PALMIET RIVER CATCHMENT MANAGEMENT PLAN

Update and Review

April 2010

Freshwater Consulting Group

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1. INTRODUCTION AND CONTEXT

1.1 Historical context of the CMP 2000

In 1989, a range of water resource development options were identified by the Western Cape System Analysis (WCSA) to augment water supplies to the Cape Metropolitan Area (CMA) based on projected demand. Amongst the development options considered, two were located within the Palmiet River catchment: (1) an inter-basin water transfer between the Palmiet and Steenbras Rivers (Palmiet Phase 1) and (2) the construction of additional dams on the main stem of the lower Palmiet River (Palmiet Phase 2).

In February 1995, the Department of Water Affairs (formerly Department of Water Affairs and Forestry, DWAF) approved the Palmiet Pumped Storage Scheme (Palmiet Phase 1). This first phase proposed that the Cape Metropolitan Council make use of the Eskom Pumped Storage Scheme to abstract 22 Mm^3/a from the Kogelberg Dam on the Palmiet River, via the off-channel Rockview, to the Upper Steenbras Dam.

Approval of Palmiet Phase 1 was, however, conditional upon the development of a Catchment Management Plan (CMP) and the completion of an Environmental Water Requirement study (EWR) for the Palmiet River. To this end, the Palmiet River Catchment Management Steering Committee (PSC) was elected in July 1996. The PSC contracted two groups of independent consultants to develop the CMP and conduct the EWR (Common Ground Consulting and Southern Waters Ecological Research and Consulting respectively). The EWR was completed in October 1998 and the CMP in August 2000.

The purpose of the CMP is to identify and formulate responses to major issues affecting the network of rivers in the catchment that arise from social and economic activities, including *inter alia* water resource development, farming, industry and urban settlement. The scope of the CMP therefore extended beyond the implementation of EWR for the Palmiet River to include other river management issues. The CMP recommended that an adaptive management approach be adopted with an annual and five year cycle of review and appraisal. To date, no review of the initial CMP has been carried out. This document therefore represents the first review and assessment of achievements of the initial CMP 2000 and an updated statement of river condition.

1.2 Rationale and justification

The initial impetus to develop a CMP for the Palmiet River system arose from the need to reconcile the livelihood and economic value of human activities within the catchment with the ecological functions and services of its aquatic ecosystems. Urban settlements, intensive agriculture and its associated industries have, to a significant extent, transformed these ecosystems away from natural. The Palmiet River catchment is one of the most intensively farmed regions in the Overberg. Of the 11 400 ha of irrigated land in the Overberg, 66 % (7600 ha) fall within the Palmiet River catchment alone (DWAF 2004). The CMP was to provide the blueprint for an ongoing Catchment Management Strategy that would slow, halt, or reverse the rate of degradation arising from physical disturbances to riparian corridors, point and non-point pollution sources, as well as modifications to river flow by major water resource infrastructure.

A number of changes have occurred in the catchment since the Palmiet CMP was drafted in 2000. In particular growth in water demand has risen steadily both within and beyond the borders of the catchment. In 2007, the DWA completed the Western Cape Reconciliation Strategy (WCRS) to inform decisions on interventions that would reconcile water supply to meet demand in the Western Cape until 2030. Given current trends in population growth, the DWA has adopted a Water Conservation/Water Demand Strategy (WC/WDS) which is intended to maintain demand at 2008 levels until 2013. Together with the recently completed Berg River

Dam, the WC/WDS should assure supplies until 2019 when further interventions will become necessary. Amongst the options being considered in the Palmiet River catchment beyond 2019 are raising the Lower Steenbras Dam and extending the Palmiet Transfer Scheme thereby maximising abstraction using Eskom's Palmiet Pumped Storage Scheme (DWA 2009).

There have been both positive and negative developments with respect to water use in the catchment since the drafting of the initial CMP. A significant land-use change in the past decade has been the decrease in irrigated orchards, while the area under vineyards increased. Vineyards require less water for their irrigation, and this together with the implementation of more water-efficient irrigation systems has led to reduced demand (Danie Bosch, GWUA *pers. comm.*). Also the increased cost of fertilizers has led to their reduced application, with possible implications for improved water quality. Meanwhile, increased overloading of the Grabouw Waste Water Treatment Works (WWTW) due to population growth in the urban areas has led to deteriorating water quality in the Palmiet River downstream (Belcher 2009).

In addition to changes water use and quality in the catchment, there have also been changeovers in water resource governance structures. Since 2000, considerable progress has been made with respect to the devolution of water resource management from central government to Catchment Management Agencies (CMAs). In 2005, the establishment of the Groenland Water User Association (GWUA) was approved by the Minister of Water Affairs and Forestry and the first committee was elected later that year. The GWUA has since taken over as an advisory body from the Palmiet River Catchment Management Steering Committee (PSC). Whereas the former PSC had little recourse to legal action to deal with contraventions, the Groenland WUA now have a mandate to ensure compliance through legal channels and charge levies for water use. This represents a significant achievement and an opportunity to translate public policies into action.

1.3 Terms of Reference

This report provides a review of the CMP 2000 a decade after it was first promulgated. The existing Catchment Management Plan for the Palmiet River (CMP 2000) subdivided the catchment into Management Units and identified a desired condition, or Management Class, for each. The achievement of the key CMP aims was dependent on meeting the EWR, as well as a number of other non-flow related management objectives, as a means of maintaining and/or improving the condition of the river in these Management Units. The CMP proposed the monitoring of river condition at five Environmental Water Requirement (EWR) monitoring sites, to track progress in achieving or maintain the desired Management Class in each Management Unit. To date, very little monitoring has been carried out. In relation to the water resource development approved when the CMP was initiated, namely Palmiet Phase 1, therefore, it has not been possible to determine whether the annual transfer of water from the Palmiet River to the Western Cape Water Supply System has significantly affected the health of the river. Also, very little information exists on the condition of the tributaries.

The Terms of Reference for the present study were agreed as follows:

- Undertake limited field work to clarify the impacts associated with winter flows in the lower Palmiet River
- An investigation of current rights and practice with regard to diversion of flows in the Klein Palmiet River
- Clarification of the releases made from Eikenhof Dam
- Collation of all existing information, including flow and water quality data

All of the above were to be used to update the CMP. The deliverable from this exercise would be:

- An updated statement of river condition in each of the Management sub-units as defined in the existing CMP
- Revision of the future management objectives for each Management Unit, including measurable criteria for evaluation
- An evaluation of the “next steps” that are required to give effect to the objectives in the revised CMP, provided as an action plan or set of tasks with clear terms of reference
- Recommendations regarding the most appropriate monitoring programme, including the location of additional monitoring sites and appropriate monitoring techniques.

2. SYNOPSIS OF THE PALMIET RIVER CATCHMENT MANAGEMENT PLAN 2000 (CMP 2000)

The sections that follow provide a synopsis of the key issues in the development of the CMP.

2.1 The CMP 2000 development process

The development of CMP 2000 was undertaken by the PSC following the five steps outlined below and around which the CMP report was structured (CMP 2000).

(Step 1) The production of a **Plan of Study**

(Step 2) **Review** of available information on the catchment:
a. Vision for the catchment
b. State of the catchment
c. Targets for catchment management

(Step 3) Developing the **Policy Framework** (Pg. 8)
a. Analysing and developing goals and objectives for management of the Palmiet catchment

(Step 4) Developing the Administrative and **Regulatory Framework** (Pg. 13)
a. Developing mechanisms for implementing policy objectives
b. Developing principles for a Water Allocation Plan

(Step 5) Developing a **Procedural Framework** (Pg. 50)
a. Outlining strategies for monitoring and review
b. Outlining a Programme of Actions

Several constraints were identified to developing the CMP including: (1) the absence of detailed information on the state of the catchment, (2) budgetary constraints that limited the collection of baseline terrestrial information and (3) planning in the initial CMP was addressed at a strategic level rather than focused planning on specific problems associated with particular river reaches. The latter was identified as a requirement of the next phase in the development of the CMP. The current review attempts to redress this last issue to some degree.

2.1.1 Identification of Management Units

The CMP divided the Palmiet River into six Management Units based on sub-catchments and additional land use criteria. These Management Units comprised:

1) **Eikenhof**: the catchment area from the source of the river to the Eikenhof Dam
2) **Arieskraal**: the catchment area draining into the Palmiet River from Eikenhof Dam to the Arieskraal Dam
3) **Klein Palmiet**: the catchment area draining to the Palmiet River from downstream of Arieskraal Dam to the confluence of the Klein Palmiet and Palmiet Rivers
4) **Solva**: the catchment area draining to the Palmiet River from downstream of the Klein Palmiet River confluence to to the boundary of the Kogelberg Reserve.
5) **Kogelberg**: the catchment area draining to the Palmiet River from Solva to the head of the estuary
6) **Estuary**: head of the estuary to the sea

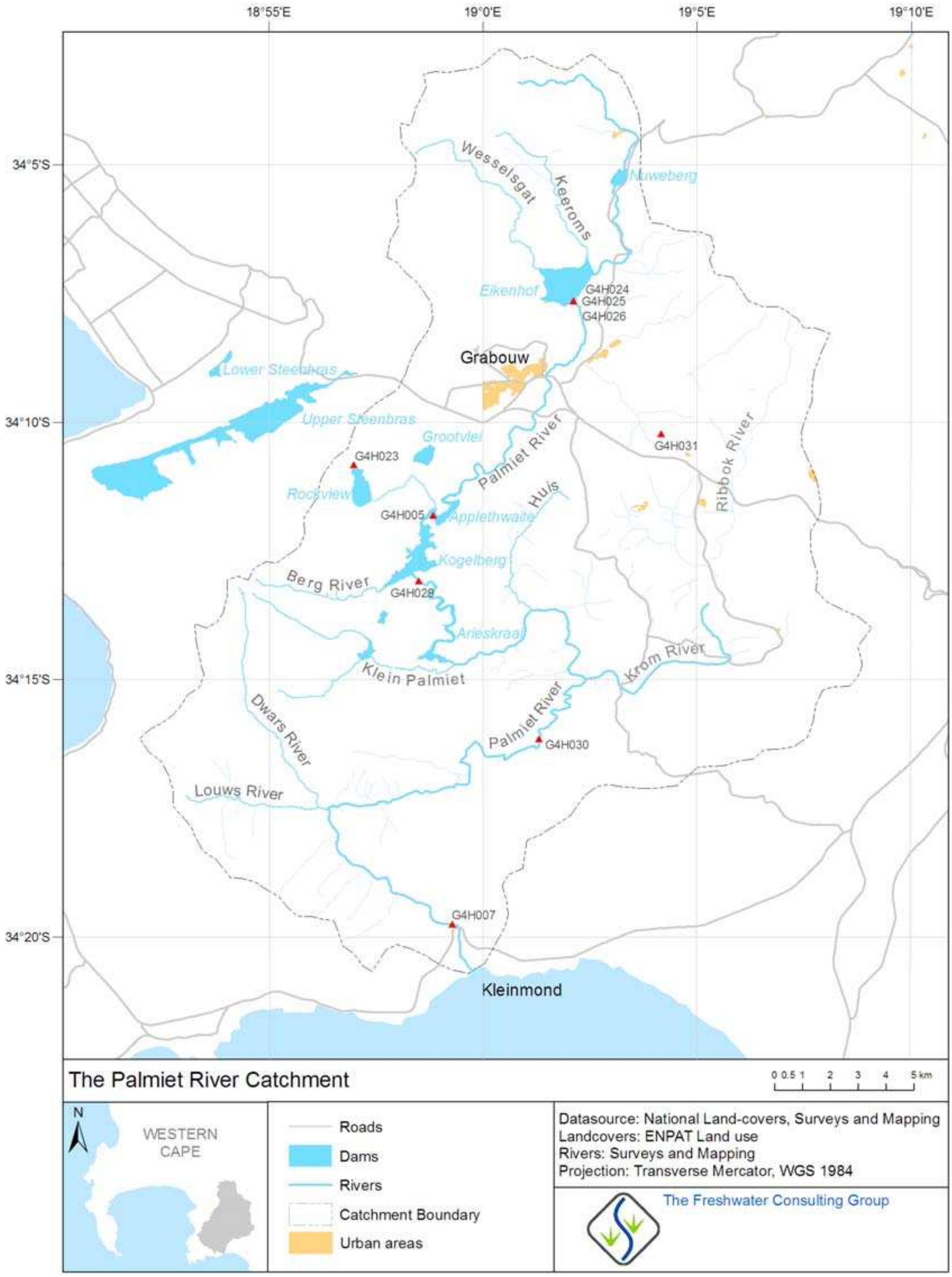

Figure 2.1 The Palmiet River catchment rivers showing the location of urban settlements, perennial rivers, major water resources infrastructure and gauging weirs.

The then-current status of each Management Unit 1-6 were outlined in terms of predominant land use, vegetation, water quality, aquatic macroinvertebrates, the presence or absence of indigenous fish species, as well as major physical and flow perturbations (CMP 2000).

2.2 Policy Framework

2.2.1 Vision

The Policy Framework of CMP 2000 outlined a vision for the catchment, a list of priority issues requiring management interventions were defined, the agreed upon EWR Scenario was identified and the Resource Quality Objectives (RQOs) for the river in each Management Unit were set, based on implementation of the agreed upon EWR. The vision was formulated by the PCS at a workshop held in August 1996 was to 'manage the Palmiet River Catchment Area so that optimal use is made of the total resources (land, water and air) to sustain the ecological, social and economic requirements and to maintain the unique conservation status and scenic beauty of the area' (CMP 2000).

2.2.2 Priority issues

Priority issues were identified and deemed to require management interventions in the initial CMP. These included:

The river ecosystem:	water quality, water quantity, channel morphology
The terrestrial ecosystem:	biodiversity conservation, alien vegetation clearing
Landuse practices:	farming, forestry, urban environment
Social issues:	water supply to catchment users, recreation and tourism, awareness and education
Water demand management	
Water allocation	
Management of water infrastructure	

The management approach to each of these issues, together with detailed objectives, strategies and indicators were laid out in the **Regulatory Framework** in the CMP 2000 report (Section 1.4 of that report).

2.2.3 Environmental Flow Requirement Scenarios and Resource Quality Objectives

Following the conclusion of the EWR study (Brown and Day 1998), a public workshop was held in February 2000 that included all stakeholder groups. At this workshop, each of four alternative EWR Scenarios for each of four reaches of the Palmiet River was presented and their social, economic and ecological consequences elucidated (Common Ground Consulting 2000b, Southern Waters 1998a). EWR Scenarios 3 and 4 for all portions of the river were rejected by the stakeholder groups on the grounds that their ecological costs were too high. Taking into consideration the views expressed at the public workshop together with a careful consideration of the available technical information, the PSC selected Scenario 1, the 'Minimum Degradation' scenario for all parts of the river, as the preferred water resource development path for the catchment.

In each river reach, the EWR Scenario 1 requires that, (1) the quantity and timing of flows released downstream of dams, abstractions or diversions of water be managed in a way that results in the least biophysical impacts beyond current levels and (2) that specific Resource Quality Objectives (RQOs) be met through the former management interventions in order to maintain or achieve the desired condition in the river. This desired condition was expressed as one of a number of Management Classes (Table 2.1, Figure 2.1).

The RQOs, together with specific management recommendations to achieve these objectives for each river Management Unit (Section 1.3.4 this report) and in terms of each component of the river ecosystem are outlined in the CMP (CMP 2000, Appendix B). They have been incorporated into the updated statement of the present and desired condition of the river in this CMP as detailed in Section 3 of this report.

Table 2.1 Generic Management Classes used to summarise general river condition, based on Kleynhans 1996.

MANAGEMENT CLASS	DESCRIPTION
Class A	100% of potential value; unmodified, natural.
Class B	80-99% of potential value; largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the assumption is that ecosystem functioning is essentially unchanged.
Class C	60-79% of potential value, moderately modified. A loss and change of natural habitat and biota has occurred, but basic ecosystem functioning appears to be predominantly unchanged.
Class D	40-59% of potential value, largely modified. A loss of natural habitat, and taxa and a reduction in basic ecosystem functioning has occurred.
Class E	20-39% of potential value, seriously modified. The loss of natural habitat, taxa and ecosystem functioning is extensive.
Class F	0-19% of potential value, modifications have reached a critical level and there has been an almost complete loss of natural habitat and biota. In the worst cases, basic ecosystem functioning no longer exists.

2.3 Regulatory Framework

The Regulatory Framework described in the Palmiet CMP 2000 delineated a set of management objectives, actions, and performance indicators for each of the Priority Issues that were outlined within the Policy Framework, i.e. the river ecosystem, terrestrial ecosystems, land use practices, social issues, water demand management, water allocation and the management of water infrastructure (Section 0 this report). The objectives, actions and indicators are unique to each Management Unit. The responsibilities of various agencies and organisations as well as time the frames for achieving each of the objectives were also given.

2.4 Administrative Framework

The delegation of water management from central government to catchment level in South Africa is currently being achieved through the CMAs that have been tasked with developing Catchment Management Strategies (CMS) in each of the WMAs within the framework of the National Water Resource Strategy (NWRS). The CMP therefore provides the basic outline for the ongoing CMS. The Palmiet CMP 2000 was intended to form part of the CMP developed for the Breede Water Management Area (WMA) which is currently overseen by the Breede Overberg Catchment Management Agency (BOCMA) (formerly Breede Catchment Agency). The Administrative Framework described in Palmiet CMP 2000 provided an inventory of the agencies and organisations responsible for decision-making and for implementing the preventative and remedial actions identified in the Regulatory Framework.

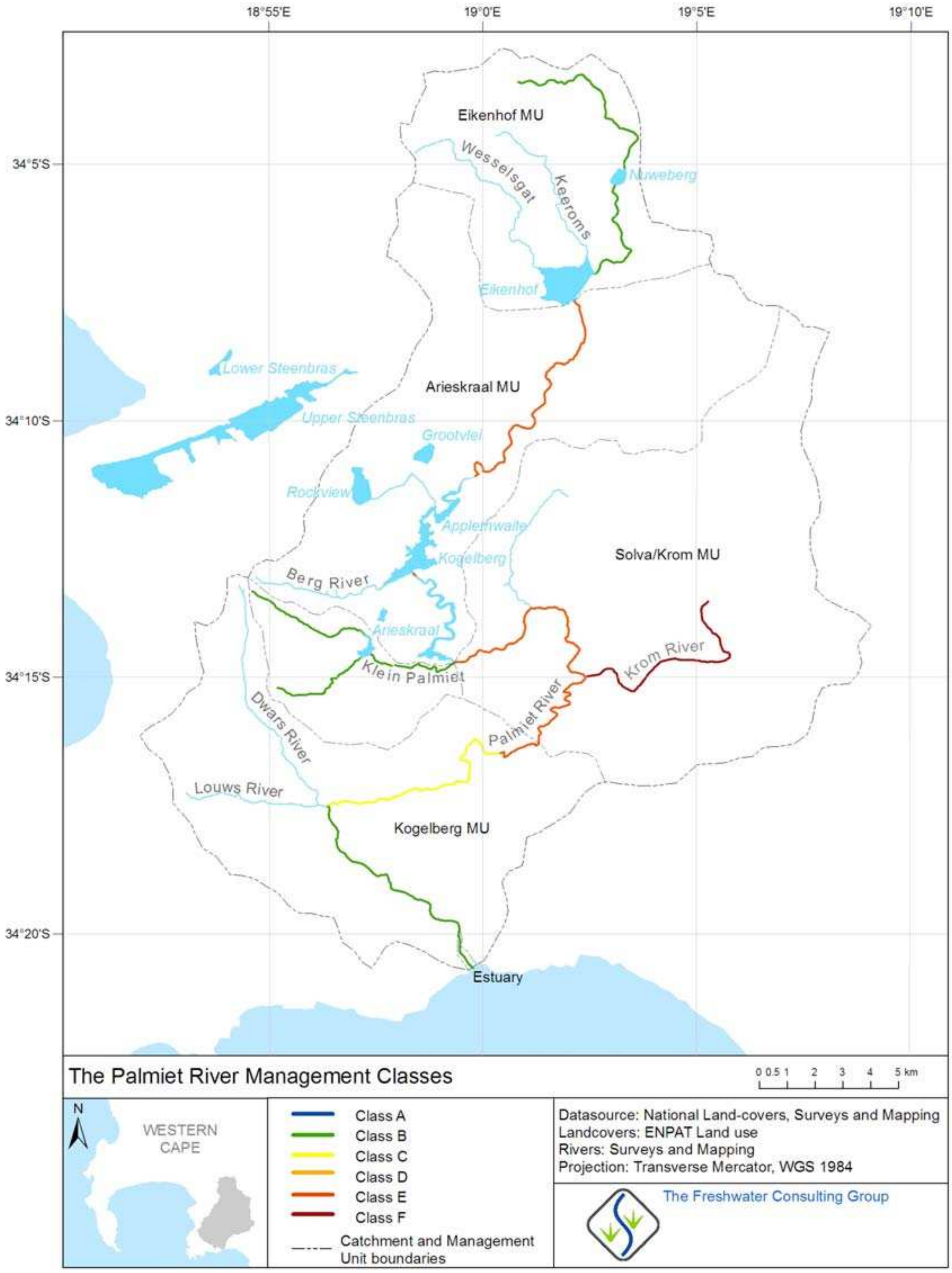

Figure 2.2 Desired Management Classes (A – F) for the Palmiet River under Scenario 1 (Minimum Degradation) as defined in the CMP 2000.

2.5 Procedural Framework

The Palmiet CMP 2000 recommended an adaptive management approach involving iterative annual and five year cycles of implementation, monitoring and review (Figure 2.3). The Procedural Framework recommended that a Plan of Action be drawn up that outlines actions to be taken to implement the CMP.

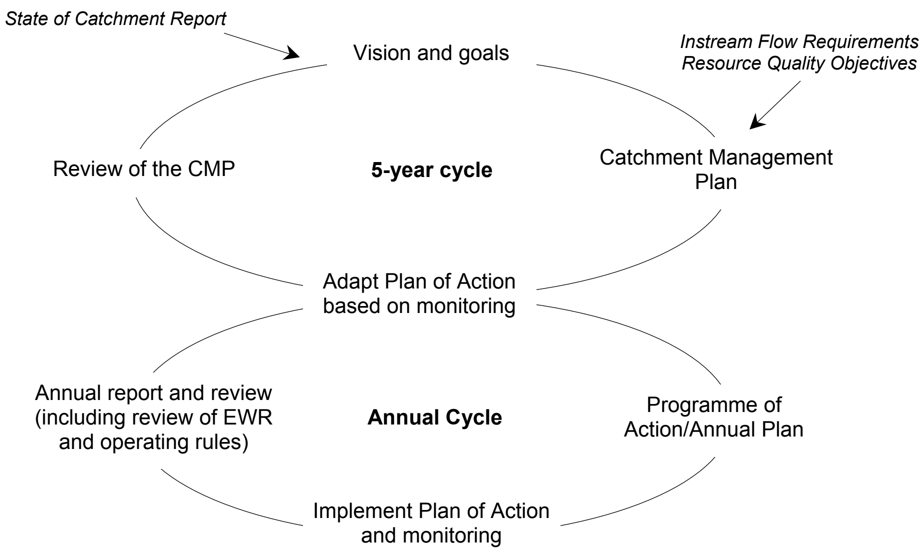

Figure 2.3 Adaptive management system for the Palmiet River as recommended in the CMP 2000.

Priority actions were to be revised on an annual basis. It also recommended that a Monitoring Programme be designed to evaluate whether or not the RQOs of the Ecological Reserve (the EWR) and the CMP are met.

Following from this section, Section 3 of this review evaluates the implementation of the EWRs and addresses other flow-related management issues. Section 4 then provides an updated statement regarding the biophysical river condition within each of the management units and provides specific management objectives for both flow and non-flow related issues.

3. SYNOPSIS OF THE ENVIRONMENTAL WATER REQUIREMENTS FOR THE PALMIET RIVER SYSTEM

3.1 Introduction

In this chapter the results of the EWR prepared by Southern Waters (Southern Waters 2001) and CAPE EWR compliance assessment prepared by the Freshwater Consulting Group (Ractliffe and Jonker 2009) are summarised. The discussion in this chapter is organised according to the Ecological Zones (equivalent to reaches of the Palmiet River) and their corresponding EWR sites identified in the EWR study (Figure 3.2). A brief description of the principles behind the setting of the EWRs for the Palmiet River is given in Sections 3.1.2 to 3.1.3 (refer to Southern Waters 2001, Section 2 for a more detailed description). These sections will facilitate the interpretation of the EWR and CAPE EWR compliance assessment findings that follow (Sections 3.2 to 3.4). A further summary of

3.1.1 Overview of the EWR Process

The South Africa Water Act (1998) stipulates that, after basic human needs are met, a certain volume of water in a river (the Reserve) be set aside to maintain ecological processes. The quantity of water in the Reserve, together with the timing and frequency of flows of different magnitudes that makes up this volume, is determined by means of Instream Flow Requirement (IFR), or what are now more commonly referred to as Environmental Water Requirement (EWR) studies.

To maintain its natural functioning and levels of biological diversity, a river ecosystem depends on complex interdependencies between the physical (water and sediment) and chemical processes that occur within its channel or along its banks and the communities of plants and animals that inhabit it. One of the most distinctive features of a river's natural flow regime is its variability over daily, seasonal and inter-annual time intervals. Amongst the primary objectives of the EWR is therefore to understand how this variability is important for these biophysical processes. This does not necessarily mean leaving as much water in the river as possible. In fact, during certain times of the year, leaving too much water in the river or adding to the flow can be as detrimental to the ecosystem as leaving too little (for example irrigation releases). One of the principal challenges of the EWR process is therefore to develop an understanding of the seasonal and inter-annual cycles of wetting and drying that naturally occur in the river using historical flow data and existing biological information. The primary objective of the EWR study was to assess whether more water could be abstracted from the Palmiet River without further degrading the river system downstream. The EWR was determined using the Downstream Response to Intended Flow Transformations (DRIFT) which at the time was a relatively novel methodology (King *et al*. 2004). DRIFT uses the present-day flow regime as a starting point and describes the consequences for the river of further reducing, or increasing, the flow at different times of the year (Southern Waters 2001). Information on each physical and biological component of the river ecosystem, i.e. its hydrology, sedimentology, plants and animals is compiled by specialists in each field who then use this information to assess how each ecosystem component is most likely to respond to flow change. The degree to which each ecosystem component responds to each change in flow is the associated with a certain condition of the river (the Ecological Category[1]) for any component and the river reach as a whole.

[1] The terminology used by DWA to describe the ecological condition of a river reach has changed repeatedly over the past decade. Currently, the term Ecological Category described the ecological condition or status or ecological integrity of the river, and is divided into seven categories. The term Management Class refers to the future condition formally identified by DWA for the management of a river reach. The different Ecological Categories and Management Classes (A-F) have the same definitions, as provided in Table 2.1.

While the EWR study evaluated the consequences of four Scenarios, i.e. levels of reduction, for each of the river reaches or Ecological Zones, the findings summarised here focus only on the Minimum Degradation Scenario (Scenario 1) that was decided as being the most appropriate scenario by the PSC (Common Ground 2000a).

3.1.2 River zonation and site selection

One of the first steps in the Palmiet River EWR process was to select study sites within broadly similar ecological zones. Three such zones, referred to as Ecological Status Zones, and nine sub-zones were identified along the course of the river and assigned an alphanumeric code (Table 3.1). Four EWR sites were selected in the three zones: Site 1 (Zones 1C), Site 2 (Zone 2C), Site 3 (Zone 3A), Site 4 (Zone 3A) (Figure 3.2). The EWRs determined at each site are representative of the sub-zone within which the site was located. No EWR was determined for the upper reaches of the Palmiet River where flows are largely natural and water resource development is not planned. No EWR was possible for the river reaches close to Grabouw and Elgin because the extensive degradation of the river here precluded the scientists from identifying the biological responses to further changes in flow that would facilitate compiling an EWR Scenario. Instead, the recommendation here was for a flow management plan to be identified in the future.

Table 3.1 Ecological zones and sub-zones selected on the Palmiet River for the purposes of the EWR showing the activities that were conducted for the purposes of the EWR assessment.

Zone	Sub-zone	Description	Activities
1	A	Upstream Nuweberg State Forest	None
	B	Nuweberg State Forest to Nuweberg Dam	None
	C	Nuweberg Dam to Eikenhof Dam	Full EWR assessment (Site 1)
2	A	Eikenhof Dam to the N2 (Grabouw and Elgin	Situation assessment
	B	N2 to Arieskraal Dam	Environmental Flow Management Plan
	C	Downstream Arieskraal Dam to Krom River confluence	Full EWR assessment (Site 2)
3	A	Krom River confluence to Dwars/Louws confluence	Full EWR assessment (Site 3)
	B	Dwars/Louws confluence to DWA weir G4H007	None (catered for by EWR Site 4)
	C	DWA weir G4H007 to estuary mouth	Full EWR assessment (Site 4)

3.1.3 Hydrological analysis

Hydrological data used for EWR assessments are of two kinds: (1) observed flow records (using data obtained from gauging weirs) and (2) flows simulated from rainfall records using a hydrological model (commonly the Pitman model). The periods of time for which observed records are available are generally too short for meaningful analysis and since water resources in most catchments have been exploited for the full length of the historical record. Therefore, the only way to describe the pattern of flows in the natural river before human intervention is to simulate them using a hydrological model. Simulated hydrological data can therefore either represent the natural flow regime, i.e. the naturalised flow, or by deducting estimated volumes of water use and abstraction over the historical period, they can represent the flows in the river as they currently occur, i.e. Present Day flows.

