Quality Reserve

The water quality reserve is a description of the water quality that is required to maintain the aquatic ecosystem in a predetermined state. The water quality reserve determination is generally synchronised with the determination of the water quantity reserve. Information is exchanged at various stages during the two determination processes. The water quality team participates in the water quantity specialist workshop to contribute water quality aspects to the deliberations about the flow requirements. After the flows have been recommended to achieve the specific level of protection, the water quality that would achieve the same level of protection is specified. This becomes the ecological water quality Reserve because it only considers the needs of the aquatic ecosystem.

The first two steps of the reserve determination process were the same for the quality and quantity procedures. During this step the boundaries of the study area (the Breede River Basin) and the level of the determination (a comprehensive determination) were specified by the Department. The next step was to subdivide the study area into resource units for which a Reserve was determined. For the water quality Reserve determination, the study area was divided into 10 water quality resource units (Table E1) that corresponded largely to the IFR resource units.

TABLE E1 : WATER QUALITY RESOURCE UNITS

WATER QUALITY RESOURCE UNIT	DESCRIPTION	CORRESPONDING IFR UNIT
1	Upper Breede River from origin to Wit River confluence	IFR 1
2	Upper Breede River from Wit River to Molenaars confluence	
3	Middle Breede River from Molenaars to Kogmanskloof confluence	IFR 3
4	Middle Breede River from Kogmanskloof to Riviersonderend confluence	
5	Lower Breede River from Riviersonderend to Buffelsjags River	
6	Lower Breede River from Buffelsjags to estuary	IFR 4
7	Riviersonderend River from Theewaterskloof Dam to Bok River	IFR 5
8	Riviersonderend River from Bok River to Breede River confluence	
9	Baviaans River	IFR 6
10	Molenaars River	IFR 2

The next step was to identify monitoring points in each resource unit which could be used to characterise background or natural conditions in the reach and a monitoring point that could be used to characterise the present water quality status in the reach. This informed the determination process of what water quality conditions should have been like under natural conditions and what it was at present. At the specialist workshop, the level of protection that was required to maintain the ecosystem in a specific

ecological category, was recommended for each resource unit. The water quality that would maintain the aquatic ecosystem in the recommended ecological category was then determined.

The present water quality status and the recommended water quality category and the status of the other components of the reserve are summarised in Table E2.

TABLE E2 : PRESENT ECOLOGICAL STATUS AND RECOMMENDED ECOLOGICAL RESERVE CATEGORIES

WATER QUALITY RESOURCE UNIT	PRESENT STATE (DWAF, 2002)[3]							EIS[2]	WQ[1] ERC
	HYDROLOGY	GEO-MORPHOLOGY	VEGETATION	FISH	INVER-TEBRATES	ECO-SYSTEM	WQ[1]		
1 (IFR 1)	D	D/E	D/E	D/E	D/E	D/E	B	M	B
2							C		B
3 (IFR 3)	C/D	C	C	D	D	C/D	B	M	B
4							C/D		C
5							C		C
6 (IFR 4)	C	B	C	C	C	C	C	H	C
7 (IFR 5)	E	E	E	E	C/D	E	B	H	B
8							B/C		B
9 (IFR 6)	B	B	C	A/B	A/B	B	A/B	VH	A/B
10 (IFR 2)	A/B	B	B/C	E	A/B	B	A/B	VH	A/B

1 WQ = Water quality, water quality categories as determined in this water quality Reserve study..

2 VH = very high, H = high, M = moderate, L = low environmental importance & sensitivity.

3 Present states for the other ecosystem components were only determined at the IFR sites during the quantity Reserve study.

The Reserve is aimed at the provision of water of a quality suitable for human consumption and for aquatic ecosystems, and does not address water quality for other uses such as irrigation. The analyses of water samples drawn from the various water quality sampling points indicate that these quality requirements are likely to be met throughout the system if Reserve quantity requirements are also met.

Throughout the Breede River Basin there are reaches and tributaries with particularly good water quality. These play an important role in the improvement of downstream water quality conditions, and potentially act as refugia for biota from adjacent, more impacted, reaches. These areas were identified and it is recommended that they be protected in order to maintain the downstream river health. Likewise there are reaches and tributaries that have been severely impacted by irrigation return flows. These reaches impact negatively on the downstream reaches and it is recommended that measures should be taken to improve water quality where these are situated upstream of important or sensitive ecosystems.

It is recommended that regular monitoring of dissolved oxygen, temperature and turbidity (or suspended solids) be undertaken to monitor compliance with the water quality Reserve specifications. Efforts should

also be made to link the monitoring of river health to the biotic objectives as per the revised water quality Reserve methodology that became available in 2002.

RECALCULATION OF THE RESULTS PRESENTED IN THIS REPORT

While the Breede River Reserve Study was underway, the Department initiated a project to review and to revise the water quality Reserve methodology. In January 2003, the Breede River Basin Study (BRBS) water quality team met with the Resource Directed Measures (RDM) Directorate and the Directorate of Water Resources Planning and it was decided that :

1. this report should be completed by incorporating all the comments received, and
2. the water quality Reserve be recalculated using the new methodology and incorporating the results into a new extended executive summary.

The Reserve results in this report therefore refer to the methods that were available from the RDM Office at the time the study was done in 2001. The results of the recalculated Reserve are documented in Report No. PH 00/00/3602 (2003). The layout of the latter report mimics the format in which the results are presented to the Director General for approval. This was done at the request of the Resource Directed Measures (RDM) Directorate to facilitate the transfer of the results into the standard RDM reporting format.

BREEDE RIVER BASIN STUDY

ECOLOGICAL RESERVE DETERMINATION (WATER QUALITY)

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APPENDICES

TERMS AND ABBREVIATIONS

Assessment category	The DWAF Resource Protection policy includes the process of classification. A water resource is described as being in a Category (A-F). Each category is described in terms of the water quality, water quantity, habitat, and biotic composition, which are appropriate for a particular level of ecosystem health. A Category A resource is near to natural, a Category D resource is used to capacity, and Category E or F resources have been used beyond a level which is sustainable, and are degraded and degrading. The assessment category is the category that a particular resource is judged to be in at the time of evaluation, and is part of the description of the Present Ecological State (PES).
AEV	Acute Effects Value - a calculated value, based on toxicity results, that is a measure of organism response to toxic substances in the short term (exposures of less than 4 days).
Box and whisker plots of monthly TDS concentrations	The month numbering of the box and whisker plots is based on the calendar year, January being the first month.
BRBS	Breede River Basin Study
CEV	Chronic Effects Value - a calculated value, based on toxicity results, that is a measure of organism response to toxic substances in the longer term (exposures of more than 10 days).
DWAF	Department of Water Affairs and Forestry
EMC	Ecological Management Class - the Class for which management objectives should be set for a resource.
IFR	instream flow requirements
IWQS	Institute for Water Quality Studies
km^2	square kilometres
m^3/s	cubic metres per second
mg/ℓ	milligrams per litre - to define the concentration of dissolved solids.
mS/m	milli-Siemens per metre - units of electrical conductivity used to define dissolved solids concentrations
Nutrients	Chemicals which plants use for growth, and which contribute to algal growth in aquatic ecosystems. They are forms of nitrogen and phosphorus, and include nitrate, nitrite, and phosphate. Ammonia can be considered as a nutrient and as a toxicant, as it is a toxic form of nitrogen.
PES	Present Ecological State - a description of the current status of a range of ecological components (water quality, aquatic invertebrates, fish, etc.).
pH	A measure of acidity or alkalinity of the water.
RDM	Resource Directed Measures

Temp	Temperature of the water.
TDS	Total Dissolved Solids - a measure of salinity. Salinity can also be measured as EC or Electrical Conductivity.
TMS	Table Mountain Sandstone.
Toxicity	A term describing a measure of the harmfulness of chemicals to living organisms. Certain chemicals, such as salts, might only be harmful when they occur in much higher concentrations than is natural. Other chemicals, such as pesticides and metal ions, can be toxic in very low concentrations.
TSS	Total Suspended Solids - a measure to turbidity, or the amount of fine suspended material in the water.
TWQR	Target Water Quality Range - the concentration of a particular chemical that will ensure protection of aquatic resources and biota. Used in the South African Water Quality Guidelines.

BREEDE RIVER BASIN STUDY

ECOLOGICAL RESERVE DETERMINATION (WATER QUALITY)

1. INTRODUCTION

Preface

While the Breede River Reserve Study was underway, the Department initiated a project to review and to revise the Reserve water quality methodology. The new methodology became available during the last quarter of 2002. Early in 2003, the Breede River Basin Study (BRBS) water quality team met with the Resource Directed Measures (RDM) Directorate and the Directorate of Water Resources Planning and it was decided that :

1. this report should be completed by incorporating the all the comments received, and
2. the water quality Reserve be recalculated using the new methodology and incorporating the results into a new extended executive summary.

The Reserve results in this report refer to the methods that were available from the RDM Office at the time the study was done. The results of the recalculated Reserve are documented in DWAF Report No. PH 00/00/3602 (2003).

Introduction

The Breede River is the largest river in the Western Cape and one of the most heavily utilised water resources in the region. The river originates in the Ceres Valley and flows in a south-easterly direction until it reaches the Indian Ocean at St Sebastian Bay on the Southern Cape Coast. The Breede River has developed into one of the largest wine and food producing regions in South Africa and is an important area for the production of high value crops under intense cultivation. Historically, the major water quality issue has been the rising salinities in the Middle to Lower Breede River as well as some of the tributaries in this section of the basin. The major aim of this report is to assess the status of the river with respect to the salinity situation.

Description of Study Area

The headwaters of the Breede River are situated along the Skurweberg and Gydoberg Mountains in the Ceres Basin and the Hex River Mountains. The Upper Breede River originates in the Ceres basin and drains through Michell's Pass in a south-easterly direction to join with the Riviersonderend before reaching the Indian Ocean at St Sebastian Bay. The Breede River is bordered on the north and south-west by high mountain ranges composed of quartizites and sandstones of the Table Mountain Group. The sandstone and shales of the Bokkeveld and Witteberg groups dominate the area south of the Breede River, while the valley itself is

comprised of sediments from the Dwyka and Ecca groups. The total catchment area is about 12 600 km^2.

1.1 Background to Water Quality in the Breede River Basin

Most of the runoff in the Breede River and its tributaries originates in relatively pristine high rainfall source areas underlain by sandstone rocks of the Table Mountain Group (TMG). Consequently, the natural quality of most of the streamflow is excellent. Historically, the dominant water quality issue in the Breede River catchment has been progressively rising salinities in the middle and lower reaches of the main stem, as well as in certain tributaries, such as the Kogmanskloof and the Poesjenels, due to increasing irrigation return flow impacts.

The central and lower river valley is underlain by, *inter alia*, shales and conglomerates that give rise to high groundwater salinities, which may become exacerbated by percolating return flows. In the Hex River Valley, where the presence of high-yielding aquifers has led to groundwater being a major source of irrigation water, groundwater salinities are rising due to irrigation return flows. In other words, a semi-closed loop effect of salinisation may be developing.

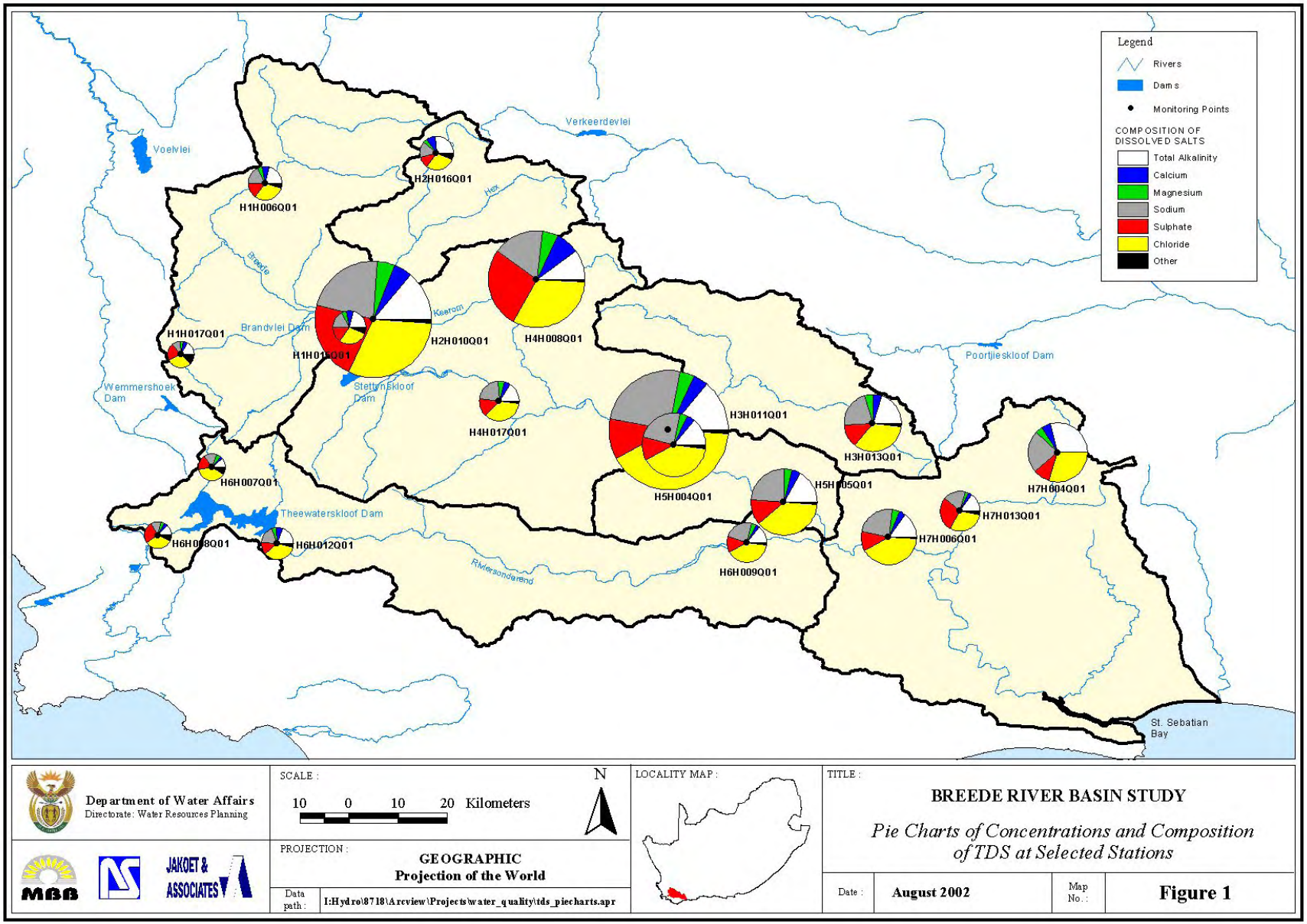
1.2 Salinity Status of the Breede River Basin

Salinisation is the increase in salinity of water and the problems that different water users experience as a result of the higher inorganic salt content.

Since the 1960s, salinity concentrations in the Breede River increased considerably during the summer months. This has lead to concerns being expressed about the fitness of the water for the irrigation of high-value, salt sensitive crops. As a result of these concerns, a number of studies have been undertaken to determine the origins of salts that are observed in the Breede River and to identify ways to manage salinisation of the river.

The median total dissolved solids (TDS) concentrations observed over the past ten years at selected monitoring stations in the Breede River, were plotted as pie diagrams in Figure 1. The size of the circle is proportional to the TDS concentration. From Figure 1, it can be seen that the TDS concentrations in the headwaters of the Breede River and the Riviersonderend were low. The concentrations then increased in a downstream direction. The highest increase took place in the Breede River (H4 sub-catchment) between Brandvlei Dam and the Bonnievale area (H5H004Q01 and H5H005Q01 monitoring stations). There was then a reduction in TDS downstream of the Riviersonderend confluence. A minor increase in TDS was observed along the Riviersonderend River. The high salinities in the lower reaches of the Hex, Koo and Kogmanskloof Rivers are also evident from Figure 1.

The major ions and cations making up the composition of the TDS concentration, are also illustrated in Figure 1. There do not seem to be major changes in the TDS composition in the Breede River Basin.


Legend
Rivers
Dams
Monitoring Points
COMPOSITION OF DISSOLVED SALTS
Total Alkalinity
Calcium
Magnesium
Sodium
Sulphate
Chloride
Other
Voelvlei
Verkeerdevlei
Breede
Keerom
Brandvlei Dam
Wemmershoek Dam
Stettynskloof Dam
Theewaterskloof Dam
Poortjieskloof Dam
R.Riversonderend
St. Sebatian Bay
H1H006Q01
H2H016Q01
H1H017Q01
H1H015Q01
H2H010Q01
H4H008Q01
H4H017Q01
H3H011Q01
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Department of Water Affairs
Directorate: Water Resources Planning
SCALE :
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LOCALITY MAP :
TITLE :
BREEDE RIVER BASIN STUDY
Pie Charts of Concentrations and Composition of TDS at Selected Stations
PROJECTION :
GEOGRAPHIC
Projection of the World
Data path :
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Date :
August 2002
Map No. :
Figure 1

However, it appears that the chloride content of the TDS increases in a downstream direction. This increase would need to be investigated further. The sulphate content in the Koo and Hex Rivers areas appeared to be higher that in other parts of the Breede River Basin which may warrant further investigation.

1.3 Nutrient Status of the Breede River Basin

Eutrophication is the increase in plants nutrients, phosphorus and nitrogen, in rivers and streams and the resultant proliferation of rooted and free floating aquatic plants in the watercourses.

Basin wide trends in ortho-phosphate concentrations

Dissolved or ortho-phosphate concentrations are generally low in rivers and streams that are unimpacted by manmade activities. The ortho-phosphate concentrations in the headwaters of the Breede River and its tributaries were generally low. There was a minor increase in the median concentrations along the Breede River. However, elevated concentrations were observed at the lower reaches of the Hex, Kogmanskloof and Buffeljags Rivers. These are generally associated with manmade activities such as leaching from fertilised agricultural areas or the discharge of treated effluents into river courses. The main source is probably treated effluents being discharged into the river and its tributaries.

Basin wide trends in dissolved nitrogen concentrations

The dissolved nitrogen concentrations in the Breede River Basin showed similar spatial trends to those observed in the phosphate concentrations. There appeared to be a very minor increase in the median dissolved nitrogen concentrations along the length of the Breede River. However, the median concentrations below Brandvlei Dam (H1H015Q01) appeared to be higher that those observed further downstream. Elevated dissolved nitrogen concentrations have also been observed in the downstream reaches of the Hex and Kogmanskloof Rivers, and these are mostly associated with agriculture in the area.

1.4 Summary

The two key water quality problems in the Breede River basin that have received most attention have been salinisation of the river and high nutrient concentrations in some reaches of the river and its tributaries.

Concerns have also been expressed about **suspended sediment loads** as a result of inappropriate farming practises such as not adhering to guidelines for establishing buffer strips next to watercourses or changing watercourses.

Concerns have also been expressed about the **bacteriological quality** of the water in the Breede River and its tributaries.

Lastly, concerns have also been expressed about the presence of **agrochemicals** in surface and ground waters in the Breede River catchment. A Water Research Commission project which was completed recently, investigated the quality of surface and ground water supplies in the rural western Cape with regard to agrochemicals (London *et al*. 2000). Initial findings indicate that even though endosulfan and chlorpyrifos levels were low, elevated levels of these pesticides have been recorded in the Hex River study area. It is assumed that the pesticide situation would probably be similar in other areas in the Breede River catchment where pesticides are used for intensive agriculture.

