National Aquatic Ecosystem Health Monitoring Programme (NAEHMP):

River Health Programme (RHP)

Implementation Manual

water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

Version 2

May 2008

Published by

Department of Water Affairs and Forestry
Resource Quality Services
Private Bag X313
PRETORIA 0001
Republic of South Africa
Tel: (012) 808 0374

ISBN No.: 978-0-621-383343-0

This document should be cited as:

Department of Water Affairs and Forestry (DWAF), 2008. National Aquatic Ecosystem Health Monitoring Programme (NAEHMP): River Health Programme (RHP) Implementation Manual. Version 2. ISBN No. 978-0-621-383343-0, Department of Water Affairs and Forestry, Pretoria, South Africa.

APPROVAL

TITLE	National Aquatic Ecosystem Health Monitoring Programme (NAEHMP): River Health Programme (RHP) Implementation Manual.
DATE	June 2008
AUTHORS	Helen Dallas, Chris Dickens, Liesl Hill, Neels Kleynhans, Delana Louw, Jonathan Taylor, Christa Thirion
REVIEWER	Kevin Murray
EDITORS	Kevin Murray and Liesl Hill
REPORT NO.	N/0000/00/REQ/0308
ISBN NO.	978-0-621-383343-0
WEB ADDRESS	www.dwaf.gov.za

Recommended:

16 Jan 2009

Mr A Diefenbach
for Acting Director: Resource Quality Services

Approved:

27/01/2009

Mr Mbangiseni P. Nepfumbada
Chief Director: WRIM

ACKNOWLEDGEMENTS

The following people are thanked for their inputs, comments and assistance towards the development of this document (listed alphabetically according to surname):

Project Study Team

Helen Dallas	Freshwater Research Unit / The Freshwater Consulting Group, University of Cape Town
Chris Dickens	Institute of Natural Resources
Liesl Hill	Council for Scientific & Industrial Research (CSIR), Natural Resources and the Environment
Neels Kleynhans	Department of Water Affairs & Forestry, Resource Quality Services
Anneli Kühn	Department of Water Affairs & Forestry, Resource Quality Services
Delana Louw	Water for Africa
Bonani Madikizela	Department of Water Affairs & Forestry, Resource Quality Services
Pumza Maseti	Department of Water Affairs & Forestry, Resource Quality Services
Ramogale Sekwele	Department of Water Affairs & Forestry, Resource Quality Services
Mike Silberbauer	Department of Water Affairs & Forestry, Resource Quality Services
Wilma Strydom	CSIR, Natural Resources and the Environment
Jonathan Taylor	University of the North West
Christa Thirion	Department of Water Affairs & Forestry, Resource Quality Services
Colleen Todd	Department of Water Affairs & Forestry, Resource Quality Services

EXECUTIVE SUMMARY

Introduction

The NAEHMP: RHP

The River Health Programme (RHP) is a nationwide-monitoring system assessing the health of rivers. It is a component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP). This manual provides an overview of how the RHP is implemented and maintained. Detailed procedures are published in a series of manuals.

National perspective

The RHP is designed to monitor the general state of river reaches and provide an overview of the ecological health of the country's rivers. As a 'national' programme, it is not the intention to provide detailed day-to-day information. However, this national perspective does not preclude provincial or local organisations carrying out additional monitoring for their own purposes. This manual describes the minimum necessary to address the national perspective.

Data acquisition

National sites

By April 2008 a total number of 639 sites had been identified in a series of workshops attended by a broad range of stakeholders. For biomonitoring to contribute formally to the national programme, these sites must be used.

Regional and local sites

Should other sites also require monitoring these should be selected with appropriate care and diligence. A distinction is made between reference and monitoring sites.

Reference sites

A reference site is a location that reflects a reference condition. This is the natural or least-impacted physical, chemical and biological characteristics of a site, river reach or river type, in the absence of anthropogenic stress.

Monitoring sites

Monitoring sites, selected to monitor integrity or health, are those sites identified as important in assessing the condition of a river or reach. Sites may range from those showing little impact to those experiencing a large impact (with respect to water quality or habitat degradation).

Biotic indices

Biotic indices are numerical indices, which use one or more components of the biota to provide a measure of the biological condition of a site. They provide a scientific basis for management decisions that affect those aquatic resources.

Biological response Indices

These indices are (or will be) used in the RHP and EcoClassification / EcoStatus process.

- Diatoms (No index developed yet);
- Macroinvertebrates – SASS (South African Scoring System) and MIRAI (Macroinvertebrate Response Assessment Index);

- Fish – FRAI (Fish Response Assessment Index);
- Riparian vegetation – VEGRAI (Riparian Vegetation Response Assessment Index); and
- Habitat integrity – IHI (Index of Habitat Integrity).

Driver Indices

These indices are used in the RHP and EcoClassification / EcoStatus and provide a habitat template for the biological components.

- Hydrology – HAI (Hydrological Driver Assessment Index);
- Geomorphology – GAI (Geomorphology Driver Assessment Index); and
- Physico-chemical – PAI (Physico-chemical Driver Assessment Index).

Prioritisation

It is not practical, or cost-effective to monitor all RHP sampling sites at the same intensity (*i.e.* frequency and extent). Sampling sites should therefore be prioritised to distinguish between high, medium and low priority sites. Generic criteria for prioritisation are provided.

Quality assurance

Quality assurance procedures are provided for the following contexts:

- Method design;
- Analytical quality control;
- Data quality assurance;
- Data interpretation; and
- Proficiency testing schemes.

Data management and storage

The Rivers Database

The Rivers Database enables RHP practitioners to capture RHP data on their individual computers and to transfer these data to the national database, which is maintained on the internet. System access is controlled via compulsory user registration.

Database structure

The Rivers Database consists of three primary components:

- Rivers Server (web application running on the internet which is the centralised repository of data at a national level);
- Rivers Client (windows application running on a desktop, also allowing data uploading from local databases to the national database – the Rivers Server); and
- Query Master (for extracting data - a local version running on the desktop and a server version running on the internet).

Training

Currently training is provided by The Freshwater Consulting Group (Helen.Dallas@uct.ac.za; Tel: 021 650 3631). It is envisaged that in the future this training will be taken over by the Rivers Administrator.

Support

General administrative enquiries should be addressed to the Rivers Administrator (contact details are available on the Rivers Server website). For technical questions related to installation or the security of the site, please contact River Technical Support, Soft Craft Systems at:

Andrewm@softcraft.co.za or Tel: 021 671 4852.

Information generation and dissemination

Primary information users

Primary information users are those who rely heavily on by the information they receive. They include:

- Department of Water Affairs and Forestry;
- Department of Environmental Affairs and Tourism;
- Water Research Commission;
- Conservation agencies; and
- Provincial departments of the environment.

Specific users within DWAF include:

- The Minister (including the relevant parliamentary portfolio committees);
- Directorate: National Water Resources Planning;
- Directorate: Resource Directed Measures;
- Directorate: Water Use; and
- DWAF Regional Offices.

Secondary information users

Secondary information users are those who benefit from RHP information but do not necessarily rely on it to perform their function. They include the general public and teachers and students at tertiary education institutions.

National perspective

The national perspective (at which this manual is primarily aimed) requires national coverage for national and strategic purposes. Reference and impacted monitoring sites are included which represent the entire country at a high level. Monitoring typically detects long-term changes.

Provincial perspective

There are similar needs at a provincial level but there may be additional needs that are specific to the province. For example, these include provincial State of Rivers Reporting, identifying “hot spots” requiring management intervention, and the issuing of water use licences and compliance monitoring.

Local perspective

While there would be some interest at local level in provincial and national RHP data, such data would typically not be at a spatial and temporal resolution that would be of use to local government. Local RHP monitoring may require more site-specific monitoring of anthropogenic activities upstream and downstream of pollution sources. Sometimes sites would only be monitored for a relatively short period, and at relatively higher frequencies.

Reporting formats

Guidance is available for reporting formats that have been used while still allowing a degree of individual style.

Reporting levels There are three reporting levels assumed, namely:

- Basic;
- Intermediate; and
- Advanced.

Basic These assume consumers have a limited knowledge and understanding of water resources management. Categories may include:

- Lay public; or
- Informed public.

Intermediate These users have a general (but not in-depth) understanding of water resources management. Categories may include:

- Informed public;
- Water resource / environmental / conservation managers; and
- Technical water resource managers.

Advanced These users have a technical and scientific background, with specialisation in one or more aspects of aquatic ecosystems. They would contribute to the RHP and will have seen or routinely used many of the RHP products. They would have a direct input into Reserve and State of Rivers (SoR) type reports, in addition to other management reports and specialist impact studies.

Information dissemination A wide variety of media can be used, including publications (technical report, scientific publications, State-of-River reports, posters, abstracts, newsletters, information brochures, etc.), networking (conferences, workshops, training sessions, and field days), web pages and email, video presentations, and media releases and media articles.

Governance

Requirements The main concern is the implementation and maintenance of a monitoring programme with a design based on sound scientific principles and operationally feasible protocols, as a means to inform sound river management. For this to be successful, every organisation involved in the RHP, has to:

- Have a clear understanding of the Programme's purpose and objectives;
- Agree on their respective role and responsibilities;
- Accommodate the Programme within their internal business and strategic plans; and
- Work together in a collaborative and cooperative manner.

Legislative context A wide variety of Acts constitute the high level legislative context for the RHP.

Memoranda of A signed memorandum of (co-operative) understanding between key

Understanding government departments and other collaborating organisations within the PTT, would clearly spell out the roles, functions and responsibilities that each organisation agree to undertake. It is therefore a useful document to contribute to the successful implementation and maintenance of the Programme.

The governance model While the design, development, and standardisation (concepts, methods, processes) of the RHP is coordinated at a national level, implementation activities largely take place at the provincial level. This model of implementation has to date relied strongly on voluntary participation, informal arrangements and a fair amount of flexibility that caters for the diversity of resource realities (both human and financial) across the country.

Main national role players The national custodians of the RHP and the main role players at national level are:

- The Department of Water Affairs and Forestry (DWAF);
- The Department of Environmental Affairs and Tourism (DEAT); and
- The Water Research Commission (WRC).

Main provincial role players The Programme is implemented at a provincial / Catchment Management Agency (CMA) / regional level. Collaboration plays a crucial role. Each province has a network of implementers who work together in a Provincial Task Team (PTT), under the leadership of a Provincial Champion. The following may participate:

- DWAF Regional Offices;
- SANParks;
- Provincial parks boards;
- Academic institutions;
- Conservation agencies;
- Water boards; and
- Private sector organisations and industry.

Their primary role is to actively work together in a PTT, sharing skills and resources to achieve goals that would not be possible for any one organisation working alone.

Corporate governance DWAF, because of its leading role in the RHP, has some unique governance elements that are critical to the success of the Programme. These relate to political endorsement and accountability, technical leadership and communication, and capacity and skills.

Network governance Three areas are recommended for future attention for governing the national network of RHP practitioners and participating organisations:

- A performance management system for a cluster of participating organisations at the spatial scale of a province or Water Management Area (WMA);
- A community of practice to foster inter-organisational learning and

knowledge sharing; and

- A national research and development programme to ensure dynamic development and scientific credibility of the Programme.

Capacity building

Capacity building can occur in a variety of ways and contexts:

- Communities of practise;
- Field work;
- Workshops;
- Meetings and symposia;
- In-house training;
- Coaching and mentoring;
- Research and development;
- Education and awareness creation among stakeholders enabling stakeholder participation in decision-making processes that don't necessarily relate to the RHP.

CONTENTS

GLOSSARY

Accuracy. How close a measured or estimated value is to the real, or accepted, value. (See ***Precision***.)

Biomonitoring. Use of biological attributes of a water body to assess its environmental health condition.

Biota. Animal and plant life characterising a given area.

Biotic index. A numerical index which uses one or more components of the biota to provide a measure of the biological condition of a site.

Biotope. An area of uniform environmental conditions and biota.

Community of practice. A group of people who (a) share a passion and (b) meet regularly and informally to learn and practice how to do things better.

Diatoms. Unique algae that possess a cell wall constructed almost entirely of silica.

Download. Transfer of data and information from another computer to your computer. In the RHP this usually refers to transfers from the central web-based Rivers Database to local computers.

EcoClassification. Short for Ecological Classification process, the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative the natural or close to the natural reference condition.

Ecological Importance and Sensitivity. Ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience)

Ecoregion. Regions of relative homogeneity in ecological characteristics or in relationships between organisms and their environments. Boundaries are not distinct and one region merges into the next.

EcoStatus. Abbreviation of "Ecological status", the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services.

Ecological Reserve. See ***Reserve***.

Indicator. See ***Index***.

Index. A number or ratio (a value on a scale of measurement) derived from a series of observed facts; can reveal relative changes as a function of time (http://wordnet.princeton.edu/perl/webwn).

Invertebrate. An animal lacking a backbone and internal skeleton.

Macroinvertebrates. Invertebrates visible to the naked eye.

Macro site. Those monitoring sites identified during the RHP site selection process that have not yet been "ground-truthed" *i.e.* the exact location has not yet been defined.

Monitoring. The measurement, assessment and reporting of selected properties of water resources in a manner that is focussed on well-defined objectives.

Monitoring, baseline. The assessment and characterisation of existing conditions to provide a standard, or "baseline," against which future change is measured.

Monitoring site. A physical location at which monitoring occurs.

Monitoring, standard. Monitoring at sites selected to assess the condition of the site, river reach or river. Typically assessed relative to baseline monitoring or reference conditions.

Multimetric index. An index that combines indicators, or metrics, into a single index value (www.epa.gov/bioindicators/html/multimetric.html).

Photoautotrophic. Use light, an inorganic electron source, and CO_2 as a carbon source.

Precision. How well a series of measurements agree with each other. For numbers, it is the number of figures (digits) in a measured or estimated value that are significant, *i.e.* actually contain information. (See ***Accuracy***.)

Present Ecological State (PES). The current health or integrity of rivers compared to the natural or close-to-natural reference condition. It is expressed in terms of drivers (physico-chemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the EcoStatus.

Quality Assurance (QA). The implementation of all activities that minimise the possibility of quality problems occurring. These include, among others, training, instrument calibration and servicing, quality control, producing clear and comprehensive documentation, and so on.

Quality Control (QC). The process of ensuring that recommended procedures are followed correctly by detecting and correcting quality problems when they arise, so that the accuracy of primary observations or measurements is (a) defined, (b) within acceptable limits and (c) recorded.

Reserve. Defined by the National Water Act as the quantity and quality of water required:

1. To satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act (108:1997), for people who are now or who will in the reasonably near future, be (a) relying upon, (b) taking water from or (c) being supplied from, the relevant water source (the Basic Human Needs Reserve); and
2. To protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource (the Ecological Reserve).

Reference condition. The expected condition that reflects natural or least-impacted physical, chemical and biological characteristics of a site, river reach or river type, in the absence of anthropogenic stress.

Reference site. A location exhibiting a reference condition.

Resource quality objectives (RQOs). Numeric or descriptive (narrative) goals for resource quality within which a water resource must be managed. These are given legal status by being published in a *Government Gazette*.

Substratum. A surface on which an organism occurs.

Water quality. The physical, chemical, radiological, toxicological, biological and aesthetic properties of water that (1) determine its fitness for use or (2) that are necessary for protecting the health of aquatic ecosystems. Water quality is therefore reflected in (a) concentrations of substances (either dissolved or suspended), (b) physico-chemical attributes (*e.g.* temperature), (c) levels of radioactivity and (d) biological responses to those concentrations, physico-chemical attributes or radioactivity.

Upload. Transfer of data and information from your local computer to another computer. In the RHP this usually refers to transfers from your local Rivers Database to the central web-based Rivers Database.

Voucher specimen. A specimen archived in a permanent collection (usually in a museum, being an institution with a mandate to preserve materials indefinitely). It serves as physical evidence of occurrence at a specific time and place and of any identifications and descriptions based on it. This assumes that it is archived with adequate collection data. Type specimens are voucher material.

ACRONYMS

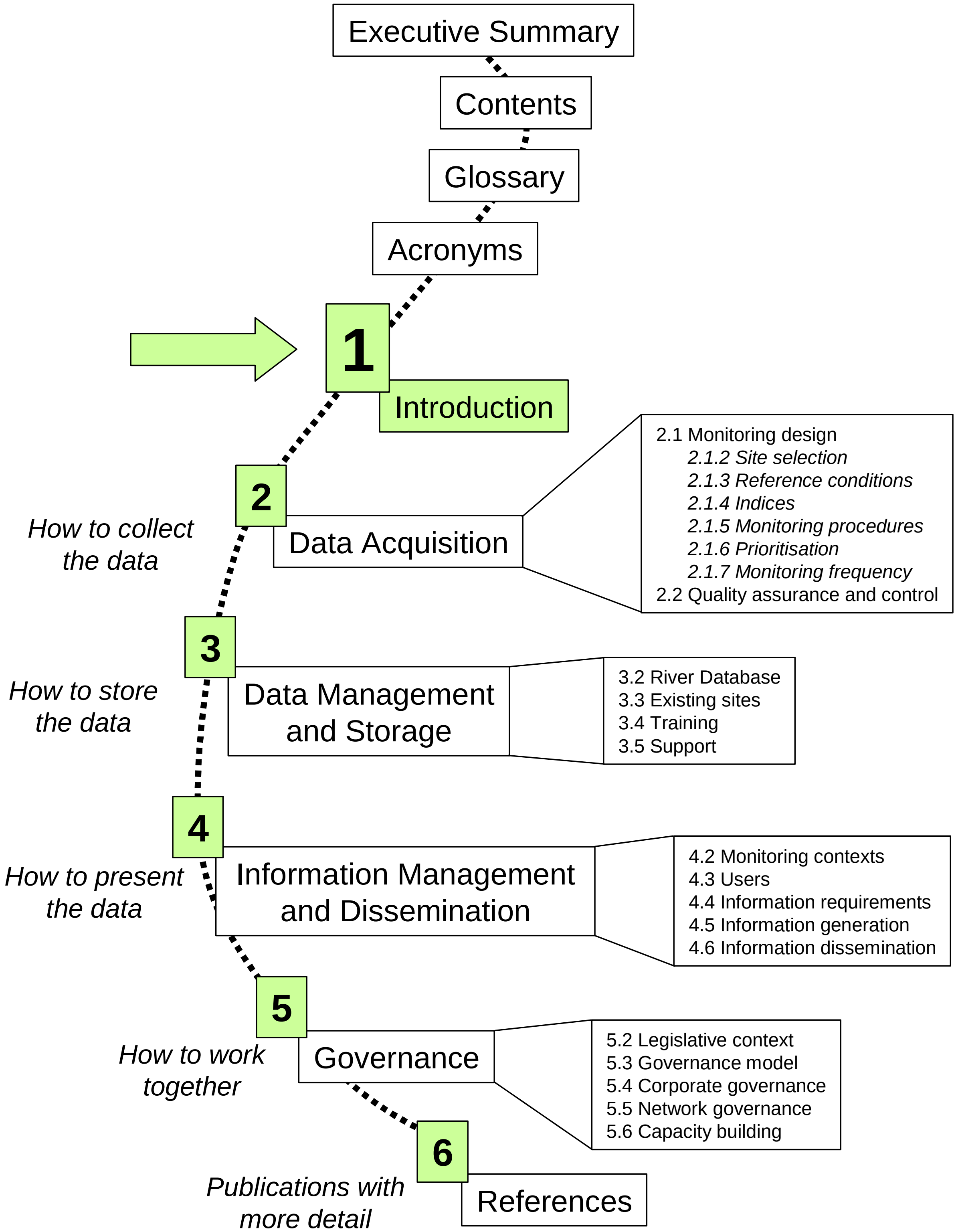
Technical

ASPT	Average Score Per Taxon
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GAI	Geomorphology Driver Assessment Index
HAI	Hydrological Driver Assessment Index
IHAS	Integrated Habitat Assessment System
IHI	Index of Habitat Integrity
MIRAI	MacroInvertebrate Response Assessment Index
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
PAI	Physico-chemical Driver Assessment Index
PES	Present Ecological State
RDM	Resource Directed Measure
REC	Recommended Ecological Category
RHP	River Health Programme
SASS	South African Scoring System
SoE	State of Environment
SoR	State of Rivers
SPI	Specific Pollution sensitivity Index
VEGRAI	Riparian Vegetation Response Assessment Index

Organisational

CBO	Community Based Organisation
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
NGO	Non-Governmental Organisation
WRC	Water Research Commission

Manual Roadmap



SECTION 1: INTRODUCTION

This section describes the purpose of this manual and gives an overview of the NAEHMP, its historical development and its first 10-year review.

1.1 PURPOSE OF THIS MANUAL

Scope

This manual describes the resource and technical requirements necessary to implement and maintain the river component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) at a national level.

Legislative requirement

Section 137 of the National Water Act (Act 36 of 1998) (RSA, 1998) requires that national monitoring systems be established to collect data and information on our water resources. The River Health Programme (RHP) is such a monitoring system focussed on assessing the health of rivers in particular. The NAEHMP is a management information system intended to provide information on the health or integrity of aquatic resources in general (as required by Section 137(f) of the Act) in order to support the management of these resources (Roux, 1997).

Purpose

The purpose of this manual is to:

- Provide an overview of the definitive RHP procedures to collect, store, interpret and distribute data and information on the health of rivers, and
- Provide an overview of how the RHP is governed.

The detailed procedures are published in several manuals and guideline documents and are available on the supplementary CD included with the manual.

Audience

The manual is primarily aimed at:

- Department of Water Affairs and Forestry (DWAF) officials who have the responsibility to manage the implementation and maintenance of the Programme at national level, and
- Provincial and local implementers of the Programme and river health practitioners who need a general overview of the Programme.

1.2 NAEHMP OVERVIEW

Responsibility

The Department of Water Affairs and Forestry (DWAF), as the legal custodian of water resources in South Africa, is responsible for managing these resources. One component of this responsibility is the development, implementation and maintenance of national water resource quality monitoring programmes (DWAF, 2004a). The NAEHMP: RHP is one component of this suite.

Purpose

DWAF initiated the NAEHMP in 1994 in response to the need for information regarding the ecological state of aquatic ecosystems. (It was previously known as the National Aquatic Ecosystem Biomonitoring Programme (NAEBP)). The ecological state is based on the biological condition of these resources in relation to the human-induced disturbances affecting them.

The primary focus of the Programme is the state of health of aquatic ecosystems, which include rivers, wetlands, estuaries and aquifer dependent ecosystems (Roux, 1997). The Programme initially focussed on rivers in a sub-programme known as the River Health Programme (RHP).

Vision

To implement, maintain and improve biomonitoring for all inland aquatic ecosystems in South Africa and throughout the southern African region.

Objectives

The formal objectives of the NAEHMP (Roux, 1997; Murray; 1999) are to:

- Measure, assess and report on the ecological state of aquatic ecosystems;
- Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- Identify and report on emerging problems regarding the ecological state of aquatic ecosystems in South Africa; and
- Ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

The ultimate intention of the provision of such data and information is to create a level of awareness that empowers all stakeholders to participate meaningfully in integrated water resources management.

1.3 RHP DESIGN

Monitoring scope

The NAEHMP: RHP is designed to measure, assess and report on the general state of river reaches and to provide an overview of the ecological health of the country's rivers. It is not the intention to provide day-to-day operational answers or monitor exact conditions at any specific site (Roux *et al.*, 1999).

However, this perspective of a national overview does not preclude carrying out additional monitoring activities considered necessary at provincial, catchment and local levels. Indeed, such higher resolution monitoring is crucial for broader integrated water resources management. However, it is not necessary for the national programme *per se*.

Phased approach

A phased approach was followed for the development of the RHP. In the first few years the emphasis was mainly on research and development of basic monitoring protocols. After that, the Programme was pilot tested and became operational in most of the provinces.

Implementation model

DWAF played the leading role in the initiation and development of the Programme. The Department however realised from the start that they alone did not have the necessary capacity and resources to implement and maintain a programme of this nature and extent on a national basis. This lead to the development of a partnership between DWAF, the Department of Environmental Affairs and Tourism (DEAT) and the Water Research Commission (WRC), who together form the national custodians of the Programme.

Rollout

With this national focus on programme development and coordination in place, implementation of the Programme was rolled out at a provincial level. The RHP is a truly cooperative venture with participants from many government and non-governmental organisations, including conservation agencies, provincial and local authorities, universities and private sector organisations. All these organisations have an interest in collecting data and making information available on the state of rivers in their areas of concern.

1.4 10-YEAR REVIEW PROCESS

Periodic review

Inevitably stakeholder information needs evolve, new legislation comes into place and new monitoring techniques become available. Therefore, as with any monitoring programme, it is essential to periodically review and revise the design of the programme. Towards the end of 2003, after being in existence for almost ten years (having been initiated before the National Water Act came into effect in 1998), a process was initiated to review the design of the RHP component of the Programme.

Purpose

The purpose of the review process was to:

- Align the design of the Programme with the National Water Act (Act 36 of 1998) (RSA, 1998) and DWAF's Strategic Framework for National Water Resource Quality Monitoring Programmes (DWAF, 2004a);
- Refine and test the suite of biological and secondary indices to be included as part of the national Programme;
- Investigate options to expand the scope of the Programme to include other aquatic ecosystems such as wetlands and estuaries;
- Formalise the Programme as a national programme, including its governance and to make roles and responsibilities at national and provincial levels explicit;
- Develop a systematic national plan to monitor, assess and report on

representative river types countrywide; and

- Address priorities identified during a planning workshop in terms of Quality Assurance and Control (QA & QC), Data Management and Storage and the Biomonitoring Short Course.

Approach

The review process was addressed through a number of focussed projects:

- The Inception Phase aimed to (a) align the NAEHMP: RHP with DWAF's Strategic Framework for National Water Resource Quality Monitoring Programmes, (b) formalise the Programme as a national programme, and (c) develop a systematic national monitoring plan.
- The National Coverage Phase aimed to further develop and refine QA & QC procedures, the Rivers Database and the Biomonitoring Short Course.
- A number of smaller projects, co-funded by the WRC, aimed to (a) develop a wetlands health index and (b) further develop, refine and test biological and secondary indices that form part of the suite of RHP indices.

1.5 STRUCTURE OF THIS MANUAL

Data Acquisition

Section 2 provides an overview of:

- National site selection and reference conditions;
- Indices;
- Monitoring procedures; and
- Quality assurance and control.

Data Management and Storage

Section 3 provides a description of the following aspects relating to the Rivers Database:

- Installation requirements;
- Structure;
- Existing sites; and
- Support.

Information Generation and Dissemination

Section 4 provides an overview of:

- The information users;
- Information requirements;
- Different levels of data interpretation and reporting; and
- Channels for information dissemination.