To aid the interpretation of the hydrological data (observed or simulated), river flows are separated into categories based on their magnitude. High flows are defined as periods when the river is in flood and low flows as the periods between floods. The low flows are further divided into a wet season low flow and dry season low flow as follows:

Wet season: June, July, August, September, October, November
Dry season: December, January, February, March, April, May.

High flows (floods) are separated into Flood Classes (referred to as flow bands in the EWR Report, Southern Waters 2001) that are defined by their magnitude and the frequency with which they occur. Small floods will recur every year, whereas large floods may recur once every decade or more. For the purposes of the EWR, four Flood Classes were recognised as recurring every year. For each flood class, the following was described: the number of events that occur per year, the average duration and the months in which they occur. This was repeated for each EWR site.

An example is shown in Figure 3.1 where four within-year Flood Classes are recognised in the annual hydrograph (Class 1 to 4). Six Class 3 floods with an average magnitude of 32 m^3/s can be identified by the arrows in Figure 3.1. The magnitude and frequency of floods occurring in each Flood Class for the 30-year observed flow record was identified in this manner.

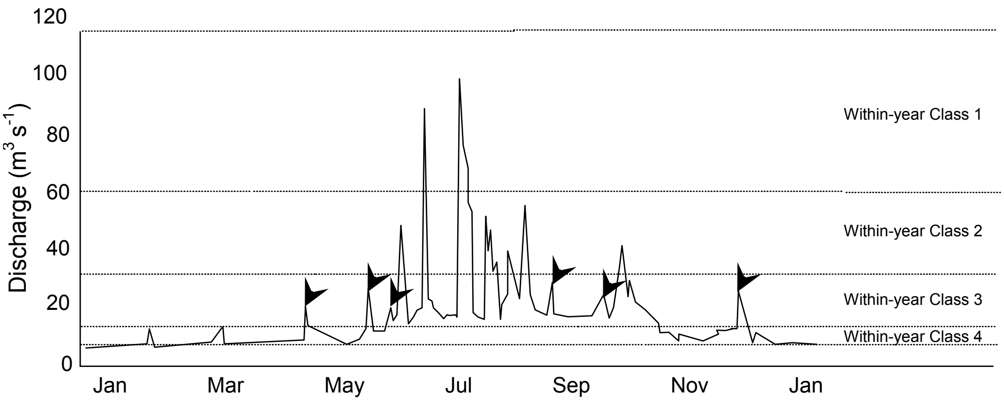

Figure 3.1 Identification of within-year Flood Classes (adapted from Southern Waters 2001). Class 3 floods are identified with arrows.

3.1.4 Identifying consequences of flow change

Each component of the flow regime as described in Section 3.1.3 is considered to play a role either in shaping the channel and banks of a river and/or being of significance to some aspect of river organism's life history. For example, low flows are considered important for shaping the channel and maintaining migratory corridors, whereas high flows are responsible for scouring sediments from the bed, or providing cues for reproduction and migration (Table 3.2). The task of specialists on the EWR team is therefore to define the response of their particular ecosystem component (e.g. geomorphology, vegetation, fish) at each level of reduction defined by the given Scenarios. It in this way it is intended that trade-offs be achieved between water use and environmental degradation.

For changes to low flows on the Palmiet River, the Minimum Degradation water level (Scenario 1) was established and three additional levels of reduction considered. At each EWR site a range of physical parameters were estimated for each Scenario and each level of flow reduction. The specialists were then required to describe the response of each ecosystem component to that level of low flow reduction.

Table 3.2 Flow categories (dry season, wet season and flood classes) and some examples of the ecosystem functions they perform.

Flow category	Ecosystem Function
Dry season low flow	Maintain habitat, channel shape
Wet season low flow	Maintain habitat, channel shape
Intra-annual flood Class 1	Fish spawning, flush out poor water quality
Intra-annual flood Class 2	Fish spawning, flush out poor water quality
Intra-annual flood Class 3	Sort sediments, maintain habitat heterogeneity
Intra-annual flood Class 4	Sort sediments, maintain habitat heterogeneity
Inter-annual flood up to 1:2 year	Maintain tree line
Inter-annual flood up to 1:5 year	Maintain tree-shrub zone
Inter-annual flood up to 1:10 year	Channel maintenance; re-set physical habitat
Inter-annual flood up to 1:20 year	Channel maintenance; re-set physical habitat

To define the minimum degradation condition for lowflows in each of the wet and dry seasons, the range of low flow discharges in the river (i.e. outside of a flood condition) is identified, along with the percentage of time that each discharge level is reached or exceeded in a year. This is called the Lowflow Flow Duration Curve (FDC). The larger flows within the FDC occur obviously for a smaller percentage of time, and the specialists at the EWR workshop identify which of these larger lowflow values might be taken away without significant effects on the functioning of the riverine ecosystem, thus defining an upper limit threshold flow. Flows smaller than the upper limit threshold would continue to occur with the same frequency with which they would have occurred under natural flow conditions. The volume of water represented by the reduced portion of the lowflow range is then available for storage or abstraction.

Using ecological information on the different levels of impacts associated with increasing levels of flow modification, both low and high flows, the EWR process results in a number of scenarios, each linked to a volume available for use and a set of consequences (or impacts) for the river downstream. The scenarios are usually a “minimum degradation” scenario, and then a further set of scenarios that have increasingly greater impacts.

In the sections that follow, a description of the minimum degradation EWR for each site is provided, since this was the one chosen in terms of the management objectives for the river. The extent to which the EWR for each river zone has been met over the past decade is also presented, based on the findings of the CAPE reserve implementation audit.

3.2 Zone 1: EWR Site 1

The upper sub-zones 1A and 1B do not need an EWR since they will remain undeveloped. Site 1 is located on the main stem of the Palmiet River roughly halfway between the Nuweberg and Eikenhof Dams in Zone 1C (Figure 3.2). The EWRs recommended for at Site 1 therefore account for the portion of the river from downstream of Nuweberg Dam to where it flows into Eikenhof Dam. The river reach at EWR Site 1 was assigned a Management Class B with the vegetation assigned a Class C, since the area had recently been cleared. The objective of flow management in this zone was that an overall Class B should be maintained and that the vegetation class should be improved.

3.2.1 Water resource infrastructure

The first major dam on the Palmiet River, the Nuweberg Dam, is located in Zone 1B at an altitude of 500 m *amsl* (Figure 3.2) approximately 8 km from the source of the Palmiet River main stem. It is a 20 m, bottom release earth-fill holding dam with a capacity of 3.9 Mm^3. It is owned by the Nuweberg Dam Syndicate and it supplies irrigators in this syndicate. The EWR report indicates that irrigation releases are made from Nuweberg which artificially increase the flow in the river, but not to the level that it reverses seasonal baseflow signatures.

The Eikenhof Dam, in Zone 1C is another 4.5 km downstream at 317 m *amsl*. It is a 47 m earthfill bottom release dam for irrigation supply. It is owned by the Groenland Irrigation Board and supplies irrigation water to 5865 ha of agricultural land, domestic water to Grabouw and industries (e.g. Appletiser). It was originally built to store 22.1 Mm^3 of water, but the spillway was raised in 1998 increasing its capacity to 29 Mm^3. There are seven gauging weirs in irrigation piplines downstream of Eikenhof Dam: the Ecological Release Pipeline (G4R002), Theewaterskloof Municipality-Pipline (G4H032, Eikenhof-Pipline (G4H031), Elfco-Pipeline (G4H027), Applegarth-Pipeline (G4H026), Highlands-Pipeline (G4H025) and Groenland-Pipeline (G4H024) (Figure 2.1).

3.2.2 Management objectives and Environmental Water Requirements

Zone 1 is currently an Ecological Category B river and the agreed management objective was to maintain this condition, i. e. a Management Class B. The principal flow-related impact in this zone are the irrigation releases made from Nuweberg Dam that, during the summer, result in dry season low flows being elevated between 1.5 and 6 times higher than natural. Although this does not constitute a flow reversal (i.e. higher dry season flows than wet season), the elevated flows and unnatural constancy of flow impacts to some degree both macroinvertebrate and vegetation communities.

EWR Site 1 is located between the Nuweberg and Eikenhof Dams in Zone 1C (Figure 3.2). Since there are no daily flow records for this or any upstream reach, flow volumes and sequences for EWR Site 1 were estimated by means of simulated data using flow records from gauging weir G4H007 (Figure 2.1).

Lowflows—The Present Day MAR at EWR Site 1 (11 Mm^3/a) was estimated at 70 % of the natural MAR (16 Mm^3/a) (Figure 3.3). The objective of river flow management in Zone 1 is to meet a volume of 12.56 Mm^3/a (78 % of Present Day; 62 % natural MAR) leaving a theoretical 3.5 Mm^3/a available for abstraction. In order to achieve these volumes, the EWR study recommended that an upper wet season lowflow discharge value of 0.49 m^3s and an upper dry season lowflow discharge of 0.17 m^3/s be released from Nuweberg Dam (Table 3.3).

It is important to note here that these discharge values are not the lower thresholds below which flows cannot fall, but rather the upper lowflow levels above which flows may be abstracted. Flows will occur naturally in the river that are often much lower than these, reflecting the natural day-to-day and week-by-week variability of the river. In order to emulate as closely as possibly this natural variability, inflow discharges to the dam upstream need to be converted to the equivalent release levels downstream using a Rule Curve. As yet, no Rule Curve has been developed for this section of the river and gauging weirs would need to be operational both upstream and downstream of the Nuweberg Dam for such a Rule Curve can be developed.

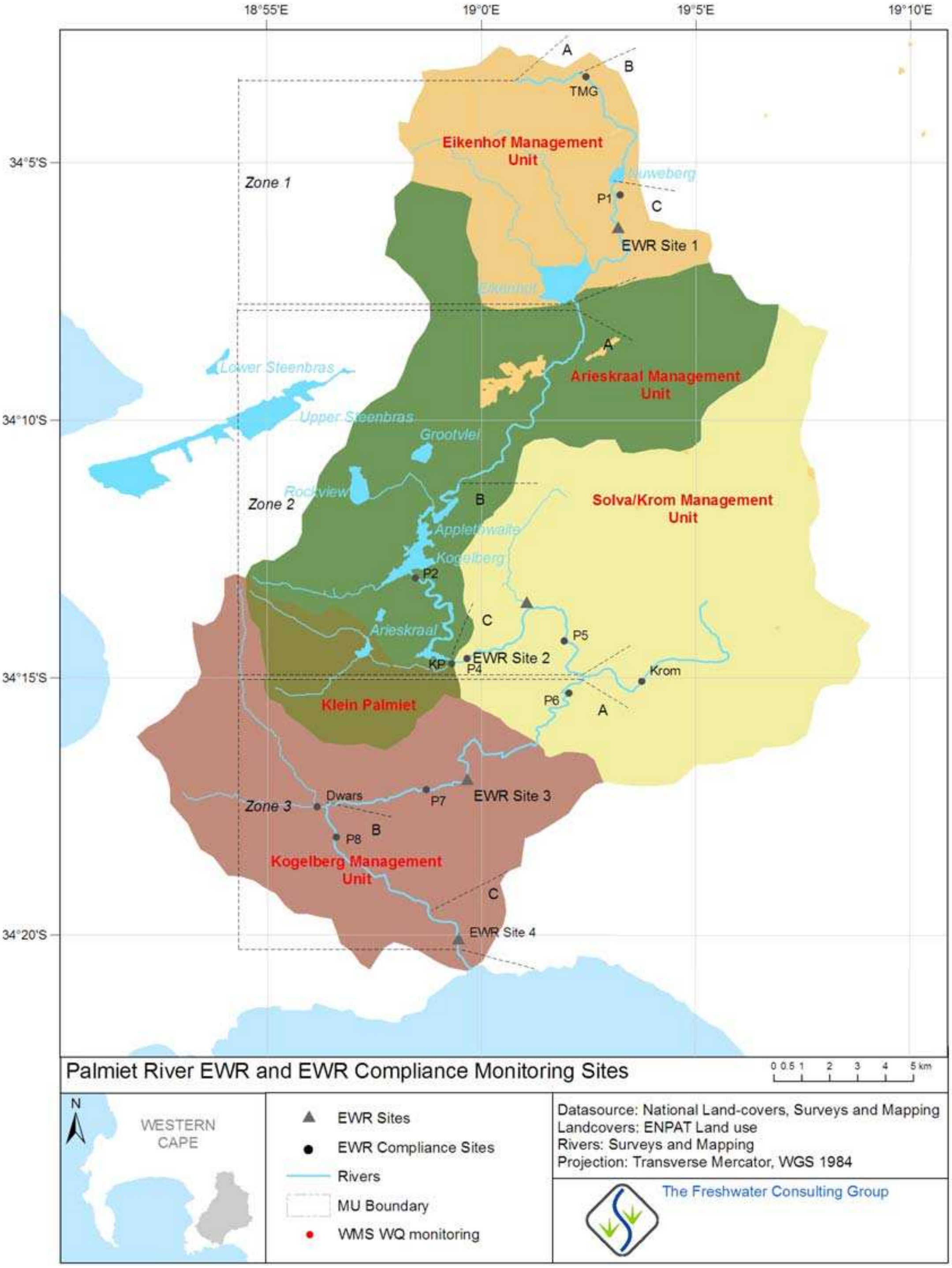

Figure 3.2 EWR Ecological Zones (1-3) and sub-zones (A, B, C) on the Palmiet River. Management Units (MUs) selected for the Catchment Management Plan (MU 1 = Eikenhof, MU 2 = Arieskraal, MU 3 = Klein Palmiet, MU 4 = Solva, MU 5 = Kogelberg and MU 6 = Estuary). and the of the EWR Sites, the monitoring sites selected for the 2009 CAPE EWR compliance assessment.

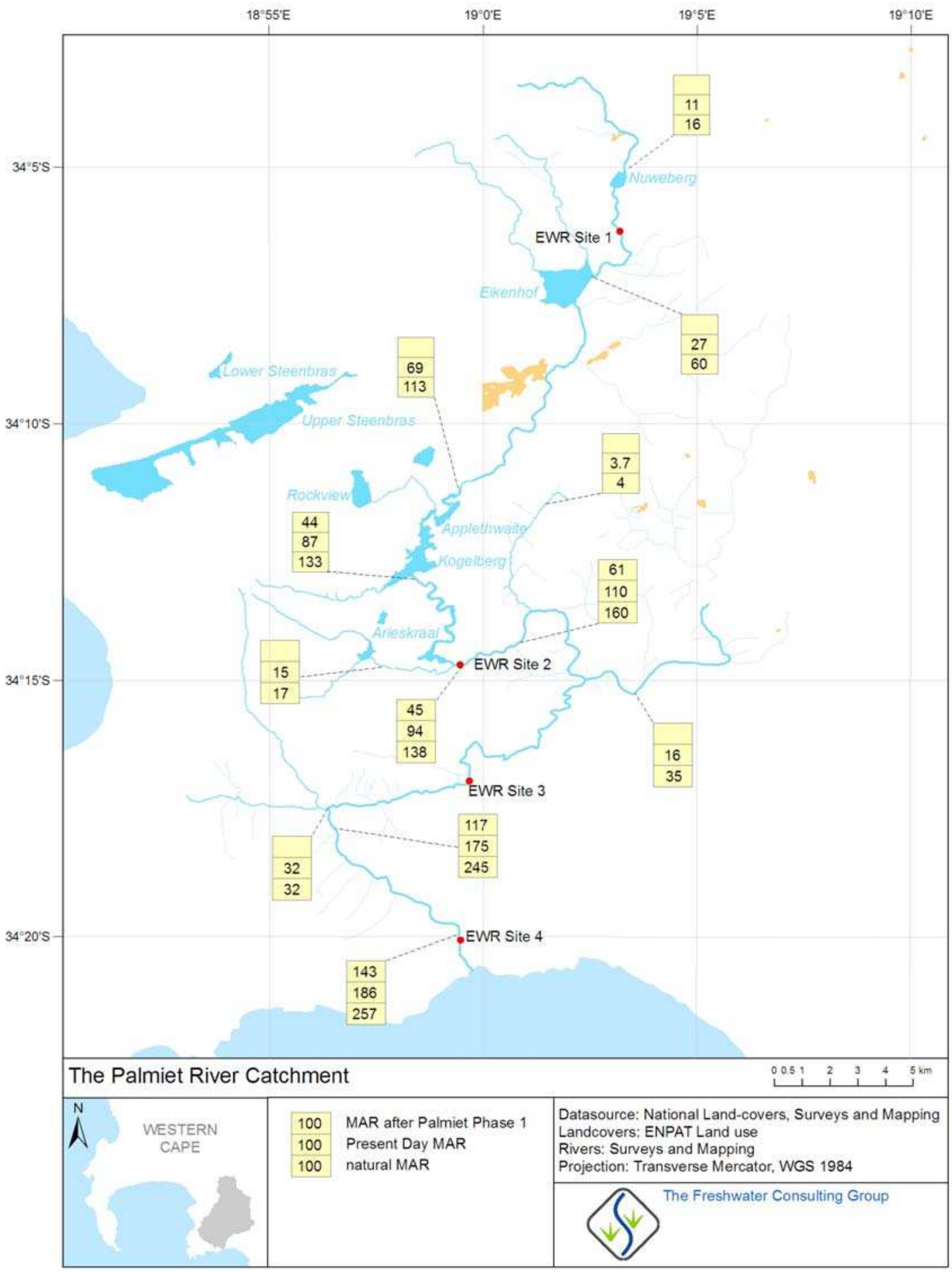

Figure 3.3 Simulated incremental Present Day and natural MAR (Mm^3/a) for selected river reaches in the Palmiet River catchment (adapted from Southern Waters 2001).

Table 3.3 Upper discharge EWR values set for the wet season and dry season at EWR Site 3 with the volumes required for the EWR and the volumes available.

	Upper Discharge (m^3/s)	EWR Volume (Mm^3)	Available for Abstraction (Mm^3)
Wet season	0.49	6.26	Total Wet and Dry: 3.5 Mm^3
Dry season	0.17	0.82	

High flows—Under the Minimum degradation scenario these remain unchanged from present day. Table 3.4 summarises the characteristics of the present day flood regime at EWR Site 1. These should, on average, be the floods that are experienced by the river at present. Note that the figures reported in Table 3.4 are based on simulated rather than observed data. Without gauging weirs in place at Nuweberg, it would not be possible to verify whether natural flows do in fact conform to these values.

Table 3.4 Characteristics of the present-day and recommended future flood regime at EWR Site 1, organized into different high flow bands.

RETURN PERIOD	Peak daily discharge band	Average peak daily discharge	Average volume	Average duration
Events with a return period greater than 1 year				
1:20 year	13 m^3/s	-	4.8 M m^3/a	10 days
1:10 year	11 m^3/s	-	2.7 M m^3/a	10 days
1:5 year	9 m^3/s	-	2.2 M m^3/a	10 days
1:2 year	6 m^3/s	-	1.9 M m^3/a	10 days
Within-year events				
3 times per annum	3 – 6 m^3/s	4.21 $m^3 s^{-1}$	1.3 M m^3/a	10 days
4 times per annum	1.5 – 3 m^3/s	2.16 $m^3 s^{-1}$	0.7 M m^3/a	8 days
5 times per annum	0.5 – 1.5 m^3/s	1.00 $m^3 s^{-1}$	0.4 M m^3/a	8 days
6 times per annum	0.1 – 0.5 m^3/s	0.30 $m^3 s^{-1}$	0.1 M m^3/a	8 days

3.2.3 Evaluation of EWR Compliance and Resource Quality Objectives

This site was not evaluated in the 2009 CAPE EWR compliance assessment (Ractliffe and Jonker 2009) and such an assessment would not be possible without a gauging weir downstream of Nuweberg. The EWR assessment suggested that the principal issue in this zone was that dry season lowflows are unnaturally elevated by between 1.5 and 6 times (Section 3.2.2). In addition to rectifying this, it is here recommended that a Rule Curve be developed that will enable natural variability to be restored to the river downstream of Nuweberg Dam. However, as noted in Section 3.2.2 the development of such a Rule Curve – as well as the ability to assess compliance with the EWR – depends upon the existence of operational gauging weirs both upstream and downstream of the dam.

3.3 Zone 2: EWR Site 2

Zone 2 extends from the outlet of the Eikenhof Dam to the confluence of the Krom with the main stem of the Palmiet River (Figure 3.2). It includes some of the most intensively developed parts of the catchments, including the major residential and industrial centers, as well as all the major dams. It is as a consequence badly degraded. A Situation Assessment conducted for the EWR assessment concluded that water pollution, poor management of the riparian zone and reduced flows (especially summer lowflows) were major issues that needed addressing in this zone. EWR Site 2 is located immediately downstream of the Arieskraal Dam and the confluence of the Klein Palmiet River with the main stem of the Palmiet River (Figure 3.2). The Zone is further subdivided into three subzones: 2A from the outlet of the Eikenhof Dam to the back-up waters of the Peninsula Dam, 2B from the former location to the Arieskraal Dam wall and 2C, from the Arieskraal Dam wall to the confluence of the Krom River.

3.3.1 Water resource infrastructure

The Peninsula Dam is the first in a series of dams that occupy Zone 2B. It is owned by Elgin Orchards, Weltevreden Farm, Applethwaite Farm, Shannon Vineyards and Water Wheel Investments and operated for irrigation only. The Applethwaite Dam with a capacity of 2.9 Mm^3 is owned and operated by Applethwaite Farm. It opens immediately into the Kogelberg Dam and back-up waters of the Arieskraal Dam are located another 950 m downstream of the Kogelberg Dam wall. End-to-end, the four dams occupy ~14.5 km (15 %) of the length of the Palmiet River.

With a dam wall height of 54 m and a maximum capacity of 33.7 Mm^3, the Kogelberg Dam is the largest dam in the Palmiet River catchment. Together with the off-channel Rockview Dam on the watershed dividing the Palmiet from the Steenbras River catchments, it comprises part the Palmiet Pumped Storage Scheme that generates 400 MW of power for distribution to the national ESKOM grid over peak periods (weekdays). Of the Kogelberg Dam's 33.7 Mm^3 maximum capacity, 16.5 Mm^3 is circulated weekly for power generation. During off-peak periods, the former volume of water is pumped from Kogelberg into Rockview Dam at a rate of 2.5 $M.m^3$/day. Over peak periods the water is released back into Kogelberg through the turbines at a rate of 156 m^3/s (~3.5 Mm^3/day). During winter, once flows measured at the Campanula weir (G4H030) reach or exceed 4.33 m^3/s (the wet season low flow capping discharge, Section 3.3.2), water is transferred to Steenbras Dam (22 Mm^3/a). The Arieskraal Dam owned by Arieskraal Syndicate consisting of twelve members and has a storage capacity of 5.5 Mm^3. It used for direct abstraction to surrounding farms for irrigation.

3.3.2 Management objectives and Environmental Water Requirements

The results of the EWR assessment for Site 2 were inconsistent with those obtained for Sites 3 & 4. This was attributed to the severe impacts of Arieskraal Dam immediately upstream – particularly the unnaturally low and constant releases during summer. Due to the considerably modified flow conditions at this site, it was not used to set or monitor the EWR. Rather, the EWR at Site 3 was considered to be an adequate representative of requirements and conditions for Zone 2C: even though flow records for Site 3 are measured downstream of the inflow of the Krom River.

As pointed out in the introduction to this section, water quality issues are of most concern in Zone 2. Environmental flows have been released from Eikenhof Dam since its inception. One important development in respect of the EWR is the agreement reached in 2009 by the Eikenhof Irrigation Board/Groenland WUA to allow the EWR released at Nuweberg Dam (Table 3.3) to pass through Eikenhof Dam. This agreement means that for the reaches represented by Zones 2A and B, along the middle reaches through Grabouw, summer flows of relatively clean water are likely to provide some dilution capacity for the water quality issues resulting from return effluent from industrial and residential point and non-point sources as well as the Grabouw WWTW. It is recommended here, therefore, that a Flow Management Plan be developed for subzone 2A that would mitigate water quality issues, as well as restore some ecological functioning to the river in these reaches.

In subzone 2B, the river segments between the dams are very short and almost completely back up on each other. Management issues relating to the river ecosystem in these segments are therefore not relevant here. However, the issue of the water allocation now coming out of Eikenhof – at least the lowflow EWR total of 7 Mm^3 – and how this proceeds to the lower river, especially in summer, is a matter of concern.

3.3.3 EWR Compliance and Resource Quality Objectives

This site was not evaluated in the 2009 CAPE EWR compliance assessment (Ractliffe and Jonker 2009). However, as pointed out in Section 3.3.2, the EWR at Site 3 further downstream (Section 3.4) was considered to be an adequate representative of requirements and conditions for Zone 2C. Some indication of the flow conditions downstream of Arieskraal Dam were presented in the 1999 EWR study (Southern Waters 2001) and these conditions are considered unlikely to have changed in the decade since the study was undertaken as the outlet mechanism for Arieskraal (the principal limitation to the implementation of the EWR) has not been modified in that time. Dry season low flows are lower and more constant than they were under natural conditions (Table 3.5). Geelwateruintjie *Nymphoides* spp. immediately downstream of the Arieskraal Dam wall was noted during the course of the EWR study as well a during a site visit for the present study. This is a species that is more characteristic of standing waters and is therefore symptomatic of the continued reduced flow conditions that predominate here.

Table 3.5 Low flow percentiles at IFR Site 2 for dry season naturalised and dry season present day with releases (Southern Waters 2001).

Percentile	Naturalised dry season (m^3/s)	PD dry season with releases (m^3/s)
1%	3.17	1.36
5%	-	0.75
10%	1.44	0.44
30%	0.81	0.14
60%	0.40	0.08

3.4 Zone 3: EWR Site 3 & 4

Zone 3 begins on the Palmiet River main stem where it confluences with the Krom River and ends at the upper limit of the estuary. EWR Site 3 is located on the main stem of upstream of the confluence of the Dwars and Louws Rivers and downstream of the Campanula weir (G4H030) and EWR Site 4 is located downstream of the DWA gauging weir G4H007 and upstream of the road bridge over the estuary (Figure 3.2). The location of Zone 3 in the lower reaches of the Palmiet River and the fact that the river in this zone flows through the Kogelberg Biosphere Reserve means that the implementation of the EWR in this region is of the highest priority.

3.4.1 Water resource infrastructure

Apart from the presence of two gauging weirs at Campanula (G4H030) and the estuary (G4H007), there is no other water resource infrastructure in this zone, but it is particularly vulnerable to the location and operation of dam infrastructure described in Section 3.3.1. The key water resource developments that impact on this reach are the Palmiet Pumped Storage Scheme and Arieskraal Dam.

3.4.2 Management objectives and Environmental Water Requirements at Site 3

EWR Site 3 was assigned a Management Class of C at the EWR workshop reflecting the then ecological condition (Ecological Category) in this reach. The objective of river flow management at EWR Site 3 would thus be to maintain the river in this class which would provide for the abstraction of 37 Mm^3/a.

Lowflows—The Present Day MAR at EWR Site 3 (134 Mm^3/a) was estimated at 66 % of the natural MAR (204 Mm^3/a) and the EWR Requirement for this site was 97.65 Mm^3/a. The Minimum Degradation Scenario (Scenario 1) adopted for EWR Site 3 stipulated that only flows in excess of the 10th percentile of the present-day flows in the river could be abstracted during the lowflow months without adverse effects. This is equal to a discharge of 0.92 m^3/s. For the wet season the 30th percentile was used as this threshold, equal to a discharge values of 4.33 m^3/s. This means that, in terms of the EWR, <u>non-flood flows</u> greater than 4.33 m^3/s could be abstracted.

Table 3.6 Upper discharge EWR values set for the wet season and dry season at EWR Site 3 with the volumes required for the EWR and the volumes available for abstraction.

	Upper Discharge (m^3/s)	EWR Volume (Mm^3)	Available for Abstraction (Mm^3)
Wet season	4.33	48.38	32.32
Dry season	0.92	8.98	5.46
		Total	**37.78**

High flows—Under the Minimum degradation scenario these remained unchanged from present day situation. Based on the simulated hydrology, Table 3.8 summarises the characteristics of the present day flood regime at EWR Site 3. These should, on average, be the floods that are experienced by the river at present. Table 3.9 shows the distribution of these floods over the calendar months, based on the average flood patterns in the river.

Table 3.7 High flow Flood Classes considered for EWR Site 3 showing those with return intervals greater than one year (1:2 – 1:20) and those that occur every year (Within-year events: 3-6 times per annum), as well as the peak and average peak daily discharge, volume and duration of each event.