2. THE BREEDE RIVER BASIN

2.1 DELINEATION OF THE STUDY BOUNDARIES

The first step in a water quality Reserve study is to delineate the study area based on the criteria described in DWAF (1999) and in consultation with the water quantity Reserve team. The Breede River catchment comprises the drainage areas of six basins. These are the Ceres basin (upper part of H100), the Upper Breede River catchment (rest of H100), the Hex River catchment (H200), the Middle Breede River catchment (H300, H400, H500), the Riviersonderend catchment (H600), and the Lower Breede River catchment (H700). The Hex River was excluded from this Reserve study because a Reserve study was already underway in the Hex River catchment.

2.2 LEVEL OF RESERVE DETERMINATION

The Reserve determinations at the six IFR sites were undertaken at a comprehensive level but without any additional data collection. As part of a Water Research Commission project, water samples and river biota were collected at two sites (Appendix A) and the salt tolerance of the biota was determined in order to set boundaries for the different TDS categories. Reserve determinations were also undertaken for four additional water quality resource units (see Section 3) but these were done at a rapid/intermediate level depending on whether monitoring data were available for the additional resource unit.

3. DELINEATION OF THE WATER QUALITY RESOURCE UNITS

The Breede River was divided into six resource units for the water ***quantity*** Reserve determinations:

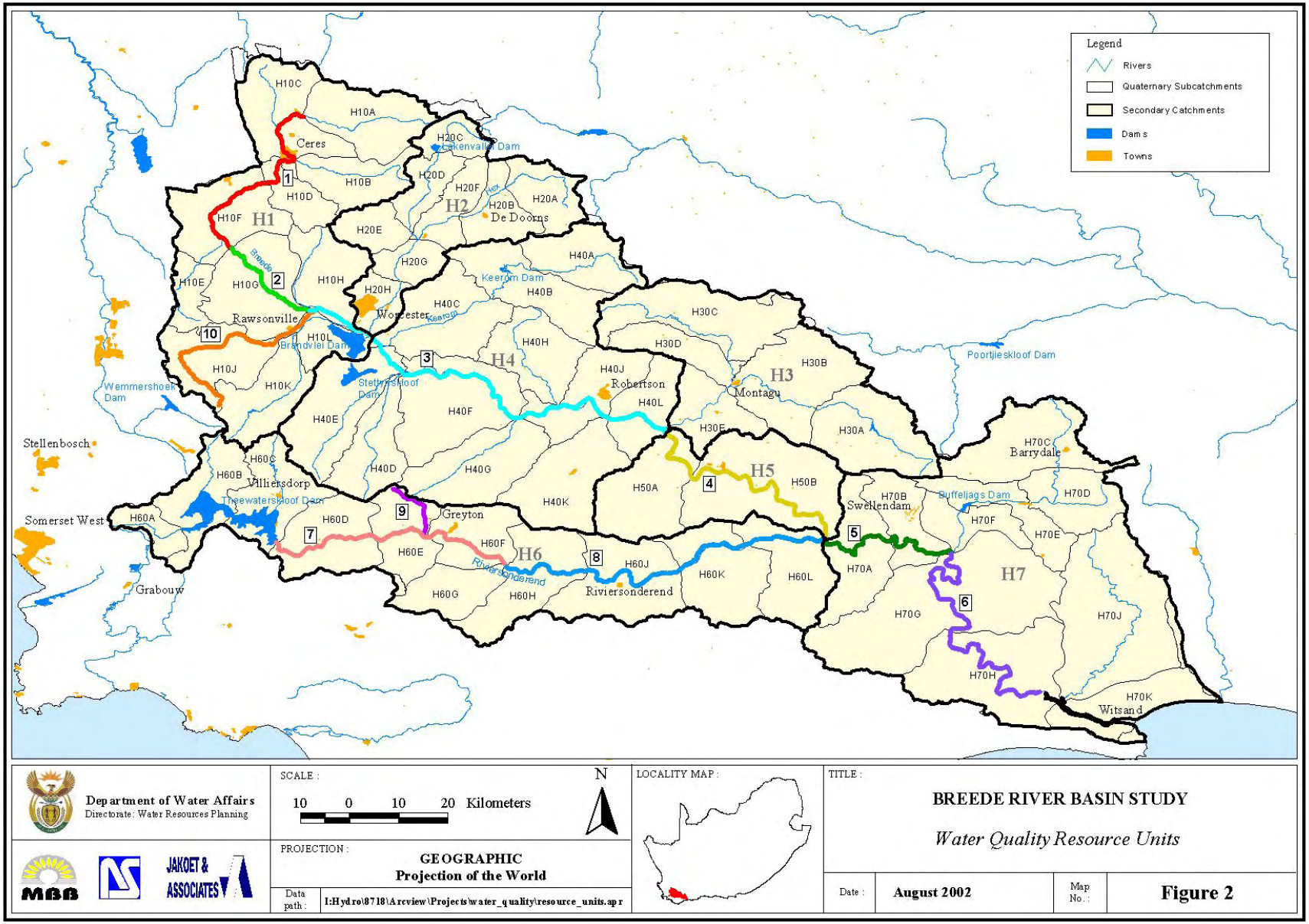
1. IFR1 – Upper Breede River from Witbrug to confluence with the Wit River.
2. IFR2 – Molenaars River from confluence with the Elands River to the confluence with the Tierkloof River.
3. IFR3 – Middle Breede River from Moordkuil to Bonnievale.
4. IFR4 – Lower Breede River from confluence with the Buffelsjags River to the head of the estuary.
5. IFR5 – Riviersonderend River from confluence with the Baviaans River to the town of Riviersonderend.
6. IFR6 – Baviaans River from the dam to the town of Genadendal.

For the water quality Reserve determination, the study area was divided into 10 water quality resource units (Table 1, Figure 2), most of which corresponded to the IFR resource units but adding additional resource units so that the complete Breede River is covered by water quality resource units. The additional water quality resource units were also in areas where there was evidence that the observed water quality was different from the upstream resource unit.

TABLE 1 : WATER QUALITY RESOURCE UNITS DEFINED FOR THE BREEDE RIVER WATER QUALITY RESERVE DETERMINATION

WATER QUALITY RESOURCE UNIT	DESCRIPTION	CORRESPONDING IFR UNIT
1	Upper Breede River from origin to Wit River confluence	IFR 1
2	Upper Breede River from Wit River to Molenaars confluence	
3	Middle Breede River from Molenaars to Kogmanskloof confluence	IFR 3
4	Middle Breede River from Kogmanskloof to Riviersonderend confluence	
5	Lower Breede River from Riviersonderend to Buffelsjags River	
6	Lower Breede River from Buffelsjags to estuary	IFR 4
7	Riviersonderend River from Theewaterskloof Dam to Bok River	IFR 5
8	Riviersonderend River from Bok River to Breede River confluence	
9	Baviaans River	IFR 6
10	Molenaars River	IFR 2

Water quality Reserves were not determined for the other Breede River tributaries but were referred to in the descriptions of the different main stem reaches.


Legend
Rivers
Quaternary Subcatchments
Secondary Catchments
Dams
Towns
H1
H2
H3
H4
H5
H6
H7
Ceres
De Doorns
Rawsonville
Worcester
Robertson
Montagu
Stellenbosch
Somerset West
Grabouw
Villiersdorp
Greyton
Riviersonderend
Swellendam
Barrydale
Witsand
Brandvlei Dam
Stettynskloof Dam
Keerom Dam
Theewaterskloof Dam
Wemmershoek Dam
Buffeljags Dam
Poortjieskloof Dam
Department of Water Affairs
Directorate: Water Resources Planning
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BREEDE RIVER BASIN STUDY
Water Quality Resource Units
PROJECTION :
GEOGRAPHIC
Projection of the World
Data path :
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Date :
August 2002
Map No. :
Figure 2
MBB
JAKOET & ASSOCIATES

4. SITE SELECTION AND AVAILABILITY OF WATER QUALITY DATA

The Breede River catchment has some 104 gauging stations where the Department of Water Affairs and Forestry collects water samples to characterise water quality in the Breede River basin. The length of the data record and sampling frequency differ from station to station. At best, it can be expected that the sampling stations were monitored on a weekly basis, but this is usually not the case.

The water quality monitoring points that were selected to characterise the water quality resource units are described under each water quality resource unit.

5. WATER QUALITY RESOURCE UNIT 1 – UPPER BREEDE RIVER TO WIT RIVER CONFLUENCE (INSTREAM FLOW REQUIREMENTS (IFR) 1 SITE)

5.1 DESCRIPTION

The closest monitoring site to the IFR 1 site at Mooiplaas is H1H006Q01 – Breede River at Witbrug. Between Witbrug and the IFR site there is quite intensive agricultural development consisting of mostly orchards and vineyards. Upstream of Ceres the agricultural land-use is mainly orchards and some dryland agriculture but few vineyards.

At present the TDS is moderate to low at the IFR site. TDS concentrations increased during the winter months which are an indication of a wash-off process mobilising salts in the catchment during high runoff (and flow) periods. There appears to be a first flush effect in May when TDS concentrations increase quite rapidly. TDS concentrations are low in the summer, specifically during the months of January to March.

On a multi-year scale, long-term TDS concentrations show a high/low TDS cycle of about 10 years. High TDS concentrations generally coincide with the wet years of the cycle and low TDS concentrations generally coincide with drier years of the cycle. This suggests that more salts are mobilised during the wetter years than during the drier years.

Nitrate is washed off the catchment during the high flow winter months resulting in elevated nitrogen concentrations in winter, peaking in about July. This is a wash-off process that also impacts on TDS. A relationship between nitrates and flow was observed. In summer, nitrates increase as flow increases up to a flow of about 3-4 m^3/s after which the concentrations do not increase further and gradually reduce during high flow events. In winter, the nitrates increase up to a flow of about 4-5 m^3/s after which the increase is reversed. Phosphates show no relationship with flow or season.

Toxic substances are of concern, specifically because the IFR site is so close to the intensive agricultural area of the Wolseley area. Pesticides are used in these areas to control pests and studies in the Hex River valley have found that pesticide residues are found in rivers flowing through intensive agricultural areas. No toxicity tests have been done in this resource unit to confirm the presence of pesticides or herbicides (London *et al*., 2000).

5.2 WATER QUALITY INFORMATION

The routine DWAF monitoring station closest to the IFR Site 1 is H1H006Q01 – Breede River at Ceres Commonage/Witbrug. The closest monitoring point on the RiversDatabase is H1BREE-WYSERS situated downstream of the IFR 1 site at Wysersdrift, Rawsonville. The monitoring point, H1H013Q01, on the Koekedou River was selected as reference site for this water quality resource unit.

REFERENCE STATE SITE	
Monitoring station	H1H013Q01 – Koekedou River at Ceres/Persephone
Sampling frequency	2 weekly
Full data record	08/20/1971 – 09/15/1999 (372 samples)
Data record used	01/01/1995 – 09/15/1999 (54 samples)
Data assessment	Good data record to characterise unimpacted conditions in the Upper Breede River.
PRESENT STATE DATA	
Monitoring station	H1H006Q01 – Breede River at Ceres Commonage/Witbrug
Sampling frequency	Weekly
Full data record	08/20/71 – 09/23/1999 (927 samples)
Data record used	01/01/1995 – 09/23/1999 (206 samples)
Data assessment	Moderate to poor to assess present state because of the distance between the DWAF monitoring station and IFR Site 1 further downstream.

5.3 REFERENCE CONDITIONS

Water quality at the reference site, H1H013Q01, is good and shows little seasonal variability.

Summary statistics of water quality at H1H013Q01 – Koekedou River at Ceres/Persephone (1995 - 1999).

VARIABLE	VALID N	MEAN	MEDIAN	MINIMUM	MAXIMUM	25%TILE	75%TILE	VARIANCE	STD.DEV.
EC	54	6.372222	6.2	3.3	10.1	5.2	7.1	2.591855	1.609924
TDS	54	38.87037	36.5	23	55	34	46	67.09609	8.19122
pH	54	6.62037	6.685	5.48	7.27	6.43	6.91	0.149362	0.386474
NA	54	5.107407	5.1	3	7.4	4.3	5.7	1.279189	1.131013
MG	54	1.492593	1.5	0.8	2.4	1.2	1.8	0.158057	0.397564
CA	54	2.968519	2.8	0.8	7.2	2	3.9	1.777292	1.333151
F	54	0.102037	0.09	0.05	0.34	0.07	0.11	0.003047	0.055197
CL	54	8.107407	7.65	4.6	15.5	6.5	9.8	4.856548	2.203758
NO_2NO_3	54	1.089074	0.718	0.154	4.257	0.533	1.517	0.773562	0.879524
SO_4	54	5.194444	4.9	1	9.7	3.6	6.5	4.076761	2.019099
PO_4	54	0.014407	0.013	0.003	0.053	0.008	0.018	7.59E-05	0.008712
TAL	54	8.040741	8.45	1.5	15.6	5.3	10	9.879441	3.143158
SI	54	2.909259	3	1.49	4.13	2.49	3.36	0.384037	0.619707
K	54	1.147963	1.025	0	3.84	0.59	1.47	0.472518	0.6874
NH_4	54	0.046093	0.0345	0	0.31	0.022	0.056	0.002099	0.045815

5.4 PRESENT WATER QUALITY STATE

5.4.1 Salinity

Long-term changes – there appears to be a small increasing trend in TDS although this is masked by a long-term cyclical change (about 10 years) in TDS (Figure 3). However, it appears that since the 1990s, there has been an increase in the frequency at which higher TDS concentrations were observed (represented by the 75 percentiles and maximum values).

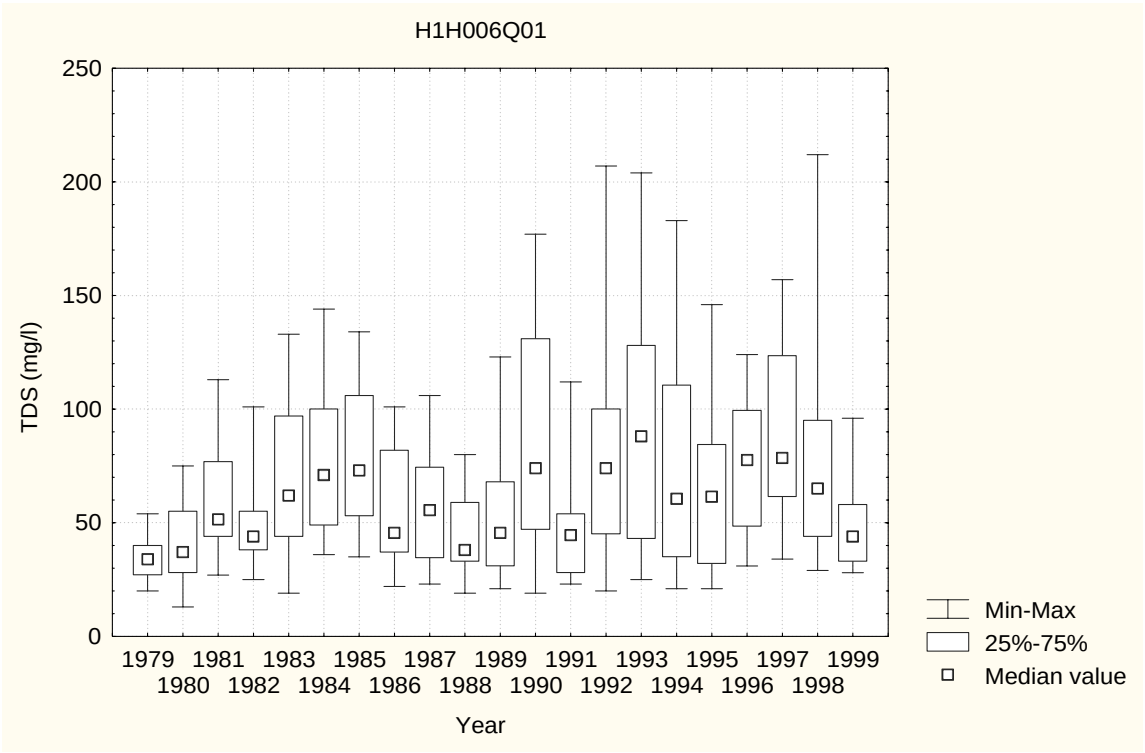

Figure 3 : Long-term changes in TDS measured in the Upper Breede River at H1H006Q01 - Breede River at Ceres/Witbrug

Seasonal changes – a strong seasonal cycle is evident in TDS with elevated TDS concentrations occurring during the winter months (Figure 4).

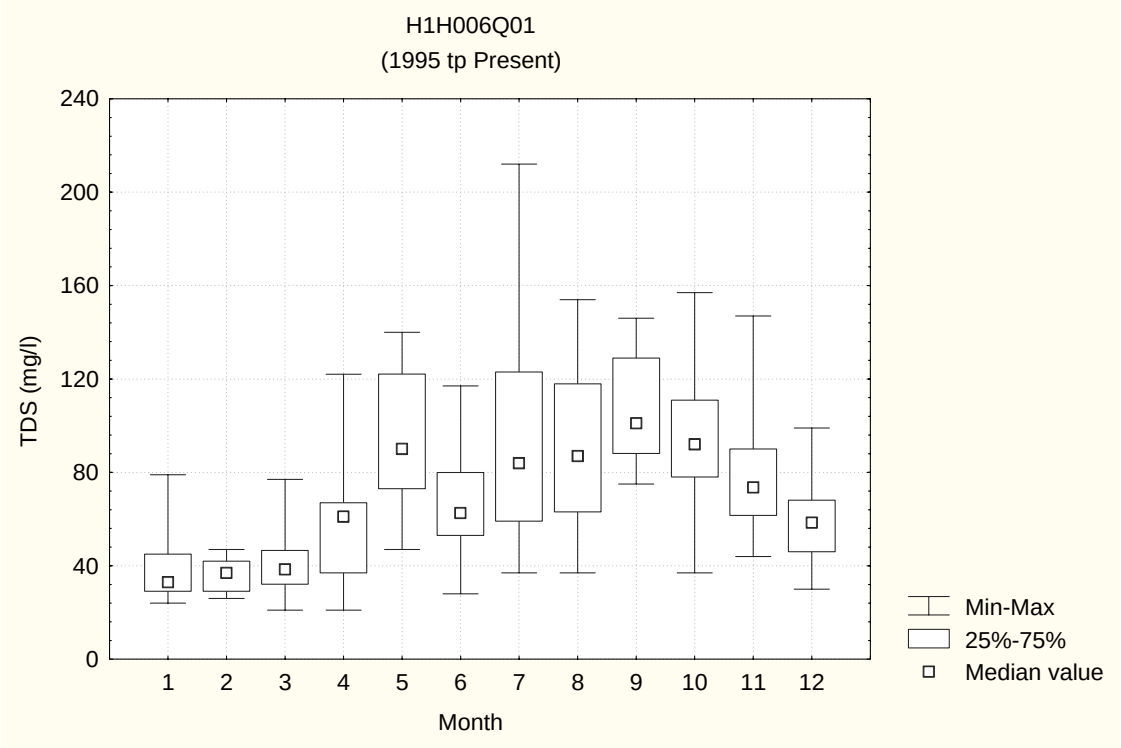

Figure 4 : Monthly box-and-whisker plot of TDS concentrations recorded in the Upper Breede River at H1H006Q01

The present TDS state falls well within a Category B river.

H1H006Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	29	29	32	37	73	53	59	63	88	78	62	46
50 percentile	33	37	39	61	90	63	84	87	101	92	74	59
75 percentile	45	42	47	67	122	80	123	118	129	111	90	68
Category	A	A	A	B	B	B	B	B	B	B	B	B

5.4.2 pH

The present pH state falls within a Category A river.

