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LETABA CATCHMENT
RESERVE DETERMINATION STUDY – RESOURCE UNITS REPORT

FINAL

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Letaba Catchment Reserve Determination Resource Units Report i

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EXECUTIVE SUMMARY

The Letaba Catchment is located in Limpopo Province and covers an area of approximately 13 400 km^2. The catchment is drained by the Groot Letaba River and its major tributaries the Klein Letaba, Middle Letaba, Letsitele and Molototsi rivers. From the confluence of the Klein and Groot Letaba rivers, the Letaba River flows through the Kruger National Park until it joins with the Olifants River near the border with Mozambique.

More than 20 major instream dams have been constructed in the Groot Letaba catchment, which has resulted in this catchment being highly regulated. The existing limited water resources in the Letaba Catchment have been severely overexploited at the expense of the environment in order to meet the commercial (irrigation, afforestation and industry) and rapidly increasing domestic water demands.

The water shortages experienced in the Letaba Catchment area have led to intense competition for the available water resources between different sectors. A substantial portion of the population does not have access to the basic level of service and planned extensions to irrigation have consequently been put on hold. The KNP is located at the lower end of the catchment, is internationally renowned as a conservation resource, and is responsible for significant tourism and contribution to South Africa’s GDP. In order to sustain the flow of the Letaba River in the KNP and ultimately aquatic biota, riparian vegetation and terrestrial animal life, water has to be released from the series of dams starting at the headwaters of the catchment. Furthermore, there is an international obligation to release water to Mozambique at the eastern boundary of the KNP.

It is these conflicting water uses that have led to this study due to the need for compulsory licences in order to achieve resource protection and equity needs. In order to achieve the required resource protection in the Letaba catchment a comprehensive Reserve study is required to provide Ecological Water Requirement Scenarios from which the Reserve can be selected by the Department of Water Affairs and Forestry (DWAF). This will provide a range of Ecological Categories for which flow scenarios can be developed as well as a recommended Ecological Category.

In order to undertake a catchment Ecological Reserve determination it is necessary to break down the catchment into Resource Units (RUs) which are each significantly different to warrant their own specification of the Reserve, and to clearly delineate the geographic boundaries of each of the RUs. It is not appropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches as these sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach.

The apportionment of a catchment into RUs for the purpose of determining the Reserve for rivers is done primarily on a biophysical basis, according to the occurrence of different ecological regions (ecoregions) within the catchment. Since the endpoint of a Reserve determination is an ecological one, the principle is to break down the catchment into units that are relatively homogenous on an ecological basis, to ensure the Reserve is set in appropriate terms.

The determination of RU's *via* ecoregions and/or geohydrological response units could then be further resolved into smaller Resource Units that are more suited to management requirements. In the Letaba catchment, this could be as a result of a weir that is used for irrigation or the Tzaneen or Ebenezer Dam. The different operational procedures of river reaches also result in biophysically different river reaches that also need to be considered in determining the RUs.

The RU determination process considers the above issues, as well as the results of the Habitat Assessment Integrity (an evaluation of river sectors according to instream and riparian Habitat Integrity). The result of overlaying all this data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process, local knowledge and financial considerations are required for the final delineation.

The EWRs are determined for each Resource Unit by means of either the following:

- An EWR site is selected within the RUs and represents a critical site within the relevant river section. Results generated for the RU at the EWR site will then be relevant for the RU as a whole.
- If no EWR site is selected within the RU then extrapolated results from adjacent Resource Units with EWR sites are used.

The reasons for an EWR site not being selected within the RU could be due to the characteristics of the river within the RU not meeting the criteria for EWR sites. Due to the number of RU within the study area, it is not practical and/or cost-effective to address EWR sites within each RU as the budget was limited to a maximum of 7 sites.

The EWRs are set for each of the EWR sites, and it is therefore vital that the:

- Sites are selected to provide as much information as possible about the variety of conditions in a river reach so that the specialists relate to the habitat the EWR site represents;
- Persons involved in selecting the sites understand and are experienced with the use of sites in EWR studies.

The key specialist of the project team, using the following process, undertook the EWR site selection for the Letaba Comprehensive Reserve:

- Assessment of the 1994 IFR report for the Letaba River.
- Availability of previous site survey data from 1994 IFR study.
- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments, land use and of dams.
- The locality and characteristics of major tributaries.
- The Habitat Integrity Assessment of the different river reaches.
- The accessibility of the sites for follow-up monitoring.
- The available habitat diversity for fish, macroinvertebrates, marginal and riparian vegetation.
- The suitability of the sites for accurate hydraulic modeling throughout the range of possible flows, especially low flows.

- The locality of geomorphological reaches and representative reaches within the geomorphological reaches.
- Discussions with local experts on potential sites per sub-catchment.
- Viewing of available videos to pre-select potential EWR sites

Prior to the site selection field trip members of the project team undertook reconnaissance trips to a number of potentially suitable sites. The key specialists then visited the sites with high potential. The decision making process for the selection of the EWR sites in the Letaba catchment was driven by the following:

- Major tributaries that contribute to the MAR of the catchment
- Major instream dams that divide the river
- Budget for only 7 EWR sites
- Major land use activities that could impact on both water quality and quantity
- Assess ability
- Availability of habitat diversity
- Ability to determine the KNP and Mozambique releases.

One of the difficulties of defining Resource Units is the scale or level of resolution required. The main tributaries of the Letaba River (Groot Letaba, Letsitele, Klein Letaba) may be delineated into distinct ecological zones due to their origin being on the escarpment. Due to the steep gradients of the upper catchment of these tributaries the different resource units would be so short that defining separate EWRs for each zone would be impractical and costly. The length of ecologically distinct sections of river was therefore also taken into consideration when defining Resource Units.

The Letaba catchment was broadly delineated into nine Resource Units (Figure A). Due to the importance of certain tributaries in terms of annual flow not all of these resource units could be catered for in this study. Consequently the seven EWR site (Figure A) where carefully chosen to maximize the opportunities for accurately determining a comprehensive Reserve for the Letaba River.

The Molototsi River, due to its highly seasonal nature and the lack of adequate monitoring data, was not chosen as an appropriate EWR site. The influence of this river on the Groot Letaba is seen at EWR site 4.

No EWR site was chosen for the Middle Letaba River. EWR 5 (Klein Letaba) was, however, selected to be directly downstream of the confluence of Middle and Klein Letaba Rivers. Furthermore the Middle Letaba Dam (used for irrigation and domestic water supply) does not release water downstream into the river.

No EWR site was selected in the Nsami River dues to its contribution to the MAR of the Letaba River being small in comparison to the other tributaries.

The seven EWR sites selected for the Letaba Comprehensive Reserve are as follows (Figure A).

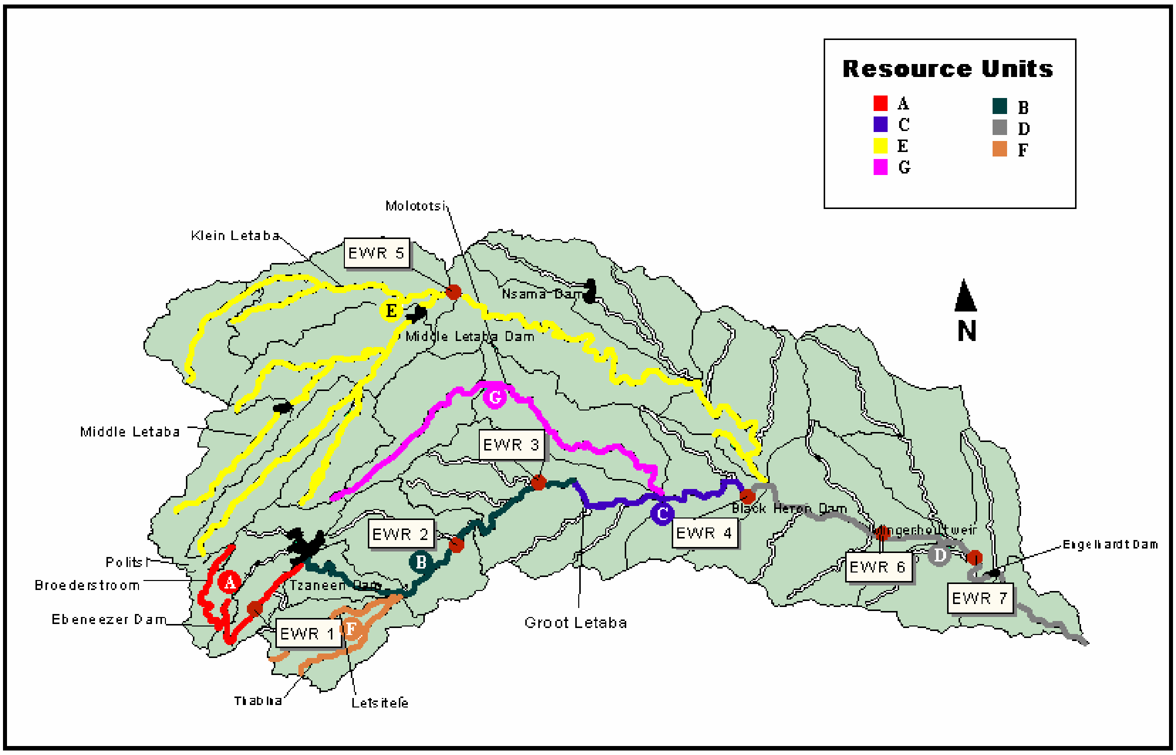

Figure A: Main resource units and chosen EWR sites in the Letaba Catchment

EWR 1: Groot Letaba River upstream of Tzaneen Dam (Appel)

EWR 1 is located between Ebenezer and Tzaneen Dam and has a short length of this RU (30 km). There are three weirs between the dams which are all small structures and their purpose is to divert water into structures for abstraction for irrigation and water supply to Tzaneen Municipality. There are many similar structures in the Groot Letaba River, these weirs were not considered important enough to subdivide this RU. The Tzaneen Dam due to its large size and being instream it makes a logical end point to this RU.

EWR 2: Letsitele River (Letsitele Tank)

This EWR site is situated on the Letsitele River, which is a tributary of the Letaba River, and is not unregulated. The river channel at this site is largely degraded due to erosion and local sources of water quality pollution. The site is in a highly disturbed area and extends below a railway bridge. A DWAF gauging weir occurs just upstream which allows accurate measurement of flow. The main impacts on water quantity and water quality at this site are upstream stream flow reduction (forestry) and a township with no formal sewer system immediately upstream.

EWR 3: Groot Letaba River (Hans Marensky)

This EWR site is situated on the Groot Letaba River, downstream of the Tzaneen Dam and upstream of the Molototsi River confluence. This site is located about 7km upstream of

Prieska Weir, but does not experience backwater effects from the weir. The river at this site is characterised by the presence of boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams), large weirs (Junction, Yamorna and Jasi weirs) as well as direct abstraction for irrigation.

Two sites were used at this EWR site, one upstream of the Prieska weir (3a, Hans Marensky) and the other downstream of the Prieska weir (3b). The downstream site was used in this comprehensive reserve study as the riparian vegetation in this reach of river had a good number of indicator species on the macro-channel floor. The 3D spatial habitat modelling was undertaken at EWR Site 3b.

EWR 4: Groot Letaba River upstream of KNP (Letaba Ranch)

This EWR site is situated on the Groot Letaba River, downstream of the Molototsi River and upstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock, large boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams) as well as the irrigation abstraction weirs and canals.

EWR 5: Klein Letaba River

This EWR site is situated on the Klein Letaba River, downstream of the confluence of the Middle Letaba River and Middle Letaba Dam.

The river at this site has a predominantly sandy bed with an upstream bedrock control associated with a large pool. There has been extensive encroachment by vegetation of the active river channel with very limited stones in current habitat. A short run consisting of a few small cobbles and pebbles was sampled at the lower end of the site.

EWR 6: Groot Letaba River in KNP (Lonely Bull)

This EWR site is situated on the Groot Letaba River in the Kruger National Park, downstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles. There were very little stones in current habitat due to the low flows experienced at the time of sampling.

The main impacts at this site are the reduction in flow due to upstream impoundments as well as direct abstraction for irrigation.

EWR 7: Groot Letaba River in KNP (Letaba Bridge)

This EWR site is situated on the Groot Letaba River, downstream of the EWR 6 site. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles. Between the EWR 6 and EWR 7 sites there is a tributary that flows north south from within the Kruger National Park that during the summer season contributes to the flow at this EWR site. There are very little stones in current habitat due to the low flows experienced at the time of sampling. EWR 7 was selected to determine only the low flows during the dry season upstream of Letaba Rest Camp.

The 3D spatial habitat modelling was undertaken at EWR Site 7.

EWR 7 site is important due to future Mozambique flow releases as well as to ensure that the flows at this site meet the ecological requirements of the fauna and flora within the Kruger National Park so that this national park can honour its mandate of protecting biodiversity.

ACRONYMS

BMT	Benchmark Table
D: RDM	Directorate: Resource Directed Measures
DWAF	Department of Water Affairs & Forestry
DFED	Limpopo Province Department of Finance and Economic Development
EIS	Ecological Importance and Sensitivity
EC	Ecological Category
EQR	Ecological Quality Requirements
EMC	Ecological Management Class
ERQO	Environmental Resource Quality Objective
EWR	Ecological Water Requirements
EWRS	Ecological Water requirement Scenarios
FAII	Fish Assemblage Integrity Index.
GI	Geomorphological Index
GIS	Geographical Information System
GPS	Geographical Positioning System
GSI	Gonado Somatic Index
HQI	Habitat Quality Index
IFR	Instream Flow Requirements
IHI	Index of Habitat Integrity
KNP	Kruger National Park
MAR	Mean Annual Runoff
MIS	Management Information System
PES	Present Ecological State
PESC	Present Ecological State Category
PHD	Pulles Howard & de Lange (Inc)
PBMT	Potential Bed Material Transport.
PRA	Participatory Rural Appraisal
PSP	Professional Service Provider
RBA	Rapid Biological Assessment
RDM	Resource Directed Measures
RHP	River Health Programme.
RQO	Resource Quality Objective
SANP	South African National Parks
SASS	South African Scoring System

SI	Socio/cultural importance
SoRR	State of River Report
SPATSIM	Spatial and Time Series Information Modelling
WR200	Water Resources 2000
WRYM	Water Resources Yield Model

AGREED TERMINOLOGY

a, b, c Regression coefficients in the rating relationships

Aggradation: increased sediment storage in the river channel resulting in an increase in the height of the bed of the river

Anastomosing: Channel types characterized by a widened macro-channel with secondary distributaries which may extend across an area three to four times the average width of the river and this effect may extend over several kilometres (summarised from Heritage *et. al.*, 2000)

Anions: Negatively charged ions.

Area : Cross-sectional flow area (m^2)

Average flow depth: Cross-sectional flow area divided by the width of the water surface (m)

Biotope: Area of uniform environmental conditions.

Braided: These channels are defined as alluvial systems that exhibit channel splitting and rejoining over a distance of a few distributary widths (summarised from Heritage *et. al.*, 2000)

Biocides: Substances that kill living organisms, i.e. herbicides kill plants and pesticides kill animals.

Cations: Positively charged ions.

Discharge: Volumetric flow rate (m^3/s)

Eutrophic: With an excess of plant nutrients.

Eutrophication: The process whereby excess nutrients accumulate in a body of water.

Ecological category: Ecological Categories range from Category A (unmodified) to Category D (largely modified). A range of these categories is identified as likely future management aims for each Resource Unit.

Ecological specifications (EcoSpecs): Clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity), which define the Class (Natural, good or fair and serve as an input to Resource Quality Objectives. EcoSpecs refer explicitly and only to ecological information, whereas RQO's include economic and social objectives.

Ecological importance: An expression of the importance of a water resource to the maintenance of ecological diversity and functioning on local and wider scales.

Ecological Reserve: The quantity and quality of water required to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.

Ecological sensitivity: The system's ability to tolerate disturbance, and its capacity to recover from disturbance once it has occurred.

Floodplain: Extensive lateral accumulation of finer sediments as a result of flood deposition by lateral or vertical accretion (summarised from Heritage *et. al.*, 2000)

Flow depth: Maximum flow depth measured from lowest bed elevation (m)

Island: Large mid-channel accumulation of consolidated sediment at a level coincident with any floodplain deposits. These features are inundated less frequently than in-channel bar deposits (taken from Heritage *et. al.*, 2000)

Habitat: Combination of biotopes making up the living space of an organism.

Heavy metal: Metals with an atomic mass >40,08, generally toxic to biota.

EWR: Instream Flow Requirements.

Key Species: Species whose presence is indicative of certain ecological conditions.

Lateral bar: Accumulation of unconsolidated sediment attached to the side of a channel (summarised from Heritage *et. al.*, 2000)

LC50 (median lethal concentration): The concentration of a toxin at which 50% of the test population dies.

Level of assessment: Different levels of Ecological Reserve assessment are distinguished by overall confidence in the final outcome: low, medium and high confidence.

Longitudinal: Along the length of the river

Longitudinal profile: gradient (slope) analysis of the length of the river channel and main tributaries

Macroinvertebrates: Invertebrates living in water for part or all of their life cycle.

Macro-reach: Large (10-100km) scale units of the main trunk and tributaries of the river system, delineated primarily by changes in slope, geology and sediment (supply) characteristics, as defined in DWAF (1999) by Rowntree and Wadeson (1999).

Major ions: Those ions that usually form the bulk of total dissolved solids in inland waters (i.e. calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride and sulphate).

n*:* Manning's resistance coefficient

Nutrient: In aquatic biology, usually a limiting nutrient – an element whose scarcity can limit plant growth (e.g. compounds of nitrogen, phosphorus).

pH: The negative log of the hydrogen ion activity; a measure of acidity (pH<7) or alkalinity (pH>7).

Pool: Topographic low point characterized by finer sediments, slow flowing water generally confined within a pool, as part of a pool riffle sequence (summarised from Heritage *et. al.*, 2000).

Pollutant: A substance that contaminates.

Pollution: Unfavourable alteration of our surroundings, normally as a result of human actions; the presence of any substances that impairs the usefulness of water.

Potential Bed Material Transport: Modelling exercise undertaken as part of the Geomorphological component of comprehensive Reserve Determination studies, as described in Dollar (2002) for the Thukela Reserve Determination study.

Planform: The typical pattern of the active channels assumed within the confines of the river valley/floodplain/macro-channel.

Present ecological state (PES) for water quality: A measure of current water quantity, using data from the 1 – 3 years prior to the assessment for water quality variables, biotic indicators and habitat.

RBA: Rapid Biological Assessment.

Rapid: Steep bedrock sections representing areas of more resistant lithology where the river has exploited structural weaknesses to create a series of smaller steep channels within the rock (summarised from Heritage *et. al.*, 2000)

Resistance: Overall resistance to flow imposed by the river channel, including all resistance components, e.g. bed roughness, vegetation, channel plan form, etc.

Riffle: Accumulation of courser sediment as a topographic high point as part of a pool-riffle sequence (summarised from Heritage *et. al.*, 2000)

Riparian zone: The area of land adjacent to a stream or river that is at least periodically influenced by fluctuations in water levels (Mitsch and Gosselink, 1986) and river related processes (Rogers, 1995)

Riparian vegetation: Vegetation associated with the riparian zone

Receiving waters: Waters receiving effluents.

Reference condition: The natural ecological conditions for a particular *resource* unit. The reference conditions define “protected” water resources and may be used to calibrate the other Classes.

Resource unit: An area of ecological similarity for which a distinct ecological Reserve and present state are determined.

SASS: South African Scoring System (a Rapid Biological Assessment technique).

Salinisation: The process whereby the saltiness of soils and rivers increases, often as a result of irrigation.

Single thread: Generally referring to the relatively straight and meandering channels types restricted to the width of the incised macro-channel (summarised from Heritage *et. al.*, 2000)

Stage/water level: Elevation of the water surface relative to local datum (m)

SVD: Substrate, Velocity, and Depth Preferences.

Turbidity: An expression of the optical property of water that causes light to be scattered and absorbed.

Uniform flow: Invariant flow conditions in a longitudinal direction

Velocity: Speed at which water moves per unit time past a fixed point in a given direction (m/s)

Water quality: The value or usefulness of water, determined by the combined effects of its physical attributes and its chemical constituents, and varying from user to user.

Water quality variable: Individual attribute or constituent of a given sample of water (e.g. salinity, temperature) that varies in magnitude and whose variation alters water quality.

Wetted perimeter: Amount of channel in contact with flow, measured along the cross-section (m)

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1. INTRODUCTION

1.1 BACKGROUND

The Water Law Principles of 1996 clearly set the direction of the future of water resources management. The twin threads of sustainability and equity run through the Principles, the National Water Policy of 1997 and the National Water Act (NWA, Act 36 of 1998). The key to balancing sustainability and equity lies in the provisions for the Reserve, and in our ability to quantify a Reserve, as well as to manage water uses so as to meet the Reserve.

The NWA is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without seriously affecting the functioning of the natural environment. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the Reserve for water resources.

The Reserve is defined as the quantity and quality of water required; (a) to satisfy basic human needs and (b) to protect aquatic ecosystems. The basic human needs component of the Reserve is fairly easy to quantify as it is based on average water consumption per capita and standard drinking water standards. The quantity and quality of water needed to protect aquatic ecosystems is more difficult to quantify and the methods of doing so are under continual development and improvement.

The move to integrated management of water resources, on an ecosystem basis, requires the introduction of a new set of tools for resource management, tools that are flexible, protective and can take account of extreme differences within South Africa, both in socio-economic conditions, and in natural variability of aquatic ecosystems. The move to resource management has been a gradual one over the last ten years, driven by need, as South Africa approached the limits of new development of water resources and was forced to begin a shift to careful management of existing available resources. To support this change, new tools and new ways of making decisions have been under development within the Department of Water Affairs and Forestry (DWAF) and within other agencies responsible for natural resource management. In response to requirements for environmental impact assessment, and as a result of the Department's commitment to follow the Integrated Environmental Management procedure in planning and implementation of major water resources developments, a considerable amount of effort within the South African scientific community was focused on finding ways to assess the water requirements of aquatic ecosystems (Ecological Water Requirements (EWR) and Estuarine Flow Requirements (EFR).

The Directorate: Resource Directed Measures (D: RDM) is tasked with the responsibility of ensuring that the Reserve requirements, which have priority over other uses in terms of the NWA, are determined before license applications are to be processed. There are several stressed catchments where applications for licensing have been received by the D: RDM. The available water resources cannot meet all the water requirements of the users in these catchments, without trade-off among water user sectors. DWAF has identified these stressed catchments where it will be desirable in the near future to undertake compulsory licensing. One of these areas identified, as a priority for compulsory licensing is the Letaba catchment. The full implementation of the Reserve will almost certainly result in curtailment of water allocations once the compulsory licensing process is implemented. Consequently, there is an urgent need for an accurate assessment of the Reserve Requirements of the Letaba River catchment.

The key RDM component, which will be addressed within this study, is to provide Ecological Water Requirement Scenarios from which the Reserve can be selected by DWAF. In order to provide EWR scenarios, an ecological classification process must be applied. This will provide a range of Ecological Categories for which flow scenarios can be developed as well as a recommended Ecological Category. As the Terms of Reference (TOR) did not require any additional inputs to the classification, the ecological input only will be supplied. This will provide input to the future classification system. In the absence of a gazetted classification system, this Reserve will be a preliminary Reserve. Resource Quality Objectives (RQOs) includes various aspects other than ecological. Only the Ecospecs, which are the ecological components of RQOs, will be supplied during this process. It must be noted that the determination of the Basic Human Needs Reserve does not form part of the TOR and will not be determined.

1.2 STUDY AREA AND CATCHMENT CHARACTERISTICS

The Letaba Catchment is located in Limpopo Province and covers an area of approximately 13 400 km^2 (Figure 1). The catchment is drained by the Groot Letaba River and its major tributaries the Klein Letaba, Middle Letaba, Letsitele and Molototsi rivers. From the confluence of the Klein and Groot Letaba rivers, the Letaba River flows through the Kruger National Park until it joins with the Olifants River near the border with Mozambique.

More than 20 major instream dams have been constructed in the Groot Letaba catchment, which has resulted in this catchment being highly regulated (Chutter and Heath, 1993). As a result, there have been no recordings of Tiger Fish outside the Kruger National Park (KNP) since 1990 (State of Rivers Report, 2001). The existing limited water resources in the Letaba Catchment have been severely overexploited at the expense of the environment in order to meet the commercial (irrigation, afforestation and industry) and rapidly increasing domestic water demands.

The major land uses in the Letaba catchment, and their probable impacts, as well as the variables that should be tested are listed in Table 1.1. The dense afforestation that takes place in the upper catchment and the intensive irrigated agriculture, of mainly sub tropical fruits, on the banks of the Groot Letaba outside the KNP, are the major water users in the study area. The instream dams are used for the supply of irrigation water for this intensive irrigated agriculture.

The water shortages experienced in the Letaba Catchment area have led to intense competition for the available water resources between different sectors. A substantial portion of the population does not have access to the basic level of service and planned extensions to irrigation have consequently been put on hold. The KNP is located at the lower end of the catchment, is internationally renowned as a conservation resource, and is responsible for significant tourism and contribution to South Africa’s GDP. In order to sustain the flow of the Letaba River in the KNP and ultimately aquatic biota, riparian vegetation and terrestrial animal life, water has to be released from the series of dams starting at the headwaters of the catchment. Furthermore, there is an international obligation to release water to Mozambique at the eastern boundary of the KNP.

Table 1.1: Land uses and their impacts in the Letaba catchment (SRK 1989; Consultburo 1997) and associated water quality problems

Land use	WQ impact	Sub-catchment impacted	Water quality problems
Forestry	Increased turbidity due to sedimentation	Groot Letaba above Tzaneen Dam	Electrical conductivity
Industrial activity	Minimal as most effluent is recycled or used for irrigation	Groot Letaba, below Tzaneen	Dissolved oxygen
			PH
Irrigation agriculture	Salinisation and release of biocides into the environment	Groot Letaba from Tzaneen to Letaba Ranch	Organochlorine pesticides Endosulfan Dieldrin, Aldrin and Endrin Heptachlor and Heptachlor epoxide Lindane Triazine family of herbicides.
			Nutrients – nitrogen and phosphates
			Chlorophyll-a
			Mg^{+}, Na^{+}, Ca^{+}, SO_4^{-}, Cl^{-}
Dense settlements & informal settlements	Sewage effluent leading to eutrophication	All catchments above Kruger National Park	PO_4-P
			Total inorganic nitrogen
			Dissolved oxygen
			NH_3
			Chl *a*

It is these conflicting water uses that have led to this study due to the need for compulsory licences in order to achieve resource protection and equity needs. In order to achieve the required resource protection in the Letaba catchment a comprehensive Reserve study is required.

1.3 ASSUMPTIONS AND LIMITATIONS

The delineation of a river into Resource Units is based on the assumption that rivers consist of discrete sections that are ecologically different from each other. The identification of such units is straightforward where there are sudden changes in conditions, such as a natural waterfall, tributary junction, introduction of a large effluent or large impoundment (such as the Tzaneen Dam). The problem is that most rivers in their natural state change gradually downstream and comprise a continuum of change rather than discrete boundaries. This makes the identification of such boundaries difficult and highlights the need to specify exactly why boundaries were chosen. Despite this potential problem of non-discrete boundaries, the use of delineation of a river into Resource Units is an essential component of river management and the assessment of EWRs.