Return Intervals	**Peak daily discharge**	**Average peak daily discharge**	**Volume**	**Duration**
Events with a return interval > 1 year				
1:20 year	137 m^3/s	-	c. 32 Mm^3/a	c. 8 days
1:10 year	117 m^3/s	-	c. 26 Mm^3/a	c. 8 days
1:5 year	78 m^3/s	-	c. 20 Mm^3/a	c. 7 days
1:2 year	52 m^3/s	-	c. 15 Mm^3 a	c. 6 days
Within-year events				
3 per annum	20-40 m^3/s	29.1 m^3/s	c. 7.0 Mm^3/a	c. 6 days
4 per annum	10-20 m^3/s	14.5 m^3/s	c. 4.0 Mm^3/a	c. 6 days
5 per annum	5-10 m^3/s	7.3 m^3/s	c. 3.0 Mm^3/a	c. 6 days
6 per annum	2.5-5 m^3/s	3.7 m^3/s	c. 1.0 Mm^3/a	c. 6 days

Table 3.8 Monthly distribution and volumes (Mm^3) characteristic of Wet season and Dry season high flows at EWR Site 3 under Present Day conditions.

	Months												
	Linked				Linked						Linked		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Within-year band	1	1	1	1	2,3	3	4,3	4,4,3	2	2	2	1,1	17 events
Volume required (Mm^3)	0.53	0.53	0.53	0.53	6.06	1.35	5.70	10.05	0.35	0.35	0.70	1.06	27.74

Water available for use—Under these conditions, an additional volume of 37.78 Mm^3 per annum would be available for use.

3.4.3 Management objectives and Environmental Water Requirements at Site 4

The Ecological Category of EWR Site 4 was described as a B condition and it was agreed that it should be maintained in this state, i.e. a Management Class B. It was suggested that a fish ladder at the DWAF gauging weir located at the head of the estuary would restore marine-freshwater migration route.

Lowflows— The Minimum Degradation Scenario (Scenario 1) adopted for EWR Site 4 stipulated that only flows in excess of the 10th percentile of the present-day flows in the river (equal to a discharge of 1.36 m^3/s) could be abstracted during the lowflow months without adverse effects, whilst this value for the wet season was the 30th percentile, or 5.75 m^3/s.

High flows— Under the Minimum degradation scenario these remain unchanged from present day. Based on the simulated hydrology, Table 3.11 summarises the characteristics of the present day flood regime at EWR Site 4. These should, on average, be the floods that are experienced by the river at present. Table 3.12 shows the distribution of these floods over the calendar months, based on the average flood patterns in the river.

Table 3.9 High flow Flood Classes considered for EWR Site 4 showing those with return intervals greater than one year (1:2 – 1:20) and those that occur every year (Within-year events: 3-6 times per annum), as well as the peak and average peak daily discharge, the volume and duration of each event.

Return Intervals	Peak daily discharge	Average peak daily discharge	Volume	Duration
Events with a return interval > 1 year				
1:20 year	171 m^3/s	-	c. 35 Mm^3/a	c. 8 days
1:10 year	146 m^3/s	-	c. 33 Mm^3/a	c. 8 days
1:5 year	107 m^3/s	-	c. 30 Mm^3/a	c. 8 days
1:2 year	72 m^3/s	-	c. 20 Mm^3/a	c. 7 days
Within-year events				
3 per annum	36-72 m^3/s	52.1 m^3/s	c. 12.0 Mm^3/a	c. 6 days
4 per annum	18-36 m^3/s	25.7 m^3/s	c. 6.5 Mm^3/a	c. 6 days
5 per annum	9-18 m^3/s	13.2 m^3/s	c. 3.6 Mm^3/a	c. 6 days
6 per annum	3-9 m^3/s	5.7 m^3/s	c. 1.6 Mm^3/a	c. 6 days

Table 3.10 Monthly distribution and volumes (Mm^3) characteristic of Wet season and Dry season high flows at EWR Site 4 under Present Day conditions.

	Months												
	Linked				Linked						Linked		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Within-year band	1	1	1	1	2,3	3	4,3	4,4,3	2	2	2,2	1,1	18 events
Volume required (Mm^3)	0.98	0.98	0.98	0.98	8.86	2.45	8.53	14.61	0.05	0.05	0.10	1.96	42.06

3.4.4 Evaluation of EWR Compliance at Site 3 & 4 and recommendations for refinement

Dry Season—In terms of the dry season EWR requirement, the scenario selected for the future management of the river recognised that the then-present-day situation would simply continue, which is not to say that there are no adverse impacts on the downstream ecosystem. Currently, Arieskraal Dam is drawn down in summer by means of direct irrigation abstractions and constant releases via the bottom outlet in the order of 0.2 m^3/s for irrigators downstream. This water is abstracted by irrigators before it reaches the confluence of the Krom River. No water over and above the irrigation releases is released from Kogelberg or Arieskraal Dams as a result of the constraints on the outlet. This implies that the EWR along this reach of the Palmiet River to Site 3 has to be met by runoff from the incremental Klein Palmiet, Huis and Krom river catchments downstream of Arieskraal Dam - rivers whose flows are already utilised for irrigation and diversion into off-channel storage. The Klein Palmiet River is dammed in its upper reaches, but the landowner is currently awaiting release instructions for environmental flows.

Some recent developments may alter matters in this stretch of river, however. Firstly the agreement by farmers to allow the EWR at EWR Site 1 to pass through Eikenhof Dam and flow downstream unabstracted (Section 3.3.2). This means that there should be 0.82 Mm^3 available through the dry months that could be used to augment downstream flows in the Palmiet River, without changing the current water rights allocations between Eikenhof and Arieskraal Dams. The Arieskraal Dam outlet pipe is capable of releasing up to 2 m^3/s but an orifice plate has been bolted onto the outlet pipe which prevents any variation in releases from the dam. However, the EWR audit recommended that changes to this outlet structure be made, which would firstly allow for the EWR entering the Kogelberg/Arieskraal Dams to be released downstream and secondly allow for greater variation in flow to be provided, albeit within the constraint of a maximum discharge of 2 m^3/s. Even though the EWR daily flow releases at EWR Site 1 are not very large, this would nevertheless be an improvement on current flow conditions downstream of Arieskraal Dam, given the very lowflows being released at present. It would, however, require commitment on the part of downstream irrigators not to abstract this water from the river.

A second aspect is the contribution of the Klein Palmiet River. The reduction in summer lowflows in this river urgently requires re-evaluation. In terms of the Water Act, all river ecosystems are required to be assessed for their Environmental Water Requirements, and such a study is suggested for this system.

A third aspect of the lowflow EWR that deserves comment is the fact that only two seasons were specified in the EWR process, wet and dry, covering five and seven months respectively. The current practice in EWR assessments is to provide for flow scenarios separately for each calendar month. The EWR scenarios should thus be re-compiled on a monthly basis.

Wet Season—Wet season flows in the river downstream of Arieskraal Dam are constrained by the draw-down of Arieskraal Dam over the summer. Any flow in excess of the bottom release capacity of that dam requires that Arieskraal be full and spilling. Also, the operation of the Palmiet Pumped Storage Scheme (Section 3.3.1) and the requirement that there is sufficient storage capacity in Kogelberg Dam to generate power, has implications for flow patterns in the river.

Although no specific high-flow winter releases are currently made from Kogelberg and/or Arieskraal Dam to meet the high-flow EWRs at Campanula, occasional releases of up to 15 m^3/s are made from Kogelberg Dam during large flood events or during periods of high inflow in order to prevent too much water being stored in Kogelberg Dam, which could result in artificial floods spilling over Kogelberg Dam towards the end of the week, if a full dam coincides with high turbine discharges (156 m^3/s) as described previously. Despite this, occasional spills do occur at Kogelberg Dam, when high inflows into the dam (from the upstream catchment) coincide with a relatively full dam. When Arieskraal Dam is also full, towards the middle to end of winter, these spills result in high flows along the lower Palmiet River. Although such flows usually correspond to natural flood events and sometimes meet the high-flow EWRs along the lower Palmiet River, this is not intentional.

It is important to emphasise that managed high-flow releases from Kogelberg and Arieskraal Dams are restricted by the capacities of the existing outlet works at these dams. Kogelberg Dam can release a maximum of 15 m^3/s whilst Arieskraal Dam has no release mechanism and any flood flows in the Palmiet River downstream are only achieved through spillage.

A refinement of the current practice would be to use natural inflows at the selected EWR Sites to guide EWR releases. The possibility of using the incremental catchment between Gauges G4H030 and G4H007 as a 'natural' indicator catchment should be investigated.

In terms of the wet-season EWR, the major requirement relates to when water may be abstracted from the system via Rockview Dam. The operating rule governing transfers to Steenbras Dam stipulates that transfer of water can only occur once the gauge at G4H030 (Campanula) registers the wet season capping flow in the Palmiet River recommended in the EWR (4.33 m^3/s). Therefore the first inflows into the Kogelberg Dam during wet season months are used to fill Arieskraal Dam, although care is taken to maintain sufficient water in Kogelberg Dam to operate the Palmiet Pumped Storage Scheme. Thereafter, once the maximum lowflow discharge of 4.33 m^3/s is reached, abstraction of water from Rockview Dam to Steenbras occurs.

The evaluation of whether this rule has been followed during the CAPE EWR compliance audit was complicated by the fact that there are no records of water volumes abstracted directly from Kogelberg Dam for the City of Cape Town. The water pumped from Kogelberg to Rockview on a daily basis may be used either for power generation or some of it may be transferred via the Steenbras Dam for use by the Cape Metropolitan Area. However, records from DWA gauging weir located between Rockview and Steenbras Dams (G4H023) (Figure 2.1) provide some indication of the volumes of water transferred from the Kogelberg Dam. Table 3.11 shows a net seasonal surplus (+) of water for most years at Sites 3 and 4. This suggests that, despite transfers of water from Kogelberg Dam, in most instances the EWR is being met in terms of the bulk volume of water present in the river.

Table 3.11 Annual wet season shortfall (-) or surplus (+) volumes of water measured at EWR Sites 3 (fixed and rule curve) and 4 (fixed) as compared with transfers from Kogelberg Dam to Upper Steenbras Dam determined from flows measured between the Rockview and Steenbras Dams (G4H023) between the years 2000-2007.

Hydro Year	EWR Shortfall / Surplus (Mm^3)			Transfer to Upper Steenbras (Mm3)
	Site 3		Site 4	
	Fixed	Rule curve	Fixed	
2000	+92.8	+57.5	+139.6	15.9
2001	+61.9	+41.0	+83.6	10.1
2002	-15.4	-0.7	+1.8	30.3
2003*	-20.8	+30.1	-4.3	22.0
2004	+39.6	+9.7	+72.4	37.8
2005	+5.9	No data	+34.8	31.9
2006	Missing data	No data	+107.2	17.9
2007	+128.4	No data	+168.1	5.9

A complementary approach to assessing compliance was to examine discharge at Campanula (G4H030) and Rockview (G4H023) gauging weirs (Figure 2.1) for the years 2000-2002 (Figure 3.4) and 2000-2005 (Figure 3.5), to compare the timing, duration and magnitude of transfers of water from the Kogelberg Dam, via Rockview to Upper Steenbras Dam with the flow in the downstream Palmiet River. As stated above, compliance with the requirements of the EWR requires that transfers (red line) should only occur once Campanula weir (black line) registers a flow of 4.33 m^3/s (blue line).

It is clear from these figures that in many instances the operating rule has not been adhered to and that abstractions have taken place at discharges well below the wet-season capping flow. Also evident from these figures is that transfers have frequently taken place during the earlier part of the wet-season before Arieskraal Dam is likely to be full and spilling (around June/July). This implies that all early wet-season low flows and floods are being withheld until the dam is overtopping and that the EWR is therefore not being met over this period. A final point to draw from these figures as well as Table 3.11 is that the highest interbasin transfers of water has taken place during drier years when pressures on the scheme to deliver water to the Cape Metropolitan Area are presumably higher. The degree of compliance with the EWR over these periods is therefore less at times when pressures on the downstream ecosystem are already intensified as a result of naturally dry conditions.

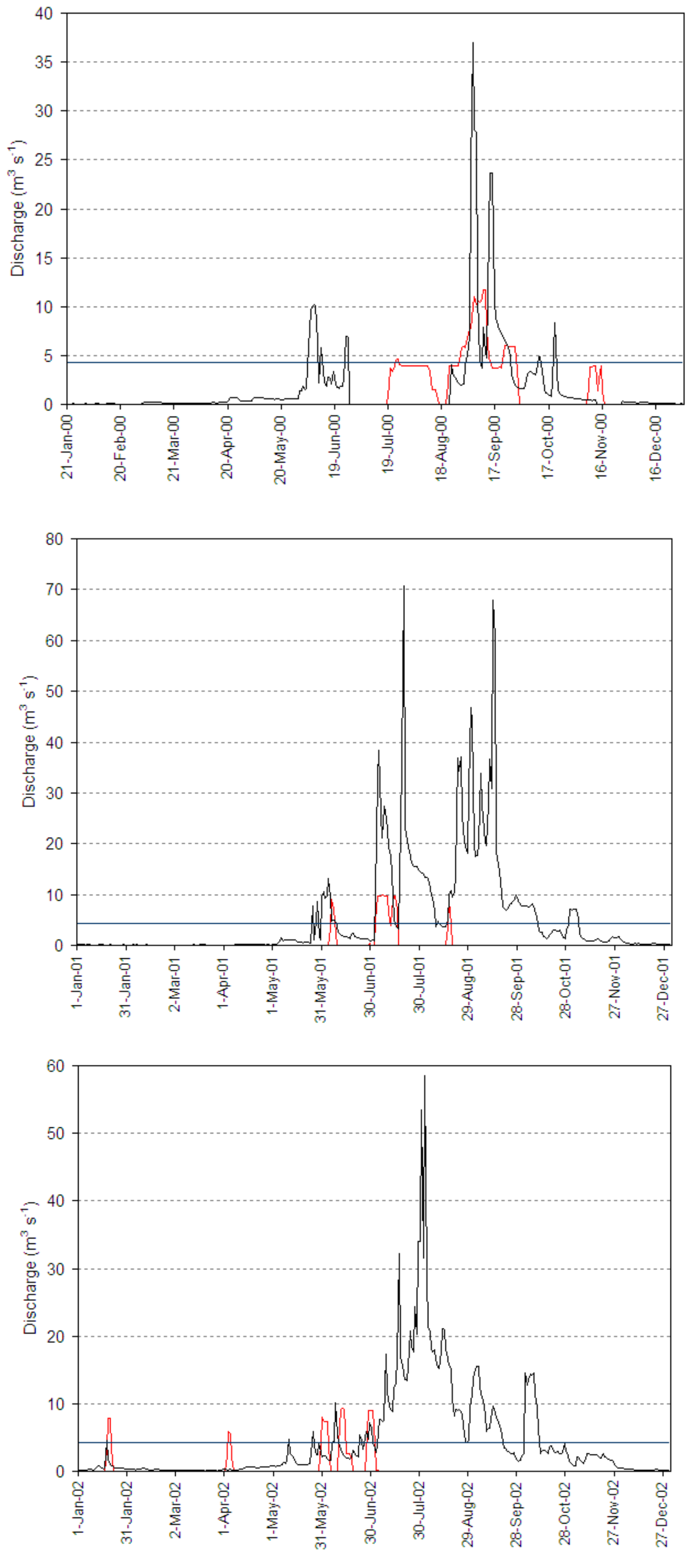

Figure 3.4 Mean Daily Discharges measured at the Campanula gauging weir G4H030 (black line), inflows into Steenbras Dam from Rockview dam G4H023 (red line) and the wet season capping flow of 4.33 m^3/s (blue line) for the years: 2000, 2001 and 2002.

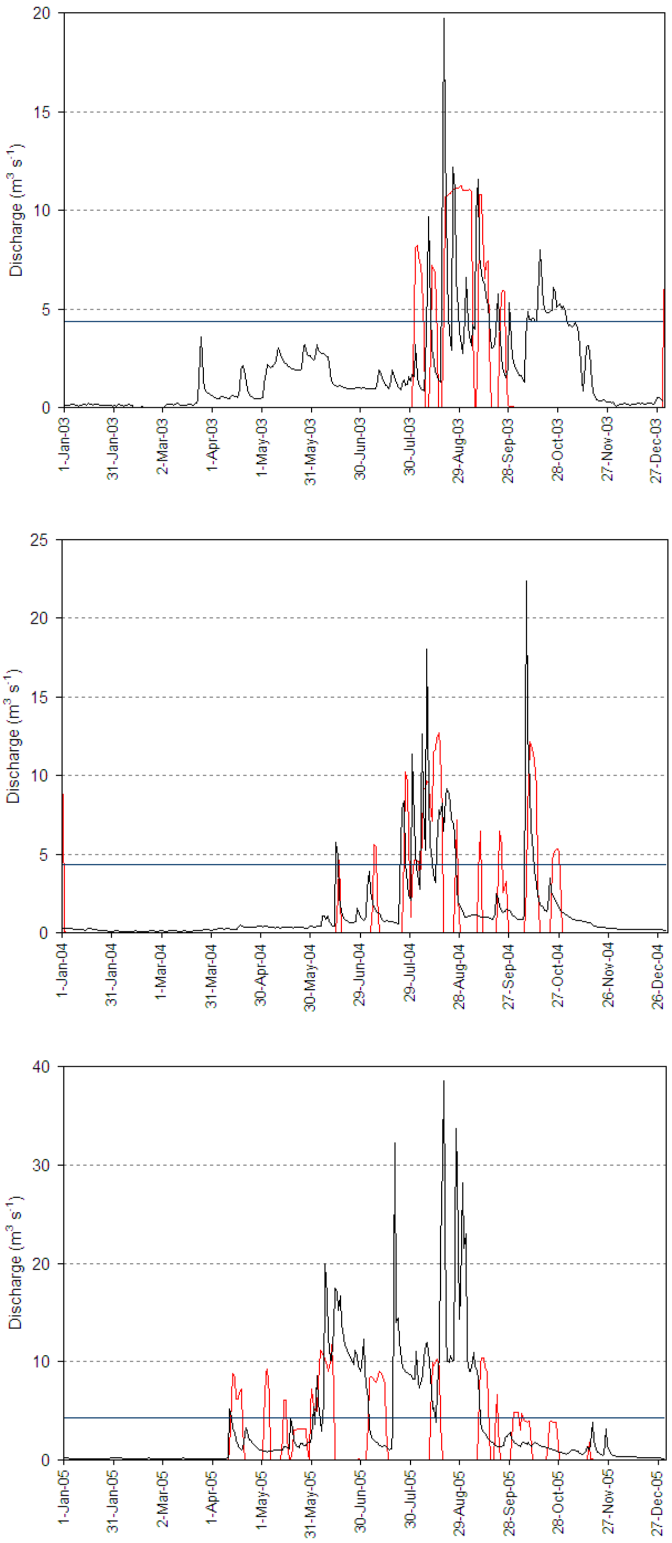

Figure 3.5 Mean Daily Discharges measured at the Campanula gauging weir G4H030 (black line), inflows into Steenbras Dam from Rockview dam G4H023 (red line) and the wet season capping flow of 4.33 m^3/s (blue line) for the years: 2003, 2004 and 2005.

3.4.5 Summary of EWR compliance in Zone 3

The principal impediment to implementing the EWR at Sites 3 and 4 is the limitations of the release outlet on the Arieskraal Dam wall. This limits appropriate flows from being delivered to the river downstream until the Arieskraal Dam overtops. As a consequence, Class 3 floods are delayed early in the wet season (May-Jun) and there are no Class 1 floods late in the dry season (Jan-Apr) when Arieskraal ceases to spill. In addition, unnaturally uniform lowflows are released continually during the dry season. During the wet season, because of the requirement to build capacity in the Kogelberg Dam for hydropower generation, wet season lowflows are higher than expected (the equivalent of Class 2 and 3 floods) and present in the river for longer periods of time than they would be under natural conditions. Most of the tributaries, aside from the Klein Palmiet River are too intensively developed either to undertake an EWR study enforce its compliance. In summary therefore the following points need to made regarding EWR compliance and refinement in Zone 3 (additional comments from the EWR compliance study can be found in Appendix A):

- The EWR audit recommended that changes to the Arieskraal outlet structure be made, which would firstly allow for the EWR entering the Kogelberg/Arieskraal Dams to be released downstream and secondly allow for greater variation in flow to be provided. This would require a commitment on the part of downstream irrigators not to abstract this water from the river.

- For the initial EWR, only two seasons were specified in the EWR process (wet and dry). The current practice in EWR assessments is to provide for flow scenarios separately for each calendar month. The EWR scenarios should thus be re-compiled on a monthly basis.

- As recommended for the Nuweberg Dam, flows released from Arieskraal Dam need to based on the Rule Curve developed based on inflows from the upstream catchment.

- Constant releases of 15 m^3/s from Kogelberg Dam (equivalent to Class 2 floods) should be avoided when Arieskraal is overtopping.

- Late summer/early winter flows should be stored in Kogelberg for filling of this dam, as well as Arieskraal Dam before transfers can begin – even if flows at Campanula register the wet season capping flow of 4.33 m^3/s.

3.5 Tributaries

No EWR studies have been undertaken on any of the tributaries in the Palmiet River catchment. Very little information is therefore available on the EWRs for these systems. Most of the major tributaries (particularly the Huis and Krom Rivers) feed numerous farm dams and the land adjoining them is intensively cultivated. Farm dam capacities have been estimated at 3.7 Mm^3 upstream of DWA gauging weir G4H005 and 14 Mm^3 for the Krom River upstream of DWA gauging weir G4H007. Combined, these two volumes comprise a significant proportion of the total storage capacity of the other major storage dams in the catchment (68.7 Mm^3) (Southern Waters 1998b).

The degraded condition of the Huis and Krom Rivers precludes either the determination of the EWR on these systems or its enforcement. The catchment of the Klein Palmiet River is, however, considerably less developed than these former two rivers despite a single private farm dam in its upper reaches. Aside from the intrinsic conservation value of the river system itself, it also has the potential to supplement flows in the main stem Palmiet over the lowflow season. A major impediment to implementing an EWR on this river, as pointed out already, is the presence of the Klein Palmiet Dam and no information is available either on its operation or the volumes of water currently being abstracted from it.

Flow modification in the Klein Palmiet River

Previous reports make no mention of the presence of a dam on the Klein Palmiet River and most have assumed a largely unimpacted flow regime. However, the EWR compliance audit (Ractliffe and Jonker 2009) showed that the downstream ecosystem was being impacted by lower than natural flows over the dry season. Further investigation during the course of this study, however, revealed that the Klein Palmiet Dam (~20 ha in extent) may be contributing to the degraded conditions downstream. In all other respects, the Klein Palmiet River is largely natural with little apparent invasion of the riparian zone by alien vegetation or impaired water quality conditions. The opportunities for restoring this system to a Ecological Category A/B river are considerable (it is currently listed as a Category C river).

The reduction in summer lowflows in the Klein Palmiet River urgently requires re-evaluation. In terms of the Water Act, all river ecosystems are required to be assessed for their Environmental Water Requirements, and such a study is suggested for this system.

Table 3.12 Summary of the EWR values set for the Palmiet River in Zones 1 – 3 (Figure 3.2).

ZONE 1A	
No EWR set	
ZONE 1B	
No EWR set	
ZONE 1C	
Lowflow EWR Volume:	12.56 Mm^3/a
Available for abstraction	3.5 Mm^3/a
Wet Season EWR lowflow flow rates (June-November)	0.49 m^3/s
Dry Season EWR lowflow flow rates (December-May)	0.17 m^3/s
No storage in the Nuweberg Dam or abstraction should commence before flows in the river in Zone 1C reach these volumes. All <u>non-flood</u> flows over and above the flow rates stipulated above can be abstracted.	

ZONE 2A
No EWR was set for this zone because of the degraded condition of the river in this zone. A Flow Management Plan that would include a water audit was recommended in this zone to mitigate poor water quality conditions (Section 3.3.2)
ZONE 2B
No EWR was set for this zone that includes four dams situated end-to-end
ZONE 2C
Because of the degraded conditions downstream of the Arieskraal Dam, EWR Site 3 was used to set the EWR for this zone (Refer to Zone 3A below).

ZONE 3A	
Lowflow EWR Volume:	97.65 Mm^3/a
Available for abstraction	37 Mm^3/a
Wet Season EWR lowflow flow rates (June-November)	4.33 m^3/s
Dry Season EWR lowflow flow rates (December-May)	0.92 m^3/s
No storage in any of the dams immediately upstream and abstraction downstream should commence before the flow rates in Zone 2C reach the values stipulated above. All <u>non-flood</u> flows over and above the flow rates stipulated above can be abstracted.	
ZONE 3B	
Refer to Zone 3A	
ZONE 3C	
Lowflow EWR Volume:	138.58 Mm^3/a
Available for abstraction	47.8 Mm^3/a
Wet Season EWR lowflow flow rates (June-November)	5.75 m^3/s
Dry Season EWR lowflow flow rates (December-May)	1.36 m^3/s
No storage in any of the dams on the Palmiet River main stem immediately upstream and abstraction downstream should commence before the flow rates in Zone 2C reach the values stipulated above. All <u>non-flood</u> flows over and above the flow rates stipulated above can be abstracted.	

Note: As pointed out in Section 3.2.2, the discharge values reported above are not the lower thresholds below which flows cannot fall, but rather the upper lowflow levels above which storage and/or abstraction may commence. Flows will occur naturally in the river that are often much lower than these, reflecting the natural day-to-day and week-by-week variability of the river.

4. BIOPHYSICAL STATE OF THE RIVER

4.1 Introduction

Four major components of the river ecosystem need to and can be managed:

- water quantity (when, where, how much major and minor water infrastructure and abstractions),
- water quality (waste water treatment, fertilizers, pesticides, buffer zones)
- channel morphology (flow, physical disturbance, buffer zones), and
- alien invasive species (vegetation and fish).

Flow-related aspects have been dealt with in Chapter 3, for each of the EWR zones. The identification of future management steps there was based on the EWR compliance audit as well as our re-evaluation of some of the historically-accepted water resource management practices. The present chapter presents an updated statement of the biophysical condition of the river, based on the same subdivision of the catchment into Management Units as delineated by the CMP 2000, but simplified and organised differently within scope of current review. This chapter therefore deals primarily with the last three components listed above, i.e. water quality, channel morphology and alien invasive species. In addition to the four sites selected for the EWR study (Southern Waters 2001), nine sites were selected for the catchment-wide biophysical assessment undertaken for the CAPE EWR compliance study (Ractliffe and Jonker 2009) (Figure 3.2, Table 4.1).

Table 4.1 Sites selected for the CAPE EWR compliance assessment (Ractliffe and Jonker 2009) together with a description of their location within each of the Management Units identified in the CMP 2000. The location of these sites is shown in (Figure 2.1).

River zones used for the EWR assessment (1999)	Management units used for the Catchment Management Plan (2000)	Sites for the CAPE EWR compliance assessment
Zone 1:	**Nuweberg Management Unit**	
A: Upstream of Nuweberg State Forest	Upstream of Nuweberg State Forest	TMG
B: Nuweberg State Forest to Nuweberg Dam	State Forest to Nuweberg Dam	
C: Nuweberg Dam to Eikenhof Dam (EWR Site 1).	Nuweberg to Eikenhof Dam	Site P1
Zone 2:	**Arieskraal Management Unit**	
A: Eikenhof Dam to the N2	Eikenhof Dam to the N2	
B: N2 to Arieskraal Dam	N2 to Arieskraal Dam	Site P2
	Klein Palmiet Management Unit	KP
	Downstream of Arieskraal Dam to the confluence with the Palmiet River	Site 3
	Solva Management Unit	
C: Downstream of Arieskraal Dam to the confluence with the Krom River (EWR Site 2).	Downstream of Klein Palmiet confluence to Krom River confluence	Site P4; Site P5
Zone 3:	**Kogelberg Management Unit**	
A: Krom River confluence to the confluence with the Dwars and Louws rivers (EWR Site 3)	Krom River to Stokoes Bridge	Site P6
	Stokoes Bridge to upstream confluence with Dwars and Louws Rivers	Site P7
B: the confluence with the Dwars and Louws rivers to the DWAF gauging weir No. G4H007	Confluence with Dwars and Louws Rivers to DWAF gauging weir G4H007	Site P8
C: the DWAF gauging weir No. G4H007 to the estuary (EWR Site 4).	the DWAF gauging weir No. G4H007 to the estuary	

The CAPE EWR compliance study included an assessment of water quality, vegetation, algal and invertebrate assemblages. Data for the study were supplemented from sites selected for the Table Mountain Group Aquifer (TMGA) monitoring study, a parallel study undertaken by FCG and other parties. In this report, where no new information is available, the review comments pertaining to the state of the river in the sections that follow are based on findings of the EWR compliance study and the CMP 2000. Additional information was added where available, in order to improve estimates of the current status of the river reaches. Gaps in information have been identified where they occur.