H1H006Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	7.0	6.8	7.0	7.0	7.2	6.9	7.0	7.0	7.4	7.3	7.3	7.1
50 percentile	7.1	7.0	7.2	7.3	7.3	7.2	7.3	7.4	7.4	7.4	7.5	7.2
75 percentile	7.2	7.2	7.4	7.4	7.4	7.3	7.4	7.4	7.6	7.5	7.5	7.5
Category	A	A	A	A	A	A	A	A	A	A	A	A

5.4.3 Temperature

No data available, no concerns about unnatural temperatures noted. RiversDatabase – 26.4°C was recorded on 15/01/2000.

5.4.4 Dissolved Oxygen

No data available. No concerns noted about low DO concentrations.

5.4.5 Total Suspended Solids

No TSS data available, medium to low sediment production area (Midgley *et al*. 1994). RiversDatabase – 2 NTU was recorded on 15/01/2000.

5.4.6 Nutrient Status

The median PO_4 concentration (1995 to present) was 0.032, which falls in a B category. The total inorganic nitrogen to PO_4 ratio of 9.25 puts the river in D category. It was argued that the overall nutrient status was probably a C category.

5.4.7 Toxic Substances

No measurements are available but research in the Hex River catchment (London *et al*. 2000) raised concerns about the impact of agricultural pesticides on river ecosystems, especially is heavily cultivated areas such as those directly upstream of IFR Site 1.

5.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: Moderate *Confidence:* High
Determinants: Presence of rare an endangered species. Presence of diversity of habitat types and refugia. Important for migration.
Social rating: Low
Determinants: Some subsistence fishing and recreation.
Information source: DWAF (2002)

5.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	D	D
Water Quality	B	B
Geomorphology	D/E	D/E→D
Riparian vegetation	D/E	D/E→D
Fish	D/E	D/E→D
Aquatic invertebrates	D/E	D
Ecosystem status	D/E	D/E
	Long term	D

Information source: DWAF (2002)

5.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS* (mg/ℓ)	B	B	<45	<45	<45	<300	<300	<300	<300	<300	<300	<300	<300	<300
			A	A	A	B	B	B	B	B	B	B	B	B
pH	A	B	Maintain within the current range of 6.5 to 7.7, based on the PES pH range											
Temp (°C)	-	B	Maintain within 3% of seasonal temperature pattern at reference site											
DO (% Sat)	-	B	Maintain between 80-100% saturation											
TSS (mg/ℓ)	-	B	Maintain within 15% of seasonal TSS pattern at reference site. Prevent biofilm formation by maintaining the flows at greater flows required to slightly move fines and clays (0.93 m^3/s) and gravel (1.98 m^3/s)											

***** Maintain the median summer (Jan – Mar) TDS concentrations < 45 mg/ℓ (Category A) and for the remaining months, < 300 mg/ℓ (Category B) for 95% of the time.

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	C	B	< 0.015 mg/ℓ
Ortho-phosphate (mg/ℓ)	C	B	< 0.05 mg/ℓ
Total inorganic nitrogen: Total phosphorus ratio	C	B	>10:1
Ortho-phosphate: Total phosphate (%)	C	B	<20%
NO_2NO_3-N (mg/ℓ)	C	B	Maintain winter concentrations at < 0.8 mg/ℓ for 95% of the time and summer concentrations < 0.5 mg/ℓ for 95% of the time.

Toxic substances

Pesticides are a concern as a result of intensive agriculture upstream of the IFR site.

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	B	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

Where CEV is the chronic effect value, AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

5.8 GENERAL CONSIDERATIONS

It is recommended that a monitoring programme be designed and implemented to collect temperature and dissolved oxygen data over at least one season at the reference site in order to characterise the natural variability in these two parameters.

6. WATER QUALITY RESOURCE UNIT 2 – BREEDE RIVER FROM WIT RIVER TO MOLENAARS RIVER CONFLUENCE

6.1 DESCRIPTION

The land-use changes from one dominated by orchards and some dryland crops in resource unit 1 to one where vineyards dominate as the main agricultural land-use. Although there are no monitoring points in this resource unit, SASS and ASPT scores seem to indicate that water quality in this reach is poorer and probably in a Category C. It was therefore identified as a separate water quality resource unit.

6.2 WATER QUALITY INFORMATION

No routine water quality monitoring point in this water quality resource unit.

6.3 REFERENCE CONDITIONS

Same as Section 5.3.

6.4 PRESENT WATER QUALITY STATE

There was no routine water quality monitoring point in this water quality resource unit and, based on the SASS and ASPT scores recorded in this study (WDAF, 2002), it was assumed that water quality would be at least one category poorer (Category C) as a result of the extensive farming in this water quality resource unit.

6.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

No ecological importance and sensitivity was assigned to this resource unit.

6.6 ECOLOGICAL RESERVE CATEGORY

No ecological Reserve category was assigned to this resource unit.

6.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

The ecological water quality specifications in this water quality resource unit were assumed to be the same as for IFR 1 resource unit (Section 5.7) thus proposing that the present water quality within this resource be improved from a PES of C to an EMC of B.

7. WATER QUALITY RESOURCE UNIT 3 – MIDDLE BREEDE RIVER FROM MOLENAARS TO KOGMANSKLOOF RIVER CONFLUENCE (IFR 3)

7.1 DESCRIPTION

There is a good water quality data record at the IFR 3 site. Water quality is measured on a regular basis at H4H017Q01 – Breede River at Le Chasseur.

TDS water quality at the Le Chasseur site is good because releases of low TDS water are made from Brandvlei Dam during the summer months in order to:

1. Meet the water quantity requirements of irrigation farmers. The river is used as a conduit for irrigation water released from Brandvlei Dam and is abstracted for the Robertson canal, the Angora canal and the Zandrift canal. Pump schemes abstracting directly from the Middle Breede River include the Agterkliphoogte, Uitnood, Klaasvoogds and Kogmanskloof pump schemes.
2. Meet the irrigation water quality targets for water abstracted at Zanddrift. The EC target at Zanddrift is to maintain EC at less than 70 mS/m for 50% of the irrigation season (summer) and at less than 120 mS/m for 80% of the irrigation season (summer). These TDS targets have been set to mitigate the effect of high salinity return flows (from tributaries like the Poesjenels, Vink and Kogmanskloof Rivers) that reduces the suitability of the water for the irrigation of vines.

The result of this TDS management practice in the Middle Breede River is that TDS concentrations at Le Chasseur are low (Category B) during the summer months. The main sources of salinity are irrigation return flows.

Nitrates exhibit the same pattern as observed at the IFR 1 site, elevated nitrate concentrations during the winter high flow months suggesting a washoff effect. Phosphates showed no clear change in concentration with flow.

Concern was expressed about the high colloidal turbidity of water released from Brandvlei Dam. The turbidity is generated in the dam as a result of wind action on the colloidal clays of the reservoir basin. The elevated turbidity of the released water has a negative effect on vegetation and biota in the river.

Land-use that affects this part of the Middle Breede River is dominated by intensive irrigation agriculture in the Hex River valley, the Rawsonville area, the Nuy area and the Hoeks River area. Downstream of Le Chasseur the Poesjenels, Vink, Keisers and Kogmanskloof Rivers enter the Breede River. Some of the tributaries entering the river have very high TDS concentrations. This is evident from comparing the median TDS concentration at Le Chasseur (1995 to 1999)

(133 mg/ℓ) with those observed in the Poesjenels (3826 mg/ℓ), Vink (1557 mg/ℓ), Kogmanskloof (1671 mg/ℓ) for the same data period.

7.2 WATER QUALITY INFORMATION

The routine DWAF monitoring station closest to the IFR3 site is H4H017Q01 – Breede River at Le Chasseur. The closest RiversDatabase monitoring point is H4BREE-MOORD situated upstream of the IFR site at Moordkuildrift near Brandvlei Dam.

REFERENCE STATE SITE	
Monitoring station	No monitoring station could be identified that could serve as a reference site for this water quality resource unit.
PRESENT STATE DATA	
Monitoring station	H4H017Q01 – Breede River at Le Chasseur.
Sampling frequency	Weekly
Full data record	07/14/1980 - 09/21/1999 (1011 samples)
Data record used	01/01/1995 – 09/21/1999 (214 samples)
Data assessment	Good to assess present state because the monitoring point is very close to the IFR site.

7.3 REFERENCE CONDITIONS

No water quality monitoring point could be identified to serve as a reference condition for the Middle Breede River. All the monitoring points in the Middle Breede River were established after significant agricultural development of the catchment and any data record therefore reflects only impacted conditions.

7.4 PRESENT WATER QUALITY STATE

7.4.1 Salinity

Long-term trends – The long-term TDS trend show a slight overall decreasing trend but also a long-term (about 10 year) cycle (Figure 5). Water quality in the middle reaches is affected by freshening releases from Brandvlei Dam to control TDS levels further downstream, primarily to meet irrigation TDS requirements.

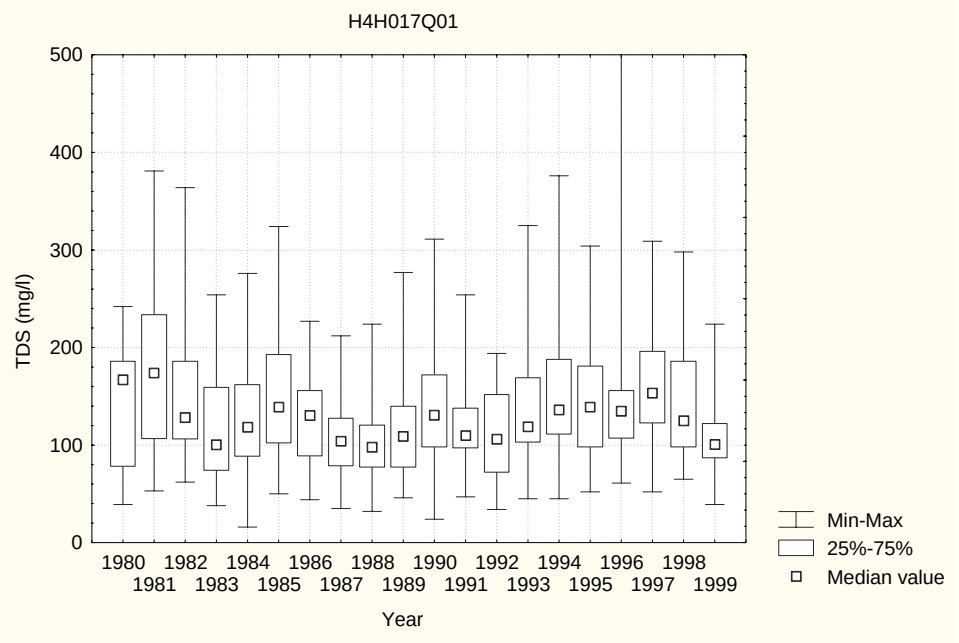

Figure 5 : Box-and-whisker plots of annual TDS concentrations recorded in the Middle Breede River at H4H017Q01

Seasonal trends – The plot of monthly TDS concentrations recorded at Le Chasseur (H4H017Q01) shows a number of effects (Figure 6). It shows the reduction in TDS during the winter high flow months (June to September), it also shows the effect of controlling TDS with freshening releases during the irrigation months (October to April), and the increase in TDS just before the onset of winter rains (no TDS control) (April/May).

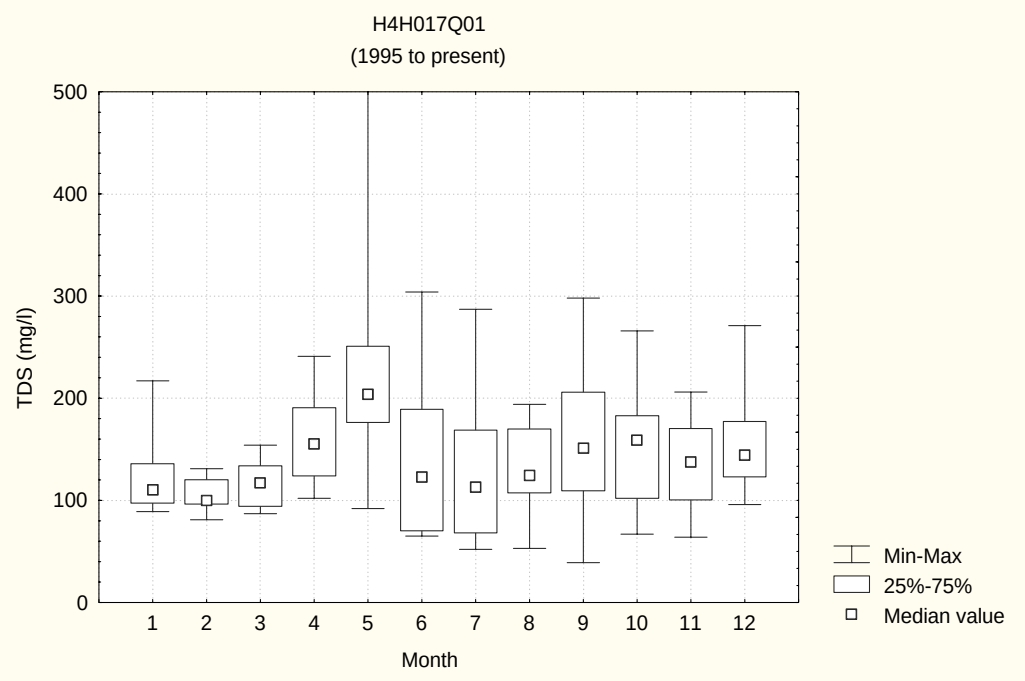

Figure 6 : Box-and-whisker plots of monthly TDS concentrations recorded in the Middle Breede River at H4H017Q01

The present TDS status falls within a Category B river.

H4H017Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	97	96	94	124	176	70	68	107	109	102	100	123
50 percentile	111	100	117	155	204	123	113	124	151	159	138	145
75 percentile	136	120	134	191	251	189	169	170	206	183	171	177
Category	B	B	B	B	B	B	B	B	B	B	B	B

7.4.2 pH

The present pH status appears to vary between an A and B category, with an overall B category.

H4H017Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	7.3	7.4	7.4	7.5	7.4	6.9	7.2	7.0	7.3	7.5	7.3	7.4
50 percentile	7.5	7.5	7.5	7.6	7.6	7.2	7.3	7.3	7.4	7.6	7.4	7.6
75 percentile	7.6	7.6	7.5	7.7	7.6	7.6	7.4	7.4	7.6	7.8	7.6	7.7
Category	A	B	A	B	B	A	A	A	A	B	A	B

7.4.3 Temperature

No observed temperature data. No concerns noted about unnatural temperatures in this reach of the river. RiversDatabase – 22.4 °C was recorded on 13/01/2000.

7.4.4 Dissolved Oxygen

No observed dissolved oxygen data. Some concerns have been expressed about the impact of urban and industrial effluents, with high organic content, being discharged to the river and the impact this may have on dissolved oxygen concentrations.

7.4.5 Total Suspended Solids

Low sediment production area (Midgley *et al*. 1994). RiversDatabase – 68 NTU (recorded 13/01/2000).

7.4.6 Nutrient Status

The median PO4 concentration (1995 to present) is 0.025, which falls in a B category. The total inorganic nitrogen to PO4 ratio of 9.9 puts the river in D category. It was felt that the overall nutrient status was probably a C category.

7.4.7 Toxic Substances

No measured data exist, although concerns have been raised about the impact of intensive agriculture close to the river on pesticide and herbicides in the river (London *et al.*, 2000).

7.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: Moderate *Confidence:* High
Determinants: Presence of rare an endangered species. Presence of diversity of habitat types and refugia. Important for migration
Social rating: Moderate
Determinants: Recreation and ecotourism as well as the potential for recreation.
Information source: DWAF (2002)

7.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	C/D	
Water Quality	B	B
Geomorphology	C	C
Riparian vegetation	C	C
Fish	D	D
Aquatic invertebrates	D	D
Ecosystem status	C/D	C/D
	Long term	C/D

Information source: DWAF (2002).

7.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS (mg/ℓ)	B	B	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
			B	B	B	B	B	B	B	B	B	B	B	B
pH	B	B	Maintain between 7.0 – 8.0 for 95% of the time.											
Temp (°C)	-	B	Maintain within 3 deg C of seasonal range at Middle Breede reference site.											
DO (% Sat)	-	B	Maintain between 80-100% of saturation.											
TSS (mg/ℓ)	-	B	Maintain within 15% of seasonal range at the reference site. *Note* – releases to maintain the TDS irrigation targets in the Middle Breede River will mean that TSS targets will not be met because water in Brandvlei Dam is very turbid due to high colloidal clay content.											

Note – as long as the TDS is managed to meet the requirements for irrigation users at Zanddrift (carry on current practice if freshettes to maintain TDS), TDS will be maintained in a Category B.

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	B	B	< 0.015
Ortho-phosphate (mg/ℓ)	B	B	< 0.05
Total inorganic nitrogen: Total phosphorus ratio	B	B	> 10:1
Ortho-phosphate: Total phosphate (%)	B	B	< 20%
NO_2NO_3-N (mg/ℓ)	B	B	Maintain winter concentrations at < 0.8 mg/ℓ for 95% of the time and summer concentrations < 0.5 mg/ℓ for 95% of the time.

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	B	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

Where CEV is the chronic effect value, AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

7.8 WATER QUALITY REFUGIA AND "HOT SPOTS"

The tributaries with very high TDS concentrations are regarded as "hot spots" that would have a marked impact on water quality in the Middle Breede River. An improvement in water quality would probably result in improved conditions in the Middle Breede River. However, the converse is also true.

8. WATER QUALITY RESOURCE UNIT 4 – MIDDLE BREEDE RIVER FROM KOGMANSKLOOF TO RIVIERSONDEREND CONFLUENCE

8.1 DESCRIPTION

This water quality resource unit was not defined as a formal IFR reach. However, the water quality team decided to examine the present state in this resource unit because a good data record existed and it was decided to set a water quality Reserve at a rapid level (low confidence).

8.2 WATER QUALITY INFORMATION

The routine DWAF monitoring station in this water quality resource unit is H5H005Q01 – Breede River at Wagenboomsheuwel/Drew.

Monitoring points used to characterise the reference and present state of the Sanddriftkloof River

REFERENCE STATE SITE	
Monitoring station	No monitoring station could be identified that could serve as a reference site for this water quality resource unit.
PRESENT STATE DATA	
Monitoring station	H5H0005Q01 – Breede River at Wagenboomsheuwel/Drew
Sampling frequency	Weekly
Full data record	02/15/1973 – 09/14/1999 (1121 samples)
Data record used	01/01/1995 – 09/14/1999 (191 samples)
Data assessment	Good to assess present state because a good data record exists at this site to characterise the present state

8.3 REFERENCE CONDITIONS

No water quality monitoring point could be identified to serve as a reference condition for the Lower Breede River. All the monitoring points were established after significant agricultural development in the catchment had taken place and data records therefore reflect only impacted conditions.

8.4 PRESENT WATER QUALITY STATE

8.4.1 Salinity

Long-term changes – there appears to be a small increasing trend in TDS although this is masked by a long-term cyclical change (about 10 years) in TDS (Figure 7). However, it appears that since the 1990s, there has been an increase in the frequency at which higher TDS concentrations have been observed (as represented by the 75 percentiles and maximum values).