One of the difficulties of defining Resource Units is the scale or level of resolution required. The main tributaries of the Letaba River (Groot Letaba, Letsitele, Klein Letaba) may be delineated into distinct ecological zones due to their origin being on the escarpment. Due to the steep gradients of the upper catchment of these tributaries the different resource units would be so short that defining separate EWRs for each zone would be impractical and costly. The length of ecologically distinct sections of river was therefore also taken into consideration when defining Resource Units.

1.4 PREVIOUS STUDIES AND TERMINOLOGY USED

Previous studies have been undertaken by DWAF attempting to define the environmental flow requirements of the Letaba River and it tributaries (DWAF 1994 and 1996). During the 1994 refinement study (DWAF 1996), new (more suitable) Instream Flow Requirements (IFR) sites were selected. The terminology of IFR has been changed to Ecological Water Requirements (EWR) and this abbreviation will be used in this report as well as all subsequent reports on the Letaba comprehensive reserve determination.

Where possible, the same sites will be selected in the current study (if still suitable after 9 years considering catchment changes and flooding) and an attempt made to find or re-establish the same cross-sections.

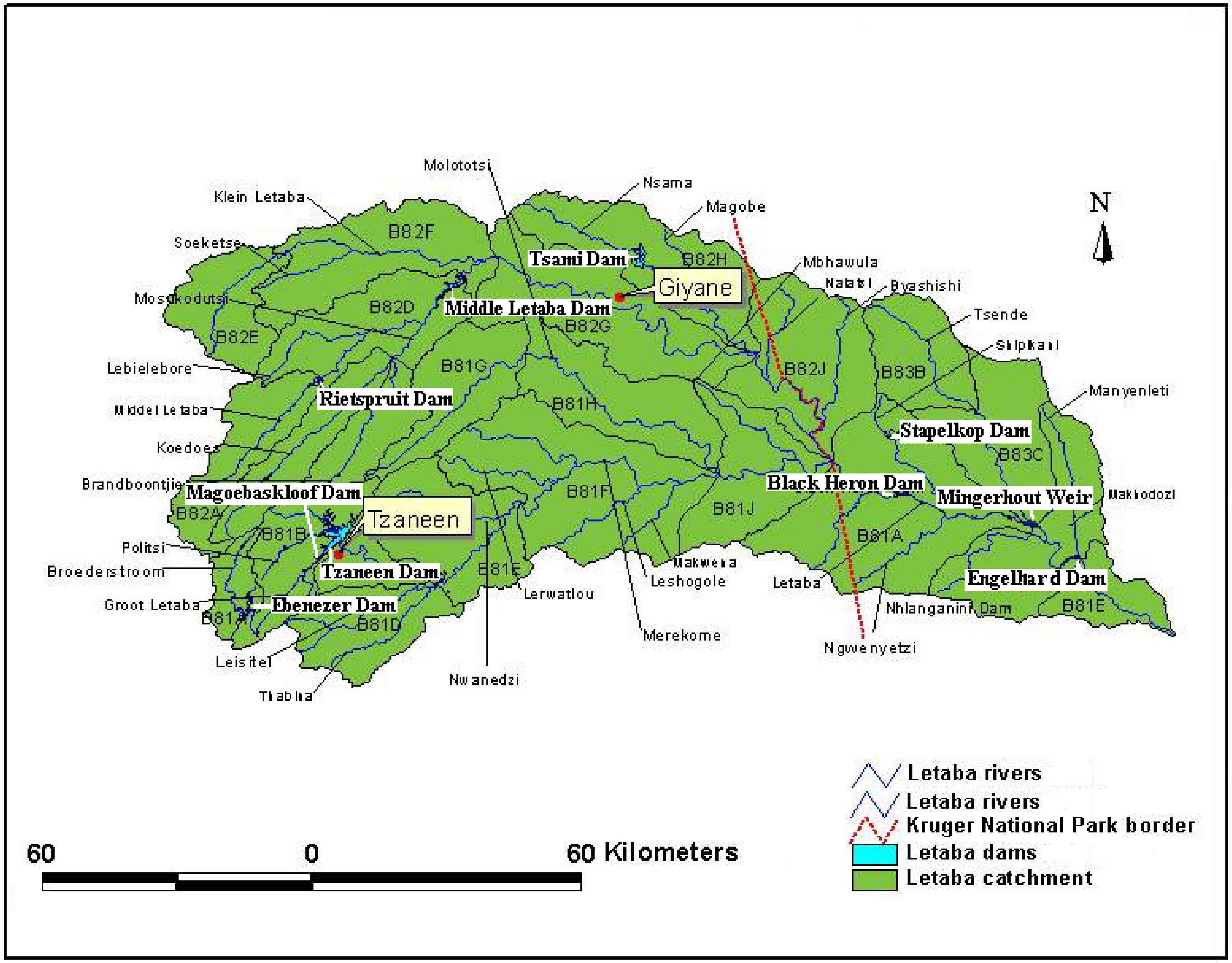


Figure 1.1: Study area indicating major rivers, dams and quaternary catchments

2. OBJECTIVES OF REPORT

The overall objectives of this report is to

- describe the process followed to define the Resource Units (RUs);
- provide the quantity and quality RUs;
- describe the process followed to select EWR sites within the RUs;
- describe the EWR sites.

2.1 REPORT STRUCTURE

This report combines various aspects of the Letaba catchment that relates to delineation of the RU's and EWR sites. The specialists involved in this study made contributions to each specific chapter.

The methods used for the process used in the definition of RUs and choice of specific EWR sites are discussed in each of the Chapters 4 to 10. The chapters are summarised as follows:

Introduction and background (Chapter 1)

Brief introduction and background to study area as well as limitations to study approach.

Report structure (Chapter 2)

This chapter.

Resource Units Approach (Chapter 3)

This chapter describes the general approach used during delineation of a river.

Ecoregional classification (Chapter 4)

This chapter provides the Ecoregional classification as provided by DWAF for Levels I and II.

Geomorphological (or stream) classification (Chapter 5)

The physical structure of a river system is determined by the geomorphological processes, which shape the channel. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems. This chapter describes the geomorphological classification of the river into zones.

Water quality delineation (Chapter 6)

The study area is also defined into water quality units based on availability of data and any areas of potential change in water quality. This chapter documents the procedure and the results.

River Habitat Integrity (Chapter 7)

The habitat integrity is an assessment of the amount of relative change in habitat condition from reference conditions, which has taken place. This chapter provides a detailed assessment of the habitat integrity for the instream and riparian components of the rivers within the selected study area on a 5km basis.

Present operation of the system (Chapter 8)

Present operation of the system and locality of operational structures can play a role in defining RUs. The present operation of the system is qualitatively described in this chapter for use in assessing the RUs.

Define the RUs (Chapter 9)

The process that is used to define the RU is described as well as all the factors that are used to determine the RU. The results are provided in map format.

EWR site selection (Chapter 10)

Instream Flow Requirements (EWRs) are set at specific points at the river. These points are called EWR sites and are critical sites within a reach of river. The EWR sites should answer to certain criteria and a sequential process to determine the EWRs are required. The results and process are documented in this chapter.

References (Chapter 11)

The references used in this report are recorded in this chapter.

3. RESOURCE UNITS APPROACH

In order to undertake a catchment Ecological Reserve determination it is necessary to break down the catchment into Resource Units (RUs) which are each significantly different to warrant their own specification of the Reserve, and to clearly delineate the geographic boundaries of each of the RUs (DWAF 1999).

This is because it is not appropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches as these sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach.

The apportionment of a catchment into RUs for the purpose of determining the Reserve for rivers is done primarily on a biophysical basis, according to the occurrence of different ecological regions (ecoregions) within the catchment. Since the endpoint of a Reserve determination is an ecological one, the principle is to break down the catchment into units which are relatively homogenous on an ecological basis, to ensure the Reserve is set in appropriate terms (DWAF 1993).

The determination of RU's *via* ecoregions and/or geohydrological response units could then be further resolved into smaller Resource Units which are more suited to management requirements (DWAF 1999). In the Letaba this could be as a result of a weir that is used for irrigation or the Tzaneen or Ebenezer Dam. The different operational procedures of river reaches also result in biophysically different river reaches that also need to be considered in determining the RUs.

The RU determination process considers the above issues, as well as the results of the Habitat Assessment Integrity (an evaluation of river sectors according to instream and riparian Habitat Integrity). The result of overlaying all this data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process, local knowledge and financial considerations are required for the final delineation.

The EWRs are determined for each Resource Unit by means of either the following (Louw & Hughes 2001):

- An EWR site is selected within the RUs and represents a critical site within the relevant river section. Results generated for the RU at the EWR site will then be relevant for the RU as a whole.
- If no EWR site is selected within the RU then extrapolated results from adjacent Resource Units with EWR sites are used. The reasons for an EWR site not being selected within the RU could be due to:
    - The characteristics of the river within the RU do not meet the criteria for EWR sites.
    - Due to the number of RU within the study area, it is not practical and/or cost-effective to address EWR sites within each RU as the budget was limited to a maximum of 7 sites.

3.1 HISTORICAL RESOURCE UNITS SITES

The 1996 IFR refinement workshop relied upon three EWR sites outside of the KNP and two sites inside the KNP (DWAF 1996).

- EWR 1 Letsitele Tank.
- EWR 2 Prieska Weir
- EWR 3 Letaba Ranch
- EWR 4 KNP
- EWR 5 KNP low flow.

The following points can be noted for each of the sites.

Letsitele Tank (IFR 1 now EWR 2).

- Due to the nature of the lower Letsitele River, the site cross sections were through deep water habitats. This made surveying difficult in all but the lowest of flows.
- The site is in a highly disturbed area and extends below a railway bridge.
- Shallow water habitats are available, but it proved difficult to relate flows from the deep transects to the shallow areas.
- A gauging weir occurs just upstream which allows accurate measurement of flow.
- The site has changed following floods in both 1996 and 2000.

Prieska Weir (IFR 2 now EWR 3b).

- The site transects were largely across bedrock rapids, approximately 300 meters downstream from Prieska weir.
- The river at this point flows in numerous deep bedrock channels (braided). Surveying of these channels in anything but low flow is very dangerous due to (crocodiles)
- Because of the bedrock, the instream channel is unlikely to be significantly changed following the floods of 1996 and 2000.
- The riparian zone changed drastically during the 1996 floods. As a result, the area became heavily infested with alien plants (castor oil, cocklebur etc) and access to the transects became extremely difficult. Following the 2000 floods the situation has worsened with much woody debris adding to the access problem.

Letaba Ranch (IFR 3 now EWR 4).

- Transects at this site were made across both a bedrock outcrop which formed a small island and across a gravel channel.
- The river channel changed drastically in the 2000 floods and although the bedrock area remains the channel is unrecognizable.
- EWR 3 occurs on a bend.
- A whole host of large four legged beasties occur at this site

Black Heron Dam (IFR4 – no used in this study).

- Due to scouring below the dam and other influences emanating from the proximity of the dam, this site was of very little use to the previous EWR exercise.
- This site has changed considerably during the 2000-floods.
- A new site was selected during the refinement stages about 15km downstream at the Mopani-Phalaborwa Bridge.
- This site was a better representation of the Letaba River in the KNP.

Letaba Rest Camp (IFR5 – close to current EWR 7).

- An additional site was selected to determine only the low flows during the dry season upstream of Letaba Rest Camp.
- This site has changed considerably during the 2000-floods.

While it could be desirable to use existing sites and rely on historical information, due to recent disturbances, the process would require that these existing sites be treated in the same way as any new site.

The hydraulic data provided for the first study was inaccurate and could not be used. Results generated at this study were therefore meaningless. During the 1994 refinement study, new (more suitable) IFR sites were selected and an extensive calibration exercise was undertaken by Mr Mick Angliss on the sites outside of the KNP. This resulted in a reasonable confident conversion of ecological requirements to flow. Where possible, the same sites will be selected (if still suitable after 9 years considering catchment changes and flooding) and an attempt made to find or re-establish the same cross-sections.

Another key point re the historical EWRs is that the refinement did not include a hydrological analysis of the Middle and Klein Letaba. Any results in the KNP was therefore problematic, both from the low flow confidence hydrology aspects as well as completely unrefined hydraulics. There is now a much larger body of photographic and aerial video footage, for reference purposes. The fish study team has also developed a more detailed knowledge of the catchment due to the continued sampling and the River Health Programme.

4. ECOREGIONS

4.1 APPROACH

The ecoregion typing approach developed in the USA (Omernik 1987) was applied and tested at a preliminary level in South Africa. Ecoregional classification allows the grouping of rivers according to similarities based on a top-down approach. The purpose of this approach is to simplify assessments and statements on ecological water requirements. One of the advantages of such a system is the extrapolation of information from data rich rivers to data poor rivers within the same hierarchical typing context.

The principles and fundamentals of the approach entail the following:

- Ecoregions can be identified or typed according to various levels of detail. The principle of river typing is that rivers or river reaches grouped together at a particular level of the typing hierarchy will be more similar to one another than to rivers in other groups.
- An ecosystems approach recognises that ecosystem components do not function as independent systems but that they exist only in association with one another.
- Ecosystems and their components display regional patterns that are reflected in spatially variable combinations of causal factors such as climate, mineral availability (soils and geology), vegetation and physiography. These factors interact, but the importance of each factor in determining the character of ecosystems varies from place to place.
- Omernik's (1987) approach is based on patterns of terrestrial characteristics and on the premise that relatively homogenous areas exist and that these areas can be defined by simultaneously analysing a combination of causal and integrative factors. In this approach, ecoregions are regions of relative homogeneity in ecological characteristics or in relationships between organisms and their environments.
- Ecoregional classification uses multiple characteristics at each level of a typing hierarchy. Ecological regions are then regions within which there is relative similarity in the mosaic of ecosystems and ecosystem components (biotic and abiotic, aquatic and terrestrial).
- The delineation of ecological regions requires evaluating maps of all geographic phenomena believed to cause or reflect spatial differences in ecosystems. Where combinations of these phenomena coincide spatially, the ecosystems are likely to be similar. The process requires qualitative examination to account for the differences in generality, accuracy, and particular classifications of each map. The regions are essentially sketched (Kleynhans *et al,* 2002), using expert judgement to delineate boundaries.
- Ecoregional classification is a hierarchical procedure that involves the delineation of ecoregions with a progressive increase in detail at each higher level of the hierarchy, i.e. essentially the same characteristics are used at the various levels but with more detail as one moves to a higher level in the hierarchy. In addition, the characteristics that are more or less important can vary from one place to another.

4.2 ECOREGION LEVEL 1

The current effort used available information to delineate ecoregion boundaries at a very broad scale (i.e. Level I) for South Africa. Attributes such as physiography, climate, rainfall, geology and potential natural vegetation were evaluated in this process and 18 Level I ecoregions were identified.

Level I Ecoregional information was made available by DWAF who undertook the study (Thirion *et al.* in prep.), Figure 4.1.

4.3 ECOREGION LEVEL II

The next Ecoregion Level (II) used the same attributes but in more detail. Physiography can for example, be looked at in more detail by considering terrain morphological classes, slopes, relief, altitude, etc (Table 4.1).

At this stage it seems evident that typing up to Level II will be required in order to link the ecoregion typing to the stream channel through stream classification. Stream classification is a separate hierarchy and includes geomorphological classification according to zones, segments and reaches). It is likely that the geomorphological segment level will provide information that can be linked to biological segments (i.e. fish, invertebrate and riparian vegetation segments) that can form a basis for the assessment and estimation of ecological reserve requirements.

The Ecoregions Level II for the Lowveld were supplied by C Thirion of RQS DWAF (Figure 4.1).

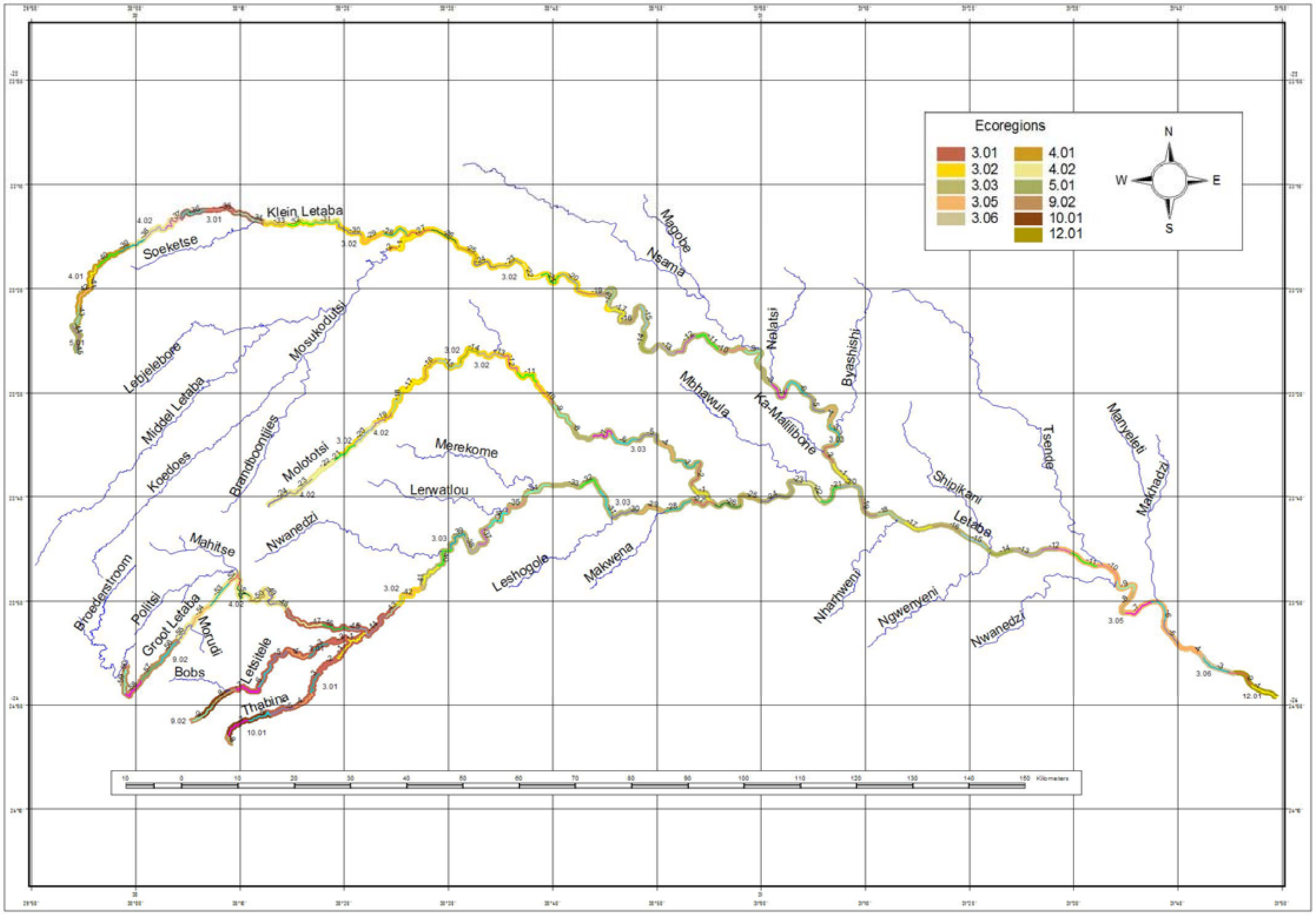


Figure 4.1: Ecoregions Level II for the lowveld

Table 4.1: Attribute data for all Ecoregion level II for the Letaba catchment

Main Attributes	Lowveld 3.01
Terrain Morphology: Broad division	**Plains; moderate relief;** Open Hills, Lowlands, Mountains; moderate to high relief; Closed Hills, Mountains; moderate and high relief
Terrain Morphology	Slight irregular plains; Strongly undulating plains Hills and Lowlands High Mountains
Vegetation types (dominant types in bold) (Primary)	**Sour Lowveld Bushveld;** Mixed Bushveld Patches Afromontane Forest
Altitude (m a.m.s.l.)	500 to 900 (900 to 1300 limited)
MAP (mm)	<20 to 34
Coefficient of variation (% of annual precipitation)	55 to >65
Rainfall concentration index	Mid summer
Rainfall seasonality	
Mean annual temp (°C)	16 to 22
Mean daily max temp (°C) February	26 to 32
Mean daily max temp (°C) July	20 to 24
Mean daily min temp (°C) February	17 to >20
Mean daily min temp (°C) July	6 to 9
Median annual simulated runoff (mm) for quaternary catchment	40 to 200; >250

Main Attributes	Lowveld 3.02
Terrain Morphology: Broad division	Plains; low relief (limited); **Plains; moderate relief;** Open Hills, Lowlands, Mountains; moderate to high relief
Terrain Morphology	Slightly undulating plains (limited) **Slight irregular plains;** Moderately undulating plains Hills and Lowlands
Vegetation types (dominant types in bold) (Primary)	**Mixed Lowveld Bushveld;** Sour Lowveld Bushveld
Altitude (m a.m.s.l.)	300 to 1100
MAP (mm)	400 to 700
Coefficient of variation (% of annual precipitation)	20 to 34
Rainfall concentration index	60 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	18 to 22
Mean daily max temp (°C) February	26 to 32
Mean daily max temp (°C) July	20 to 24
Mean daily min temp (°C) February	16 to >20
Mean daily min temp (°C) July	6 to 9
Median annual simulated runoff (mm) for quaternary catchment	20 to 100

Main Attributes	Lowveld 3.03
Terrain Morphology: Broad division	Plains; low relief; **Plains; moderate relief;** Open Hills, Lowlands, Mountains; moderate to high relief
Terrain Morphology	Slightly undulating plains **Slight irregular plains;** Extremely irregular plains (almost hilly) Hills and Lowlands
Vegetation types (dominant types in bold) (Primary)	**Mopane Bushveld;** Mopane Shrubveld

Main Attributes	Lowveld 3.03
Altitude (m a.m.s.l.)	100 to 700
MAP (mm)	300 to 600
Coefficient of variation (% of annual precipitation)	25 to 34
Rainfall concentration index	60 to >64
Rainfall seasonality	Mid summer
Mean annual temp (°C)	20 to >22
Mean daily max temp (°C) February	28 to 32
Mean daily max temp (°C) July	22 to 26
Mean daily min temp (°C) February	18 to >20
Mean daily min temp (°C) July	6 to 9
Median annual simulated runoff (mm) for quaternary catchment	10 to 100

Main Attributes	Lowveld 3.04
Terrain Morphology: Broad division	**Plains; low relief;** Plains; moderate relief; Closed Hills, Mountains; moderate and high relief
Terrain Morphology	**Plains;** Extremely irregular plains (almost hilly) Hills
Vegetation types (dominant types in bold) (Primary)	**Mopane Bushveld**
Altitude (m a.m.s.l.)	300 to 700
MAP (mm)	300 to 500
Coefficient of variation (% of annual precipitation)	25 to 34
Rainfall concentration index	≥65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	20 to >22
Mean daily max temp (°C) February	28 to 32
Mean daily max temp (°C) July	22 to 26
Mean daily min temp (°C) February	>20
Mean daily min temp (°C) July	8 to >10
Median annual simulated runoff (mm) for quaternary catchment	20 to 40; 60 to 100

Main Attributes	Lowveld 3.05
Terrain Morphology: Broad division	**Plains; low relief**; Plains; moderate relief
Terrain Morphology (Secondary)	**Plains,** Slightly undulating plains (limited) Slight irregular plains (limited)
Vegetation types (dominant types in bold) (Primary)	**Mopane Shrubveld;** Lebombo Arid Mountain Bushveld
Altitude (m a.m.s.l.)	100 to 500
MAP (mm)	300 to 800
Coefficient of variation (% of annual precipitation)	25 to 34
Rainfall concentration index	≥65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	20 to >22
Mean daily max temp (°C) February	28 to 32
Mean daily max temp (°C) July	22 to 26

Main Attributes	Lowveld 3.05
Mean daily min temp (°C) February	>20
Mean daily min temp (°C) July	8 to 9
Median annual simulated runoff (mm) for quaternary catchment	20 to 100

Main Attributes	North Eastern Highlands 4.01
Terrain Morphology: Broad division	Closed Hills, Mountains; moderate and high relief
Terrain Morphology	Low Mountains
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld
Altitude (m a.m.s.l.)	700 to 1300
MAP (mm)	300 to 800
Coefficient of variation (% of annual precipitation)	20 to 34
Rainfall concentration index	60 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to 20
Mean daily max temp (°C) February	24 to 30
Mean daily max temp (°C) July	18 to 22
Mean daily min temp (°C) February	14 to 17
Mean daily min temp (°C) July	4 to 7
Median annual simulated runoff (mm) for quaternary catchment	20 to 60

Main Attributes	North Eastern Highlands 4.02
Terrain Morphology: Broad division	Closed Hills, Mountains; moderate and high relief
Terrain Morphology	Low Mountains
Vegetation types (dominant types in bold) (primary)	**Sour Lowveld Bushveld;** Mixed Lowveld Bushveld Patches Afromontane Forest
Altitude (m a.m.s.l.)	500 to 1500
MAP (mm)	400 to 1000
Coefficient of variation (% of annual precipitation)	<20 to 29
Rainfall concentration index	55 to >65
Rainfall seasonality	Mid summer
Mean annual temp (°C)	16 to 22
Mean daily max temp (°C) February	22 to 30
Mean daily max temp (°C) July	16 to 24
Mean daily min temp (°C) February	14 to 19
Mean daily min temp (°C) July	4 to 7
Median annual simulated runoff (mm) for quaternary catchment	40 to 250

Main Attributes	Northern Plateau 5.01
Terrain Morphology: Broad division	Plains; low relief; Plains; moderate relief
Terrain Morphology (Primary)	Slightly undulating plains; Moderately undulating plains
Vegetation types (dominant types in bold)	**Mixed Bushveld**, Clay Thorn Bushveld (limited) North Eastern Mountain Grassland (limited)
Altitude (m a.m.s.l.)	900 to 1500

Main Attributes	Northern Plateau 5.01
MAP (mm)	300 to 500
Coefficient of variation (% of annual precipitation)	30 to 34
Rainfall concentration index	60 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp (°C)	16 to 20
Mean daily max temp (°C) February	24 to 30
Mean daily max temp (°C) July	18 to 22
Mean daily min temp (°C) February	14 to 19
Mean daily min temp (°C) July	2 to 5
Median annual simulated runoff (mm) for quaternary catchment	10 to 60

Main Attributes	Lebombo Uplands 12.01
Terrain Morphology: Broad division	Closed hills, mountains; moderate and high relief
Terrain Morphology (Primary)	Hills; **Low Mountains**
Vegetation types (dominant types in bold) (Primary)	**Lebombo Arid Mountain Bushveld**; Sweet Lowveld Bushveld
Altitude (m a.m.s.l.)	100 to 700
MAP (mm)	400 to 800
Coefficient of variation (% of annual precipitation)	<20 to 34
Rainfall concentration index	50 o >65
Rainfall seasonality	Early to mid summer
Mean annual temp (°C)	18 to >22
Mean daily max temp (°C) February	26 to 32
Mean daily max temp (°C) July	20 to 26
Mean daily min temp (°C) February	18 to >20
Mean daily min temp (°C) July	8 to >110
Median annual simulated runoff (mm) for quaternary catchment	40 to 150

Main Attributes	Eastern Bankenveld 9.02
Terrain Morphology: Broad division	Plains; low relief (limited); Open Hills, Lowlands, Mountains; moderate to high relief; **Closed Hills, Mountains; moderate and high relief**
Terrain Morphology	Plains (limited), Parallel hills and lowlands; **Low mountains**
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld Patches Afromontane Forest North Eastern Mountain Grassland
Altitude (m a.m.s.l.)	700 to 1700
MAP (mm)	400 to 1000
Coefficient of variation (% of annual precipitation)	<20 to 34
Rainfall concentration index	55 to >65
Rainfall seasonality	Early to mid summer
Mean annual temp (°C)	10 to 22
Mean daily max temp (°C) February	18 to 30
Mean daily max temp (°C) July	12 to 22
Mean daily min temp (°C) February	8 to 17

Main Attributes	Eastern Bankenveld 9.02
Mean daily min temp (°C) July	0 to 7
Median annual simulated runoff (mm) for quaternary catchment	20 to 150; 200 to >250

Main Attributes	Northern Escarpment Mountains 10.01
Terrain Morphology: Broad division	**Closed Hills, Mountains; moderate and high relief**
Terrain Morphology	High mountains
Vegetation types (dominant types in bold) (Primary)	Patches Afromontane Forest North Eastern Mountain Grassland Sour Lowveld Bushveld
Altitude (m a.m.s.l.)	500 to 2100
MAP (mm)	500 to 1000
Coefficient of variation (% of annual precipitation)	<20 to 29
Rainfall concentration index	55 to 64
Rainfall seasonality	Early to mid summer
Mean annual temp (°C)	10 to 22
Mean daily max temp (°C) February	16 to 30
Mean daily max temp (°C) July	14 to 24
Mean daily min temp (°C) February	8 to 19
Mean daily min temp (°C) July	0 to 7
Median annual simulated runoff (mm) for quaternary catchment	40 to 150; 200 to >250

5. STREAM CLASSIFICATION

The physical structure of a river ecosystem is determined by the geomorphological processes, which shape the channel. These processes determine the material from which the channel is formed, the shape of the channel and the stability of the bed and banks. The channel geomorphology in turn determines the substrate conditions for the stream fauna and flora and the hydraulic conditions for any given flow discharge. Geomorphology provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems. Whilst rivers are resilient to temporary flow reductions (such as droughts) and to water quality problems, structural changes to the river channel (damage to the riparian zone, sediment inputs from catchment erosion or reservoir induced changes in the flow regime), can cause long term irreversible effects (Kochel, 1988).