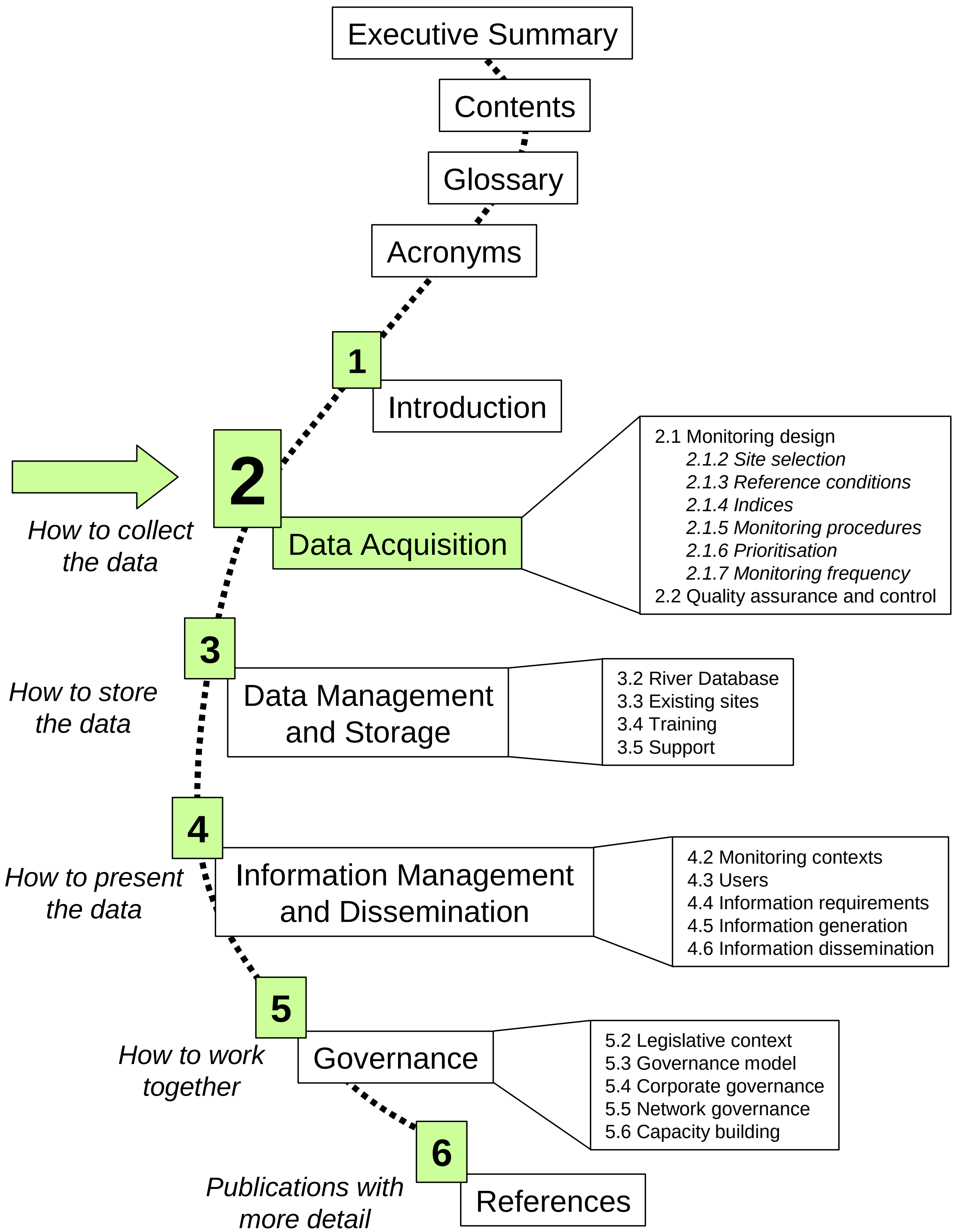
Governance

Section 5 provides a description of:

- The legislative context;
- The RHP governance model;

- The role players;
- Their roles and responsibilities;
- Corporate and network governance; and
- Forms of capacity building.

Manual Roadmap



SECTION 2: DATA ACQUISITION

This section summarises how sites are selected, the concept of reference conditions, the indices used, the monitoring procedures and quality assurance and control.

2.1 MONITORING DESIGN

2.1.1 Introduction

Screening

The NAEHMP: RHP is designed to monitor the state of health or integrity of aquatic ecosystems in South Africa. It is not aimed at monitoring site-specific impacts or conditions. The Programme is therefore a screening-level monitoring programme based on a relatively low sampling frequency and a low resolution of sites. The sites are selected to ensure that adequate coverage is given to all types of rivers in the country (Roux, 2004).

Biological integrity

The Programme's assessment philosophy is based on the concepts of biological integrity. Use is made of biological indicators and indices (macroinvertebrates, fish, and riparian vegetation) and indices for assessing instream and riparian habitats (Roux, 1997; Roux, 2004).

A centralised data management system has been established for storing RHP data (DWAF, 2007a; Dallas *et al.*, 2007). To ensure that data and information generated are of a reliable and credible quality, Quality Assurance and Control (QA & QC) procedures have also been established (DWAF, 2007b).

Scope

Monitoring design refers to what needs to be monitored (*i.e.* the indicators), where (site selection), how (monitoring protocols and procedures) and when (the frequency) in order to meet the Programme's objectives.

This section summarises these components of the Programme.

2.1.2 Site selection

2.1.2.1 National sites

Selection process

National monitoring sites have been identified for South Africa. They were selected during a series of workshops attended by regional experts and biomonitoring practitioners, representing a broad range of organisations including government departments (regional and national), local authorities, Parks Board and Conservation agencies, universities and the private sector (Dallas, 2005a).

The selected sites

In April 2008 a total number of 639 national sites had been identified of which 260 are existing sites and 379 are proposed macro sites. Of the existing sites, more than 100 are considered to be potential reference sites.

On CD:
Dallas 2005a
Dallas 2005b

The macro sites require field verification as they represent potential sites selected using the desktop and local knowledge method. Field verification is required before these sites can be considered national sites. A site selection report noting the sites and the water management area form part of a Record of Decision report.

2.1.2.2 Regional and local sites

Context

For biomonitoring to contribute formally to the national programme, the above-mentioned national sites must be used. However, there may be reasons relating to provincial or local priorities that require other monitoring sites to be identified. This section summarises how this is done.

Site verification

Selection of sites for biomonitoring is an important process and adequate time and effort must be assigned to this task to ensure that sites provide optimal information and are representative of conditions in a defined river reach.

Reference and monitoring sites

There are two types of sites, namely **reference** and **monitoring** sites. The RHP design allows for the comparison between monitoring sites and reference sites or conditions (Roux, 1997). In reality, reference sites are difficult to locate. (Indeed, to the purist, they may not strictly exist anywhere because of the widespread impact man has already had on the planet.) Therefore reference conditions are often generated using alternative methods (see Section 2.1.3).

Iterative process

Site selection is often an iterative process with potential sites being selected initially using desk-top and local knowledge. This is followed by a ground-truthing or site verification phase and then a data collection and analysis phase (*e.g.* Dallas 2000). The process is based on the Ecoregional approach (Kleynhans *et al*., 2005; Kleynhans *et al*., 2007d) which allows for rivers to be grouped according to similarities.

Programme objectives

The objectives of the Programme should always be borne in mind when selecting sites. However, the following summarises more specific criteria that are used.

Number of sites

The number of sites increases with increasing:

- Natural heterogeneity of the area, or
- Variety of land uses or potential anthropogenic impacts on river health.

However, in reality it is often financial and logistical constraints that ultimately determine the number of sites.

Upfront questions

Answers to the following questions will assist the RHP practitioner locating reference and monitoring sites appropriately:

- What is the extent of the area to be monitored (*i.e.* a river reach, a river, a catchment, a Water Management Area)?
- How homogenous is the area to be monitored in terms of natural characteristics (*i.e.* geology, natural vegetation, gradient, climate,

etc.)? Spatial coverage maps of ecoregions (Levels I and II), vegetation, geology, etc. are useful.

- Are there rivers / tributaries, or river reaches, which represent the reference or natural condition, within the area to be monitored? Identification of protected areas such as reserves or wilderness areas is useful.
- How homogenous is the area to be monitored in terms of anthropogenic modifications and impacts (*e.g.* land uses, water quality impacts, physical modifications, etc.)? Spatial coverage maps of land use are useful.
- What are the key anthropogenic activities that need to be monitored and where do they occur?
- What studies have been undertaken in the proposed monitoring area? These could include Reserve studies, specialist studies, scientific studies, consultancies, etc.
- Has an aerial survey been undertaken in the proposed monitoring area? This is often used for determining of the Index of Habitat Integrity.
- What existing biomonitoring sites are present in the proposed monitoring area and at what frequency have these been monitored and by whom? Are they still actively monitored?
- What other monitoring sites (*e.g.* hydrological or water quality) exist in the proposed monitoring area and what monitoring data exist for these sites?

Reference sites

A reference site is a location that reflects a reference condition. This is the natural or least-impacted physical, chemical and biological characteristics of a site, river reach or river type, in the absence of anthropogenic stress.

It is recommended that, where possible, several reference sites be selected for a particular river type (or spatial unit). This is often difficult. However, multiple sites:

- Allow for the incorporation of natural variability; and
- Safeguard against unexpected destruction of a single reference site compromising the biomonitoring programme and interpretation of results.

The scarcity of reference sites in many regions necessitates the reconstruction of the reference condition using alternative methods (see Section 2.1.3).

Preparatory work

On CD:
Kleynhans *et al.*, 2007b

The purpose of preparatory work is to collect and collate all relevant data that assist in guiding the specification of a reference condition. This data will also provide a synoptic view of disturbances in the system. Information sources include:

- Land cover database (CSIR / ARC land cover 1996 (Thompson 1996) or CSIR / ARC land cover 2000), topo-cadastral maps; 1:250 000 and 1:500 000 scale. GIS coverages for these are buffered to within 500 m on both sides of the river. The various land cover classes are quantified in terms of the area (ha) that it covers. From this information an indication of activities around the river can be obtained. Depending on availability and resources, either the 1996 or 2000 land cover information can be used.

- Topo-cadastral maps provide general information on catchment activities.
- Aerial photographs that span a period of time prior to major modifications up to most recent can be obtained from The Chief Surveyor General, Department of Land Affairs.
- High resolution Google Earth images provide useful information on relatively recent developments.
- Remote sensing data can be used where readily available and where there is expertise available to process these data.
- DWAF catchment study reports are available for certain catchments. Contact the DWAF library in Pretoria.
- ISP (Internal Strategic Perspective) reports of DWAF (www.dwaf.gov.za).
- Ecoregional context (Kleynhans *et al.*, 2005).
- Geomorphic zones (DWAF, 1:500 000 scale).
- Hydrological information can be obtained from www.dwaf.gov.za, Midgley *et al.*, (1994) and Spatsim (Hughes, 2005).
- Water quality data can be obtained on www.dwaf.gov.za.

Factors to consider

Ensure that a spatial framework is used so that the full range of reference conditions is represented.

Incorporate local knowledge and select potential reference sites using information regarding the extent to which a site has been disturbed / impacted. Criteria used to assess the level of disturbance often include a qualitative assessment of land-use, water quality impacts, modifications to discharge and physical alterations to the channel.

Final selection of reference sites is conducted after examination of the biotic data.

Monitoring sites

Monitoring sites, selected to monitor integrity or health, are those sites identified as important in assessing the condition of a river or reach. Sites may range from those showing little impact to those experiencing a large impact (with respect to water quality or habitat degradation).

Factors to consider

Monitoring sites, which are used for state of the river / environment (SoR / SoE) reporting, should be selected to ensure an adequate distribution of sites within the area under consideration. The distribution of sites must cover all river types (or spatial units) and levels of impact.

This is important in order to obtain objective information for SoR / SoE reporting on environmental trends within the catchment. Sites should be selected to represent the river types and land use patterns in each Water Management Area (WMA). They should be located so that the full range of the effects of the different land uses can be evaluated.

When monitoring sites are selected, they should:

- Be suitable for application of monitoring methods prescribed herein;
- Be accessible (*e.g.* close to access roads), and safe;
- Provide the maximum possible information; and
- Be representative in terms of reflecting upstream impacts as well as habitat.

When the national monitoring sites are selected, they should take into account:

- Proximity to other DWAF national monitoring points (*e.g.* chemical monitoring points, hydrological (flow) gauging stations, etc.);
- Availability of historical information;
- The diversity of aquatic habitats as well as their suitability for sampling macroinvertebrates, fish and assessing riparian vegetation;
- The ecological importance and sensitivity of the quaternary catchment in which the river reach is situated; and
- Priority areas identified by DWAF for compulsory licensing and ecological Reserve determinations (specifically sites used to determine the ecological water requirement).

Site verification

On CD:
Appendix Crocodile-Sabie Reserve,
Kleynhans & Louw, 2007b
Dallas 2005c

Site verification is a ground-truthing exercise to determine the actual specific location of potential sites.

For example, the macro sites for the national programme (those locations identified during the RHP site selection process, and for which supporting attribute data were not available (Dallas, 2005a)) are visited by provincial implementation teams and scientists of Resource Quality Services (DWAF).

What to check for on site

Verification should assess the suitability of a site to provide information on the integrity of various biological groups and the extent to which a particular biological group may serve as an indicator of river health.

The following are important:

- *A site must be representative of the river reach or spatial unit it is delineating*. For example, for fish the velocity-depth and cover classes at a site should be representative of the river reach or spatial unit. Avoid, if possible, sites close to artificial structures such as bridges and weirs. These may not be representative of the river reach.
- *A site must be suitable for biomonitoring of the different RHP indices (macroinvertebrates, fish, riparian vegetation, diatoms, etc.)*. For example, an optimum macroinvertebrate site would be a site at which all or most of the aquatic biotopes are present, *i.e.* Stones-in–current, Stones-out-of-current, Vegetation-in-current, Vegetation-out-of-current, Sand, Gravel and Mud. As a minimum requirement, a site should have a stony or vegetation biotope. The quality and quantity of the biotopes should also be considered.

- *A site must have habitats that are amenable to sampling.* For example, consider the ease with which sampling methods, like electro-shocking and seine netting, can be used for fish sampling. Non-wadeable rivers are also difficult to sample unless a boat or canoe is available.
- *A site must be easily accessible and safe (in terms of both dangerous animals and crime)*.

A simple approach to assess the suitability of biological groups to indicate integrity in a specific river reach has been developed (Appendix Crocodile-Sabie Reserve, Kleynhans & Louw, 2007b)

Assessment units for habitat integrity

Homogenously impacted river reaches should be identified according to the diversity of impacts. A broad assessment of the types of land cover along each river reach is conducted, which provides an indication of impacts and habitat modification. If impacts and modifications along a river reach are not homogenous, river sections should be assessed separately to provide a representative indication of habitat integrity.

Site characterisation

Once reference and monitoring sites have been selected, the sites have to be characterised. This aims to standardise the data collected. It distinguishes between information gathered when visiting a site for the first time and information that needs to be gathered subsequently on monitoring visits.

A Site Characterisation Field Manual (with Field Datasheets) (Dallas, 2005c) describes this in detail. The results must form part of a Record of Decision report.

2.1.3 Reference Conditions

Introduction

The concept of reference conditions is fundamental to the RHP. This section summarises what they are, why they are necessary and how they are generated or derived for some indices.

2.1.3.1 Overview

Definition

A reference condition is the expected condition that reflects natural or least-impacted physical, chemical and biological characteristics of a site, river reach or river type, in the absence of anthropogenic stress.

Reference conditions enable the degree of deviation from natural conditions (typically degradation) to be ascertained. They are the foundation for developing biological criteria for the protection of aquatic ecosystems and evaluating impacts at monitoring sites (Dallas, 2000; Dallas, 2002).

Regional reference conditions

The natural variability in rivers of South Africa resulting from differences in climate, landform, geology, vegetation, soil type, etc. necessitates the use of regional reference conditions rather than national reference conditions. These would therefore take into account different natural variation at different sites, river reaches or rivers in different regions.

Spatial framework

A reference site is representative of the river type (or spatial unit) for which it provides a reference. It is therefore normally selected within a spatial framework. The commonly used spatial framework in South Africa is Ecoregion Level I or II (Kleynhans *et al*., 2005, Kleynhans *et al*., 2007d) and longitudinal (geomorphological) zone (Rowntree & Wadeson, 1999).

> On CD:
> Kleynhans *et al*., 2005; 2007d
> Rowntree & Wadeson, 1999

Generation

The process by which reference conditions are derived varies from one biotic component to another. However, some general principles apply. Reference conditions may be generated using:

- Data from several reference sites that are located in the same spatial unit as the monitoring site(s) (which may be analysed using multivariate analysis);
- Data from a single reference site that is located in the same spatial unit (*e.g.* ecoregion and geomorphological / longitudinal zone) as the monitoring site(s);

Few, if any, truly pristine sites remain. Even near-pristine sites are scarce. In some instances, particularly in the lower reaches of rivers, reference conditions may simply be the “best available”. In such cases it is usually necessary to supplement data from reference sites with:

- Historical information and data; and
- Expert knowledge (*e.g.* including extrapolation of expected frequency of occurrence of relevant taxa).

The level of confidence one can place in the reference condition depends on the amount of data used. In some instances the reference condition can only represent an approximation of expected natural reference conditions.

Interpretation of data

The ultimate objective of biomonitoring is to use biota to reflect the degree of disturbance at a site. Reference conditions define what is expected to occur naturally at a site and hence provide a means of comparing observed conditions with expected conditions. However, this is a complex task requiring careful consideration of many factors. The methods for interpreting biomonitoring data for the different biotic components are discussed separately in Section 4.5.

2.1.3.2 Macroinvertebrates

What to do

Reference conditions for aquatic macroinvertebrates have not yet been determined for all regions in South Africa. However, they are currently being developed for the national sites. In the interim, do the following:

- *National sites*. Practitioners can refer to a series of documents, which give reference conditions for selected regions and river reaches, and provide guidance on generating reference conditions (Thirion, 2007).
- *Other sites*. If reference conditions are not yet available, less experienced practitioners should wait until reference conditions have been determined by the designated teams. However, experienced practitioners may develop interim reference conditions using reference conditions from similar river reaches from the same EcoRegion and longitudinal / geomorphological zone, or historical data. The documents above can be used for guidance. These interim reference conditions can then provide input into the process involving the designated teams.

The following summarises how reference conditions are derived.

International approaches

On CD:
Dallas, 2000
Thirion, 2007

Internationally, there are two fundamentally different approaches for classifying reference sites and generating reference conditions for aquatic macroinvertebrates:

- *The regional approach*: This classifies reference sites *a priori*, based on geographic and physical attributes. This approach assumes that monitoring site characteristics match the chosen regional reference sites.
- *The multivariate approach*: This classifies reference sites *a posteriori* using multivariate analysis of macroinvertebrate fauna. It makes no prior assumptions about the similarity of macroinvertebrate assemblages at different sites. Rather, faunal data are used to group sites that have similar taxonomic composition, thus providing an objective way of grouping reference sites with similar macroinvertebrate assemblages.

South African approach

A regional approach has been adopted in South Africa. A hierarchical spatial classification system divides the country in a logical and ecologically-meaningful way so that variation between rivers (and biotic assemblages) in the country is best accounted for.

Currently defined reference conditions

Reference conditions for macroinvertebrates have not yet been determined for the all regions. Of those that have been determined, some have been generated through multivariate analysis of data (*e.g.* Dallas, 2000; Dallas & Day, 2007) while for others use has been made of historical information and expert opinion (see Thirion, 2007). Either way it is critical that reference conditions be generated within the context of a spatial unit such that natural spatial variation in macroinvertebrate assemblages are taken into account (see Dallas, 2004a for more details).

Components

Reference conditions for macroinvertebrates comprise two components:

- An expected "Reference Score"; and
- An expected list of "Reference Taxa", including expected abundances and frequency of occurrence.

Reference Score

These are based on the metrics generated using the SASS method (Dickens & Graham, 2002) and include the SASS5 Score and the Average Score per Taxon (ASPT). A preliminary method for interpreting SASS data based on these two metrics has been formulated (Dallas, 2007a). The method however requires regional validation and testing before it can be used nationally.

Reference Taxa

Taxa expected to be present at a site in the absence of anthropogenic impacts are called the "Reference Taxa". Methods for determining the list of Reference Taxa vary and their expected frequencies of occurrence vary. They include:

- The compilation of a reference list for taxa from a least-impacted site in the same spatial unit (*e.g.* Level I or II Ecoregion and geomorphological zone) with similar habitat to the monitoring site;
- The generation of a reference list of taxa based on multivariate analysis of macroinvertebrate assemblages from a suite of reference sites within a spatial unit. The relative frequency of occurrence of each Reference Taxon is often provided. Whilst this method is more robust it is also more data intensive.
- In the absence of suitable reference sites then data and information from similar sites in other rivers, as well as historical information, can be used to generate a derived reference list of taxa expected under reference conditions. A thorough knowledge of the area under consideration is essential in order to compile a suitable derived reference list.

In all instances cognisance needs to be taken of aquatic habitat and other abiotic factors (*e.g.* substratum) that may influence the presence or absence of an invertebrate taxon.

The generation of reference lists of taxa is planned for 2008. Available data and expert knowledge will be used to derive lists of reference taxa for each of the national RHP sites.

2.1.3.3 Fish

What to do

To obtain or derive reference conditions for fish, do the following:

- *National sites*. Reference conditions have been determined for all the currently defined national monitoring sites. Obtain these from Kleynhans *et al.*, (2007b).
- *Other sites*. For some other site (required for provincial / local purposes) use reference conditions from similar river reaches from the same Ecoregion and longitudinal / geomorphological zone. Fish filter models are under development that will enable users to derive reference species lists based on historical data and correlated environmental attributes.

The folowing summarises how the existing reference conditons have been established.

The index

The response of fish to modified environmental conditions is measured in terms of the Fish Response Assessment Index (FRAI) (Kleynhans, 2007). This index is based on a combination of:

On CD:
Kleynhans, 2007

- Fish species habitat preferences;
- Intolerance to habitat changes; and
- Present frequency of occurrence of species compared to the reference frequency of occurrence.

Consistency

Various guidelines can be provided to enable assessors to derive the expected reference list of species and their reference frequency of occurrence at a monitoring site. However, variation in the interpretation of different assessors is possible. To ensure consistency, fish specialists countrywide have derived the reference frequency of occurrence (FROC) of fish species during a number of specialist workshops. The specific aims were to:

- Specify fish reference frequency of occurrence attributes for each of the national RHP sites as specified for each of the 19 Water Management Areas in South Africa; and
- Specify fish reference frequency of occurrence attributes for additional fish sampling sites.

FROC: Derivation and use

The derived list of fish species is based on species that are known to be present or to have been present under close-to-reference habitat conditions. Species that are derived to have been present under relatively recent reference habitat conditions are also identified. The resulting species reference list is a combination of both.

The FROC rating refers to a particular ecologically defined reach of a river (**Table 2.1**). Ratings are scored from 1 to 5. For example, if a species under natural reference conditions occurs at 3 out of 5 sites in a reach, its frequency of occurrence would be 60%. This would give a frequency of occurrence rating of 4 (present at most sites; >50-75% of sites).

The purpose of the FROC is to provide a reference list of species as well as a reference frequency of occurrence for these species. This reference information is then used in the FRAI formula to assess the present condition of the fish assemblage. The reference lists of fish species and the maps showing the sites are provided in Kleynhans *et al.* (2007b). The FROC is provided in the Excel database which is attached to that report.

Table 2.1: Frequency of occurrence (FROC) ratings used in the calculation of the fish index (FRAI).

FREQUENCY OF OCCURRENCE (FROC) RATING	DESCRIPTION
0	Absent
1	Present at very few sites (≤10% of sites)
2	Present at few sites (>10-25%)
3	Present at about >25-50 % of sites
4	Present at most sites (>50- 75%)
5	Present at almost all sites (>75%)

2.1.3.4 Habitat integrity and riparian vegetation

What to do

No formal method has yet been documented to obtain or derive reference conditions for habitat integrity and riparian vegetation in a river reach. However, the purpose is to identify those conditions that would characterise the habitat and riparian vegetation in a river reach in the absence of any human impact.

The folowing summarises the approach.

Impact-based

As for the other indices, assessment of habitat integrity is based on an interpretation of the deviation from the reference condition. Specification of the reference condition follows an impact-based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system.

Deriving a reference condition

To derive a reference condition, information is obtained on abiotic changes that can potentially influence river habitat integrity and riparian vegetation. Surveys can be used or a variety of data sources (*e.g.* see Section 2.1.2.2). It is then established how these affect the main drivers of the system, *i.e.* hydrological, geomorphological and physico-chemical conditions. This is used to determine how what the impacts would be on the natural riverine habitats. The severity of impacts depends on the nature of the river. Some river types will be more sensitive to impacts than others.

A neighbouring river reach in a less-impacted condition can also be used to determine reference conditions.

Selection of assessment units

Naturally homogenous river sections should be delineated using ecoregions (including consideration of the components used to define ecoregions), longitudinal zones, river size (*e.g.* stream order or Mean Annual Runoff) and hydrological information.

Future plans A more structured approach is planned for determining the reference conditions for both habitat integrity and riparian vegetation.

2.1.4 Indices

2.1.4.1 Overview

Biotic indices Biotic indices are numerical indices, which use one or more components of the biota to provide a measure of the biological condition of a site. One of the advantages of biotic indices is that they formalise what any good biologist, familiar with local biota, knows about the biological condition of a river. They also communicate the biological condition to managers providing a scientific basis for management decisions that affect those aquatic resources. **Figure 2.1** provides a conceptualisation of the relationship between biological indicators and what they may tell us about the environment.

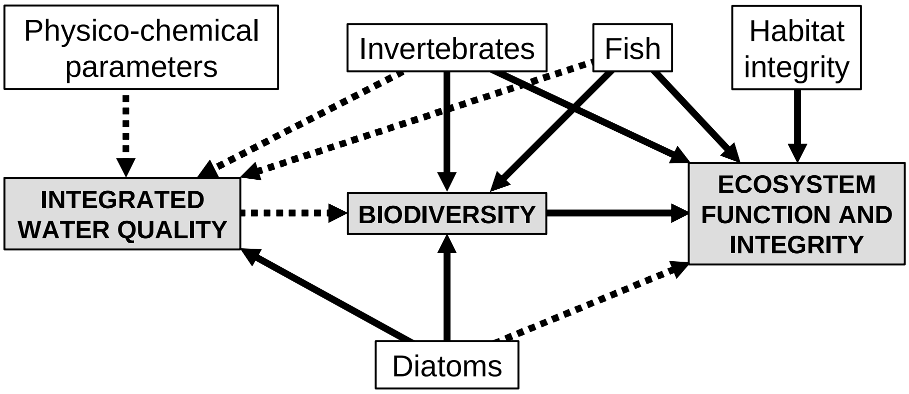


Figure 2.1: What the various indices indicate.
Solid arrows = strong relationship, dotted arrows = weaker relationship.

Rapid bioassessment Historically, biotic indices have often been calculated *a posteriori* from quantitative macroinvertebrate sampling (*e.g.* Chutter, 1972). However, labour and time constraints associated with such quantitative sampling has prompted the development of qualitative rapid bioassessment methods such as the SASS (South African Scoring System, Chutter, 1998, Dickens & Graham, 2002). These rapid bioassessment methods use simplified data interpretation methods (though the generation of biotic indices). However, they also reduce the time needed to process samples, either by being field-based or by limiting taxonomic resolution to that of family or higher.

Loss of information Because biotic indices summarise data there is inevitably a loss of information. Therefore it is also recommended that other information collected during the biomonitoring be examined when analysing and interpreting biomonitoring data.

Range of tools There is currently a range of RHP tools available for undertaking an assessment of the health or condition of aquatic resources. Each of these tools makes use of indices and / or models that summarise the biological response data into one or more metrics (*e.g.* MIRAI, FRAI, EcoStatus, etc.). Indices currently used are listed below and are described in more detail in the following sections.

Biological response Indices

These indices are (or will be) used in the RHP and EcoClassification / EcoStatus process.

- Diatoms (No index developed yet);
- Macroinvertebrates – MIRAI (Macroinvertebrate Response Assessment Index);
- Fish – FRAI (Fish Response Assessment Index);
- Riparian vegetation – VEGRAI (Riparian Vegetation Response Assessment Index); and
- Habitat integrity – IHI (Index of Habitat Integrity).

Driver Indices

These indices are used in the RHP and EcoClassification / EcoStatus and provide a habitat template for the biological components.

- Hydrology – HAI (Hydrological Driver Assessment Index);
- Geomorphology – GAI (Geomorphology Driver Assessment Index); and
- Physico-chemical – PAI (Physico-chemical Driver Assessment Index).

Determining river ecological health

These indices are also used as inputs into the suite of EcoStatus assessments which form part of the Ecological Reserve process. **Figure 2.2** indicates the relationship between the different indices used to determine river ecological health.

Ecological category

In some instances the respective EcoStatus models (*e.g.* MIRAI, FRAI and VEGRAI) are used. They categorise the biological component being assessed by providing an Ecological Category. This is expressed as A to F where A represents the close to natural and F a critically modified condition (**Table 2.2**)

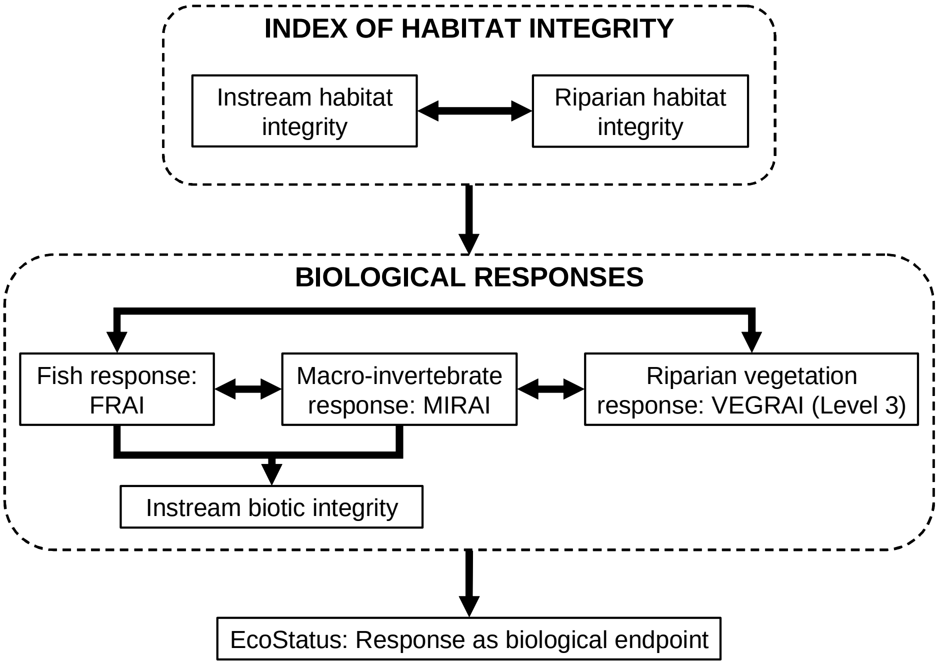


Figure 2.2: The relationship between the indices used to determine river ecological health according to the EcoStatus procedure.