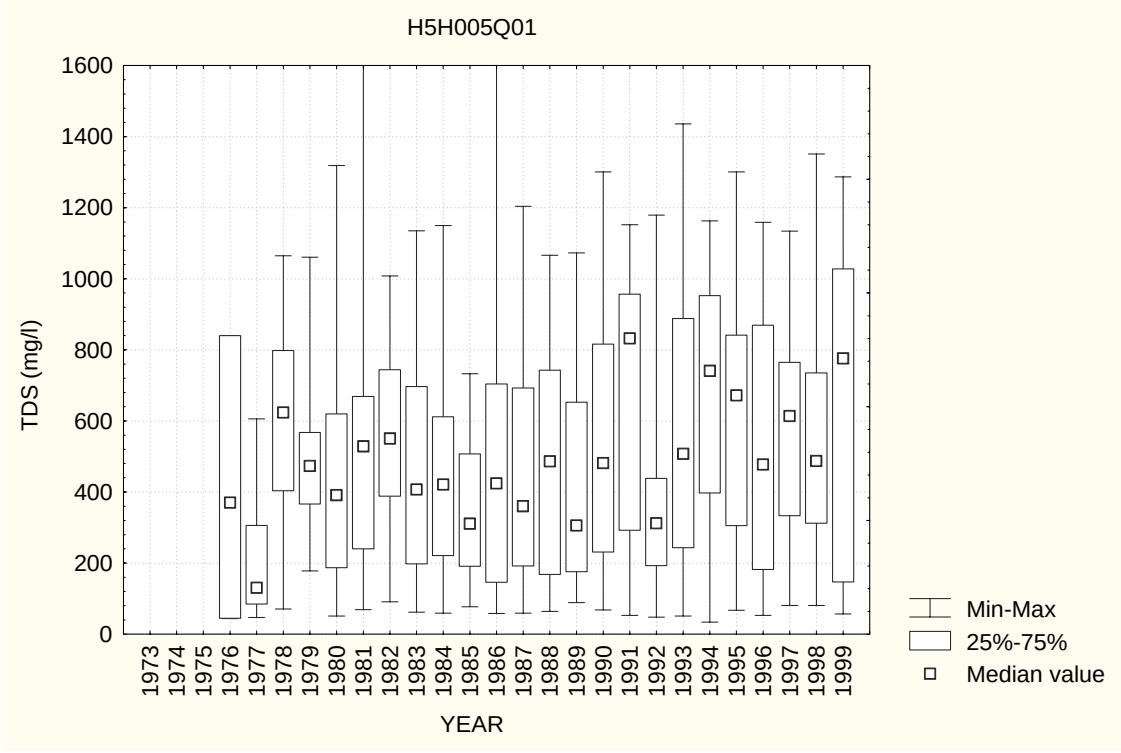

Figure 7 : Long-term changes in TDS measured in the lower Middle Breede River at H5H005Q01

Seasonal changes – there is a strong seasonal change in TDS with elevated TDS values being observed during the summer months (Figure 8).

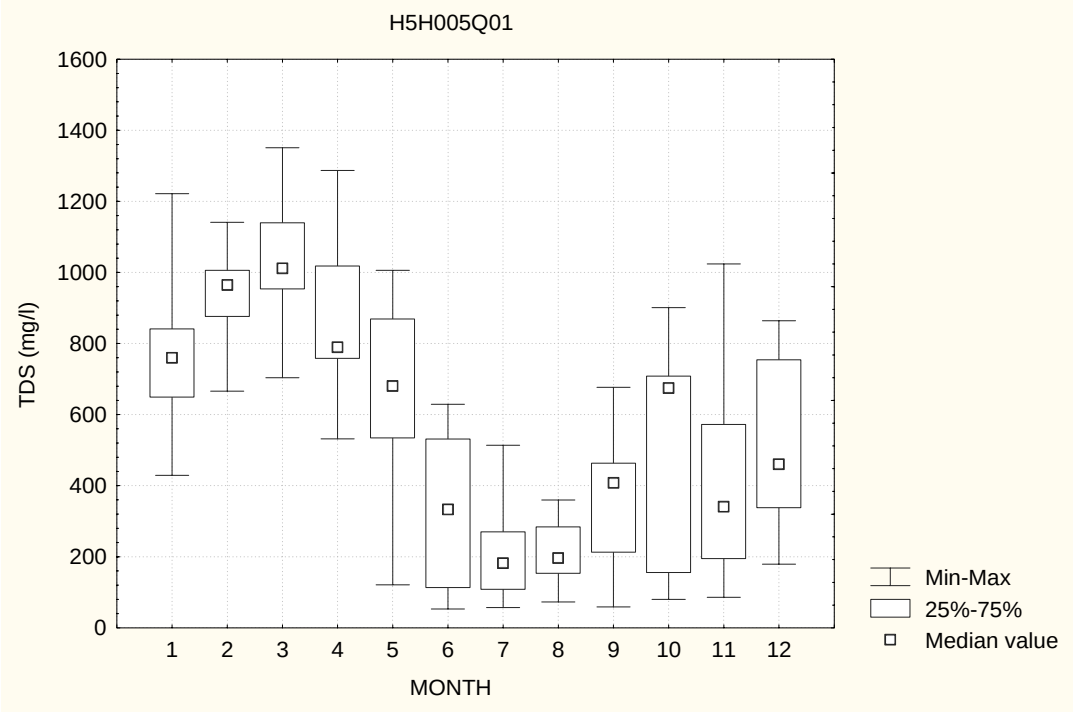

Figure 8 : Monthly box-and-whisker plot of TDS concentrations recorded in the lower Middle Breede River at H5H005Q01

The present TDS state falls within a D category, especially during the late summer months.

H5H005Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	649	876	953	758	534	113	108	153	213	156	194	338
50 percentile	760	965	1012	790	680	333	182	196	408	675	341	461
75 percentile	841	1006	1140	1018	869	531	270	285	464	709	572	756
Category	C	D	D	C	C	C	B	B	C	C	C	C

8.4.2 pH

The present pH state falls within a Category C river.

H5H005Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	8.1	8.19	8.33	8.17	8.03	7.32	7.26	7.5	7.52	7.67	7.45	7.69
50 percentile	8.24	8.29	8.38	8.23	8.17	7.79	7.54	7.62	7.95	8.22	7.69	7.87
75 percentile	8.32	8.37	8.51	8.30	8.25	7.92	7.68	7.88	8.28	8.35	8.06	8.16
Category	C	C	C	C	C	B	B	B	B	C	B	B

8.4.3 Temperature

No data available, no concerns about unnatural temperatures noted. RiversDatabase – 22.8°C was observed on 1/11/1995 and 25 °C observed on 15/01/2000.

8.4.4 Dissolved Oxygen

No data available. No concerns noted about low DO concentrations. RiversDatabase – DO of 8 mg/ℓ was observed on 1/11/1995.

8.4.5 Total Suspended Solids

No TSS data available, medium to low sediment production area (Midgley *et al*. 1994). RiversDatabase – 1 NTU recorded on 1/11/1995 and 2 NTU was recorded on 15/01/2000.

8.4.6 Nutrient Status

The median PO_4 concentration (1995 to 1999) is 0.020, which falls in a B category. The total inorganic nitrogen to PO_4 ratio of 7.7 puts the river in D category. It was argued that the overall nutrient status was probably a C category.

8.4.7 Substances

No measurements are available but research in the Hex River catchment (London *et al*. 2000) raised concerns about the impact of agricultural pesticides on river ecosystems, especially is heavily cultivated areas in the area upstream of Bonnievale.

8.5 ECOGICAL IMPORTANCE AND SENSITIVITY

The following EIS was set for the IFR site from Moordenaarskuil to upstream of the Kogmanskloof confluence and would probably be valid for this water quality resource unit.

EIS rating: Moderate *Confidence:* High

Determinants: Presence of rare, endangered and unique species. Presence of refugia. Important for migration.

Social rating: Moderate *Confidence:* Low

Determinants: Recreation and ecotourism as well as the potential for recreation.

Information source: (DWAF, 2002)

8.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001 for the IFR reach from Moordenaarskuil to upstream of the Kogsmanskloof confluence. A B water quality category was set for that river reach. However, there is deterioration in water quality downstream of the Sanddfrift canal and a C water quality category is recommended for this water quality resource unit.

COMPONENT	PES	EMC
Hydrology	C/D	
Water Quality	C	C
Geomorphology	C	C
Riparian vegetation	C	C
Fish	D	D
Aquatic invertebrates	D	D
Ecosystem status	C/D	C/D
	Long term	C/D

Information source: (DWAF, 2002)

8.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
TDS (mg/ℓ)	C/D	C	<800	<800	<800	<800	<800	<300	<300	<300	<300	<800	<800	<800
			C	C	C	C	C	B	B	B	B	C	C	C
pH	C	B	Maintain within the current range of 7.5 – 8.5 for 95% of the time											
Temp (°C)	-	C	Maintain within 4°C of the seasonal range observed for the Middle Breede reference site.											
DO (% Sat)	-	C	Maintain at >80% saturation											
TSS (mg/ℓ)	-	C	Velocities should be high enough to prevent sedimentation and biofilm formation in riffles. Maintain within 20% of the seasonal range of a Middle Breede reference site.											

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	-	C	< 0.03 mg/ℓ (median)
Ortho-phosphate (mg/ℓ)	B	C	< 0.05 mg/ℓ (median)
Total inorganic nitrogen: Total phosphorus ratio	-	C	> 5:1
Ortho-phosphate: Total phosphate (%)	-	C	<40%

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	B	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

Where CEV is the chronic effect value, AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

9. WATER QUALITY RESOURCE UNIT 5 – LOWER BREEDE RIVER FROM RIVIERSONDEREND TO BUFFELSJAGS RIVER

9.1 DESCRIPTION

The dominant land-use in this part of the catchment changes to dryland agriculture. Water quality in this resource unit also improves as a result of Riviersonderend water diluting the poor quality water from the Middle Breede River. A dominant land-use along the two main tributaries in this reach, the Hermitage and Buffeljags Rivers, is pasturelands.

9.2 WATER QUALITY INFORMATION

Monitoring points used to characterise the reference and present state of the water quality resource unit 5 – Lower Breede River from Riviersonderend to Buffelsjags River.

REFERENCE STATE SITE	
Monitoring station	No monitoring station could be identified that could serve as a reference site for this water quality resource unit.
PRESENT STATE DATA	
Monitoring station	Same as for Section 10.2 (H7H006Q01 – Breede River at Swellendam)

9.3 REFERENCE CONDITIONS

No reference conditions defined.

9.4 PRESENT WATER QUALITY STATE

Same at for Section 10.4

9.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

No EIS was set for this resource unit. The EIS that was set for the Lower Breede River IFR site (Buffelsjags confluence to the upstream end of the estuary) is probably not appropriate for this water quality resource unit.

9.6 ECOLOGICAL RESERVE CATEGORY

No ecological class was set for this water quality resource unit at the IFR workshops that took place from 4-8 June 2001.

9.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

Same as for Section 10.7 (C category specifications)

10. WATER QUALITY RESOURCE UNIT 6 – LOWER BREEDE RIVER FROM BUFFELSJAGS RIVER TO ESTUARY (IFR 4)

10.1 DESCRIPTION

The closest monitoring point to IFR 4 is H7H006Q01 close to Swellendam. Although this point is some distance upstream of the IFR site, the current macro trends will probably be evident at the IFR site.

At present, TDS concentrations are high during the summer months and low during the winter months. The reasons for the high TDS concentrations during the summer months are high irrigation return flows in the Middle Breede River. During the summer, crops are irrigated and drainage water infiltrates into the high salinity Bokkeveld shales, and eventually leaches into drainage ditches which discharge into the Middle Breede River and some of its tributaries such as the Kogmanskloof, Poesjenels and Vink Rivers. There is little water remaining in the river below the Sanddrift canal takeoff which can dilute the high salinity irrigation return flows. The flow from the Riviersonderend River causes some dilution resulting in a slightly better TDS quality at Swellendam. During the winter months, elevated river flows and the absence of active irrigation results in a significant improvement in TDS from a Category C to a Category B river. The elevated summer TDS is the result of irrigation return flows through subsurface drainage rather than washoff processes.

Under natural conditions, surface water rarely leaches into the shales because these are protected by lithosolic and hardpan soils. However, as the higher slopes of the Breede River valley were brought under cultivation, these protective layers were broken up by deep ripping as part of preparing the soils before planting. It is this process and the draining of the irrigated soils that have resulted in irrigated return flows to the Middle Breede River.

Nitrogen that has accumulated on the agricultural lands during the summer months is washed into the Breede River and its tributaries during the winter months resulting in elevated NO_2NO_3-N concentrations in the winter months, peaking in July and August. This is a washoff process and is dependent on rainfall to mobilise the nitrogen from the catchment. Two peaks are evident at H7H006Q01, one in May that corresponds to a peak observed in the Riviersonderend River and one in July that corresponds to a peak observed in the Breede River upstream of the Riviersonderend confluence.

Phosphate does not seem to be related to flow at this monitoring station and does not really change with flow.

Some concerns were expressed about the presence of toxic substances. However, toxics appear to be a concern where intensive irrigated agriculture is practiced. This is mainly restricted to the Middle Breede River that is probably too far upstream to affect the IFR site downstream of

Swellendam. There may be an effect from agriculture below the Buffelsjags Dam and along the Hermitage River.

10.2 WATER QUALITY INFORMATION

The routine DWAF monitoring station closest to the IFR Site 4 is H7H006Q01 – Breede River at Swellendam, which is quite some distance upstream of the IFR site. The Buffelsjags River enters the Breede River between H7H006Q01 and the IFR site. There are two routine monitoring stations on the Buffelsjags River, both situated at the Buffelsjags Dam (H7H013Q01 and H7R001Q01).

Monitoring points used to characterise the reference and present state of water quality resource unit 6 – Lower Breede River from Buffelsjags confluence to the upstream end of the Breede River estuary.

REFERENCE STATE SITE	
Monitoring station	No monitoring station could be identified that could serve as a reference site for this water quality resource unit.
PRESENT STATE DATA	
Monitoring station	H7H006Q01 – Breede River at Swellendam
Sampling frequency	Monthly
Full data record	03/16/1966 – 09/14/1999 (842 samples)
Data record used	01/01/1995 - 09/14/1999 (214 samples)
Data assessment	Poor to assess the present state because the monitoring point is quite far upstream of the IFR site and the Buffelsjags River joins the Breede River between the monitoring point and the IFR site

10.3 REFERENCE CONDITIONS

No water quality monitoring point could be identified to serve as a reference condition for the Middle Breede River. All the monitoring points in the Lower Breede River were established after significant development of the catchment and data record therefore reflect only impacted conditions.

10.4 PRESENT WATER QUALITY STATE

10.4.1 Salinity

Long-term trend – there appears to be a moderate increasing trend in the annual TDS recorded at H7H006Q01 (Figure 9). The graph also indicates the wide fluctuation in TDS over an annual cycle. This is the effect of irrigation return flows (increasing TDS) and winter flows (decreasing TDS).

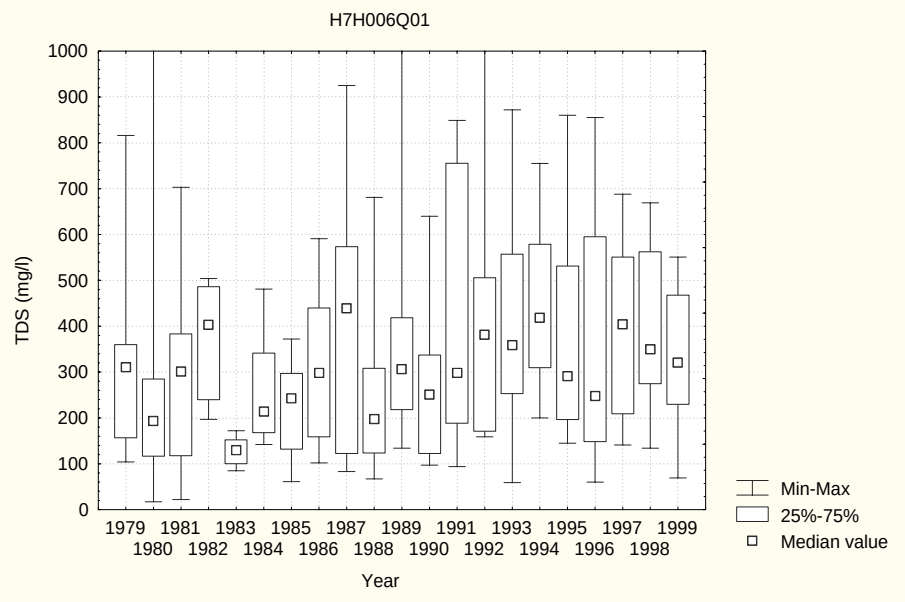

Figure 9 : Box-and-whisker plots of annual TDS concentrations recorded in the Lower Breede River at H7H006Q01

Seasonal trends – A strong seasonal trend is apparent when the monthly TDS concentrations at H7H006Q01 are examined (Figure 10). It shows the large reduction in TDS during the high flow winter months followed by increased concentrations during the low flow summer months.

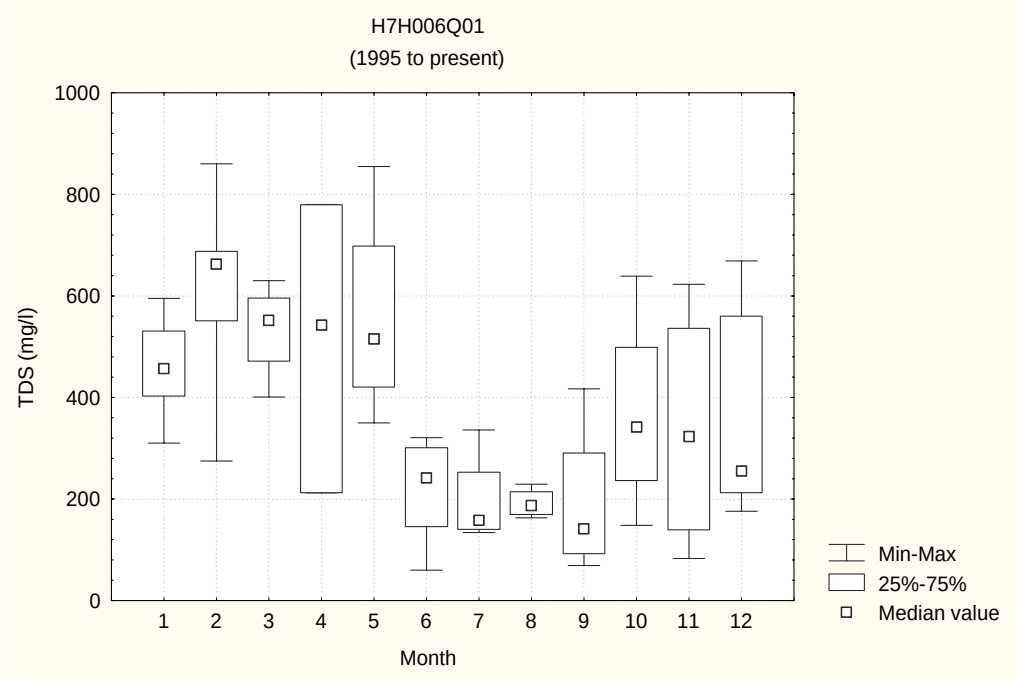

Figure 10 : Box-and-whisker plots of monthly TDS concentrations recorded in the Lower Breede River at H7H006Q01

The TDS present state varies between a C category in summer and B category in winter. The overall category is a C category.

H7H006Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	402	551	471	212	420	145	140	169	92	237	140	212
50 percentile	457	663	552	542	516	242	158	188	141	342	323	255
75 percentile	531	688	596	780	698	301	253	215	291	499	537	560
Category	C	C	C	C	C	B	B	B	B	C	C	B

10.4.2 pH

The pH present state is a B category.