The aim of the longitudinal zonation is to subdivide the longitudinal profile into morphologically uniform zones. Channel gradient is well correlated with many channel properties including channel pattern, channel type, bed material and reach type (Rowntree, 2000). Changes in gradient down a longitudinal profile usually mark morphological changes and thus provide the basis for the delineation of zones. These breaks are usually due to changes in lithology, but can also be as a result of tectonic activity or the upstream migration of knick points (Dollar, 1998). Zones were delineated on the basis of significant breaks in the longitudinal profile. The zones were then classified using the system of Rowntree and Wadeson (1999, Table 5.1).

Rowntree and Wadeson (1999) have developed a hierarchical classification system, which is based on a combination of desktop, and field approaches and aims to provide a scale-based framework linking the various components of the river system, ranging from the catchment to the instream habitat (Table 5.1). The system consists of six levels:

- the catchment,
- the segment,
- the zone,
- the reach,
- the morphological unit and
- the hydraulic biotope.

Table 5.1: Definition of geomorphological classification levels (after Rowntree and Wadeson, 1999)

Hierarchical unit	Description	Scale
Catchment	The catchment is the land surface that contributes water and sediment to any given stream network.	Can be applied to the whole river system, from source to mouth, or to a lower order catchment above a specified point of interest.
Segment	A segment is a length of channel along which there is no significant change in the flow discharge or sediment load.	Segment boundaries will tend to be co-incident with major tributary junctions.
Longitudinal zone	A zone is a sector of the river long profile that has a distinct valley form and valley slope.	Sectors of the river long profile.
Reach	The reach is a length of channel characterised by particular channel pattern and channel morphology, resulting from a uniform set of local constraints on channel form.	>00s of meters.
Morphological Unit	The morphological units are the basic structures recognised by fluvial geomorphologists as comprising the channel morphology and may be either erosional or depositional features.	Morphological units occur at a scale of an order similar to that of the channel width.
Hydraulic biotope	Hydraulic biotopes are spatially distinct instream flow environments with characteristic hydraulic attributes.	Hydraulic biotopes occur at a spatial scale of the order of 1 m^2 to 100 m^2 and are discharge dependent.

Catchment, segment and zone classifications are derived from desktop studies using available secondary data sources. Classification to zone is normally undertaken.. Zone, morphological unit and hydraulic biotope classifications are applied to specific sites, based largely on field assessment backed up by reference to large scale maps (normally 1: 50 000) and aerial photographs.

The information requirements include:

- Catchment assessment
- River long profile and delineation of longitudinal zones
- Site descriptions, incorporating the:
  - Determination of the relationship between flow and habitat type and composition
  - Assessment of long-term channel change at the site
  - Potential Bed Material Transport (PBMT) modelling exercise (Dollar and Rowntree 2003)
  - Subsequent evaluation of the ranges of flows that are significant in terms of observed site conditions.

The method used for the PBMT modelling exercise was developed by Dollar and Rowntree (2003). Methods for all remaining components of the study are described in the RDM manual (DWAF 1999, Louw and Hughes 2002).

In a Comprehensive determination of the ecological Reserve, zonal classification geomorphological zones are used to guide the spatial framework for the delineation of water RUs, the assessment of habitat integrity, and EWR site selection.

Geomorphological River Zonation

The longitudinal zonation of South African rivers reflects regional geology, tectonic events and long term fluvial action which together have affected the shape of their long profiles. The classic concave long profile may be disrupted by a number of features including outcrops of more resistant rock and rejuvenation due to tectonic uplift or a fall in sea-level. Rowntree and Wadeson (1999) have developed a zonal classification system for South Africa based on work carried out on a number of different rivers around the country (Table 5.2).

Table 5.2: Geomorphological zonation of river channels

Zone	Zone class	Gradient class	Characteristic channel features
A. Zonation associated with a 'normal' profile			
Source zone	S	not specified	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	A	> 0.1	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
Mountain stream	B	0.04 - 0.099	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool, approximate equal distribution of 'vertical' and 'horizontal' flow components.
Transitional	C	0.02 - 0.039	Moderately steep stream dominated by bedrock or boulder. Reach types include plain-bed, pool-rapid or pool riffle. Confined or semi-confined valley floor with limited flood plain development.
Upper Foothills	D	0.005 - 0.019	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow flood plain of sand, gravel or cobble often present.
Lower Foothills	E	0.001 - 0.005	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool- riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.
Lowland river	F	0.0001-0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.
B. Additional zones associated with a rejuvenated profile			
Rejuvenated bedrock fall / cascades	Ar Br Cr	>0.02	Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.

Zone	Zone class	Gradient class	Characteristic channel features
Rejuvenated foothills:	Dr Er	0.001 - 0.019	Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/ pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro channel activated only during infrequent flood events. limited flood plain may be present between the active and macro-channel.
Upland flood plain	Fr	< 0.005	An upland low gradient channel, often associated with uplifted plateau areas as occur beneath the eastern escarpment.

Longitudinal Profiles of the Letaba River catchment

Six longitudinal zones were identified along the (Groot) Letaba main stem channel. Zones 1, 4 and 5 were further sub-divided in to two sub-categories (*a* and *b*) due to major slope differences and/or tributary junctions (Table 5.3). A further 2 zones were identified in the Klein Letaba (Figure 5.1).

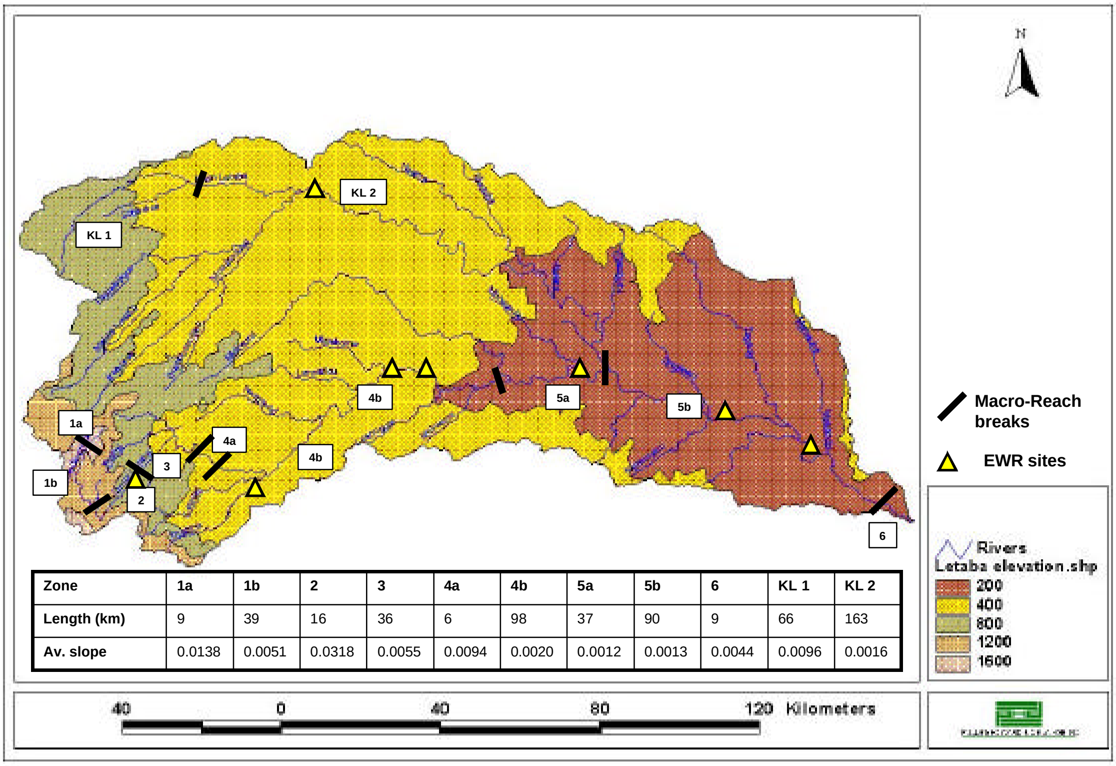
Characteristics of the Groot Letaba longitudinal zones

Six zones were identified on the Letaba mainstem channel, which were further subdivided into 9 units.

Zone 1: Zones 1(a) and 1(b) represent the extreme upper reaches of the river as they flow over and off of the upper escarpment (Fig. 5.2). These reaches are generally characterised by the Pietersberg group (schists and amphibolites) from the Swazian period. Zone 1(a) is found above 1500 masl and is only 9kms long with an average slope of 0.0138. Zone 1(b) found between 1500-1300 metres above sea level (masl) and is 39kms long and relatively steep (average slope 0.0051). The main channel is still small and represents a small section of the catchment. The catchment is heavily afforested in this region.

Zone 2: This short (16km) zone is representative of the river as it flows down the steep escarpment (Figure 5.2) between 1300 and 800 masl. The average slope is 0.0318 in this zone. Its granite geology is exposed in the bed of the river, resulting in the creation of steep bedrock gorges typified by bedrock rapids, pools and occasional small waterfalls. The confined gorge opens out into a slightly wider valley where boulders and cobbles begin to dominate the bed and bedrock pool/rapid and later pool/riffle becomes the dominate channel patterns. Small floodplain pockets begin to occur as well as occasional instream depositional bars which are not found further upstream.

EWR 1 (Appel) is located in this longitudinal zone. The site, a pool/riffle sequence dominated by boulders and cobbles, is fairly typical of the zone.



Zone	1a	1b	2	3	4a	4b	5a	5b	6	KL 1	KL 2
Length (km)	9	39	16	36	6	98	37	90	9	66	163
Av. slope	0.0138	0.0051	0.0318	0.0055	0.0094	0.0020	0.0012	0.0013	0.0044	0.0096	0.0016

Figure 5.1: Letaba catchment showing the longitudinal zone boundaries and location of the EWR sites

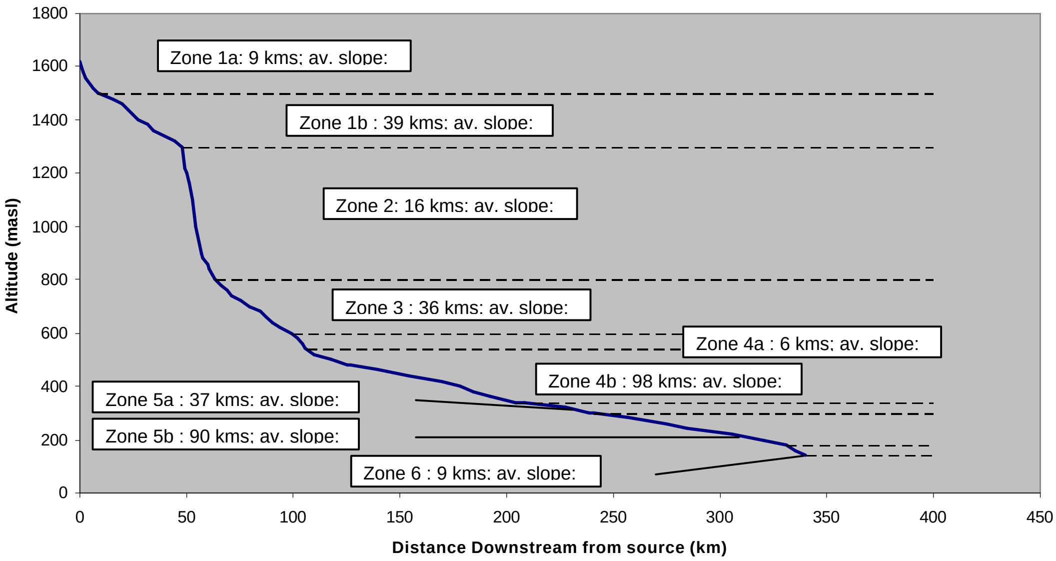


Figure 5.2: Longitudinal profile of the mainstem Letaba River showing the zone boundaries

Zone 3: This longitudinal zone is found between 800 and 600 masl. It is 36kms long and much flatter than zone 2, but is dominated by the Tzaneen (formerly Fanie Botha) Dam. Both zones 2 and 3 flow over Vaalian Group granites. Long pools with isolated bedrock rapids/riffle outcrops and an almost continuous floodplain occur upstream of the Tzaneen Dam. The area is highly afforested. Downstream of the dam the channel pattern is pool/riffle with occasional small bedrock anastomosing sections. Bedrock influence in the channel is high. However, at the lower end of the zone, more alluvial-influenced channel patterns begin to occur due to the influence of the Yamorna Weir.

Zone 4: This longitudinal zone is found between 600 and 340 masl. The zone, which is dominated by Swazian gneiss geology, was subdivided into two sub-units. Zone 4(a), although only 9kms long, is much steeper than 4(b). Zone 4(a) is found between 600 and 540 masl. Here the channel pattern changes to a more alluvial-influenced mixed pool/rapid channel type. Bedrock influence remains high in the active channel, but instream depositional features, such as bedrock core bars, as well as lateral deposits of sediment, are more common. Both these features and the macro-channel banks are well-vegetated.

Zone 4(b) is 98kms long and much flatter (0.0020) than 4(b). The zone maintains a strong inchannel bedrock influence and mixed pool/rapid and bedrock anastomosing channel patterns are common. Further downstream, as more sediment is introduced from lowveld tributaries, the more alluvial channel patterns of braiding and alluvial single thread occur. Some sandy lateral bar deposits also begin to appear, but the general absence of braid bars (and other instream sand bars) may be caused by the retention of bed sediments in the numerous dams and weirs in this section of the river and adjoining tributaries.

The EWR site located at Prieska Weir is in this zone. The site is more confined than is typical for this zone, but the bedrock influence on the macro-channel bed is typical of the zone. The site is thus fairly typical of this longitudinal zone.

Zone 5: Zone 5 is much flatter than upstream. This zone was divided into two subunits due to the influence of the Klein Letaba confluence in this zone. Zone 5(a) represents the river below 540 masl until the confluence with the Klein Letaba 37kms downstream. Again, Swazian Gneiss is the dominant geology here. Extensive sections of the mixed braided channel type, separated by occasional pool-rapid sections associated with large bedrock (dyke) outcrops, are typical of this subunit. The confluence with the Molototsi provides a locally high sediment load to the main channel, but this soon reverts back to the sandy braided sections interspersed with bedrock pool-rapid sections seen upstream. The valley is unconfined, the macro-channel quite shallow and both the macro-channel and active channels are wide.

Although there is almost no change in slope between Zone 5(a) and 5(b), the channel pattern is altered by the high sediment inputs from the Klein Letaba. Zone 5(b) extended for 90kms from the confluence with the Klein Letaba until 180 masl. This zone represents most of the Letaba River within the Kruger National Park.

Swazian Gneiss, with ultramafic schist and gabbro intrustions, is initially the geology over which the river flows. However in the middle of this zone the river flows through quaternary sediments which overly Letaba formation basalts.

More alluvial-influenced channel patterns, such as alluvial anastomosing and alluvial single thread, become the dominant patterns in this zone. However there are still some small, uncommon, bedrock-influenced anastomosing and pool-rapid sections. The macro-channel floor here tends to be wide and sandy with a small misfit active channel flowing within it.

Two EWR sites (Lonely Bull and Letaba Bridge) are found in the long Zone 5 (b). Both these sites can be considered to be typical of the zone.

Zone 6: This is a short (9km long), steep (slope 0.0044) zone, which represents the section of river which flows over the Letaba formation granites at the western edge of the Kruger National Park before its confluence with the Olifants River near the Mozambique border. Here the river has incised into the underlying bedrock, creating a steep, confined, highly bedrock-influenced section of river.

Characteristics of the Klein Letaba longitudinal zones

The Klein Letaba was divided into two longitudinal zones (Figure 5.3) based on slope characteristics.

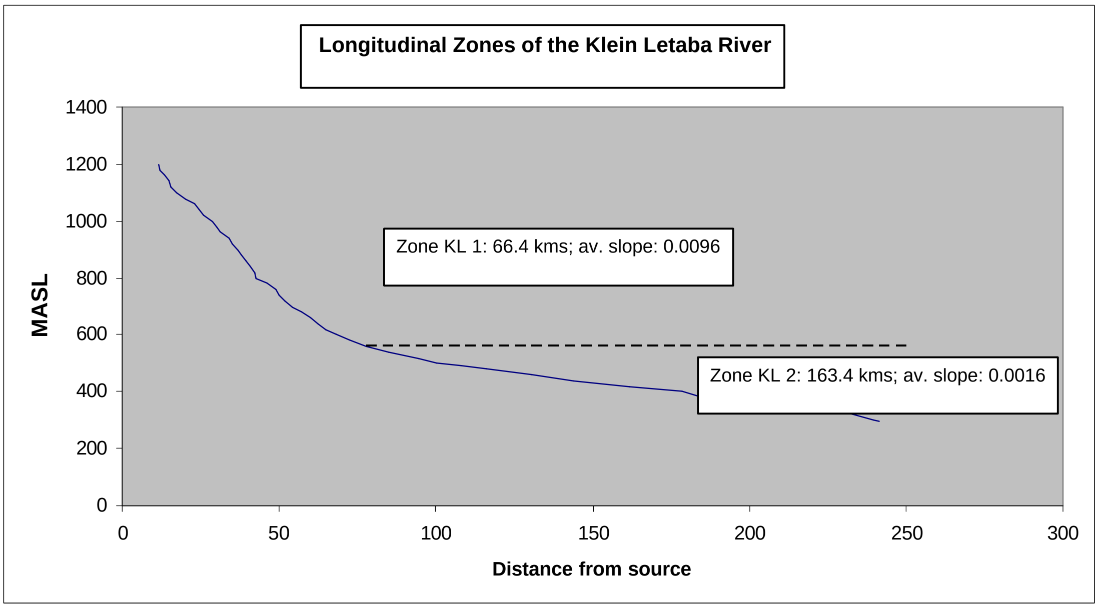


Figure 5.3: Longitudinal profile of the Klein Letaba River showing the zone boundary

Zone 1: Zone 1 represents that section of the river from the lower escarpment down to 560 masl. This is the steeper (slope 0.0096), smaller (66 kms long) of the two zones.

Zone 2: This zone represents that section of the river from 560 masl downstream until the confluence with the Groot Letaba. The semi-arid nature of the extensive catchment, which is dominated by Gneiss, results in a high sediment production. This is delivered to the tributaries and, due to the low slope of the area, stored in them and in the main stem of the Klein Letaba. Extensive alluvial sections therefore dominate the channel with occasional bedrock outcrops causing local controls. The EWR site 5 (Klein Letaba) located here is typical of the zone.

Table 5.3: Summary of the longitudinal zone characteristics

Zone	Altitude (masl)	Length (km's)	Average slope	Channel characteristics (based on slope after Wadeson, 1999)
1a	above 1500	9	0.0138	Mountain stream (0.01-0.1)
1b	1500-1300	39	0.0051	Foothills (cobble bed) (0.005-0.01)
2	1300-800	16	0.0318	Rejuvenated Bedrock Fall (0.01-0.5)*
3	800-600	36	0.0055	Rejuvenated Foothills (0.001-0.01)*
4a	600-540	6	0.0094	Rejuvenated Foothills (0.001-0.01)*
4b	540-340	98	0.0020	Rejuvenated Foothills (0.001-0.01)*
5a	340-297	37	0.0012	Rejuvenated Foothills (0.001-0.01)*
5b	297-180	90	0.0013	Rejuvenated Foothills (0.001-0.01)*
6	180-140	9	0.0044	Gorge
KL 1	above 560	66	0.0096	Rejuvenated Foothills (0.001-0.01)*
KL 3	560-297	163	0.0016	Rejuvenated Foothills (0.001-0.01)*

Where: * = zones associated with rejuvenated river profiles

6. WATER QUALITY UNITS

6.1 INTRODUCTION

The information presented in this document serves as the Water Quality Units (WQUs) for the Letaba catchment area.

6.2 METHOD

Water Quality Unit's delineation was based on the following factors:

- Literature regarding water quality issues in the catchments.
- Information gathered by Dr Jay Walmsley, previously team leader of the water quality team.
- A meeting with Mr Jacob Matlala, DWAF Water Quality Management, Polokwane, and his team of pollution control officers for the Letaba catchment.
- Liaison with Mr Kobus Myburgh of Resource Quality Services, DWAF, and Mr Thinus Brandt, Chief Industrial Technician, DWAF Tzaneen.
- The perusal of 1:50 000 maps of the study area, depicting land-use activities, point and diffuse sources of pollution, and catchment characteristics such as towns, tributaries, dams, etc.
- The ecoregional classification (Level I and II) of the area.
- Liaison with the national DWAF office and acquisition of water quality information from the DWAF-WMS (Water Management System) database.
- Information regarding the position of biomonitoring sites. Biomonitoring data will be accessed from the national Rivers Database or the macroinvertebrate specialist on the team.
- A field survey of 1 – 5 December 2003. During this survey water quality samples were taken at selected points for analysis by RQS, DWAF, as a once-off survey. Chlorophyll-*a* analyses are of particular relevance. A number of points did not have any water in the channel – EWR team members will be requested to collect water samples from these sites during an EWR survey.

6.3 RESULTS

Figure 6.1 is a land-use map of the catchment area, and shows the water quality sites sampled during the December field survey (WQUs 1 – 17), EWR sites (EWR 1 – 7), biomonitoring sites (BIO 1 – 28) and DWAF monitoring points provisionally to be used for RC and PES assessments. The delineation of WQUs as shown in Table 6.1.

It is important to note that a detailed assessment and manipulation of the water quality has not been undertaken as part of this report and will be reported on in a separate report (Scherman 1995). Data indicated in Table 6.1 to be used for determining Reference Condition (RC) and Present Ecological State (PES), is taken from an assessment reported on in the Inception report (Heath 1994). Furthermore water quality sites were not located at the Level of ecoregion Level II divisions, as the number of sites would not be practically feasible in terms of data availability and other resources.

Table 6.1: Water quality units and descriptive information for the Letaba Reserve study area

WQU no.	Description	Monitoring point data available and used for assessing RC + PES	Land use activities and implications for water quality
1	Headwaters of Groot Letaba upstream of input to the Ebenezer Dam (on the R528 upstream of the bridge crossing)	Preferred DWAF mon. points: B8H064Q01 (Onverwacht Ebenezer Dam) **(PES)** OR B8R001Q01 (Ebenezer Dam Wall) **(RC and PES)** OR Alternatively B8H032S01 (Pietersburg Treatment Works-Ebenezer Dam-Treated), B8H053Q01 (Dap Naude Dam on Broederstroom River); B8R001Q02 (Point in Ebenezer Dam) WQ = No sample taken EWR = No site Biomonitoring site: Exists (Walmsley pers. comm.), but cannot be located (site may be in WQU 2).	Main land use is afforestation (*Eucalyptus* and *Pinus* species). Some cultivated lands (bananas and citrus). Water quality problems relating to electrical conductivity. Water quality impacts relating to increased turbidity due to sedimentation (SRK 1989; Consultburo1997).
2	Groot Letaba downstream of Ebenezer Dam (output) to upstream of Tzaneen Dam (input)	Preferred DWAF mon. points: B8R050Q01 Groot Letaba at Tzaneen Dam wall **(RC and PES)** or B8R005Q01 Groot Letaba at Tzaneen Dam wall **(RC and PES)** OR Alternatively: B8H014Q01(Grysappel) WQ = Site 1 (situated on the R528 bridge crossing the Groot Letaba) EWR = Site 1 (Tzaneen – close to DWAF site) Biomonitoring site: Exists (Walmsley pers. comm.), but cannot be located (site may be in WQU 1).	Predominantly forested (*Eucalyptus* and *Pinus* species). Water is abstracted for irrigation (cultivated lands – bananas, mangos and tea plantations), few rural / urban settlements. Water quality problems relating to electrical conductivity. Increased turbidity due to sedimentation (SRK 1989; Consultburo,1997).
3	Groot Letaba downstream of Tzaneen Dam (output) to upstream of the confluence with the Letsitele River tributary	Preferred DWAF mon. points: B8H050Q01 downstream of Tzaneen Dam wall **(RC, PES)** WQ = Site 3 (situated below the Letaba Estate off the R529 from Tzaneen at a bridge crossing) EWR = No site Biomonitoring site = Nkowankowa Bridge (BIO 21)	Irrigation agriculture (cultivated lands – banana and citrus), industrial and urban / domestic water use (Tzaneen). Industrial activity noted - creosote plant and oxidation ponds (in Tzaneen), timber processing (before Letsitele tank on the R71). Water quality impact is minimal as most of the effluent is recycled or used for irrigation. Water quality problems relating to dissolved oxygen (SRK 1989; Consultburo1997).
4	Groot Letaba downstream of confluence with Letsitele to upstream of Prieska Weir (after Hans Merensky Nature Reserve)	Preferred DWAF mon. points: B8H009Q01 (Groot Letaba at 'The Junction') **(RC and PEC)** or B8H017Q01 Groot Letaba at Prieska **(RC)** OR Alternatively: B8H043Q01 Hans Merensky Dam on Ramadepa River **-** downstream) or B8R002Q01 (Hans Merensky Dam on Ramadepa River – near dam wall)	Main land use irrigation agriculture, namely citrus plantations (Noted: Strong biocide odour in the air). Water quality impacts relating to salinisation and release of biocides into the environment. Water quality problems relating to, for example chlorophyll-a,

WQU no.	Description	Monitoring point data available and used for assessing RC + PES	Land use activities and implications for water quality
		WQ = Site 5 ('The Junction); Site 6 (Nagude Farm Estate); Site 7 (Bridge crossing at Sukkel Sukkel to Giyani) EWR = Site 3 Prieska Biomonitoring site = 'The Junction' (BIO 22) and Nagude (BIO 23)	pesticides, herbicides, nitrogen and phosphate, Magnesium, Sodium etc (SRK 1989; Consultburo1997)
5	Groot Letaba downstream of Prieska Weir (after Hans Merensky Nature Reserve) to upstream of the confluence with the Molototsi River tributary	Preferred DWAF mon. points: B8H017Q01 Groot Letaba at Prieska **(RC)** Alternatively: B8H026Q01 Groot Letaba irrig. Masalaal canal inlet at Prieska WQ = Site 15 Nondweni (downstream of Nondweni biomonitoring site and a weir and upstream of bridge crossing) EWR = No site Biomonitoring site = Nondweni (BIO 25)	Main land use is dense rural settlements (limited subsistence agriculture, with livestock). Very few citrus plantations or irrigation agriculture (one adjacent to the WQ sampling site). Very dry landscape. Where plantations exist and land use is irrigation agriculture: Water quality impacts relating to salinisation and release of biocides into the environment. WQ problems relating to, for example chlorophyll-a, pesticides, herbicides, nitrogen and phosphate, Magnesium, Sodium etc (SRK 1989; Consultburo 1998). Where rural settlements exist: Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
6	Groot Letaba downstream of confluence with the Molototsi River tributary to upstream of the confluence with the Klein Letaba (northern boundary of the Groot Letaba Nature Reserve)	Preferred DWAF mon. point: B8H008Q01 Groot Letaba at Letaba Ranch (Groot Letaba Nature Reserve) **(RC and PES)** WQ = Site 14 (Rondaliekamp, Groot Letaba Nature Reserve) EWR = Site 4 Letaba Ranch Biomonitoring site = Letaba Ranch camp 3 (BIO 27), Slab weir and road bridge (BIO 26), and Letaba Ranch EWR site (BIO 28).	Rural / domestic water use and limited cultivated lands before the Nature Reserve. The water quality sampling point was taken in the Nature Reserve but downstream of dense rural settlements and informal settlements (limited subsistence agriculture and livestock).
7	Letaba River downstream of the Klein Letaba confluence with the Groot Letaba into the Kruger National Park (eastern boundary) to the Mozambique border.	Preferred DWAF mon. points: B8H028Q01 Letaba River at Mhlangeni Dam (KNP) **(RC and PES);** B8H029Q01 Letaba River Mingerhout Dam (KNP) **(RC)** or B8H018 Letaba River at Engelhardt Dam **(RC)** Or Alternatively: B8H034 Letaba (Black Heron KNP) WQ = Site 16 (Upstream of Lonely Bull EWR site and Mingerhout Dam) Site 17 (Upstream from Letaba Rest Camp at bridge crossing and upstream of Engelhardt Dam)	Kruger National Park – Protected land or conservation area.