2.1.4.2 EcoClassification

Definition

EcoClassification is the term used to mean the Ecological Classification process. This refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative the natural or close to the natural reference condition.

Biological response basis

The RHP follows the EcoClassification process (Kleynhans and Louw 2007a) to assess biological response data in terms of the severity of biophysical changes. However, it focuses primarily on biological responses as an indicator of ecosystem health. There is only a general assessment of the cause-and-effect relationships between the drivers (*e.g.* physico-chemistry, geomorphology, hydrology) and the biological responses. The RHP thus focuses on the reference conditions and Present Ecological State (PES) steps of the EcoClassification process.

Purpose

The purpose of EcoClassification is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river.

The EcoClassification process is an integral part of the Ecological Reserve determination method and of any Environmental Flow Requirement method. Flows and water quality conditions cannot be recommended without information on the predicted resulting state, namely the Ecological Category.

Ratings

In EcoClassification process indices are determined for all the Driver and Response components using a rule-based modelling approach. This is based on rating the degree of change from natural on a scale of 0 (no change) to 5 (maximum relative change) for various metrics. Each metric is also weighted in terms of its importance for determining the Ecological Category under natural conditions for the specific river reach in question.

EcoClassification steps

Do the following:

- Determine reference conditions for each component (*e.g.* fish, macroinvertebrates, habitat, and riparian vegetation).
- Determine the PES for each component as well as for the EcoStatus. The EcoStatus refers to the integration of physical changes by the biota and as reflected by biological responses. The EcoStatus represents the ecological endpoint and is therefore a combination of the measured biological responses - fish, invertebrates and riparian vegetation.
- Determine the trend (*i.e.* moving towards or away from the reference condition) for each component as well as for the EcoStatus.
- Determine causes for the PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) of the biota and habitat.
- Considering the PES and the EIS, suggest a realistic and practically attainable Recommended Ecological Category (REC) for each component as well as for the EcoStatus.
- Determine alternative Ecological Categories (ECs) for each component as well as for the EcoStatus for the purposes of providing various scenarios.

Minimum suite of indices

The selection of biological response indices for use in a biomonitoring programme is flexible, although there is a minimum suite for RHP determination. This includes:

- Macroinvertebrates;
- Fish;
- Riparian vegetation; and
- Habitat integrity.

2.1.4.3 EcoStatus

Definition

The EcoStatus (Ecological Status) represents an ecologically integrated state representing a series of:

On CD:
Kleynhans and Louw, 2007a

- Drivers (namely, hydrological, geomorphological, and physico-chemical); and
- Responses (namely, macroinvertebrates, fish and riparian vegetation).

It is defined as:

'*The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services*'.

Historical development

Development followed a two-step process:

- Devising consistent indices for the assessment of the Ecological Category (EC) of individual biophysical components.
- Devising a consistent process whereby the EC of individual components can be integrated at various levels to derive the EcoStatus of the river.

Underlying principle

EcoStatus is based on the principle that the biological responses integrate the effect of the modification of the drivers and that this results in an ecological endpoint. Indices are determined for all the Driver and Response components using a rule-based modelling approach. The modelling approach is based on rating the degree of change from natural on a scale of 0 (no change) to 5 (maximum relative change) for various metrics. Each metric is also weighted in terms of its importance for determining the EC under natural conditions for the specific river reach under consideration.

Determination

The metrics of each driver component are integrated to provide an EC for each component, although the three drivers are not integrated to provide a driver EC. The information required from the drivers refers to the information contained in individual metrics, and which can be used to interpret habitat required by the biota. This information can then be used to determine and interpret biological responses.

The fish and macroinvertebrate response indices are used to determine an instream Ecological Category using the Instream Response Model. The purpose of this model is to integrate the EC information on the fish and macroinvertebrate responses to provide the instream EC. The basis of this determination is the consideration of the indicator value of the two biological groups to provide information on:

- *Fish*: Diversity of species with different requirements for flow, cover, velocity-depth classes and modified physico-chemical conditions of the water column.
- *Macroinvertebrates*: Diversity of taxa with different requirements for biotopes, velocity and modified physico-chemical conditions.

EcoStatus levels

The EcoClassification process, and specifically the detail and effort required for assessing the metrics, varies according to the different levels. The process to determine the EcoStatus also differs on the basis of different levels of information. There are five EcoStatus levels. These five levels of EcoStatus determination are associated with an increase in the level of detail required to execute them. As the EcoStatus levels become less complex, less-complex tools must be used (such as the Index of Habitat Integrity). The most detailed level is EcoStatus Level 4. This is used for Intermediate and Comprehensive Reserve determinations.

EcoStatus level for RHP

EcoStatus Level 3 is recommended for the RHP. The manual (Kleynhans and Louw, 2007a) explains these different tools, how they work and when they should be applied.

2.1.4.4 Diatoms

Unique algae

The diatoms are unique amongst the algae in that they possess a cell wall constructed almost entirely of silica (Round *et al*., 1990). On average they will account for 40% of any given algal assemblage (Round *et al*., 1990) and thus may be used as a proxy for all the other groups of algae present.

Diatoms in the RHP

Diatoms are currently under consideration for inclusion in the RHP. **A South African index for the RHP has not yet been developed**, although diatom samples are frequently collected and examined within the umbrella of the RHP.

Use as indicators

A number of attributes of diatoms and diatom communities make them useful indicators of water quality. These include their wide occurrence, their broad tolerance range, short generation times, sensitivity to changes in nutrient concentrations, their rapid response to and recovery from eutrophication, and so on. Consult de la Rey *et al.* (2004) for more information.

The relationship between diatoms and other biotic and abiotic components used to monitor aquatic ecosystems is indicated in **Figure 2.1**.

Testing and application

Recently diatom indices, developed in Europe and elsewhere, have been tested in South Africa and found in all cases to be applicable for accurately reflecting water quality (de la Rey *et al.*, 2004; Harding *et al*., 2005; Taylor *et al.*, 2005; Archibald & Taylor, 2007; Taylor *et al*., 2007b; Taylor *et al*., 2007c) and have also been included for the first time in a SoR report (RHP, 2005).

Diatoms are currently being used to infer water quality for a number of projects and applications. They are considered to be a useful addition to the current suite of bioindicators used in South Africa because they have a very strong relationship with water quality.

Index currently in use in South Africa

After the testing referred to in the section above, the Specific Pollution sensitivity Index (SPI) (CEMAGREF, 1982) was considered to be one of the most reliable indices and is now used to indicate water quality in South Africa for a number of applications.

2.1.4.5 Macroinvertebrates (SASS and MIRAI)

Occurrence and role

On CD: Dickens and Graham, 2002 Thirion, 2007

Aquatic macroinvertebrates form a major component of the biota of aquatic ecosystems. They are associated with aquatic habitats such as stony beds; marginal and instream vegetation; gravel, sand and mud.

They are mostly primary (feeding on plant material) and secondary (feeding on planktonic or benthic organisms) consumers near the base of the food chain. They are therefore essential elements in the functioning of aquatic ecosystems. Macroinvertebrates are heavily dependent on the aquatic environment in which they live. They are sensitive to factors such as water quality, water quantity (environmental flows), and habitat and food availability.

Use as indicators

There is general consensus that macroinvertebrates are amongst the most sensitive components of aquatic ecosystems and they have been widely used in bioassessment. Briefly, as summarised by Rosenberg and Resh (1993):

- Macroinvertebrates are ubiquitous and diverse, and are therefore affected by a variety of disturbances in many different types of aquatic habitats.
- Sensitivity to stress varies with species and the large number of species within an assemblage offers a spectrum of responses to environmental stresses.
- In their aquatic phase, macroinvertebrates are largely non-mobile and are thus representative of the location being sampled, which allows effective spatial analyses of disturbance.
- They have relatively long life cycles compared to other groups (*e.g.* planktonic organisms), which allows elucidation of temporal changes caused by disturbances.

However, one limitation of using macroinvertebrates in bioassessment is their heterogeneous distribution and patchiness that result in spatial and temporal variability in macroinvertebrate assemblages (*e.g.* Dallas, 2004a; Dallas, 2004b).

Macroinvertebrates are one of the most commonly assessed components of the biota. SASS (South African Scoring System) is used as the routine rapid bioassessment tool to assess water quality and general river condition.

South African Scoring System (SASS)

SASS is a qualitative, multi-habitat, rapid, field-based method that requires identification of macroinvertebrates mostly to family level. Sensitivity weightings are used to calculate the biotic index. These have been pre-assigned to individual taxa according to the water quality conditions each taxon is known to tolerate.

Data interpretation is based on two calculated values (metrics), namely SASS Score, which is the sum of the sensitivity weightings for taxa present at a site, and Average Score Per Taxon (ASPT), which is the SASS Score divided by the number of SASS taxa recorded at the site.

SASS has proved to be an efficient and effective means of assessing water quality impairment and general river health (*e.g.* Dallas, 1997; Chutter, 1998). A detailed description of the SASS protocol (version 5) is given in Dickens and Graham (2002).

Macro-invertebrate Response Assessment Index (MIRAI)

The basis of MIRAI is that aquatic macroinvertebrate assemblages reflect the prevailing flow regime, water quality and available habitat at a site in a river. The aim of MIRAI is to provide a habitat-based cause and effect foundation to interpret the deviation of the macroinvertebrate assemblages from the reference condition.

The MIRAI is used to determine the Ecological Category (EC) based on:

- An interpretation of the environmental requirements, preferences and intolerances of macroinvertebrate taxa constituting the natural assemblage in a particular spatial unit; and

- Their responses to changes in habitat conditions as brought about by driver components (Thirion, 2007).

The MIRAI is used to determine the macroinvertebrate EC by integrating the ecological requirements of the macroinvertebrate taxa in an assemblage and their response to modified habitat conditions.

Details about the model and how to use it are provided in Thirion (2007). MIRAI can be completed using information collected during a standard SASS survey (Dickens and Graham, 2002) or using more detailed information such as that collected for intermediate and comprehensive Reserve studies.

2.1.4.6 Fish (FRAI)

The Index

FRAI (Fish Response Assessment Index) is a habitat-based, cause-and-effect index aimed at interpreting deviation of a fish assemblage from the reference condition.

On CD:
Kleynhans, 2007

Basis

FRAI is an assessment index based on:

- The environmental intolerances and preferences of the reference fish assemblage; and
- The response of the constituent species of the assemblage to particular groups of environmental determinants or drivers (**Figure 2.3**).

These intolerance and preference attributes are categorised into metric groups with constituent metrics that relate to the environmental requirements and preferences of individual species.

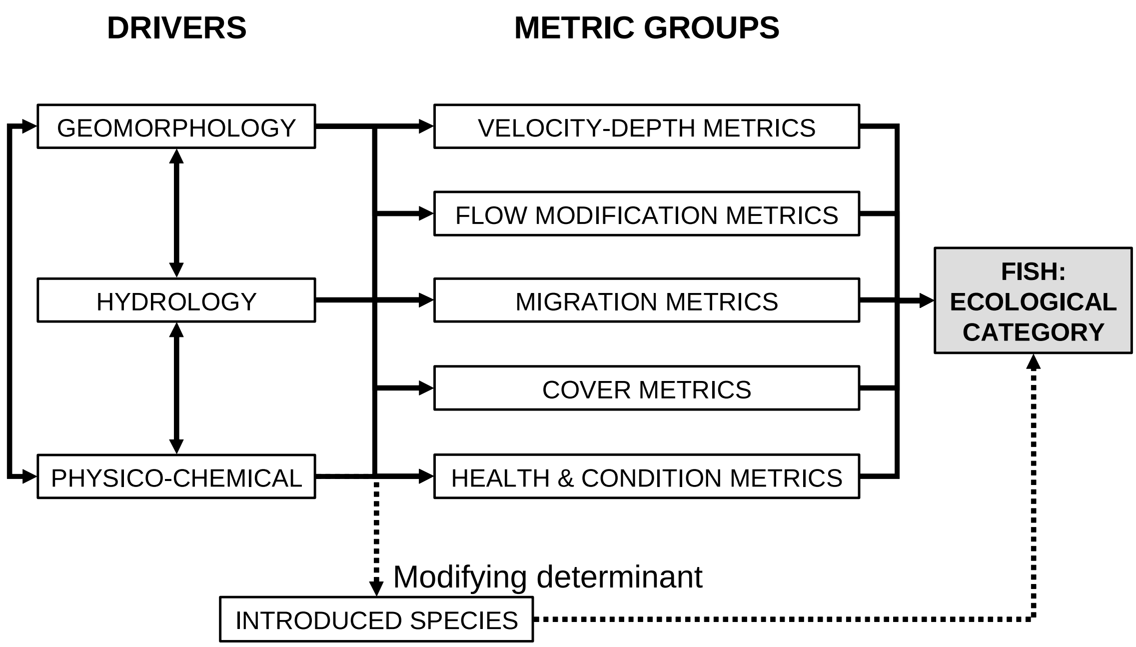


Figure 2.3: The relationship between drivers and fish metric groups.

Assessment Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually the FRAI is based on a combination of fish sample data and fish habitat data.

Index of integrity Changes in environmental conditions, either due to natural phenomena or human influences, are related to fish stress and form the basis of ecological response interpretation. The FRAI functions as an index that assesses the integrity of the fish assemblage in an ecologically defined river section and is expressed in terms of the present, observed assemblage compared to the reference assemblage.

Calculation To relate drivers and the resulting fish habitat template to the stress response of fish, the life-history requirements and environmental preferences of species must be considered. Fundamentally, the FRAI is a comparison between the reference and current fish assemblage. The intolerances and preferences of fish species as well as their reference frequency of occurrence are taken into account in the calculation of the index. This is achieved by:

- Considering information on the life-history strategies and habitat preferences and requirements of each of the species in the assemblage. An expert-knowledge database that includes a semi-quantitative rating of the intolerances, cover preferences and flow (velocity-depth) preferences is available for the majority of South African freshwater fish species and was built into the FRAI model. Where this database is not sufficient, available literature on South African freshwater fish, as well as local experts, should be consulted. Intolerance is rated from 1 (tolerant) to 5 (intolerant) and preferences from 0 (no preference) to 5 (very high preference).
- Evaluation of fish habitat potential (*i.e.* the potential that the habitat provides suitable conditions for a fish species to live there) at a site in terms of the diversity of velocity-depth classes present and the presence of various cover types at each of these velocity-depth classes. This includes consideration of breeding requirements and early life-history stages, survival / abundance, frequency of occurrence in a river section, cover, health and condition and water quality. This provides a framework within which the presence, absence and frequency of occurrence of species can be interpreted. Habitat assessment includes a general consideration of impacts that may influence the condition or integrity of fish habitat at a site.
- Following the sampling of fish at a site within a fish habitat segment, sampling results are compared to the frequency of occurrence of species under reference conditions (refer to Section 2.1.3.3). Frequency of occurrence is assessed according to **Table 2.1**.
- The deviation of the sampled fish assemblage from the reference situation is transformed to a percentage and similarly to other EcoStatus indices, the result is expressed in terms of six categories (**Table 2.2**).

Table 2.2: Generic ecological categories for EcoStatus components (Kleynhans & Louw, 2007a).

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

2.1.4.7 Riparian vegetation (VEGRAI)

The index

The Riparian Vegetation Response Assessment Index (VEGRAI) was designed as part of the suite of models used to assess ecological status. It aims to provide a practical and rapid approach to assess changes in riparian vegetation condition.

On CD:
Kleynhans *et al.*, 2007c

General features

- VEGRAI considers the condition of the different vegetation zones separately but allows for the integration of zone scores to provide an overall index value for the riparian vegetation zone as a unit.
- It is based on the interpretation of the influence of riparian vegetation structure and function on instream habitat.
- Vegetation is assessed based on woody and non-woody components in the respective zones and according to the different vegetation characteristics.
- It provides an indication of the causes of riparian vegetation degradation.
- It is impact based, i.e. the condition of the riparian vegetation is assessed relative to a reference condition.
- The reference condition is broadly defined and based on the natural condition in the absence of anthropogenic impacts. Where possible reference conditions are derived based on reference sites or river reaches.
- Although biodiversity characteristics are used in assessing the riparian vegetation condition, it is not a biodiversity assessment index *per se*.

Application to RHP Level 3 of the index (aimed at general aquatic ecologists) is recommended for application in the RHP and for rapid Ecological Reserve purposes.

Model structure The VEGRAI model is a spreadsheet model component consisting of a series of metrics and metric groups (illustrated in **Figure 2.4**), each of which is rated in the field with the guidance of field datasheets. The metrics in VEGRAI:

- Describe the status of riparian vegetation in both its current and reference states; and
- Compare differences between the two states as a measure of vegetation response to an impact regime.

The riparian vegetation zones (Marginal, Lower and Upper) are used as the metric groups. For the simplified Level 3 version, the Lower and Upper zones are combined to form the Non-Marginal metric group (zone). A range of metrics for each metric group are selected of which some are essential for both Levels 3 and 4 (Abundance and Cover) and the others are optional (Species Composition, Population Structure and Recruitment). The metrics are rated and weighted (see below) and an Ecological Category (A-F) determined. This represents the Ecological Category for the riparian vegetation state.

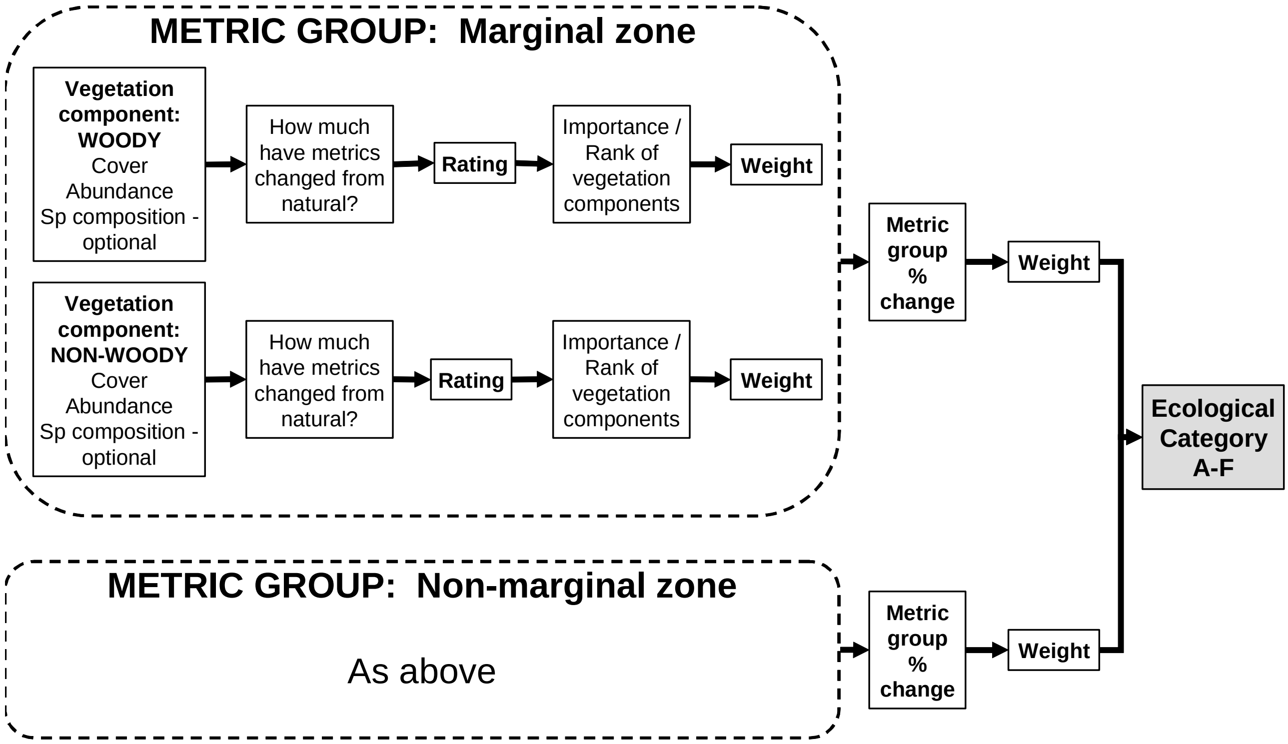


Figure 2.4: VEGRAI 4 structure.

2.1.4.8 Habitat integrity (IHI)

The index

On CD:
Kleynhans *et al.*, 2007a

Habitat integrity is measured using the Index of Habitat Integrity (IHI). The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, 1996; Kleynhans *et al*., 2007a).

Assessment levels

There are two levels of assessment for the IHI based on two methods:

- An aerial video of a river; or
- Site or ground-based information.

Methodology

The IHI methodology assesses the habitat integrity by considering the current condition of instream and riparian zones. The assessment of the integrity of each zone is based on the appraisal of metric groups, each of which has a number of metrics.

The assessment is based on an interpretation of the deviation from the reference condition (*i.e.* least-impacted condition). Deviation from reference conditions is determined using an impact-based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system. This information is obtained via site visits, surveys and / or other available data sources. Changes are interpreted in terms of modification of the drivers of the system, *viz.* hydrology, geomorphology and physico-chemical conditions and how these changes would impact on the natural riverine habitats.

2.1.5 Monitoring procedures

Introduction

The procedures summarised in this section are those applied during field visits to either reference or monitoring sites in the ongoing routine monitoring. In other words, these procedures apply after the sites have been identified and characterised.

2.1.5.1 Diatoms

Field procedure

Field procedures are very rapid and simple, and include:

- Selection of suitable river reach or site and substratum (usually rocks);
- Removal of the diatom communities from the substratum; and
- Storage and preservation of the sample.

Laboratory procedure

Laboratory procedures are more complex and time consuming than field techniques but still well within the grasp of a well trained technician:

- A portion of the sample is oxidised to remove organic material;
- The oxidising agent is removed with the aid of strong acids;
- The sample is then rinsed using centrifugation or by decanting;
- The cleaned sample is dried onto a cover slip and a microscope slide is made;
- The cells on the slide are then identified and enumerated. This information is used as the basis for calculating the diatom index score.

Key References

Taylor, J.C., P.A. de la Rey and L. van Rensburg. 2005. Recommendations for the Collection, Preparation and Enumeration of Diatoms from Riverine Habitats for water quality monitoring in South Africa. *African Journal of Aquatic Sciences* 30 (1): 65-75.

Taylor J.C., W.R. Harding and C.G.M. Archibald. 2007. An illustrated guide to some common diatom species from South Africa. Report to the Water Research Commission of South Africa. WRC TT282/07. (On CD.)

2.1.5.2 Macroinvertebrates

Minimum national requirements

As a minimum the national sites should be sampled at the prescribed frequency. Results should be entered into the MIRAI model. A reference condition should be determined and the MIRAI model run for each site.

More sites can be sampled and the sampling frequency increased if necessary. Results should again feed into the MIRAI model. The additional sites can be included into a reach used for the national programme.

SASS and MIRAI

The monitoring procedures for SASS and MIRAI are the same.

On CD:
Dickens and Graham, 2002
Thirion, 2007

Sampling procedure

Sampling is undertaken in Stones, Vegetation and Gravel / Sand / Mud biotopes separately, and collected material is tipped into three separate sorting trays for processing and identification.

For Stones biotope:

- Kick Stones-in-Current and bedrock for 2 minutes (maximum 5 minutes).
- Kick Stones-out-of-Current and bedrock for 1 minute.

For vegetation biotope:

- Sweep marginal vegetation (In-Current and Out-Of-Current) for 2m total.
- Sweep aquatic vegetation for an area of $1m^2$.

For Gravel / Sand / Mud biotope:

- Stir and sweep gravel, sand, mud for 1 minute total.

Lastly, hand picking and visual observation are conducted for 1 minute and taxa noted are recorded in biotope where they were found.

Taxa in each tray are identified for 15 minutes per biotope. Identification may stop if no new taxon has been seen after 5 minutes. Abundance is estimated using the following scale: 1 = 1, A = 2 to10, B = 11 to 100, C = 101 to 1000, D = >1000.

Reference collection

Voucher specimens should be collected from all new sites sampled. These can be sent to the appropriate institute for curatorship.

It is also recommended that a reference collection for a site be curated by the RHP practitioner.

Applicability

The SASS method is designed for low / moderate flow hydrology and is not applicable in wetlands, impoundments, estuaries and other lentic habitats (Dickens & Graham, 2002). It has not been tested sufficiently in ephemeral systems and its use in such systems should thus be with caution. The method is optimal when there is a diversity of aquatic biotopes for sampling.

Accreditation

The method has been accredited to ISO standards and practitioners are accredited via a proficiency testing procedure (see Section 2.2.5).

Key References

Dickens, C.W.S and P.M. Graham 2002. The South African Scoring System (SASS) version 5 Rapid Bioassessment Method for Rivers. *African Journal of Aquatic Science*. 27: 1-10.

Chutter, F.M. 1998. Research on the rapid biological assessment of water quality impacts in streams and rivers. WRC Report No 422/1/98. Water Research Commission, Pretoria, South Africa.

Thirion, C. 2007. Module E: Macroinvertebrate Response Assessment Index. In River EcoClassification: Manual for EcoStatus Determination (version 2). Water Research Commission Report No. TT 333/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

2.1.5.3 Fish

Minimum national requirements

The minimum requirements for the national programme are:

- Check and confirm the reference information for the site (FROC);
- Set up the FRAI model with reference information;
- Conduct representative sampling at the site;
- Assess fish habitat at the site and the reach;
- Populate the FRAI model with sampled fish and habitat data; and
- Run the FRAI model according various options to obtain FRAI value.

Additional requirements for provincial and local sites:

- Use addional site information in FROC database to derive reference information for provincial and local sites. If this is not appropriate, then do the following:
- Use expert knowledge to develop reference conditions for the site; or
- Use a fish filter model (under development) to derive reference conditions; or
- Consider a combination of the approaches above.

Main steps

The main steps in the calculation of the fish index are given in **Table 2.3** and summarised in the following text.

On CD:
Kleynhans, 2007

Table 2.3: Main steps and procedures in the calculation of the FRAI.

	STEP	PROCEDURE
Field - based	1. Identify river sections earmarked for assessment.	As for study requirements and design (see Section 2.1.2).
	2. Determine present state for drivers.	Index of Habitat Integrity.
	3. Select representative sampling sites.	Field survey in combination with requirements of other RHP-related survey activities.
	4. Determine fish habitat condition at site.	Assess fish habitat potential. Assess fish habitat condition.
	5. Representative fish sampling at site or in river section.	Sample all velocity depth classes per site if feasible. Sample at least three stream sections per site.
Office-based	6. Collate and analyze fish sampling data per site.	Transform fish sampling data to frequency of occurrence ratings.
	Execute FRAI model.	See Kleynhans (2007)

1. Identify river sections

This step is common to the overall EcoStatus assessment (including the RHP) and will provide the necessary spatial framework for FRAI determination.

2. Determine present state for

The purpose is to provide information on the fish response and associated habitat condition and *vice versa* (*i.e.* fish responses that are possible, given

drivers certain habitat conditions). This assessment considers the whole river section to be studied. The IHI should be determined for the reach under investigation (see Section 2.1.5.5).

3. Sampling site selection

Site selection should consider the following (see also Section 2.1.2):

- Habitat present at the site should be representative of the river unit or spatial unit under consideration. This means that the velocity-depth and cover classes at a site should be as representative of the river delineation as possible.
- Preferably, sites should not be close to artificial structures such as bridges and weirs, as information from such sites may not necessarily be representative of the river delineation.
- Habitats at the site should be amenable to sampling. Factors such as the ease with which various sampling techniques such as electro-shocking and seine netting (including nets of various dimensions) can be used, should be considered.