Water quality conditions in the catchment obtained from data supplied in the DWA Water Management System database are reported separately for each Management Unit was well in Section 4.7 where longitudinal changes in water quality conditions are compared. What follows is a discussion of the biophysical state of the river system by Management Unit.

4.2 Eikenhof Management Unit (Present Ecological Category: B; Desired Management Class: B)

This Management Unit covers the catchment from the source zones of the upper Palmiet River to Eikenhof Dam. Major tributaries of the Palmiet River in this management unit include the Keeroms and Wesselsgat Rivers, which drain to the Eikenhof Dam from the north-west (Figure 4.1). Four monitoring sites are located in this Management Unit: Table Mountain Group (TMG) aquifer monitoring site, water quality monitoring site WMS 1-10999, the EWR compliance site P1 and EWR Site 1 (Figure 4.1).

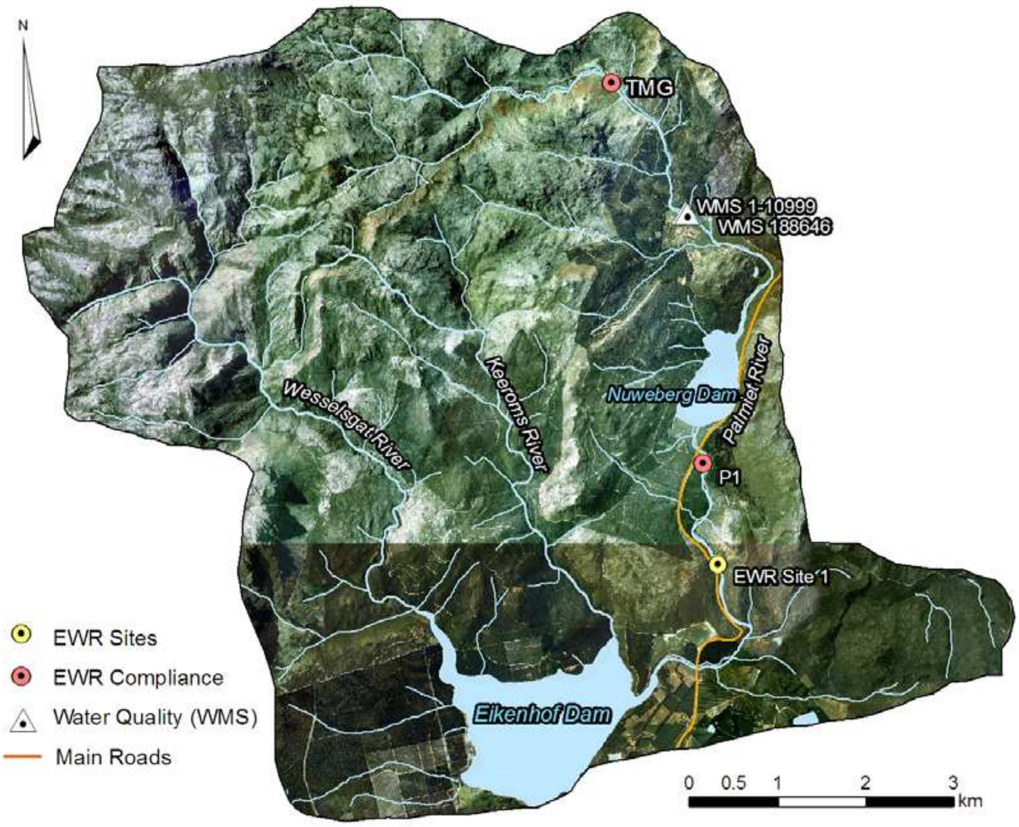

Figure 4.1 Satellite image of the Eikenhof Management Unit showing major water bodies, rivers, EWR sites, EWR compliance study sites and water quality monitoring (WMS) sites.

The biodiversity value and conservation importance of this unit is high in terms of its function as a source zone for the Palmiet River, as well as its largely intact riparian vegetation, aquatic macroinvertebrate and indigenous fish communities.

4.2.1 State of the river

The river systems in the Eikenhof Management Unit are largely undisturbed, particularly in the Nuweberg and Hottentots Holland Nature Reserves where natural veld predominates, but impacts from farming, forestry, forestry clearing, invasion by exotic vegetation and dams are evident the west and north Nuweberg and Eikenhof Dams respectively comprising the lower portion of the catchment unit (Figure 4.1).

Plate 4.1 Eikenhof Management Unit: (a) an undisturbed reach on the upper reaches of the Palmiet River in the Nuweberg area, (b) bank erosion caused by forestry clearing on a reach of the Keeroms River and (c) erosion in a hillslope seep wetland – also a consequence of forestry clearing operations in the Nuweberg area.

Some of the main forestry impacts arise from a failure to designate and maintain the stream and especially the hillslope seeps intact by having appropriate set-back distances for forest plantations (Plate 4.1, Table 4.2). Similarly, unbridled forestry road development and poor maintenance contribute to severe erosion in places. Agricultural activities are restricted within this management unit, and extend only along the southern and eastern edges of Eikenhof Dam. The Nuweberg WWTW package plant at the Forestry Station is the only point-source effluent in the Eikenhof Management Unit. Water quality in the unit is being monitored by the DWA at WMS 1-10999 and WMS 188646 – the latter only 15 data points (Figure 4.1). Generally elevated nutrient and conductivity values from this plant are reflected in the elevated levels in the main stem Palmiet River at WMS 1-10999 compared with the reference site in the upper Palmiet River, for example, where orthophosphate levels are always below 0.002 mg/*l*. This nutrient, a major pollutant implicated in eutrophication of rivers and dams, has a median value at WMS 1-10999 of 0.03 mg/*l*.

Table 4.2 Summary table of the state of individual ecosystem components for the Eikenhof Management Unit.

Component	Characteristics	Primary impacts	Consequence
Habitat quality and channel morphology	Hillslope seepage wetlands, valley-bottom wetlands, mountain stream, foothill, cobble-boulder-bed channel	Forestry, forestry clearing	Channel bank erosion, hillslope seep and channel bank erosion, potential for siltation of interstitial habitats
Water Quality	Low pH, Low conductivity, low nutrients	Nuweberg WWTW, Forestry clearing	El evated orthophosphate levels, Increased suspended solids, pH changes
Primary production	Oligotrophic (Chl *a* < 1.7 mg m^{-2}), predominantly green algae	Nuweberg WWTW,	Increased algal biomass, species dominance
Riparian vegetation	Lower mountain Fynbos and riparian zone communities. Key taxa: palmiet (*Prionium serratumI*), smalblar (*Metrosideros angustifoliaI*), *Berzelia lanuginosa* (hillslope seepage wetlands)	Forestry	Disturbance to and clearing of natural riparian vegetation
Invertebrate community	Key taxa: Leptocerid caddisflies, Ephemerellid mayflies, Elmid riffle beetles (*Elpidelmis* endemic), Notonemurid stoneflies	Forestry clearing, Nuweberg WWTW	Reduced water quality conditions, loss of key taxa, potential for siltation of habitats
Fish community	Key taxa: Cape galaxias (*Galaxias* spp.), Cape Kurper (*Sandelia capensis*)	Dams, exotic fish species, forestry clearing, Nuweberg WWTW	Potential for siltation of habitats, potential for invasion by exotic species, reduced health as a consequence of water quality

4.2.2 Revised management objectives

The objective for the Eikenhof Management Unit is to maintain the unimpacted river reaches within the unit in a Class B condition and to restore impacted reaches. The Management Unit should be managed to enhance its value as a source zone for the Palmiet River, as well as the biodiversity, scientific, conservation and recreational values of its aquatic and semi-aquatic ecosystems. The key steps to this end include:

- delineate seep wetlands and streams and map buffer zones around these;
- manage forestry road development and clearing operations in a manner that minimises disturbance to hillslope seepage wetlands, valley bottom wetlands, river channels and water quality conditions;
- identify Areas of Potential Concern (AOPC) and focus rehabilitation efforts around critical areas;
- identify potential invasion routes for exotic fish species and secure habitat for existing indigenous fish populations[2];
- implement measures to improve water quality from point source discharges.

4.2.3 Monitoring

The objectives of the monitoring should be to assess the impact of forestry clearing operations and riparian corridor rehabilitation efforts in terms of their impact in the ecosystem components identified in Table 4.2. Once programmes are identified in the respective Keeroms and Wesselsgat River catchments, control and impact sites should be sampled to track the outcome of the conservation efforts.

[2] Indigenous fish populations in this reach represent possibly the most downstream distribution of indigenous fish in the catchment. This, together with their uncertain taxanomic status (potentially new species) highlights their conservation worthiness (*pers. comm.* Ernst Swartz, South African Institute for Aquatic Biodiversity, Grahamstown).

On the Palmiet River itself, a control site exists within the Hottentots Holland Nature Reserve and is likely to be monitored annually as part of the TMG Aquifer Monitoring Programme (TMG; Figure 4.1). The existing P1 monitoring site downstream of Nuweberg Dam (Figure 4.1), used for the River Health Programme and the 2008 EWR compliance study, is not an appropriate site because of impacts of the R321 road and the particular character of the channel there. However, monitoring downstream of the Nuweberg Dam is recommended and the site should therefore be moved further downstream to the location of the site used for the initial EWR study (EWR Site 1) (Figure 4.1).

Water quality data should be collected from each of the monitoring sites at the time of biological sampling, to aid in interpretation of the biological data and to augment the Water Quality Monitoring Programme outlined in Section 5.1. The variables of interest to each ecosystem component are listed in Table 4.3.

Table 4.3 River ecosystem components and monitoring variables of interest for the Eikenhof Management Unit.

Component	Variables
Habitat quality and channel morphology	Wetland and river Habitat Integrity Assessment
Water Quality	Temperature, pH, conductivity, Nutrients (PO_4, NO_3, NO_2, NH_4)
Primary production	Trophic status (Chl *a*), biomass (AFDM) community composition
Riparian vegetation	Community composition and zonation across wetland or stream channel
Invertebrate community	SASS, macroinvertebrate community composition
Fish community	Species composition, population structure

4.3 Arieskraal Management Unit (Present Ecological Category: E; Desired Management Class: D)

The Arieskraal Management Unit includes the catchment from immediately downstream of Eikenhof Dam to the Arieskraal Dam wall. Here the Palmiet River flows through farming, urban and light-industrial areas for some 4 km before reaching the back-up waters of the Peninsula Dam (Figure 4.2). The remaining 10 km of river within this management unit is inundated by the Applethwaite, Kogelberg and Arieskraal Dams. Streams draining the south-western slopes of the Groenlandberg (Witklippieskloof) feed into the main stem Palmiet River from the north-eastern side of the catchment, immediately downstream of Elkenhof Dam, but relatively few tributaries enter the river from lands comprising the eastern catchment, where intensive farming and damming of streams has reduced most tributaries to narrow ditches between waterlily-covered dams. From the north-west, the Klipdrift River is the major inflow to the Palmiet River, flowing through the Grabouw Plantation, fruit-packing industrial areas and the formal and informal residential areas of the town of Grabouw on its way to the Palmiet River main stem.

South of the N2 National road, the streams draining the TMG sandstone, northern foothills of the Kogelberg are intercepted by the Kogelberg Dam, named tributaries of which include the Klein Dwarsrivier, Bergrivier and the Boegoekloof and Wolwekloof Rivers.

4.3.1 State of the river

Amongst the primary impacts in this Management Unit is polluted runoff from urban, industrial and agricultural areas. Intensive agriculture adjacent the riparian corridor as well as bulldozing and destabilisation of banks exacerbates invasion by exotic vegetation. In farming areas these sorts of practices have altered the riparian zone vegetation communities and river channel morphology.

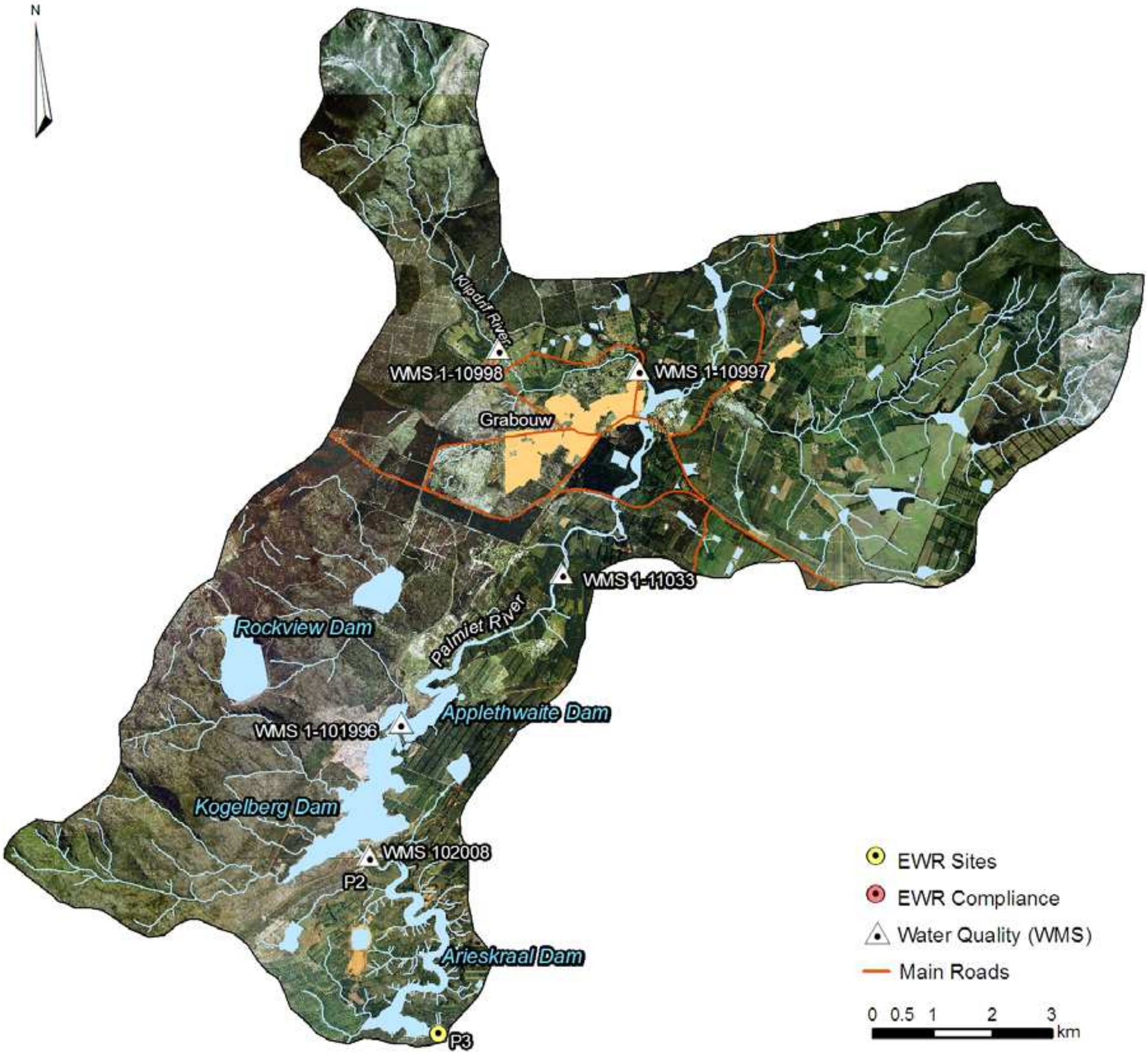

Figure 4.2 Satellite image of the Arieskraal Management Unit showing major water bodies, rivers, EWR sites, EWR compliance study sites and water quality monitoring (WMS) sites (note: only those WMS sites referred to in the text are shown).

Non-point-source water quality impacts are difficult to quantify, but water quality from three locations on the Palmiet River in this management unit (Eikenhof Dam and Applethwaite Dam) show increases in nutrients and conductivity, especially from the middle of the last decade (Appendix B). The Klipdrift River, which flows through the informal settlement, is the most heavily impacted by urban runoff. Data from two sampling stations on the Klipdrift River show elevated nutrient and conductivity levels at the most downstream of the two stations (WMS 1-10997) illustrating the combined effects of farming and urban (informal settlement) runoff on the river (Appendix B and Figure 4.2).

Treatment plants at Molteno Brothers, Grabouw Waste Water Treatment Works, Elgin Orchards and Two-A-Day Fruitpackers, and the all discharge effluent with high concentrations of phosphates, nitrates and ammonia, as well as high dissolved solids (Appendix B). A recent assessment of the current impact of the Grabouw WWTW (Belcher 2009) indicates that the Palmiet main stem is largely modified (Ecological Category D) with regard to instream condition, but impacts on the riparian zone, including bank modification and alien vegetation are even more extensive (Ecological Category E to F). Using a dataset for the past five years, Belcher

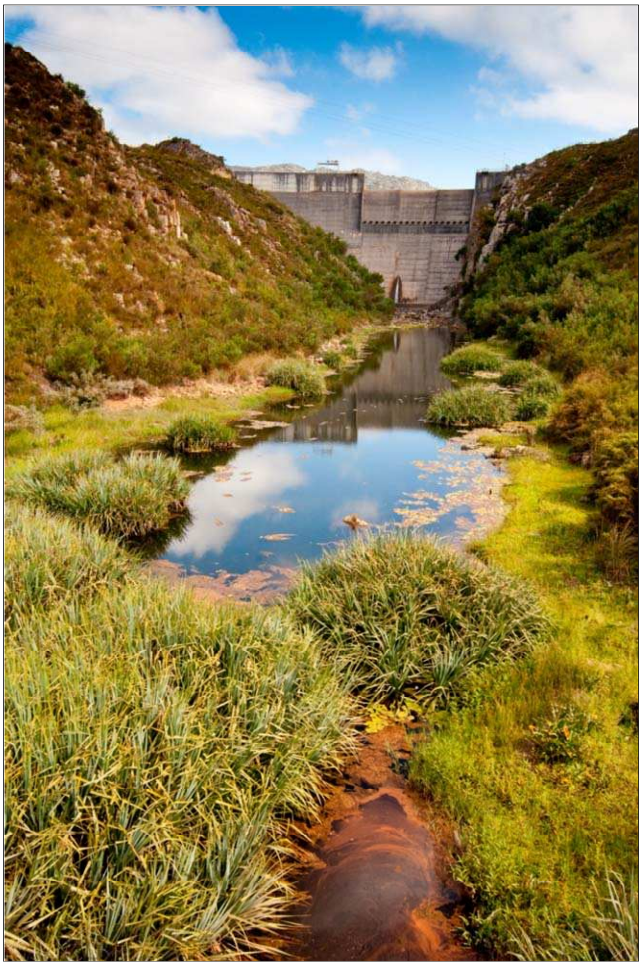

Plate 4.2 Modified flow conditions downstream of the Kogelberg Dam, Arieskraal Management Unit.

(2009) showed that water quality deteriorates dramatically between the Molteno Brothers and Oudebrug sites (WMS 1-11033, Figure 4.2) on the Palmiet River, with nutrient levels indicative of hypertrophic conditions and very high Chemical Oxygen Demand.

In addition to the extensively modified water quality conditions in this Management Unit, the four dams located here (the Peninsula, Applethwaite, Kogelberg and Arieskraal Dams) have short intervening river reaches and end-to-end occupy ~10 km (15 %) of river length. The naturally lotic (flowing water) habitats that would have occurred in the river here have been altered to lentic (standing water) habitats with consequent changes to the ecosystem. Downstream of the dams (Plate 4.2) the short intervening reaches are highly modified by flow regulation and bottom releases. These transformations are manifest in changes to the composition and structure of both the vegetation and invertebrate communities.

4.3.2 Revised management objectives

The national DWA Recommended Management Class for Quaternary catchment G40C is a Class C, but this includes all the area upstream of Arieskraal Dam. The CMP 2000 indicated that management objective in the Arieskraal Management Unit was to improve its current Ecological Category E condition to a Category D. This would entail minimising existing impacts (especially water quality) such that they are not manifest downstream. The Grabouw Waste Water Treatment Works (WWTW) is currently being upgraded (Belcher 2009) and this should contribute significantly to improving water quality.

The EWR process also recommended that a flow management plan be compiled for this management unit as already discussed in Section 3.3.2 that would alleviate water quality conditions, particularly over the summer months. The Flow Management Plan should include an audit of all sources where flow is augmented by industrial effluent.

Additional measures to improve river condition, however, should address the channel bank and riparian degradation and should include limiting runoff from urban areas through enforcing buffer zones.

Table 4.4 Summary table of the state of individual ecosystem components for the Arieskraal Management Unit.

Component	Characteristics	Primary impacts	Consequence
Channel morphology	Foothill and lowland river, pool-riffle sequence	Urban, agricultural and industrial development, alien invasive species	River channel confinement and entrenchment, loss of bank integrity
Water Quality	Elevated concentrations of nutrients, high Chemical Oxygen Demand (COD) (Belcher 2009)	Urban, agricultural, industrial runoff, waste water treatment works	Severely impaired water quality conditions pose a health risk and degrade river ecosystem
Primary production	not assessed	not assessed	not assessed
Riparian vegetation	95% exotic (e.g. *Acacia mearnsii*), orchards, vineyards, exotic species, remnant riparian species	Alien invasive species	Loss of riparian zone vegetation
Invertebrates	Taxa tolerant of severely impaired water quality conditions: Planaria (flat worms), hirudinae (leeaches), oligocheate (aquatic earthworms), chironimidae (midges).	Urban, agricultural, industrial runoff, waste water treatment works	Predominance of macroinvertebrate community by taxa tolerant of severely impaired water quality conditions
Fish community	not assessed	not assessed	not assessed

Key issues in the Arieskraal Management Unit include:

- Identification and mitigation of major point and non-point pollution sources;
- reinstatement of buffer zones in high impact areas where feasible;
- public education and information dissemination programmes on the importance of river health;
- upgrading of the Grabouw WWTW (in progress).

4.3.3 Monitoring

The monitoring objectives in the Arieskraal Management Unit should focus on the water quality impacts to the water chemistry, primary productivity and invertebrate communities downstream of Grabouw. There are several additional DWA water quality monitoring sites (Appendix B) in the Arieskraal Management Unit in addition to those reported on here that can be included in any future monitoring studies. Little information exists on the condition or conservation-worthiness of the tributaries in this region and a Situation Assessment of these rivers would therefore be of value for identifying conservation-worthy rivers or those requiring remediation.

4.4 Klein Palmiet Management Unit (Present Ecological Category C[3]; Desired Management Class B)

The Klein Palmiet Management Unit is located on the western edge of the Palmiet River catchment and encompasses the Klein Palmiet River catchment that drains the eastern slopes of the Dwarsrivierberg (Figure 4.3). With an aerial extent of ~24.7 km^2 it is the smallest of the Management Units, but one of the most important of those outside of the Kogelberg Biosphere Reserve because of its conservation value and potential for rehabilitation. The terrestrial ecosystems are particularly rich in endemic taxa and species of conservation concern, including as it does both Kogelberg Sandstone and Elgin Shale Fynbos vegetation types.

[3] For the CMP 2000 it was rated as a Category B river, but more recently it was assessed for the EWR compliance study and rated as a Class C (Ractliffe and Jonker 2009) attributed to low-flow impacts.

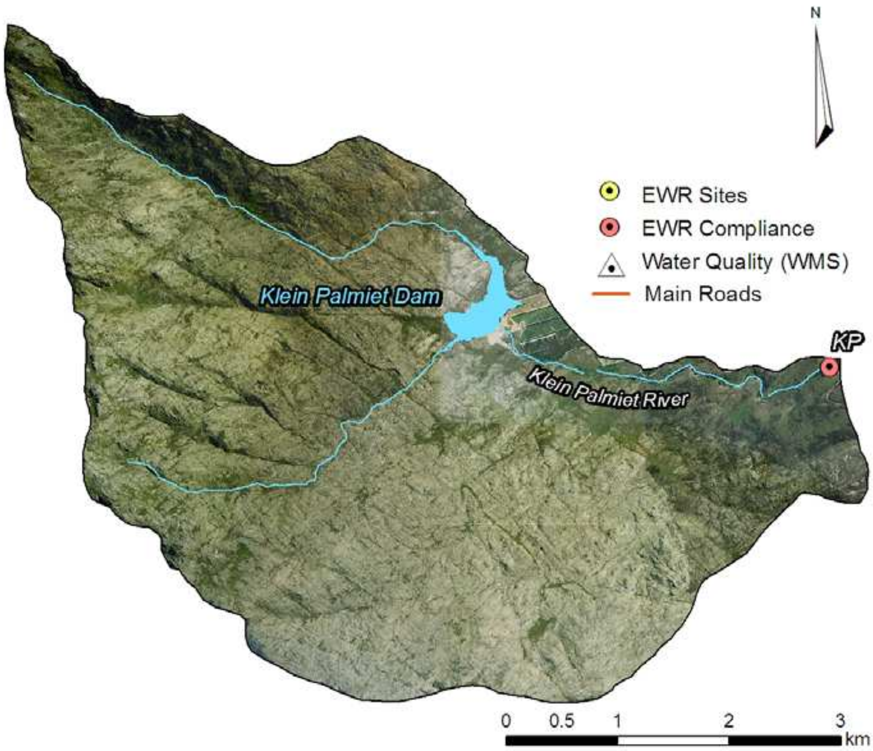

Figure 4.3 Satellite image of the Klein Palmiet Management Unit showing major water bodies, rivers, EWR sites, EWR compliance study sites and water quality monitoring (WMS) sites.

4.4.1 State of the river

The Klein Palmiet Management Unit through which the Klein Palmiet River flows is relatively undeveloped relative to the remainder of the catchment. However, from a water resources perspective, indications are that a large (~20 ha) privately owned dam located 3.5 km from the Klein Palmiet River's confluence with the main stem of the Palmiet River is giving rise to ecological changes in the downstream aquatic ecosystem (Plate 4.3).

Table 4.5 Summary table of the state of individual ecosystem components for the Klein Palmiet Management Unit.

Component	Characteristics	Primary impacts	Consequence
Channel morphology	Hillslope seepage wetlands, valley-bottom wetlands, mountain stream, foothill	not assessed	not assessed
Water Quality	No information	not assessed	not assessed
Primary production	Oligotrophic, but higher than normal for Western Cape (Chl *a* ≥ 5 mg m^{-2}),	Flow regulation	Lower than normal flows and high water temperatures, build up of periphyton
Riparian vegetation	No information	not assessed	not assessed
Invertebrates	Key taxa: Paramelitid amphipods, beatid mayflies	Flow regulation	Lower than normal flows and high water temperatures, change in community composition
Fish community	No information	not assessed	not assessed

Plate 4.3 Klein Palmiet Management Unit: (a) Klein Palmiet River valley facing east (b) Klein Palmiet Dam and (c) spillway. Note the presence of pines on the northern banks (a).

Elevated Chl *a* and periphyton biomass levels, as well as the composition of the macroinvertebrate community, suggest the predominance of unnaturally low flows and high temperatures for part of the year in the Klein Palmiet River (Ractliffe and Jonker 2009) (Table 4.5). At the time of the site visit for the EWR compliance study (December 2008), flows were very low and the sedge *Isolepis fluitans* commonly found in riffles and runs had died. Temperatures were found to be very high (27 °C) and organic biofilms had accumulated on stone surfaces. Although the riparian corridor appears to be intact for much of its length, pine plantations and exotics are present on the northern banks and vigilance with regard to invasion of the riparian zone by these species will need to be exercised.

4.4.2 Revised management objectives

The objective for the Klein Palmiet Management Unit is to improve the current Ecological Category C condition to a Category B. Its value as critical source zone for the Palmiet River downstream of the Arieskraal Dam needs to be acknowledged and the biodiversity, scientific, conservation values of the aquatic and semi-aquatic ecosystems preserved. Key issues include:

- provide for environmental flows in the river downstream of the Klein Palmiet Dam (Section 3.5);
- identify Areas of Potential Concern and focus rehabilitation efforts around critical areas, in particular the degree of invasion by exotics and plan clearing operations;
- delineate wetlands and map buffer zones around these and river channels;
- manage any clearing operations in a manner that minimises disturbance to hillslope seep wetlands, valley bottom wetlands, river channels and water quality;
- identify potential invasion routes for exotic fish species and secure habitat for remaining indigenous fish populations.

4.4.3 Monitoring

Little information is available for this management unit. A monitoring site for the EWR compliance study was located on the lower reaches of this river (KP) (Figure 3.2) and it is here recommended that an additional monitoring site be located upstream of the Klein Palmiet Dam. A Situation Assessment of this river is recommended with the objective of implementing EWR on the river (Table 4.6).

Table 4.6 River ecosystem components and monitoring variables of interest for the Klein Palmiet Management Unit.