WQU no.	Description	Monitoring point data available and used for assessing RC + PES	Land use activities and implications for water quality
		EWR = Site 6, Lonely Bull and Site 7, Letaba Rest Camp Biomonitoring site: Sites within the Kruger National Camp .	
8	Upper Letsitele (Craighead Estate) to upstream of the R529 bridge crossing from Tzaneen to Lydenberg (just after Nkowankowa turn off)	Preferred DWAF mon. points: Possibly use point for WQU 9. WQ = Site 2 (Craig Head Estate in Letsitele Valley upstream of bridge crossing) EWR = No site Biomonitoring site = Craighead Estate (BIO 1)	Main land use irrigation agriculture, namely citrus plantations (mangos and bananas). Also afforestation. Water quality impacts relating to salinisation and release of biocides into the environment. WQ problems relating to, for example chlorophyll-a, pesticides, herbicides, nitrogen and phosphate, Magnesium, Sodium etc (SRK 1989; Consultburo1997).
9	Lower Letsitele downstream of the R529 bridge crossing to upstream of the confluence with the Groot Letaba	Preferred DWAF mon. points: B8H010Q01 Letsitele River at Mohlabas Reserve **(RC and PES)** WQ = Site 4 (upstream of Letsitele tank and downstream of bridge crossing) EWR = Site 2 (Letsitele tank) Biomonitoring site: Letsitele tank (BIO 2)	Predominantly urban/domestic water use with little cultivated lands. Noted is the Nkowankowa Sewage works. Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
10	Headwaters of the Middle Letaba to upstream (input) of the Middle Letaba Dam (north of Rotterdam settlement)	Preferred DWAF mon. points: B8H054Q01 Middle Letaba River at Middle Letaba Dam Wall **(PES)** OR Alternatively: B8R007Q01 (Middle Letaba Dam – near dam) WQ = Site 13 no sample taken as river dry (at a bridge crossing) EWR = No site Biomonitoring site: No site	Main land use is dense rural/urban settlements (limited subsistence agriculture, with livestock). Very dry landscape. Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
11	Downstream of Middle Letaba Dam (output) to upstream of confluence with Klein Letaba	Preferred DWAF mon. points: B8H056Q01 (Middle Letaba Dam on Middle Letaba River – Downstream) WQ = Site 12 no sample taken (after dam wall) EWR = No site Biomonitoring site: No site	Main land use is dense rural/urban settlements (limited subsistence agriculture, with livestock). Water quality impacts relating to sewage effluent leading to eutrophication. WQ problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
12	Upper/headwaters of the Klein Letaba upstream of the confluence with the Middle Letaba River	Preferred DWAF mon. points: No current monitoring point (Brandt, pers. comm.). B8H015 Little Letaba @ Rossbach (it was closed in 1978 due to a poor notch layout, but should still give an indication of what the flows where like during that period) WQ = No sample taken	Main land use is dense rural/urban informal settlements (limited subsistence agriculture, with livestock). Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example

WQU no.	**Description**	**Monitoring point data available and used for assessing RC + PES**	**Land use activities and implications for water quality**
		EWR = No site Biomonitoring site: Majosi sewage outflow (BIO 7)	Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
13	Klein Letaba downstream of the confluence with the Middle Letaba to upstream of Giyani (upstream of weir before Elim road bridge crossing)	Preferred DWAF mon. points: B8H033Q01 Klein Letaba at Tabaan **(PES)** WQ = Site 11 EWR = Site 5 (Klein Letaba Malanga) Biomonitoring site: Below Middle Letaba Confluence (BIO 9); Hlaneki Weir (BIO 10)	Mainland use is dense urban settlements and informal settlements, Giyani etc (limited subsistence and cultivated agriculture, with livestock). Noted: number of sewage works and waste disposal sites. Also area for malaria control (high risk area). Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
14	Klein Letaba downstream of Giyani weir at Elim road to upstream of confluence with Groot Letaba	Preferred DWAF mon. points: No monitoring point found (confirmed with DWAF (Brandt, pers. comm.). WQ = Site 9 (just north of Ka-Ngove) and Site 10 (upstream of Mutsondi and Nsama tributary's - no sample taken as dry) EWR = No site Biomonitoring site: Below Giyani Sewage Works (BIO 13); Giyani Elim road bridge (BIO 8); Kremetart Big Tree (BIO 12)	Main land use is dense urban settlements and informal settlements, Giyani etc, with domestic effluent (limited subsistence and cultivated agriculture, with livestock). Noted: number of sewage works and waste disposal sites. Also area for malaria control (high risk area). Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998).
15	Headwaters of Molotsi River to upstream of the confluence with the Groot Letaba	Preferred DWAF mon. points: No point exists. WQ = Site 8 (no sample taken – at R529 bridge crossing to Giyani - river dry) EWR = No site Biomonitoring site: Below Modjadji Dam (BIO 17); Modjadji bridge (BIO 18), Sekhiming bridge (BIO 19); Dzumeri Weir (BIO 20)	Main land use is rural informal settlements, Ka-Dzumeri (limited subsistence and cultivated agriculture, with livestock). Very dry landscape. Headwater region of Molototsi has cultivated lands with formal settlements. Water quality impacts relating to sewage effluent leading to eutrophication. Water quality problems relating to, for example Total inorganic nitrogen, dissolved oxygen etc (SRK 1989; Consultburo 1998)

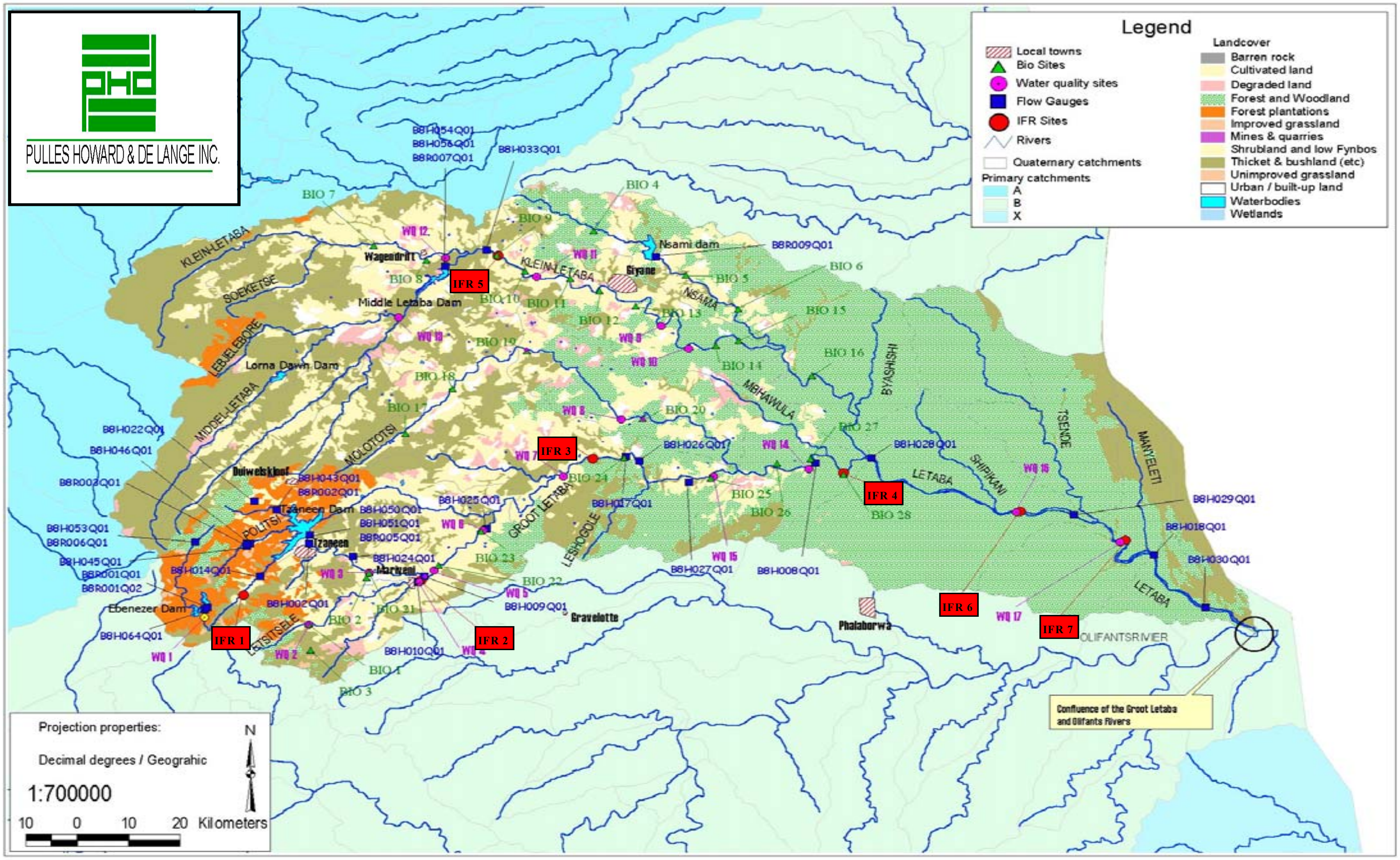


Figure 6.1: Land-use map of the Letaba catchment area showing water quality, EWR, DWAF monitoring and biomonitoring sites.

7. HABITAT INTEGRITY

7.1 INTRODUCTION

Engelbrecht and Kleynhans (1994) undertook an assessment of the conservation status of the Groot Letaba River during 1994. The assessment was undertaken as a component of the Letaba River Instream Flow Requirement (EWR) Study. The method used for the 1994-conservation status report of the Groot Letaba River was developed by Kleynhans (1996). This report was the first time that the methods had been described as the Index of Habitat Integrity (IHI).

The 1994 assessment of conservation status fell within a critical drought period, which extended from 1991 to 1996. Careful comparisons may be made between the status of the river as observed in the 1994 drought survey and the post flood situation occurring in 2001.

The Groot Letaba River falling between the Tzaneen Dam and the Kruger National Park has been subjected to numerous aquatic surveys since 1994. The most recent of these, was a systematic biomonitoring survey of the Letaba Catchment, which took place in the 2000 - 2001 season. This survey took place after the substantial floods of the 2000 rain season. The results of this biomonitoring survey were captured in the Letaba and Luvuvhu River Systems, State of River Report (2001).

In January 2001, a hippo and crocodile census was undertaken within the Groot Letaba River Catchment (Rodgers and Angliss, 2001). This survey was undertaken by helicopter and permitted the additional assessment of the Groot Letaba River Habitat. Although desirable, the habitat integrity of the river was not included in the 2001 State of Rivers Report due to time constraints. Numerous tributaries to the Letaba River were filmed during January 2001 for the purposes of determining the IHI of each.

7.2 APPROACH

The method employed for this study was essentially that described by Kleynhans (1996) and in Appendix 1 (Fouche and Moolman 2004).

7.2.1 Sources of information

The Letaba River catchment has been flown several times for the purposes of video recording. The most recent aerial survey was undertaken in January 2003 (Dana Grobelaar, *personal communication*). It was agreed in the Inception Report for the Letaba Comprehensive Reserve (Heath 2004) that the videos available are sufficient to assist with the choice of EWR sites and no extra surveys, or editing of existing videos were undertaken. The KNP video coverage was limited to down to the Black Heron Dam only and consequently aerial photographs and expert knowledge supplied by Dr A Deacon was used for the IHI for the Kruger National Park.

The currently available Letaba videos are as follows:

- 1994: Groot Letaba
- 1994: Nwanedzi
- 1994: Lesitele

- 2001: Letsitele
- 2001: Thabina to Letsitele confluence
- 2001: Molototsi
- 2001: Klein Letaba
- 2001: Middle Letaba - to Dam
- 2001: Groot Letaba - upstream of Tzaneen Dam
- 2001: Groot Letaba - downstream of Dam to sector 31.
- 2003: Groot Letaba above Tzaneen Dam to Black Heron Dam in the KNP.

7.2.2 Data interpretation

During the subsequent viewing of the video material, all assessment data from the survey and the video were transcribed onto field data forms. Information on the following aspects as well as an assessment of the severity of modifications was transcribed for each segment of the river:

Following the method defined by Kleynhans (1996), the instream and riparian components of the river were rated using largely qualitative procedures (See Appendix 1 for details of methods used).

This information was then reviewed subjectively to obtain a better understanding of the impacts occurring along the river length. The final subjective assessment for each segment and river zone was conducted with this background knowledge.

7.3 RESULTS AND DISCUSSION

For the detailed discussion of the results of the habitat assessment of the Groot Letaba and major tributaries see Appendix A (Fouche and Moolman 2004, Figures 7.1 to 7.7).

7.3.1 Groot Letaba instream and riparian habitat integrity

Instream

Above Ebenezer Dam the source waters of the Groot Letaba, including the Broederstroom River are considered as a largely modified (D) river (Figure 7.2). The streams pass through the Magoebaskloof forest area and past the village of Haenertsburg prior to entering the dam.

The instream habitat diversity is almost devoid of indigenous fish and has a poor invertebrate assemblage. Sedimentation has significantly reduced the benthic habitat for both fish and invertebrates. Alien fish, predominantly bass and trout heavily infest the streams.

The Ebenezer Dam is located at the confluence of the Helpmekaar and Broederstroom rivers on the Groot Letaba River. The dam was built to meet domestic water demands of Tzaneen and Polokwane and its environs as well as to provide for irrigation downstream.

The combined impact of Ebenezer Dam and the numerous smaller dams and forestry has a serious impact on the flow regime and the instream habitat is moderately modified (D) down to the Tzaneen Dam.

The Tzaneen Dam was commissioned in 1977 and was constructed to meet the irrigation water demands along the Groot Letaba River valley. The irrigation water is released directly to the Groot Letaba River by means of a system of pipe outlets. The released water is abstracted directly from the river by pump irrigators and also diverted from the river by five large diversion weirs. The weirs also serve of providing reserve storage and the water is conveyed from these weirs to the irrigators by means of a bulk water supply canal. The instream habitat is seriously modified (E) below the Tzaneen Dam and ranges between seriously and moderately modified (D) due to the large surface area of the Letaba River being impounded by weirs, the flow regime being modified due to irrigation requirements and the large number of villages along the river in the former Gazankulu. Water quality in this unit is rated as moderate, due to the influence that Tzaneen Dam has on regulating water temperature. The effect of fertilizers and pesticides increases along the rivers length.

The instream habitat assessment improves to moderately modified in the lower Letaba River from the vicinity of the Letaba Ranch (a nature reserve) and throughout the KNP. The major reason for the relatively low Instream habitat assessment scores in the KNP is due to the reduction in flow, due to upstream influences, continues to impact on the local fauna and on the aesthetic appeal of the area, and sediment entering the KNP from both the Klein Letaba and the Groot Letaba is influencing the aquatic habitat. The crocodile population at the bottom reaches of the Letaba River is threatened by the frequent cessation of flows of both the Letaba and Olifants rivers.

Riparian

The riparian habitat integrity above the Ebenezer Dam is seriously modified (E) due to banana and citrus plantations, exotic vegetation, numerous small in and off channel storage, trout dams and forest bridges. Furthermore informal settlements are scattered throughout the area and erosion from plantations and forest tracks are also problem.

The riparian habitat integrity below Ebenezer Dam and down to Tzaneen Dam ranges from moderately to largely modified (C/D). The river continues to pass through the exotic forestry area, but there are areas of spectacular indigenous forest.

The riparian zone in this unit is narrow and dominated by trees associated with bedrock such as Mingerhout *Breonadia salicina*. Other large specimens of indigenous riparian trees occur but these do not form a large canopy structure as is evident in the alluvial sections. Common species here include *Acacia sieberiana Bridelia micrantha* and *Syzigium cordatum.* Alien plant invasion is evident all along this unit with dominant species including pines *Pinus* sp., Bluegums *Eucalyptus* sp. as well as Giant reed *Arunda donax, Lantana camara*, Bugweed *Solanum mauritianum* and seringa trees *Melia azederach*.

The riparian habitat integrity below Tzaneen Dam to the Letaba Ranch area is seriously modified (E). This is due to the following:

- the surrounding area is dominated by extensive citrus and banana plantations, which closely border the riparian zone.
- exotic vegetation within the riparian zone is not as problematic as in both the upper and downstream units. Exotic species identified by the air survey team again included *Lantana camara*, Eucalyptus sp., Giant Reed *Arunda donax*, Jacaranda *Jacaranda*

mimosifolia, Mauritius Thorn, Acacia sp., Bugweed *Solanum mauritianum*, Paraffin Bush, Bamboo, Sisal, and others.

In the lower reach (GL8) due to a large number of villages along the river in the former Gazankulu the riparian vegetation decreases in status (E). Castor oil, Lantana and Cocklebur are the dominant exotic plants. There is some serious bank, sheet and donga erosion occurring in lower segments. Large numbers of cattle tracks lead to the river and in places rural agricultural plots extend into the river.

Within the Letaba Ranch and KNP the riparian vegetation status ranges from (C to D, Figure 7.3). In this section of the river many of the flood terraces were removed or scoured during the 2000 floods. Where terraces remain, the riparian forest structure has been severely impacted with only remnant populations of pre-flood species occurring. Virtually no tall canopy forest occurs and large riparian trees and tree thickets are restricted to isolated pockets that were protected from the flood scour. Establishing seedlings and coppices from some of the broken tree stumps left behind following the floods of 2000 suggest that the riparian zone is re-establishing and recovering in certain areas respectively. Flow modification in these lower reaches of the river is however is likely to influence the extent and rate of the recovery of the riparian zone. Exotic vegetation does occur but is not considered a serious problem at this time. Castor Oil, Cocklebur and *Sesbania punicea* occur in low volumes.

7.3.2 Letsitele instream and riparian habitat integrity

The upper catchment of the Letsitele River extending from the source in the Wolkberg mountain area of the Drakensberg, past state forests and waterfalls to Craighead Agricultural Estates. The area is largely natural with the instream and riparian habitat assessment values largely natural (B).

The Letsitele River from Craighead Agricultural Estates to the confluence of the Groot Letaba River is seriously to critically modified for both instream and riparian habitats (Figure 7.4 and 7.5, E/F). The resource unit passes through commercial citrus, mango, avocado, paw paw and banana orchards, rural settlements and communal lands before reaching Letsitele town. Riparian vegetation cover is very variable in condition and is considered to be in a moderate condition for the whole unit. Some areas are denuded of vegetation and have extensive erosion, while others have much better vegetation. Exotic vegetation is present along the full length of the river and includes Lantana, Eucalyptus, Giant Reed, Jacaranda, Mauritius Thorn, Acacia spp., Bugweed, and Paraffin Bush. There is a sewage works below Mohlaba’s location, sand mining near Khujwana and several fords across the river.

The instream habitat is typically pool riffle sequences. However, pools and weir backwaters are heavily silted. There are 10 weirs of assorted sizes and there are numerous pumps and off channel storage dams in the upper portion of the unit. Water abstraction is considered a large to serious impact for the whole of the Letsitele River Catchment Several species of flow dependent fish occur in this unit. Water quality impacts include solid waste disposal, salination and release of biocides, together with rural settlement run off.

7.3.3 Thabina instream and riparian

The upper Thabina River, from source to the Thabina Dam is a mountain stream extending from the Wolkberg region of the Drakensberg Mountains. It feeds into the Thabina Dam in the Provincial Thabina Nature Reserve. In this reserve, there is critical infestation with Paraffin Bush and other alien plant invaders. The area is moderately modified for both instream and riparian habitat (C, Figure 7.4 and 7.5).

Below the Thabina Dam the instream habitat varies from largely to moderately modified (D to C). Only seepage flow and spilling floodwaters is released from the dam. Below the dam, water is abstracted for domestic use.

Water abstraction is considered a large to serious impact for Thabina River catchment. Extending from the wetland to the Letsitele River, there are 4 weirs and numerous pumps and road crossings. Water quality impacts are likely to be due to flow regulation.

Water quality related to elevated temperature and low oxygen levels is due to the dam, operational procedure of the dam, rural communities along the river and rural agricultural practices.

Below the Thabina Dam the riparian habitat varies from moderately to largely modified (C to D).

Immediately below the dam, there is a small-protected area where the riparian vegetation is exceptional. However, below this, there has been extensive vegetation removal and there is massive erosion (donga, sheet and bank). Agricultural plots extend right into the river channel. Cattle tracks to the water are common.

There is an extensive wetland area, which was perceived to be an important wetland area, which contributed towards the biodiversity of the catchment while performing all normal wetland functions. The wetland was dominated by reeds and bulrushes and contained numerous deep pools with water lilies. After the 2003 drought the wetland is barely discernible from other cattle grazing areas. The drought period combined with flow regulation most probably contributed towards this decline. Villages and agricultural plots immediately adjacent to the river and erosion and dongas contribute sediment to the river and pool habitats are clearly silted up.

7.3.4 Molototsi instream and riparian

The instream habitat of the Molototsi River varies from moderately to largely to modified (C to D, Figure 7.6 and 7.7). The upper catchment of the Molototsi River extends from its source near Duiwelskloof to the Modjadji Dam. The area is predominantly ex Gazankulu homeland and is comprised of rural settlements and agriculture. The locality of the Modjadji Dam and water abstraction are thought to pose a serious impact on the functioning of the downstream Molototsi River. There is only one disused weir below Dzumeri and water abstraction by local people is through sand points dug manually into the sandy river channel.

The instream habitat assessment (C to D) is probably an over estimate as the Molototsi River is annually dry for most of the winter months and no winter instream assessments are possible. The seasonal nature of this sandy river does not lend itself to biomonitoring. Nevertheless, hardy pool dwelling species do persist in the larger permanent pools scattered along the river at bedrock intrusions. Several tributaries enter the Molototsi and at the junction to these rivers, there is often a deep pool, which acts as a refuge for fish.

The riparian habitat of the Molototsi River is largely modified (D) and highly variable due to the large areas of former homeland (Gazankulu) through which the river passes. Limited Exotic vegetation has been recorded in this section of the river. Castor oil, Lantana, Bugweed and Cocklebur are the dominant exotics. The river is deeply incised and has areas of extensive erosion. While some rural agriculture exists along the river, the region is predominantly used for rural cattle farming. Cattle tracks to the river have contributed to serious donga erosion. Bank erosion is highly evident on the rivers bends. Several roads and bridges traverse the river.

Below Dzumeri, the river passes through relatively undisturbed mopani bushveld.

7.3.5 Klein Letaba instream

The instream habitat of the Klein Letaba River is largely modified (D, Figure 7.6). The instream habitat is limited to meandering sandy runs and gravel riffles and occasional pools near bedrock outcrops. Marginal vegetation occurs where the river flow approaches the banks and in this habitat a moderate fish and invertebrate community was recorded in the 2000 biomonitoring survey.

However, the impact that Middle Letaba Dam has on the catchment is thought to be severe. The dam does not cater for any releases of flow for the environment, although seepage flow may help maintain some permanent

Return flows from Giyani Sewage Works are considered a major water quality problem, but the only other real impacts are those stemming from agricultural biocides and from rural run off.

Large permanent pools marginal vegetation and undercut banks provide for most lowveld pool dwelling fish species. The migration passage from the Letaba River is open.

7.3.6 Klein Letaba riparian

The riparian habitat of the Klein Letaba River improves from largely modified (D) to largely natural (B, Figure 7.7).

The upper Klein Letaba River (D) passes through the old homeland are of Gazankulu. Cattle farming dominate this area, although there are a number of settlements and low cost housing projects close to the river. There is extensive overgrazing and erosion. A small sewage treatment plant discharges into the river at Majosi. Many tracks occur along the river, bridges, crossings and areas of sand mining occur. This resource unit also encompasses a large area of commercial agriculture that is irrigated from the Middle Letaba Irrigation Scheme. This scheme grows banana’s paw paw, avocado’s and mangos while also providing for some market garden crops. Immediately below Giyani is an old sisal project and a dairy farm.

Extensive subsistence cultivation and vegetable gardening occurs right up to the edge of the macro-channel and within the remnants of the riparian zone throughout this unit. Most riparian shrub and smaller tree species have been removed while some large fruit bearing trees such as figs (*Ficus syccamorus*) and Jackal Berry (*Diospyros mespilliformis*) remain. There is also evidence of overgrazing on the terraces and on the macro-channel banks and livestock paths and erosion are common throughout. Alien vegetation is dominated by Castor oil (*Sesbania punicea*) Bugweed (*Solanum mauritianum*) and Cocklebur.