H7H006Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	7.7	7.8	7.8	7.5	7.6	7.3	7.3	7.3	7.2	7.7	7.4	7.5
50 percentile	7.8	7.8	8.0	8.0	7.9	7.4	7.4	7.4	7.7	7.9	7.7	7.7
75 percentile	7.9	8.1	8.0	8.2	8.1	7.7	7.5	7.5	7.9	8.0	8.0	7.9
Category	B	B	B	B	B	A	A	A	B	B	B	B

10.4.3 Temperature

No observed temperature data. River Health monitoring at site H7BREE-SWELL: 24.6 °C (1/11/95).

10.4.4 Dissolved Oxygen

No observed DO data. Some concerns about the potential of water hyacinth in the lower reaches to cause wide diurnal or short-term fluctuations in DO levels. Concerns have also been expressed about the potential impacts of organic material being washed off the pasture lands and affecting the dissolved oxygen concentration. River Health monitoring site H7BREE-SWELL: 7.56 mg/ℓ (1/11/95).

10.4.5 Suspended Solids

No TSS data available, low sediment production area (Midgley *et al.* 1994). River Health monitoring site H7BREE-SWELL: 2.4 mg/ℓ TSS and 2 NTU (1/11/95).

10.4.6 Nutrient Status

The median PO_4 concentration (1995 to present) is 0.018, which falls in a B category. The total inorganic nitrogen to PO_4 ratio of 12.2 puts the river in C category. It was felt that the overall nutrient status was a C category.

10.4.7 Toxic Substances

No measured data exists although concerns have been raised about a cumulative effect of pesticides and herbicides as a result of intensive agriculture close to the river in the middle reaches of the Breede River as well as the Hermitage River at Swellendam.

10.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: High *Confidence:* High
Determinants: Important for migration route, conservation and natural areas.
Social rating: Moderate
Determinants: Recreation depends on a healthy functioning ecosystem as well as aesthetic value.
Information source: DWAF (2002)

10.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	C	
Water Quality	C	B
Geomorphology	B	B
Riparian vegetation	C	C
Fish	C	C
Aquatic invertebrates	C	B/C
Ecosystem status	C	B/C
	Long term	B/C

Information source: DWAF (2002).

10.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS (mg/ℓ)	C	C	<800	<800	<800	<800	<300	<300	<300	<300	<300	<800	<800	<800
			C	C	C	C	B	B	B	B	B	C	C	C
pH	B	B	Maintain within current range of 7.2 – 8.2 for 95% of the time											
Temp (°C)	-	C	Maintain within 4º Celsius of the seasonal range observed the Lower Breede reference site.											
DO (% Sat)	-	B	Maintain between 80% - 100% of saturation											
TSS (mg/ℓ)	-	C	Velocities should be high enough to prevent sedimentation and biofilm formation in riffles. Maintain within 20% of the seasonal range of a Lower Breede reference site.											

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	-	C	< 0.03 mg/ℓ (median)
Ortho-phosphate (mg/ℓ)	B	C	< 0.05 mg/ℓ (median concentration)
Total inorganic nitrogen: Total phosphorus ratio	C	C	>5:1
Ortho-phosphate: Total phosphate (%)	-	C	< 40%
NO_2NO_3-N	-	C	Maintain NO_2NO_3-N summer concentrations < 0.3 mg/ℓ and winter concentrations < 1 mg/ℓ

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	B	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

Where CEV is the chronic effect value, AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

10.8 GENERAL CONSIDERATIONS

IFR Site 4 is situated downstream of the DWAF salinity management point at Zanddrift Canal and does not benefit from the controlled releases for dilution purposes. The site is also downstream of the confluence with the Riviersonderend River and the Buffeljags River and this would probably improve the water quality in the river.

11. WATER QUALITY RESOURCE UNIT 7 – RIVIERSONDEREND FROM THEEWATERSKLOOF DAM TO BOK RIVER

11.1 DESCRIPTION

Water quality deteriorates along the length of the Riviersonderend River downstream of Theewaterskloof Dam. The water quality team decided to break the river into two parts, the reach from the dam to the Bok River confluence and from there to the confluence with the Breede River.

11.2 WATER QUALITY INFORMATION

There is no routine DWAF monitoring station close to the IFR5 site. The closest monitoring point upstream of the site is the weir downstream of Theewaterskloof Dam, H6H012Q01. Sampling point H6H009Q01 is situated in the lower reaches of the Riviersonderend. There is a change in water quality from Theewaterskloof Dam to the confluence with the Breede River (Figures 11 and 12). The present water quality state is probably poorer than that measured at the outflow from Theewaterskloof Dam but better than that measured at H6H009Q01. The closest RiversDatabase monitoring point is H6RIV1-DWARS situated on the farm "Dwarshoek" near the gauging weir H6H012Q01.

Monitoring points used to characterise the reference and present state of the Sanddriftkloof River

REFERENCE STATE SITE	
Monitoring station	H6H008Q01 – Riviersonderend at Swarte Water/Nuweberg Forest Reserve
Sampling frequency	Monthly
Full data record	02/27/1967 – 08/24/92
Data record used	Full data record
Data assessment	Good to characterize the headwaters of the Riviersonderend system.
PRESENT STATE DATA	
Monitoring station	H6H012Q01 – Theewaterskloof Dam on Riviersonderend: downstream weir
Sampling frequency	Monthly
Full data record	02/03/1977 – 08/24/1999 (448 samples)
Data record used	01/01/1995 – 08/24/1999 (50 samples)
Data assessment	Moderate to assess present state of river quality. Although Theewaterskloof Dam is closer to the IFR site, the water quality at the downstream weir (H6H012Q01) will be modified by the time it reaches the IFR site but not to the same extent as observed at the downstream monitoring point.
PRESENT STATE DATA	
Monitoring station	H6H009Q01 –Riviersonderend at Reenen
Sampling frequency	Monthly
Full data record	12/04/1973 - 09/14/1999 (885 samples)
Data record used	01/01/1995 – 09/14/1999 (56 samples)
Data assessment	Moderate to assess present state

11.3 REFERENCE CONDITIONS

Water quality at the reference site situated in the headwaters of the Riviersonderend River in the Nuweberg Forest Reserve, H6H008Q01, is good and shows little seasonal variability.

Summary statistics of water quality at H6H008Q01 – Riviersonderend at Swarte Water/ Nuweberg Forest Reserve are presented below.

	VALID N	MEAN	MEDIAN	MINIMUM	MAXIMUM	25%TILE	75%TILE	VARIANCE	STD.DEV.
EC	378	4.045238	3.6	1.8	34.4	3	4.4	5.999301	2.449347
TDS	247	22.73279	22	7	59	18	26	60.00148	7.746062
pH	254	4.775945	4.5	1.88	8.21	4.19	5.2	0.815208	0.902888
NA	252	3.80119	3.7	0.5	14.6	2.9	4.4	2.488086	1.577367
MG	252	0.786111	0.7	0	4.9	0.5	1	0.289966	0.538485
CA	252	0.89881	0.7	0	7.9	0.35	1.1	1.081552	1.039977
F	252	0.045794	0.03	0	0.4	0	0.06	0.003883	0.062317
CL	252	7.274603	6.8	1.6	22.6	5.6	8.6	6.99258	2.644349
NO_2NO_3	252	0.044	0.011	0	3.04	0.0095	0.03	0.042843	0.206986
SO_4	252	3.584524	3.05	0	16.9	1.3	4.85	8.489122	2.91361
PO_4	251	0.016231	0.012	0	0.295	0.007	0.02	0.000508	0.022542
TAL	254	4.750787	4.2	0	23.9	2	6.5	14.61532	3.822998
SI	249	1.305663	1.11	0.05	11.18	0.66	1.69	1.025226	1.012535
K	251	0.31757	0.28	0	1.4	0.19	0.4	0.042731	0.206715
NH_4	247	0.057328	0.04	0	1.05	0.02	0.07	0.006723	0.081991

11.4 PRESENT WATER QUALITY STATE

11.4.1 Salinity

Long-term trends - Salinities (TDSs) recorded at the weir downstream of Theewaterskloof Dam show slight increase towards the end of the record period. The concentrations in the lower reaches (as recorded at H6H009Q01) were consistently higher and since 1995 the TDS increased by about 100 mg/ℓ between the two monitoring points (Figure 11).

Seasonal trends - An examination of the monthly TDS concentrations recorded in the river since 1994 shows a distinct seasonal pattern. At both stations, TDS concentrations appear to increase during the early winter, peaking in about June and then reducing towards the summer months (Figure 12). The difference in TDS between the outlet of Theewaterskloof Dam and the lower reaches of the river is biggest during the winter.

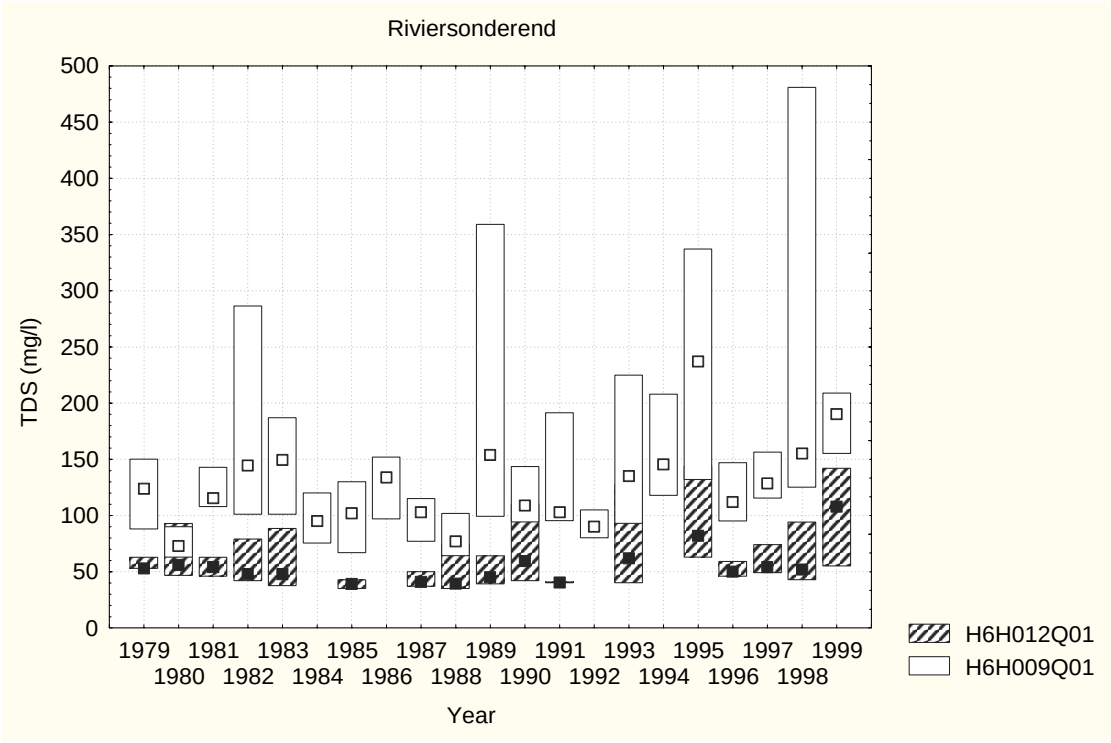

Figure 11 : Box plots (25, 50 and 75 percentiles) of annual TDS concentrations observed in the Riviersonderend

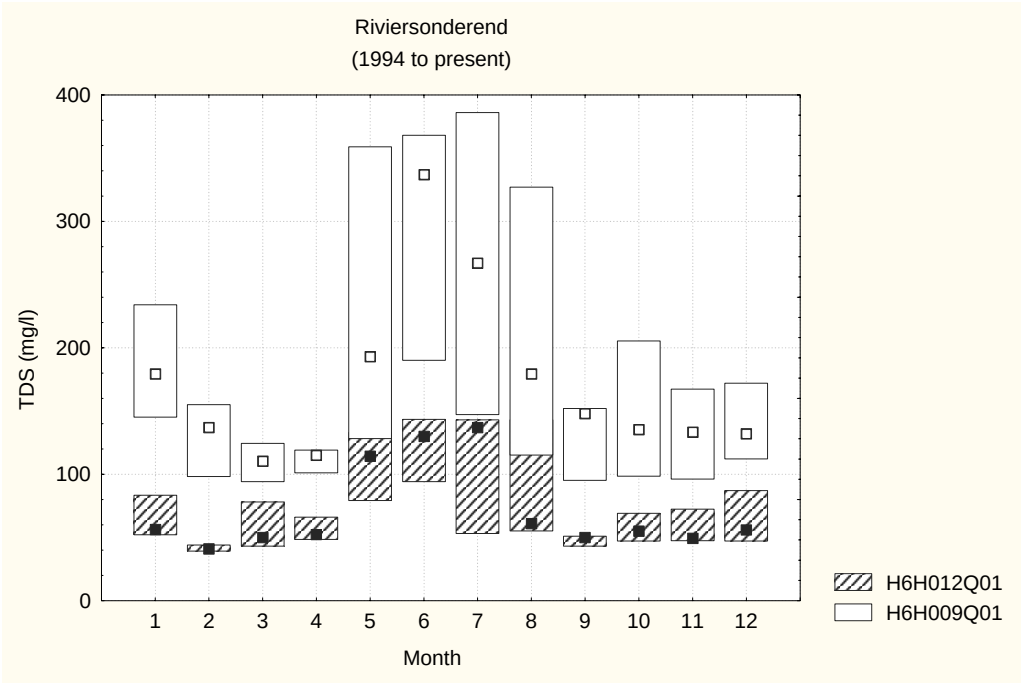

Figure 12 : Box plots (25, 50 and 75 percentiles) of monthly TDS concentrations observed in the Riviersonderend River

The present status of the median TDS concentrations is a Category B at H6H12Q01 (Theewaterskloof Dam) and Category B at H6H009Q01. The TDS category at IFR Site 5 is probably a B category.

H6H012Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	52	39	43	49	79	94	53	55	43	47	448	47
50 percentile	57	41	50	53	115	130	137	61	50	55	49	56
75 percentile	84	44	78	66	133	144	143	143	51	69	73	87
Category	B	A	B	B	B	B	B	B	B	B	B	B

H6H009Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	145	98	94	101	128	190	147	115	95	98	96	112
50 percentile	180	137	110	115	193	337	267	180	148	136	134	132
75 percentile	234	155	125	119	359	368	386	327	152	205	167	172
Category	B	B	B	B	B	C	B	B	B	B	B	B

11.4.2 pH

The pH present status at the IFR site is probably an A.

H6H012Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	7.0	7.1	7.1	7.1	7.0	7.3	7.1	7.2	7.1	7.1	7.0	6.9
50 percentile	7.1	7.3	7.1	7.2	7.3	7.4	7.4	7.2	7.2	7.3	7.2	7.1
75 percentile	7.2	7.5	7.3	7.3	7.2	7.7	7.4	7.4	7.3	7.3	7.3	7.3
Category	A	A	A	A	B	A	A	A	A	A	A	A

H6H009Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	7.0	7.1	7.1	7.1	7.0	7.3	7.1	7.2	7.1	7.1	7.0	6.9
50 percentile	7.1	7.3	7.1	7.2	7.3	7.4	7.4	7.2	7.2	7.3	7.2	7.1
75 percentile	7.2	7.5	7.3	7.3	7.2	7.7	7.4	7.4	7.3	7.3	7.3	7.3
Category	A	A	A	A	A	A	A	A	A	A	A	A

11.4.3 Temperature

No temperature data is available. There are no concerns other than the modified temperature regime close to the Theewaterskloof Dam outflow structure. RiversDatabase – 17.1°C observed on 1/11/95.

11.4.4 Dissolved Oxygen

No dissolved oxygen data are available. RiversDatabase – 7.74 mg/ℓ observed on 1/11/95.

11.4.5 Total Suspended Solids

No TSS data available, low sediment production area (Midgley *et al*. 1994). RiversDatabase: 1 NTU recorded on 1 /11/95.

11.4.6 Nutrient Status

The median PO4 concentrations (1995 to 1999) are 0.01 and 0.018 respectively, both fall in the B category. The total inorganic nitrogen to PO4 ratio of 3.2 and 9.0 puts the river in D category. It was felt that the overall nutrient status was a C category.

11.4.7 Toxic Substances

No concerns about toxic substances were noted.

11.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: High *Confidence:* High
Determinants: Presence of rare and endangered species, species and taxon richness, diversity of habitat types and refugia, sensitivity to flow related water quality changes, migration routes.
Social rating: Low
Determinants: Water supply source, recreation dependent on a natural functioning ecosystem and potential for recreation.
Information source: DWAF (2002)

11.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	E	
Water Quality	B	B
Geomorphology	E	E→D
Riparian vegetation	E	E/D→D
Fish	E	E/D→D
Aquatic invertebrates	C/D	C/D
Ecosystem status	E	D/E
	Long term	D

Information source: DWAF (2002)

11.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS (mg/ℓ)	B	B	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
			B	B	B	B	B	B	B	B	B	B	B	B
pH	A	B	Maintain values between the current range 6.6 – 7.4											
Temp (°C)	-	B	Maintain within 3º Celsius of reference site											
DO (% Sat)	-	B	Maintain between 80 – 100% saturation											
TSS (mg/ℓ)	-		Flows in excess of $10m^3/s$ are required to prevent deposition at transects 2b and 3 Note - Except for transect 2b, there will be little movement of material.											

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	-	B	< 0.015 (median)
Ortho-phosphate (mg/ℓ)	B	B	< 0.05 (median)
Total inorganic nitrogen: Total phosphorus ratio	-	B	> 10:1
Ortho-phosphate: Total phosphate ratio	-	B	< 20%

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	B	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

Where CEV is the chronic effect value, AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

12. WATER QUALITY RESOURCE UNIT 8 – RIVIERSONDEREND FROM BOK RIVER TO BREEDE RIVER CONFLUENCE

12.1 DESCRIPTION

The major land-use in this part of the catchment is dryland agriculture. In the valley close to the river, some pastures occur.

12.2 WATER QUALITY INFORMATION

The River Health monitoring point in this river reach is H6RIVI-KLIPF, situated on the farm "Klipfontein" near the gauging weir H6H009Q01.

Monitoring points used to characterise the reference and present state of Resource Unit 8

REFERENCE STATE SITE	
Monitoring station	H6H008Q01 – Riviersonderend at Swarte Water/Nuweberg Forest Reserve
Sampling frequency	Monthly
Full data record	02/27/1967 – 08/24/92
Data record used	Full data record
Data assessment	Good to characterise the headwaters of the Riviersonderend system.
PRESENT STATE DATA	
Monitoring station	H6H009Q01 –Riviersonderend at Reenen
Sampling frequency	Monthly
Full data record	12/04/1973 - 09/14/1999 (885 samples)
Data record used	01/01/1995 – 09/14/1999 (56 samples)
Data assessment	Moderate to assess present state

12.3 REFERENCE CONDITIONS

Same as described in Section 11.3.

12.4 PRESENT WATER QUALITY STATE

12.4.1 Salinity

Long-term changes – there appears to be a small increasing trend in TDS although this is masked by a long-term cyclical change (about 10 years) in TDS (Figure 13). However, it appears that since the 1990s, there has been an increase in the frequency at which higher TDS concentrations have been observed (represented by the 75 percentiles and maximum values).