Component	Variables
Habitat quality and channel morphology	River Habitat Integrity Assessment
Water Quality	Temperature, pH, conductivity, Nutrients (PO_4, NO_3, NO_2, NH_4)
Primary production	Trophic status (Ch *a*), biomass (AFDM) community composition
Riparian vegetation	Community composition and zonation across wetland or stream channel
Invertebrate community	SASS, macroinvertebrate community composition
Fish community	Species composition, population structure

4.5 Solva/Krom Management Unit (Present Ecological Category F; Desired Management Class D)

The Solva/Krom Management Unit is the most intensively farmed region of the Palmiet River catchment, coinciding as it does with the fertile Malmesbury Shales. Most of the unit comprises the Krom River catchment, but the Huis River and significant length of the main stem of the Palmiet River also flow through this unit (Figure 4.4). Three relatively large farm dams are located on the lower reaches of the Krom River including the Wintersat, Lorraine and Krabbefontein Dams, the latter impounding the waters of the Krom to the point where it joins the main stem of the Palmiet River. Several monitoring sites are located within the Management Unit, including Sites P4-P6 as well as the Krom monitoring site (spot water quality only, upstream of the Krabbefontein Dam, Figure 4.4) that were selected for the EWR compliance study. EWR Site 2 is also located in this Management Unit.

4.5.1 State of the river

Approaches to managing the tributary and main stem rivers differ, and these should be assessed and dealt with separately. A statement with regard to the state of the Krom and Huis Rivers cannot be made due to a lack of information, but it can be assumed that these rivers are severely impacted for most of their lengths by intensive agricultural activity and the abundance of farm dams.

Along the main stem of the Palmiet River, the riparian zone vegetation is intact in places, but heavily invaded in others by *Acacia longifolia* and *Pinus pinaster* (e.g. Buttonquail Farm to the Iron bridge at Solva, Plate 4.4). Aquatic vegetation species such as *Nymphoides indica* more commonly found in standing water have become established in the main channel due flow regulation by Arieskraal Dam (Ractliffe and Jonker 2009). There are high abundances and diverse composition of collector-detritivore invertebrate groups. This and the dominance of Simuliid blackfly and Trichopteran caddisfly larvae suggest a constancy of flow, i.e. little variability, and water rich in suspended organic matter from Arieskraal Dam during summer.

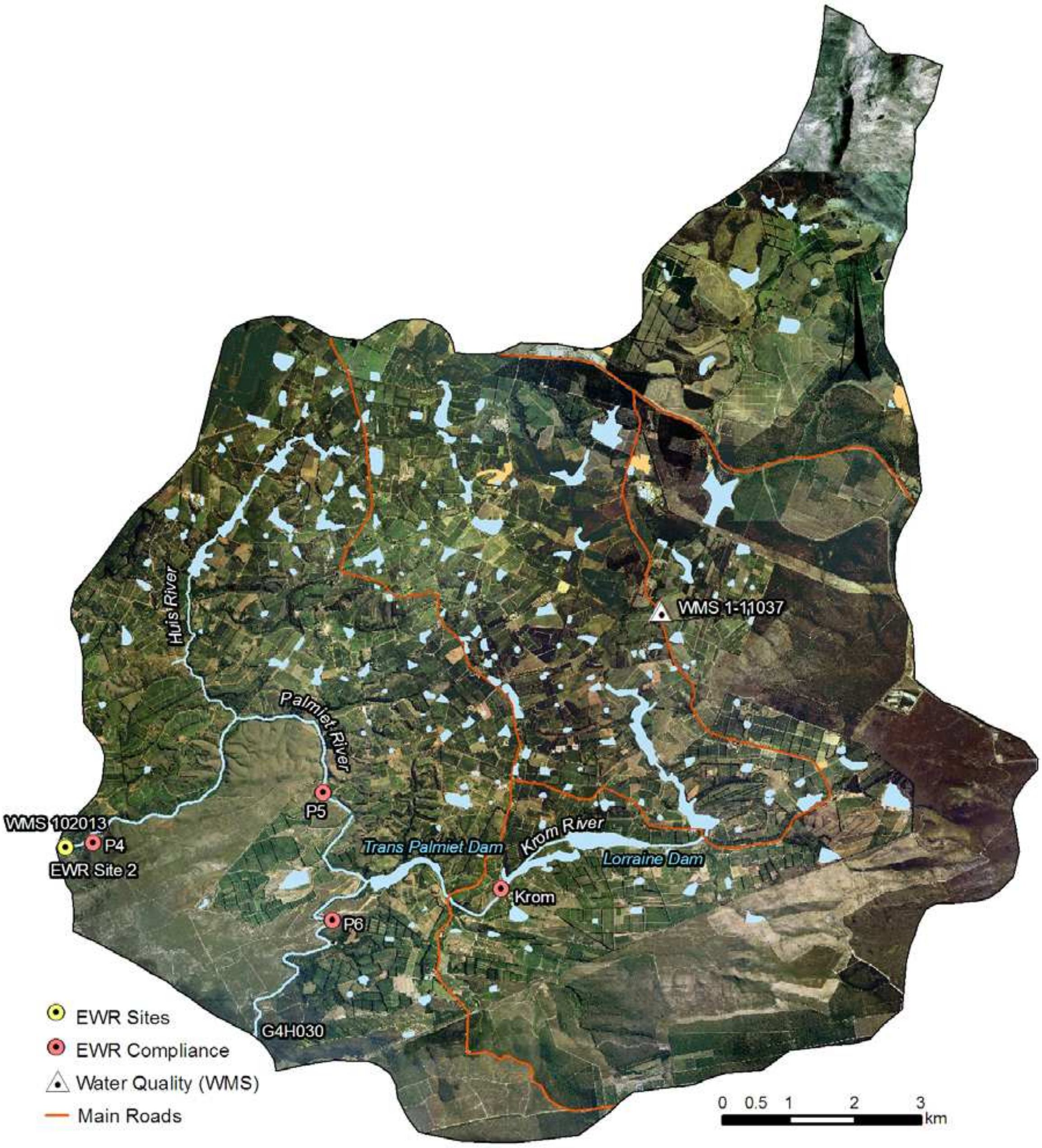

Plate 4.4 A heavily invaded riparian zone on the main stem of the Palmiet River in the Solva/Krom Management Unit between Sites P4 and P5 on the Solva farm.

Water quality on the Krom River is impaired by agricultural runoff with implications for conditions in the Palmiet River as suggested by the doubling in conductivity values between Sites P4 (6.4 mS /m) and P5. (11.0 mS/m) (Ractliffe and Jonker 2009). Conductivity values in the Krom River at the Krom Site were amongst the highest measured anywhere in the catchment (35.9 mS/m).

Ractliffe and Jonker (2009) concluded that water quality conditions were being moderately impacted by agricultural practices in the lower Palmiet River, but that further investigations, particularly with regards to nutrient loading in winter, need to be undertaken. An additional water quality issue in this Management Unit is the colder than natural conditions (14.0 – 19.0 °C) during the summer months as a consequence of the bottom-release outlet valves on Arieskraal Dam (see summary Table 4.7).

Figure 4.4 View of the main stem of the Palmiet River in the Solva/Krom Management Unit. The riparian zone is largely transformed by invasive alien vegetation species

4.5.2 Revised management objectives

It is recommended that the Krom River be improved from a Ecological Category F (according to the CMP 2000 classification) to a Category E. However, given the extensive area of land under cultivation, the large number of private dams, the severely degraded condition of many of the rivers and the absence of buffer zones, this may prove difficult to achieve – particularly given the fact that very little land adjoining rivers remains for introducing buffer zones and that land already under cultivation is unlikely to be surrendered for this purpose.

Table 4.7 Summary table of the state of individual ecosystem components for the Solva/Krom Management Unit.

Component	Characteristics	Primary impacts	Consequence
Channel morphology	Hillslope seepage wetlands, Foothill and lowland river, pool-riffle sequence	Alien invasive vegetation	Loss of riparian vegetation reduces bank stability
Water Quality	Naturally oligotrophic, pH mildly to strongly acidic	Agricultural runoff, cold bottom-release water from Arieskraal Dam	Oligo- to mesotrophic, elevated conductivity and nutrients (PO_4, NO_3, NO_2, NH_4) values, low temperatures (14-19 °C) during summer
Primary production	Naturally low Chl *a* (~5 mg/m^2)	Flow regulation: insufficient early summer flows, nutrient enrichment	Elevated Chl *a* concentrations downstream of Arieskraal Dam
Riparian vegetation	Lower mountain Fynbos and riparian zone communities. Key taxa: palmiet (*Prionium serratumI*), smalblar (*Metrosideros angustifolial*),	Invaded by *Acacia longifolia* and *Pinus pinaster*	Replacement of riparian vegetation by alien invasive species
Invertebrates	Hydropsychidae, Simuliidae	Particulate organic matter from Arieskraal Dam, low temperatures from bottom-releases	Altered benthic macroinvertebrate compostion and community structure favouring collector-detritivores
Fish community	Inadequately sampled	Alien invasive species likely to be present	not assessed

Having said this however, it should be noted that the impaired water quality conditions in the Krom/Solva Management Unit are being manifest in the Kogelberg Management Unit – a region of high conservation priority (Section 4.6). The necessity of addressing this issue, therefore, cannot be overlooked. A management approach to this section Section 5.4. Along the main stem of the Palmiet River, clearing of alien invasive vegetation and vigilance with regard to its spread downstream is a high priority since this unit is immediately upstream of the environmentally sensitive Kogelberg Management Unit.

4.5.3 Monitoring

Very little information is available on the ecological status of either the main stem Krom or its tributaries and a Situtation Assessment of these rivers and associated wetlands would be of value for targeting management interventions. A number of monitoring sites are located in this Management Unit , including the EWR Site 1, EWR compliance study sites P4-P6 and the Krom, as well as DWA WMS sites. Recommended variables to be monitored are shown in Table 4.8.

Table 4.8 River ecosystem components and monitoring variables of interest for the Solva/Krom Management Unit.

Component	Variables
Habitat quality and channel morphology	River Habitat Integrity Assessment
Water Quality	Temperature, pH, conductivity, Nutrients (PO_4, NO_3, NO_2, NH_4)
Primary production	Trophic status (Ch *a*), biomass (AFDM) community composition
Riparian vegetation	Community composition and zonation across wetland or stream channel
Invertebrate community	SASS, macroinvertebrate community composition
Fish community	Species composition, population structure

4.6 Kogelberg Management Unit

The Kogelberg Management Unit incorporates the Kogelberg Biosphere Reserve (KBR) which is marked by an extraordinarily high levels floral diversity (1650 species, of which 178 are rare and 77 endemic) and a wide diversity of terrestrial and freshwater habitats. It is consequently regarded as the 'floristic heart' of the Cape Floral Kingdom and as such is managed under UNESCO's Biosphere Reserve concept (WCNCB 2003). Indications are that the diversity of freshwater invertebrate species is also high – the KBR is considered a hotspot for Odonatan (damselfly and dragonfly) diversity, with a large number of regionally endemic, restricted rare and globally threatened species being present (Grant and Samways 2007).

Many of these species are habitat specialists, depending on specific river biotopes to complete their larval development. In addition, the Palmiet River in this Management Unit represents one the last remaining lowland rivers of any significant size anywhere in the Western Cape that has not been severely degraded. Together, these factors highlight the overwhelming importance of managing all upstream catchments in manner that limits the downstream displacement of impacts to the lower reaches - whether such impacts arise from urban, agricultural or industrial runoff, flow regulation or alien species invasions.

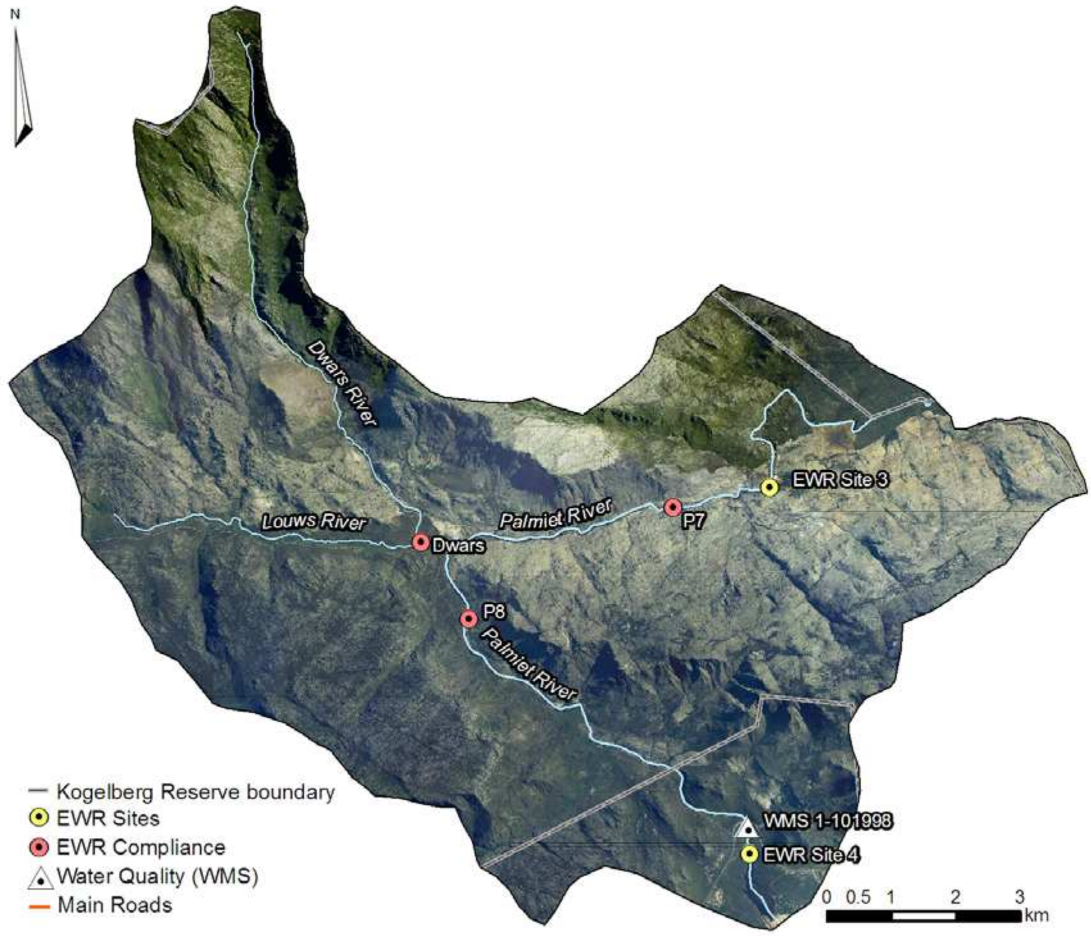

Figure 4.5 Satellite image of the Kogelberg Management Unit showing major water bodies, rivers, EWR sites, EWR compliance study sites and water quality monitoring (WMS) sites and the Kogelberg Biosphere Reserve boundary.

4.6.1 State of the river

Riparian vegetation communities are largely intact and the river bank morphology undisturbed in the Kogelberg Management Unit with typical Western Cape riparian plants species being present, including: wild almond (*B. stellatifolium*) smalblar (*M angustifolia*) as well as waterwitels (*Brachylaena neriifolia*). The Ecological Status of the riparian vegetation community along these reaches is therefore considered to be a class B. The EWR compliance study (Ractliffe and Jonker 2009) suggested however, that water quality conditions at Sites 7 and 8 are subject to nutrient enrichment.

Evidence for this was demonstrated by the dominance of the algal community by cyanophytes and chlorophytes and particularly the blue-green algae *Aphanothece* sp. The Ecological Category for water quality was therefore set at a Class C. Based on SASS scores, the EWR compliance study found the invertebrate assemblages to be a Category C and a low Category B at Sites P7 and P8 respectively. This was believed to reflect the dominance of blue-green algae which are unpalatable to invertebrate assemblages.

Conductivity levels were found both in the EWR study and EWR compliance study to be elevated above the ranges expected for this section of the river.

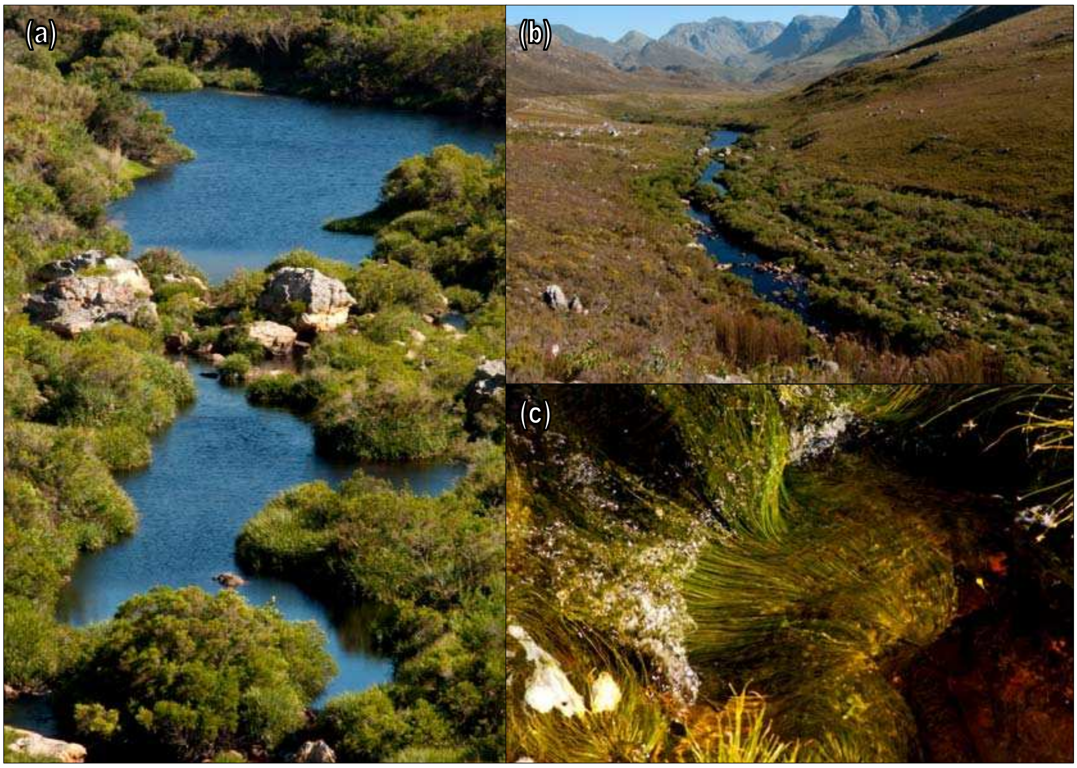

Plate 4.5 The Palmiet River in the Kogelberg Management Unit illustrating (a) the main stem with a largely intact riparian vegetation zone including wild almond (*B. stellatifolium*) and smalblar (*M. angustifolia*), both common in the tree-shrub zone of Western Cape fynbos rivers, (b) a braided floodplain reach of the Palmiet River in the Kogelberg Biosphere Reserve and (c) typical tannin coloured waters of the Dwars River showing *Isolepis fluitans* in a riffle.

Thus there is good evidence for the fact that the impacts resulting from nutrient enrichment from the catchments upstream of the Kogelberg Dam, as well as the Huis and Krom Rivers, are being manifest in the Kogelberg Management Unit. In terms of the fish fauna in this unit, surveys for the EWR study (Southern Waters 1998a) reported the highest densities of invasive fish species (largemouth bass, smallbouth bass and bluefill sunfish) anywhere in the catchment and the situation is not considered likely to have changed in the intervening years (Table 4.7). In addition to the impact of invasive alien fish species, it should be noted hear that the DWA weir G4H007 at the head of the estuary is likely to present a barrier to migratory species including the threatened freshwater mullet (*Myxus capensis*), eels (*Anguilla mossambica*) (although to a lesser extent because of this organisms ability to ascend instream barriers) and the migratory Cape river shrimp *Palaemon capensis*. The weir is known to impact the latter species (Coetzee 1991) which occurs in the Palmiet River at the westernmost limit of its distribution range.

4.6.2 Revised management objectives

Any management interventions within the Kogelberg Management Unit itself should take cognisance of the Kogelberg Biosphere Reserve Management Plan (WCNCB 2003) that exists for this region. One of the key issues in this unit is to halt the downstream spread of alien vegetation along the river margins. This issue of alien vegetation is, to a large extent, being addressed by excellent reserve management, which undertakes regular monitoring and clearing operations within the boundaries of the reserve that, for the most part, overlap with, or contain the Kogelberg Management Unit. The other important issue that has been highlighted in this Management Unit is nutrient enrichment from upstream catchments. The mitigation of these impacts call for actions to be taken in the upstream Solva/Krom and Arieskraal Management

Units as discussed in the previous sections of this report. The presence of barriers to migration in rivers is considered a major factor contributing to the decline of migratory fish and invertebrate species in South African river systems.

Table 4.9 Summary table of the state of individual ecosystem components for the Solva/Krom Management Unit.

Component	Characteristics	Primary impacts	Consequence
Channel morphology	Hillslope seepage wetlands, Foothill and lowland river, pool-riffle sequence	-	Largely undisturbed
Water Quality	Naturally oligotrophic, pH mildly to strongly acidic	Agricultural runoff from the Krom/Solva Management Unit	Higher than expected levels of conductivity
Primary production	Naturally low Chl *a* (~5 mg/m^2)	Agricultural runoff from the Krom/Solva Management Unit	Dominance of algal community by cyanophytes and chlorophytes
Riparian vegetation	Lower mountain Fynbos and riparian zone communities: palmiet (*Prionium serratumI*), smalblar (*Metrosideros angustifoliaI*), wild almond (*Brabejum stellatifolium*)	Alien invasive species	Very limited invasion
Invertebrates		Moderately impaired water quality	
Fish community	Indigenous *Galaxias* spp. and kurper (*Sandelia*) present in un-invaded tributary reaches	High densities of alien invasive fish species present	Loss of indigenous fish populations from the Palmiet River main stem

With respect to these migratory species, the DWA has undertaken to provide fish passage facilities at all its weirs and it is therefore suggested here that the construction of a fish ladder on the DWA gauging weir G4H007 be investigated.

4.6.3 Monitoring

The primary objective in the Kogelberg Management Unit should to monitor the impact of water quality conditions either directly from WMS stations or through its impact on algal or invertebrate communities. There are five established sites within the unit where this can take place (EWR Sites 3 and 4, P7, P8 and Dwars, Figure 2.1). There is also a DWA water quality monitoring station present (WMS 101998) from which time series data can be regularly downloaded and used to assess trends and the outcome of upstream management interventions. The monitoring variables of interest in this unit are listed in Table 4.8.

Table 4.10 River ecosystem components and monitoring variables of interest for the Solva/Krom Management Unit.

Component	Variables
Habitat quality and channel morphology	River Habitat Integrity Assessment
Water Quality	Temperature, pH, conductivity, Nutrients (PO_4, NO_3, NO_2, NH_4)
Primary production	Trophic status (Ch *a*), biomass (AFDM) community composition
Riparian vegetation	Community composition and zonation across wetland or stream channel
Invertebrate community	SASS, macroinvertebrate community composition
Fish community	Species composition, population structure

4.7 Summary of changes in the Water Quality conditions along the length of the Palmiet River

Data from selected WMS sites (Table 4.11) were analysed to provide summaries of spatial (longitudinal) and temporal trends in water quality. These data were obtained from the Water Management System (WMS) database, DWA Resource Quality Services. Six sites were selected form strategic locations within the catchment to represent each of the Management Units. Four water quality variables are reported: pH, Conductivity, PO_4^+-P and NO_3^+-N. The focus of this summary is on inter- rather than intra-annual variation and on comparisons between sites. Intra-annual (winter-summer) variation in water quality variables and its significance are discussed in Ractliffe and Jonker (2009).

Table 4.11 Water Management Sites (WMS) selected for water quality analysis in this section.

Management Unit	WMS Site Name	WMS Site number
Eikenhof	Nuweberg	1-10999
Arieskraal	Oudebrug	1-11033
	Applethwaite	1-101996
Solva/Krom	Kogelberg Dam	102008
	Krom River	1-11037
Kogelberg	Estuary	101998

pH

Median pH values for the years on record increased dramatically from their lowest at Nuweberg (typical values between 4 and 5 pH units, characteristic of poorly buffered acid waters drainaing TMG sandstone slopes) to values between 6.5 and 7.5 pH units at Oudebrug and from there through to the estuary (Figure 4.6)[4]. One noticeable development in recent years is the increased range in pH at Nuweberg, with a large number of high readings, suggesting period release of polluted effluent into the river upstream of the sampling point.

Conductivity

Lowest recorded annual median conductivity values for the years on record were obtained from the Nuweberg site (3.97 mS/m) and highest from the Krom River site (58.74 mS/m) (Figure 4.7). The data show an increase in conductivities between the 1970s and present at the Applethwaite and Estuary sites, the Applethwaite site showing the most pronounced increase from the 10-12 mS/m range to 15-19 mS/m.

Orthophosphates PO_4-P

Lowest recorded annual median phosphate concentrations for the years on record were obtained from the Nuweberg site (0.03 mg/*l*), although few data from this location exist (Figure 4.8) and data from within the Nuweberg Reserve are less than 0.015 mg/*l*.

Values of phosphate above 0.02 mg/*l* suggest enrichment (see discussion in Ractliffe and Jonker 2009), which may stem from wastewater discharges or urban or agricultural runoff. The highest phosphate values were recorded at the Oudebrug site downstream of the town of Grabouw and the sewage works (annual median 0.19 mg/), indicating that the river in this reach becomes hypertrophic , with the highest values in 2006 and 2007. The reduction in phosphate levels in the main stem Palmiet River downstream of Oudebrug is probably a consequence of the trapping of sediment (and thereby phosphate which adsorbs to sediment articles) in the Eikenhof, Kogelberg and Arieskraal Dams. Here then, the damming of the river has the effect of improving water quality in the important downstream reaches. However, the influx of

[4] A substantial increase was evident around 1988 or 1989 for those sites with a record extending back to these dates. These are believed associated with the change in pH sample collection methods and therefore should not be interpreted as reflecting actual changes in pH and applies to all DWA gauges nation-wide.

increasing loads of this nutrient into the dams will have consequences in the long term, and it is of utmost importance that nutrient loading in the Palmiet River be addressed.

In this regard, it should be a requirement for all sewage treatemtn works to release water of at least Special Standards, which is the highest standard of effluent currently stipulated by DWA, although additional requirements can be set if needed (Wilna Kloppers DWA Regional Office, pers. comm.).

Nitrates NO_3-N

Nitrate, nitrite and ammonium are the three main forms of nitrogenous compounds in rivers, and collectively are referred to as Total Inorganic Nitrogen (TIN). TIN values above 0.5 mg/*l* indicate a shift from oligo- to meso-trophy, i.e. nutrient enrichment (see discussion in Ractliffe and Jonker 2009. For the comparison of data, missing values of ammonium meant that only NO_3-N is shown. As was the case with phosphates, the lowest recorded annual median nitrate concentrations for the years on record were obtained from the Nuweberg site (0.15 mg/*l*) (Figure 4.9). This and the Estuary site were largely within the oligotrophic range, but the remainder of the river indicated moderate to high levels of mesotrophy with regard to nitrogen. The decline in NO_3-N at Oudebrug may simply reflect the fact that, as the sewage works upstream decline in function, more of the nitrogen in the effluent was passed into the river in the form of ammonium, a potentially toxic compound if present in its unionized form.

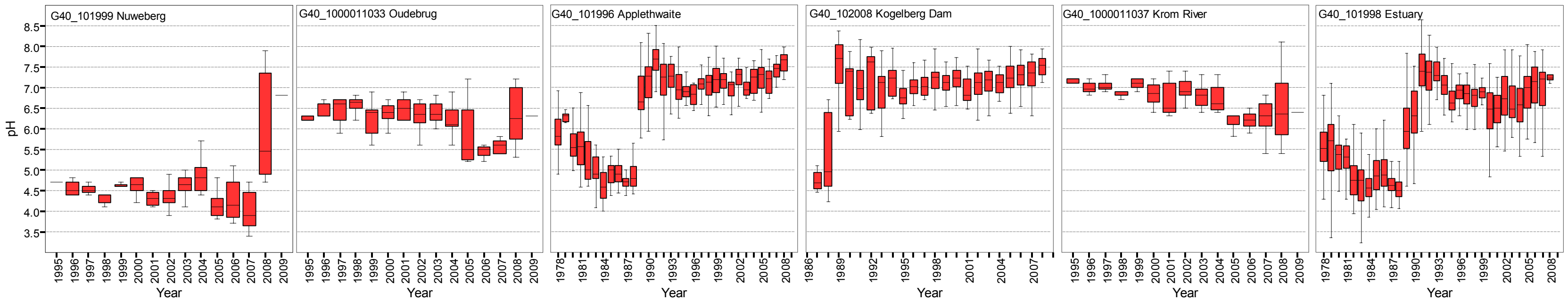

Figure 4.6 Annual pH values for WMS sites on the Palmiet River. Median (centre line), 25 % and 75 % quartiles (box) and minimum and maximum (whiskers) from monthly samples.