4. Fish habitat assessment at site

Habitat potential assessment: This evaluates fish habitat potential (*i.e.* the potential that the habitat will provide suitable conditions for a fish species to live there) at a site in terms of the diversity of velocity-depth classes present and the presence of various cover types at each of these velocity-depth classes.

This provides a framework within which the presence, absence and frequency of occurrence of species can be interpreted.

Habitat assessment includes a general consideration of impacts that may influence the condition or integrity of fish habitat at a site. Abundance of velocity-depth classes (slow-deep, slow-shallow, fast-deep and fast-shallow) and cover are rated as follows: 0 – absent; 1 – rare; 2 – sparse; 3 – common; 4 - abundant; 5 – very abundant. The following habitat characteristics are assessed:

- Overhanging vegetation;
- Undercut banks & root wads;
- Substrate;
- Instream vegetation; and
- Water Column.

Habitat Condition: This provides an indication of the deviation of the habitat from the reference condition. In contrast to the assessment of driver conditions or the IHI in a river section, fish habitat condition assessment is done for the site and modifications that have a direct influence on fish habitat at the site are considered.

5. Fish sampling

The information provided here refers to minimum requirements. It is up to the operator to decide on the inclusion of additional information. Appendix D of Kleynhans (2007) can be consulted on validation of the FRAI and sampling considerations. Due to practical considerations, fish surveys are usually done during the low-flow period of the year.

Sampling effort and results are reported per velocity-depth class sampled. However, sometimes the mosaic of velocity-depth classes makes it difficult or impossible to do this, *e.g.* combinations of fast-deep and fast-shallow classes may exist. In this case, the dominant velocity-depth class should be used as the unit of reference for sampling effort. However, the presence of other velocity-depth classes should also be indicated.

All species sampled are counted and anomalies such as tumours, external parasites and other abnormalities are indicated. The fish sampling forms in the RHP site characterisation field manual (Dallas, 2005c) should be used to capture relevant fish-related data.

Sampling apparatus

The following apparatus are often used for catching fish in the different velocity-depth classes:

- *Fast-deep and fast-shallow*: An electrical shocking apparatus, one operator and two dip net handlers are used in these habitat types. Capture results are recorded as number of fish caught per unit of time (minutes).
- *Slow-deep*: A large seine net (*e.g.* 70 m long, 1.5 m deep, mesh size 2.5 cm) can be used. A cast net (diameter = 1.85 m, mesh size = 2.5 cm) can used in pools not suitable for seining. Capture results are recorded as number of fish caught during each sampling effort.
- *Slow-shallow*: An electrical shocking apparatus, one operator and two dip net handlers are used in this habitat type. However, a small seine net (5 m long, 1.5 m deep, mesh size = 1 mm) can be also used. Capture results are recorded as number of fish caught per unit of time (minutes), or number of fish caught during each effort with a net, respectively.

Standardisation

Although all these methods are options, it is generally recommended that electrical shocking apparatus be used for fish integrity assessment (Kleynhans, 2007). Apparatus used in the different velocity-depth classes has not yet been standardised nationally. Prior to such standardisation, it is important that the apparatus and effort spent in sampling fish be kept similar in a particular river and for a particular study.

Representative sampling

Although guidelines for representative sampling at a site still needs specification for streams of different sizes and different fish species richness, sampling at sites in the Crocodile River (Kleynhans, 1999) and Elands River (Kleynhans, 2007, Appendix D) used the following general approach:

- Standard electro-shocking effort: Electricity was actually applied in the water for 60-80 minutes per site. It is recommended that where possible, at least three stream sections be sampled per site (*e.g.* 3 sections each sampled for 20 minutes) and that the results be recorded separately. The three river sections should be spaced to minimise possible correlation between the sites (Kleynhans, 2007).
- Standard small seine (see above) net effort: 2 efforts per site.
- Standard large seine (see above) net effort: 3 efforts per site.
- Cast net (see above) effort: 20 throws per site.

Electro-shocking is the sampling method of preference in all wadeable habitats and the RHP in particular. Destructive sampling methods such as fish poisons and gill nets are not used. It is important to note that all velocity-depth classes are not necessarily present or possible to sample at a site. Neither are all sampling methods necessarily applied at a site.

6. Collate and analyse fish sampling data per site

Sampling data at different velocity-depth classes should be recorded separately. If only certain velocity-depth classes were sampled, it is important to take this into account when assessing the data. This is done by setting reference conditions only for those habitats actually sampled. For example, a slow-deep habitat may not have been sampled. In this case, species that would occur predominantly in this velocity-depth class should be excluded from the assessment. This is one reason why samples should be as representative as possible.

Fish sampling data per site or per stream length sampled are transformed to frequency of occurrence ratings (Kleynhans, 2007).

Key Reference

Kleynhans, C.J. 2007. Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). WRC Report No. TT 330/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

2.1.5.4 Riparian vegetation

Minimum national requirements

The minimum requirements for the national programme are:

- Using available information, delineate the river reaches to be assessed according to natural attributes (ecoregions, etc.) and human impacts;
- Derive relative reference conditions by conceptually excluding human impacts and, where possible, comparing to naturally similar but less impacted neigbouring stream;
- Determine the length of respective reaches;
- Assess the respresentivity of sites in the chosen reaches;
- Identify marginal and non-marginal zones;
- Gather information on native woody and non-woody species;
- Gather information on introduced species.

Preparatory work

Information on land use and anthropogenic impacts must be obtained prior to any field visit. The scope and sources of information are described in the manual (Kleynhans *et al*., 2007c).

> On CD:
> Kleynhans *et al.*, 2007c

Field survey

The time needed to undertake a VEGRAI assessment is about 2 hours. However, this depends on:

- The complexity and size of the river; and
- Whether or not a separate assessment of both banks is required.

Field work consists of a structured evaluation of the riparian vegetation, starting with the identification of the different zones, and followed by assessment for each metric group and metric. When arriving at the site, the following process should be followed:

- Walk upstream and downstream until you are confident that enough variability (biotic and abiotic) has been viewed to give an overview of the river in that area.
- Pay particular attention to flow, geomorphic morphology, substrata, elevation, vegetation structure and species, as well as impacts on each of these. These have all been shown to determine riparian vegetation distribution, and therefore their variability should be covered sufficiently when determining the extent of the site.
- Describe the general characteristics of the site on the datasheets provided.
- If the riparian vegetation status on the two banks is sufficiently different, then assess each bank separately as if different sites.
- Document a description of the site and associated reasoning on the field datasheet.
- Complete the field datasheet during the site assessment. This provides all the information to populate the model.

Key Reference Kleynhans, C.J., J. Mackenzie and M.D. Louw. 2007. Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). WRC Report No. TT 332/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

2.1.5.5 Habitat integrity

Minimum national requirements The minimum requirements for the national programme are the same as those for riparian vegetation (VEGRAI).

Preparatory work Information on land use and anthropogenic impacts must be obtained prior to any site visit. This information should relate directly to prominent indicators of instream habitat and riparian zone modification. See Kleynhans *et al.* (in prep.) for the scope and sources of such information.

Field survey The selected sites should be visited and the appropriate data recorded. It is important that as many sections and sites be visited during the field survey as possible.

Instream habitat monitoring collects information relating to aspects such as flow modification, abstraction, runoff, effluents, inter-basin transfers, bed modification, exotic aquatic macrophytes, algal growth, introduced habitat-modifying fauna, rubbish dumping and low water crossings.

Riparian zone monitoring gives attention to erosion, rubbish dumping, trampling, mining, roads, vegetation removal, invasion of alien and native vegetation, forestry, industries, channel straightening, urbanisation, off-channel dams, artificial covering, animal farming, dry land farming and irrigation.

General catchment activities considered relate to erosion, roads, urbanisation, vegetation removal, waste disposal, trampling, industries, mining, invasive alien and native vegetation, forestry and animal farming.

Key Reference Kleynhans, C.J, M.D. Louw and M. Graham. In Preparation. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Manual for Index of Habitat Integrity. WRC Report No. TT XXX/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

2.1.6 Prioritisation

2.1.6.1 Overview

Rationale

The catchment areas in which RHP sampling sites are located vary in terms of their strategic importance, ecological importance and sensitivity, water uses and land use activities. For many of these sites, historical data are available while for newly identified sites no data are available and baseline conditions have to be established.

It is not practical, or cost-effective to monitor all RHP sampling sites at the same intensity (*i.e.* frequency and extent). Sampling sites should therefore be prioritised to distinguish between high, medium and low priority sites. This will determine the urgency and frequency at which sites will be monitored.

Key considerations

RHP sampling site priorities are determined by the following factors:

- The compulsory licensing priority of the catchments in which the sites are located (according to the National Water Resource Strategy (DWAF, 2004b));
- The Ecological Importance and Sensitivity (EIS) rating of these catchments at quaternary catchment level;
- The Present Ecological State (PES) category of the quaternary catchments; and
- The monitoring status of the national RHP sites: Priority sites include (a) those that have not been monitored in the past five years (*e.g.* in 2008 those last monitored prior to or including 2002) and (b) sites that have never been monitored. Those monitored more recently or those monitored on a frequent basis have a lower priority.

2.1.6.2 For Water Management Areas

Compulsory licensing priorities

On CD:
Hill *et al*., 2008

The same priorities that are used for compulsory licensing in the National Water Resources Strategy (DWAF, 2004b) are being used as a first step to prioritise the catchments in which RHP sites are located. This is followed by site prioritisation.

Site prioritisation

The rules for prioritising sites as high (1), medium (2) or low (3) are summarised in **Table 2.4**.

Site priorities per WMA

Priorities may vary from one Water Management Area to the next. See Hill *et al*., (2008) for more detail.

Table 2.4: Generic site prioritisation rules.
All three conditions must apply (or be ignored if indicated with a "-").

	Priority	Condition 1: EIS	Condition 2: PES	Condition 3: Monitored at least once in last 5 years?
High	**1a**	High / Very High	A / B	No
	1b	High / Very High	A / B	Yes
Medium	**2a**	Moderate	A / B / C	No
	2b	Moderate	A / B / C	Yes
	2c	High / Very High	C / D / E / F	-
Low	**3a**	Low / Marginal	A / B / C	No
	3b	Low / Marginal	A / B / C	Yes
	3c	Moderate	D / E / F	-
	3d	Low / Marginal	D / E / F	-

2.1.7 Monitoring frequency

Rationale

Biotic indices integrate effects over time. The frequency with which biomonitoring is undertaken is therefore less frequent than for chemical monitoring. The optimum sampling frequency will vary for the different biotic indices, for example aquatic macroinvertebrates, which have a relatively short life span, will be sampled more frequently than fish, which have a longer life expectancy.

Baseline monitoring

Baseline monitoring is the assessment and characterisation of existing conditions to provide a standard, or "baseline," against which future change is measured. A series of measurements is taken prior to the initiation of a management activity and used for comparison (a "baseline") with the series of measurements taken afterward (Elzinga *et al*., 1998).

It may also be important to determine whether the baseline is stable (stationary) or changing in a particular direction. Note that the baseline must be distinguished from the reference which typically would be the natural or unimpacted condition of the system. However, if the resource is not influenced by human impacts, the baseline may represent the reference condition.

Standard monitoring

Standard monitoring refers to the monitoring at sites selected to assess the condition of the site, river reach or river. These may range from point-source monitoring to State of the River, catchment or Water Management Area monitoring. For RHP purposes, the site should be representative of the resource unit delineated. The frequency and timing of monitoring varies for the different biotic indices. For the national sites the sampling frequency summarised in **Table 2.5** is applicable.

Timing

For practical and safety reasons, monitoring is usually conducted during low-flows which typically occur in the dry season or at the end of the wet season.

Monitoring

The national sites will be monitored in five-year cycles during which each

frequency: RHP sites site will be monitored comprehensively (macroinvertebrates, fish, riparian vegetation and habitat integrity) at least once. It is however envisaged that sites which are sensitive, important or located in highly impacted catchments (category 1 priorities) will be revisited and monitored more frequently during a cycle, however in a less comprehensive manner. They might for example only include a particular but appropriate biological component for a particular river, such as macroinvertebrates or fish (**Table 2.6**).

These monitoring frequencies should be re-visited after a five year monitoring cycle is complete.

**Table 2.5: Typical (*i.e.* for general river health assessment) and proposed RHP monitoring frequencies for biomonitoring indices (adapted from Murray, 1999).
Note: Proposed frequencies take into account monitoring priorities.**

INDEX	TYPICAL FREQUENCY	RHP FREQUENCY (IN FIRST 5-YEAR CYCLE)	TIMING
Diatoms*	Once a year	To be specified	During low-flow conditions.
Macroinvertebrates (SASS5)	2-3 times a year	Existing high priority (Category 1) and new sites# at least once a year; Existing medium priority sites (Category 2), at least every 2 years; Existing low priority sites (Category 3 and 4 sites), at least every 3 years.	Optimally during the dry season, at the end of the dry season and at the end of the wet season. The high flow period, when floods are likely, should be avoided.
Fish (FRAI)	Every 3 years	Existing high priority (Category 1) and new sites at least every three years; Existing medium to low priorities (Category 2-4), every five years	During low flow conditions.
Riparian vegetation (VEGRAI)	Every 3 years	Existing high priority (Category 1) and new sites at least every three years; Existing medium to low priorities (Category 2-4), every five years	At any time of year, although may be best during the growth season. The high flow period, when floods are likely, should be avoided.
Habitat Integrity (IHI)	Every 3 to 5 years	Existing high priority (Category 1) and new sites at least every three years; Existing medium to low priorities (Category 2-4), every five years	At any time of year. The high flow period, when floods are likely, should be avoided.

* An index to monitor diatoms in South Africa has not yet been developed.
# Sites not monitored before or for longer than 5 years and that have been verified.

2.2 QUALITY ASSURANCE AND CONTROL

2.2.1 Introduction

Measuring *correctly*

On CD:
DWAF, 2007b

There is the old adage that "*you cannot manage what you cannot measure*". But it could be added that if you cannot measure *correctly*, then you are no better off than had you not measured at all and furthermore the expense incurred during the measurement would be wasted.

Data quality

The River Health Programme (RHP) is all about data, its collection and its reporting in a meaningful and accurate manner. These data tell the story of a river and highlight the stresses and strains resulting from the many pressures exerted by society.

The credibility of the RHP rests on the quality of the data that is produced. If this credibility was to be lost, then all the effort to produce and implement a river health monitoring programme would have been wasted. Furthermore, if the data used to determine river health cannot be trusted, then the management of our resources also cannot be trusted.

This important section summarises the approach for quality assurance (QA) and quality control (QC) within the RHP.

2.2.2 Importance

Logical chain

It is important that there is clear understanding of the objective of monitoring an aquatic ecosystem. Sample collection forms part of a logical chain, so weakness in any one of these steps could invalidate the monitoring process (See **Figure 2.5**).

Accuracy and precision

The objective of sampling is to characterise a representative portion (the "sample") of a system such as a river reach. A method must be both accurate and precise in order to obtain a meaningful sample (**Figure 2.6**). Accuracy refers to how well a measurement agrees with an accepted value whilst precision indicates how well a series of measurements agree with each other.

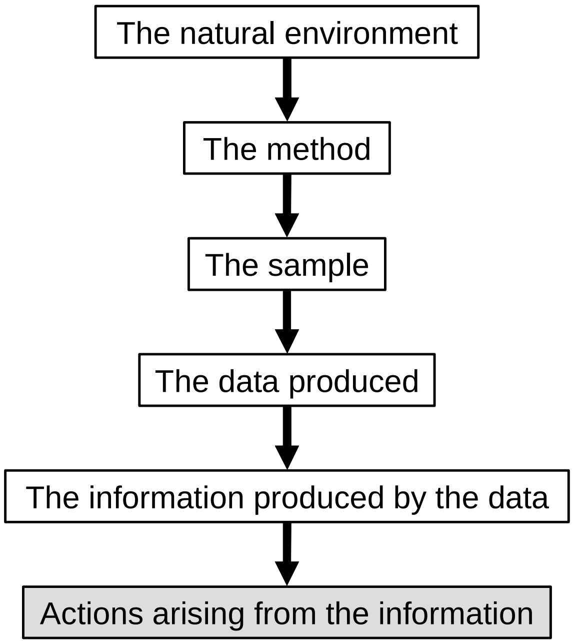


Figure 2.5: Important linkages in sampling, data and information production.

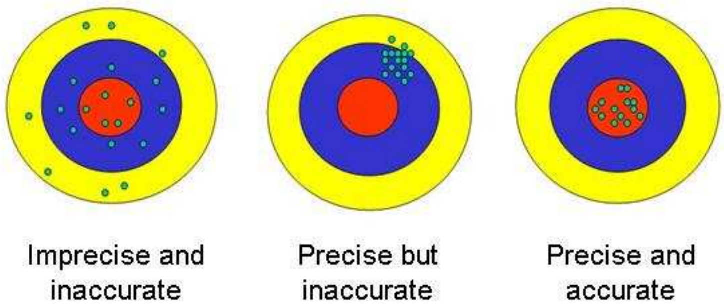


Figure 2.6: The difference between methods that are weak (*i.e.* neither precise nor accurate) and those that are precise and accurate.

2.2.3 Overview of procedures

The people

There are a number of ways to ensure that the data produced by the RHP will be of excellent quality and will thus perform its intended function. Many of these ways revolve around the people who carry out field surveys and this is often the weak point in the production of quality data.

In addition to this there is an ongoing need to bring new people into this field, all of whom need to be trained and brought to a point where there can be confidence in their performance.

Table 2.6 summarises the procedures that need to be put in place for a comprehensive quality assurance system. They are described in more detail below.

Table 2.6: Recommended quality assurance procedures and their purposes. See text for more detail.

PROCEDURE	PURPOSE
Method design and performance	To ensure the method does what it is meant to.
Analytical Quality Control procedures	To ensure that both the methods and the people working with them are at high standards. There should be no "short cuts".
Data quality assurance	To ensure that data captured in a database is the same as that collected in the field and is secure over a long time period.
Data interpretation	To ensure the data are interpreted in a standardised way. Data are of little use if different people interpret the data differently.
Proficiency Testing Schemes	To regularly test that practitioners carry out procedure correctly. Accreditation of practitioners forms a part of Proficiency Testing.

Method design and performance

Much hinges on the design of a method that is used for the development of data. It is important that a method is tested to ensure that it produces data that are meaningful and accurate. The method must be repeatable (*i.e.* produce comparable results) under two different scenarios:

- Different people apply the same method to the same site; and
- The same person repeats the same method at the same site.

Analytical Quality Control procedures

The methods used by the RHP have analytical quality control procedures incorporated into them. These will vary considerably depending on the method. Analytical quality control procedures for RHP methods are quite complex because field samples are collected by a person. It is quite often the person who will determine the eventual quality.

See each method below for more detail.

Data quality assurance

Good record keeping is an essential part of quality assurance. Original datasheets should be kept for as long as possible. It is also vital that transcription of data from data sheets to electronic format is accurate. To assist with this the Rivers Database has been developed as the national data storage and management system for the River Health Programme (See Section 3).

Data interpretation

The interpretation of biological data can often be complex. It is largely dependent on the knowledge and skills of the person doing the interpreting. This is very difficult to regulate and for the most part it would not be desirable to do so. Nevertheless there is a need to guide the interpretation of data, even though this may at times be overridden by a specialist in the field.

See Section 4.4 for more detail.

Proficiency

For chemical analyses proficiency testing is done by sending a standard

Testing Schemes (PTS)

sample to participating analysts for analysis. On completion of the analysis, the sample is returned to a central controller who assesses the performance of the participants and circulates a performance report.

However, for field-based methods (like those used in the RHP) practitioners gather at a selected field location and test their performance in the field. This is incorporated into the accreditation process summarised below.

See each method below for more detail.

Accreditation of practitioners

Accreditation entails that "candidate practitioners" demonstrate their understanding and ability to apply a method during a field assessment or audit day. If their performance is up to the standard set by the auditor, then they become "accredited" practitioners for that particular method. This manual provides guidance on this process in some detail.

Accreditation Process

Accreditation methods have been developed for the following three methods (**Figure 2.6**):

- South African Scoring System (SASS);
- Fish Response Assessment Index (FRAI); and
- Index of Habitat Integrity Model (IHI).

The following have not yet been through this process:

- Macroinvertebrate Response Index (MIRAI);
- Riparian vegetation index (VEGRAI);
- Diatoms.

Candidate practitioners are required to undergo a separate accreditation process for each of the methods that they wish to use. Each process is directed locally by a Provincial Auditor who then informs the National Auditor of the results. The entire accreditation process is overseen by the Resource Quality Services directorate of DWAF.

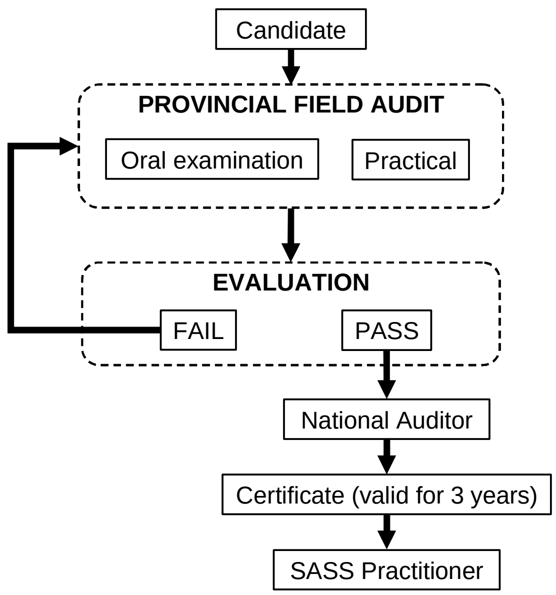


Figure 2.6: The accreditation process for SASS as an example.

2.2.4 Method design and performance

Method validation

It is important that all methods used by the RHP are scientifically sound and of produce data of known quality. **Table 2.7** summarises the method validation steps that have been used by the authors to document their methods during development. Method validation is the process that confirms that the procedure employed for a specific test is suitable for its intended use. However, it is by no means exhaustive or prescriptive.

Note: The steps in **Table 2.7** have been followed by the authors of the RHP methods and should be documented in the published methods. It is not necessary for the users of these methods to repeat this exercise.

Table 2.7: Steps for the proper documentation of any RHP method (DWAF, 2007b).

Step	Step description	Requirement
1	Scope of the Method	What the method can be used for; what aspects of the ecosystem does it describe; how does it relate to other methods?
2	Limitations	What are the limitations for implementing the method / index; where should it NOT be used and under what circumstances?
3	Safety hazards	Are there health and safety issues that need to be considered?
4	Sample / data collection	a) Sampling area / reach: Description of the extent of river reach or catchment to be sampled / investigated; what constitutes a good site? b) Field equipment / supplies needed. c) Sampling / data collection protocol. d) Additional information that may be useful.
5	Sample processing	This only applies to samples that need to be processed before analysis.
6	Sample / data analysis	Description of the analytical procedure in detail.
7	Analytical quality control	a) Intra-laboratory proficiency testing. b) Inter-laboratory proficiency testing. c) External auditing of samples / assessments.
8	Calculation of results	1. Check that the calculation of results is reliable and consistent. 2. Four aspects need to be checked in relation to the results that are produced: (a) Range, (b) Accuracy, (c) Bias, and (d) Robustness.
9	Interpretation of data	Tools that translate scientific data into easily understood information and thus enable sound management decisions to be made regarding water resources.
10	Variability and sources of error	These are elements that could lead to error in the final analysis.
11	Training and proficiency testing	There is a need for good training and tight adherence to the written method, supplemented by regular proficiency testing and accreditation of operators / practitioners.
12	Documentation of method	Methods used should be properly documented and published in the literature

	and validation	so that they are widely available.
13	Summary and conclusions	

2.2.5 QA guide for the SASS method (macroinvertebrates)

2.2.5.1 Analytical Quality Control

Procedures

A key process for ensuring that SASS data are accurate is to provide for accreditation of those persons who collect the data. Samples collected by a SASS practitioner are returned to the laboratory where an independent person would take a sub-sample (commonly 10%) and send the sample to an expert for confirmation. Variation would be allowed to pre-defined limits.

Periodically the SASS practitioner should be accompanied by a competent person into the field and his / her procedures checked.

Periodically a responsible person should re-survey a site soon after this was done by the practitioner. The re-survey results should be within pre-defined limits and also the biota families found should concur within pre-defined limits.

2.2.5.2 Accreditation field day

Introduction

The SASS field accreditation has been in operation for a few years prior to writing. Many people have been through the process which is acknowledged to be tough but effective in accrediting those who are most qualified in SASS. The process is summarised as follows:

Proficiency testing

Proficiency testing occurs on the accreditation field day and is an integral part of the process on the day. Note that proficiency testing is not a training exercise – candidates should already be highly skilled in the method.

Choosing a site

The Provincial SASS Auditor should select a suitable site for the field day and should advertise the event widely. The site should be relatively central and accessible. It should have a good selection of biota as well as biotopes to allow full testing of the sampling techniques.

Materials needed

The required materials are detailed in the report (DWAF, 2007b).

Stages

There are three stages:

- An oral test to determine the theoretical appreciation a candidate has for the method. This includes the broader understanding of where SASS5 fits into the RHP as well as its Scope and Application and some interpretation of results.
- A demonstration of ability to apply the correct SASS5 sampling protocol.
- Identification of SASS5 aquatic invertebrates in a pre-collected set of 'live' samples.

Accreditation The candidate will need to pass all three sections to become an accredited SASS practitioner. The candidate will then be issued with a letter which indicates their performance per section and successful candidates will receive a certificate. The certificate will be valid for a period of three years after which the practitioner should be retested in order to remain accredited.

2.2.6 QA guide for the FRAI method (fish)

2.2.6.1 Analytical Quality Control

Procedures There must be a check on the performance of the electro-shocker equipment which should be generating the required output (volts, amps and pulses, etc.) before and after every field survey. Failure of either check will invalidate the sample collected.

Periodically a knowledgeable person should visit the site and examine each of the metrics completed by the practitioner. Variation would be allowed within pre-defined limits.

Periodically a skilled FRAI person should re-survey a site soon after a practitioner and test the result. Not only should the scores relate but so should the species composition. Variation would be allowed within pre-defined limits.

2.2.6.2 Accreditation field day

Introduction As above, a key process for ensuring that FRAI data are accurate is to provide for accreditation of those persons who collect the data. A field accreditation day should be carried out periodically and should be advertised widely. The site for the field day will be chosen by the Provincial FRAI Auditor and should be in good condition with a diverse range of fish.

More detail on individual aspects of the procedures on the day is provided in the report (DWAF, 2007b).

Proficiency testing Proficiency testing occurs on the accreditation field day and is an integral part of the process on the day. A candidate practitioner needs no particular prior qualification but must have previously undertaken training in fish identification. It is likely that either considerable first-hand experience in the field or a qualification in environmental or biological sciences will be necessary to demonstrate competence to the satisfaction of the Auditor. As above, note that proficiency testing is not a training exercise – candidates should already be highly skilled in the method.

Preparation In the performance of any FRAI assessment, there is a need to have certain information prior to the site visit. The candidate must collect this information before the field day, so must be notified in advance of the reach to be used for the accreditation.

Equipment Each candidate and the Provincial FRAI Auditor should supply his / her own equipment for the field day which must be functional and must meet the specifications of the FRAI method.

Health and safety	Safely-functioning equipment and knowledge of safety measures is a requirement.
Evaluation: Section A - theory	The auditor will pose a number of general questions around the background of biomonitoring and FRAI and will enter into a discussion with the candidate.
Evaluation: Section B - Fish collection	Each candidate must show an ability to capture fish using the correct methods in all available biotopes. Fish collection is done by a team where the team leader is the candidate practitioner in charge of his / her own team. The method of collection should closely follow the FRAI method and deviations or short cuts must be sanctioned. The candidate must demonstrate an understanding and sensitivity of biodiversity and humane treatment of the fish.
Evaluation: Section C - Fish identification	It is imperative that the practitioner is able to identify the species that are collected.
Evaluation: Section D - Completion of FRAI sheet and interpretation of results	The candidate must demonstrate that they are able to convert the raw information from the fish collection and identification into an Ecological Category.
Accreditation	Accreditation as a FRAI Practitioner is given for a period of five years to persons who pass the test.

2.2.7 QA guide for the IHI method (habitat integrity)

2.2.7.1 Analytical Quality Control

Procedure	The IHI method does not use any equipment. Therefore, the procedure for this method entails a knowledgeable person visiting the site and examining each of the metrics in the IHI method that were previously completed by the practitioner. Variation would be allowed within pre-defined limits.