In the middle reaches of the Klein Letaba some magnificent areas of bush still exist but the riparian cover is variable and is considered moderate (C) for the resource unit. Well-developed terraces with established riparian tree populations and good canopy and population structure occur along sections of the river throughout this unit. A high diversity of indigenous riparian trees and large specimens of many of the riparian flow indicator species also occur throughout. Exotic vegetation is dominated by Castor Oil, Mauritius Thorn, *Sesbania punicea*, and Cocklebur. Flame thorn is also problematic.

The lower reach of the Klein Letaba to the Groot Letaba River Confluence is largely natural (B) with a large area of relatively unspoiled bushveld and approximately 25 km of the river borders the KNP. There are no major impacts and only a few tracks, fences, disused lands and cattle. The impact of upstream abstraction has not been fully recognized. The riparian vegetation is in a very good condition and there are few exotic plants. The riparian vegetation has a well-developed species and canopy structure throughout apart from along a few sections where the riparian zone narrows or the vegetation is naturally sparse as a result of flow or substrate influence. Only the occasional Castor oil and Cocklebur have been noted on flood damaged terraces.

An important geothermal wetland borders the river at Baleni. This natural Heritage Site discharges into the Klein Letaba and is responsible for maintaining some surface water in this zone. The spring is situated on a geological intrusion, which causes a naturally high salt load in the water at this point.

7.3.7 Middle Letaba instream and riparian

The instream habitat of the Middle Letaba River is largely modified (D, Figure 7.6).

The flows of the Middle Letaba River are largely modified below the Middle Letaba Dam. The dam does not have a facility to release water for environmental flows and the dam has largely been responsible for isolating the Middle Letaba Catchment from The Klein Letaba Catchment. Water quality is moderately impacted by agricultural products.

The deep pools below the dam wall hold a significant population of fish species. At least two species occur in these pools that are thought to be absent in the dam itself (*Synodontis zambezensis* and *Schilbe intermedius*). At least two alien fish species occur in the dam and in the pools below the dam wall (C*yprinus carpio* and *Micropterus salmoides*).

The riparian habitat of the Middle Letaba River improves from largely modified (D) to moderately modified (C, Figure 7.7).

Two distinct areas dominate the Middle Letaba upstream of the Middle Letaba Dam. The land use is commercial agriculture, where tomatoes are the target crop and rural homeland areas. The area has numerous instream and off channel storage dams occurring in all major tributaries to the Middle Letaba Dam. The short section of the Middle Letaba River between the dam wall and the Klein Letaba passes through an area of relatively undisturbed bush. riparian vegetation in this area is good below the scour zone and there are few aliens.

7.3.8 Nsama River instream and riparian

The Nsama River extends across the Lowveld just north of Giyani and meets the Klein Letaba just upstream of the KNP fence line. The river is distinctly seasonal but holds a sizeable dam - the Nsami Dam. This dam is linked to the Middle Letaba Irrigation Scheme and Giyani Water Works by the 76km long irrigation canal extending from the Middle Letaba Dam. The Nsami Dam has no release capabilities and spills infrequently.

The instream habitat of the Nsama River is largely modified (D) and the riparian habitat is moderately modified (C, Figure 7.6 and 7.7). The Nsama River passes through ex Gazankulu areas, which are largely used for subsistence farming. Some irrigated bananas occur downstream from Nsami Dam. The riparian vegetation is predominantly in a good condition and the infestation by exotic plants is low.

The lower river supports a large number of deep permanent pools and it is thought that these may act as an important refuge for fish to re colonize the lower Klein Letaba River. The alien fish *Cyprinus carpio* has been recorded well below the Nsami Dam.

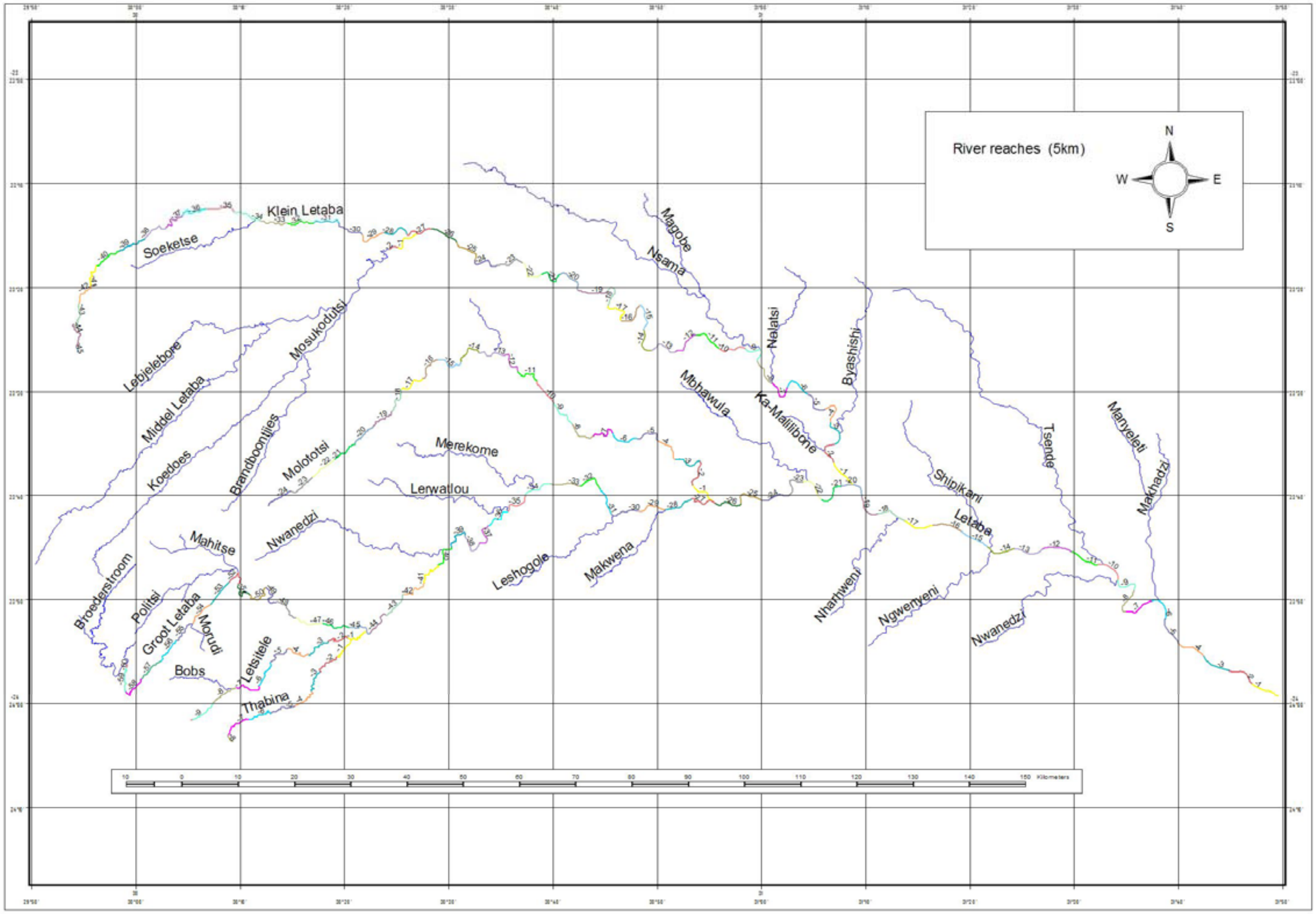
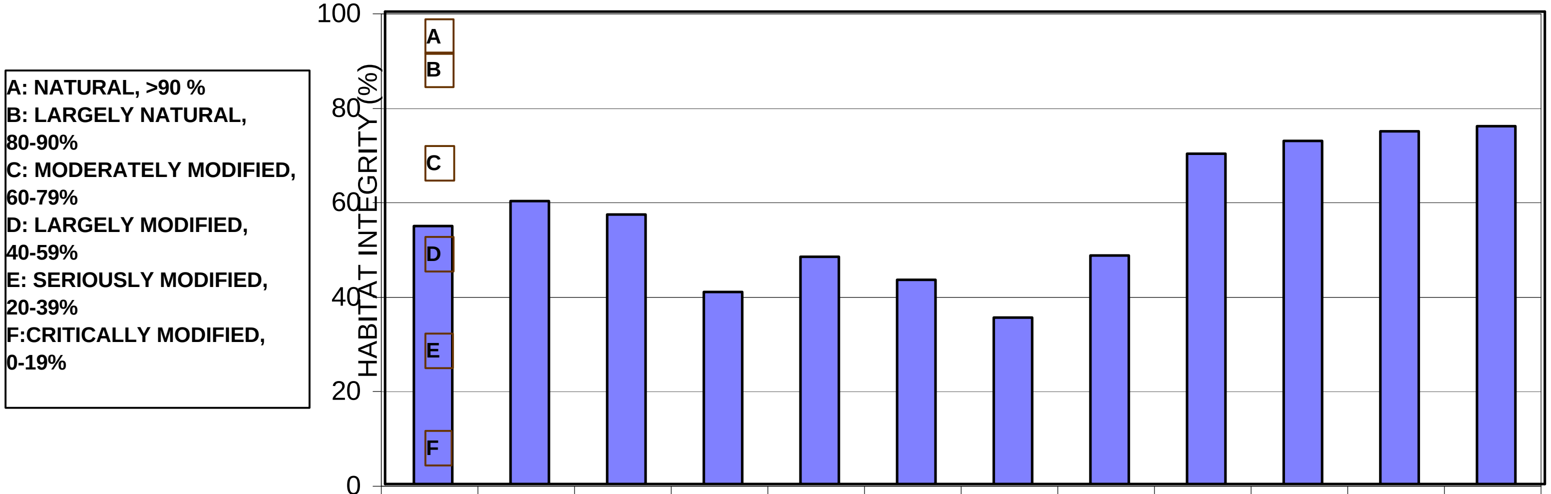


Figure 7.1: Study area indicating 5 km and level II ecoregions

FIG A1: INSTREAM HABITAT INTEGRITY OF THE GROOT LETABA AND LETABA RIVER.

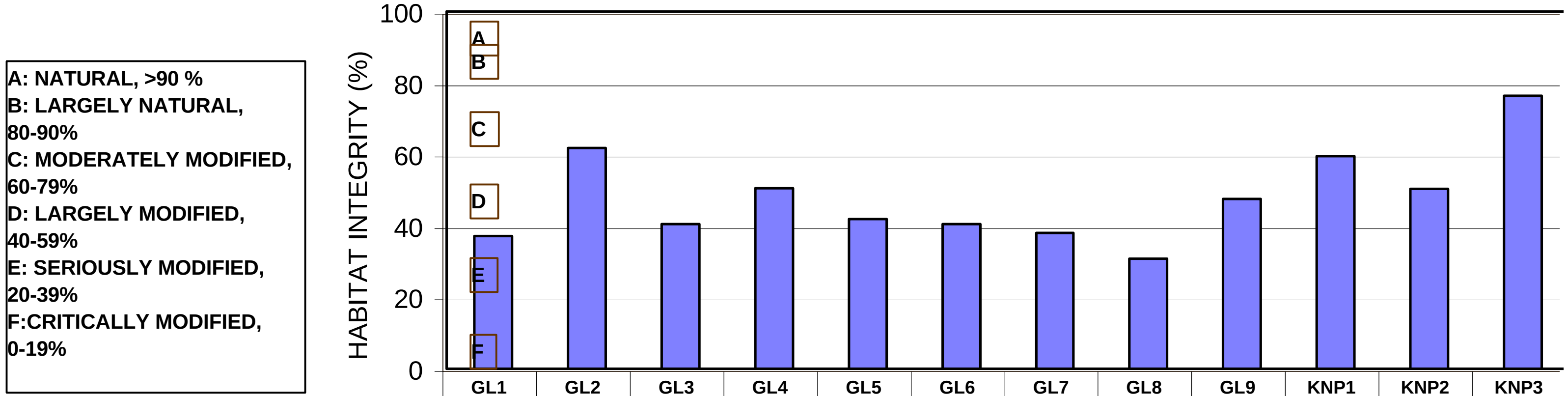


	GL1	GL2	GL3	GL4	GL5	GL6	GL7	GL8	GL9	KNP1	KNP2	KNP3
INSTREAM HABITAT INTEGRITY (%)	55	60	57	41	48	43	35	48	70	73	75	76
WATER ABSTRACTION (IMPACT 1 - 25)	10	8	10	15	15	16	18	12	5	3	0	0
FLOW MODIFICATION ((IMPACT 1 - 25)	12	19	15	18	15	15	16	15	17	17	18	18
BED MODIFICATION (IMPACT 1 - 25)	15	6	12	15	15	13	16	15	5	5	5	5
CHANNEL MODIFICATION (IMPACT 1 - 25)	8	6	7	4	4	4	8	5	5	5	5	5
WATER QUALITY (IMPACT 1 - 25)	8	10	10	10	10	12	12	12	10	8	6	4
INUNDATION (IMPACT 1 - 25)	8	10	12	15	14	15	15	15	1	0	0	0
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	20	13	10	3	1	1	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	25	10	3	3	0	0	0	0	0	0	0	0
RUBBISH DUMPING (IMPACT 1 - 25)	5	3	5	5	3	2	5	3	0	0	0	0

SECTOR NO (---> FLOW DIRECTION)

Figure 7.2: Instream habitat integrity of Groot Letaba

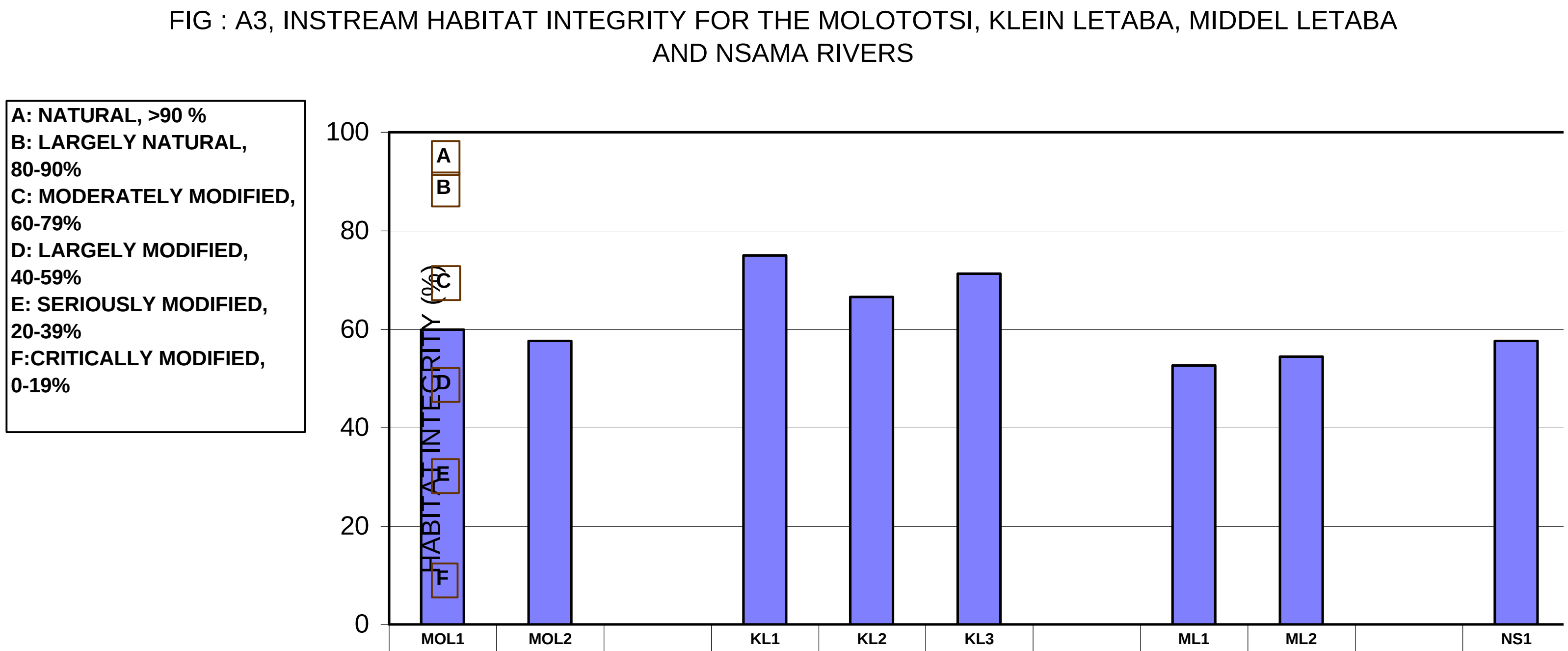
FIG :A2 RIPARIAN ZONE HABITAT INTEGRITY OF THE GROOT LETABA AND LETABA RIVER.



	GL1	GL2	GL3	GL4	GL5	GL6	GL7	GL8	GL9	KNP1	KNP2	KNP3
RIPARIAN ZONE HABITAT INTEGRITY	37	62	40	51	42	40	38	31	48	59	50	76
VEGETATION REMOVAL (IMPACT 1 - 25)	12	8	8	7	10	13	15	16	12	3	3	3
EXOTIC VEGETATION (IMPACT 1 - 25)	18	15	22	10	15	10	15	13	6	3	3	3
BANK EROSION (IMPACT 1 - 25)	13	5	5	7	12	10	15	15	12	12	8	2
CHANNEL MODIFICATION (IMPACT 1 - 25)	8	5	8	6	5	10	5	5	5	3	12	0
WATER ABSTRACTION (IMPACT 1 - 25)	5	5	8	5	5	8	5	5	5	5	5	5
INUNDATION (IMPACT 1 - 25)	10	5	13	10	5	12	10	5	5	5	12	5
FLOW MODIFICATION (IMPACT 1 - 25)	6	10	10	15	10	12	10	12	12	13	13	11
WATER QUALITY (IMPACT 1 - 25)	6	8	8	12	12	10	5	3	3	3	3	3

SECTOR (-> FLOW DIRECTION)

Figure 7.3: Riparian habitat integrity of Groot Letaba

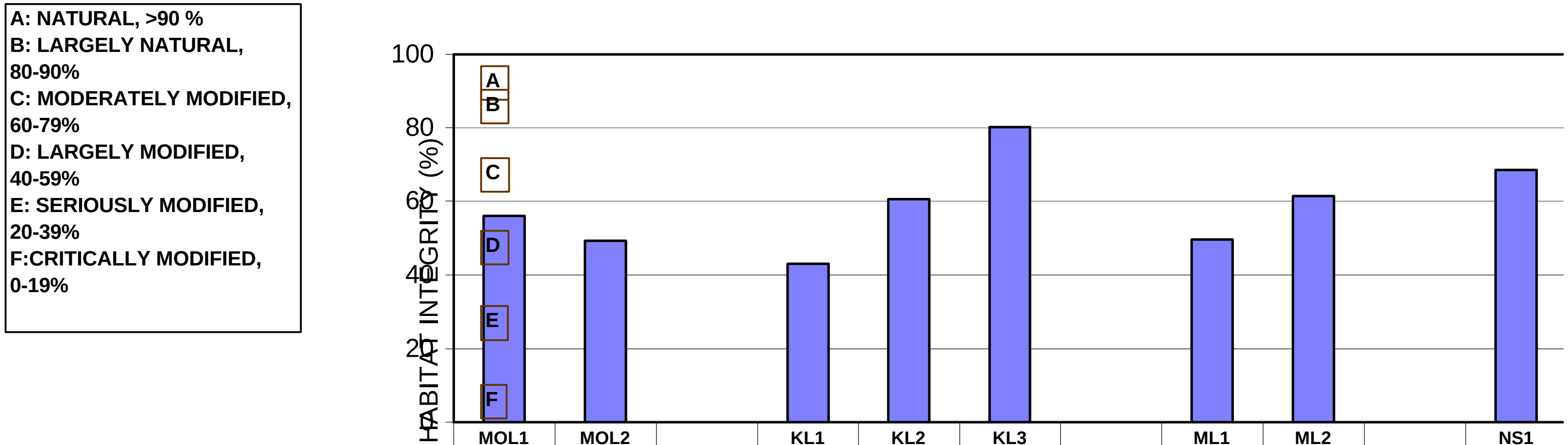


	MOL1	MOL2	KL1	KL2	KL3	ML1	ML2	NS1
INSTREAM HABITAT INTEGRITY (%)	60	58	75	67	71	53	55	58
WATER ABSTRACTION (IMPACT 1 - 25)	14	12	5	5	5	15	15	15
FLOW MODIFICATION ((IMPACT 1 - 25)	15	18	5	18	18	15	20	15
BED MODIFICATION (IMPACT 1 - 25)	10	12	12	5	5	5	8	8
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	5	5	5	5	5	5	8
WATER QUALITY (IMPACT 1 - 25)	4	5	8	10	5	8	8	5
INUNDATION (IMPACT 1 - 25)	10	3	5	5	3	18	5	12
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0	0	0	0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	10	0	0	0	0	8	12	5
RUBBISH DUMPING (IMPACT 1 - 25)	5	3	5	8	1	7	3	3

SECTOR NO (---> FLOW DIRECTION)

Figure 7.4: Instream habitat integrity of Letsitele and Thabina

FIG :A4, RIPARIAN ZONE HABITAT INTEGRITY FOR THE MOLOTOTSI, KLEIN LETABA, MIDDEL LETABA AND NSAMA RIVERS

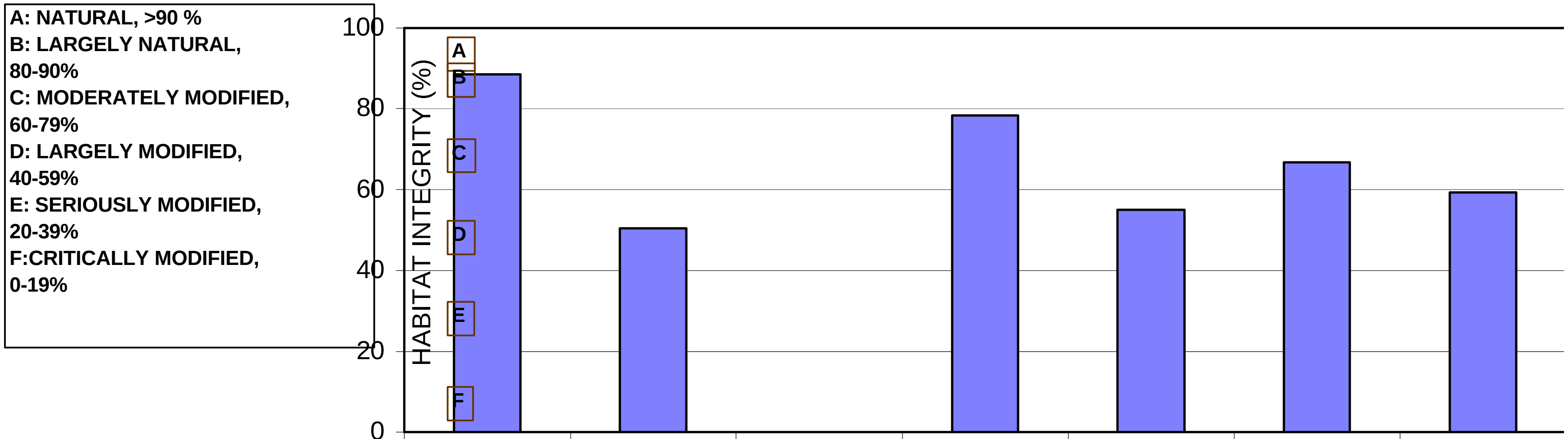


	MOL1	MOL2		KL1	KL2	KL3		ML1	ML2		NS1
RIPARIAN ZONE HABITAT INTEGRITY	56	49		43	61	80		50	61		69
VEGETATION REMOVAL (IMPACT 1 - 25)	15	12		18	10	5		15	5		10
EXOTIC VEGETATION (IMPACT 1 - 25)	12	10		8	10	5		8	8		8
BANK EROSION (IMPACT 1 - 25)	5	15		16	12	10		10	10		10
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	8		4	8	3		10	10		10
WATER ABSTRACTION (IMPACT 1 - 25)	5	5		4	4	2		8	4		5
INUNDATION (IMPACT 1 - 25)	5	5		3	3	2		5	5		10
FLOW MODIFICATION (IMPACT 1 - 25)	5	10		5	10	10		12	15		5
WATER QUALITY (IMPACT 1 - 25)	5	5		5	5	2		5	5		5

SECTOR (-> FLOW DIRECTION)

Figure 7.5: Riparian habitat integrity of Letsitele and Thabina

FIG : A5, INSTREAM HABITAT INTEGRITY FOR THE LETSITELE AND THABINA RIVERS



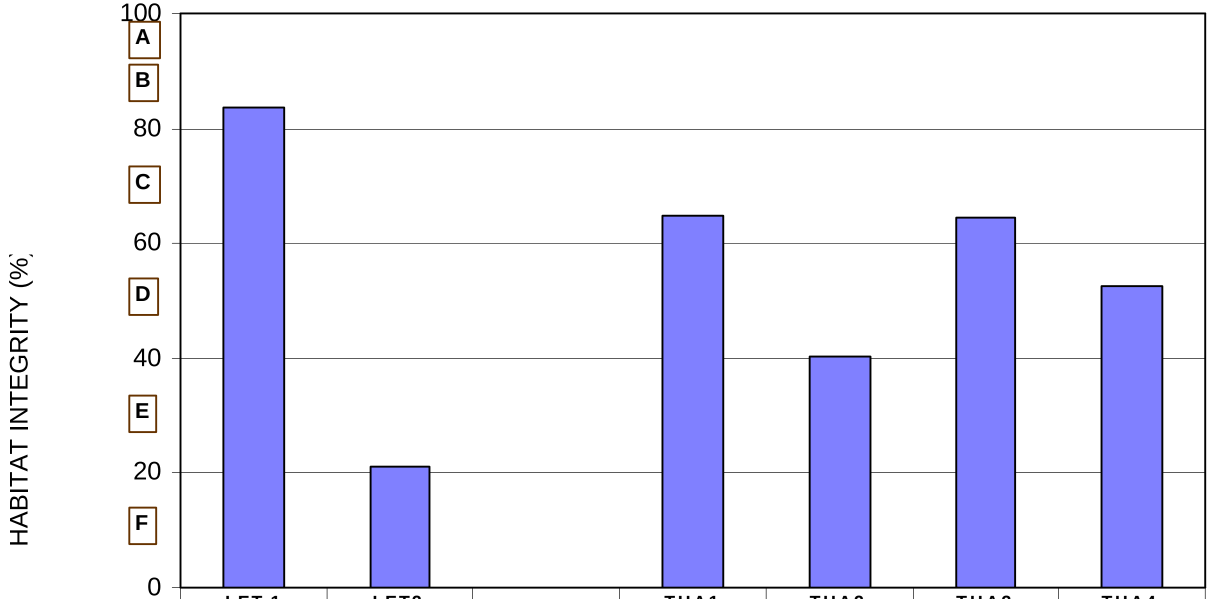
	LET 1	LET2		THA1	THA2	THA3	THA4
INSTREAM HABITAT INTEGRITY (%)	89	50		78	55	67	59
WATER ABSTRACTION (IMPACT 1 - 25)	3	15		3	20	15	12
FLOW MODIFICATION ((IMPACT 1 - 25)	5	15		7	20	15	15
BED MODIFICATION (IMPACT 1 - 25)	5	10		7	5	5	12
CHANNEL MODIFICATION (IMPACT 1 - 25)	5	8		5	5	5	5
WATER QUALITY (IMPACT 1 - 25)	0	12		3	5	5	5
INUNDATION (IMPACT 1 - 25)	5	12		15	5	3	8
EXOTIC MACROPHYTES (IMPACT 1 - 25)	0	0		0	0	0	0
EXOTIC FAUNA (IMPACT 1 - 25)	0	3		0	0	0	0
RUBBISH DUMPING (IMPACT 1 - 25)	0	5		0	5	5	10

SECTOR NO (---> FLOW DIRECTION)

Figure 7.6: Instream habitat integrity of Molototsi, Klein Letaba, Middle Letaba and Nsama rivers

FIG :A6, RIPARIAN ZONE HABITAT INTEGRITY FOR THE LETSITELE AND THABINA RIVERS.