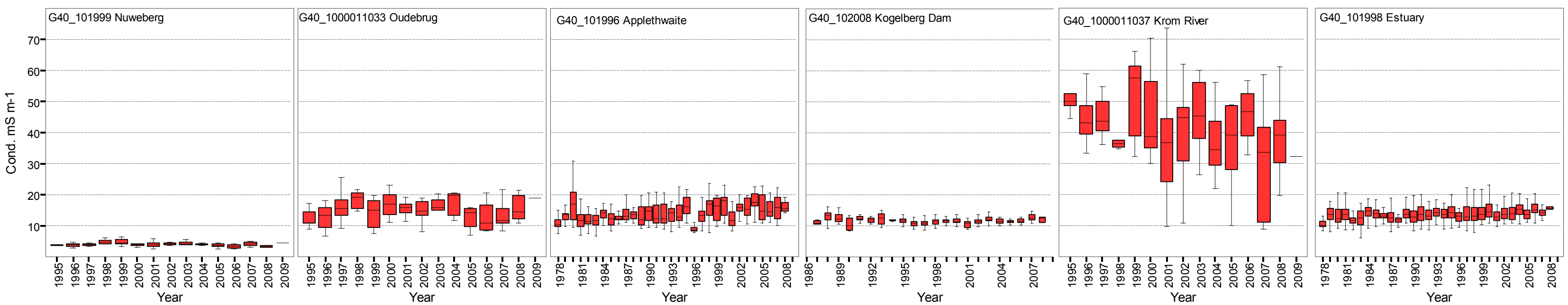

Figure 4.7 Annual conductivity values (mS/m) for WMS sites on the Palmiet River. Median (centre line), 25 % and 75 % quartiles (box) and minimum and maximum (whiskers) from monthly samples.

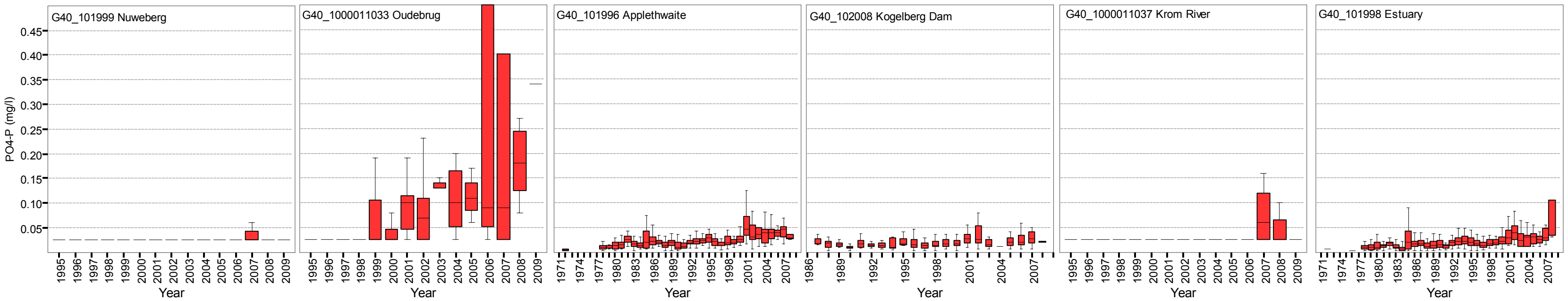

Figure 4.8 Annual soluble reactive phosphorus (PO_4^-P) (mg/l) values for WMS sites on the Palmiet River. Median (centre line), 25 % and 75 % quartiles (box) and minimum and maximum (whiskers) from monthly samples.

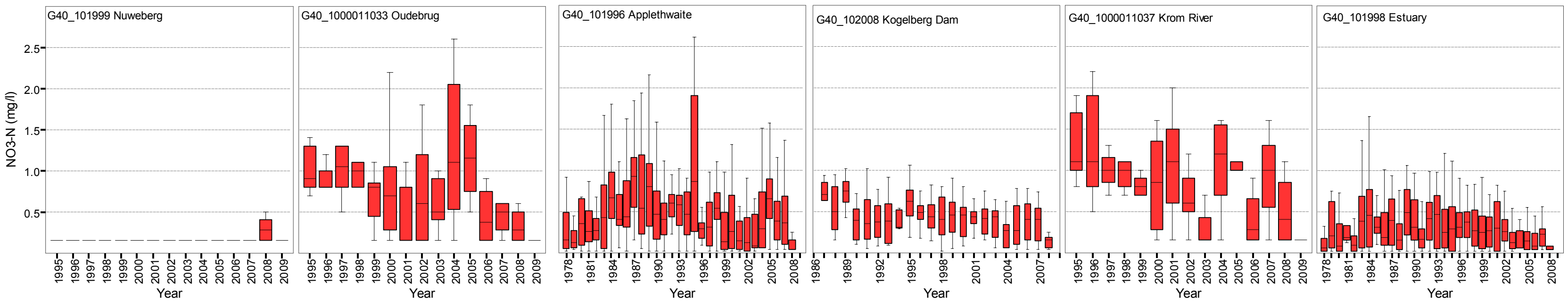

Figure 4.9 Annual nitrate (NO_3-N) values (mg/l) for WMS sites on the Palmiet River. Median (centre line), 25 % and 75 % quartiles (box) and minimum and maximum (whiskers) from monthly samples.

4.7.1 Invertebrate SASS Scores

Invertebrates living in river systems have relatively short life cycles and therefore respond quite rapidly to environmental changes. Different taxonomic groups of invertebrates display different levels of sensitivity to changes in water quantity or quality. These two factors make invertebrate communities particularly useful as indicators of environmental change. The South African Scoring System (SASS) assigns different taxa scores according to their known sensitivity to water quality conditions – a higher score being assigned to more sensitive groups. SASS has been successfully applied throughout South Africa as an indicator of the prevailing water quality conditions in catchments and is an integral part of the DWA River Health Programme. SASS scores and Average Score Per Taxon (ASPT) values are used to set thresholds corresponding the Ecological Categories A-F that have been defined in Table 2.1.

SASS has been used as a monitoring tool in the Palmiet River since 1998 and relatively good data therefore exist to show long term trends In Figure 2.1 (Ractliffe and Jonker 2009). SASS scores were compared for the years 1998, 2001, 2003, 2007 and 2008 at a number of sites throughout the catchment (Figure 4.10). A number of points emerge from this. Firstly, the upper Palmiet River site in the Nuweberg areas (Site TMG), and two sites in the Kogelberg Management Unit: the Dwars and EWR Site 4 (equivalent to Site 'K') fall into an Ecological Category A or B for all the years sampled. Secondly and as expected, Site P2 downstream of the Kogelberg Dam and P3 downstream of the Arieskraal Dam as well as Site P6 immediately downstream of the Krom River confluence on the Palmiet River main stem all scored the lowest (Category E and D) reflecting both water quality and quantity impacts at these sites as discussed in Section 4.3 and 4.5. The low score obtained for Site P7 is believed to reflect the predominance of blue-green algae and impaired water quality already suggested for this site in Section 0.

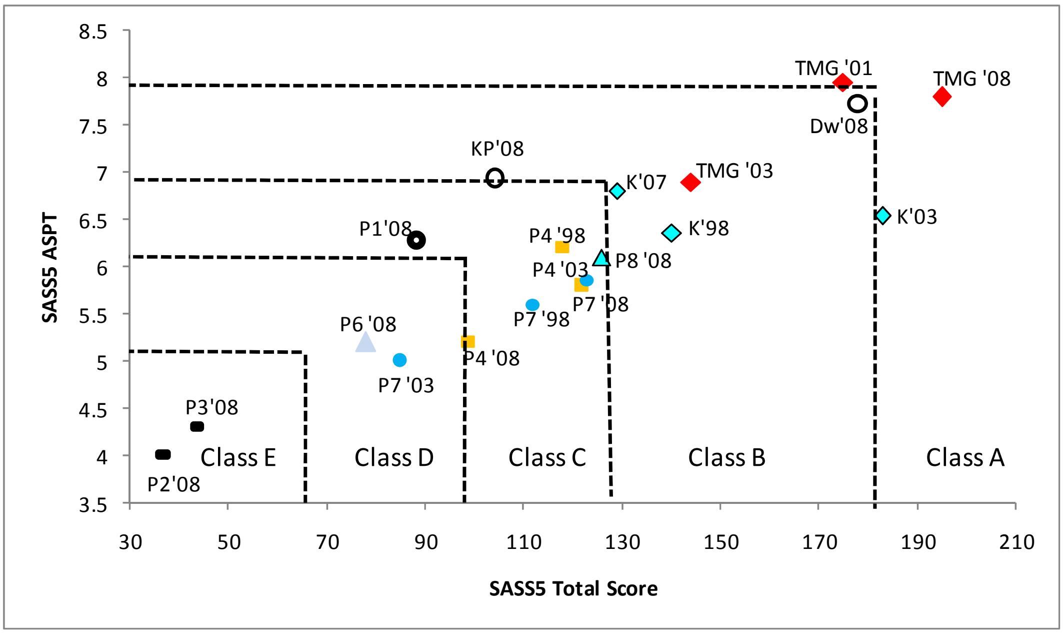

Figure 4.10 ASPT vs. SASS5 scores for each sampling site, showing the results of the current study as well as historical data for sites within the Palmiet River catchment. TMG and P1-P8 are the sites used in the current study, with the year (e.g. '08) added as suffix. K = Palmiet River in the Kogelberg Biosphere Reserve, at EWR Site 4, KP = Klein Palmiet, River Dw = Dwars River. Also shown are the biological bands, combination of SASS score and ASPT ranges that are equivalent to Ecological Status Classes A-F (Ratcliffe and Jonker 2009).

The Resource Quality Objectives, i.e. the desired state for the invertebrate assemblages in the lower Palmiet River can be summarised as follows:

- From Arieskraal Dam to Stokoes Bridge – improve from current Class D to a Class B.
- From Stokoes Bridge to the Dwars confluence – improve from a Class C to a Class B.
- From the Dwars confluence to the estuary – improve from a Class B to a Class A.

It is believed that addressing the major water quality issues in the catchment, together with managing flows as prescribed in Chapter 3 would facilitate the accomplishment of these objectives.

5. RECOMMENDED STRATEGIES AND ACTIONS

Strategies to address the issues of concern raised in this review of the Palmiet River Catchment Management Plan are presented in this chapter. Management issues in this document were split into two main areas: (1) major water resource management issues that relate to the implementation of the Ecological Reserve in the main stem and tributaries of the Palmiet River and (2) the biophysical impacts of primarily non-flow related impacts arising from human activities within the catchment. Addressing these two issues requires different approaches and involves different stakeholders. Major water resource allocation and management issues in the catchment have largely been dealt with in Chapter 3 and the implementation of the recommendations made in that chapter will require close cooperation with the DWA, ESKOM and dam operators. Addressing the issues in the second area of concern will require multi-faceted sector-by-sector (agriculture, forestry, etc.) and Management Unit-specific approaches. The strategies and approaches recommended in this chapter are in addition to those outlined in Chapter 3 and intended to provide a more focused plan of action for the issues raised in Chapter 4.

Four key strategic focal areas – supported by a single coordinated basin-wide monitoring and assessment programme – have been identified where it is believed resources could best be allocated in support of key management objectives. The identification of the focal areas was based on an assessment of the priorities within each Management Unit, together with the factors that were perceived to be impinging on river system either within, or downstream of the Management Unit. For example, biodiversity and conservation values are considered paramount in the Eikenhof and Kogelberg Management Units. Strategies in these areas therefore focus on halting and/or reversing degradation of river and wetland systems, whereas in the Arieskraal and Krom/Solva Management Units, where complete restoration of ecosystem functioning is not considered feasible, the focus is rather on improving conditions to the point where impacts are not transferred downstream. It is intended that the objectives listed be developed into the Terms of Reference for future projects in each of these focal areas.

To some extent, the strategic focal areas outlined here overlap with those identified in the Breede River Internal Strategic Perspective (DWAF 2004), but they are aimed at specific needs within the Palmiet River catchment itself. Issues that have not been addressed here, including water conservation and demand management strategies and a coordinated approach to clearing riparian zones of alien vegetation, were addressed in the latter report as well as the initial Palmiet River CMP 2000.

Specific time frames should be set for achieving particular goals in each of the focal areas and it is suggested that projects fall in line with the 5 year cycle of implementation, monitoring and review that was outlined in the initial CMP 2000 and presented in this document (Chapter 2, Figure 2.3). Supporting all these strategies should be ongoing monitoring programme designed to quantifiably assess progress and achievements in each focal area, and the outline of such a programme is presented in Section 5.1 below.

Furthermore, together with broader Management Unit- and sector-based management approaches, smaller-scale targeted rehabilitation and restoration projects can be identified on the basis of their short- to medium term feasibility, landowner interest and conservation-worthiness. Apart from the direct benefits that may accrue to river and wetland systems themselves, these smaller-scale projects would also be of value as ‘showcases’ demonstrating the benefits of sustainable management practices and models for what can be achieved in the long term.

5.1 Basin-wide wetlands delineation, State of the River and wetlands assessment and strategic planning

The assessment of river condition in the current report has been made on the basis of data from the initial Palmiet River CMP (Common Ground Consulting 2000a), the Palmiet River EWR study (Southern Waters 2001) and the EWR compliance study (Ractliffe and Jonker 2009) and supplemented with water quality data provided by the DWA Water Management System stations and DWA gauging weirs. For certain parts of the system, very little additional information is available for prioritising management interventions. A glaring omission has been the absence of data on the location and extent of wetlands in the catchment. In addition, the assessments of river condition in this report were made at the scale of the Management Units. These Management Units are not homogenous entities with respect to river condition and more detailed reach-by-reach analysis of river condition is required – particularly in the tributaries about which very little is known.

Prior to, or in parallel with, the implementation of the management interventions recommended here, therefore, it is recommended that a state of the river assessment and wetland delineation study be undertaken in the respective Management Units that will address the knowledge gaps identified in this report. The scope and objectives of such a State of the River update and assessment is suggested as follows:

- A desktop delineation of wetlands (including stream channels) based on satellite and orthophoto imagery, with partial field verification of wetland edges;
- an assessment of the current condition and conservation importance of the wetlands, partially modeled using GIS-based modeling techniques, with field verification of selected areas;
- a field-based assessment of the condition of key tributaries;
- a GIS cover of the wetlands, including information on their condition and conservation importance;
- recommendations for the management and rehabilitation of wetlands of highest importance, particularly where these adjoin residential, agricultural or forestry areas;
- identification of targeted areas for forestry clearing or better practice (e.g. buffer zones) to enhance wetland conservation;
- identification of wetlands of special concern for the protection of threatened species (link with CapeNature and incorporate National Freshwater Ecosystem Priority Areas).

In addition to the state of the river assessment and wetland delineation study, a monitoring programme needs to be initiated to assess progress and achievements of management interventions. The location of the monitoring sites and the variables of interest have already been outlined for each of the Management Units in Chapter 4.

5.2 Eikenhof Management Unit forestry and alien vegetation land management strategy

SAFCOL is currently decommissioning their commercial forest plantations at Nuweberg and clearing operations are currently underway. Some of this land is intended for use by resource-poor farmers, but land unsuitable for agriculture is targeted for rehabilitation with indigenous vegetation (DWAF 2004). Ultimately, the clearing operation will result in less water use in the previously forested areas and an estimated 4.5 Mm^3/a could eventually become available for use in the lower catchment areas (DWAF 2004). However, in the short term, increased runoff and destabilisation of the soil is likely to intensify soil erosion and evidence of this is already apparent in parts of the Eikenhof Management Unit. Where clearing has taken place around a hillslope seeps and river channels, significant gully and river bank erosion is apparent. Failure to designate set-back distances for forest plantations around river channels and hillslope seeps is primarily responsible for this. Forestry road development and poor maintenance are also contributing to erosion in places. The Nuweberg area is a valuable source zone for the Palmiet River and loss of hillslope wetlands is likely to impact runoff into the Palmiet and impair the water quality of downstream river ecosystems. Guidelines for clearing operations around wetlands and river channels need to be developed and incorporated into forestry clearing management plans. The data from the wetland delineation study recommended in Section 5.1 needs provided with these guidelines. The key objectives are as follows:

- provide a GIS layer of key wetlands and river channels in forestry areas;
- Provide guidelines with regard to best practice for both setback distances for plantations, and for tree felling operations around seeps and wetlands;
- liaise with SAFCOL and forestry clearing teams;
- monitor the impacts of clearing at a control and impact site;
- document and publicise examples of successful execution of best practice.

5.3 Arieskraal Management Unit water audit and Flow Management Plan

The Arieskraal Management Unit includes all the major residential and industrial centers in the catchment. This fact, together with the location of all of the major water resource infrastructure within its boundaries, means that its river ecosystems are amongst the most degraded in the catchment in terms of modified flow conditions, impaired water quality and loss of riparian zones. Non-point pollution sources in the Grabouw area stem from rapid expansion of informal settlements and insufficient sanitation facilities to service these areas and the formal residential areas. The Klip River has been identified as one of the primary sources of this pollution (DWAF 2004). Additional sources of pollution are likely to arise from runoff from the city centre itself and the Grabouw WWTW is a major polluter of the river.

Although it is not considered feasible to restore river ecosystem functions completely in this Management Unit, mitigating water quality impairment upstream of the Applethtwaite Dam and reducing nutrient loading in the dams and lower river is considered a high priority. Upgrading the Grabouw WWTW would, no doubt, alleviate part of the problem, although steps should be taken to ensure that Special effluent Standards are both stipulated and adhered to in future expansion of the WWTW. Improving sanitation in informal settlements is obviously desirable from a social as well as an environmental perspective. The implementation of clean water releases from Eikenhof Dam will dilute pollutant concentrations, which may improve conditions in this reach, but will not affect loading in the downstream parts of the river,

The key focus of the strategy suggested for the Arieskraal Management Unit is therefore to conduct a water audit of industrial water effluent points, to identify worst point and non-point pollution sources (e.g. Klipdrif River, industry) and then to use the information generated in this assessment to design a Flow and Water Quality Management Plan as has already been recommended for this part of the river in Section 3.3.2. The key objectives are as follows:

- assess quantity and quality of flow augmented from industrial effluent sources;
- identify pollution ‘hotspots’ and recommend remedial actions;
- ensure that the EWR from Nuweberg reaches Eikenhof Dam without being abstracted along the riverthrough liaison with dam operators and farmers;
- compile the information and strategies into a Flow Management and Water Quality Plan that has, as one of its key objectives, the mitigation of water quality impairment by appropriate flow management, but which also addressed non-flow impacts in the reach.

5.4 Krom/Solva River Management Unit water resource use and riparian zone management strategy

Together with the Arieskraal Management Unit, the Krom/Solva Management Unit has a major impact on downstream river ecosystem. Situated as it is on Malmesbury shales, it is the most productive agricultural unit in the catchment and farmers have paid scant attention to the necessity for protecting water courses or implementing sustainable riparian zone management practices, particularly since productive land is frequently found adjoining river systems. The large number of farm dams in this area (Figure 4.4) testifies to the extensive modification of river ecosystems in this catchment. However, the necessity for mitigating some of the water quality impacts cannot be ignored since they are being manifest in the Kogelberg Management Unit, a region, as pointed out, with a high conservation priority.

To some extent, water quality conditions in the main stem of the Palmiet River will improve if the recommendations made in this report regarding EWR releases Kogelberg and Arieskraal Dam are adhered to – particularly during the early winter when the first winter floods are likely to flush pollutants into the main stem from the Krom and Huis Rivers. If these early floods are withheld over this period, water quality conditions are likely to be exacerbated downstream. A more detailed assessment of intra-annual fluctuations in water quality in the Krom River is therefore a priority.

In terms of land management, a first step may be to develop riparian zone management guidelines and best-practice policy regarding application of pesticides and fertilizers, or identifying alternative, but economically viable crops that can be planted in riparian zones. The adoption of these guidelines can then be tested on selected ‘showcase’ farms with the expectation that they will become more widely adopted in the future may become more widely future. A policy with regard to planting of new land or re-planting of reconditioned land adjoining rivers should be investigated, specifically focusing on incremental establishment of adequate setback distances and watercourse buffer zones.

The strategic objectives in this Management Unit are therefore as follows:

- Investigate the timing of peak inflows of pollutants into the main stem Palmiet River from the Krom River in relation to releases from upstream impoundments;
- Develop riparian zone management guidelines and best-practice policy regarding the application of pesticides and fertilizers;
- Recommend buffer zones and planting setback distances, based on different land uses
- Identify pilot projects or ‘showcase’ farms where these guidelines can be implemented and assessed.

5.5 Conclusion

The strategic areas of focus presented in this chapter are meant as guides and are tabled as suggestions. Their key foci should be developed further, remain flexible and changed should the need arise. In addition to active management interventions, raising awareness around the value of protecting water resources and the ecosystems upon which they depend is considered as one of the key challenges in the Palmiet River catchment and fundamental to any management approach adopted within it. Education and awareness campaigns, which might include training workshops, information brochures, or best-practice manuals, should therefore form a fundamental component of each strategic focus area. The aim of these education campaigns should be to increase capacity and competence of established governance structures, to raise awareness amongst landowners, students, agricultural, forestry and conservation staff and to increase the readiness of landowners to buy in to conservation initiatives.

6. References

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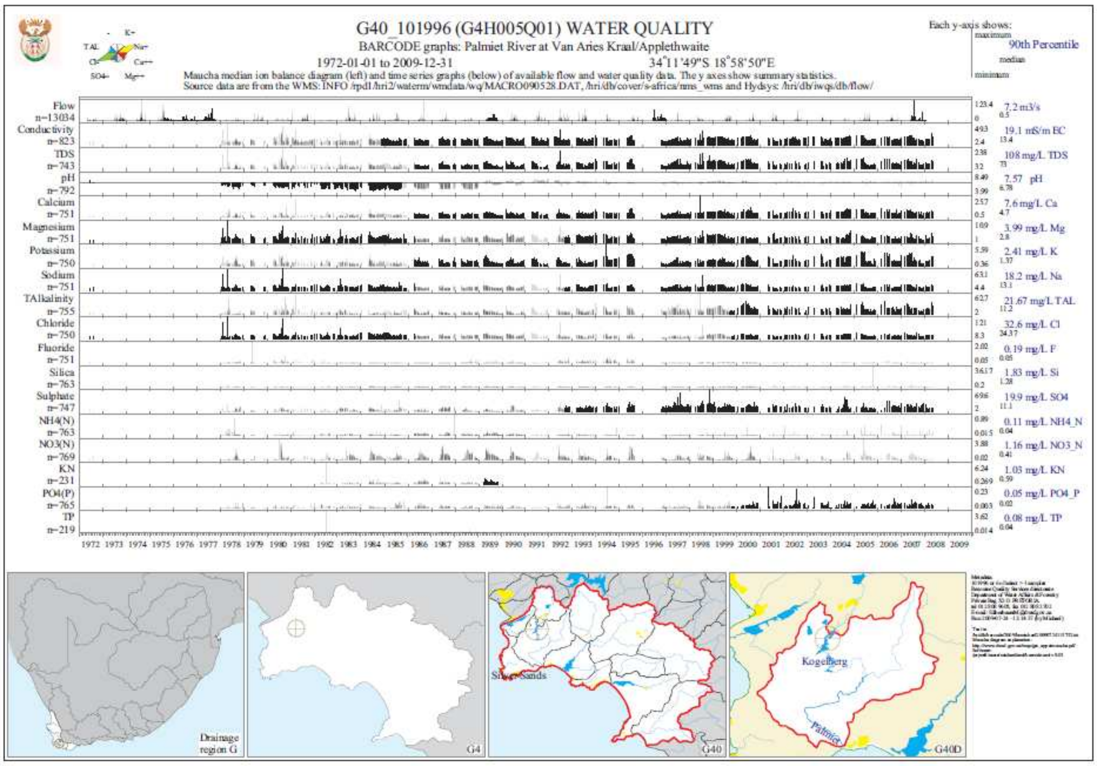
APPENDIX A

PROPOSED IMPROVEMENT TO THE OPERATING RULES FOR MAIN STEM DAMS ON THE PALMIET RIVER (Ratcliffe and Jonker 2009)

In light of the findings of this study, the following issues are highlighted as a basis for refining the operating rules for Kogelberg and Arieskraal Dams:

- Release restrictions imposed by the existing outlet works at Kogelberg and Arieskraal Dams are major concerns in terms of facilitating EWR releases. Changes to the outlet works at Arieskraal Dam to allow greater low flow variability are essential. In addition, changes to the Kogelberg Dam outlet works to allow larger flood releases and more variability would allow greater flexibility in terms of the management of these dams for meeting EWRs.
- The release 15 m^3/s from Kogelberg Dam as a constant baseflow for long periods of time in winter should be re-examined. This is currently necessitated as part of the weekly operating cycle of the Palmiet Pumped Storage Scheme, because of the need to control the impact of major releases from Rockview Dam so as to prevent the occurrence of artificial floods towards the end of the gravity cycle. The other limitations of this scheme, whereby large releases from Kogelberg Dam are usually restricted to sunny day releases once per week, should be addressed. Care should be taken to ensure that flood releases mimic natural flood events more closely.
- Natural flow in the Klein Palmiet could go a long way to restoring summer flow variability in the Palmiet River. EWR releases from Eikenhof Dam are now being made, with some provision that these will be allowed through the system, to reach Arieskraal Dam. Ideally, this EWR from Eikenhof should proceed down the full length of the river, but are prevented from doing so by the release constraints at Arieskraal Dam. The exchange of the Eikenhof EWR entering Arieskraal Dam with the Klein Palmiet diversion flows should be investigated, to allow the Klein Palmiet flows to be made available for the downstream river system.
- The EWR monthly volume rule curves established for EWR Site 3 is a more realistic basis for monitoring than the existing constant volume EWRs for the lower Palmiet River, as they make provision for climatic variability, well recognised as an important component of managing ecosystems. These should be developed for all EWR sites along the river, including the upstream sites. Further, natural inflows at the selected EWR Sites should be used to guide EWR releases. The possibility of using the incremental catchment between Gauges G4H030 and G4H007 as a ‘natural’ indicator catchment should be investigated.