2.2.7.2 Accreditation field day

Introduction	As above, a key process for ensuring that SASS data are accurate is to provide for accreditation of those persons who collect the data. An accreditation day should be organised by the Provincial IHI Auditor in each province. The event should be advertised as widely as possible to notify prospective practitioners.
Proficiency testing	Proficiency testing occurs on the accreditation field day and is an integral part of the process on the day. A candidate practitioner needs no particular prior qualification as the proof of competence will be established by the

accreditation process (an outcomes based system). It is likely that either considerable first-hand experience in the field or a qualification in environmental or aquatic sciences will be necessary to demonstrate competence to the satisfaction of the Auditor. As above, note that proficiency testing is not a training exercise – candidates should already be highly skilled in the method.

Background information

The Auditor will provide candidates with the background information as detailed in the report (DWAF, 2007b).

The candidates are encouraged to start populating the IHI model based on this information prior to the accreditation day. The focus of the field visit undertaken during the audit will essentially be to obtain additional site-specific information that will be used to finalise the scores assigned prior to the accreditation day.

Evaluation

The accreditation day consists of three components:

- A briefing session;
- Field visit and theory testing ; and
- Office computation and testing.

Office evaluation

Candidates may need up to two hours to complete the IHI model, confidence ratings and to provide a motivation for each of the ratings given. The oral evaluation is divided into three sections and includes:

- General theory;
- Questions relating to the instream assessment; and
- Questions relating to the riparian zone assessment.

Scoring

The evaluation of the candidates IHI assessment is based on three components:

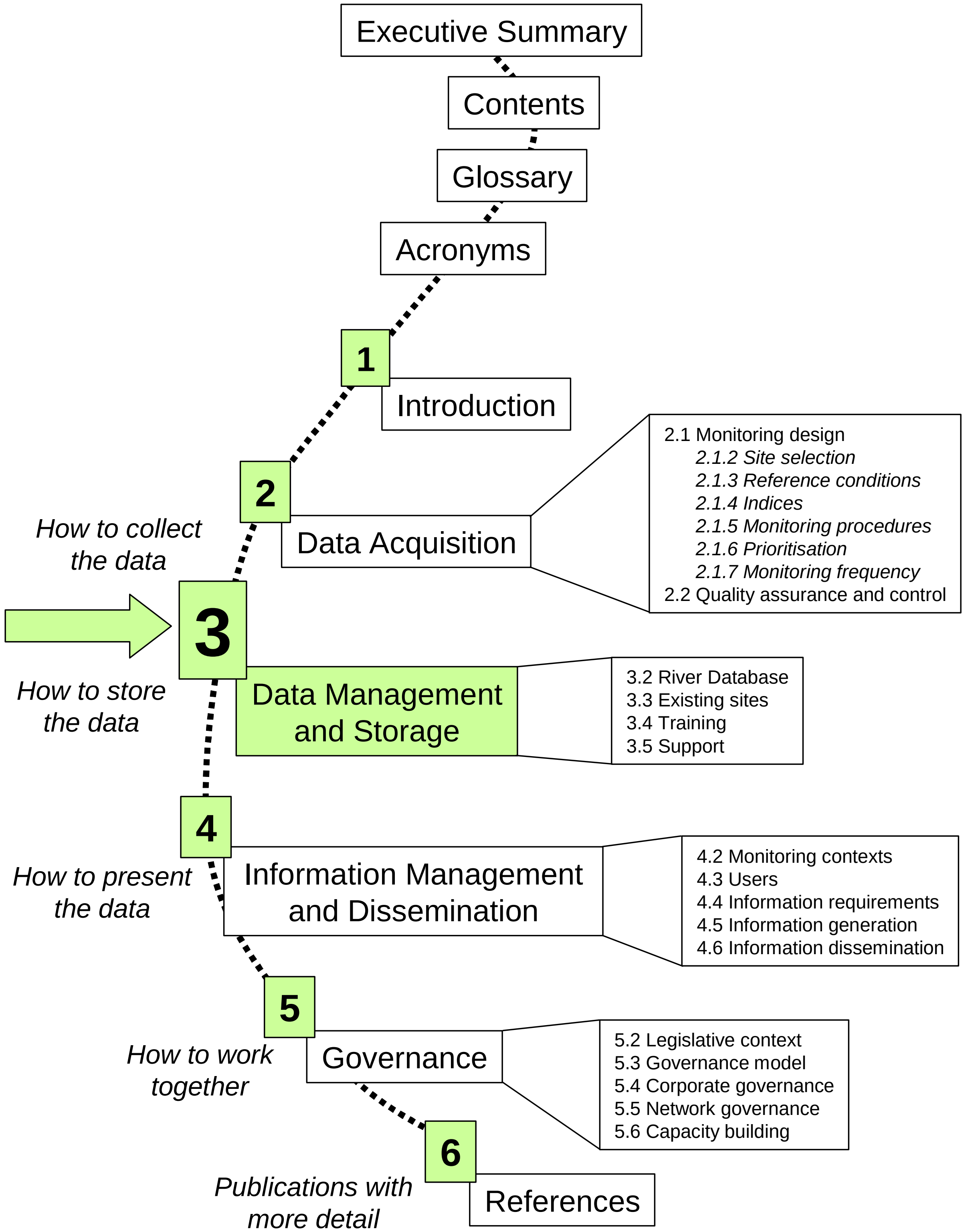
- Evaluation of activity / modification assessments;
- Evaluation of individual metric scores; and
- Evaluation of final instream and riparian IHI scores.

The marks and results collected by the Provincial IHI Auditor at the end of the day are synthesised into a report of the outcomes of each candidate.

Accreditation

Successful candidates will be issued with a certificate by DWAF (RQS) which will be valid for a period of five years. It must be appreciated that an accredited person will be regarded as an expert in IHI assessment, so must be in a post-training situation. She / he will also be able to practice anywhere within South Africa with the same credibility.

Manual Roadmap



SECTION 3: DATA MANAGEMENT AND STORAGE

This section describes the Rivers Database installation, use, structure, the existing sites, and support.

3.1 INTRODUCTION

Importance

The efficient management and safe storage of data are essential prerequisites for a successful monitoring programme. Data management and storage consists of standardised and rigorous procedures to ensure high quality and reliable data.

Components

Data management comprises:

- Field collection of data;
- Post-field handling of data in the office;
- Quality checking of data;
- Capturing of data into a database;
- Secure data storage; and
- Data extraction from the database.

Quality Control

Consideration has been given to these aspects within the Quality Control component of the RHP. Guideline documents have been produced to assist RHP practitioners in data handling, data entry and data validation (DWAF, 2007b).

Data quality

One of the major challenges of any monitoring programme is the development of a unified data system. In many instances, many of the participating organisations and individuals involved in the RHP have evolved their own means of data management designed for their own specific objectives. However these systems vary enormously.

The following generic recommendations reflect something of the industry best practice and how to prevent the loss of good quality data. Control of data quality is particularly necessary in the following three areas.

1. Data handling

Data handling primarily refers to the activities around collection and collation of data generated during RHP activities, both in the field and back in the office once field work is completed. The most common and consistent problem involves inadequate completion of field data sheets. To limit variation from one practitioner to another, standardised methods of data collection and field data sheets are associated with each of the RHP methods, for example SASS5 (Dickens & Graham, 2002), FRAI (Kleynhans, 2007) and Site Characterisation (Dallas, 2005c).

Adherence to these methods and use of the prescribed data sheets for each of these RHP tools ensures that the data collected are comparable. Accreditation of practitioners for the key RHP tools ensures that data are of high quality. The proper handling of data both in the field and thereafter is critical. Hasty field sampling and completion of field data sheets can lead to incomplete data sheets and loss of information. This greatly reduces the overall value of the sampling.

Key points related to data handling are:

- In-field completion of field data sheets;
- Post-field checking of field data sheets; and
- Appropriate filing, cross-referencing and storage of field data sheets.

2. Data entry

The capturing of data into a database is of fundamental importance in a programme of such wide extent with so many contributors. It provides a safe storage of the data in digital form, it allows for data analysis, interpretation and dissemination, and it allows for data sharing. The Rivers Database is the national data storage and management system developed for the RHP (Section 3.2).

Some general recommendations with respect to data entry are as follows (DWAF, 2007b):

- Ideally the person capturing the data into the Rivers Database should either be the person who collected the data in the field, or be closely supervised by the person who collected the data in the field.
- The person capturing the data should at least have had training in the use of the Rivers Database or be under the close supervision of someone who has had training.
- The Rivers Database manual should be available for referencing at all times during data entry.

3. Data validity checking or verification

Once the data have been entered into the Rivers Database a process of validity checking and verification of the data is crucial. This evaluates the data for completeness, correctness, and conformance / compliance to the specified method. This ensures only good quality data are available for subsequent broader use within the RHP.

DWAF (2007b) recommends a series of quality control checks that the RHP practitioner should undertake.

3.2 RIVERS DATABASE

3.2.1 Overview

Objective

The primary objective of the Rivers Database is as follows

"To facilitate the capture and safe storage of the National Aquatic Ecosystem Health Monitoring Programme river health data".

The RHP is an information-orientated programme generating large volumes of information to be analysed and interpreted for dissemination to a wide variety of people. The efficient and effective storage of RHP information is therefore critical to the Programme's success.

Desktop- & web-based

The Rivers Database enables RHP practitioners to capture RHP data on their individual computers and to transfer these data to the national database, which is maintained on the Internet. The Rivers Database is thus a combination of a desktop application (called Rivers Client) and a web-based application (called Rivers Server). The latter allows registered users to transfer data from one to the other. All RHP practitioners using the biomonitoring tools developed for RHP are encouraged to contribute their data to the national Rivers Database.

Access

System access is controlled via compulsory user registration. Site and site visit ownership is based on the user name. A manual (Dallas *et al.*, 2007), which accompanies Rivers Database Version 3.0 (DWAF, 2007a) is available for download on the Rivers Website (http://www.riv.co.za/Rivers) once users have registered.

3.2.2 Installation and use

Introduction

In order to capture and store RHP data on the Rivers Database, practitioners need to acquire a copy of the Rivers Database software and install the database. The process is as follows:

On CD:
Dallas et al., 2007
DWAF, 2007a

Obtaining a copy

RHP practitioners need to contact the RHP Programme Manager at Resource Quality Services, Department of Water Affairs & Forestry (Tel.: 012 808 9500) to obtain a CD of the Rivers Database. The manual and other relevant documentation are included on the CD. (Insert CD in CD Drive, "Cancel" Rivers setup wizard, Browse to the CD drive and Open / Save the relevant ".pdf" file).

Software and Hardware requirements

The Rivers Database is a custom program that runs within the Windows 2000, XP Professional and Windows Vista environments.

The Software and Hardware Requirements are as follows:

- Operating System: preferably Windows 2000 or Windows XP (Professional), with Service Pack 2 installed; or Windows Vista.
- Internet Information Server must be installed.

- Memory: minimum of 256 MB RAM.
- Software: Microsoft Office 2000 or greater.
- Minimum Screen Resolution: 1024 x 768.
- Hard Drive: 200MB free.
- Regional Settings: Ensure that your short date format, in Control Panel: Regional Settings is set to display an acceptable date format (dd-mm-yyyy).

Installing Service Pack 2 (SP2) and Internet Information Systems (IIS)

Before installing the Rivers application on a computer running Windows XP, please ensure that Service Pack 2 (SP2) has been installed and Internet Information Services (IIS) 5 (or greater) is installed on your computer.

- Service Pack 2 is available as an update on the Windows website (www.microsoft.com); note this is not necessary for Windows Vista.
- To install IIS on Windows 2000 or Windows XP: Click on ‘Start’, select ‘Control panel’, select ‘Add or Remove programs’, select ‘Add / Remove Windows Components’, check the ‘Internet Information Services’ checkbox and click ‘Next’. The original windows setup CD may be required to complete this task.
- To Install IIS on Vista: Click on 'Start', select 'Control Panel', select 'Programs and Features', select 'Turn Windows features on or off' on the bar on the left hand side. In the screen that pops up, check the 'Internet Information Services' checkbox. Expand the 'Internet Information Services' node (using the plus sign) and check the 'Web Management Services' and 'World Wide Web Service'. Finally, make sure that ALL check boxes under these two options are checked.

Database installation

If ‘autostart’ is enabled, the installation shield should begin automatically when the CD is inserted into the CD drive. If it does not, browse for setup.exe on the CD. Click setup.exe to start the installation process.

Depending on the software already installed on your computer, you may be prompted to accept various licensing agreements from Microsoft. Click 'Accept' and follow the prompts (if an error is displayed, make sure IIS is installed, as described above). In some cases, it may be necessary to restart the computer during the installation process. The installation process will continue automatically following the restart.

Once the installation is complete, the 'Rivers Client', 'Rivers Server' and 'Query Master' shortcuts will be available on you desktop and in the Start menu (Start / Programs / Rivers Database 2007).

Registration

System access is controlled via compulsory User Registration. New users must register before being able to access either the Rivers Server (web-site) or Rivers Client (Desktop). Once registered, the user will receive a username and password that can be used to log onto both the Rivers Server and Rivers Client.

To register as a new user:

- Start Rivers Server.
- Click on “Click here to register as a new user”.
- Complete and submit (Save) the online 'User registration form'.
- Click “Request System Access” to send an email to the Rivers Administrator.
- The Rivers database administrator will verify the user details and assign appropriate access rights to the user. The administrator will confirm the username and password that can be used to access both the Rivers Server (via the internet) and the Rivers Client on the desktop, via e-mail.
- Start the Rivers Client (Start: Programs: Rivers Database 2007: Rivers Client or click the desktop icon).
- Enter the username and password and click “OK”.
- Follow the prompts on the screen to refresh your username and password from the Server and Login to the Rivers Client for the first time.

Facilitating data transfer

The River Client component of the Rivers Database is a comprehensive data structure with forms and queries that allow the user to enter detailed information about monitoring sites and sample results on his or her own computer. For data security purposes, and to allow national reporting, each user needs to regularly synchronise the local dataset with the central database, using an automatic Internet transfer procedure.

In order not to compromise government network firewalls, the central database is located outside DWAF on a site hosted by Web Africa on the domain www.riv.co.za**.** Where firewalls exist, it will be necessary for the Information Technology (IT) section of your organisation to enable file transfer. To obtain a letter detailing this, please contact the Rivers Administrator (contact details are on the Rivers Server).

3.2.3 Database structure

Introduction

This section provides a summary of the structure of the Rivers Database 2007. For additional details please consult the manual (Dallas *et al*., 2007). It is strongly recommended that users print a copy of the manual and have it available for consultation when using the database.

Main components

The Rivers Database consists of three primary components (**Figure 3.1**):

- Rivers Server (web application running on the internet);
- Rivers Client (windows application running on a desktop); and
- Query Master (for extracting data - a local version running on the desktop and a server version running on the internet).

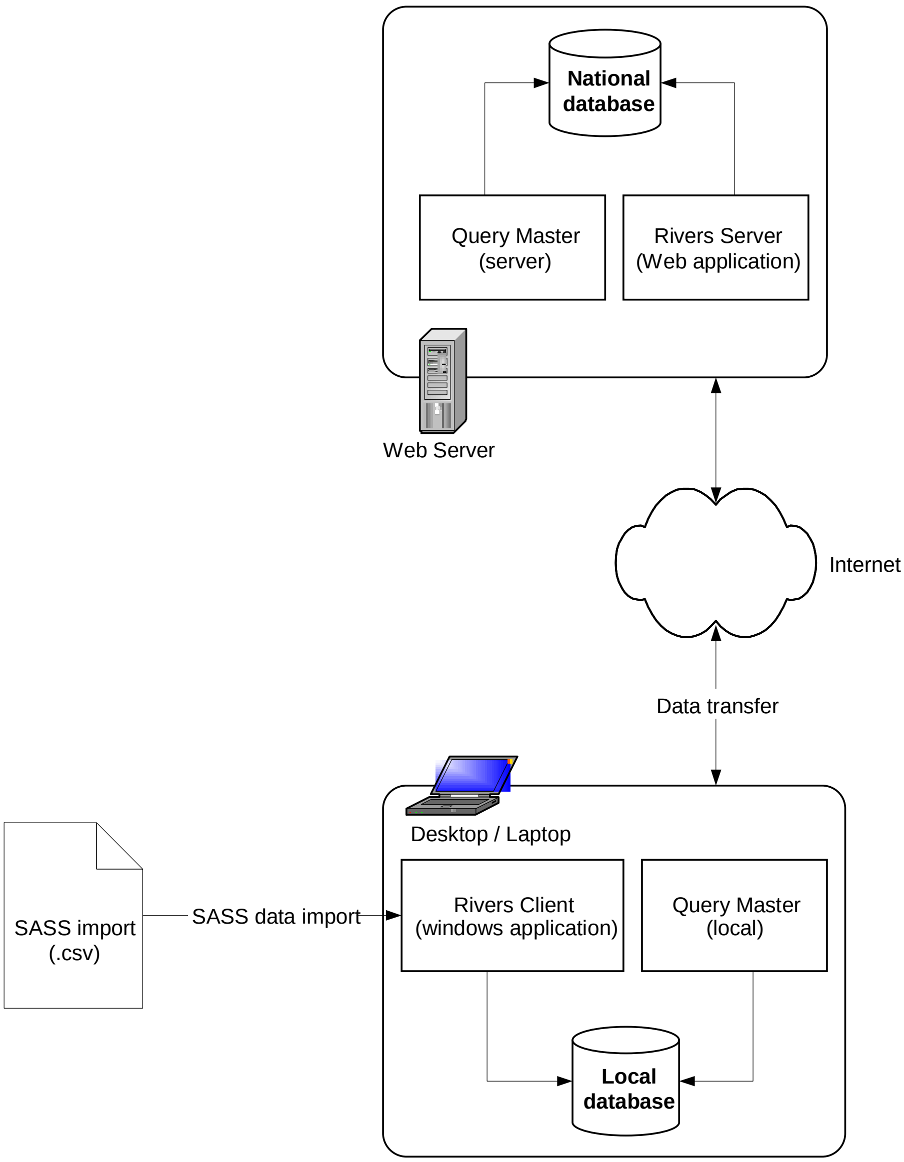


Figure 3.1: Schematic representation of the Rivers Database Version 3 (DWAF, 2007a) architecture and data flow.

Maintenance The Rivers Administrator is responsible for maintaining the database including validating rivers, updating pick lists, invertebrate lists, fish lists, and assigning rights to users.

Rivers Server The River Server's primary role is to provide a real-time, centralised repository of data at a national level. It provides a web-based interface to manage rivers, users, invertebrate and fish lists, pick lists and site photographs (**Figure 3.1**).

The Rivers Server is used to:

- Register as a new user.
- Update user information (*e.g.* if you change organisation).
- Check for existing rivers on the Rivers Server.
- Create a new river and notify the Rivers Administrator to ensure river validation.
- View existing rivers, tributaries and associated sites (including longitudinal zone, site description, and geo-reference).
- View or upload site photographs.
- Download documentation including the Rivers Database manual, EcoStatus manuals, Site characterisation manual, etc. Relevant new RHP documents will be made available when produced.
- Extract data at a national level via the Query Master.
- Contact the Rivers Administrator (via email).

Rivers Client The Rivers Client application is the primary data entry and viewing application data related to Sites and Site Visits. It provides a Data Transfer Utility that allows the Site and Site Visit data to be uploaded from your computer (the Local database) to the Rivers Server (the National database) via the internet in real-time (**Figure 3.1**).

Furthermore, data that are managed on the Rivers Server (rivers, users, invertebrate and fish lists, pick lists, etc.) and Site and Site Visit related data can be downloaded from the centralised repository on the Server.

The Rivers Client also provides an automated SASS data import facility that allows invertebrate data to be imported from an excel file (using a .csv file). (Ensure that this facility allows for importing total abundances.)

Figure 3.2 shows the data types currently included in the Rivers Client, and the relationships between them.

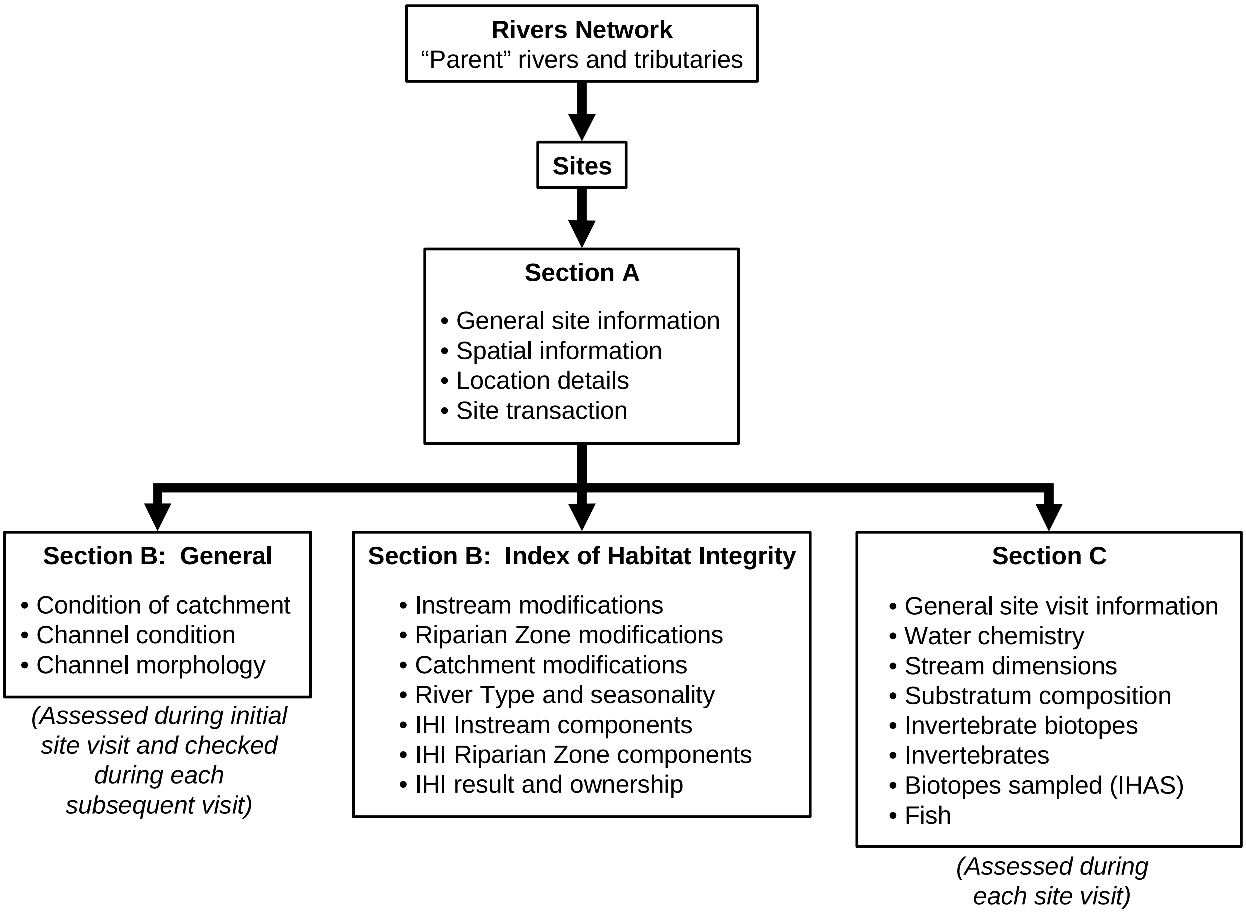


Figure 3.2: Schematic representation of the components of the Rivers Database 2007, based on the Site Characterisation manual (Dallas, 2005c).

Primary uses

The Rivers Client is used to:

- Navigate to Sites and Site Visits using the River Tree View.
- View and add Site data: Section A (General Site information, Spatial Information and Location Details).
- View and add Site Visit data: Section B - General (Condition of Catchment, Channel Condition and Channel Morphology).
- View and add Site Visit data: Section B - Index of Habitat Integrity.
- View and add Site Visit data: Section C (General Site Visit Information, Water Chemistry, Stream Dimension, Substratum Composition, Invertebrate Biotopes, Invertebrates, Biotopes Sampled – IHAS, and Fish).

Data transfer between Rivers Client and Rivers Server

Data transfer can be achieved using Rivers Client. Since data transfer is a real-time process via the internet, a broadband connection is recommended. It is essential to upload site and site visit data on a regular basis to ensure the national database remains up to date and to minimise the chance of local data loss in the event of theft or hardware failure. Users with slower internet connections will also benefit by uploading data more frequently since fewer data will mean individual upload times are faster.

Immediately after logging onto the Rivers Client, the User will be prompted to upload data changes made since the last upload (if any). It is strongly recommended that users follow this prompt and upload outstanding data.

> NB: If you experience problems uploading and downloading data, or logging on to the Rivers Server after registering online, you may get an error message similar to the following: `Proxy server HTTP 407 error`. This may be due to settings on your organisation's firewall blocking your internet connection to the Rivers Server. Please contact your organisation's system administrator to enable the River URL (to allow data to be uploaded and downloaded from the Rivers website), or contact the Rivers Administrator for support.

Other uses

Rivers Client also allows the following:

- All registered Users can edit Assessor data or add an Assessor (*i.e.* the person who actually did the sampling).
- SASS proficiency status of users is maintained and updated by the Rivers Administrator. Users are able to view the SASS proficiency validation for themselves and other users via the Rivers Client.
- SASS data import from Microsoft Excel via a .csv file is possible. Users must follow the specific procedures for arranging the SASS data in the required format (see Dallas *et al*., 2007 for details).
- Downloading of Updates: Service Packs are software patches that are released when necessary and downloaded automatically by the Rivers Client. These software patches permit users to update Rivers Client with the most recent structural, functional and data changes without having to re-install the entire Rivers Client. If an internet connection is available when a client logs on, the Rivers Client checks for new service packs and prompts the user to download the latest updates (if any). The service pack is then automatically downloaded and applied by the Rivers Client. The user can also use the Menu Toolbar to check for Updates and download them (Tools, Check for Updates).

Query Master (Server and Client)

The Query Master can be used to extract data from the database. A local version of the query master runs on the desktop and a server version runs on the web server (**Figure 3.1**). The Query Master is accessible either through Internet Explorer or via a window in the Rivers Client application. Step-by-step instructions on using the Query Master are given in the Rivers Database manual.

The Query Master consists of five main screens, each with a header that provides a description of the steps that should be followed to select data components and filter data. These forms are:

- Primary Data Component Selection;
- Secondary Data Component (Combine Components);
- Field Selection;
- Define Filter Criteria; and
- Display report.

If you are unable to open the Query Master, it is likely that your computer is not set up to view local intranet. Refer to the "Frequently asked questions – Query Master" section in the Rivers Database manual.

3.3 EXISTING SITES

Current sites

Existing data in the Rivers Database (on 29 April 2008) comprises 1687 RHP sites on 1667 rivers (**Figure 3.3**). **Table 3.1** shows the number of sites per water management area. These numbers will increase as users add data. The earliest data were collected in 1993. Currently:

- 6 011 sites have SASS survey data
- 2 830 sites have fish survey data
- 3 774 have water quality data (mostly conductivity, temperature, dissolved oxygen and pH).

Table 3.1. The number of sites per water management area.