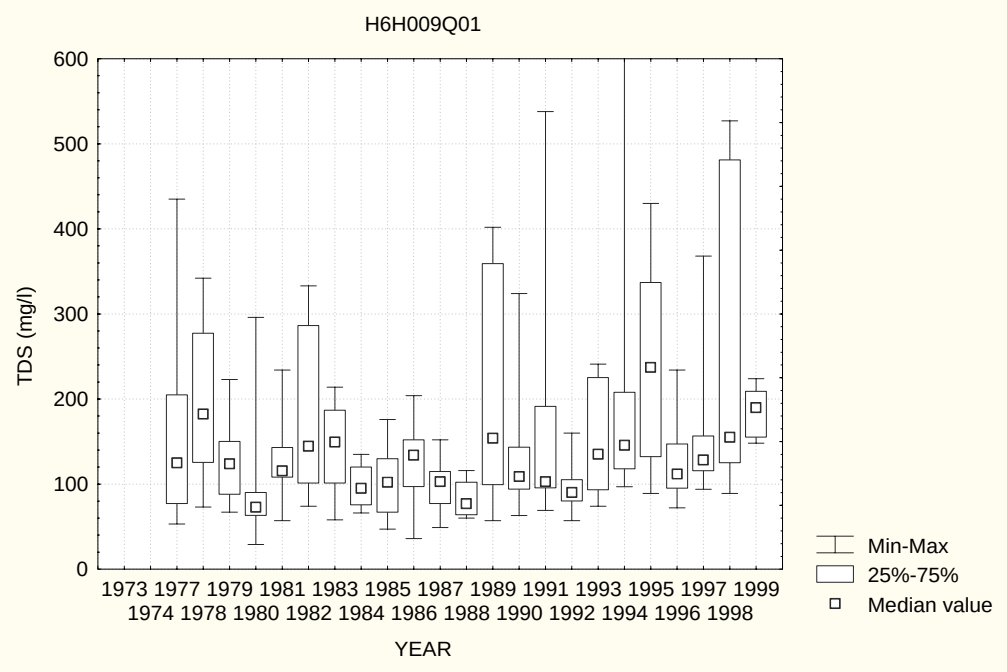

Figure 13 : Long-term changes in TDS measured in the Riviersonderend River from the Bok River to the Breede River confluence

Seasonal changes – there is a strong seasonal change in TDS with elevated TDS values being observed during the winter months (Figure 14).

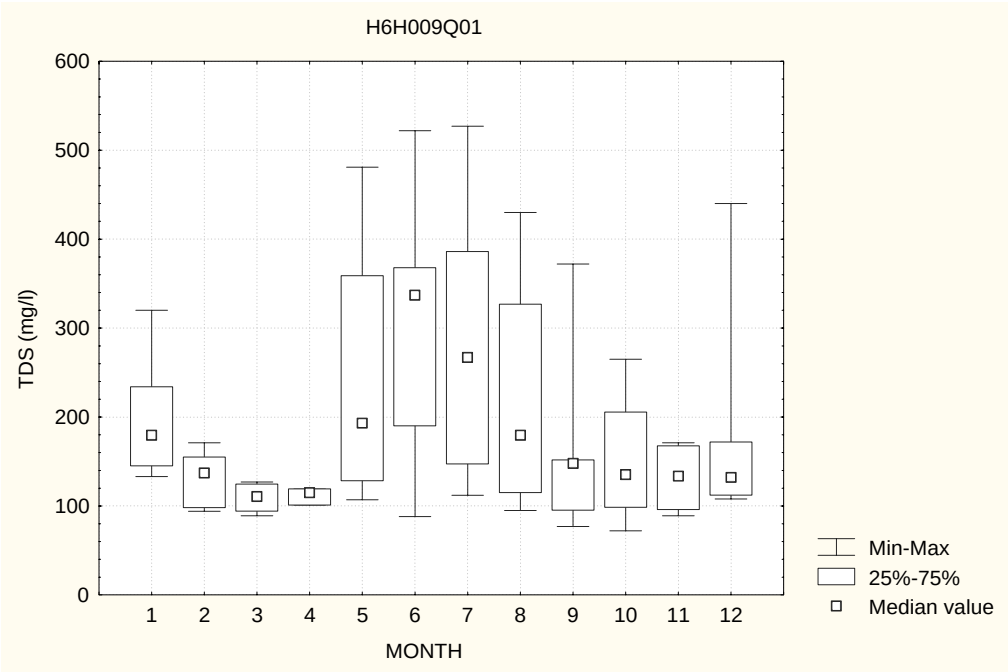

Figure 14 : Monthly box-and-whisker plot of TDS concentrations recorded in the lower Riviersonderend River at H6H009Q01

The present TDS state falls within a C category.

H6H009Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
25 percentile	145	98	94	101	128	190	147	115	95	99	96	112
50 percentile	180	137	111	115	193	337	267	180	148	136	134	132
75 percentile	234	155	125	119	359	368	386	327	152	206	168	172
Category	B	B	B	B	B	C	B	B	B	B	B	B

12.4.2 pH

The present pH state falls within a Category A river.

H6H009Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
25 percentile	7.0	7.1	7.1	7.1	7.0	7.3	7.1	7.2	7.1	7.1	7.0	6.9
50 percentile	7.1	7.3	7.1	7.2	7.3	7.4	7.4	7.2	7.2	7.2	7.2	7.1
75 percentile	7.5	7.3	7.3	7.2	7.7	7.4	7.4	7.3	7.3	7.3	7.3	7.2
Category	A	A	A	A	A	A	A	A	A	A	A	A

12.4.3 Temperature

No data is available, no concerns about unnatural temperatures were noted. RiversDatabase @ H6RIVI-KLIPF – 2.3°C recorded on 01/11/95.

12.4.4 Dissolved Oxygen

No data available. Some concern about organic material washed off pastures and the impact if may have on dissolved oxygen concentrations. RiversDatabase – 7.56 mg/ℓ DO recorded on 01/11/95.

12.4.5 Total Suspended Solids

No TSS data available, medium to low sediment production area (Midgley *et al*. 1994). RiversDatabase – 5 NTU recorded on 01/11/95.

12.4.6 Nutrient Status

The median PO_4 concentration (1995 to present) is 0.0185, which falls in a B category. The total inorganic nitrogen to PO_4 ratio of 9.0 puts the river in D category. It was argued that the overall nutrient status was probably a C category.

12.4.7 Toxic Substances

No measurements available but research in the Hex River catchment (London *et al*. 2000) raised concerns about the impact of agricultural pesticides on river ecosystems, especially in heavily cultivated areas such as that surrounding IFR Site 1.

12.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: High *Confidence:* High
Determinants: Presence of rare an endangered species, species and taxon richness, diversity of habitat types and refugia, sensitivity to flow related water quality changes, migration routes.
Social rating: Low
Determinants: Water supply source, recreation dependent on a natural functioning ecosystem and potential for recreation.
Information source: DWAF (2002)

12.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category for the Riviersonderend River was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	E	
Water Quality	B	B
Geomorphology	E	E→D
Riparian vegetation	E	E/D→D
Fish	E	E/D→D
Aquatic invertebrates	C/D	C/D
Ecosystem status	E	D/E
	Long term	D

Information source: DWAF (2002)

12.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

Same as described for Section 11.7.

13. WATER QUALITY RESOURCE UNIT 9 – BAVIAANS RIVER

13.1 DESCRIPTION

Water quality in the Baviaans River is good and can be regarded as close to reference conditions. TDS concentrations show no change with season and vary within a very narrow range (interquartile range = 9.5 mg/ℓ). TDS concentrations also show the long-term wet/dry cycle that was observed in the Molenaars River. The wet/dry cycle appears to be about 10 years long and slightly higher TDS concentrations were observed during the wet years and slightly lower TDS concentrations were observed during the dry years.

Nutrient concentrations are low and probably representative of reference conditions and are unrelated to season.

13.2 WATER QUALITY INFORMATION

There is one routine DWAF monitoring station in the Baviaans River, H6H005Q01 – Baviaans at Genadendal Mission Station. This monitoring point was used as Reference and Present State site because the catchment is largely unimpacted in terms of water quality. The River Health monitoring point, H6BAVI-GENAD, is situated near the DWAF gauging weir H6H005Q01.

Monitoring points used to characterise the reference and present state of the Baviaans River

REFERENCE AND PRESENT STATE DATA	
Monitoring station	H6H005Q01 –Baviaans River at Genadendal Mission Station
Sampling frequency	Monthly
Full data record	11/28/1972 – 08/24/1999 (399 samples)
Data record used	01/01/1995 – 08/24/1999 (53 samples)
Data assessment	Good data record to assess reference and present state.

13.3 REFERENCE CONDITIONS

The Baviaans River is largely unimpacted and is regarded as characteristic of a reference condition.

13.4 PRESENT WATER QUALITY STATE

13.4.1 Salinity

Long-term trend – There is a slight increasing trend in salinity over the past 20 years that is masked by a what appears to be a 10 year cycle of increasing and decreasing TDS (Figure 15).

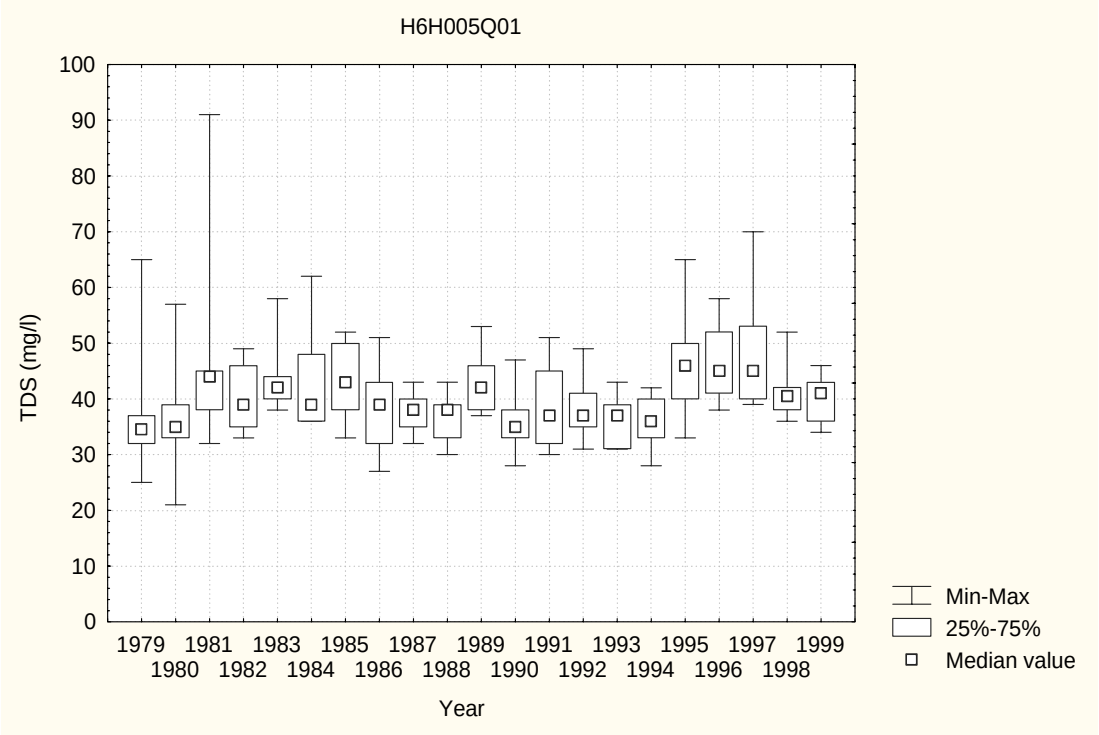

Figure 15 : Box-and-whisker plots of annual TDS concentrations observed in the Baviaans River at H6H005Q01

Seasonal trends – There is no seasonal trend in TDS recorded at H6H005Q01 over the past five years (Figure 16).

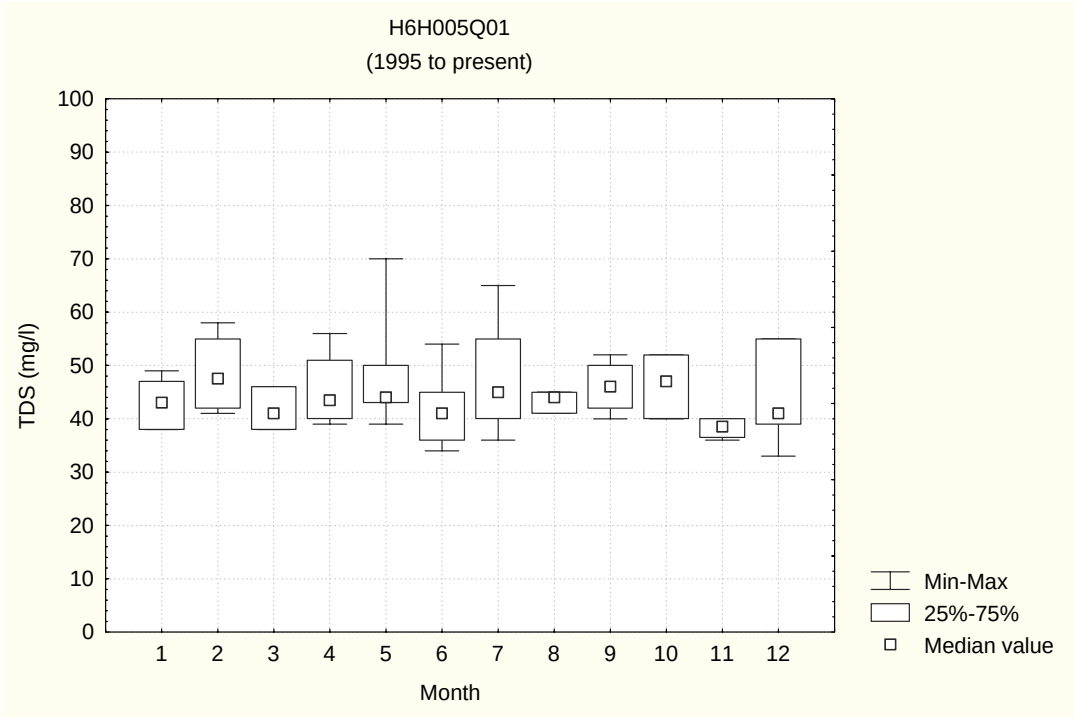

Figure 16 : Box-and-whisker plots of monthly TDS concentrations observed in the Baviaans at H6H005Q01

The present state TDS state of the Baviaans River is a Category A/B.

H6H005Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	38	42	38	40	43	36	40	41	42	40	37	39
50 percentile	43	48	41	44	44	41	45	44	46	47	39	41
75 percentile	47	55	46	51	50	45	55	45	50	52	40	55
Category	A	B	A	A	A	A	B	A	B	B	A	A

13.4.2 pH

The present pH status of the Baviaans River is a Category A.

H6H005Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	5.2	5.5	6.1	6.3	5.5	5.0	5.2	5.9	6.3	6.1	4.8	4.9
50 percentile	6.0	6.0	6.2	6.5	6.2	5.6	5.6	6.4	6.5	6.2	6.3	5.5
75 percentile	6.2	6.7	6.2	6.6	6.6	5.7	6.7	7.2	6.7	6.4	5.7	6.1
Category	A	A	A	A	A	A	A	A	A	A	A	A

13.4.3 Temperature

No measured data. No concerns noted about unnatural temperatures. RiversDatabase @ H6BAVI-GENAD – 18.3°C recorded on 01/11/95.

13.4.4 Dissolved Oxygen

No observed DO data. No concerns noted about low dissolved oxygen conditions. RiversDatabase @ H6BAVI-GENAD – 8.39 mg/ℓ DO recorded on 01/11/95.

13.4.5 Total Suspended Solids

No TSS data available, low sediment production area (Midgley *et al*. 1994). RiversDatabase @ H6BAVI-GENAD – 0 NTU and 0.7 mg/ℓ SS recorded on 01/11/95.

13.4.6 Nutrient Status

The median PO_4 concentrations (1995 to 1999) are 0.019 that fall in the B category. The total inorganic nitrogen to PO_4 ratio of 3.4 puts the river in D category. It was felt that the overall nutrient status was a C category.

13.4.7 Toxic Substances

No concerns noted about toxic substances.

13.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: Very high *Confidence:* High
Determinants: Presence of rare and endangered and unique species as well as intolerant biota. Important refugia and habitats that are sensitive to flow and flow related water quality changes.
Social rating: Moderate
Determinants: The town of Genadendal is a historic missionary station. There is also an historic mill.
Information source: DWAF (2002)

13.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	B	
Water Quality	A/B	A/B
Geomorphology	B	B
Riparian vegetation	C	B
Fish	A/B	A/B
Aquatic invertebrates	A/B	A/B
Ecosystem status	B	B
	Long term	B

Information source: DWAF (2002)

13.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS (mg/ℓ)	A/B	A/B	<150	<150	<150	<150	<150	<150	<150	<150	<150	<150	<150	<150
			A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B	A/B
pH	A	A/B	Maintain range within historical limits, between 5.6 – 7.6 in summer and between 5 – 6.8 in winter.											
Temp (°C)	-	A/B	Maintain within 2°C of historical range.											
DO (% Sat)	-	A/B	Maintain between 80-120% saturation.											
TSS (mg/ℓ)	-	A/B	Maintain at less < 10% of historical range. This site is equivalent to a reference site.											

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	-	A	< 0.007
Ortho-phosphate (mg/ℓ)	B	A/B	< 0.04
Total inorganic nitrogen: Total phosphorus ratio	-	A/B	>10:1
Ortho-phosphate: Total phosphate (%)	-	A/B	<20%

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	A	The concentrations of toxic substances should be less than the CEV for 95% of time, and less than the AEV for 99% of time.

CEV is the chronic effect value and AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

14. WATER QUALITY RESOURCE UNIT 10 – MOLENAARS RIVER IFR 2 SITE

14.1 DESCRIPTION

Water quality in the Molenaars is very good and the site is regarded as equivalent to a reference site. The closest monitoring site is H1H018Q01 where a good water quality data record exists. TDS is low throughout the year with a slight reduction during the winter months, the lowest concentration is generally observed in July. A 10-year wet/dry cycle in TDS was observed at the site, similar to that observed in the Upper Breede River at IFR1. This cycle suggests that salts in the catchment are mobilised during the wetter years.

No seasonal changes were found in nitrates and ortho-phosphate concentrations even though high concentrations are observed from time to time. There are a number of trout farms upstream of the Molenaars IFR site that have a minor impact (short term) on the nutrient status when flushing of the dams occurs. It was found that nutrients increase at low flows when the impact of these point sources is most evident. Some concerns were raised about organic material from these trout farms and the impact this may have on nutrient concentrations and dissolved oxygen.

14.2 WATER QUALITY INFORMATION

The routine DWAF monitoring station closest to IFR Site 2 is H1H018Q01 – Molenaars River Hawequas Forest Reserve. The closest RiversDatabase monitoring point is H1SMALL-LEBEN – a pump at Lebensraum Farm, downstream of IFR Site 2 on the Smallblaar River.

Monitoring points used to characterise the reference and present state of the Molenaars River

REFERENCE STATE SITE	
Monitoring station	H1H017Q01 – Elands River at Hawequas Forest Reserve
Sampling frequency	Weekly
Full data record	06/12/70 – 08/26/1992 (701 samples)
Data record used	Whole data record
Data assessment	Good to assess reference conditions.
PRESENT STATE DATA	
Monitoring station	H1H018Q01 – Molenaars River Hawequas Forest Reserve
Sampling frequency	Weekly
Full data record	06/03/1970 – 09/17/1999 (1021 samples)
Data record used	01/01/1995 – 09/17/1999 (214 samples)
Data assessment	Good to assess present state because the monitoring point is very close to the IFR site

14.3 REFERENCE CONDITIONS

Water quality at the reference site, H1H017Q01, was good and showed very little seasonal variability.