A: NATURAL, >90 %
B: LARGELY NATURAL, 80-90%
C: MODERATELY MODIFIED, 60-79%
D: LARGELY MODIFIED, 40-59%
E: SERIOUSLY MODIFIED, 20-39%
F:CRITICALLY MODIFIED, 0-19%



	LET 1	LET2		THA1	THA2	THA3	THA4
RIPARIAN ZONE HABITAT INTEGRITY	84	21		65	40	65	53
VEGETATION REMOVAL (IMPACT 1- 25)	5	15		5	15	5	10
EXOTIC VEGETATION (IMPACT 1- 25)	10	15		20	12	10	11
BANK EROSION (IMPACT 1- 25)	3	15		3	15	5	14
CHANNEL MODIFICATION (IMPACT 1- 25)	3	5		3	5	5	5
WATER ABSTRACTION (IMPACT 1- 25)	3	5		3	10	5	10
INUNDATION (IMPACT 1- 25)	3	10		3	3	5	8
FLOW MODIFICATION (IMPACT 1- 25)	3	15		3	10	15	3
WATER QUALITY (IMPACT 1- 25)	3	15		3	5	5	3

SECTOR (-> FLOW DIRECTION)

Figure 7.7: Riparian habitat integrity of Molototsi, Klein Letaba, Middle Letaba and Nsama rivers

8. CURRENT OPERATIONAL RULES

The Letaba River runs from the mountainous Heanertsburg area through the Ebenezer dam into the Tzaneen dam; a distance of some 30 kilometres, by way of a fast flowing stream. For more details on the current operational rules and procedures for the Letaba catchment, see Appendix B (PDNA 2005).

8.1 WEIRS

The Groot Letaba Water User Association manages irrigation from the Ebenezer Dam up to the borders with the Kruger National Park. Commercial farmers pump water either from the Groot Letaba River or from one of five irrigation canals. Importantly many of the farmers also have on bank storage dams. An area of 12 500 ha is irrigated annually in the river valley mainly for fruit farming of citrus, mangos and litchis. The area faces a general water imbalance and frequent water restrictions are implemented.

There are three weirs between Ebenezer and Tzaneen Dam. They are all small structures and their purpose is to divert water into structures for abstraction. In sequence from downstream of Ebenezer Dam:

- Georges Valley canal off take (Irrigation for Georges Valley Irrigation Board).
- Tzaneen Municipality off take for Purification Plant.
- Pusela canal off take (Irrigation for Pusela Irrigation Board).

Downstream of Tzaneen Dam for over ± 120 kilometres, to the Kruger National Park (KNP), there are five weirs, namely:

- The Junction weir
- The Yamorna weir
- The Jasi weir
- The Prieska weir
- The Nondweni weir

The operation of these weirs is with the Groot Letaba Water User Association (GLWUA). These weirs are opened and closed by way of manually operated sluices that are frequently blocked by trees, debris, etc. The weirs have limited capacity, having been in use from more than 20 years (with the exception of Nondweni) and are subjected to silt.

The weirs are opened and closed in order to relieve demands for water at any given time at a point where the flow of the river gets too low to deliver 0.6 cumec to KNP, after primary, industrial and irrigation allocation (or rational allocations upstream) have been satisfied.

The object is to obtain water from the nearest weir and then to “refund” the particular weir from either upstream weirs and/or the Tzaneen Dam. This operating procedure has been developed to conserve as much water as possible, in the already over-allocated Tzaneen Dam, in an attempt to lengthen the assured delivery to the downstream users.

These actions are activated through visual inspections and observations by the GLWUA’s water bailiffs, and through messages from various sources along the river and interpreted in view of their (the bailiffs) long experience of the behaviour of the river.

There are therefore no hard and fast rules operational rules.

8.2 DAMS

The DWAF Regional Office has is responsible for implementing the operating rules for Ebenezer and Tzaneen dams (Figure 1.1).

Application of the current operating rules is conducted as follows:

- At the end of each month, the inflow is calculated by comparing the gauged level (current dam level) with the previous month's level, adding the released volumes and the calculated evaporation. The previous 12 months of the inflow record are then compared with the long-term history of inflow into the dam.

- A primary reserve for domestic and industrial use sets the lower monthly limits below which no releases for irrigation will be made.

These trends are produced graphically on an Excel spreadsheet and discussed with the irrigators who apply their own restrictions during declining dam volumes in order to minimize the risk of reaching the minimum reserve levels.

A proposed new dam (N'wamitwa Dam) has been evaluated as a possible development option on the Letsitele River. However, improved operating techniques appear to offer a more favourable option compared to the construction of new dams for the present.

Dap Naude Dam

The Dap Naude Dam is located in the upper reaches of the Groot Letaba, above Ebenezer Dam (Figure 1.1). The purpose of the dam is exclusively to meet part of the domestic and industrial water demand of Polokwane via a 60 km gravity pipeline. The dam was commissioned in 1958 and is controlled and operated by Polokwane Municipality. The releases are controlled by a system of valves, which close automatically as soon as the service reservoir is full. A constant amount of 28 l/s (0.88 Mm^3 /a) is released from the dam as compensation.

Ebenezer Dam

Ebenezer Dam is located at the confluence of the Helpmekaar and Broederstroom rivers on the Groot Letaba River (Figure 1.1). The dam was built to meet domestic water demands of Tzaneen and Polokwane and its environs as well as to provide for irrigation downstream. It is owned and operated by DWAF and it was built in 1959.

Water to Tzaneen is released directly into the stream and is pumped from an abstraction point some 15km downstream. Water supply to Polokwane is released to a purification works just below the dam from where it is pumped to a header reservoir before being gravitated to Polokwane.

Irrigation water is released downstream and is either abstracted by direct pumping from the river or by diversion to the George’s Valley or Pusela Weirs, approximately 10km and 18km downstream of the dam respectively.

Magoebaskloof Dam

The Magoebaskloof Dam is located on the Politsi River, a major tributary of the Groot Letaba River (Figure 1.1). The Magoebaskloof Dam was constructed to supply urban and industrial consumers, members of the now disbanded Tzaneen Irrigation Board and Sapekoe. The latter two are irrigation water users. The Magoebaskloof Dam was originally intended to supply water for irrigation purposes only, however, the need later arose for domestic and industrial water in Politsi, Duiwelsskloof and Ga-Kgapane.

Water is released from the bottom outlets of the dam into a canal where it is conveyed to the users. Some of the irrigation users draw their water directly from the canal. The bulk of the water released from Magoebaskloof Dam is for irrigation. Water releases are therefore, to a large extent, dictate by irrigation needs.

Allocation from the dam totals 13.1 Mm^3/a, which is broken down as follows:

- Domestic use 2.034 Mm^3/a
- Agricultural use 11.044 Mm^3/a

Middle Letaba Dam

The Middle Letaba Dam is located on the Middle Letaba River about 7 km upstream of the confluence of the Middle and Klein Letaba rivers (Figure 1.1). The dam was constructed to meet irrigation, domestic and stock water demands. Domestic water from the dam also augments water supplies from Hudson Ntsan’wisi Dam (now called Nsami Dam) located throughout Giyani area in Limpopo Province.

The Middle Letaba Dam was commissioned in 1984 by DWAF. Water required to meet both irrigation and domestic water demands is released from the dam via an outlet tower and outlet works from a canal.

Tzaneen Dam

The Tzaneen Dam was commissioned in 1977 and is owned and operated by the DWAF (Figure 1.1). The Tzaneen Dam was constructed mainly to meet the irrigation water demands along the Groot Letaba River valley. The irrigation water is released directly to the Groot Letaba River by means of a system of pipe outlets. The released water is abstracted directly from the river by pump irrigators and also diverted from the river by diversion weirs and through a series of bulk water supply canals.

Nsami Dam

The Nsami Dam was commissioned in 1976 and is owned by the Department of Works (Figure 1.1).

The Nsami Dam is located on the Nsami River, a major tributary of the Klein Letaba River. The dam is sited about 10 km north of Giyani. The Nsami Dam was initially intended to supply water mainly for domestic use. Water is drawn from Nsami Dam to irrigate some of the hectors located downstream of the dam. Irrigation is drawn from Nsami Dam through the bottom outlets and discharge to an irrigation canal located downstream of the dam.

Kruger National Park dams

There are four dams within the Kruger National park that are used exclusively for animal watering. These are the Black heron, Mingerhout, Shimweni and Engelhard Dams. The Engelhard dam has a fishway that operates under high flow conditions.

The weirs and dams of the Groot Letaba are opened and closed to deliver 0.6 cumec to KNP, after basic human needs, primary, industrial and irrigation allocation (or rational allocations upstream) have been satisfied.

9. RESOURCE UNITS

91 RESOURCE UNITS CONSIDERATIONS

All the information collated was overlain on maps (Figures 9.1 to 9.7) and the rationale for the decision is provided below.

The following were considered when selecting the Resource Units (RU):

- Ecoregions (Chapter 4)
- Geomorphological classification (Chapter 5)
- Water quality (Chapter 6)
- Operation of the system (Chapter 8, Appendix B)
- Hydrology (Haumann 2005, DWAF Report No.RDM/B800/01/CON/COMP/1104)
- Habitat integrity assessment (Chapter 7)
- Local knowledge and expert judgement (DWAF regional office and local conservation organisations)

9.2 RATIONALE FOR AND DESCRIPTION OF RU

9.2.1 Groot Letaba River RU A: Source to Tzaneen Dam

This RU consists of the Groot Letaba River from it source above Dap Naude Dam, to Ebenezer Dam and down to Tzaneen Dam as indicated in Figure 9.1 (Segments GL1 to GL3).

This RU A consists of the following:

- Segment 60 to 52
- Two Ecoregion Level II with a break at Tzaneen Dam.
- Geomorphological Zones 1a, 1b and 2
- Instream habitat integrity (D)
- Riparian habitat integrity (E to C)
- The Ebenezer Dam releases water into the Letaba River via a sleeve valve

The catchment above Ebenezer Dam, which includes the Dap Naude Dam, is small and could be used as a RU but in relation to the rest of the study area, the length of this potential RU is irrelevant. The upper Letaba River catchment is highly afforested. The Geomorphological macro-reaches in this RU are representative of a river that flows over and off the upper steep escarpment and the river drops from 1500 to 800 masl. There are three weirs between Ebenezer and Tzaneen Dam (Section 8.1). They are all small structures and their purpose is to divert water into structures for abstraction for irrigation and water supply to Tzaneen Municipality. Due to the short length of this RU (30 km), and the many similar structures in the Groot Letaba River, these weirs were not considered important enough to subdivide this RU. The Tzaneen Dam due to its large size and being instream it makes a logical end point to this RU.

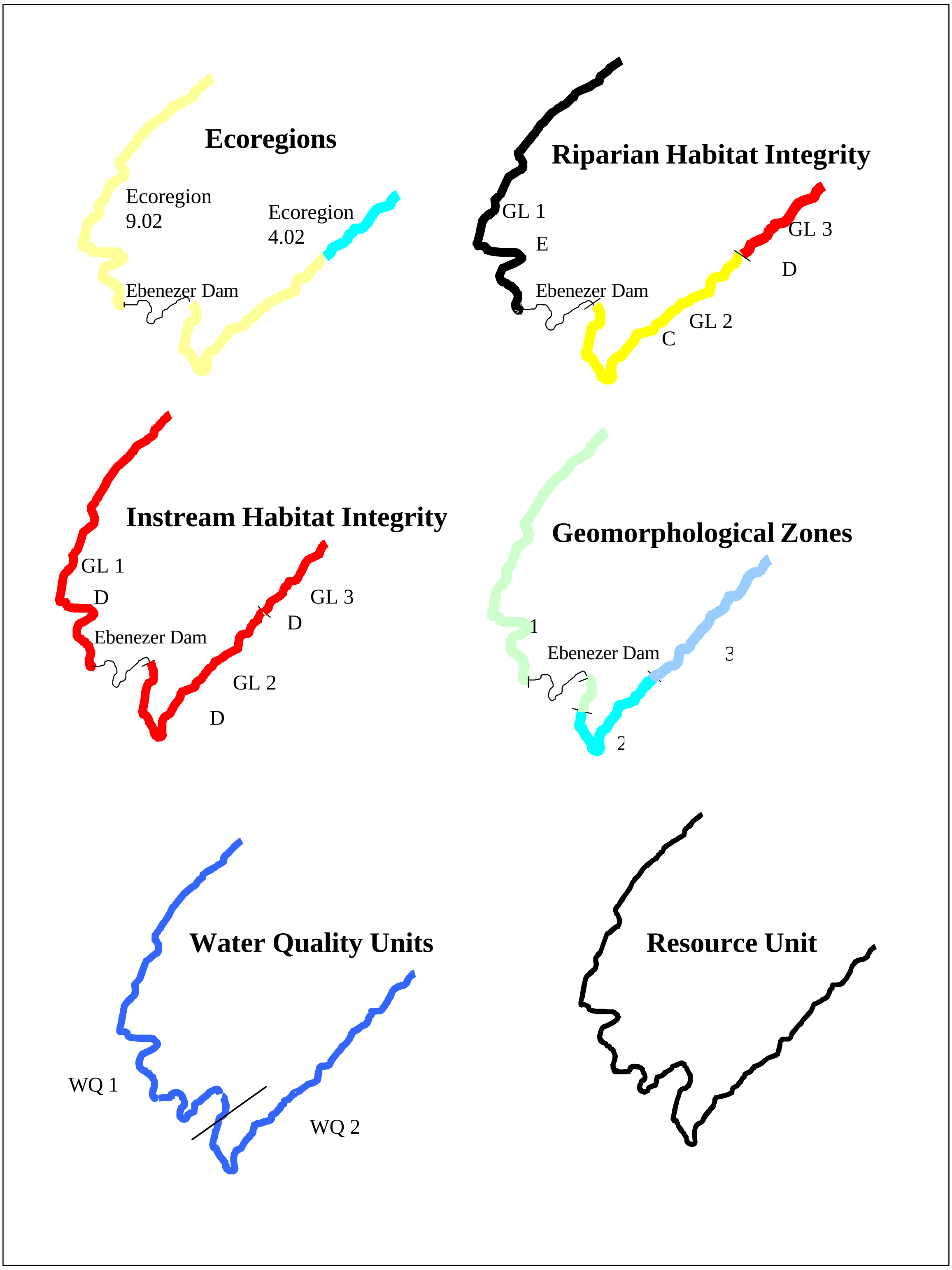


Figure 9.1: Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of upper Groot Letaba River to Tzaneen Dam.

9.2.2 Groot Letaba Resource Unit B: Tzaneen Dam to Prieska Weir

This RU consists of the Groot Letaba River from the Tzaneen Dam to Prieska Weir (Figure 9.2, Segments GL4 to GL6).

This RU consists of the following:

- Four Ecoregions Level II.
- There are three Geomorphological Zones 3, 4 and 5
- Instream habitat integrity (D)
- Riparian habitat integrity (D)
- The Tzaneen Dam consists of a complex operational rules and is driven by irrigation demands downstream as well as KNP releases.

Downstream of Tzaneen Dam to the Prieska Weir there are four weirs, namely:

- The Junction weir
- The Yamorna weir
- The Jasi weir
- The Prieska weir

This RU starts at the Tzaneen Dam (600 masl and ends some 104 km later at an altitude of 400 masl). Downstream of Tzaneen Dam the channel pattern is pool/riffle with occasional small bedrock anastomosing sections. Bedrock influence in the channel is high. However, at the lower end of the zone, more alluvial-influenced channel patterns begin to occur due to the influence of the Yamorna Weir. In macro-reach 4 (600 to 340 masl) is dominated by Swazian gneiss geology. The channel pattern changes to a more alluvial-influenced mixed pool/rapid channel type. Bedrock influence remains high in the active channel, but instream depositional features, such as bedrock core bars, as well as lateral deposits of sediment, are more common. Both these features and the macro-channel banks are well-vegetated. Zone 4(b, 98kms) maintains a strong in-channel bedrock influence and mixed pool/rapid and bedrock anastomosing channel patterns are common. Further downstream, as more sediment is introduced from lowveld tributaries, the more alluvial channel patterns of braiding and alluvial single thread occur.

This RU is divided at the upper section by the Tzaneen Dam and the lower end by the Prieska weir. The majority of this section of the Letaba River lies in one ecoregion and one geomorphology zone. The first, or upper section, below Tzaneen Dam which has three ecoregions and two geomorphological zones section of river which lies in different zones and ecoregions is too small to warrant its own RU. The water quality in this section of the river is driven by the flow releases from Tzaneen Dam and the irrigation usage from the 4 weirs.

9.2.3 Resource Unit C: Groot Letaba from Prieska weir to the confluence with Klein Letaba River

This RU consists of the Groot Letaba River Prieska weir to the confluence with Klein Letaba River (KNP boundary, Figure 9.2, Segments GL7 to GL9).

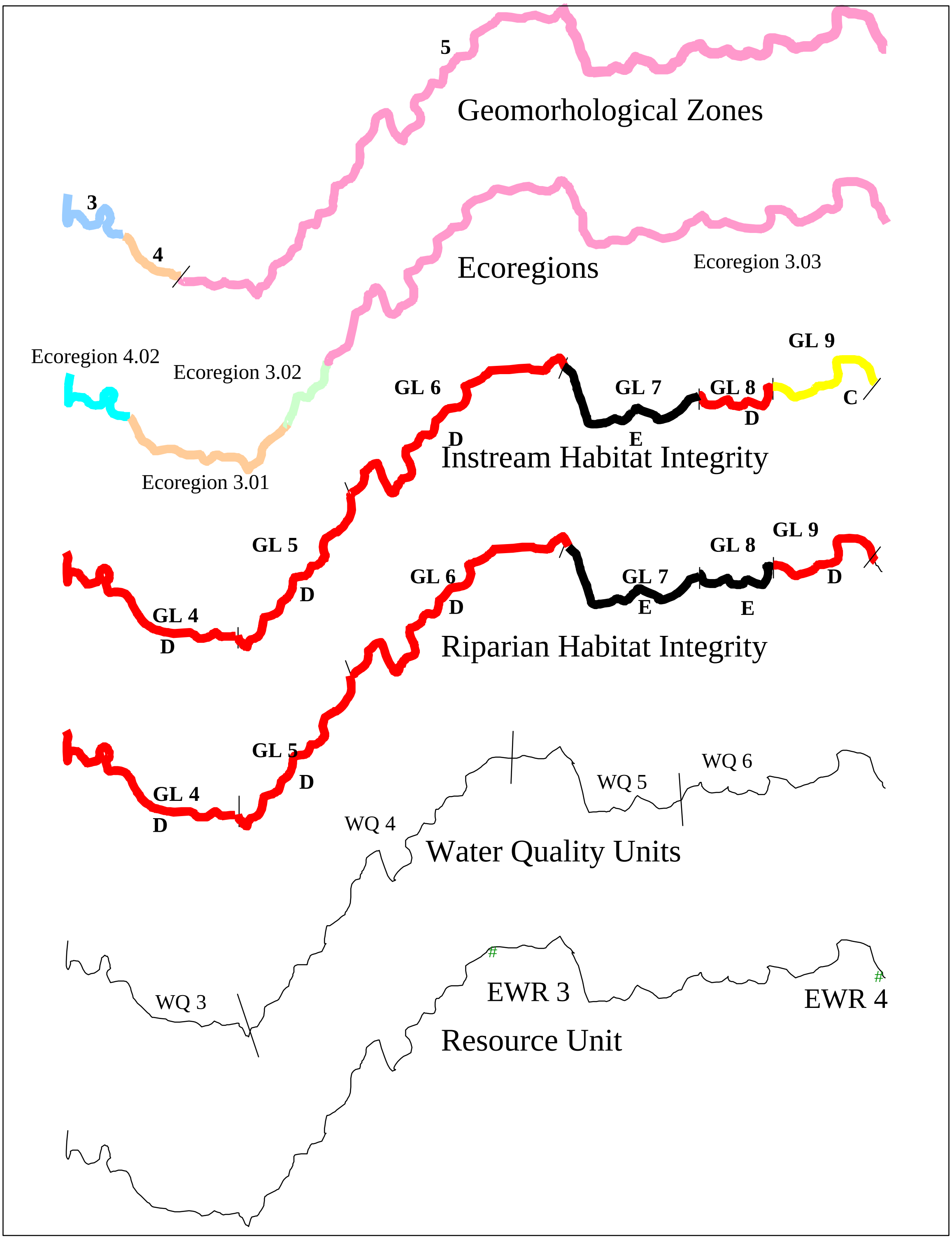


Figure 9.2: Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of Groot Letaba River from Tzaneen Dam to the confluence with the Klein Letaba River. EWR 2 is on the Letsitele River.

This RU consists of the following:

- One Ecoregions Level II.
- There are two Geomorphological Zones 5a and 5b
- Instream habitat integrity (E to C)
- Riparian habitat integrity (E to D)

- This section of the river system consists of a complex operational rules and is driven by irrigation demands downstream as well as KNP releases.

- This section of the river is approximately 40 km to the confluence with the Klein Letaba at the Kruger National Park (KNP) and consists of one weirs namely the Nondweni weir

This RU starts at some 400 masl and ends some 40 km later at an altitude of 297 masl. Zone 5(a) represents the river below 340 masl until the confluence with the Klein Letaba (37kms downstream) is the dominant by Swazian gneiss geology. The confluence with the Molototsi provides a locally high sediment load to the main channel, but this soon reverts back to the sandy braided sections interspersed with bedrock pool-rapid sections seen upstream.

This RU is divided at the upper section by the Tzaneen Dam and the lower end by the confluence with the Klein Letaba River. The majority of this section of the Letaba River lies in one ecoregion and one geomorphology zone. The first, or upper section, below Tzaneen Dam which has three ecoregions and two geomorphological zones section of river which lies in different zones and ecoregions is too small to warrant its own RU. The water quality in this section of the river is driven by the flow releases from Tzaneen Dam and the irrigation usage from the 5 upstream weirs.

9.2.4 Resource Unit D: Groot Letaba from confluence with Klein Letaba River to the confluence with the Olifants River

This RU consists of the Groot Letaba River from the confluence with the Klein Letaba River to the confluence with the Olifants River (Figure 9.3, Segment GL9, KNP 1 to 3). This RU consists of the following:

- Four Ecoregions Level II.
- There are two Geomorphological Zones 5b and 6
- Instream habitat integrity (C)
- Riparian habitat integrity (D to C)
- The Tzaneen Dam has an operating rule that is driven by irrigation demands and KNP obligations

The RU is approximately 100 km long and originates at 297 masl until its confluence with the Olifants River at 140 masl.

The major tributary in this RU is the Klein Letaba that alters the channel pattern by the high sediment inputs from the Klein Letaba. Zone 5(b) extended for 90kms from the confluence with the Klein Letaba until 180 masl. This zone represents most of the Letaba River within the Kruger National Park. The macro-channel floor here tends to be wide and sandy with a small misfit active channel flowing within it.

Zone 6 is a short (9km long), steep zone, which represents the section of river which flows over the Letaba formation granites at the western edge of the Kruger National Park before its confluence with the Olifants River near the Mozambique border. Here the river has incised into the underlying bedrock, creating a steep, confined, highly bedrock-influenced section of river.

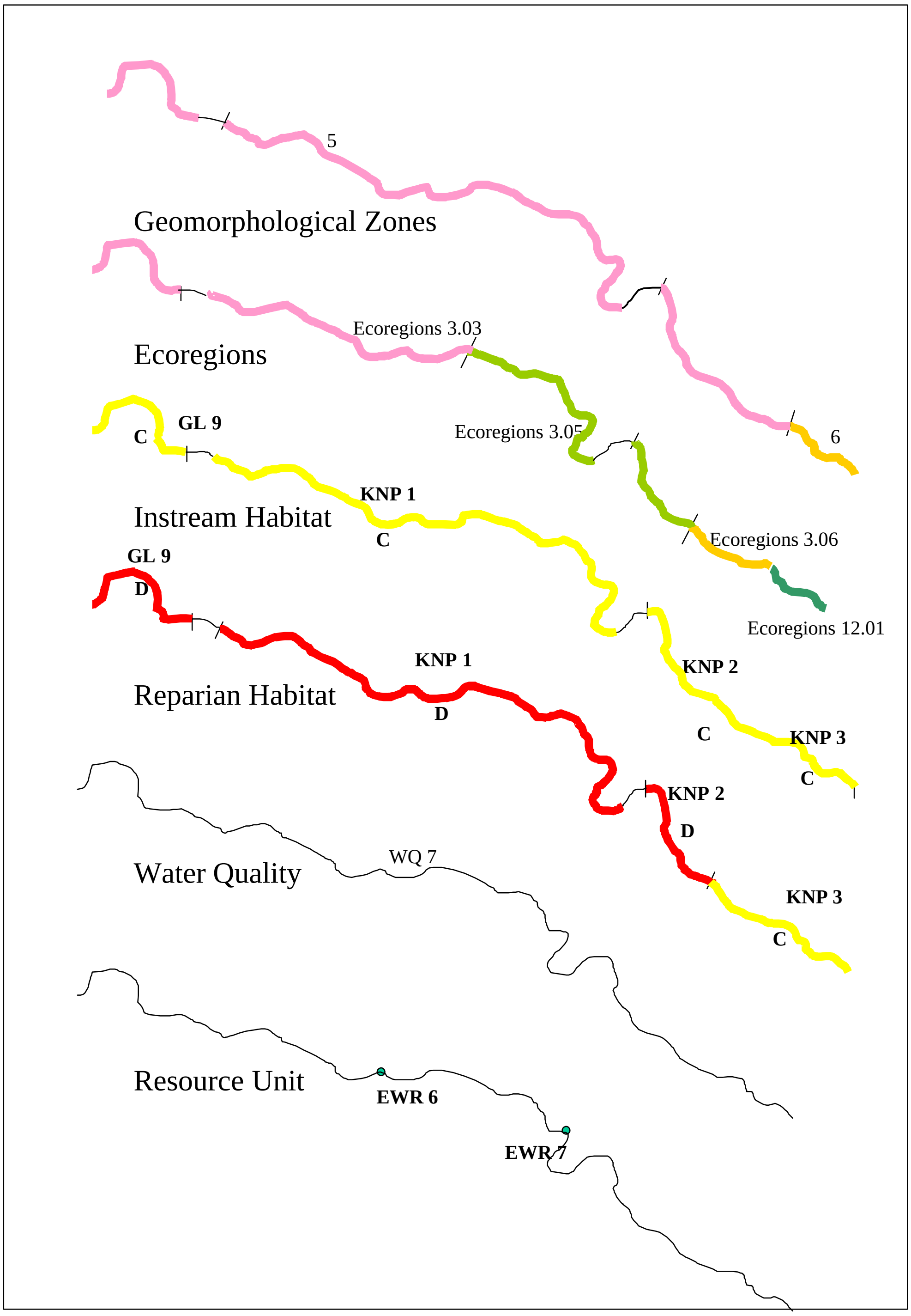


Figure 9.3 Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of Groot Letaba River from Letaba Ranch to Olifants River confluence.