Water Management Area	No. of sites
Berg	260
Breede	199
Crocodile (West) and Marico	137
Fish to Tsitsikamma	10
Gouritz	100
Inkomati	245
Limpopo	63
Lower Orange	14
Lower Vaal	44
Luvuvhu and Letaba	85
Middle Vaal	28
Mvoti to Umzimkulu	87
Mzimvubu to Keiskamma	31
Olifants	183
Olifants/Dooring	80
Thukela	22
Upper Orange	11
Upper Vaal	47
Usutu to Mhlatuze	14
Swaziland	7

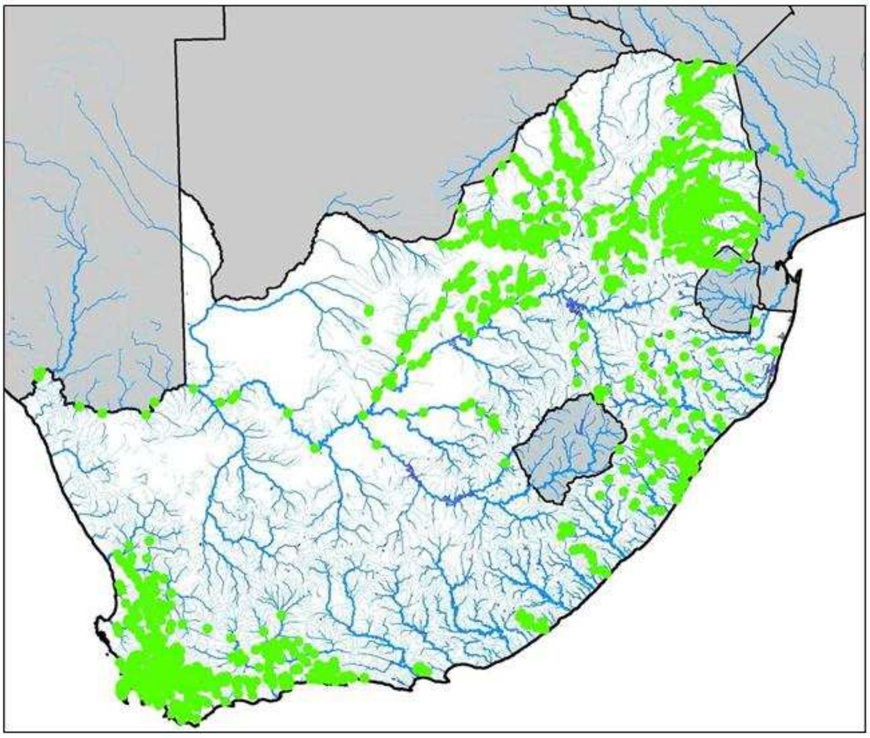


Figure 3.3: Distribution of RHP sites in the Rivers Database in February 2008.

3.4 TRAINING

Workshops

Regional training workshops have been held in Cape Town, Pretoria, Pietermaritzburg, Grahamstown and Bloemfontein. To date, more than 80 RHP practitioners have received training in the use of the Rivers Database. Further training is recommended for both new users and as refresher courses for existing users.

Trainers

Currently training is provided by The Freshwater Consulting Group (Helen.Dallas@uct.ac.za). It is envisaged that in the future this training will be taken over by the Rivers Administrator. It is recommended that trainers are identified and trained within each province for the long term sustainability and success of the database. Interested potential trainers should contact the Rivers Administrator.

Trainees

To receive training in the use of the Rivers Database, contact the Rivers Administrator or the RHP Programme Manager at Resource Quality Services, Department of Water Affairs & Forestry. Training typically takes place in 2-day workshops that can be held in any of the major centres. For first-time users pre-requisites for receiving such training include computer literacy. The workshops involve hands-on operation of the database, including installing the database, capturing data into the database, uploading and downloading data, and extracting data.

It is recommended that users receive refresher courses at least every 3 years. As with any database, aspects do evolve and improve over time. It is important that users remain familiar with the latest developments.

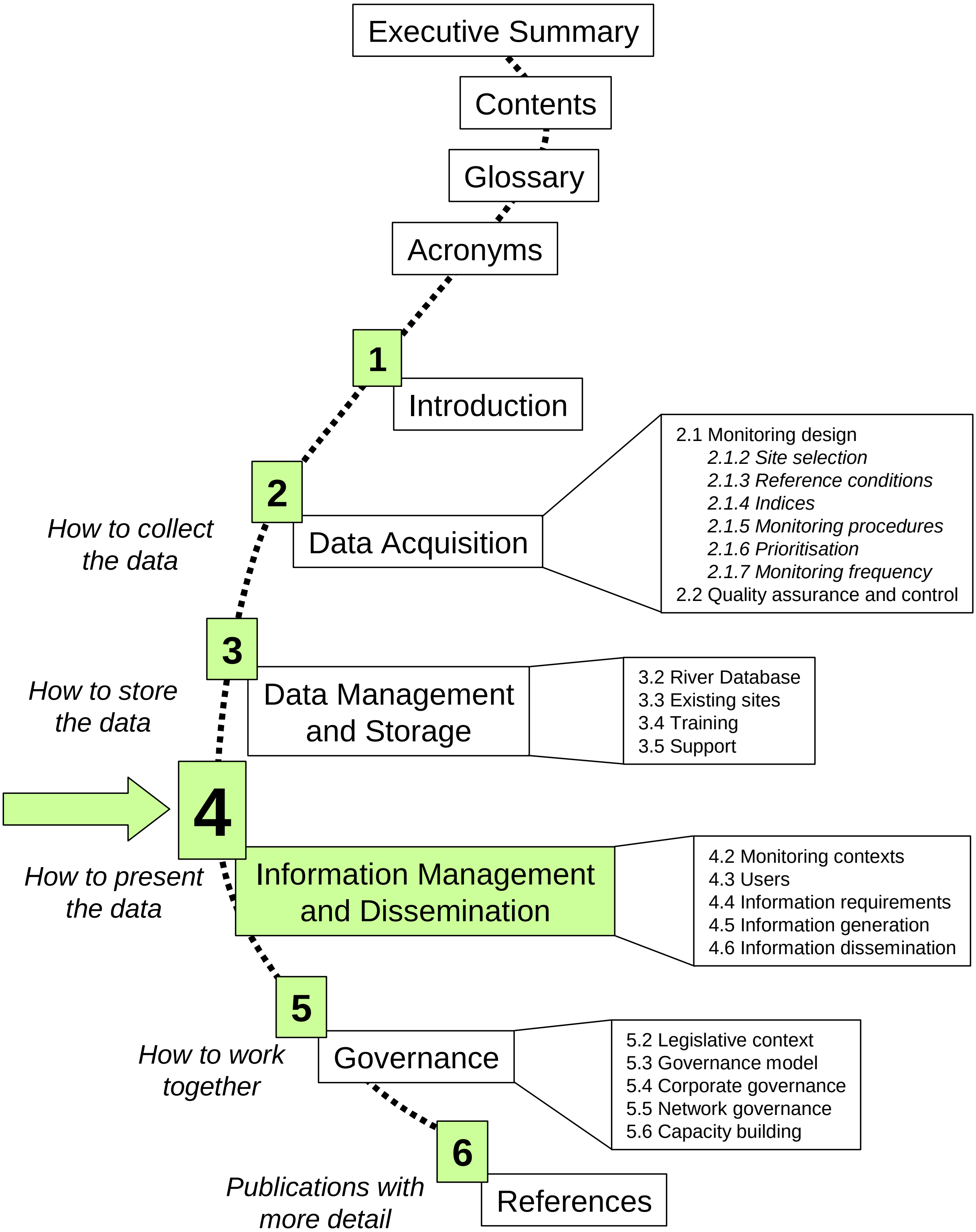
3.5 SUPPORT

Administration	For general queries including assistance with user registration, creating new rivers on the Rivers Server, populating the Rivers Client, modifying lists, please contact the Rivers Administrator (contact details are available on the Rivers Server website).
Technical	For technical questions related to installation or the security of the site, please contact River Technical Support at Soft Craft Systems at:

Andrewm@softcraft.co.za

Telephone: 021 713 0976

Manual Roadmap



SECTION 4: INFORMATION GENERATION AND DISSEMINATION

This section describes the users at whom the Programme is aimed, their information requirements, different levels of data interpretation, and dissemination channels.

4.1 INTRODUCTION

Importance

Availability of good information lies at the heart of effective and equitable decision making. The analysis and interpretation of data gathered by the NAEHMP: RHP and the dissemination of scientifically and managerially relevant information to the appropriate information users, is central to the success of the Programme. Equally important is to distribute the information on time and in an appropriate format.

Transfer media

A broad range of stakeholders make use of the information generated by the RHP, ranging from the scientific community to water resources managers and planners, politicians and the general public. It is therefore necessary for practitioners and scientists of the Programme to investigate and make use of a variety of media for packaging and disseminating information to maximise information impact. The choice of media will largely be determined by the target audience itself as well as the purpose and nature of the message to be communicated.

4.2 MONITORING CONTEXTS

Legislation

Water resource monitoring in general is often undertaken using a suite of tools and programmes, many of which are governed by legislation. Both the National Environmental Management Act (NEMA 1998) and the National Water Act (NWA 1998) have a requirement for monitoring of the water resource in order to secure sustainable development.

There are also several laws and regulations that require the monitoring and assessment of water resources. All will benefit from the use of accredited persons and the production of good quality data. **Figure 4.1** illustrates a variety of contexts to which the RHP can contribute.

The following briefly summarise some contexts.

Water resource monitoring programmes in DWAF & Water Management Institutions

The National Water Act (NWA) (Act No 36 of 1998) (RSA, 1998) provides explicitly for the monitoring and assessment of water quality as an integral part of water resources management in South Africa. DWAF has established a number of monitoring programmes. The two that would benefit most from the use of RHP accredited practitioners and the production of good quality data would be the NAEHMP and the Resource Directed Measures monitoring programme (which includes the Reserve).

Good quality RHP data can also be used though for compliance monitoring where, for example, waste is being discharged to a river.

Integrated Environmental Management The RHP provides a suite of tools that is credible and appropriate for monitoring within the broader context of Integrated Environment Management.

State of Environment reporting State of Environment (SoE) reporting is a way of assessing how well a region is progressing in terms of achieving sustainable development objectives. The RHP is well suited to monitoring in this context.

Use of Accredited Professionals Whilst the use of accredited persons is not yet mandatory in RHP, the details of all practitioners who are accredited are recorded on a central database. Any person wishing to undertake water resource monitoring as part of a tool or process should consult this database to ensure that the person who they appoint to undertake the task is competent to do so. DWAF will maintain this database of RHP accredited professionals.

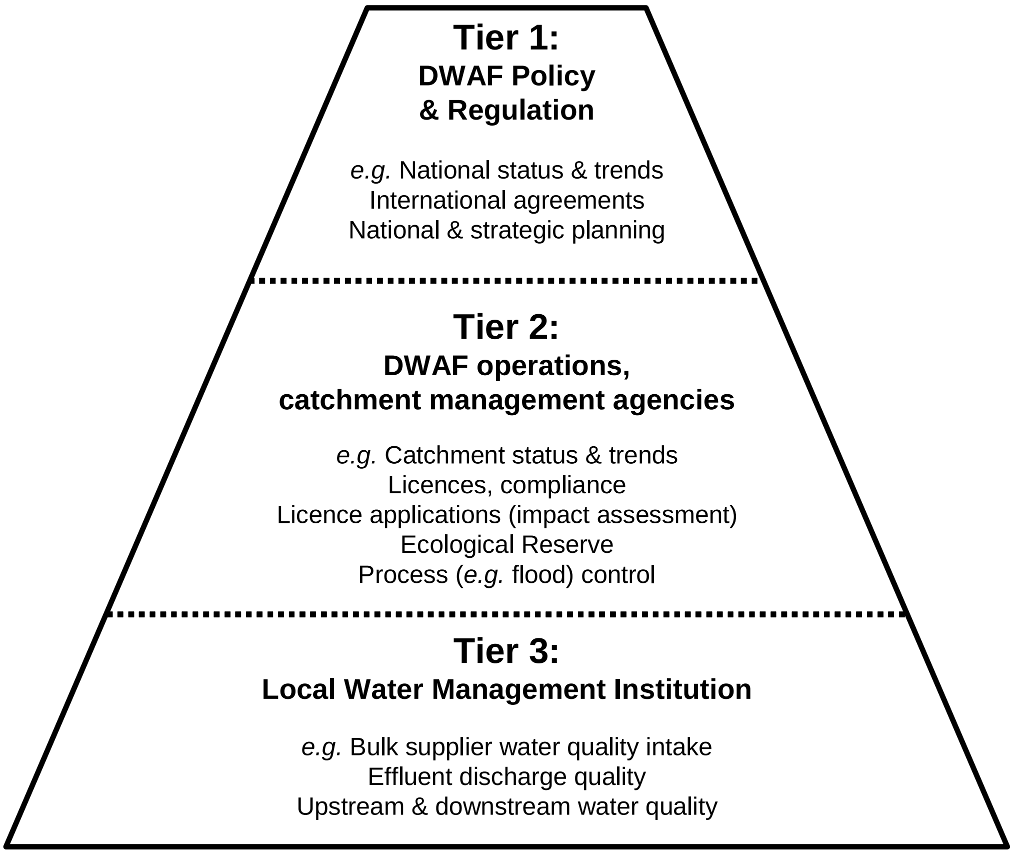


Figure 4.1: Examples of monitoring contexts at national, regional and local levels.

4.3 USERS

Stakeholders

The RHP facilitates a unique mix of stakeholder participation in the management of our water resources. While the Programme has always been directed by DWAF it has also actively engaged many other stakeholders. These range from other national government departments like the Department of Environmental Affairs and Tourism (DEAT) to funding organisations like the Water Research Commission (WRC) and various provincial and local stakeholders from around the country.

Diverse requirements

This diversity of stakeholders has made the RHP exceptionally powerful. It brings together the enthusiasm of numerous individuals and organisations all ultimately contributing to better management of the nation's water resources. Yet, each of these stakeholders has a different purpose for being involved in the RHP. They also have different responsibilities at different levels (*i.e.* national, provincial, local) and thus have different applications for the RHP information.

In addition to resource managers and planners, RHP information is also used by politicians, the general public and by teachers and learners for educational purposes. Each of these user groups has unique information requirements and one of the key challenges of the Programme is to communicate technical information in an effective and creative manner to this wide audience (Roux, 1997).

DWAF's Strategic Framework for National Water Resource Quality Monitoring Programmes (DWAF, 2004a), distinguishes between two types of information users, primary and secondary:

Primary information users

Primary information users are those who rely heavily on the information they receive. Specifically:

- They perform a DWAF Policy and Regulation function; or
- Their function cannot be performed adequately without having access to the information products produced by the Programme.

Primary information users of the NAEHMP include:

- Department of Water Affairs and Forestry;
- Department of Environmental Affairs and Tourism;
- Water Research Commission;
- Conservation agencies;
- Provincial departments of the environment; and
- Service providers to the above.

Specific users within DWAF include:

- The Minister (including the relevant parliamentary portfolio committees);
- Directorate: National Water Resources Planning;
- Directorate: Resource Directed Measures;
- Directorate: Water Use;
- DWAF Regional Offices; and
- Service providers to the above.

Secondary information users Secondary information users are those who benefit from RHP information but do not necessarily rely on it to perform their function. They include the general public and teachers and students at tertiary education institutions.

4.4 INFORMATION REQUIREMENTS

The challenge A major communication challenge is to fill the knowledge gap between technical information and the information that stakeholders need to perform their specific management tasks. To do this, it is necessary to understand the following:

- The roles and responsibilities of the Programme's stakeholders;
- What information they need; and
- How the information will be used.

The following sub-sections provide an overview of typical requirements at different levels.

4.4.1 National

Strategic perspective At a national level there is a need for RHP information on the state of rivers. This type of information has certain typical characteristics:

- National coverage for National and strategic purposes.
- Sites at which monitoring information is available are selected to represent the entire country at a high level.
- Sites include reference sites as well as monitoring sites which may be impacted.
- Monitoring is done to detect long-term changes or trends.
- The emphasis is on determining the overall EcoStatus of the river and for derivation of the Ecological Reserve.
- Information is used primarily for National State-of-Rivers Reporting (part of National State of Environment Reporting) but also for high level DWAF strategy information.
- The frequency of monitoring is relatively low (see **Table 2.5**).

4.4.2 Provincial

Strategic & management perspective At a provincial level, there is a similar need for information on the state of rivers but there may be additional needs. There is therefore a mixed strategic and provincial management perspective. Some characteristics are equivalent to the national characteristics (just at a provincial spatial and temporal scale) while others address needs that may be unique to the province, some of which may be quite local in character. For example:

- Sites are selected to represent the entire province at a high level.
- Useful information is generated for Provincial State of Rivers (part of State of Environment) Reporting.
- Information is useful to identify environmental "hot spots" that need management intervention.

- Sites would include the national sites, but would also include monitoring sites useful for day-to-day river management. This would include sites located to detect pollution or deterioration of rivers which are under threat.
- Data would be used for licence issuing, compliance monitoring and for assessment of Ecological Reserves for rivers.
- Data requirements may be more detailed *e.g.* rather than EcoStatus data, information such as species composition may be useful for purposes like nature conservation. However the national methods were not intended for this purpose so additional monitoring or other adaptations may be necessary if the data are going to be useful.
- The frequency of monitoring is more frequent than for national monitoring because there is a more urgent need to respond to the results.

4.4.3 Local

Project perspective

At a local level, there would be some interest in the provincial and national presentation of the RHP data, but generally such data would not be at a resolution that would be of use to local government. For example, national and provincial perspectives may require (a) fewer relevant monitoring sites and (b) less frequent monitoring than that required for local applications.

Local RHP data would typically have the following characteristics:

- It would focus on the impacts of anthropogenic activities on a specific river.
- Sites would tend to be located upstream and downstream of cities or other sources of water pollution, dams, etc.
- Data would be used for specific applications like compliance monitoring and for management of cities and factories, etc.
- Data would be used for specific Integrated Environmental Management activities *e.g.* EIAs, etc. relating to development projects.
- Some sites would be monitored over the long-term while others would only be of interest over the short-term, as required by the specific project.
- Frequency of monitoring would be more frequent to allow for tighter management of issues. It may also be variable depending on the nature of the project.
- Sometimes the data would need to be dissected to extract the raw data such as species composition. However, as noted for the provincial perspective, the national methods were not intended for this purpose so additional monitoring or other adaptations may be necessary. Such specific information may be used for detailed impact studies (*e.g.* location of an endemic species for conservation management), for research projects etc. (The Rivers Database does facilitate this by allowing a Data Query to find all records of a species.)

4.5 INFORMATION GENERATION

4.5.1 Introduction

Evolving process

Many different reporting formats have evolved during the development of the indices and other tools for reporting the health of rivers in South Africa. Developments were informed by the wide variety of users and consumers of the River Health Programme (RHP) data and products.

It has been a dynamic process and is ongoing. This manual is by no means the final word. New and innovative ideas are likely to emerge in the future. However it does provide some guidance to those producing reports for the Programme's information users while still allowing for a degree of individual style.

Flexibility

There are various levels of reporting information and data. They are largely determined by the particular audience or customer. In some instances "customers" have requested standard reporting formats (*e.g.* DWAF for State of Rivers (SoR) reports, or the forestry industry). In other instances particular projects or situations are sufficiently different that being prescriptive in terms of reporting formats would not be appropriate.

The following section provides some direction and standardisation of possible reporting formats and templates. It is not exhaustive and is not meant to constrain users from "borrowing" from other contexts.

4.5.2 Interpreting data

Data to information

The RHP generates data through its biomonitoring programme. The MIRAI, FRAI and IHI methods (plus those other methods that are not yet fully incorporated) all produce data which are stored on the Rivers Database. They produce EcoStatus outputs directly, simplifying their interpretation. **Tables 4.1** and **4.2** summarise the nature of the data and the associated interpretation for the RHP methods.

Table 4.1: RHP methods and the data produced.

RHP METHOD	TYPE OF DATA PRODUCED	INTERPRETATION
MIRAI	Ecological Categories	EcoStatus categories are produced (**Table 4.2**) following the standard EcoStatus guide.
FRAI	The FRAI method produces Ecological Categories.	Follow the standard EcoStatus guide (**Table 4.2**)
IHI	There is an Instream and Riparian valuation which may be treated separately and which produce Ecological Categories.	Follow the standard EcoStatus guide (**Table 4.2**).

Table 4.2: Ecological categories, category names and associated meanings with colour codes used to interpret EcoStatus and RHP data.

ECOLOGICAL CATEGORIES	NAME	DESCRIPTION	COLOUR
A	Natural	Unmodified natural	Blue
B	Good	Largely natural with few modifications	Green
C	Fair	Moderately modified	Yellow
D	Poor	Largely modified	Red
E	Seriously modified	Seriously modified	Purple
F	Critically modified	Critically or extremely modified	Black

4.5.3 Reporting levels

4.5.3.1 User classification

Classification and examples

There are various users of RHP products (data, information and reports) which may be broadly categorised as illustrated in **Figure 4.3**. Examples of the possible users within the categories are given in **Table 4.3**.

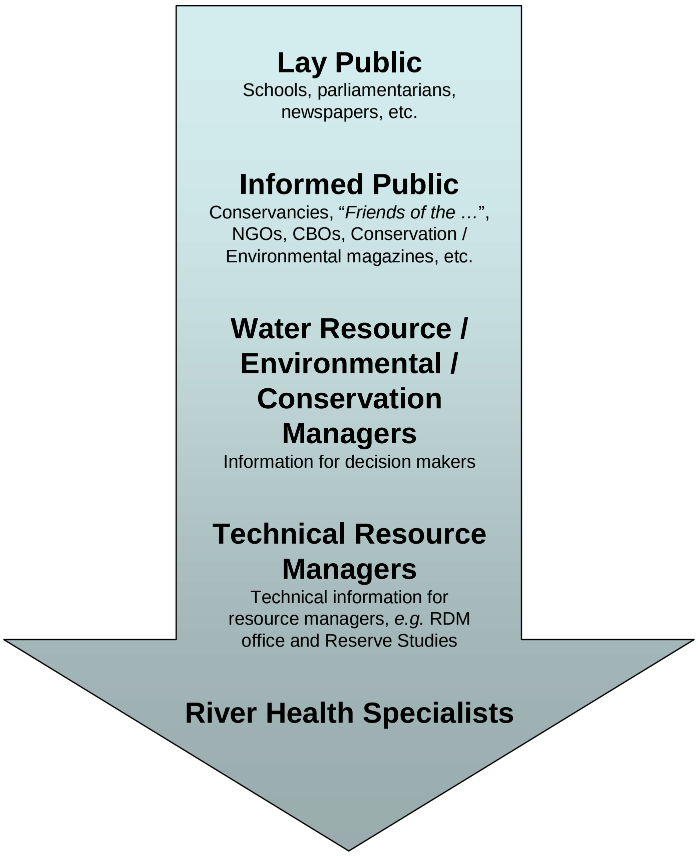


Figure 4.3: Broad categories of RHP users requiring an increasing level of detail.

Table 4.3: Examples of users within each of the broad categories, with the most basic at the top of the table.

TARGET AUDIENCE	POSSIBLE MEMBERS OF GROUP
Lay Public	• Schools (both primary and secondary levels) • Parliamentarians • The audience of newspapers and some more general magazines
Informed public	• Conservancies • "Friends of the…" • Wildlife clubs and special interest groups • Including School wildlife and conservation groups • EcoSchools • Non-governmental Organisations (NGOs), *e.g.* Wildlife and Environment Society of South Africa (WESSA), etc. • Community Based Organisation (CBOs), • Conservation magazines, etc.
Water resource / environmental / conservation managers	• Water resource managers • Conservation managers • Certain specific NGOs with a direct mandate or interest in water resources, • Certain conservancies which may be associated with or focussed around water resources • River fishing or angling clubs or societies, *e.g.* fly fishing clubs
Technical water resource managers	• Water resource managers – responsible for Rivers Health and Resource Directed Measures (RDM) or Reserve studies • Technical / research officers • Conservation Agencies (*e.g.* International Union for Conservation of Nature, Ezemvelo Kwazulu-Natal Wildlife, Cape Nature)
River Health Specialists	• Ecologists and academics • Technical / research officers

Reporting templates

A suite of reporting possibilities and ideas for templates is provided below for each of the identified users. Some are illustrated with real data. In other cases fictitious data are presented for illustrative purposes.

With each successive level of customer there is an increasing requirement to have access to the unprocessed data and information.

Increasingly "sophisticated users" are also likely to require a range of RHP tools to measure and report on the state of health of rivers. For example, they may wish to combine macroinvertebrate data as well as habitat integrity and benthic diatoms into a single report.

Levels of understanding

Examples of reporting possibilities are presented in the following sub-sections according to the typical level of understanding of the consumers. Three levels are applied, namely:

- Basic;
- Intermediate; and
- Advanced.

Table 4.4 lists various primary products for each level.

Table 4.4: Useful primary products depending on the level of understanding of the user.

LEVEL OF UNDERSTANDING	PRIMARY PRODUCTS
Basic	Smiley faces, *e.g.*  or  Icons, *e.g.*  Graphics (including mini-graphs, pie charts, maps, etc.) Summary text and tables of data
Intermediate	Graphics (including mini-graphs, pie charts, maps etc) One page summaries Technical report with trend data and summaries of EcoStatus models
Advanced	Graphics (including mini-graphs, pie charts, maps, etc.) Summary text and tables of data Spatial (GIS) / graphical summary of data using combinations of all or selected elements of all of the above products Technical / scientific report with graphs, tables and figures along with some degree of data and / or statistical analysis

4.5.3.2 Basic level

Limited knowledge These reporting formats are geared at consumers who have a limited knowledge and understanding of water resources management. Categories may include:

- Lay public; or
- Informed public.

Tabulated data Examples are given in **Tables 4.5** and **4.5.**

Graphical data Examples are given in **Figures 4.4** to **4.7.**

Table 4.5: An example of the tabulated state of health of a river system characterised by smiley faces.

SITE NAME	ECOLOGICAL CATEGORIES
A River above a city	
The River within the city	
The River below the city	

Table 4.6: Summary of tabulated data on Ecological Categories as characterised by a RHP method.

ECOLOGICAL CATEGORIES	NUMBER OF SITES WITHIN ECOLOGICAL CATEGORY	PERCENTAGE OF SITES IN EACH ECOLOGICAL CATEGORY
Natural	2	10
Good	7	35
Fair	5	25
Poor	3	15
Seriously modified	2	10
Critically modified	1	5
TOTAL	**20**	**100**

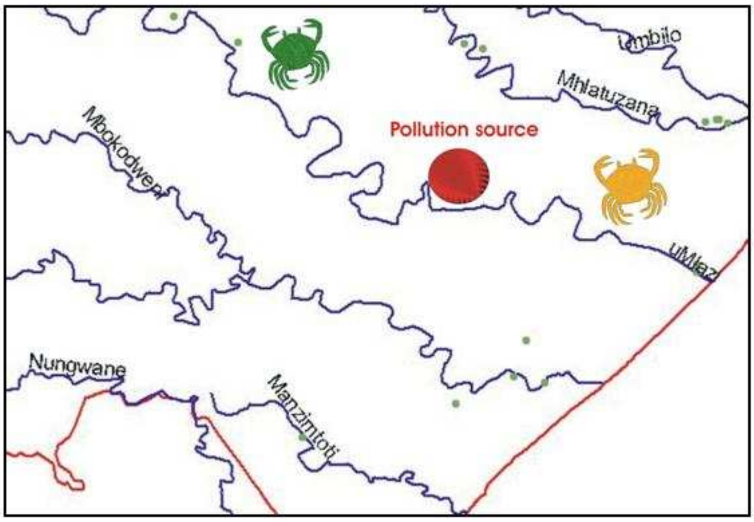


Figure 4.4: Example product of using colour coded crab icons to represent the health or condition of the river above and below a hypothetical pollution source on a river.

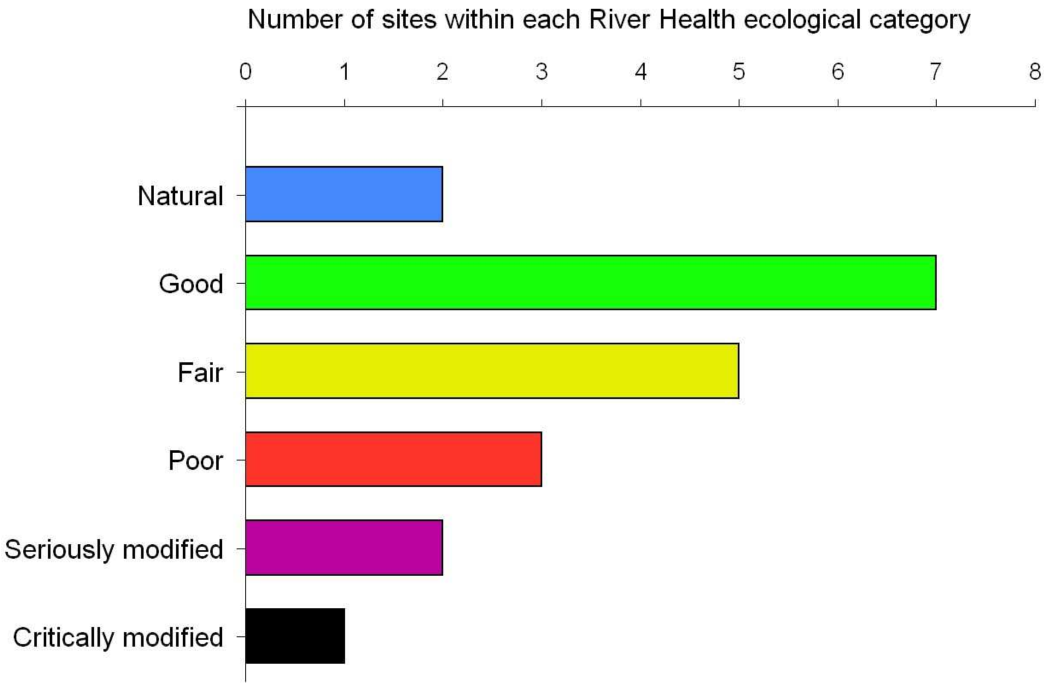


Figure 4.5: Graphical summary of data on Ecological Categories as characterised by a RHP method.