APPENDIX B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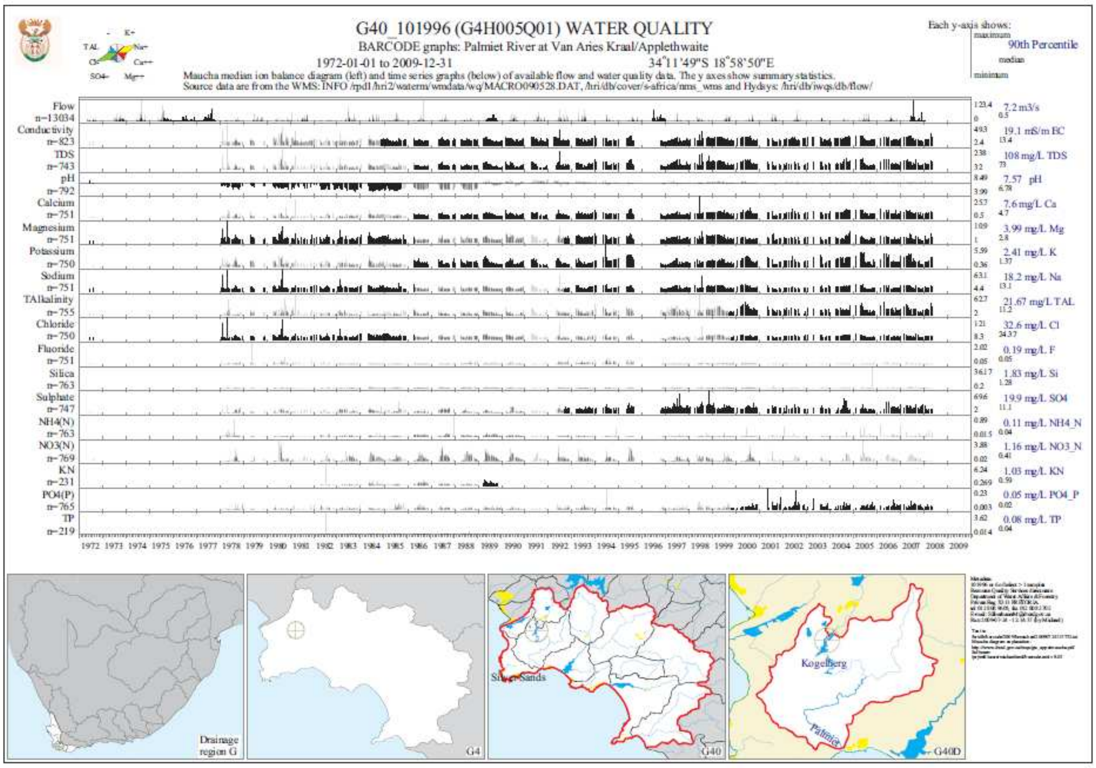
90th Percentile
median
minimum
Kogelberg
Palmiet
Drainage region G
G4
G40
G40D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Each y-axis shows:
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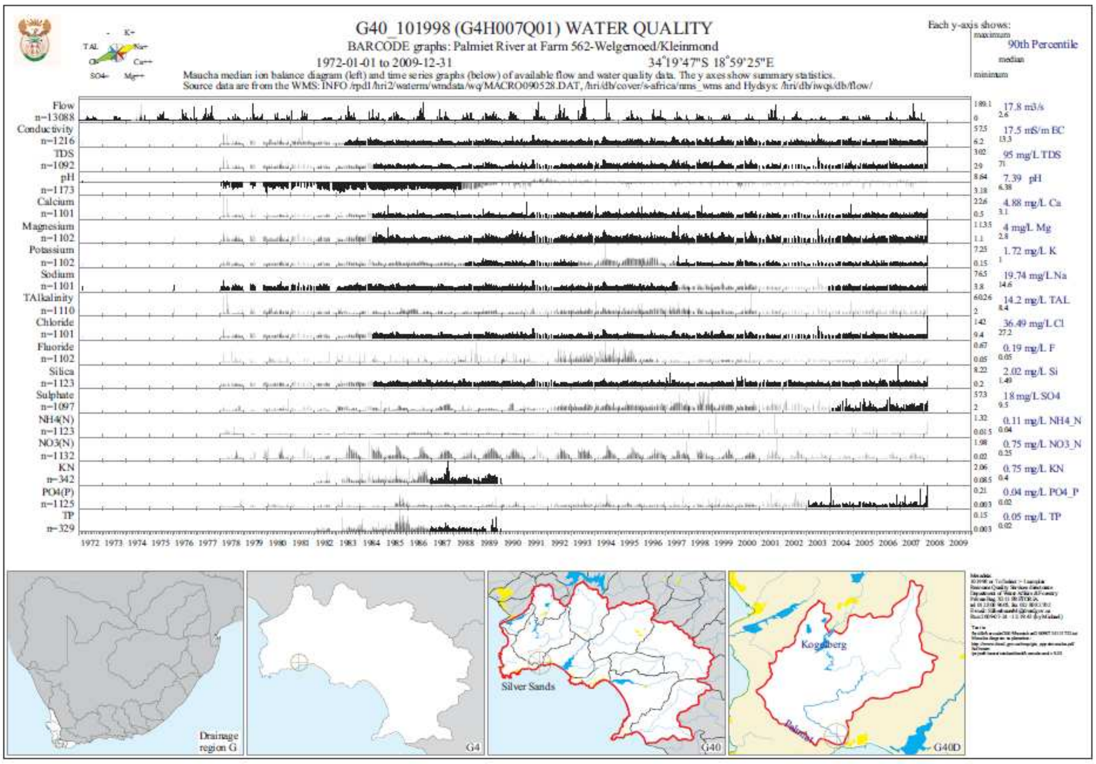
90th Percentile
median
minimum
Kogelberg
Palmiet
Drainage region G
G4
G40
G40D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Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
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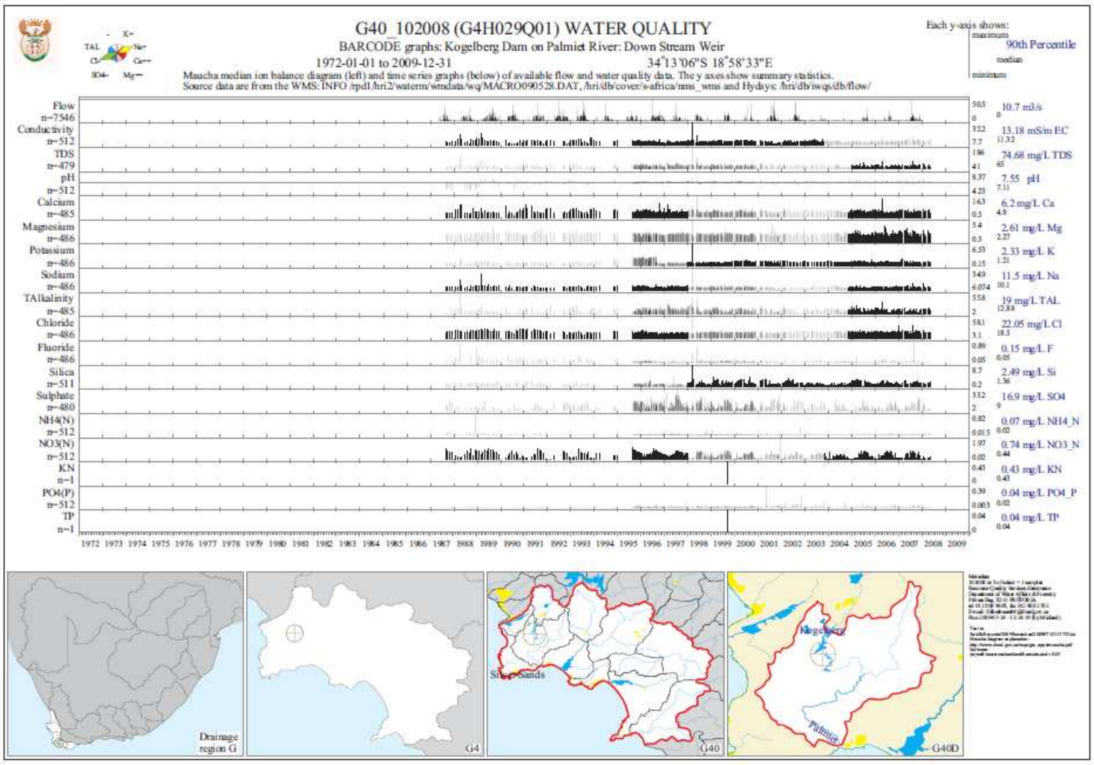
90th Percentile
median
minimum
Drainage region G
G4
Silver Sands
G40
Kogelberg
G40D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Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
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median
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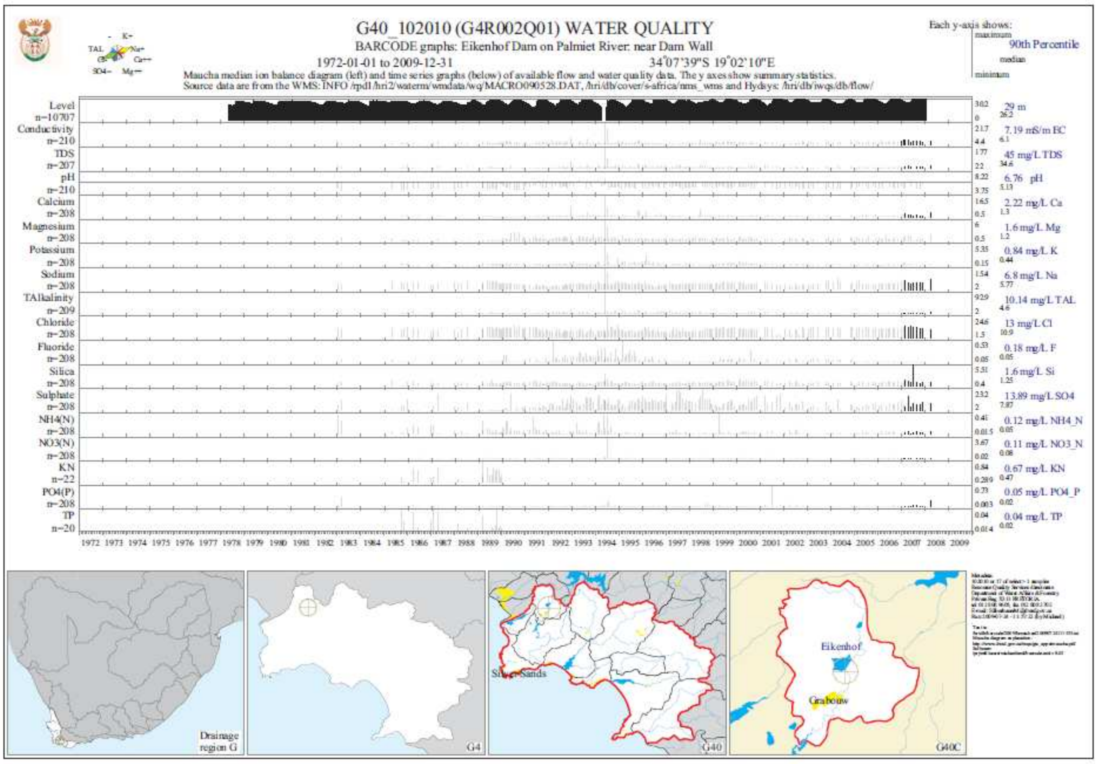
Drainage region G
G4
Silver Sands
G40
Kogelberg
G40D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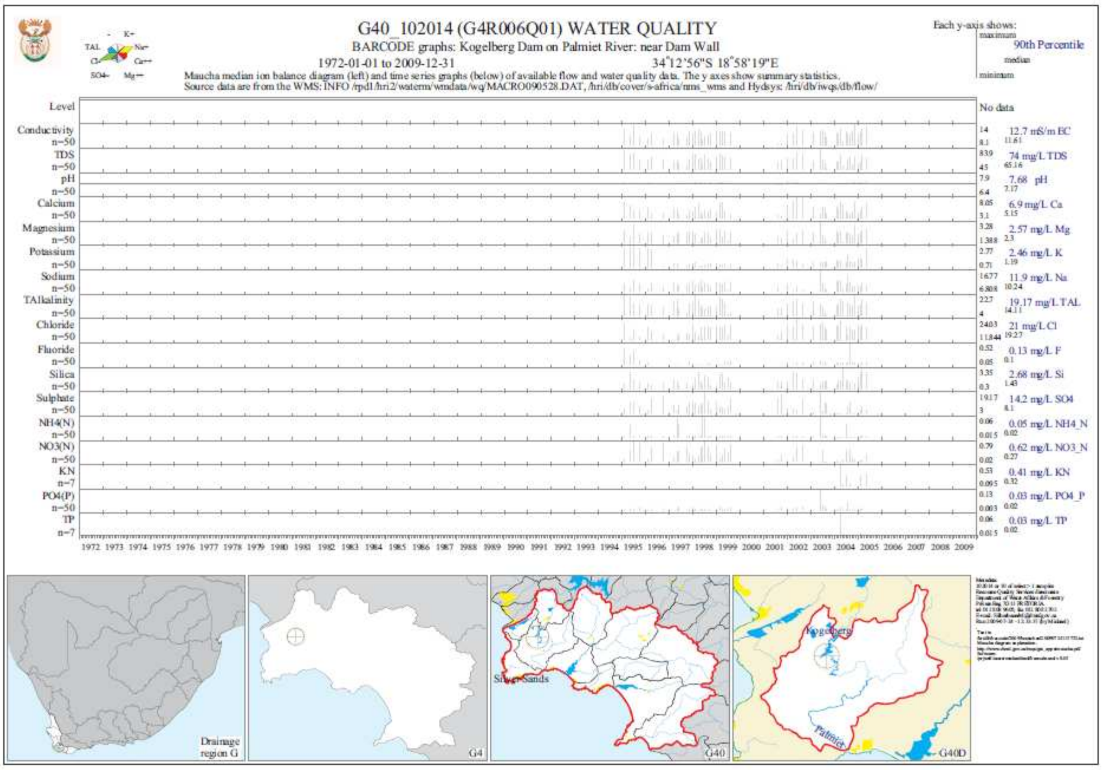
median
minimum
Eikenhof
Grabouw
Drainage region G
G4
G40
G40C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Palmiet
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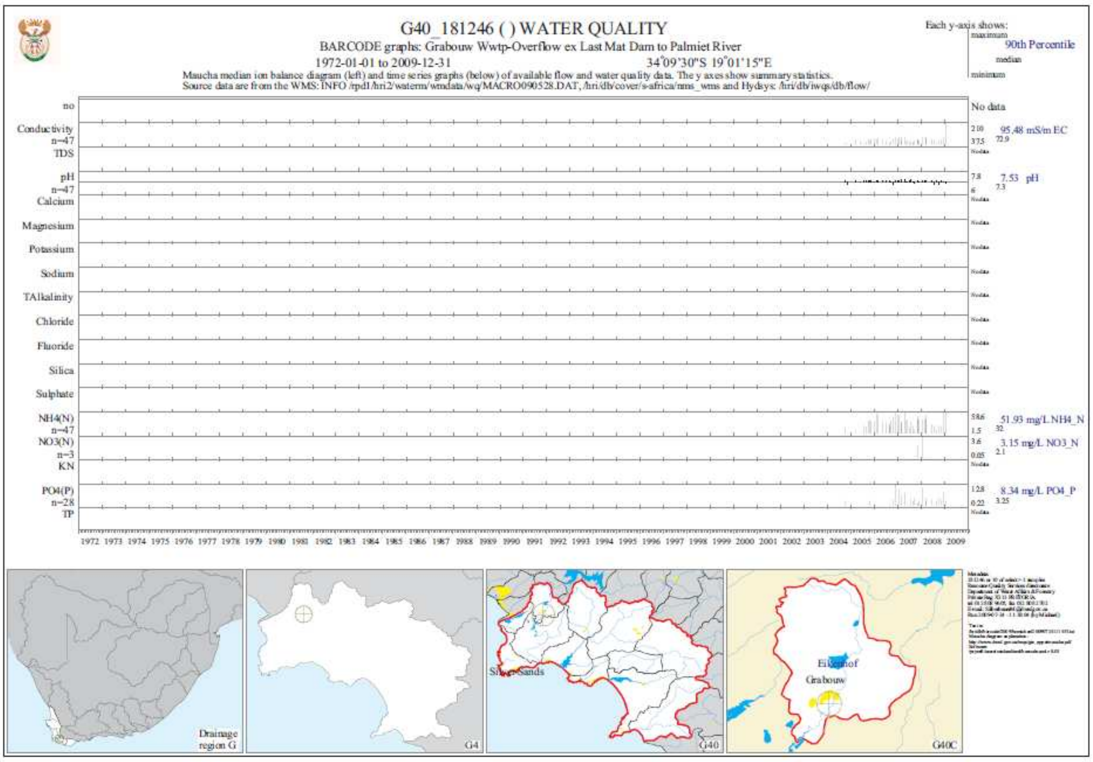
G4
G40
G40D



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7.53 pH
51.93 mg/L NH4_N
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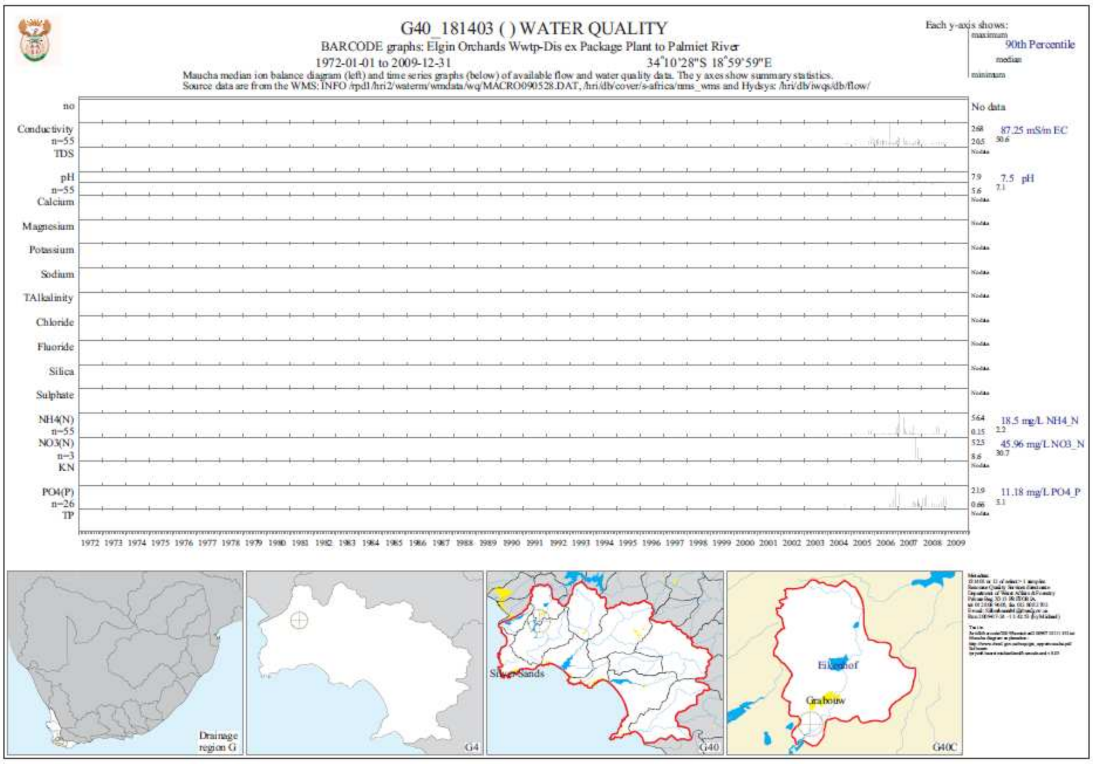
Drainage region G
G4
G40
G40C
Eikenhof
Grabouw