Within the Kruger National Park there are four dams that are used for animal watering. These dams have largely been reduced in volume due to the high sediment loads from the Klein Letaba River.

Approximately 95% of this RU lies in one Geomorphological zone and there are three ecoregions. The Habitat Integrity is the same for this whole area, and for reasons of practicality, only one RU decided upon. The water quality does not change in this section of the Letaba River as there are no major anthropogenic influences. The start point of this RU is at the confluence with the Klein Letaba and the Groot Letaba River to the confluence with the Olifants River within the KNP.

9.2.5 Resource Unit E: Klein Letaba River

This RU consists of the Klein Letaba Rive (Figure 9.4, Segment KL 1 to 3)

This RU consists of the following:

- Two Ecoregions Level II.
- There are four Geomorphological Zones 2, 3, 4 and 5
- Instream habitat integrity (C)
- Riparian habitat integrity (D to B)
- The Middle Letaba Dam is located on the Middle Letaba River about 7 km upstream of the confluence of the Middle and Klein Letaba River

The river originates in the escarpment (1200 masl) down to the lower escarpment down to 560 masl (66 kms long).

The Middle Letaba Dam is located on the Middle Letaba River about 7 km upstream of the confluence of the Middle and Klein Letaba rivers. The dam was constructed to meet irrigation, domestic and stock water demands. Domestic water from the dam also augments water supplies from Nsami Dam located throughout the Giyani area.

Zone 2 represents that section of the river from 560 masl downstream until the confluence with the Groot Letaba (some 160 km downstream). The semi-arid nature of the extensive catchment, which is dominated by gneiss, results in a high sediment production. This is delivered to the tributaries and, due to the low slope of the area, stored in them and in the main stem of the Klein Letaba. Extensive alluvial sections dominate the channel with occasional bedrock outcrops causing local controls.

The Klein Letaba River has four Geomorphological zones and two ecoregions. The instream habitat integrity is the same for this whole area, and for reasons of practicality, only one RU decided upon for the Klein Letaba River. The water quality does not change in this section of the Klein Letaba River as there are no major anthropogenic influences. The start point of this RU is the upper or head waters of the Klein Letaba to the confluence with the Groot Letaba River.

9.2.6 Resource Unit F: Letsitele River

This RU consists of the Letsitele River (Figure 9.5, Segments Let 1 and 2). This RU consists of the following:

- Two Ecoregions Level II.
- There are five Geomorphological Zones 1 to 5
- Instream habitat integrity (B to D)
- Riparian habitat integrity (B to E)

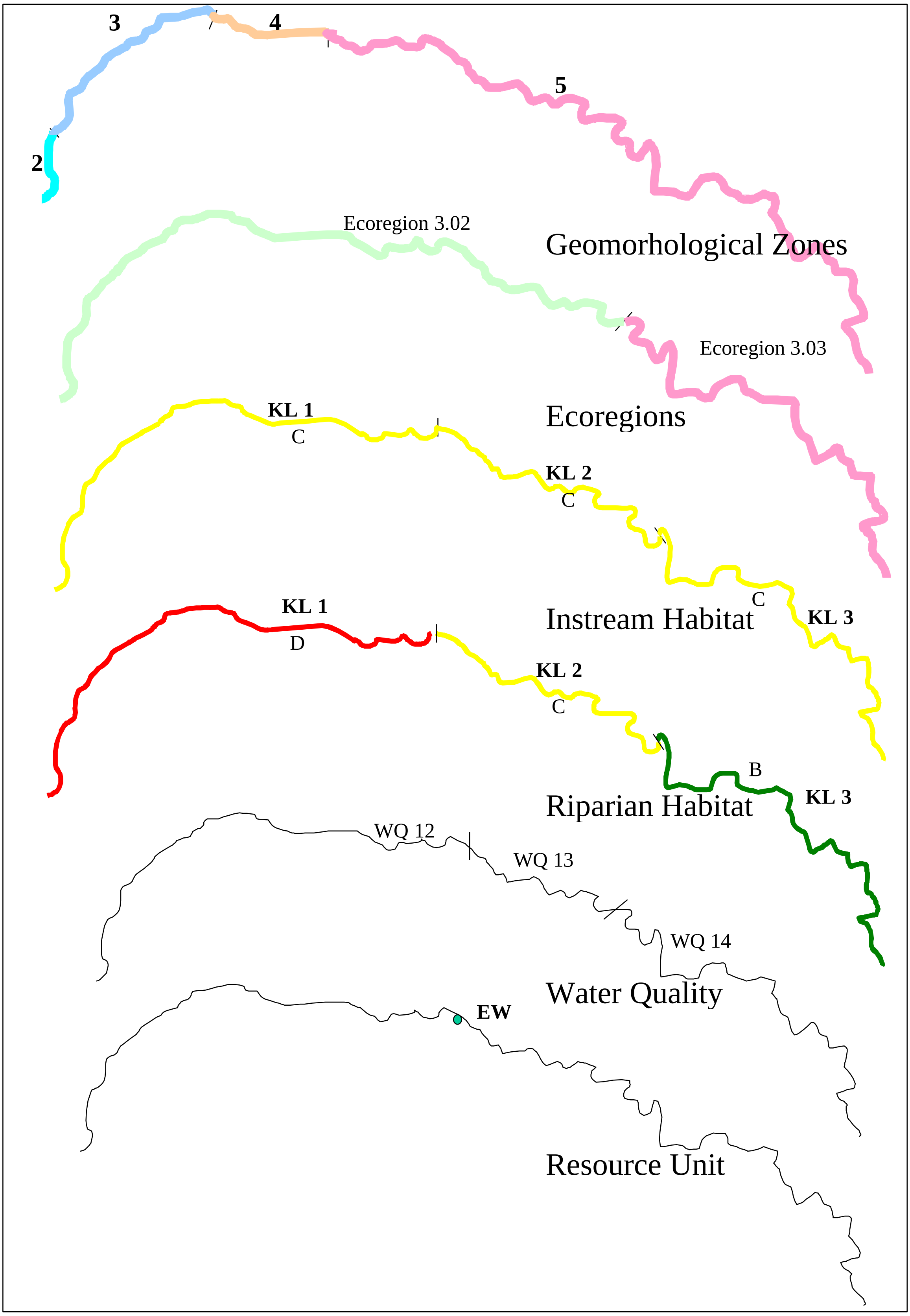


Figure 9.4 Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of the Middle and Klein Letaba Rivers.

The upper catchment of the Letsitele River extending from the source in the Wolkberg (> 1200 masl) mountain area of the Drakensberg, past state forests and waterfalls to Craighead Agricultural Estates. The area is largely natural with the instream and riparian habitat assessment values largely natural (B).

The Letsitele River below Craighead Agricultural Estates to the confluence of the Groot Letaba River is seriously to critically modified due to intensive commercial agriculture (citrus, mango, avocado, paw paw and banana), rural settlements and communal lands before reaching Letsitele town. Riparian vegetation cover is very variable in condition and is considered to be in a moderate condition for the whole unit. Some areas are denuded of vegetation and have extensive erosion, while others have much better vegetation. Exotic vegetation is present along the full length of the river.

The instream habitat is typically pool riffle sequences. However, pools and weir backwaters are heavily silted. There are 10 weirs of assorted sizes and there are numerous pumps and off channel storage dams in the upper portion of the unit. Water abstraction is considered a large to serious impact for the whole of the Letsitele River catchment.

The Letsitele River has five Geomorphological zones and two ecoregions. The instream and riparian habitat integrity also has two regions. The water quality does change in the Letsitele from the upper catchment due to the dense settlements in the lower catchment. For reasons of practicality, only one RU was decided upon for the Letsitele River. The start point of this RU is the upper, or head waters, of the Letsitele down to the confluence with the Groot Letaba River.

9.2.7 Resource Unit G: Molototsi River

This RU consists of the Molototsi River (Figure 9.6, Segments Mol 1 and 2). This RU consists of the following:

- Three Ecoregions Level II.
- There are four Geomorphological Zones 2, 3, 4 and 5
- Instream habitat integrity (C to D)
- Riparian habitat integrity (D)

The upper catchment of the Molototsi River extends from its source near Duiwelskloof to the Modjadji Dam. The area is predominantly ex Gazankulu homeland and is comprised of rural settlements and agriculture. The locality of the Modjadji Dam and water abstraction are thought to pose a serious impact on the functioning of the downstream Molototsi River.

The instream habitat assessment (C to D) is probably an over estimate as the Molototsi River is annually dry for most of the winter months and no winter instream assessments are possible. There are large permanent pools scattered along the river at bedrock intrusions. Several tributaries enter the Molototsi and at the junction to these rivers, there is often a deep pool.

The riparian habitat of the Molototsi River is largely modified (D) and highly variable due to the large areas of former homeland (Gazankulu) through which the river passes. The river is deeply incised and has areas of extensive erosion. Cattle tracks to the river have contributed to serious donga erosion. Bank erosion is highly evident on the rivers bends.

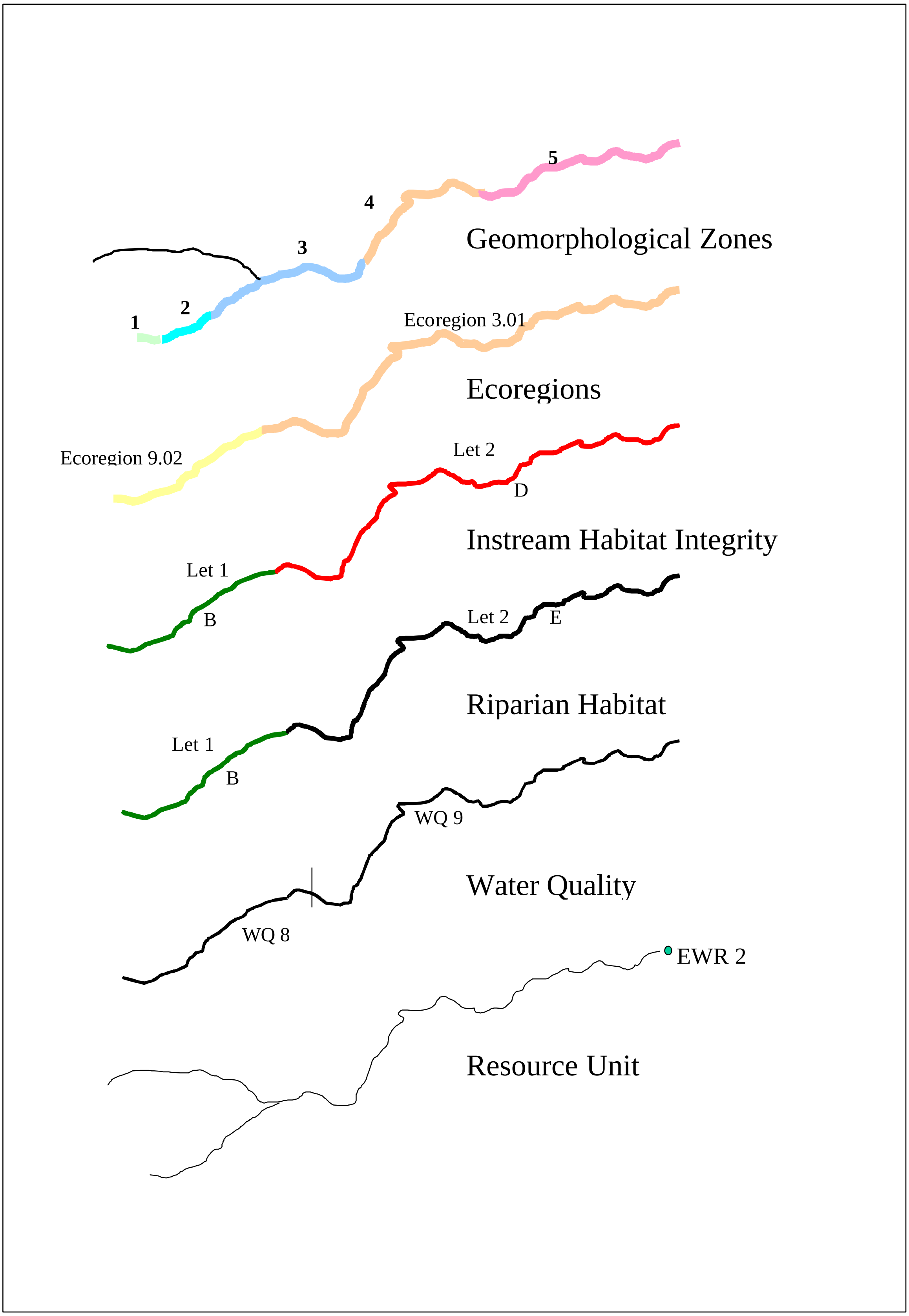


Figure 9.5: Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of the Letsitele River.

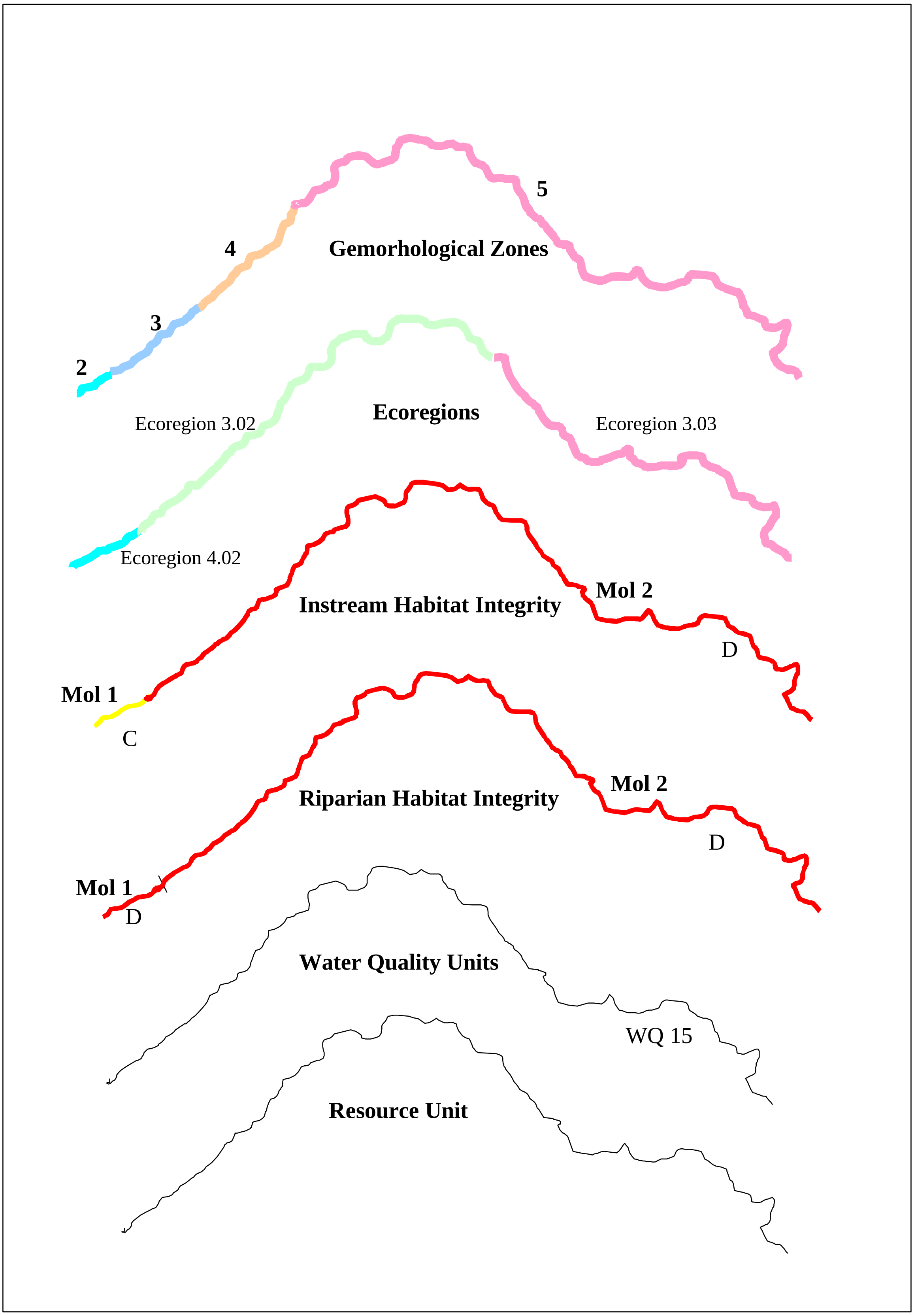


Figure 9.6 Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of the Molototsi River.

The Molototsi River has five Geomorphological zones and two ecoregions. The instream and riparian habitat integrity also has only two regions. The water quality does change in the Molototsi River from the upper catchment to the confluence with the Groot Letaba River. The river is highly seasonal with long periods of no flow in the winter months. For reasons of practicality, only one RU was decided upon for the Molototsi River. The start point of this RU is the upper, or head waters, of the Molototsi down to the confluence with the Groot Letaba River.

9.2.8 Resource Unit H: Thabina River

This RU consists of the Thabina River (Figure 9.7, Segments THA 1 to 4**)**. This RU consists of the following:

- Two Ecoregions Level II.
- There are five Geomorphological Zones 1, 2, 3, 4 and 5
- Instream habitat integrity (D to C)
- Riparian habitat integrity (D to C)
- The Thabina Dam

The upper Thabina River is a mountain stream originating in the Wolkberg region of the Drakensberg Mountains (> 1200 masl).

The Thabina Dam has not operational release capabilities and only seepage flow and spilling floodwaters is released from the dam. Below the dam, water is abstracted for domestic use.

Water abstraction is considered a large to serious impact for Thabina River catchment. Extending from the wetland to the Letsitele River, there are 4 weirs and numerous pumps and road crossings. Water quality impacts are likely to be due to flow regulation.

Below the Thabina Dam the riparian habitat varies from moderately to largely modified (C to D).

There has been extensive vegetation removal and there is massive erosion (donga, sheet and bank). Agricultural plots extend right into the river channel. Cattle tracks to the water are common.

There is an extensive wetland area that contributed towards the biodiversity of the catchment. The wetland is under threat due cattle grazing and flow regulation which could contribute towards its decline. Villages and agricultural plots immediately adjacent to the river and erosion and dongas contribute sediment to the river and pool habitats are silted up.

The Thabina River consists mainly of one Ecoregions Level II, is a relative short river that is a tributary of the Letsitele River. The instream and riparian habitat integrity also has only two regions. The water quality is not expected to change below the Thabina Dam due to only seepage flow and spilling floodwaters is released from the dam. For reasons of practicality, only one RU was decided upon for the Thabina River. The start point of this RU is the upper of the Thabina River (or head waters – above the Thabina Dam) down to the confluence with the Letsitele River.

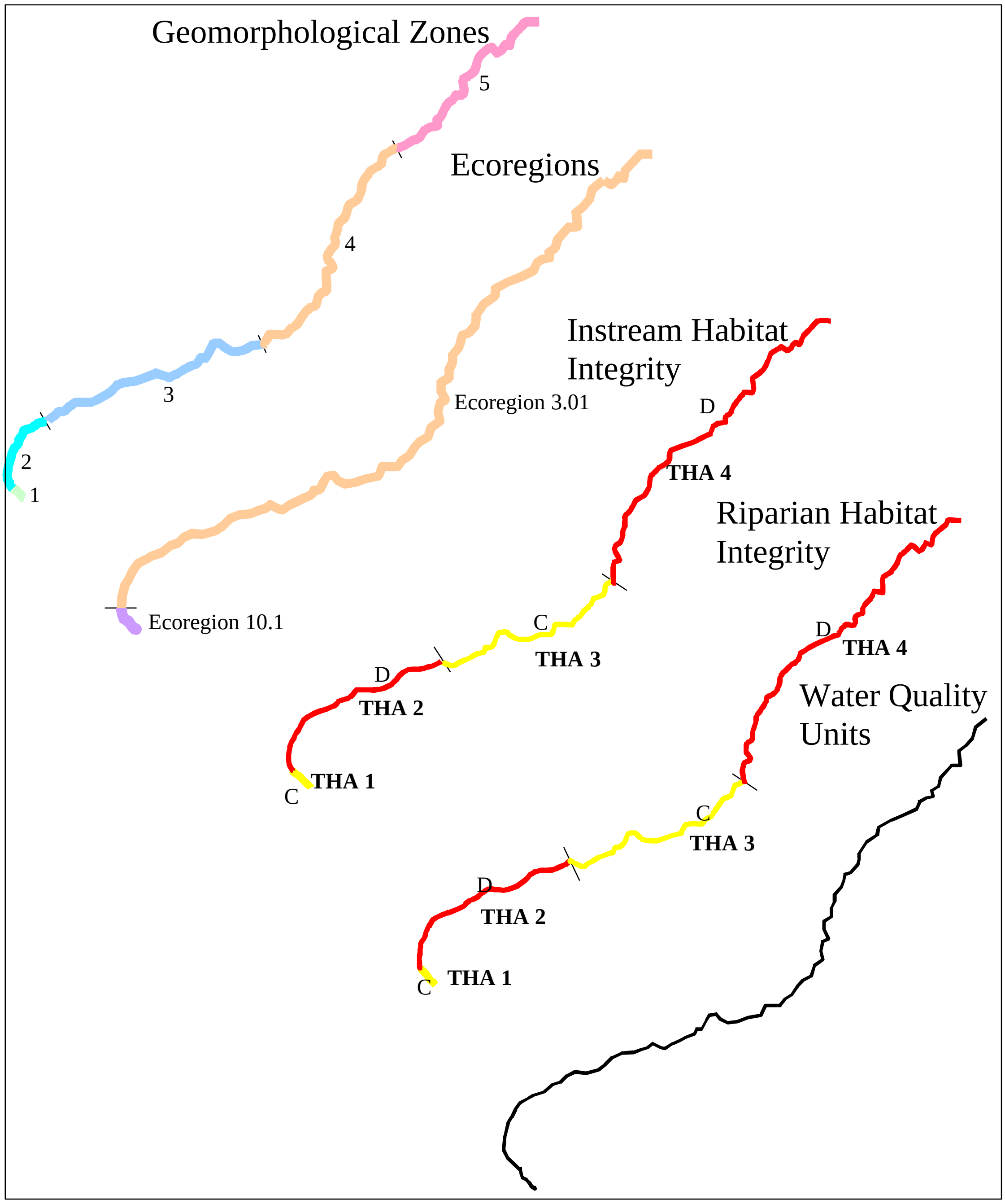


Figure 9.7 Ecoregions, riparian and instream habitat integrity and Geomorphological zonation of the Thabina River.

10. INSTREAM FLOW REQUIREMENTS (EWR) SITE SELECTION

10.1 PURPOSE OF EWR SITES

EWRs are determined during a specialist meeting where descriptions of flow in parameters such as depth and water surface level linked to habitat requirements of the various disciplines are stipulated. These parameters need to be converted to flow by means of a stage discharge curve for a specific cross-section. The description of flows in depths therefore takes place at a specific cross-section in the river called an EWR site that should represent a variety of habitats (DWAF 1999).

The selection of the EWR sites forms the basis of the preparatory work to be undertaken for the EWR specialist meeting and some of the studies (e.g. hydraulics and hydrology) are directly linked and are calculated specifically for the EWR sites.

The EWRs are set for each of the EWR sites, and it is therefore vital that the:

- Sites are selected to provide as much information as possible about the variety of conditions in a river reach so that the specialists relate to the habitat the EWR site represents;
- Persons involved in selecting the sites understand and are experienced with the use of sites in EWR studies.

In order to determine the (EWRs) of a river system, it is necessary to determine the flow requirements at a number of points within the system(DWAF 1999).

- Tributaries entering the system may introduce different channel, bank and or habitat conditions that may need to be considered separately.
- The Present Ecological State (PES) and Ecological Category (EC) of particular reaches of the river may differ and may therefore require a specific EWR.
- A river system displays biological diversity along its length, and consequently, a single EWR point is unlikely to adequately reflect this range of diversity.
- Various hydrological stage points are required within the system to cater for the inflows of tributaries and losses down the length of the system.

The more EWR sites selected for which EWRs are determined, the better the chance that the full range of habitat diversity in the system will be covered and therefore, the higher the confidence in the EWR result. The decision as to how many sites are chosen is therefore a function of the length and diversity of the river to be assessed, and a trade-off between the need to characterise the river adequately, and the constraints of time and resources.

10.2 EWR SITE SELECTION PROCESS

The detailed process to select EWR sites is described in the BBM manual (Louw and Hughes 2002). An EWR or Ecological Reserve must be determined for each RU if practically possible (depending on accessibility and financial resources).

Cross-sections at each selected EWR site were selected. Firstly, the location of key cross-sections in conjunction with other specialists was selected, and then additional cross-sections for hydraulic purposes were located. Benchmarks were installed at each of the cross-sections.

The benchmarks were clearly marked for future identification. The first set of stage-discharge data was collected. Photographs of each cross-section of selected EWR site were taken.

10.2.1 Use of the river video for the identification of possible EWR sites

The determining of possible sites in dense vegetation and over a large catchment area is difficult and time-consuming. With the large surface area of the Letaba catchment it was impossible to obtain a comprehensive overview of a river from a ground survey. The selection of EWR sites is greatly assisted means of aerial photography undertaken by several helicopter flights, which is undertaken for the Habitat Integrity assessment (Chapter 8) and capturing the river on video. The Letaba and it tributaries were not flown as part of this study, but a videos from several flights were available for use (Chapter 8). These videos were viewed EWR site selection team. Potential sites were discussed and local knowledge used to preliminary determine potential sites. These sites were evaluated and ranked and the most likely potential sites were selected for assessing by vehicle during the site selection trip.

10.2.2 Selection of EWR sites

The selection of EWR sites is further guided by a number of considerations such as (see Figures 9.1 to 9.7, Louw and Hughes 2002):

- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments and land use.
- The locality of dams.
- The locality and characteristics of tributaries.
- The habitat integrity of the different river reaches.
- The reaches where social communities depend on a healthy river ecosystem.
- The accessibility of the sites for follow-up monitoring.
- The habitat diversity for aquatic organisms, marginal and riparian vegetation.
- The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows.
- An area or site that could be critical for ecosystem functioning such as a riffle that stops flowing during periods of low or no flow. If this cessation of flow constitutes a break in the functioning of the river the biota dependent on this habitat and/or on continuity of flow will be adversely affected.
- The locality of geomorphological reaches and representative reaches within the geomorphological reaches.

The criteria in bold are the most important and therefore the overriding criteria.

10.3 SELECTION OF EWR SITES IN LETABA CATCHMENT

The EWR site selection team for the Letaba Comprehensive Reserve consisted of the following key specialists:

- Dr Ralph Heath – project manager
- Toriso Tlou – PSP and hydraulics
- Dr Neels Kleynhans – fish
- Christo Thirion- invertebrates
- Delana Louw – process overview
- Pratiba Mistry – (trainee)
- Angelina Jordanova – hydraulics
- Dr Drew Birkhead - hydraulics
- Ken Haumann - hydrology
- Robert Skoroskewski - invertebrates
- Gary Marneweck – riparian vegetation
- Mark Rountree - geomorphology
- Mick Angliss - Fish
- Dr Andrew Deacon - Fish
- Paul Fouche – Fish

Dr Patsy Scherman (water quality) was not part of the site selection field trip but had inputs into the process through an assessment of the water quality data and the development of water quality resource units.