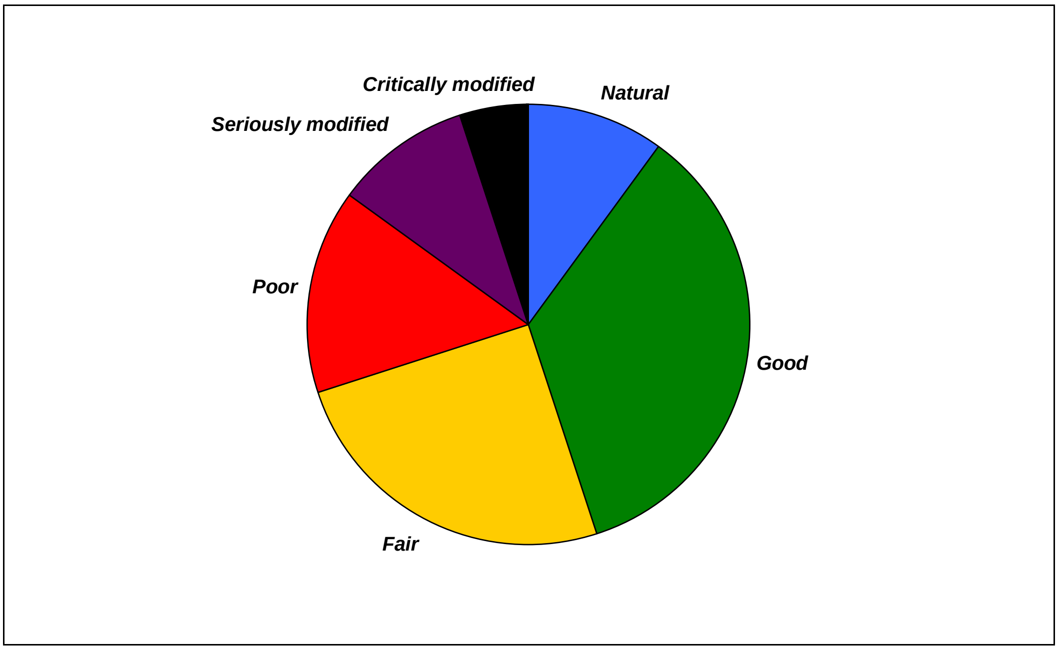


Figure 4.6: Proportion of all sites monitored within respective Ecological Categories.

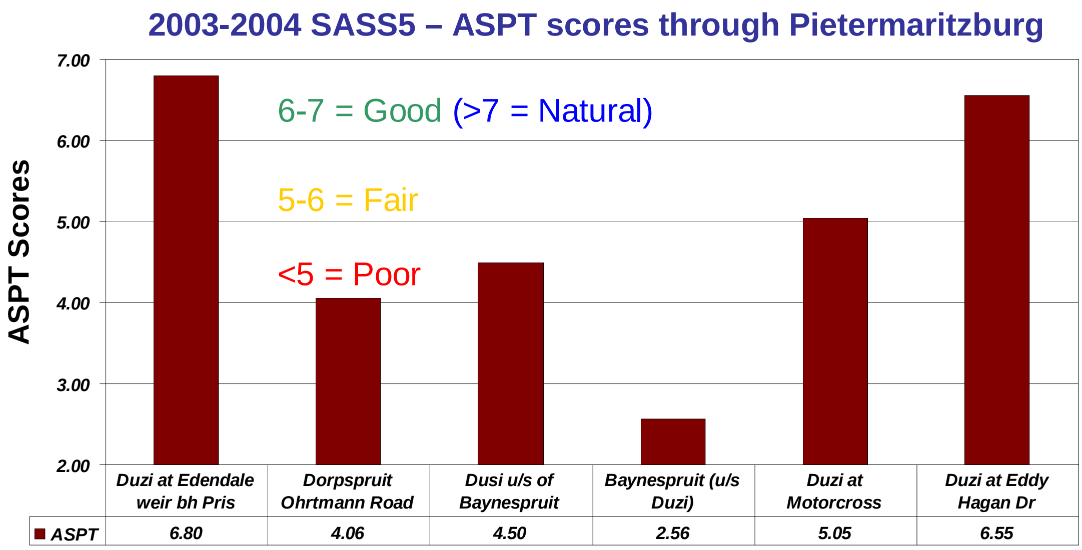


Figure 4.7: Tabulated and graphical data illustrating the health of the Msunduze River, and some of its tributaries, as it passes through the city of Pietermaritzburg

4.5.3.3 Intermediate level

General understanding

These users have a general (but not in-depth) understanding of water resources management. Categories may include:

- Informed public;
- Water resource / environmental / conservation managers; and
- Technical water resource managers.

Data interpretation

Added value and interpretation is achieved, for example, by including identification of key features or drivers of the measured state of health of monitored systems. Key management actions required to address problems identified by the RHP work undertaken may also be indicated.

The product is typically a report, giving the context and background to the study, as well as one-page summaries of sites monitored, with the present health status, key impacts and threats identified for that site or system, and key management recommendations. Previous surveys (trend data) may also be incorporated. It may include all RHP and EcoStatus indices and the information that they produce.

Examples are illustrated in **Figures 4.8** to **4.10**.

Graphical data

Examples are given above in **Figures 4.4** to **4.7.**

River: Piesang	Site: Piesang in kwaMashu @ Bhejane Bridge
Upstream	Downstream
	

Summarised River Health Status

Period	River	Site Description	Aquatic Inverts SASS5 Score	Aquatic Inverts ASPT	Diatoms (SPI)	Habitat Integrity (instream)	Habitat Integrity (riparian)	EcoStatus
2004	Piesang	Piesang in kwaMashu	**58**	**4.5**	**Nil**	**Good**	**Good**	**Fair**
2006	Piesang	Piesang in kwaMashu (canalised)	**83**	**5.93**	**Poor**	**Poor**	**Poor**	**Poor**
2007	Piesang	Piesang in kwaMashu @ Bhejane Bridge	**73**	**4.56**	**Poor**	**Poor**	**Poor**	**Poor**

Present Health Status

The river at this site is at the lower end of the kwaMashu township and as such is under extreme pressure from the upstream catchment activities. Limited access to the site in 2007 restricted sampling to the bridge site (some 200m downstream of the 2006 site). The river here appears to be highly stressed with both bioindicators showing signs of poor river health. The loss of riparian wetland buffers from the canalisation is further limiting the potential of the river to purify itself. The supporting water quality results indicate that the primary stressors appear to be nutrients (nitrogen and phosphorus) as well as significant faecal pollution.

The extensive artisanal sand mining taking place along the old Piesang River channel appears to have been reduced, compared to the 2006 observations.

Notwithstanding the poor condition of the river, youngsters in the local community appear to be making significant use of the resource for recreational purposes.

- The EcoStatus of this site continues to be "**Poor**" (see Table) in 2007, as it was in 2006.

Impacts and Threats

- This canalised section of the Piesang River has lost a significant riparian wetland system which will reduce the rivers ability to self-purify, absorb and process nutrients
- Poor water quality is affecting the aquatic biota.

Management Priorities

- Identify and control sources of nutrients and faecal contamination within the catchment.
- Implement a suitable rehabilitation and Environmental Management Plan (EMP) for this canalised section of the Piesang River.

Figure 4.8: Example "one-pager" report on a site's summarised river health status.

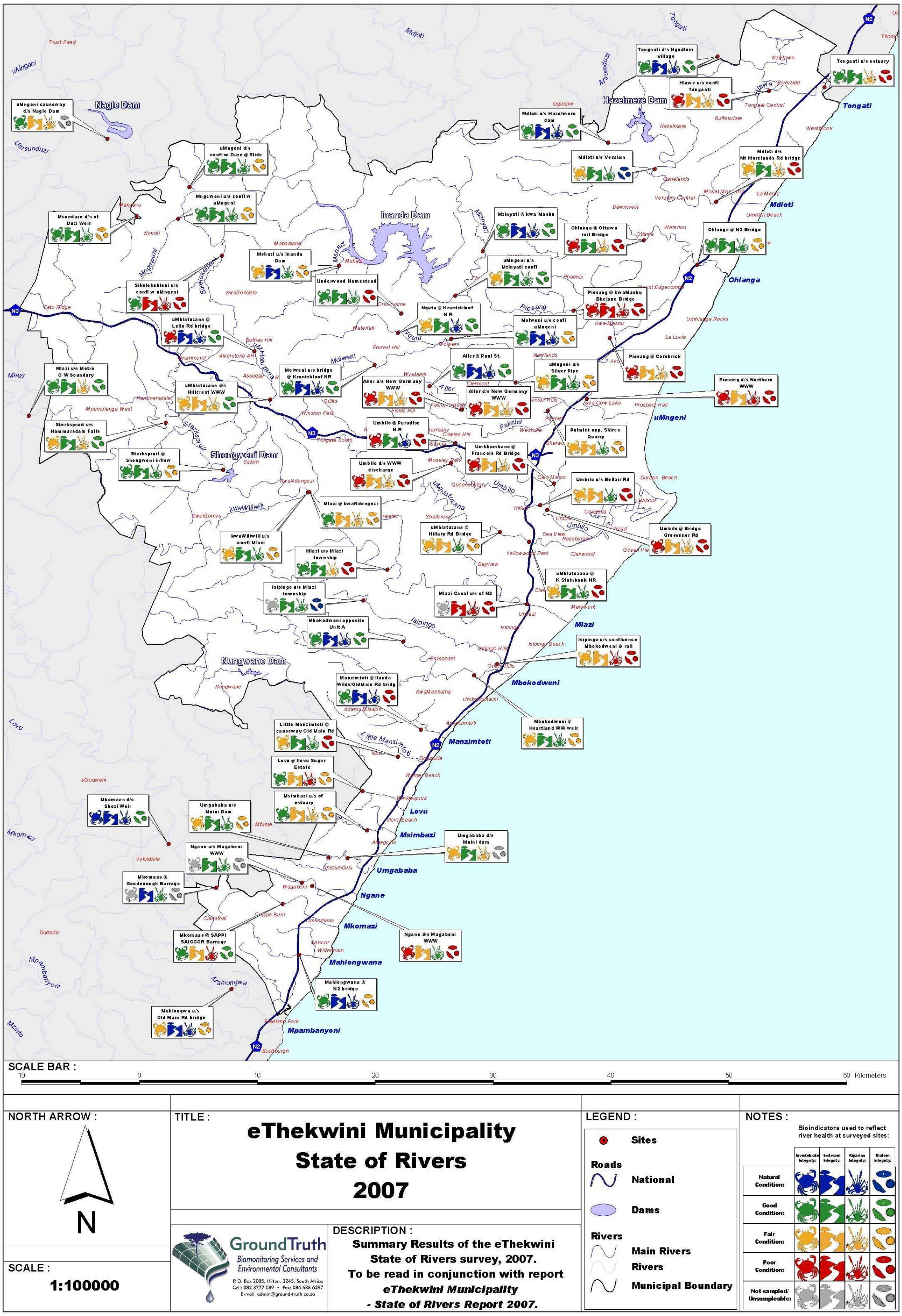


Figure 4.9: Example GIS map of a typical RHP product using RHP indices to spatially illustrate the health of rivers in the eThekwini Municipal area.

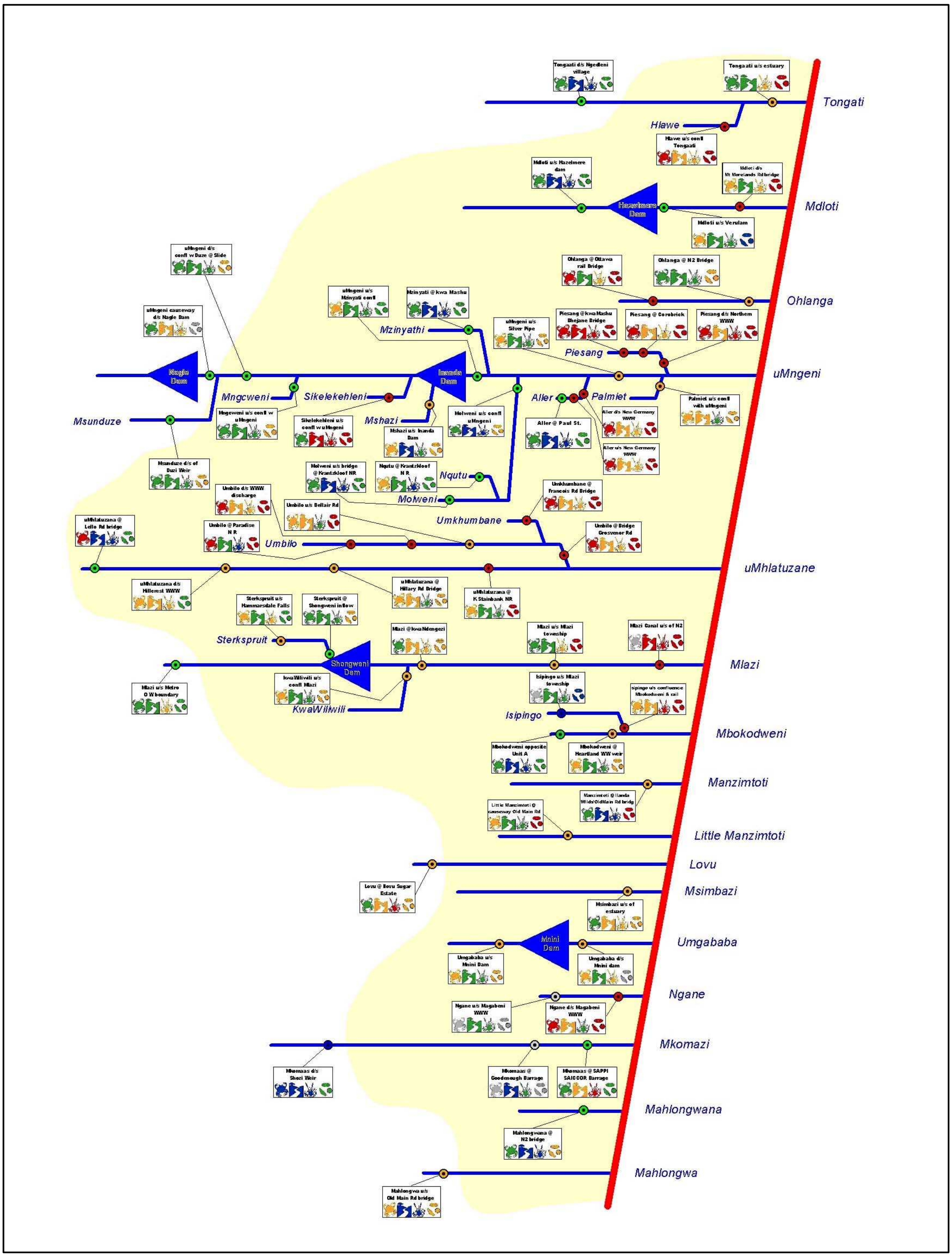


Figure 4.10: Example of a stylised rivers map (based on Figure 4.9) using RHP indices to spatially illustrate the health of rivers in the eThekwini Municipal area (shaded area of map).

4.5.3.4 Advanced level

Technical knowledge

These users have a technical and scientific background, with specialisation in one or more aspects of aquatic ecosystems. They would contribute to the RHP and will have seen or routinely used many of the RHP products. They would have a direct input into Reserve and State-of-Rivers (SoR) type reports, in addition to other management reports and specialist impact studies.

The information provided would be detailed and would include data analyses in various forms. The target audience would be other specialists and other practitioners (both within the Government, Academic and Private sector) who have a good knowledge of aquatic ecosystems and their functioning.

Categories may include:

- Scientists and academics; or
- Technical / research officers.

Diversity

Within this audience / user group the RHP products are becoming increasingly specific with respect to both the component of the study and the system or area under consideration. The data are also becoming more site or area specific, related to the specific area that the specialist is responsible for, or interested in. Reporting formats are likely to be highly diverse with different specialists presenting and analysing their information in ways most appropriate for their specialist study.

Detail

Many of the primary RHP reporting formats identified in the previous sections remain relevant for this target audience (see **Table 4.1**), although there would be a greater depth of detail in text, analysis and interpretation of the data. The data are likely to have a spatial component covering the area of interest and georeferencing of all samples / points used in the particular study. The report is likely to include:

- Graphics (including mini-graphs, pie charts, maps, etc.);
- Summary text and tables of data;
- Spatial (GIS) / graphical summary of data using combinations of all or selected elements of all of the above products; and
- Technical / scientific report with graphs, tables and figures along with some degree of data and / or statistical analysis.

The product is a technical / scientific report that provides a detailed account of the component being reported on. A large amount of interpretation is put into the results emerging from this type of RHP product, including identification of key features or drivers of the measured state of health of monitored systems (from the perspective of the specialist study).

Input to other studies

The results of these specialist studies provide the technical information that is often used to generate more technical reports, including Reserve studies, and SoR reports.

Typical contents A report should contain at least the following:

- The context and background to the study;
- A description of the study area and georeferenced sampling sites;
- Sampling methodologies;
- Data and statistical analyses (typically summary tables, and graphics, summary statistics and univariate and multivariate statistical analyses (including cluster analyses, ordinations, etc));
- Presentation of results;
- Discussion of results indicating relevance and significance to the health status;
- Key impacts and threats, as well as key management recommendations identified;
- Results may be presented with reference to other studies / areas if appropriate, for example International Union for Conservation of Nature and Red Data Species lists, to add context to the study undertaken; and
- Appendices which may include at least family level identifications of RHP taxa but in many cases morpho-species and species where appropriate.

Voucher specimens Voucher specimen from such a study would also ideally be lodged with an appropriate museum or institute, *e.g.* the Albany Museum (collection of aquatic macroinvertebrates), the Southern African Institute of Aquatic Biodiversity (SAIAB) or the Southern African National Biodiversity Institute (SANBI), etc.

Examples Notwithstanding the high project-specificity of reporting formats, some examples data analyses are presented. These illustrate the use of multivariate analyses (ordinations and cluster analyses) (**Figure 4.11**), as well as univariate summary statistics (**Figure 4.12**). Analyses for **Figure 4.11** were performed at morpho-species and family level using rank abundance (Primer version 5).

These are typical but certainly not the only tools that can be used at this level of reporting.

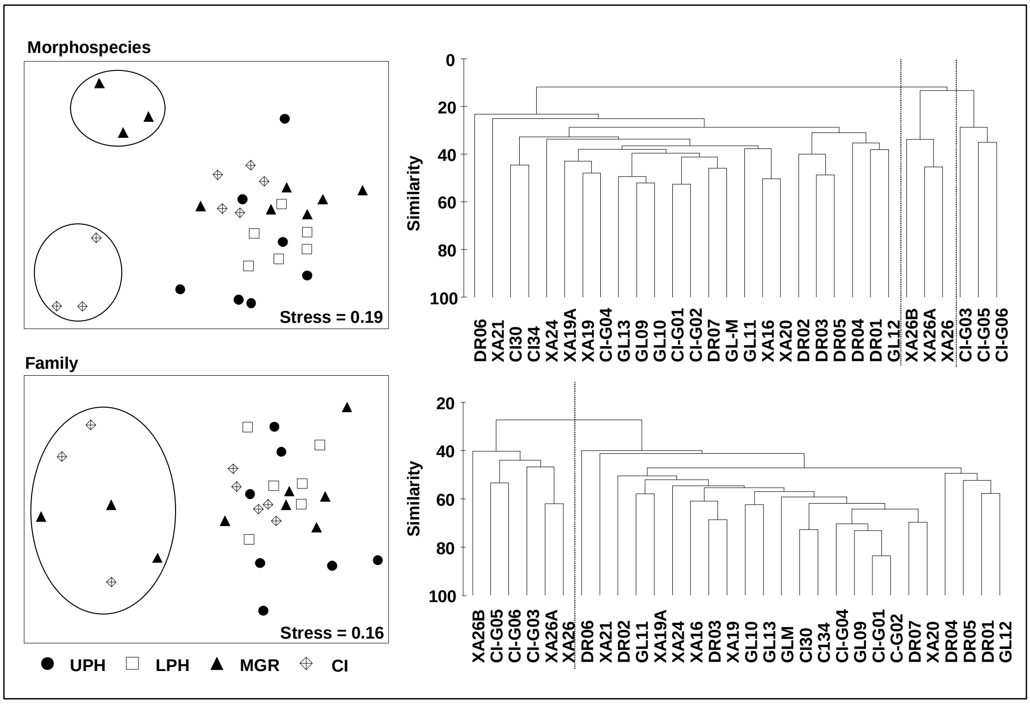


Figure 4.11: Multi-dimensional scaling (ordination) and cluster analysis (dendrogram) showing the grouping of georeferenced sites within each of the four areas based on the similarity of the macroinvertebrate fauna.

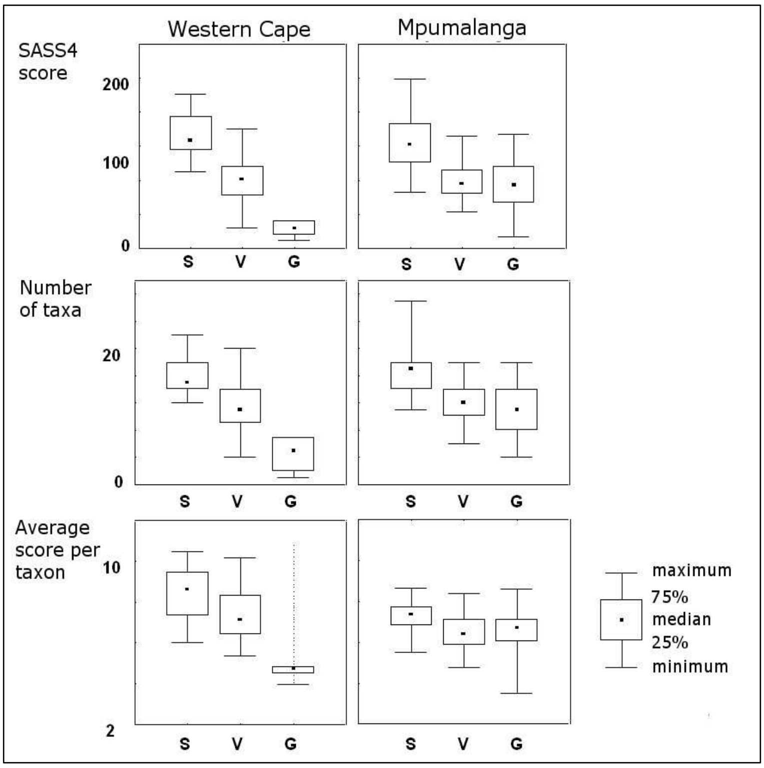


Figure 4.12: Median values for SASS4 Score, number of taxa and ASPT for each biotope group in the Western Cape and Mpumalanga. Biotope groups are: S = stones-in-current / stones-out-of-current, V = aquatic / marginal vegetation and G = gravel / sand / mud.

4.6 INFORMATION DISSEMINATION

4.6.1 Media

4.6.1.1 Publications

Technical reports and scientific publications

Technical reports and scientific publications contain the detailed data interpretation and analysis in a structured format. These reports serve a purely technical audience and are usually intended for internal use and to some extent in the wider scientific community. The sharing of findings may therefore be limited to a select audience. The findings of monitoring programmes are often of limited interest to the editor of a scientific journal unless they are of global importance (Saywell and Cotton, 1999; Australian Guidelines, 2000).

State-of-River Reports

State-of-Rivers (SoR) reports are non-technical reports aimed at resource managers, politicians and the general public. These reports are written in accessible language, in an uncomplicated style and format. A key consideration of these reports is to ensure that the information provided remains objective, credible and conveys a clear message (Strydom, 2003; Strydom *et al.*, 2007).

Posters

Posters are a good way to advertise the Programme and to create awareness (*e.g.* SoR posters and educational posters). A poster can be a great way to interest people in the results of a study. A poster should be designed with minimal information so that it only takes a quick glance to absorb the message (Cyfernet, 2008).

Abstracts

An abstract is a short written overview. It should include the reasons for conducting a study, as well as main findings, conclusions and recommendations. An abstract usually forms part of a technical report and is most useful when audiences are too busy to read a full report (Cyfernet, 2008).

Newsletters

Newsletters are generally written for a specific audience and cover timely topics that are of interest to a specific audience. Depending on the audience, the articles can contain either technical or non-technical information. Newsletters can be distributed monthly, quarterly or biennially either as hard copies (River Health: Newsletter of the RHP) or electronically (*e.g.* RHP eCommunication). It is important that the distribution is regular in order for those receiving it to begin to expect and look forward to receiving it (Cyfernet, 2008).

Information brochures, flyers and fact sheets

Information brochures, flyers and fact sheets are excellent media to create awareness about RHP matters. They are usually written in a non-technical manner. Brochures and flyers can be used to promote the RHP. Fact sheets are usually simple, one-page documents listing facts or statistics in a simple-to-read format for any audience. An example includes the RHP fact sheets on macroinvertebrates that were translated into most of South Africa's official languages.

4.6.1.2 Networking

Context

Networking takes place at professional societies, conferences, seminars, workshops, forum meetings, training and field-day demonstrations. The potential for interaction and discussion is created for individuals who share a common (often research) interest (Saywell and Cotton, 1999).

Conferences, seminars , forums and workshops

Oral presentations at conferences, seminars, workshops and forums (*e.g.* National Steering Committee meetings, Annual Champions Symposium, etc) are useful vehicles for communication results and information regarding the Programme at national, regional and local levels.

Training sessions and courses

Information on the RHP can also presented at training sessions (in-house or externally) to create a basic understanding of the concepts, advantages, uses and limitations associated with the different methods. Technical courses provide practical experience and the know-how of methods and protocols such SASS, fish identification and EcoStatus models.

Field days

Field-day demonstrations provide an informal opportunity where scientists can interact with water resource managers and other stakeholders. It provides an excellent opportunity to talk and develop an understanding of each others' challenges.

4.6.1.3 Web pages and email

Context

Internet web pages and email provide immediate and convenient dissemination of information. The Internet is a powerful means of making data available to a very wide user audience.

However, poor connectivity, slow download times and firewalls can sometimes impede and prevent access. Developers should therefore always test their pages on a slow link and alternative browsers (*e.g.* FireFox).

To avoid data being misinterpreted or misused by non-professionals, it is important to place technical reports on the RHP website, or provide associated professional interpretation instead of simply listing the data (Australian Guidelines, 2000).

The RHP web page

The RHP web page (http://www.csir.co.za/rhp/) has been developed to disseminate and share information regarding the Programme at national and provincial level. The website is in the process of being transferred to the DWAF:RQS web site where it will be managed and maintained in future.

4.6.1.4 Video presentations

Suitability

Video presentations are an expensive way of reporting data and are as such not the ideal medium to communicate scientific findings. Video recordings are more suitable and useful for training purposes and for publicity (Australian Guidelines, 2000).

4.6.1.5 Media releases and media articles

Importance

Media reports are important for disseminating general information about the RHP. They can take place in a structured / controlled or unstructured way.

Structured

The information is made available via a media release that has been produced by, for example, a media liaison officer or communications person of an organisation on behalf of the programme manager. These releases will name a contact person for further information, such as the programme or project manager.

It is advisable that the person(s) listed on a press release or who have contacts with the media, should have training in such activities. Generally, government scientists may not communicate with the media without permission.

Unstructured

Irresponsible, unstructured or incorrect reporting of environmental findings can cause misdirected public anxiety. This diverts attention from potentially more serious problems and creates extra work for communications staff. Personnel being interviewed by the print media can ask to view a transcript of the article before it is published (Australian Guidelines, 2000).

4.6.2 Dissemination channels

Challenges

To be truly useful, information must improve the understanding and knowledge of its users and contribute to effective decision-making. Understanding what users want is one challenge. Another is that we live in an era of information overload. It is usually impossible to read everything. Users also prioritise by making decisions on the perceived value of information.

It is important to establish how users prefer to receive information. However, it also important to use a variety of information dissemination channels. This increases the chances that the message gets across clearly to the right people.