G40_181403 ( ) WATER QUALITY
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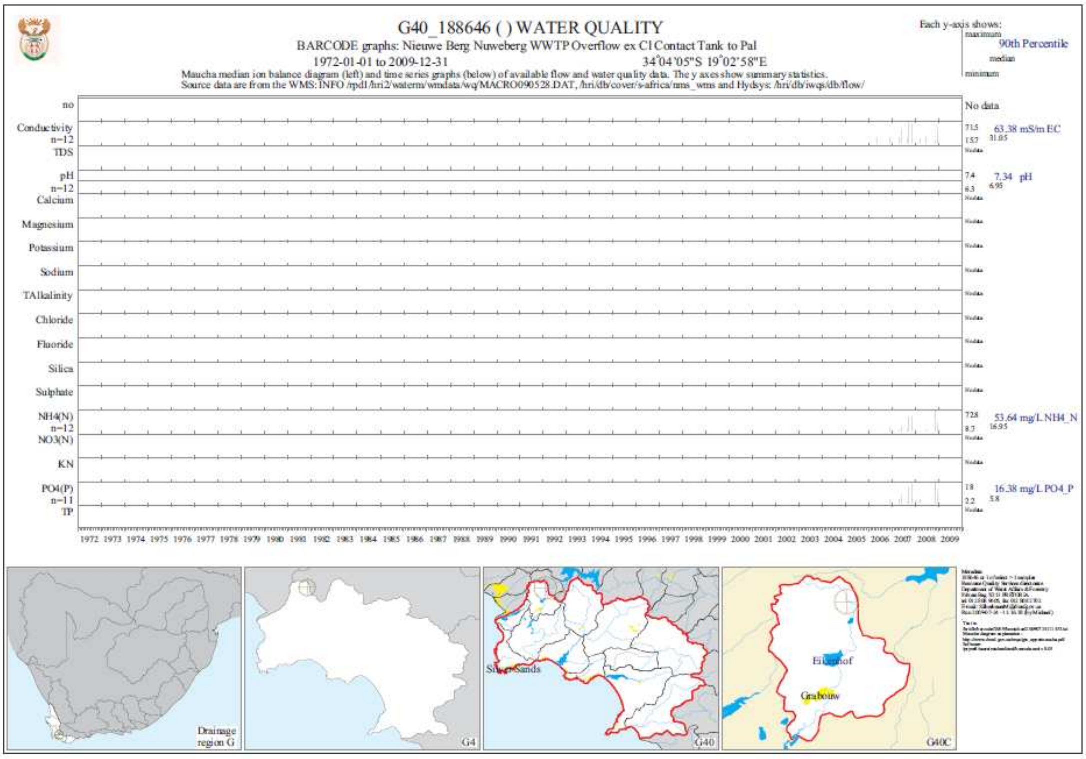
G4
G40
G40C
Eikenhof
Grabouw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NO3(N)
KN
PO4(P)
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TP
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Drainage region G
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G40
G40C
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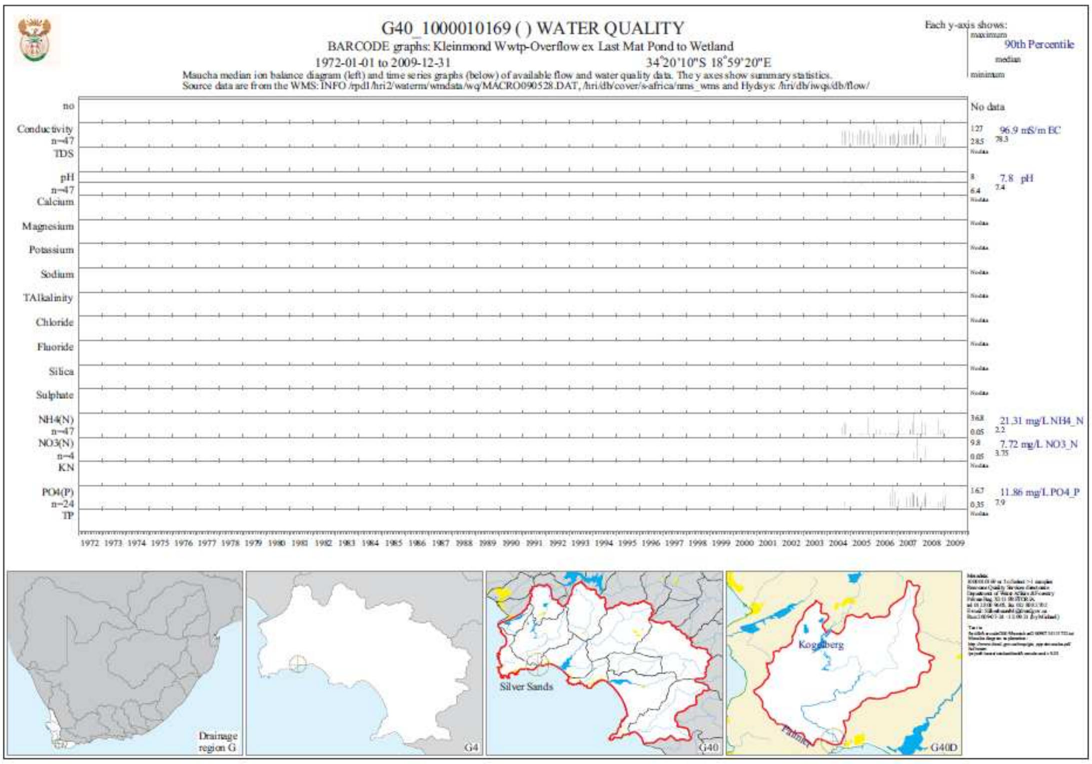
Grabouw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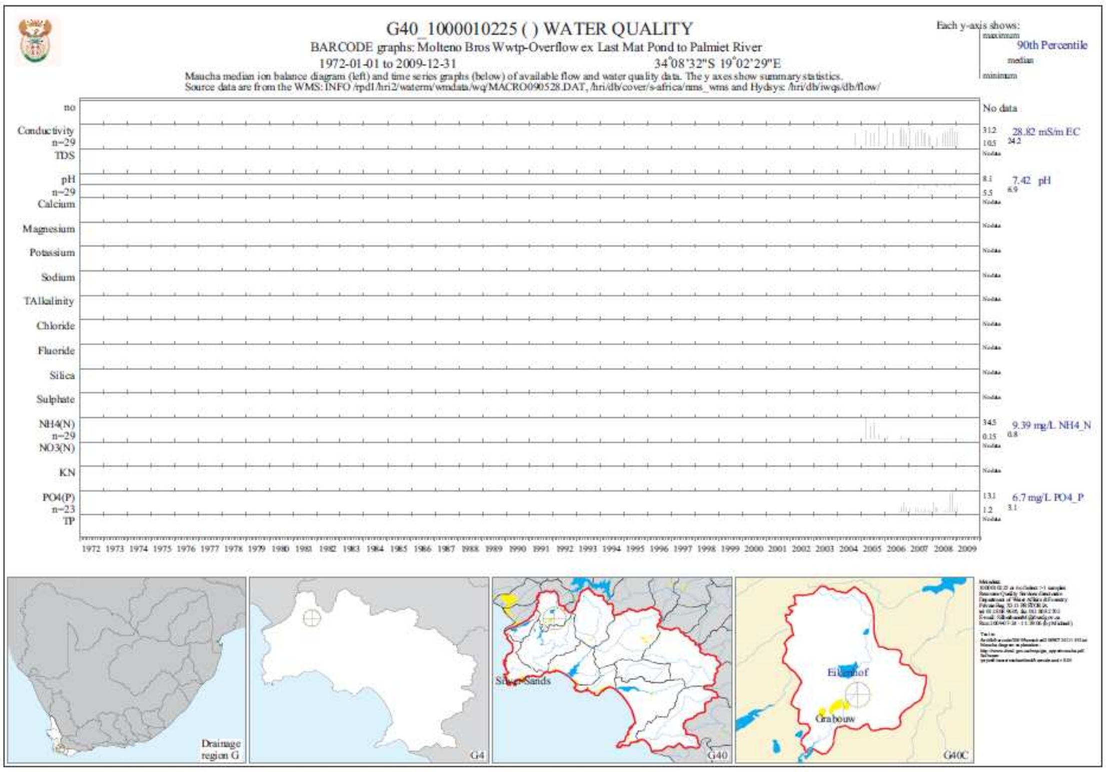
Kogelberg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G4
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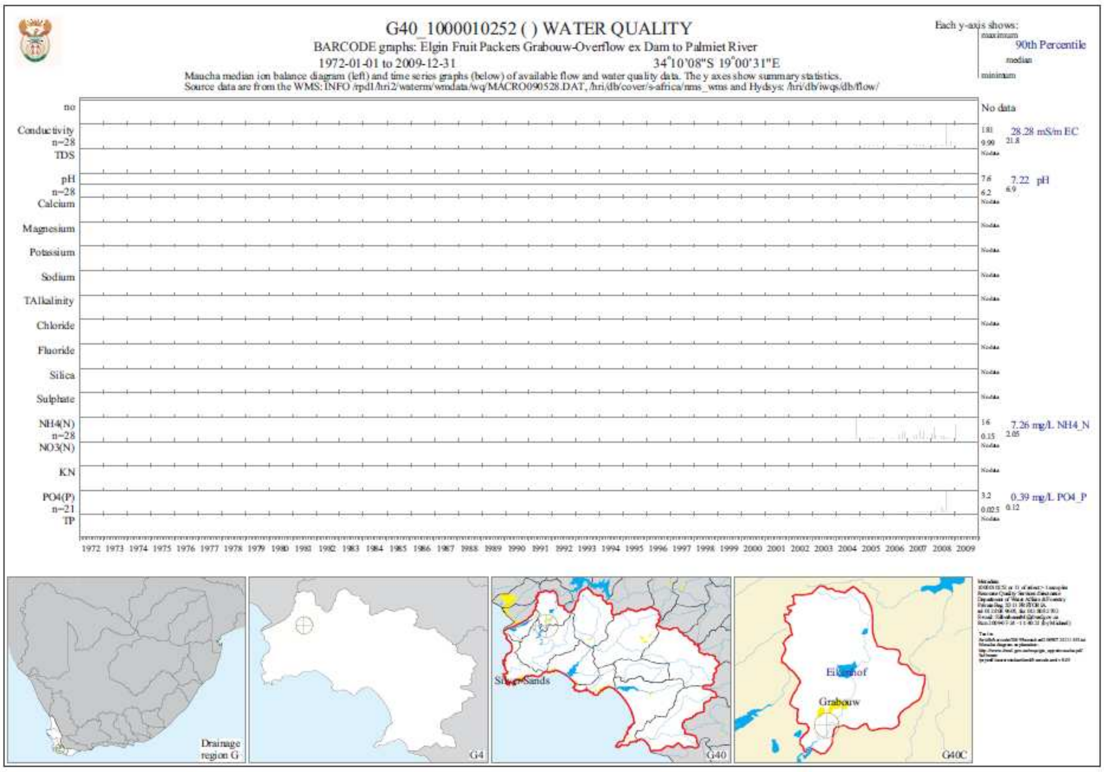
Grabouw
G40C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TP
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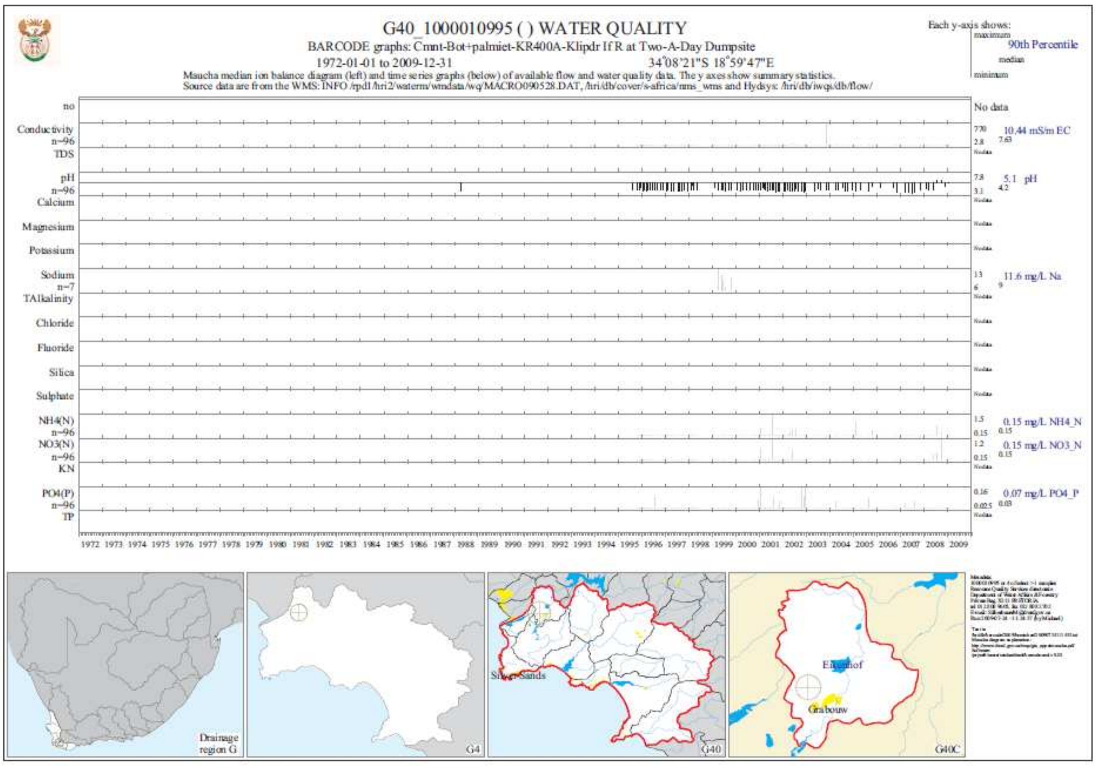
Drainage region G
G4
Silver Sands
G40
Elgin
Grabouw
G40C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minimum
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Fluoride
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TP
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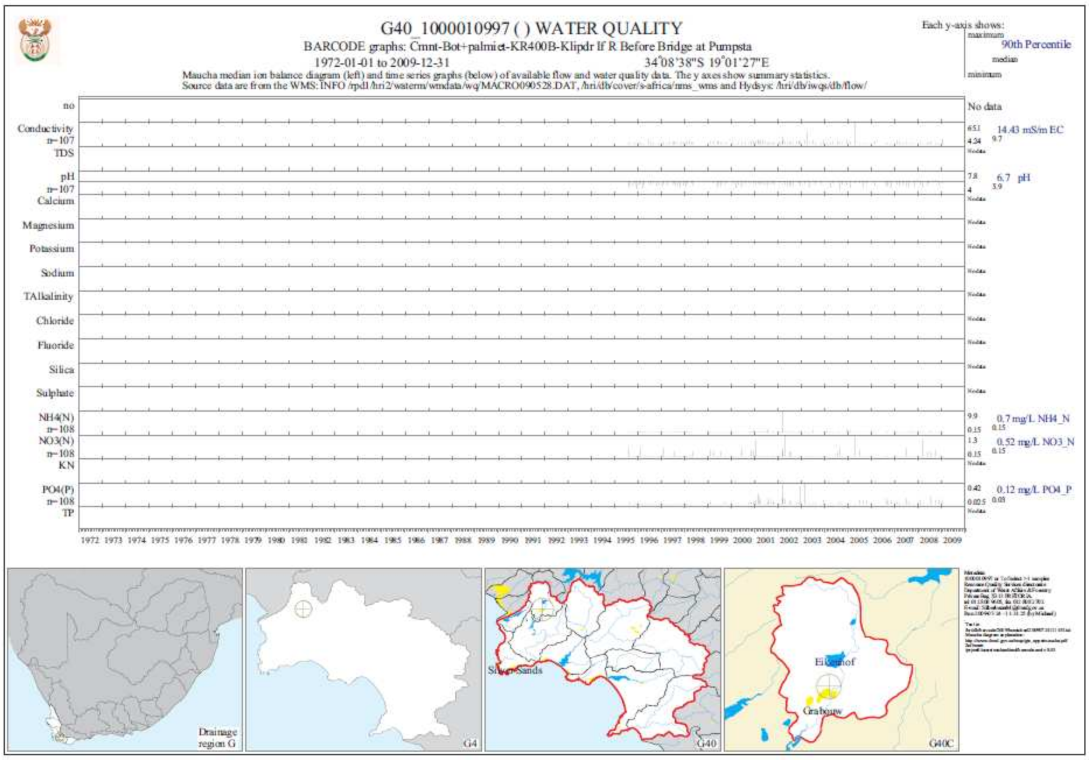
Drainage region G
G4
Silversands
G40
Elgin
Grabouw
G40C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Each y-axis shows:
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90th Percentile
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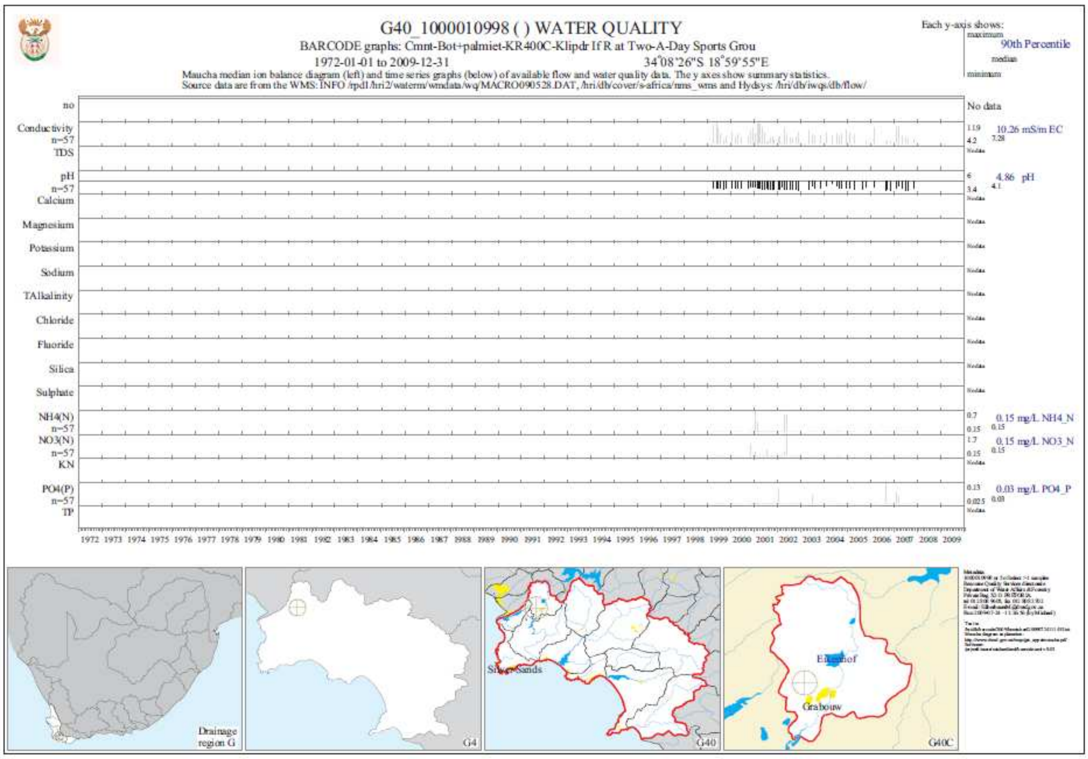
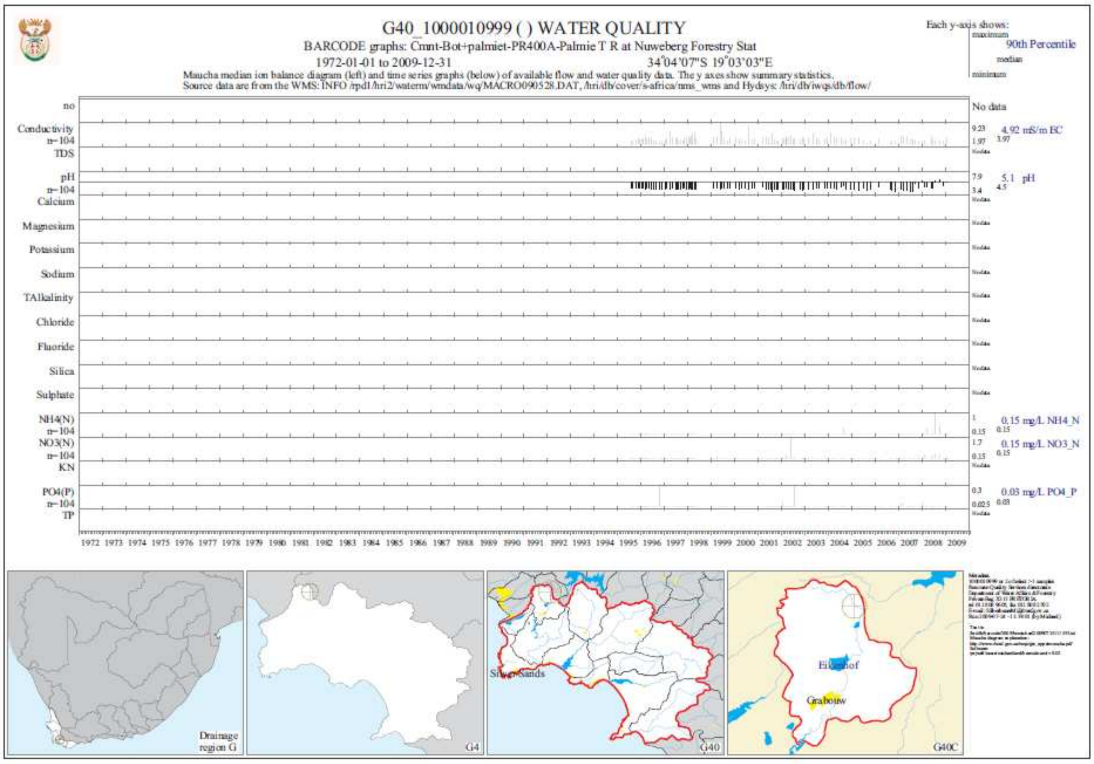
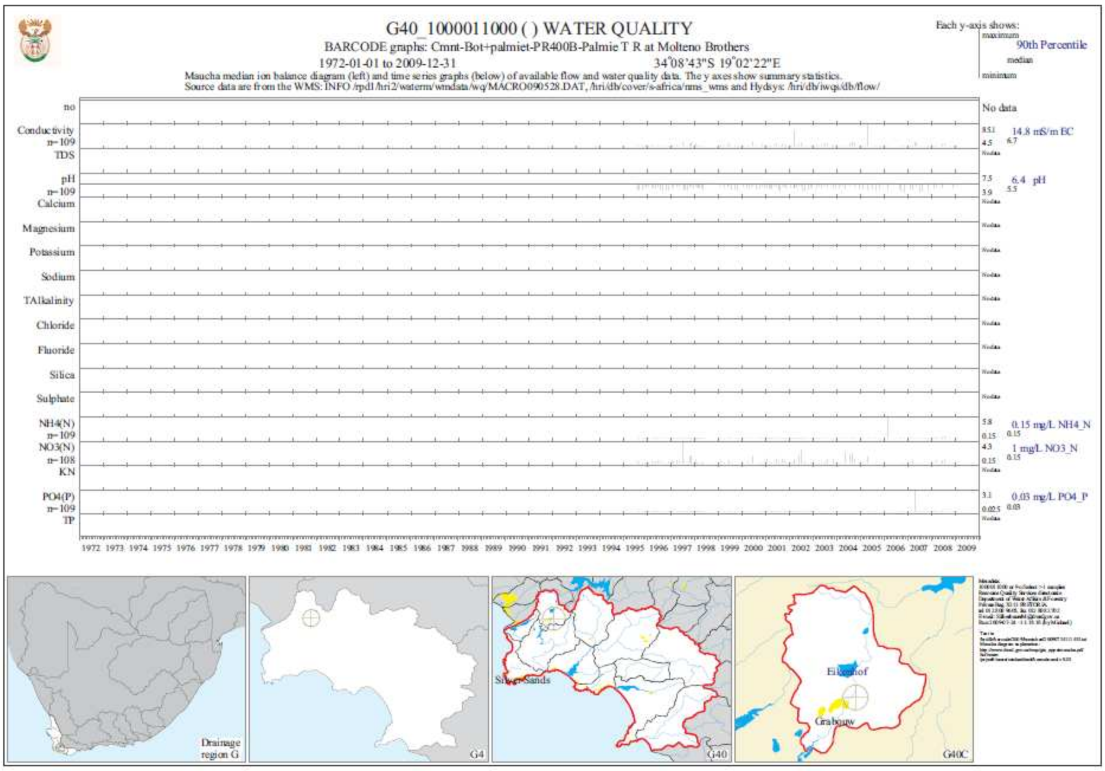
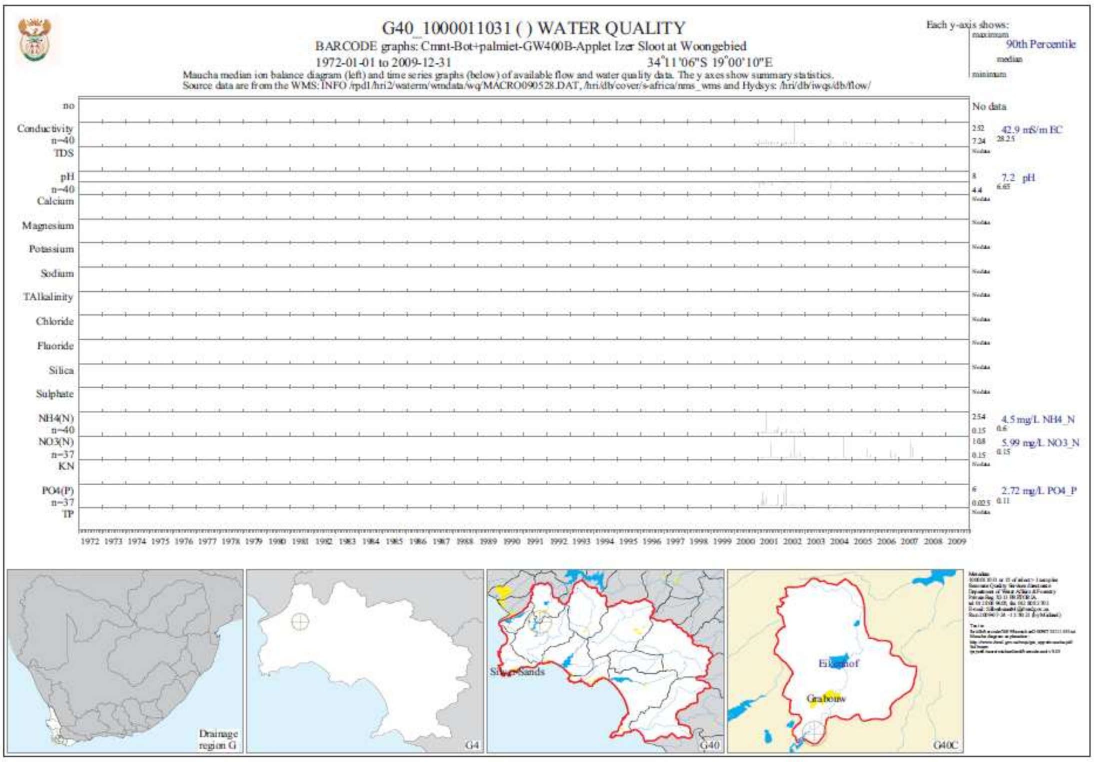
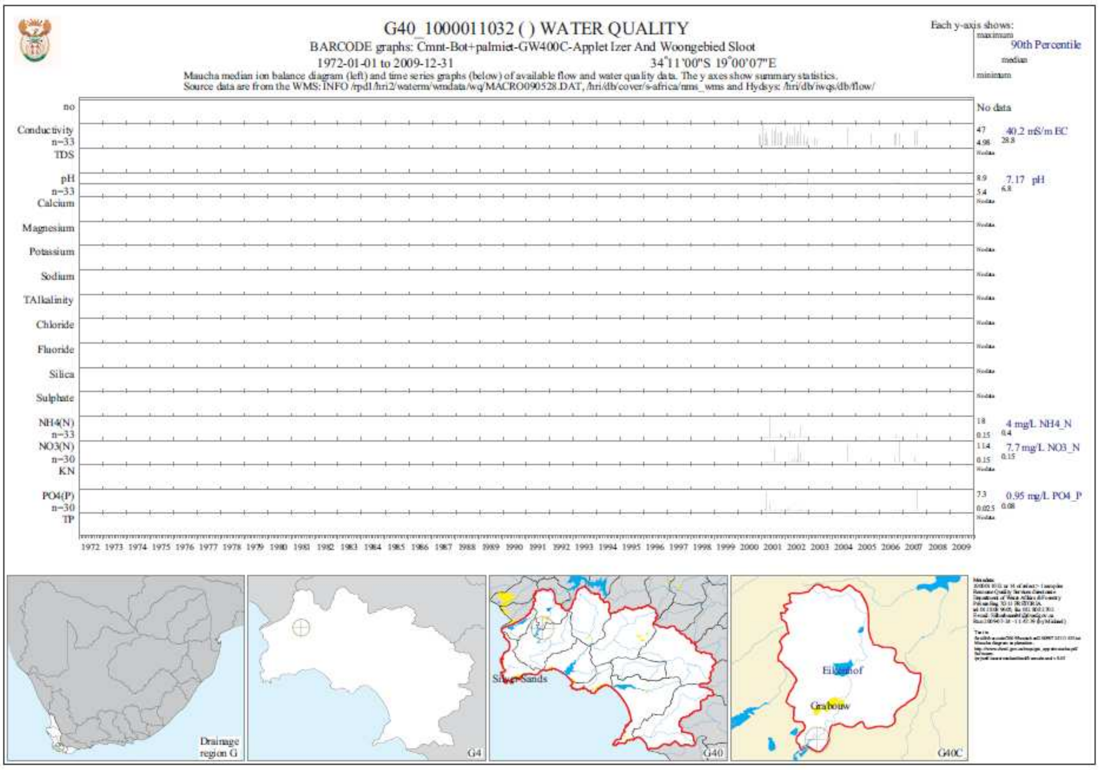
TP
No data
14.43 mS/m EC
6.7 pH
0.7 mg/L NH4_N
0.52 mg/L NO3_N
0.12 mg/L PO4_P
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Drainage region G
G4
Silversands
G40
Elgin
Grabouw
G40C

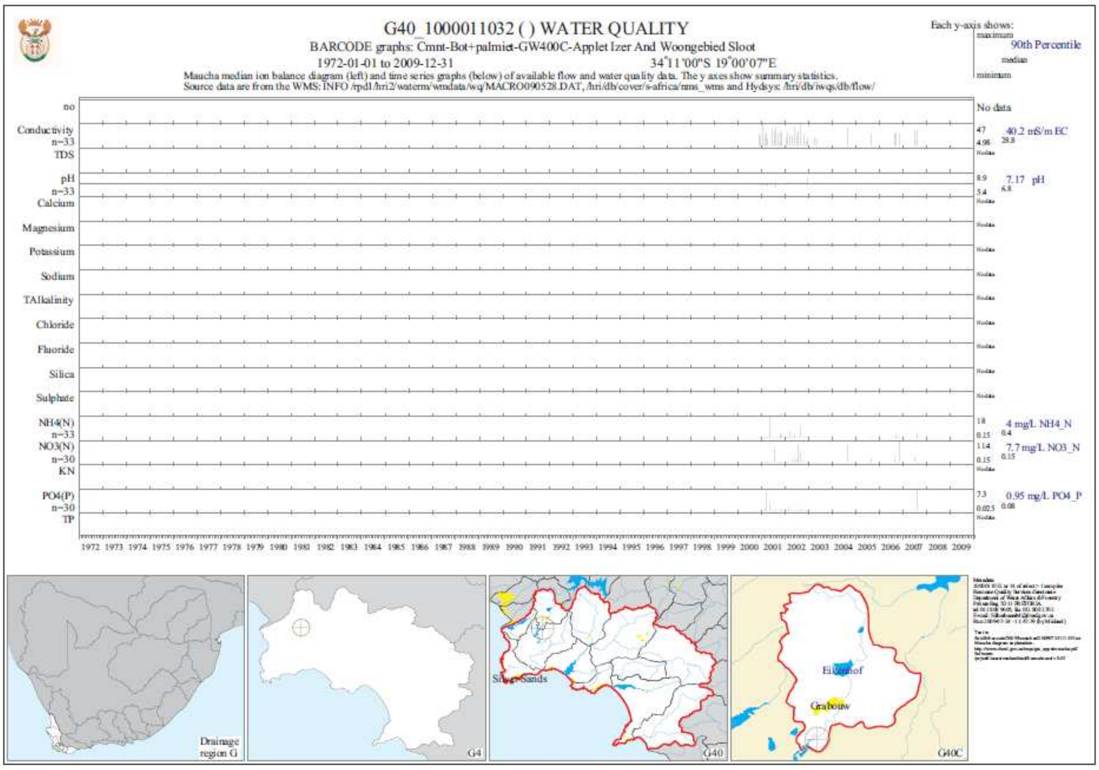

G40_1000010998 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-KR400C-Klipdr If R at Two-A-Day Sports Grou
1972-01-01 to 2009-12-31
34°08'26"S 18°59'55"E
Each y-axis shows:
90th Percentile
Conductivity
pH
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
NO3(N)
KN
PO4(P)
TP
No data
10.26 mS/m EC
4.86 pH
0.15 mg/L NH4_N
0.15 mg/L NO3_N
0.03 mg/L PO4_P
Drainage region G
G4
G40
G40C

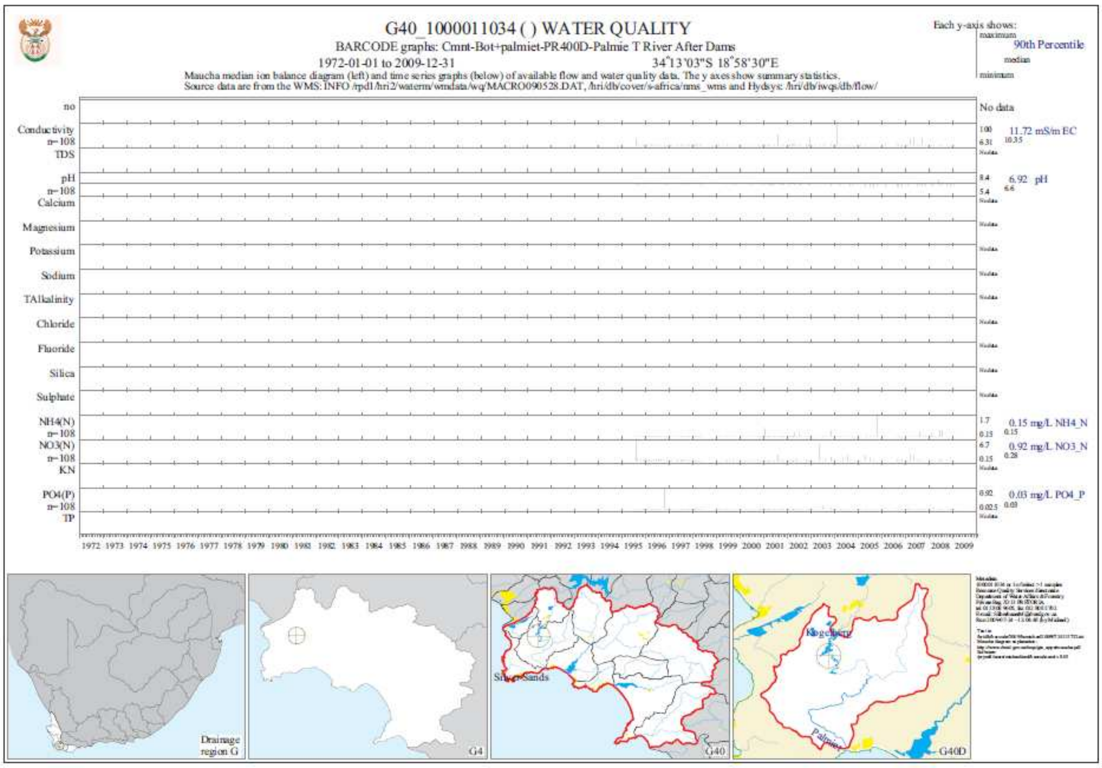

G40_1000010999 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-PR400A-Palmie T R at Nuweberg Forestry Stat
1972-01-01 to 2009-12-31
34°04'07"S 19°03'03"E
Each y-axis shows:
90th Percentile
Conductivity
pH
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
NO3(N)
KN
PO4(P)
TP
No data
4.92 mS/m EC
5.1 pH
0.15 mg/L NH4_N
0.15 mg/L NO3_N
0.03 mg/L PO4_P
Drainage region G
G4
G40
G40C


G40_1000011000 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-PR400B-Palmie T R at Molteno Brothers
1972-01-01 to 2009-12-31
34°08'43"S 19°02'22"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
90th Percentile
median
No data
Conductivity
n=109
TDS
pH
n=109
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
n=109
NO3(N)
n=108
KN
PO4(P)
n=109
TP
14.8 mS/m EC
6.4 pH
0.15 mg/L NH4_N
1 mg/L NO3_N
0.03 mg/L PO4_P
Drainage region G
G4
G40
G40C
Silver Sands
Elgin
Grabouw


G40_1000011031 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-GW400B-Applet Izer Sloot at Woongebied
1972-01-01 to 2009-12-31
34°11'06"S 19°00'10"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
90th Percentile
median
No data
Conductivity
n=40
TDS
pH
n=40
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
n=40
NO3(N)
n=37
KN
PO4(P)
n=37
TP
42.9 mS/m EC
7.2 pH
4.5 mg/L NH4_N
5.99 mg/L NO3_N
2.72 mg/L PO4_P
Drainage region G
G4
G40
G40C
Silver Sands
Elgin
Grabouw


G40_1000011032 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-GW400C-Applet Izer And Woongebied Sloot
1972-01-01 to 2009-12-31
34°11'00"S 19°00'07"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
maximum
90th Percentile
median
minimum
no
No data
Conductivity
n=33
40.2 mS/m EC
TDS
pH
n=33
7.17 pH
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
n=33
4 mg/L NH4_N
NO3(N)
n=30
7.7 mg/L NO3_N
KN
PO4(P)
n=30
0.95 mg/L PO4_P
TP
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Drainage region G
G4
Silver Sands
G40
Eikenhof
Grabouw
G40C


G40_1000011032 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-GW400C-Applet Izer And Woongebied Sloot
1972-01-01 to 2009-12-31
34°11'00"S 19°00'07"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/


G40_1000011034 ( ) WATER QUALITY
BARCODE graphs: Cmnt-Bot+palmiet-PR400D-Palmie T River After Dams
1972-01-01 to 2009-12-31
34°13'03"S 18°58'30"E
Maucha median ion balance diagram (left) and time series graphs (below) of available flow and water quality data. The y axes show summary statistics.
Source data are from the WMS: INFO /rpd1/hri2/waterm/wmdata/wq/MACRO090528.DAT, /hri/db/cover/s-africa/nms_wms and Hydsys: /hri/db/iwqs/db/flow/
Each y-axis shows:
maximum
90th Percentile
median
minimum
no
No data
Conductivity
n=108
11.72 mS/m EC
TDS
pH
n=108
6.92 pH
Calcium
Magnesium
Potassium
Sodium
TAlkalinity
Chloride
Fluoride
Silica
Sulphate
NH4(N)
n=108
0.15 mg/L NH4_N
NO3(N)
n=108
0.92 mg/L NO3_N
KN
PO4(P)
n=108
0.03 mg/L PO4_P
TP
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
Drainage region G
G4
G40
G40D

Hi again Theo,

Just to reiterate what I was saying yesterday. In order to release E-flows correctly you would, ideally, need a gauging weir upstream of the dam at a place on the river where flows weren't themselves being influenced by dams upstream. You have this scenario at Nuweberg, but not at Arieskraal where flows are modified all the way from Eikenhof. Once you had a gauging station somewhere in the catchment that wasn't impacted by dams, you could then establish a relationship between the flows at the gauging station and the point you wanted to make the releases from (i.e. Nuweberg or Arieskraal). This relationship is called a 'Rule Curve' (you will find it mentioned in the report) and it is calculated by a hydrologist. The Rule Curve will tell you: if your flow at the reference gauging station is X then you need to release Y from the dam.

There is a possibility – and it is mentioned as an option in the report on Pg 23 – that you could use Campanula Weir and the Kogelberg Weir as you 'natural indicator' weirs. And I suggest this be investigated with Anton Sparks as a first stop.

Since you don't currently have a gauging station above Nuweberg, and the use of the above weirs is not an option, the next best option may be to monitor levels in the dam itself. If you are releasing 0.17 in summer or 0.49 in winter and dam levels are dropping, that would mean you are releasing too much – there is less water coming into the dam than going out and you can tap off a little. Depending on manpower, you would want to check this on a weekly basis and adjust flows accordingly (ideally, this could all be done remotely). If dam levels are rising, that's your water to keep – as long as those base flows (0.17 and 0.49) are being released. In terms of the EWR – all floods need to be released downstream, so some of these floods will be held back until the dam starts to overtop. Not ideal, unless the outlet structures on both Nuweberg and Arieskraal are modified.

There are two issues at Arieskraal. One is the limitations of the outlet structure on Arieskraal, and secondly, as you correctly pointed out, flows in the wet season are often too high. This is because constant releases from Kogelberg which go straight into the lower river when Arieskraal is overtopping. This should be avoided.

Hope this brings more clarity

Kind regards
Bruce

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