The following process was used to determine the seven EWR sites in the Letaba catchment:

- Assessment of the 1994 IFR report for the Letaba River.
- Availability of previous site survey data from 1994 IFR study.
- The locality of gauging weirs with good quality hydrological data was determined in the Inception Report.
- The locality of the proposed developments, land use and of dams.
- The locality and characteristics of major tributaries.
- The habitat integrity of the different river reaches as determined by Angliss (2002).
- The accessibility of the sites for follow-up monitoring.
- The available habitat diversity for fish, macroinvertebrates, marginal and riparian vegetation.
- The suitability of the sites for accurate hydraulic modeling throughout the range of possible flows, especially low flows.
- The locality of geomorphological reaches and representative reaches within the geomorphological reaches.
- Discussions with local experts on potential sites per sub-catchment.
- Viewing of available videos to pre-select potential EWR sites

Prior to the site selection field trip members of the project team undertook reconnaissance trips to a number of potentially suitable sites. The key specialists then visited the sites with high potential. The decision making process for the selection of the EWR sites in the Letaba catchment was driven by the following:

- Major tributaries that contribute to the MAR of the catchment
- Major instream dams that divide the river
- Budget for only 7 sites
- Major land use activities that could impact on both water quality and quantity
- Assess ability
- Availability of habitat diversity

- Ability to determine the KNP and Mozambique releases.

One of the difficulties of defining Resource Units is the scale or level of resolution required. The main tributaries of the Letaba River (Groot Letaba, Letsitele, Klein Letaba) may be delineated into distinct ecological zones due to their origin being on the escarpment. Due to the steep gradients of the upper catchment of these tributaries the different resource units would be so short that defining separate EWRs for each zone would be impractical and costly. The length of ecologically distinct sections of river was therefore also taken into consideration when defining Resource Units.

The Molototsi River due to its highly seasonal nature and the lack of adequate monitoring data was not chosen as an appropriate EWR site. The influence of this river on the Groot Letaba is seen at EWR site 4.

No EWR site was chosen for the Middle Letaba River. EWR 5 (Klein Letaba) was, however, selected to be directly downstream of the confluence of Middle and Klein Letaba Rivers. Furthermore the Middle Letaba Dam (used for irrigation and domestic water supply) does not release water downstream into the river.

No EWR sites was selected in the Ntsami River dues to its contribution to the MAR of the Letaba River being small in comparison to the other tributaries.

No EWR sites was selected in the Thabina River dues to its contribution to the MAR of the Letaba River being small in comparison to the other tributaries. An EWR site was chosen in the Letsitele River, of which the Thabina River is the major tributary.

The coordinates of the chosen EWR sites 1 to 7 are indicated in Table 10.1.

Table 10.1: Coordinates of fixed survey stations at the EWR sites on the Letaba River

River and site name	EWR site number	Coordinates
Groot Letaba - Appel	EWR1	S23 55 03.7; E30 03 03.0
Letsitele	EWR 2	S23 53 17.0; E30 21 40.5
Klein Letaba	EWR 5	S23 15 02.9; E30 29 44.6
Groot Letaba - Hans Marensky	EWR 3	S23 38 57.8; E30 39 38.3
Groot Letaba - Letaba Ranch	EWR 4	S23 40 39.1; E31 05 55.1
Groot Letaba – Lonely Bull	EWR 6	S23 45 09.5; E31 24 26.3
Groot Letaba - Letaba Bridge	EWR 7	S23 48 35.4; E31 35 26.9

The locality of the chosen EWR sites in relation to the Resource Units in each of the main catchment of the Letaba River catchment are indicated in Figure 10.2.

The advantages and disadvantages of the EWR sites were provided by the relevant specialists and collated into Table 10.2 to 10.8. The specialists rated each site on a scale of 1 to 5 (1 = poor site, 5 = good site).

10.3.1 EWR 1: Appel Groot Letaba River

The locality of this EWR site is illustrated in Figure 10.1. Plate 10.1 is a photograph of the EWR site. At EWR 1 three cross sections were selected for use in the EWR assessment. This EWR sites is located between Ebenezer and Tzaneen Dam (Section 8.1 and 9.2.1). There are three weirs between the dams. They are all small structures and their purpose is to divert water into structures for abstraction for irrigation and water supply to Tzaneen Municipality. Due to the short length of this RU (30 km), and the many similar structures in the Groot Letaba River, these weirs were not considered important enough to subdivide this RU. The Tzaneen Dam due to its large size and being instream it makes a logical end point to this RU.

Table 10.2: Advantages and disadvantages of EWR 1

Component	Letaba Score	Advantages	Disadvantages
Fish	3	All habitat types present. Records have shown that fours species of fish that are water quality sensitive are found at this site.	Flow has been regulated for many years. Impacts of irrigation off takes and weirs will possibly fragment fish populations.
Riparian vegetation	2	Is limited flood damage in terms of the structure of the terraces and vegetation structure and thus a number of individuals of indicator species are present for assisting with setting the flows.	Highly afforested with exotic pine and eucalyptes. Chopping of mid-sized and larger trees. Active channel has narrowed due to flow modification and led to vegetation encroachment. Vegetation encroachment due to exotic giant reed *Arunda donax*
Aquatic invertebrates	3	Abundant stones in current (SIC), boulders, and pools. Substrate limited. Easy accessibility	Exotic vegetation on riverbanks. Limited marginal vegetation as a habitat. Highly regulated with flows largely determined by releases from the upstream dams. The present day discharge is approximately 30% of the virgin MAR.
Geomorphology	3	Excellent site for habitat modelling as all habitat types present. The site is characterised by a pool rapid channel type with floodplain terraces on the right bank.	The active channel has narrowed considerably through the historic photographic record, but the channel pattern is stable. Flow regulation from Ebeneezer Dam and instream weirs
Hydraulics	2	One single channel.	Channel geometry that determines the local hydraulic consists of large boulders that complicate low flow modelling, and due to turbulence at low flows makes it difficult to survey accurate water stage. Dense vegetation on both banks influences overall flow resistance at high flows.
Water quality	3	Few urban rural settlements, one water quality sampling point near EWR site	Potential water quality impacts due to cultivated agriculture (bananas and citrus) and afforestation

Plate 10.1: EWR 1 – Appel Groot Letaba Cross section (Q=0.264 m^3/s)

10.3.2 EWR 2: Letsitele Tank Letsitele River

The locality of this EWR site is illustrated in Figure 10.1. Plate 10.2 is a photograph of the EWR site. This EWR site is situated on the Letsitele River, which is a tributary of the Letaba River, which is at present unregulated (no large upstream impoundments). This site was used in the 1994 EWR study and the riparian vegetation survey results were used from the 1994 study. This site has been criticised in the past due to the potential black flooding from the Junction weir in the Letaba River. The main impacts on water quantity and water quality at this site are upstream stream flow reduction (forestry) and a township with no formal sewer system immediately upstream.

The river channel at this site is largely degraded due to erosion and local sources of water quality pollution. The site is in a highly disturbed area and extends below a railway bridge. A DWAF gauging weir occurs just upstream which allows accurate measurement of flow. The site has changed following floods in both 1996 and 2000.

At EWR 2 three cross sections were selected for use in the EWR assessment.

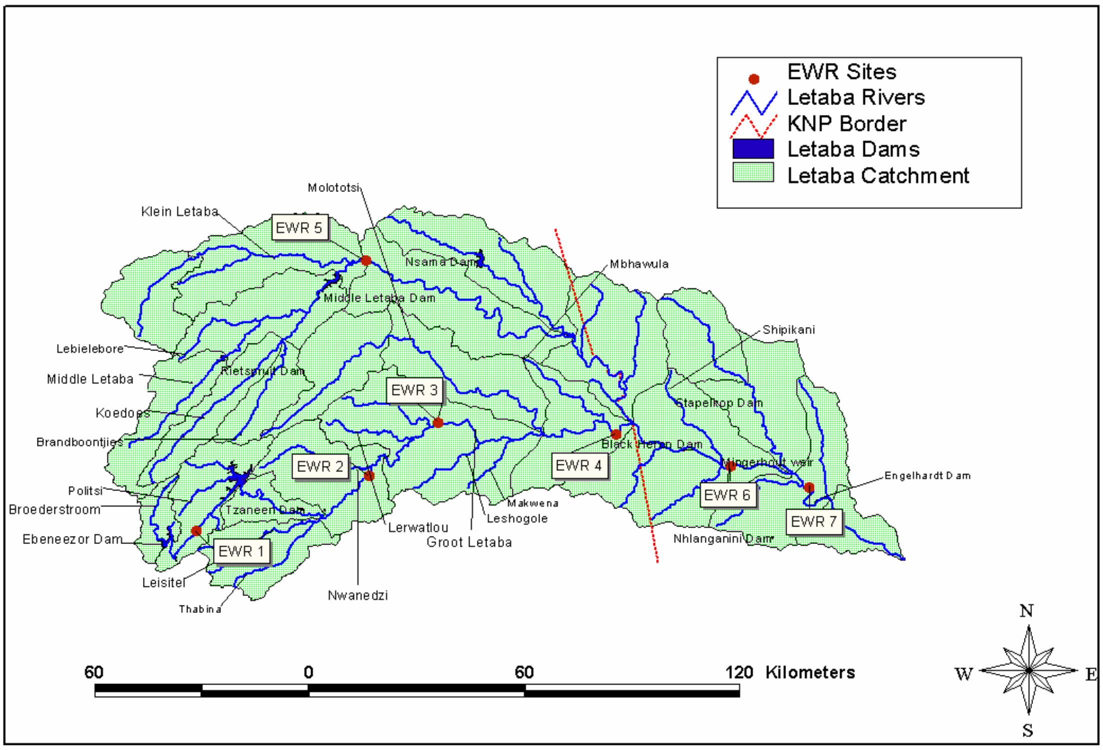


Figure 10.1: Location of the EWR sites in the Letaba Catchment

Figure 10.1: Locality of the chosen EWR sites in the Letaba catchment.

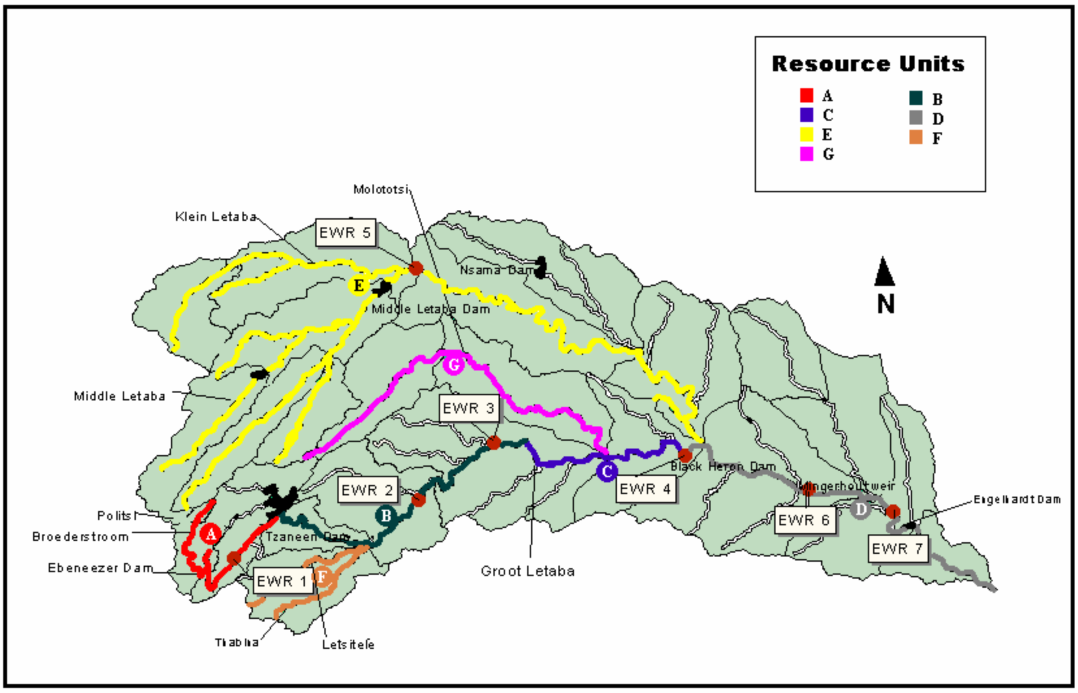


Figure 10.2: Locality of the chosen EWR sites in relation to the Resource Units in the Letaba catchment.

Table 10.3: Advantages and disadvantages of EWR 2

Component	Letaba Score	Advantages	Disadvantages
Fish	2	Wide river channel and good diverse habitats. Good records of indicator species of fish at this site.	Low flow habitat will be reduced. Water quality is impacted by upstream development, weir and enrichment in winter or low flows periods. Security is an issue.
Riparian vegetation	1	A few large specimens of indicator species are present	This site is not good for high flow hydraulics (as the site experiences backup from the Letaba), and the riparian vegetation has low confidence. Vegetation heavily impacted by over-grazing and trampling.
Aquatic invertebrates	2	Abundant stones in current (SIC), riffles, pools and substrate. Marginal vegetation	The river channel at this site is largely degraded due to erosion and local sources of water quality pollution. Limited historical data. Increase in bank erosion, siltation of riffles and degradation of marginal - fringing vegetation habitat
Geomorphology	2	This site is characterised by an incised pool-riffle channel pattern. Prior to the 2000 floods, specialists working on the previous EWR study indicated that there was a deep pool at the site that has subsequently changed to the current incised pool-riffle pattern.	This site is not good for high flow hydraulics (as the site experiences backup from the Letaba), and geomorphology specialists had low confidence at this site.
Hydraulics	2	One single channel; Weir upstream for flow records.	Backwater effect of the Groot Letaba during high flow conditions.
Water quality	2	Weir upstream for water quality records	Water quality is impacted by upstream development dense rural/informal settlements as well as sewage effluent causing eutrophication.

Plate 10.2: EWR 2 Letsitele Tank view, Q=0.85 m^3/s

10.3.3 EWR 3: Hans Marensky Groot Letaba River

The locality of EWR 3 site is illustrated in Figure 10.1. Plate 10.3 is a photograph of the EWR site. This EWR site is situated on the Groot Letaba River, downstream of the Tzaneen Dam and upstream of the Molototsi River. This site is located about 7km upstream of Prieska Weir, but does not experience backwater effects from the weir. The river at this site is characterised by the presence of boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams), large weirs (Junction, Yamorna and Jasi weirs) as well as direct abstraction for irrigation.

Two sites were used at this EWR site, one upstream of the Prieska weir (3a, Hans Marensky) and the other downstream of the Prieska weir (3b). The downstream site was used in the 1994 IFR study and it was used in this comprehensive reserve study as the riparian vegetation in this reach of river had a good number of indicator species (specifically *F. sycomorus* and *B. salicina*) on the macro-channel floor. Cross sections of EWR site 3b were available from the 1994 IFR Letaba study. The 3D spatial modelling was undertaken using RiverCAD and HEACRAS for EWR Site 3b.

At EWR 3a three cross sections were selected and at EWR 3b seven of cross sections were selected for use in the EWR assessment.

Table 10.4: Advantages and disadvantages of EWR 3a upstream

Component	Letaba Score	Advantages	Disadvantages
Fish	3	Excellent all year round habitat availability. Ten years of sampling data at this site. Backwaters good for breeding.	Crocodiles present.
Riparian vegetation	3	A backwater area occurs where the riparian vegetation is rooting. Good number of indicator species (specifically *F. sycomorus* and *B. salicina*) on the macro-channel floor.	Large-scale removal of vegetation along the top of the left bank (for irrigation farming) may impact bank stability and vegetation recruitment lower down on the macro-channel banks. Alien invasion vegetation also occurring on the upper banks of the river.
Aquatic invertebrates	3	Abundant boulders, cobbles, pebbles and pools. Historical macroinvertebrate data.	Flow regulation has resulted in a reduction in wetted area, in depth, velocity over riffles and in a variation of water level
Geomorphology	2	It is characterised by a bedrock pool-rapid channel type with small gravels, cobbles and sand bars amongst the exposed bedrock. There are currently steep banks with no benches or terraces.	The 2000 floods scoured the macro-channel floor. The many weirs and dams in this section of the river have also caused enhanced sedimentation and accumulation of finer material in some sections of the river. . Vegetation encroachment, channel narrowing, sediment trapped in weirs
Hydraulics	2	Location of nearby rated weir for the measurement of high flows and flood discharges when high flows prohibit access to the river for manual flow gauging.	The site is characterised by extensive bedrock influence and large roughness elements that are inundated at medium to high flows, multiple channels with complex flow patterns and non-uniform flow at low to medium flows. Difficult to measure medium to high flows using manual flow gauging. The short riffle feature at the site becomes drowned-out at reasonably low flows.
Water quality	2	Water quality monitoring points at the Junction weir	Water quality impacts due to intense irrigated agriculture and the use of fertilizers and pesticides. The large volume of water that is captured in weirs also results in algal blooms and elevated chlorophyll levels.

Prieska Weir (EWR 3b).

- The site transects were largely across bedrock rapids, approximately 300 meters downstream from Prieska weir.
- The river at this point flows in numerous deep bedrock channels (braided). Surveying of these channels is dangerous due to (crocodiles)
- Because of the bedrock, the instream channel is unlikely to be significantly changed following the floods of 1996 and 2000.

- The riparian zone changed drastically during the 1996 floods. As a result, the area became heavily infested with alien plants (castor oil, cocklebur etc.) and transect access has became extremely difficult. Following the 2000 floods the situation has worsened with much woody debris adding to the access problem.

Plate 10.3: EWR 3 – Hans Marensky Cross Section, Q=0.237 m^3/s

10.3.4 EWR 4: Letaba Ranch Groot Letaba River

The locality of EWR 4 site is illustrated in Figure 10.1. Plate 10.4 is a photograph of the EWR site. This EWR site is situated on the Groot Letaba River, downstream of the Molototsi River and upstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock, large boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams) as well as the irrigation abstraction weirs and canals.

This site was used in the 1994 reserve study (EWR 3 now EWR 4). Some of comments on site are (Table 10.5):

- Transects at this site were made across both a bedrock outcrop which formed a small island and across a gravel channel.
- The river channel changed drastically in the 2000 floods and although the bedrock area remains the channel is unrecognizable.
- The site occurs on a bend.
- Surveying dangerous due to a large number of animals at this site

At EWR 4 five cross sections were selected for use in the EWR assessment.

Table 10.5: Advantages and disadvantages of EWR 4

Component	Letaba Score	Advantages	Disadvantages
Fish	3	Excellent all year round habitat availability.	Crocodiles and hippos present as well as other large terrestrial mammals.
Riparian vegetation	3	Despite the flood damage, there are still a number of individuals of indicator species present along the remaining terraces and upper bank	System is naturally in a dynamic state form periods of vegetated to non-vegetated along the macro-channel floor. The lower riparian zone has a substantial loss cover and abundance along the flood terraces due to the 2000 floods.
Aquatic invertebrates	3	Abundant boulders, cobbles, pebbles and pools. Historical macroinvertebrate data available	Marginal vegetation limited due to 2000 floods. Flow regulation has resulted in a reduction in wetted area, in depth, velocity over riffles and in a variation of water level
Geomorphology	3	The main cross-section is characterised by a single active channel with an extensive, largely non-vegetated seasonal bar on the left bank. The right bank is dominated by a high ephemeral lateral terrace	Some vegetation encroachment and loss of bedrock-influenced channel patterns has occurred.
Hydraulics	2	The Letaba Ranch weir, upstream of the site for flow records.	Complex hydraulics: 2 channels with 2 different water levels, downstream bedrock sections have non-uniform flow, islands, irregular shapes, potential for non-horizontal water profile at low flows, close to a bend.
Water quality	3	Water quality monitoring points at Nondweni weir and in Letaba Ranch upstream of EWR site	Dense rural settlements, agriculture encroachment into the riparian vegetation and irrigated agriculture results in water quality problems.

10.3.5 EWR 5: Klein Letaba River

The locality of EWR 5 site is illustrated in Figure 10.1. Plate 10.5 is a photograph of the EWR site. This EWR site is situated on the Klein Letaba River, downstream of the confluence of the Middle Letaba River and Middle Letaba Dam.

The river at this site has a predominantly sandy bed with an upstream bedrock control associated with a large pool. There has been extensive encroachment by vegetation of the active river channel with very limited stones in current habitat. A short run consisting of a few small cobbles and pebbles was sampled at the lower end of the site.

There was no site on this tributary during the 1994 Reserve study.

At EWR 5 five cross sections were selected for use in the EWR assessment.

Plate 10.4: EWR 4 Letaba Ranch Cross-Section, Q=3.72 m^3/s

Table 10.6: Advantages and disadvantages of EWR 5

Component	Letaba Score	Advantages	Disadvantages
Fish	2	Good marginal vegetation and deep slow habitat as well as pools. The pools will be used as refugia during droughts.	Fast-deep habitat missing but this will be available during high flows.
Riparian vegetation	3	Upper riparian zone not altered by floods and flow changes. Marginal vegetation is naturally dynamic. Good number and representation of indicator species. Alien vegetation not an issue at this stage.	Flow has been altered due to the building of the middle Letaba Dam. Rapid vegetation encroachment on to the macro-channel floor because of the reduced flows and floods downstream of this impoundment. The lower riparian zone has a substantial loss of cover and abundance along the flood terraces due to the 2000 floods. Vegetation removal for fire wood and agricultural encroachment a problem.
Aquatic invertebrates	2	Abundant sands, cobbles, pebbles and pools.	No boulders and limited stones in current data with a very limited velocity range. Marginal vegetation limited. No historical macroinvertebrate data was available. Very low flows resulting in siltation, limitation on available flow related habitat and increases variation in physical water quality variables

Component	Letaba Score	Advantages	Disadvantages
			(such as temperature) has impacted the macroinvertebrate populations.
Geomorphology	3	The site has terraces on the right- and left-hand banks, a sandy active channel and seasonal mid-channel bar composed of sand, armoured by gravels and cobbles. This reach of the river is largely unmodified, being exposed to limited direct human changes.	Cattle heavily graze the area.
Hydraulics	2		Sand bed channel, dynamic system with sand bars and islands with vegetation that complicate hydraulic modelling. No gauging station close to the site for flow records, as well as there is no very good cross section for flow measurement.
Water quality	3	Water quality monitoring points at Tabaan in Klein Letaba upstream of EWR site and below confluence with Middle Letaba River	The main land use is dense urban settlements with limited subsistence agriculture. Water quality problems relating to low flow, temperature and urban runoff.

10.3.6 EWR 6: Lonely Bull Groot Letaba River

The locality of EWR 6 site is illustrated in Figure 10.1. Plate 10.6 is a photograph of the EWR site. This EWR site is situated on the Groot Letaba River in the Kruger National Park, downstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles.

There were very little stones in current habitat due to the low flows experienced at the time of sampling.

The main impacts at this site are the reduction in flow due to upstream impoundments as well as direct abstraction for irrigation both lawful and unlawful.

At EWR 6 three cross sections were selected for use in the EWR assessment.

Plate 10.5: EWR 5 Klein Letaba Down Stream View, Q=0.27 m^3/s

Table 10.7: Advantages and disadvantages of EWR 6

Component	Letaba Score	Advantages	Disadvantages
Fish	3	Excellent diversity in habitat for fish. Deep pools will acts as refugia during droughts.	Crocodiles and hippos present as well as other large terrestrial mammals.
Riparian vegetation	3	The dynamics of vegetation change appear to be largely natural. Upper riparian zone not altered by floods and flow changes.	The lower riparian zone has a substantial loss cover and abundance along the flood terraces due to the 2000 floods.
Aquatic invertebrates	3	Habitat has bedrock controls, small cobbles, sand and pebbles. Historical macroinvertebrate data available	Stones in current and riffle habitat limited.
Geomorphology	3	Characterised by a wide macro-channel with two active channels. Bedrock outcrops occur on the MC floor and terraces on the right bank. Moderate flows have been reduced at this site, but not as much as at other sites upstream that are closer to large dams. Enhanced sedimentation has caused some channel pattern changes, but the 2000 floods have reversed many of these.	There is a reduction in frequency, magnitude and duration of moderate and large floods (which result in decreased removal and scouring of sediment from the bed of the macro-channel) and severe reduction in low flows and increase in zero flow periods (which inhibits marginal vegetation establishment and therefore prevents active channel stabilisation).
Hydraulics	2		Complicated EWR cross section: a pool on the left side, a riffle channel

Component	Letaba Score	Advantages	Disadvantages
			on the right side, reversed flow between, different water stages across EWR cross-section. No working gauging weirs, presence of crocodiles and hippos make measurement of high flows difficult.
Water quality	2	No major impacts in water quality in the KNP	Limited historical water quality data

Plate 10.6: EWR 6 Lonely Bull – Groot Letaba River Cross-Section, Q=85 m^3/s

10.3.6 EWR 7: Letaba Bridge Groot Letaba River

The locality of EWR 7 site is illustrated in Figure 10.1. Plate 10.7 is a photograph of the EWR site. This EWR site is situated on the Groot Letaba River, downstream of the EWR 6 site. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles. Between the EWR 6 and EWR 7 sites there is a tributary that flows north south from within the Kruger National Park that during the summer season contributes to the flow at this EWR site.

There are very little stones in current habitat due to the low flows experienced at the time of sampling.

During the 1994 Reserve study a site at the Letaba Rest Camp (EWR5 – close to current EWR 7). EWR 7 was selected to determine only the low flows during the dry season upstream of Letaba Rest Camp. This EWR site is important due to future Mozambique flow releases as well as to ensure that the flows at this site meet the ecological requirements of the fauna and flora within the Kruger National Park.

The 3D spatial modelling was undertaken using RiverCAD and HEACRAS for EWR Site 7.

At EWR 7 seven cross sections were selected for use in the EWR assessment.

Table 10.8: Advantages and disadvantages of EWR 7

Component	Letaba Score	Advantages	Disadvantages
Fish	2	Diverse habitat with a deep pool that will acts as refugia during droughts.	Crocodiles and hippos present as well as other large terrestrial mammals. The same species of fish would be expected in this site as for EWR 6.
Riparian vegetation	3	The dynamics of vegetation change appear to be largely natural. Few indicator species present.	The lower riparian zone has a substantial loss of cover and abundance along the flood terraces due to the 2000 floods. Flow pattern changes have resulted in encroachment into the lower riparian zone.
Aquatic invertebrates	2	Abundant small cobbles, sand and pebbles. Historical macroinvertebrate data available	Stones in current and riffle habitat limited.
Geomorphology	2	The macro-channel floor at the site is dominated by sand and gravel, with some vegetation at the active channel margins. The small single active channel is on the extreme left of the macro-channel floor.	There is a reduction in frequency, magnitude and duration of moderate and large floods (which result in decreased removal and scouring of sediment from the bed of the macro-channel) and severe reduction in low flows and increase in zero flow periods.
Hydraulics	3	Uniform flow conditions over a wide range of discharges. Bed composed predominantly of sand and gravels with imbedded larger material (cobbles), resulting in reasonably uniform flow resistance as a function of stage.	Mobile bed material results in changes to the channel morphology over time. Difficult to measure medium to high flows using manual flow gauging due to the wide channel.A small riffle feature (containing gravels) is a temporary feature and becomes drowned-out at low flows.
Water quality	3	No major impacts in water quality in the KNP	Limited historical water quality data

Plate 10.7: EWR 7 Letaba Bridge – Groot Letaba River - Cross-Section, Q= 6.8 m^3/s

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APPENDIX A:

An assessment of the Habitat Integrity of the Groot Letaba and major tributaries based upon aerial surveys undertaken in January 2001 and January 2003. Fouche and Moolman, 2004.