Summary statistics of water quality at H1H017Q01 – Elands River at Hawequas Forest Reserve

VARIABLE	VALID N	MEAN	MEDIAN	MINIMUM	MAXIMUM	25%TILE	75%TILE	VARIANCE	STD.DEV.
EC	699	3.627754	3.4	1.3	26.5	2.9	3.9	3.46685	1.861948
TDS	626	21.96645	21	9	211	17	25	126.8133	11.26114
pH	690	5.159565	4.915	3.22	8.51	4.49	5.72	0.877844	0.936933
NA	639	3.256025	3.1	0	33	2.5	3.7	3.661558	1.91352
MG	639	0.589045	0.5	0	6.7	0.4	0.7	0.211792	0.460209
CA	639	0.86698	0.7	0	20.7	0.4	1	1.643406	1.281954
F	639	0.055117	0.03	0	1.23	0	0.07	0.006385	0.079908
CL	639	5.70939	5.3	0.7	56.9	4.2	6.6	10.10521	3.178869
NO2NO3	644	0.101152	0.03	0	17.91	0.01	0.082	0.505092	0.710698
SO4	639	4.037559	3.5	0	22.6	2	5.6	8.789214	2.964661
PO4	637	0.021848	0.012	0	2.83	0.007	0.02	0.013111	0.114505
TAL	652	5.423313	4.8	0	63.1	2.95	7.1	18.06452	4.250238
SI	634	2.278407	2.215	0.26	8.85	1.48	3.09	1.132825	1.064343
K	637	0.400094	0.33	0	7.56	0.23	0.47	0.200557	0.447836
NH4	627	0.09301	0.06	0	16.29	0.03	0.08	0.427032	0.653477

14.4 PRESENT WATER QUALITY STATE

14.4.1 Salinity

Long-term trend – a box-and-whisker plot of annual TDS concentrations show that TDS concentrations have remained largely unchanged over the past 20 years (Figure 17). There appears to be a 10-year cycle in the TDS that might be related to river flow (and therefore runoff). It appears as if wetter years result in higher TDS concentrations. This may imply higher mobilisation of salts in the catchment during wetter years.

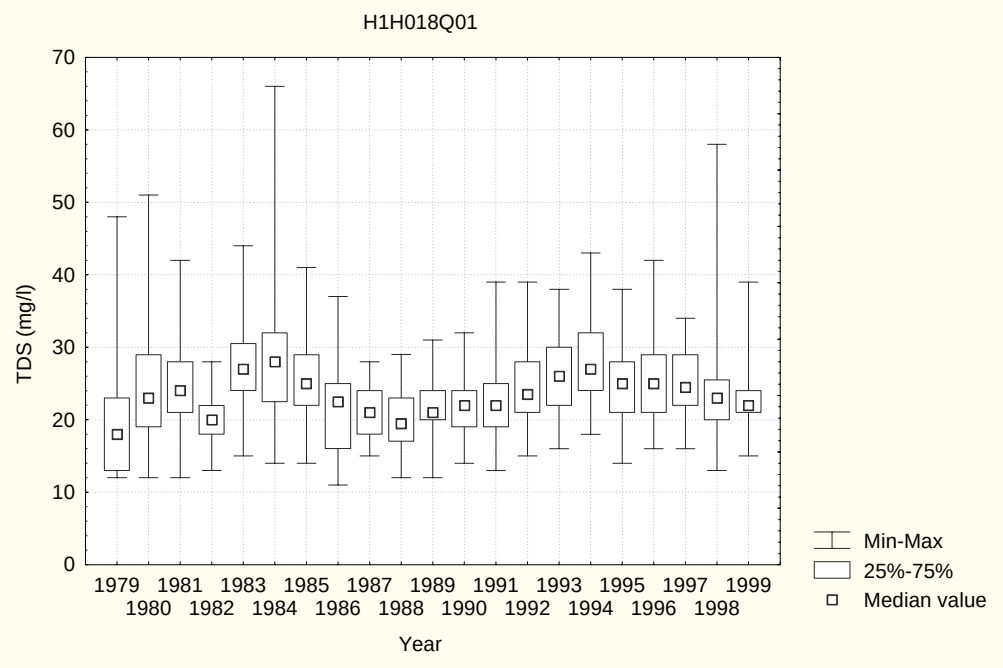

Figure 17 : Box-and-whisker plots of annual TDS concentrations recorded in the Molenaars River at H1H018Q01

Seasonal cycle – There appears to be a moderate seasonal cycle in TDS concentrations recorded in the Molenaars River (Figure 18) with lower concentrations being recorded during the winter months than during the summer months.

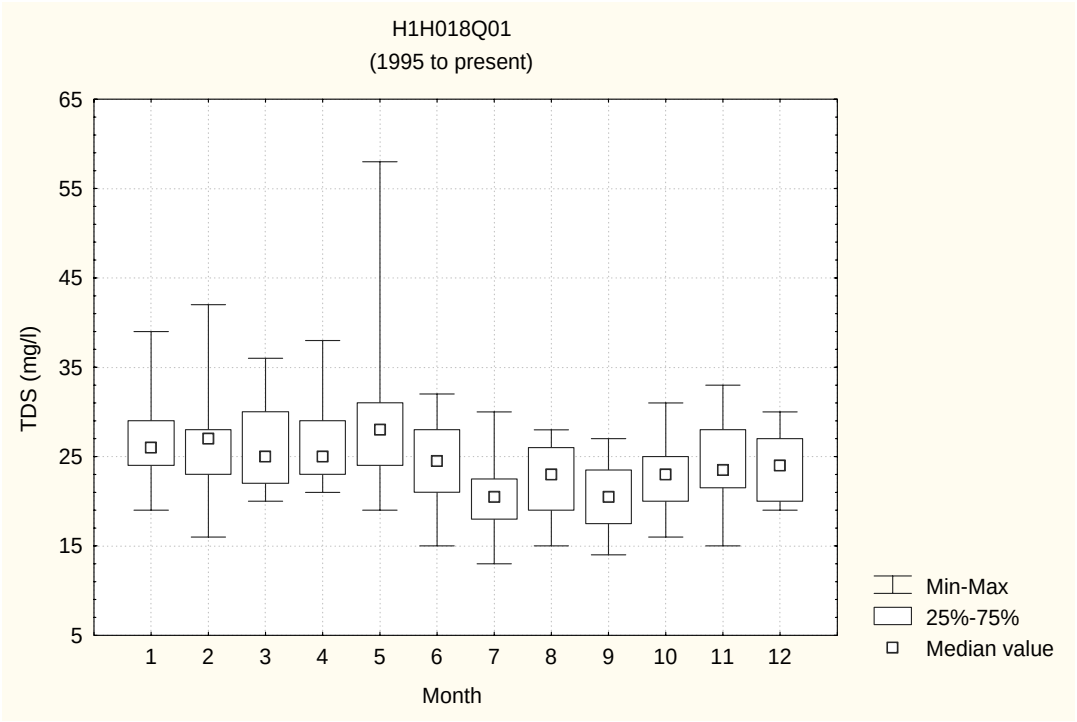

Figure 18 : Box-and-whisker plots of monthly TDS concentrations recorded in the Molenaars River at H1H018Q01

The present TDS status falls well within a Category A river.

H1H018Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	24	23	22	23	24	21	18	19	18	20	22	20
50 percentile	26	27	25	25	28	25	21	23	21	23	24	24
75 percentile	29	28	30	29	31	28	23	26	24	25	28	27
Category	A	A	A	A	A	A	A	A	A	A	A	A

14.4.2 pH

The present pH status is representative of an A category river.

H1H018Q01 STATISTIC	CALENDAR MONTH (1995 to 1999)											
	1	2	3	4	5	6	7	8	9	10	11	12
25 percentile	6.5	6.7	6.6	6.5	6.0	5.6	5.9	6.1	6.0	6.3	6.2	6.1
50 percentile	6.7	6.8	6.7	6.6	6.4	6.1	6.1	6.3	6.3	6.5	6.5	6.5
75 percentile	6.9	7.0	6.8	6.9	6.8	6.3	6.4	6.4	6.4	6.7	6.7	6.6
Category	A	A	A	A	B	A	A	A	A	A	A	A

14.4.3 Temperature

No data available. No concerns noted about unnatural temperature at the IFR site. RiversDatabase – 19°C recorded on 15/01/2000.

14.4.4 Dissolved Oxygen

No dissolved oxygen measurements available. No concerns noted about low DO concentrations in the Molenaars River.

14.4.5 Total Suspended Solids

No TSS data available, medium sediment production area (Midgley *et al.*, 1994). RiversDatabase – 0 NTU recorded on 15/01/2000.

14.4.6 Nutrient Status

The median PO_4 concentration (1995 to 1999) is 0.023 that falls in a B category. The total inorganic nitrogen to PO_4 ratio of 5.21 puts the river in D category. It was felt that the overall nutrient status was probably a C category.

14.4.7 Toxic Substances

No measurements or concerns noted about toxic substances in the Molenaars River.

14.5 ECOLOGICAL IMPORTANCE AND SENSITIVITY

EIS rating: Very High *Confidence:* High
Determinants: Presence of rare and endangered species. Presence of intolerant biota (water quality). Species/taxon richness. Presence of diversity of habitat types, refugia, and habitats sensitive to quality changes. Conservation and natural areas.
Social rating: High
Determinants: Special features and beauty spots. General aesthetic value. Sense of place. Present recreation and potential for recreation.
Information source: DWAF (2002)

14.6 ECOLOGICAL RESERVE CATEGORY

The Ecological Reserve Category was set at the IFR workshops that took place from 4-8 June 2001.

COMPONENT	PES	EC
Hydrology	A/B	
Water Quality	A/B	A/B
Geomorphology	B	B
Riparian vegetation	B/C	B
Fish	E	E
Aquatic invertebrates	A/B	A/B
Ecosystem status	B	B
	Long term	B

Information source: DWAF (2002)

14.7 RESOURCE QUALITY OBJECTIVES (ECOLOGICAL WATER QUALITY SPECIFICATIONS)

System variables

SYSTEM VARIABLES	PES	WQ EMC	CALENDAR MONTH											
			1	2	3	4	5	6	7	8	9	10	11	12
TDS (mg/ℓ)	A	A/B	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45	<45
			A	A	A	A	A	A	A	A	A	A	A	A
pH	A		Maintain the current cycle (between 5 and 95 percentiles): -For summer between 5.6 – 7.6 (Medians 6.4 – 6.8) -For winter between 5 – 6.8 (Medians 6.1 – 6.4) Note1 – First winter-runoff mobilises humics and causes a drop in pH Note 2 - Maintain wash-off event in May so that pH drops due to mobilisation of humics.											
Temp (°C)	-	A	Maintain within 2º Celsius of reference site. This site is regarded as a reference site.											
DO (% Sat)	-	A	Maintain between 80 – 120% saturation.											
TSS (mg/ℓ)	-	A	Maintain at less < 10% from reference site. This site is regarded as a reference site.											

Nutrients and nutrient ratios

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVE
Un-ionised ammonia (mg/ℓ)	A	A	< 0.007
Ortho-phosphate (mg/ℓ)	B	A/B	< 0.04 mg/ℓ
Total inorganic nitrogen: Total phosphorus ratio	-	A/B	Maintain the natural seasonal pattern. Although RDM document suggests a D category this does not seem appropriate, as this is a reference mountain stream without water quality problems.
Ortho-phosphate: Total phosphate ratio	-	A/B	< 20%
NO_2NO_3	-	A/B	Summer low flows – Maintain below 0.22 mg/ℓ for 95% of the time. Winter flows – Maintain below 0.1 mg/ℓ for 95% of the time

Toxic substances

VARIABLE	PES	WQ EMC	RESOURCE QUALITY OBJECTIVES
Toxic substances	-	A	The concentrations of toxic substances should be less that the TWQR for 90% of the time, be less than the CEV for 99% of time, and less than the AEV for 100% of time.

TWQR is the target water quality range, TCEV is the chronic effect value and AEV is the acute effect value as defined in the *South African Water Quality Guidelines, Volume 7: Aquatic Ecosystems*. 1997. Department of Water Affairs and Forestry.

15. RECOMMENDATIONS AND CONCLUSIONS

15.1 GENERAL CONSIDERATIONS

Subsequent to the completion of the Breede Reserve Workshop, a project was initiated by DWAF to update the water quality Reserve methodology. This project is nearing completion and has resulted in major changes in for example, the approach to setting a Reserve for salinity. It is recommended that the modified spreadsheet that was developed by the International Water Quality Standards (IWQS) for the new methodology be applied to the Breede River data and that the results be added to this report as a supplement to guide the setting of Reserve water quality specifications by the Department.

15.2 WATER QUALITY REFUGIA AND "HOT SPOTS"

Throughout the Breede River basin there are reaches and tributaries with particularly good water quality, which play an important role in the improvement of downstream water quality conditions, and potentially act as refugia for biota from adjacent, more impacted, reaches. In the integrated management of water quality of the Breede River, these areas should be identified and protected in order to maintain the downstream river health.

Likewise there are reaches and tributaries that are severely impacted by irrigation return flows and have very poor water quality. These tributaries and river reaches impact negatively on the downstream reaches and measures should be taken to improve water quality where these are situated upstream of important or sensitive ecosystems.

15.3 MONITORING SPECIFIC RECOMMENDATIONS

It is recommended that regular monitoring of dissolved oxygen, temperature and turbidity (or suspended solids) be undertaken to characterise the present situation in the Breede River and to monitor compliance with the water quality Reserve specifications. Efforts should also be made to link the River Health monitoring to the biotic objectives as per the revised water quality Reserve methodology that became available in 2002.

REFERENCES

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Appendix A

A hazard-based approach to applying tolerance testing in the development of ecological Reserve evaluations for salinity in the Breede River basin. Report by the Institute for Water Research, Rhodes University

A hazard-based approach to applying tolerance testing in the development of ecological Reserve evaluations for salinity in the Breede River basin

The Institute for Water Research at Rhodes University collected nymphs from sites in the Breede River basin and exposed them to different concentrations of sodium chloride. The mortalities were recorded at different times. These results were then statistically analysed and the following endpoints were determined :

Category	Description	TDS (mg/ℓ)	EC (mS/m)
A	Reference	<45	<7
B	Chronic LC_5 (lower confidence limit)	45 – 300	7 – 45
C	Chronic LC_5	300 – 800	45 – 120
D	Acute LC_5 (lower confidence limit)	800 – 1400	120 – 200
E	Acute LC_1	1400 – 1700	200 – 260
F		>1700	>260

where LC = Lethal concentration

These results were used to classify the salinity categories using the median TDS concentrations in the river.

The approach followed to determine the category endpoints was similar to the approach developed in the Olifants River Ecological Water Requirements Study and is documented in:

DWAF (2002). *Olifants River Ecological Water Requirements Assessment: Water Quality*. Appendix 1 - A hazard-based approach to applying tolerance testing in the development of ecological Reserve evaluations for salinity in the Olifants River. Report No PB 000-00-5999. Pretoria

Appendix B

Reserve calculations using the spreadsheet developed by the Institute for Water Quality Studies

The Institute for Water Quality Studies (S.Jooste) developed a spreadsheet to calculate different parameters to characterise the present ecological state for a Reserve study and to estimate boundary values for the four Reserve categories. This spreadsheet only became available after completion of the Reserve workshop. The water quality Reserve team was requested to include the results of applying the spreadsheet to the Breede River water quality data. A printout of the results page of the spreadsheet is included for the PES site of each water quality resource unit. The results of these calculations were **not** used to classify the PES or to set the water quality Reserve (as this was done at the workshop) but were included in this report to provide information that is compatible with some of the in-house methods used by the Department.

Water Quality Resource Unit 1 – Upper Breede River to Wit River confluence (IFR 1 site)

And

Water Quality Resource Unit 2 – Breede River from Wit River to Molenaars River confluence

H1H006Q01	0.1	0.5	0.9		
	10th%ile	median	90th%ile	Cat	N
Ca	1.50	4.60	8.20	A	191
Mg	1.10	3.10	6.40	A	191
K	0.54	1.03	2.56	A	191
Na	4.30	11.50	21.40	A	191
Cl	6.80	17.90	36.90	A	191
SO4	3.70	9.60	18.10	A	191
Na2SO4	5.47	14.20	26.77	B	
MgCl2	4.31	12.16	25.10	C	
CaCl2	4.16	11.48	3.60	A	
KCl	0.00	1.20	4.03	A	
MgSO4	0.00	0.00	0.00	A	
CaSO4	0.00	0.00	0.00	A	
NaCl	0.00	0.09	7.51	B	
Ca(tims)	0.19	0.50	0.93	A	
Mg(tims)	0.01	0.03	0.07	A	
K(tims)	0.05	0.13	0.26	A	
Na(tims)	0.04	0.11	0.20	A	
Cl(tims)	0.19	0.50	1.04	A	
SO4(tims)	0.04	0.10	0.19	A	
Na (other)	4.26	11.39	21.20		
K(other)	0.49	0.90	2.30		
Mg(other)	1.09	3.07	6.33		
Ca(other)	1.31	4.10	7.27		
Cl(other)	6.61	17.40	35.86		
SO4(other)	3.66	9.50	17.91		
					206
PH	6.85	7.30	7.54	A/B	A B
NH4	0.01	0.03	0.07		206
NO2_NO3	0.03	0.27	0.56		206
PO4	0.02	0.03	0.08	D	206
TIN:SP	1.45	7.44	19.26	E/F	206
NH3	0.00	0.00	0.00	A	203
TDS	32.00	66.50	122.50		206
TP	ND	ND	ND		0
KN	ND	ND	ND		0
KN:TP	ND	ND	ND		0
Non TIMS	31.73	65.78	121.07		
TAL	8.10	14.55	26.15		206

Reserve Criteria

	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	26	187	351	521
K	48	55	61	67
Mg	23	45	69	94
Ca	20	128	236	347
Cl	98	382	670	968
SO4	88	378	671	974
TDS	424.9356	1296.936	2179.936	3092.9
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.653
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve = 0.1

0.33

0.67

	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956
Variable	A	B	C	D
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	334.0675	1206.068	2089.068	3002.068
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	31.57313	22.97014	14.36457	5.761588
TIN:SP 50th	35.62399	26.34121	17.05564	7.772859
TIN:SP 90th	52.02929	41.31724	30.60197	19.88992
DO	120	94	67	40
		0.3333	0.6667	

A	A	A	E/F
A	A	B	B
A	A	E/F	
A	A	A	A
A	A		
A	A		
A	B		
A	B		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		

Water Quality Resource Unit 3 – Middle Breede River from Molenaars to Kogmanskloof River confluence (IFR 3)

H4H017Q01	0.1	0.5	0.9		
	10th%ile	**median**	**90th%ile**	**Cat**	**N**
Ca	3.90	6.60	10.70	A	209
Mg	3.30	5.70	9.70	A	209
K	0.97	1.80	2.99	A	209
Na	15.26	27.40	46.44	A	209
Cl	23.78	43.90	77.54	A	209
SO4	11.36	18.50	30.24	A	209
Na2SO4	16.80	27.36	44.73	C	
MgCl2	12.94	22.35	38.04	C	
CaCl2	10.75	18.29	18.01	B	
KCl	1.73	3.36	5.71	A	
MgSO4	0.00	0.00	0.00	A	
CaSO4	0.00	0.00	0.00	A	
NaCl	3.88	23.23	47.28	B	
Ca(tims)	0.66	1.19	2.02	A	
Mg(tims)	0.02	0.05	0.08	A	
K(tims)	0.14	0.23	0.40	A	
Na(tims)	0.10	0.16	0.27	A	
Cl(tims)	0.67	1.24	2.18	A	
SO4(tims)	0.12	0.19	0.32	A	
Na (other)	15.16	27.24	46.17		
K(other)	0.83	1.57	2.59		
Mg(other)	3.28	5.65	9.62		
Ca(other)	3.24	5.41	8.68		
Cl(other)	23.11	42.66	75.36		
SO4(other)	11.24	18.31	29.93		
					209
PH	7.10	7.47	7.76	A/B	A B
NH4	0.01	0.03	0.05		209
NO2_NO3	0.02	0.22	0.81		209
PO4	0.01	0.03	0.04	C	209
TIN:SP	1.61	8.25	37.39	D	209
NH3	0.00	0.00	0.00	A	203
TDS	83.00	133.00	217.00		208
TP	ND	ND	ND		0
KN	ND	ND	ND		0
KN:TP	ND	ND	ND		0
Non TIMS	82.11	131.41	214.23		
TAL	13.16	21.50	33.20		209

Reserve Criteria

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	51	212	376	546
K	49	56	62	68
Mg	27	49	73	98
Ca	22	130	238	349
Cl	137	421	709	1007
SO4	100	390	683	986
TDS	599.5849	1471.585	2354.585	3268
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.7
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve = 0.1 0.33 0.67

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	**A**	**B**	**C**	**D**
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	427.2339	1299.234	2182.234	3095.234
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	30.4122	22.02574	13.63677	5.250315
TIN:SP 50th	33.60733	24.64803	15.68603	6.726723
TIN:SP 90th	38.14079	28.49717	18.85066	9.207037
DO	120	94	67	40
		0.3333	0.6667	

A	A	A	E/F	
A	A	B	B	
A	A	A		
A	A	A	A	
A	A			
A	A			
B	B			
B	B			
A	B			
A	A			
A	A			
B	B			
A	A			
A	A			
A	A			
A	A			
A	A			
A	A			

Water Quality Resource Unit 4 – Middle Breede River from Kogmanskloof to Riviersonderend confluence

H5H005Q01	0.1	0.5	0.9		
	10th%ile	**median**	**90th%ile**	**Cat**	**N**
Ca	5.70	20.80	35.30	A	191
Mg	5.00	23.90	44.00	A	191
K	1.61	3.84	5.90	A	191
Na	22.60	141.30	248.90	A	191
Cl	37.00	208.50	378.50	A	191
SO4	19.00	63.00	116.00	A	191
Na2SO4	28.10	93.19	171.58	E/F	
MgCl2	19.61	93.73	172.56	E/F	
CaCl2	15.79	57.63	66.77	C	
KCl	3.06	7.34	11.27	A	
MgSO4	0.00	0.00	0.00	A	
CaSO4	0.00	0.00	0.00	A	
NaCl	20.36	172.72	310.11	B	
Ca(tims)	0.98	6.14	10.82	A	
Mg(tims)	0.04	0.10	0.15	A	
K(tims)	0.21	0.98	1.81	A	
Na(tims)	0.14	0.52	0.88	A	
Cl(tims)	1.04	5.87	10.66	A	
SO4(tims)	0.20	0.66	1.21	A	
Na (other)	22.46	140.78	248.02		
K(other)	1.40	2.86	4.09		
Mg(other)	4.96	23.80	43.85		
Ca(other)	4.72	14.66	24.48		
Cl(other)	35.96	202.63	367.84		
SO4(other)	18.80	62.34	114.79		
					191
PH	7.34	8.03	8.43	A/C	A C
NH4	0.01	0.03	0.06		191
NO2_NO3	0.01	0.13	0.74		191
PO4	0.01	0.02	0.04	B	191
TIN:SP	1.86	7.96	32.50	D	191
NH3	0.00	0.00	0.00	A	185
TDS	120.40	584.00	1024.30		190
TP	ND	ND	ND		0
KN	ND	ND	ND		0
KN:TP	ND	ND	ND		0
Non TIMS	119.02	576.95	1011.55		
TAL	20.50	94.50	163.30		191

Reserve Criteria

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	253	414	578	748
K	50	57	63	69
Mg	61	83	107	132
Ca	37	145	253	364
Cl	430	714	1002	1300
SO4	185	475	768	1071
TDS	2027.615	2899.615	3782.615	4696
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.65
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve = 0.1 / 0.33 / 0.67

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	**A**	**B**	**C**	**D**
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	1224.549	2096.549	2979.549	3892.549
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	29.41615	21.22294	13.02728	4.834067
TIN:SP 50th	32.50664	23.73644	14.96362	6.193424
TIN:SP 90th	37.76166	28.1693	18.57405	8.98169
DO	120	94	67	40
		0.3333	0.6667	

A	A	C	E/F
A	A	A	B
A	A	A	
A	A	A	A
A	A		
A	A		
A	E/F		
B	E/F		
A	B		
A	A		
A	A		
A	A		
B	B		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		

Water Quality Resource Unit 5 – Lower Breede River from Riviersonderend to Buffelsjags River, and
Water Quality Resource Unit 6 – Lower Breede River from Buffelsjags River to estuary (IFR 4)

H4H017Q01	0.1	0.5	0.9			
	10th%ile	median	90th%ile	Cat	N	
Ca	5.50	11.80	19.54	A		55
Mg	5.78	13.30	26.58	A		55
K	1.36	2.74	4.26	A		55
Na	30.60	77.20	166.32	A		55
Cl	47.68	123.00	260.48	A		55
SO4	16.52	36.10	64.84	A		55
Na2SO4	24.44	53.40	95.91	E/F		
MgCl2	22.67	52.16	104.24	E/F		
CaCl2	15.24	32.69	39.07	B		
KCl	2.60	5.23	8.13	A		
MgSO4	0.00	0.00	0.00	A		
CaSO4	0.00	0.00	0.00	A		
NaCl	28.94	111.06	234.03	B		
Ca(tims)	1.33	3.36	7.23	A		
Mg(tims)	0.03	0.07	0.11	A		
K(tims)	0.24	0.55	1.09	A		
Na(tims)	0.14	0.29	0.49	A		
Cl(tims)	1.34	3.46	7.34	A		
SO4(tims)	0.17	0.38	0.68	A		
Na (other)	30.46	76.91	165.83			
K(other)	1.12	2.19	3.16			
Mg(other)	5.75	13.23	26.47			
Ca(other)	4.17	8.44	12.31			
Cl(other)	46.34	119.54	253.14			
SO4(other)	16.35	35.72	64.16			
						55
PH	7.26	7.72	8.13	A/C	A	C
NH4	0.00	0.02	0.05			55
NO2_NO3	0.01	0.20	0.67			55
PO4	0.01	0.02	0.03	B		55
TIN:SP	1.47	10.90	39.22	D		55
NH3	0.00	0.00	0.00	A		53
TDS	142.60	325.00	653.40			55
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
Non TIMS	140.95	320.86	644.90			
TAL	23.74	49.70	95.44			55

Reserve Criteria				
	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	171	332	496	666
K	49	56	62	68
Mg	43	65	89	114
Ca	25	133	241	352
Cl	315	599	887	1185
SO4	134	424	717	1020
TDS	1382.983	2254.983	3137.983	4051
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.653
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve =		
	0.1	
0.33	0.67	

	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	A	B	C	D
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	857.8998	1729.9	2612.9	3525.9
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	29.51427	21.30172	13.08671	4.874161
TIN:SP 50th	31.70484	23.07788	14.44834	5.821384
TIN:SP 90th	35.68335	26.39151	17.09687	7.805027
DO	120	94	67	40
		0.3333	0.6667	

A	A	B	E/F
A	A	A	B
A	A	A	
A	A	A	A
A	A		
A	A		
B	C		
B	D		
A	B		
A	A		
A	A		
A	A		
B	B		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		

Water Quality Resource Unit 7 – Riviersonderend from Theewaterskloof Dam to Bok River

H6H012Q01	0.1	0.5	0.9			
	10th%ile	median	90th%ile		Cat	N
Ca	2.20	2.80	4.24	A		50
Mg	1.80	2.30	5.01	A		50
K	0.62	1.25	2.61	A		50
Na	7.76	10.00	35.12	A		50
Cl	11.86	17.35	64.48	A		50
SO4	3.46	7.30	10.04	A		50
Na2SO4	5.12	10.80	14.85	B		
MgCl2	7.06	9.02	19.65	B		
CaCl2	6.07	7.76	8.87	A		
KCl	1.18	2.39	4.99	A		
MgSO4	0.00	0.00	0.00	A		
CaSO4	0.00	0.00	0.00	A		
NaCl	0.83	9.49	65.93	B		
Ca(tims)	0.34	0.43	1.53	A		
Mg(tims)	0.02	0.03	0.07	A		
K(tims)	0.07	0.09	0.21	A		
Na(tims)	0.05	0.07	0.11	A		
Cl(tims)	0.33	0.49	1.82	A		
SO4(tims)	0.04	0.08	0.10	A		
Na (other)	7.71	9.93	35.01			
K(other)	0.55	1.16	2.41			
Mg(other)	1.78	2.27	4.94			
Ca(other)	1.86	2.37	2.71			
Cl(other)	11.53	16.86	62.66			
SO4(other)	3.42	7.22	9.94			
						50
PH	6.60	6.85	7.17	A/A	A	A
NH4	0.01	0.02	0.04			50
NO2_NO3	0.09	0.14	0.23			50
PO4	0.00	0.01	0.02	B		50
TIN:SP	7.20	12.83	38.36	D		49
NH3	0.00	0.00	0.00	A		49
TDS	43.00	55.00	143.00			50
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
Non TIMS	42.58	54.37	140.97			
TAL	7.97	11.75	16.60			50

Reserve Criteria				
	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	40	201	365	535
K	48	55	61	67
Mg	22	44	68	93
Ca	16	124	232	343
Cl	125	409	697	995
SO4	80	370	663	966
TDS	471.6486	1343.649	2226.649	3139.6
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.653
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve =			
		0.1	
	0.33	0.67	

	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956
Variable	A	B	C	D
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mg	0.01	0.04	0.07	0.1
TDS (Res)	353.9733	1225.973	2108.973	3021.973
NH3 mgN/	0.007	0.034	0.067	0.1
TIN:SP 10	28.42905	20.43404	12.43664	4.441637
TIN:SP 50	29.91004	21.62015	13.32778	5.037894
TIN:SP 90	33.35647	24.43949	15.51984	6.602861
DO	120	94	67	40
		0.3333	0.6667	

A	A	A	D
A	A	A	B
A	A	A	
A	A	A	A
A	A		
A	A		
A	B		
A	A		
A	A		
A	A		
A	B		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		

Water Quality Resource Unit 8 – Riviersonderend from Bok River to Breede River confluence

H6H009Q01	0.1	0.5	0.9			
	10th%ile	**median**	**90th%ile**	**Cat**		**N**
Ca	2.95	4.00	8.35	A		56
Mg	3.40	4.85	13.80	A		56
K	0.95	1.84	2.85	A		56
Na	20.15	34.10	106.65	A		56
Cl	32.10	57.65	181.20	A		56
SO4	10.45	17.80	30.75	A		56
Na2SO4	15.46	26.33	45.48	C		
MgCl2	13.33	19.02	54.12	D		
CaCl2	8.17	11.08	24.38	B		
KCl	1.81	3.51	5.43	A		
MgSO4	0.00	0.00	0.00	A		
CaSO4	0.00	0.00	0.00	A		
NaCl	23.60	54.22	194.73	B		
Ca(tims)	0.88	1.48	4.64	A		
Mg(tims)	0.02	0.05	0.07	A		
K(tims)	0.14	0.20	0.57	A		
Na(tims)	0.07	0.10	0.21	A		
Cl(tims)	0.90	1.62	5.10	A		
SO4(tims)	0.11	0.19	0.32	A		
Na (other)	20.08	34.00	106.44			
K(other)	0.81	1.64	2.28			
Mg(other)	3.38	4.80	13.73			
Ca(other)	2.07	2.52	3.71			
Cl(other)	31.20	56.03	176.10			
SO4(other)	10.34	17.61	30.43			
						56
PH	6.92	7.17	7.48	A/A	A	A
NH4	0.00	0.02	0.03			56
NO2_NO3	0.06	0.15	0.29			56
PO4	0.01	0.02	0.04	C		56
TIN:SP	2.41	9.92	20.09	D		56
NH3	0.00	0.00	0.00	A		49
TDS	94.50	146.50	379.00			56
TP	ND	ND	ND			0
KN	ND	ND	ND			0
KN:TP	ND	ND	ND			0
Non TIMS	93.41	144.59	373.37			
TAL	14.60	20.10	35.25			56

Reserve Criteria

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	111	272	436	606
K	48	55	61	67
Mg	31	53	77	102
Ca	17	125	233	344
Cl	238	522	810	1108
SO4	100	390	683	986
TDS	919.0517	1791.052	2674.052	3587
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.65
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve = 0.1

0.33

0.67

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	**A**	**B**	**C**	**D**
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	586.3672	1458.367	2341.367	3254.367
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	29.91003	21.62015	13.32778	5.037894
TIN:SP 50th	31.83708	23.18619	14.5327	5.881801
TIN:SP 90th	38.55581	28.85736	19.156	9.457547
DO	120	94	67	40
		0.3333	0.6667	

A	A	A	E/F	
A	A	B	B	
A	A	A		
A	A	A	A	
A	A			
A	A			
B	B			
B	B			
A	A			
A	A			
A	A			
A	A			
B	B			
A	A			
A	A			
A	A			
A	A			
A	A			
A	A			

Water Quality Resource Unit 9 – Baviaans River

H6H005Q01	0.1	0.5	0.9			
	10th%ile	**median**	**90th%ile**	**Cat**	**N**	
Ca	0.90	1.40	2.68	A	53	
Mg	1.30	1.60	1.90	A	53	
K	0.00	0.30	0.74	A	53	
Na	6.84	9.00	11.40	A	53	
Cl	11.62	14.00	18.66	A	53	
SO4	3.74	6.60	10.78	A	53	
Na2SO4	5.53	9.76	15.95	B		
MgCl2	5.10	6.27	7.45	A		
CaCl2	2.49	3.88	2.49	A		
KCl	0.00	0.53	1.41	A		
MgSO4	0.00	0.00	0.00	A		
CaSO4	0.00	0.00	0.00	A		
NaCl	1.28	10.37	18.06	B		
Ca(tims)	0.30	0.39	0.50	A		
Mg(tims)	0.00	0.01	0.02	A		
K(tims)	0.05	0.07	0.08	A		
Na(tims)	0.02	0.03	0.07	A		
Cl(tims)	0.33	0.39	0.53	A		
SO4(tims)	0.04	0.07	0.11	A		
Na (other)	6.82	8.97	11.33			
K(other)	-0.05	0.23	0.66			
Mg(other)	1.30	1.59	1.88			
Ca(other)	0.60	1.01	2.18			
Cl(other)	11.29	13.61	18.13			
SO4(other)	3.70	6.53	10.67			
					53	
PH	4.96	6.08	6.66	E/F/A	E/F A	
NH4	0.00	0.02	0.04		53	
NO2_NO3	0.01	0.04	0.14		53	
PO4	0.01	0.02	0.03	B	53	
TIN:SP	1.08	3.88	9.68	E/F	53	
NH3	0.00	0.00	0.00	A	48	
TDS	37.10	43.00	55.00		52	
TP	ND	ND	ND		0	
KN	ND	ND	ND		0	
KN:TP	ND	ND	ND		0	
Non TIMS	36.71	42.50	54.30			
TAL	3.12	7.30	13.26		53	

Reserve Criteria

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	16	177	341	511
K	47	54	60	66
Mg	19	41	65	90
Ca	15	123	231	342
Cl	80	364	652	950
SO4	81	371	664	967
TDS	312.1557	1184.156	2067.156	2980
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.65
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve = 0.1

0.33 0.67

	A	**B**	**C**	**D**
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	**A**	**B**	**C**	**D**
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	267.2952	1139.295	2022.295	2935.295
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	29.91003	21.62015	13.32778	5.037894
TIN:SP 50th	31.96988	23.29507	14.61766	5.942846
TIN:SP 90th	35.62399	26.34121	17.05564	7.772859
DO	120	94	67	40
		0.3333	0.6667	

A	A	B	E/F
A	A	B	B
A	A	D	
A	A	A	A
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	B		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		

Water Quality Resource Unit 10 – Molenaars River IFR 2 site

H1H018Q01	0.1	0.5	0.9		
	10th%ile	median	90th%ile	Cat	N
Ca	0.60	1.10	2.00	A	214
Mg	0.53	0.80	1.10	A	214
K	0.18	0.45	1.39	A	214
Na	2.53	3.50	4.40	A	214
Cl	4.13	5.30	6.90	A	214
SO4	1.70	3.70	6.70	A	214
Na2SO4	2.51	5.47	9.00	A	
MgCl2	1.98	3.14	4.31	A	
CaCl2	1.42	2.77	2.77	A	
KCl	0.00	0.63	1.73	A	
MgSO4	0.00	0.00	0.00	A	
CaSO4	0.00	0.00	0.00	A	
NaCl	0.00	0.51	3.37	B	
Ca(tims)	0.11	0.15	0.19	A	
Mg(tims)	0.00	0.01	0.04	A	
K(tims)	0.02	0.03	0.05	A	
Na(tims)	0.01	0.03	0.05	A	
Cl(tims)	0.12	0.15	0.19	A	
SO4(tims)	0.02	0.04	0.07	A	
Na (other)	2.52	3.47	4.35		
K(other)	0.15	0.42	1.34		
Mg(other)	0.53	0.79	1.06		
Ca(other)	0.49	0.95	1.81		
Cl(other)	4.01	5.15	6.71		
SO4(other)	1.68	3.66	6.63		
					214
PH	5.78	6.48	7.00	C/A	C A
NH4	0.01	0.02	0.04		214
NO2_NO3	0.05	0.10	0.19		214
PO4	0.01	0.02	0.04	B	214
TIN:SP	2.59	6.24	12.40	E/F	214
NH3	0.00	0.00	0.00	A	214
TDS	18.00	24.00	31.00		213
TP	ND	ND	ND		0
KN	ND	ND	ND		0
KN:TP	ND	ND	ND		0
Non TIMS	17.85	23.78	30.69		
TAL	2.50	6.50	11.07		214

Reserve Criteria				
	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	9	170	334	504
K	47	54	60	66
Mg	18	40	64	89
Ca	15	123	231	342
Cl	69	353	641	939
SO4	77	367	660	963
TDS	265.5897	1137.59	2020.59	2934
pH(lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4	0.01	0.04	0.07	0.1
TIN:SP	62.74753	52.48639	41.91431	31.7
NH3	0.007	0.034	0.067	0.1
DO	100	80	60	40

Select PO4 Reserve =			
			0.1
		0.33	0.67

	A	B	C	D
Na2SO4	12	32	58	84
MgCl2	9	24	44	64
CaCl2	17	61	106	152
KCl	88	100	113	125
MgSO4	59	129	199	271
CaSO4	21	333	646	968
NaCl	3	397	792	1200
Na	5	166	330	500
K	46	53	59	65
Mg	17	39	63	88
Ca	13	121	229	340
Cl	62	346	634	932
SO4	70	360	653	956

Variable	A	B	C	D
pH (lower)	6.5	6	5.5	5
pH (upper)	7.5	8	8.5	9
PO4 3- mgP/l	0.01	0.04	0.07	0.1
TDS (Res)	243.686	1115.686	1998.686	2911.686
NH3 mgN/l	0.007	0.034	0.067	0.1
TIN:SP 10th	30.16007	21.82188	13.48119	5.143008
TIN:SP 50th	33.0524	24.18734	15.31963	6.454568
TIN:SP 90th	37.35519	27.81901	18.27996	8.743784
DO	120	94	67	40
		0.3333	0.6667	

A	A	B	E/F
A	A	B	B
A	A	D	
A	A	A	A
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		
A	A		