Summary of requirements

Tables 4.7 and **4.8** provide a summary of information and dissemination requirements of the information users of the Programme. This was developed through individual interviews and personal communications. It includes a summary of the following:

- The context within which information is most likely to be used;
- The level (basic, intermediate, or advanced) at which information is most likely to be required;
- How frequently information is required; and
- How the information should preferably be packaged and distributed (this largely reflects the preferences of the person that was interviewed).

Limitations

It must be acknowledged that not all RHP stakeholder information requirements can be met. Indeed, no single monitoring programme can address all the information requirements of all its stakeholders (Roux, 1997). The data to support many of the identified information requirements would have to be generated at a more detailed level and could typically be supported by routine provincial or catchment level monitoring programmes.

Table 4.7: Information and dissemination requirements of primary information users.

STAKEHOLDER	DATA USE	REQUIREMENTS			DISSEMINATION MEDIA
		LEVEL	FREQUENCY	PRODUCTS	
		NATIONAL			
DEAT	State-of-Environment Reporting	Intermediate to advanced	5 yrs	National State-of-the Rivers Report; access to technical reports if required	Email, hand deliver hardcopy; website
WRC	Research to inform policy development & implementation	Intermediate	Quarterly	Provincial State-of-Rivers Reports; Electronic newsletter	Email, website
DWAF					
Dir:Integrated Studies	DWAF Annual Status of Resources Report	Intermediate	Annually	Provincial State-of-Rivers Reports	Mail hardcopy report
Dir:National Water Resources Planning	Planning; policy and strategy development; Integrated Strategic Plans	Intermediate	When red flags appear	National State-of-the Rivers Report; provincial State-of-Rivers Reports; one pager reports	Mail hardcopy report; Presentation
Dir:Strategy and Policy Coordination	National Water Resources Strategy; DWAF Annual Report	Intermediate to advanced	Biannually	Provincial State-of-Rivers Reports; one pager reports; national State-of-the Rivers Report	Email, hand deliver hardcopy
Dir:Water abstraction & instream use	Policy development and guidelines to Regional Offices	Intermediate to advanced	biannually	Provincial State-of-Rivers Reports; technical reports	Mail hardcopy report; website; presentation
Dir:RDM	Reserve determinations, Classification	Intermediate to advanced	Quarterly	Electronic newsletter; provincial State-of-Rivers reports; technical reports; national State-of-the Rivers Report	Email; hand deliver hardcopy; website
Dir:Communica-tions	Media releases; National Water Week; Information to the Minister and parliament	Basic	Quarterly	Electronic newsletter; national and provincial State-of-the Rivers Reports	Email; mail hardcopy

Table 4.7 continued

			PROVINCIAL AND LOCAL		
DWAF Regions	Water use licensing; Targets; RQOs	Intermediate to advanced	Quarterly	Electronic newsletter; provincial State-of-Rivers Reports; technical reports; national State-of-the Rivers Report	Mail hardcopy report; website; presentation
Conservation agencies	Conservation Management Plans;	Intermediate to advanced	Quarterly	Electronic newsletter; provincial State-of-Rivers Reports; technical reports; one pager	Email; hardcopy report; website
Environmental departments	Conservation Management plans; State-of-the-Environment reporting; EIAs	Intermediate to advanced	Quarterly	Electronic newsletter; provincial State-of-Rivers Reports; technical reports	Email; hardcopy report; website
CMAs	Catchment Management Strategy; Targets, RQOs	Intermediate to advanced	Quarterly	Electronic newsletter; provincial State-of-Rivers Reports; technical reports; one pager reports	Email; hardcopy report; website; presentation
Municipalities	Integrated development plans	Intermediate	Quarterly	Electronic newsletter; provincial State-of-Rivers reports; one pager reports	Email; mail hardcopy report; website

Table 4.8: Information and dissemination requirements of secondary information users.

		REQUIREMENTS			
STAKEHOLDER	DATA USE	LEVEL	FREQUENCY	PRODUCTS	DISSEMINATION MEDIA
General public	General information; educational	Basic to intermediate	Regularly	Brochures, general newsletters; one-pager reports; posters; State-of-Rivers reports	Website; popular press
Learners and students	Educational	Basic	Regularly	Brochures, videos; colouring books, posters	Website; popular press; videos

4.6.3 Staying relevant

Periodic feedback

Information dissemination has to be an ongoing interactive process. This ensures that information stays relevant and useful or is adapted and updated to become more relevant. Periodic attempts should therefore be made to obtain feedback from users to ascertain their needs (Denisov and Christoffersen, 2001). This can be done using telephonic or personal interviews. Questionnaires (**Appendix 4.1**) can also be used. They ask for feedback on aspects such as the style of the report, its content and value (Strydom *et al.*, 2007).

Appendix 4.1:

State-of-Rivers Report Questionnaire

Review of a State of Rivers Report: Letaba and Luvuvhu River Systems 2001

The State of Rivers reporting team needs your input to ensure ongoing improvement of our products. Please spend 1 minute to complete this page and:

> Return it to the River Health Programme exhibition stand
> Or Fax to: 012 841 2506 for attention Wilma Strydom
> Or Mail to: Wilma Strydom, Environmentek, CSIR, P O Box 395, Pretoria, 0001

	Strongly agree	Agree	Neutral	Disagree	Strongly disagre
TITLE AND COVER					
Does the cover and title inspire you to read the report?					
PRESENTATION					
Do you find the style of the report suitable?					
Is the layout clear and logical?					
Do the headings make sense?					
CONTENT					
Is the information relevant for your application?					
Do you understand the message?					
Are the most important issues addressed?					
Are questions you might have on the issues addressed?					
Is the information presented in a straightforward way?					
Is there repetition of information?					
LANGUAGE					
Is the language appropriate?					
Are there difficult terms that are not explained?					

AUDIENCE: **WHERE WOULD YOU GROUP YOURSELF?**		**What did you eventually read?**	
Policy developer		Table of contents	
Manager		The introductory pages	
Scientist		The overview pages	
Educator		Ecoregion characteristics	
Other		The river pages text	
How much did you read?		Summary page	
Less than 30%		Photographs	
30 – 60%		Text with photographs	
60 – 90%		Indicator diagrams	
100%		Maps	
Which of the following caught your eye?		Green information boxes	
Table of contents		Glossary	
The introduction and overview		Further reading list	
The river pages		Species list	
Summary page		Adaptive management cycle	
Photographs and maps		Everything	
Text with photographs			
Green information boxes			
Other			

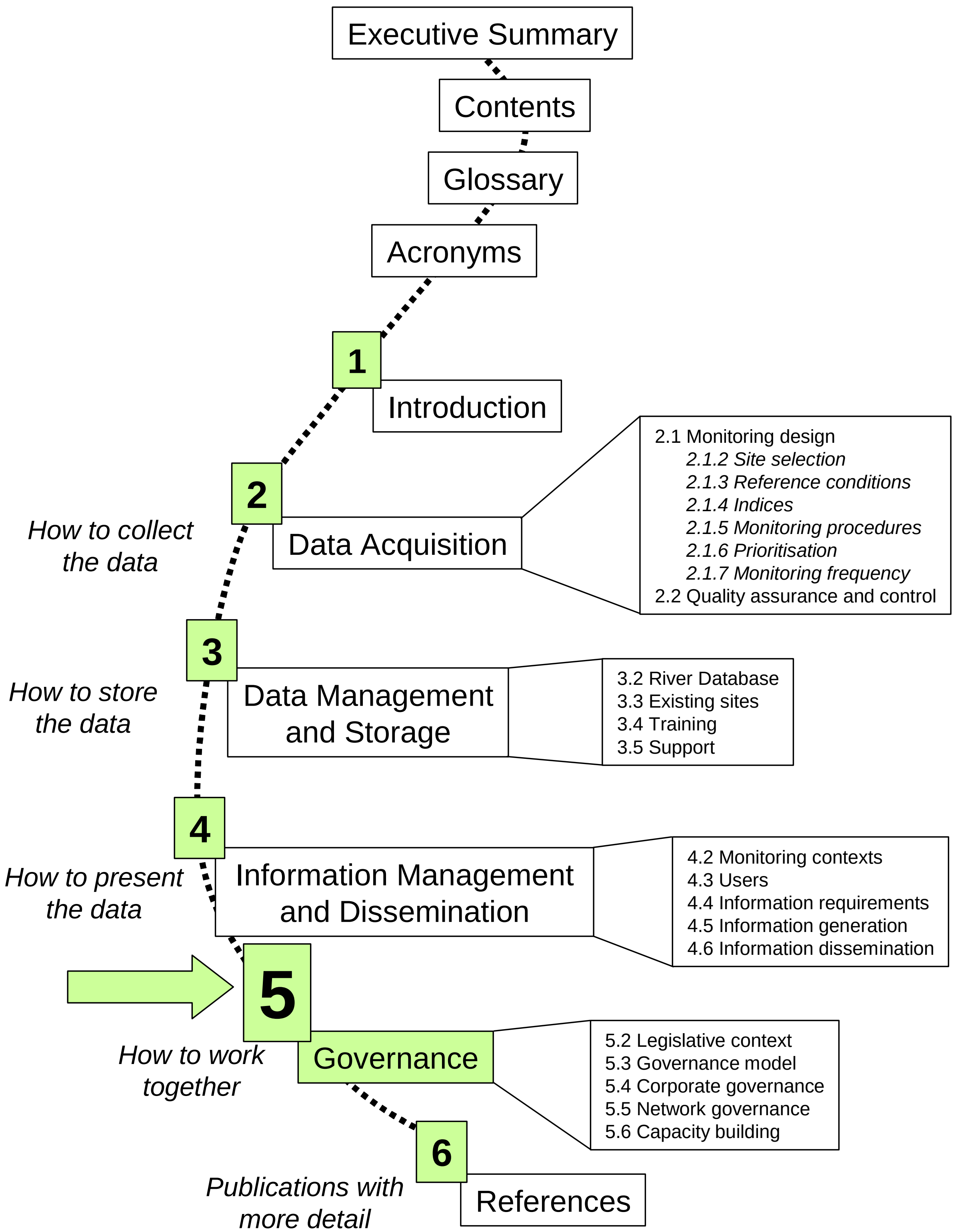
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The Letaba & Luvuvhu River Systems report is successful as a reference document.					
This report allows you to enter debate with knowledge and confidence.					
This report is suitable for general managers, top management and decision-makers.					
This report is suitable for participating public.					
This report is suitable for public in general.					

	YES	NO
Are you willing to review future reports?		

Contact details	(Optional)
Name	
Tel no	
e-mail	
Postal address	

General Comments

Manual Roadmap



SECTION 5: GOVERNANCE

This section describes the RHP's legislative context, how it should be governed, and the responsibilities of role players.

5.1 INTRODUCTION

Multiple spheres

The very nature of the NAEHMP: RHP requires the combination of a highly diverse and specialised cluster of skills which cross the mandates of a number of sectors and spheres of government. It is therefore impossible for DWAF to implement the Programme in all its facets on its own.

However, the effectiveness of ongoing development and the sustainability of the RHP will be determined by the way in which it is governed. In the RHP context, governance is the process whereby individuals and institutions, public and private, manage their common concerns.

Governance

More formally, governance refers to the means for achieving direction, control, and coordination of individuals and organisations that have varying levels of autonomy to advance the interests or objectives to which they jointly contribute. It involves the configuration of:

- Governmental and non-governmental organisations;
- Statutes;
- Organisational, financial and programmatic structures;
- Administrative rules and routines;
- Resource levels; and
- Institutionalised rules and norms.

It also involves formal organisational structures, personal relationships, and judgement by those individuals working in the complex space of administering public programmes. It is inherently political and involves bargaining, negotiation, and compromise (Imperial, 2004).

Requirements

The common concern of particular relevance is the implementation and maintenance of a monitoring programme with a design based on sound scientific principles and operationally feasible protocols, as a means to inform sound river management. For this to be successful, every organisation involved in the RHP, has to:

- Have a clear understanding of the Programme's purpose and objectives;
- Agree on their respective role and responsibilities;
- Accommodate the Programme within their internal business and strategic plans; and
- Work together in a collaborative and cooperative manner.

Section overview	This section provides and overview of the: • The legislative context within which governance operates; • Role players and their mandates, roles and responsibilities; • Different governance mechanisms which are currently in place to support the overall implementation and management of the Programme; • Key elements that are required to govern the Programme; and • Capacity building and knowledge transfer requirements.

5.2 LEGISLATIVE CONTEXT

5.2.1 Applicable legislation

Constitution of SA (Act No. 108 of 1996)	The Constitution states that citizens have a right to a clean and healthy environment and advocates the protection of the environment for the benefit of present and future generations through: • The prevention of pollution and ecological degradation; • Promotion of conservation; and • Securing of ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.
National Water Act (NWA) (Act 36 of 1998)	The NWA is the main Act relevant to the RHP. Under the NWA, the National Government is the public trustee of the nation's water resources.
National Environmental Management Act (NEMA) (Act No. 107 of 1998)	The NEMA largely governs the sustainable use of the environment (including the aquatic environment) and the protection of ecosystems. It also advocates the principle of cooperative environmental governance between government departments and stakeholders, with integrated environmental management being the key underlying principle.
National Environmental Management: Protected Areas Act (Act No 57 of 2003)	The NEMPPA provides a mandate to the managers of the protected areas, such as National Parks and nature reserves, on aspects of nature protection and conservation within the protected areas, including aquatic ecosystems.
National Environmental Management: Biodiversity Act (Act No. 10 of 2004)	This Act focusses on the management and conservation of South Africa's biodiversity, including freshwater biodiversity.

Water Research Act (Act 34 of 1971)

The WRC was established as part of Section 2 of this Act which relates to water research and development.

Intergovernmental Relations Framework Act (Act 13 of 2005)

Within the co-operative governance context, this Act is intended to formalise the relations between (and within) the three spheres of government, i.e. national, provincial and local.

5.2.2 Memoranda of Understanding

Formal agreements

Most of the organisations that are involved in the RHP have a mandate or responsibility that relates directly to aquatic ecosystem monitoring, reporting and management, water related research and development, or freshwater biodiversity conservation. However, the fact that their mandates and responsibilities overlap is no guarantee that their activities will be aligned. There can therefore be duplication of effort and wasting of precious resources. In the spirit of co-operative governance, this could be partially overcome by a more formal agreement between the organisations in which they commit themselves to specific responsibilities.

One such formal agreement is a Memorandum of Understanding (MoU).

The MoU

A Memorandum of Understanding (MoU) can be defined as "a legal document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. Depending on the exact wording, a MoU however lacks the binding power of a contract." (Wikipedia, 2008).

Usefulness

In the RHP context, a signed memorandum of (co-operative) understanding between key government departments and other collaborating organisations within the PTT, would clearly spell out the roles, functions and responsibilities that each organisation agree to undertake. It is therefore a useful document to contribute to the successful implementation and maintenance of the Programme. It also assists these government departments in justifying their RHP expenditure to top management and even their auditors.

Contents

The following aspects would typically for part of a RHP MoU:

- Scope of the MoU;
- Co-ordination of functions with respect to the monitoring of aquatic ecosystem health;
- The measures to resolve non-compliance with the MoU;
- The resolution of disputes in respect of the interpretation or application of the MoU;
- Mechanisms and procedures for co-operation between the parties which include legal mechanisms;
- Sustainability of the MoU (such as incorporation into stakeholder Business Plans);
- Record of delegation;

- Expert assistance and support ;
- Resource requirements;
- Sharing of relevant information;
- Duration of the agreement; and
- Amendments and addendums to the MoU.

5.3 GOVERNANCE MODEL

Successful flexibility

While the design, development, and standardisation (concepts, methods, processes) of the RHP is coordinated at a national level, implementation activities largely take place at the provincial level (**Figure 5.1**). Roux (2004) noted that this model of implementation has to date relied strongly on voluntary participation, informal arrangements and a fair amount of flexibility that caters for the diversity of resource realities (both human and financial) across the country. This approach has proved to be very successful.

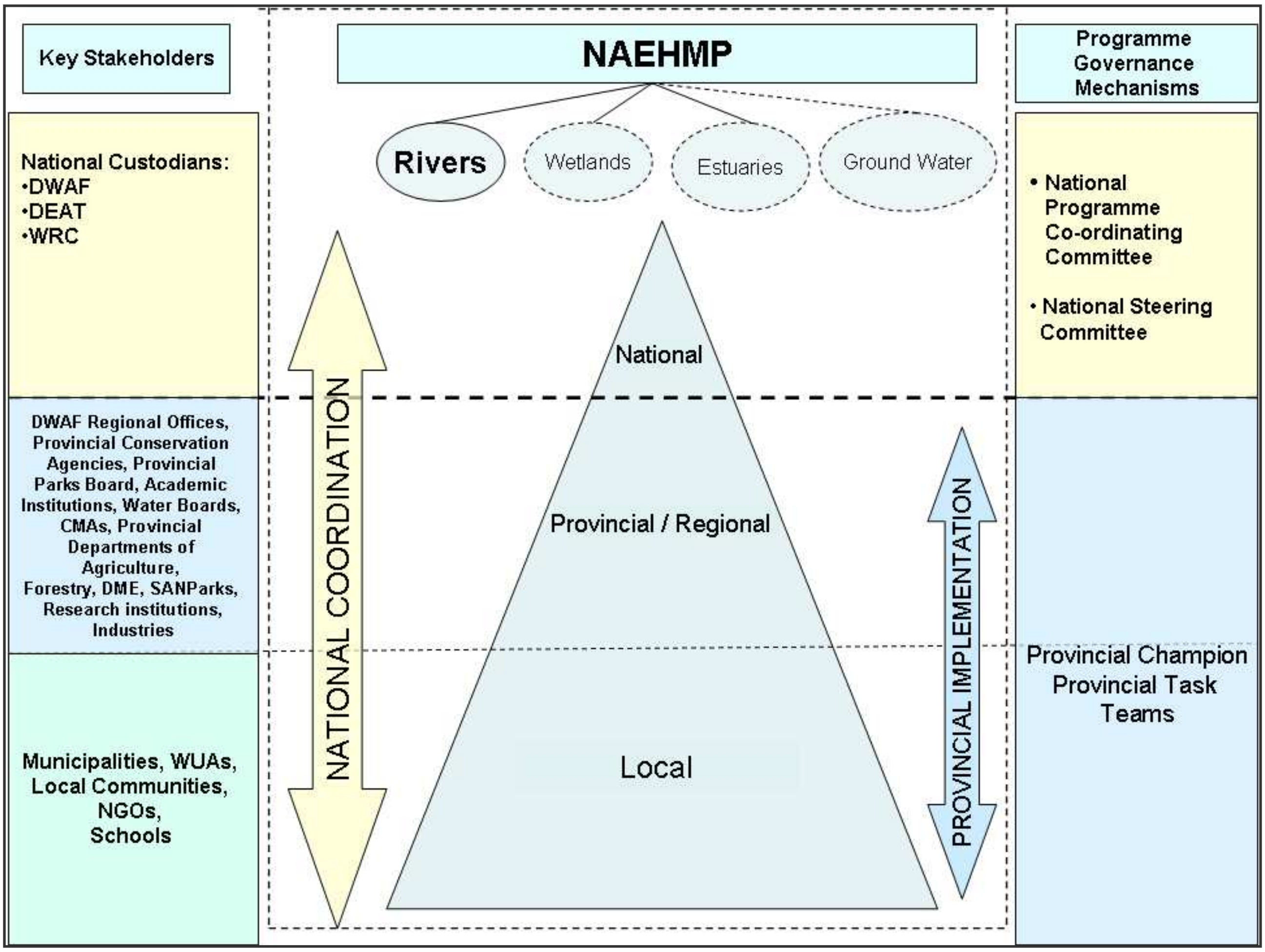


Figure 5.1: NAEHMP: RHP governance model.

Vulnerability

Notwithstanding the success of this model, having to rely on the commitment of individuals leaves the Programme very vulnerable. To maintain and strengthen support for the Programme, it is necessary to formalise the relationships, partnerships, and roles and responsibilities that support action for and commitment to the Programme. However, this must not stifle the informal collaborative style that has been characteristic of the Programme.

Section overview This section describes these mandates, roles and responsibilities at national, provincial and local levels.

5.3.1 National level

5.3.1.1 Custodians

Main role players The national custodians of the RHP and the main role players at national level are:

- The Department of Water Affairs and Forestry (DWAF);
- The Department of Environmental Affairs and Tourism (DEAT); and
- The Water Research Commission (WRC).

5.3.1.2 Roles and responsibilities: Overview

Mandates

- DWAF is the legal custodian of water resources and the primary water management agency in the country. It has a mandate under the National Water Act (Act No. 36 of 1998) to monitor water resources;
- DEAT is the central agency responsible for taking care of the natural environment, including the water component; and
- WRC has a responsibility to promote co-ordination, cooperation and communication in water research and development, funding of water research according to priorities, promoting effective transfer of information and knowledge and ensuring capacity building in the water sector.

Primary role The three national partner organisations, DWAF, DEAT and the WRC, provide strategic guidance to the Programme and support the development, ongoing improvement and standardisation of the monitoring protocols and the implementation procedures.

Responsibilities DWAF plays the lead role in the overall administration, management and coordination of the RHP and provides the necessary funding and human resources to maintain these functions (see **Table 5.1**). This includes resources for the monitoring of the national RHP sites in instances where Provincial Task Teams (PTTs) do not have the capacity to do so.

As co-custodians of the Programme,

- DEAT provides political endorsement, strategic guidance and co-funds State-of-Rivers reporting where appropriate; and,
- WRC supports and provides funding for research and development relating to further development and maintenance of the Programme.

5.3.1.3 Roles and responsibilities: Operational

Table 5.1 summarises the operational roles and responsibilities at national level.

Table 5.1: National operational roles players and their responsibilities.

ROLE PLAYER	RESPONSIBILITIES
DWAF: Chief Director: WRIM	• Mobilise funding for developmental and operational requirements; • Guide implementation process; • Mobilise support across sectors; • Monitor implementation process and sustainability of programme; • Chairperson of the National Steering Committee.
DWAF: Director Resource Quality Services	• Integrate the RHP with organisational business plan of the RQS; • Secure short, medium and long term resources (human and financial); • Monitor progress in terms of RQS' business plan.
DWAF: Deputy Director: Water Resource Quality Monitoring	• Manage and co-ordinate National Water Resource Quality Monitoring Programmes (including the RHP); • Carry financial management responsibility of RHP and other national resource quality monitoring programmes; • Oversee development and maintenance of the RHP Business Plan; • Provide guidance and support to the RHP Programme Manager.
DWAF Quality Assurance Manager (RQS)	• Oversee and manage overall quality control and assurance of the RHP.
DWAF Programme Manager and Operational Assistant (RQS)	*Coordination* • Organise and facilitate programme meetings; • Organise Annual Steering Committee Meetings; • Organise and facilitate the Annual Champions Symposium; • Coordinate inputs to NAEHMP: RHP webpage; • Coordinate inputs to DWAF annual report and State-of-the-Nation's Aquatic Resources Report; • Organise information sessions with DWAF Regional Offices and interested parties. • *Data acquisition, storage and management* • Maintenance of stakeholder database. *Information generation and dissemination* • Coordinate the report on the State of the Ecological Health of South Africa's Rivers, every five years; • Prepare annual RHP progress report to the Chief Director: Water Resource & Information Management (WRIM); • Distribute relevant information products to the various stakeholders (*e.g.* State-of-Rivers products, brochures, newsletters, reports) on time and as specified in **Table 4.8**; • Review and evaluate technical reports. *Stakeholders communication* • Facilitate communication with stakeholders, including DWAF Regional Offices, DWAF Head Office Directorates, national, provincial and local government, custodians, Provincial Champions, NGOs, and the general public; • Electronic newsletter (eCommunication) on a quarterly basis; • Attend and present at conferences, symposiums, forum meetings, workshops, and information sessions. *Programme management and administration* • Budgeting; • Investigating funding opportunities; • Ensure that a core number of staff required to sustain the Programme, is maintained; • Facilitate training and skills transfer; • Manage Professional Service Providers (PSPs) as and when required; • PSP contract administration and management; • Review and update business case as appropriate; • Provide logistical and technical support to implementation teams.

	Facilitation of training and skills transfer • In-house coaching and attendance of short courses. *Periodic review of the Programme's core functions* • Review conducted as per the Strategic Monitoring Framework (DWAF, 2004a) or as demanded by circumstances. *Communication of RHP Research and Development requirements to the WRC.*
DWAF Specialist Scientists	• Provide technical / scientific expertise; • Guide and assist with the development or refinement of methods / techniques / protocols; • National auditing of methods, protocols and national site data ; • Maintain certification of practitioners.

5.3.1.4 National Programme Co-ordinating Committee

Role

The overall role of this committee is to discuss and manage the day-to-day responsibilities and activities of the Programme.

Membership

The committee consists of a chairperson (the RHP Programme Manager), specialist scientists, and Resource Quality Services (DWAF) staff. Any professional service providers involved in RHP related projects will also be on this committee.

Responsibilities

- Decisions regarding the Programme or that affect the Programme will be communicated to the National Steering Committee and provincial stakeholders through existing communication channels (*e.g.* RHP eCommunication, RHP website or newsletters). The Programme Manager will be responsible for this communication;
- Coordinate the monitoring and reporting of national sites;
- Identify, coordinate and communicate the availability of training opportunities;
- Ensure that national and provincial initiatives are aligned with the Programme's objectives;
- Engage with Provincial Champions and PTTs on a regular basis;
- Review products generated by the Programme at national and provincial level;
- Coordinate all research and development (R&D) regarding the RHP, including the development, testing and standardisation of new protocols, and the refinement and standardisations of existing protocols and methods.

Meetings

National Co-ordinating Committee meetings are held on a monthly or two-monthly basis or as determined by the Committee.

5.3.1.5 National Steering Committee

Role

The overall role of this committee is to offer strategic guidance and support to the Programme in terms of funding, concept and method development, and quality assurance.

Membership This committee consists of a chairperson (Chief Directorate: Water Resources & Information Management) and 14 members of inclusive stakeholder organisations (*e.g.* DWAF, WRC, DEAT, SANParks, and scientific advisors) represented by senior officials with authority to make decisions, as well as the RHP Manager.

Responsibilities

- Provide sound, strategic support to the RHP;
- Ensure that proper links are established with other programmes or projects that would have an impact on, or make use of, the information generated by the RHP;
- Make recommendations in respect of the resources that would be needed;
- Review the products generated by the Programme;
- Ensure that proper, functional governance is in place to sustain the Programme, *i.e.* from the national office through to provincial departments, CMAs, local municipalities and other partners.

Meetings Steering Committee meetings are held annually.

5.3.2 Provincial level

5.3.2.1 Overview

Collaboration The Programme is implemented at a provincial / Catchment Management Agency (CMA) / regional level. Collaboration plays a crucial role. Each province has a network of implementers who work together in a Provincial Task Team (PTT), under the leadership of a Provincial Champion. The following may participate:

- DWAF Regional Offices;
- SANParks;
- Provincial parks boards;
- Academic institutions;
- Conservation agencies;
- Water boards; and
- Private sector organisations and industry.

Their primary role is to actively work together in a PTT, sharing skills and resources to achieve goals that would not be possible for any one organisation working alone.

5.3.2.2 Provincial Champion

Role The overall role of the Provincial Champion is to drive the implementation and maintenance of the Programme within the provincial context. Ideally this role should be fulfilled by an employee of a DWAF Regional Office, or a Provincial Department of Nature Conservation or Environmental Affairs employee with a background and experience in freshwater ecology (Roux, 1997). It is important that the role and responsibilities of a Provincial

Champion are:

- Endorsed and supported by his / her organisation; and
- Form part of the person's performance agreement or work plan.

Responsibilities

- Convene and coordinate PTT activities, including monitoring of provincial sites, by whom and at what frequency;
- Ensure that provincial monitoring data are captured on the Rivers Database;
- Initiate, coordinate and source funding for provincial State-of-Rivers reporting; and
- Represent the PTT at the annual Provincial Champions symposium and, when required, the National Steering Committee Meeting.

Champions Symposium

The RHP Champions Symposium is an annual forum for scientists, provincial and local implementers and the national custodians. It allows them to get together to discuss developments, progress and issues relating to the Programme at the national and provincial level. The Symposium also enables all involved to share experiences and ideas regarding the operation and maintenance of the Programme and to learn from one another.

Participation

Participants in the symposium include the national custodians, Provincial Champions, members of the PTTs, DWAF Regional Office representatives, scientists, and where necessary, professional service providers involved in the RHP and related projects.

5.3.2.3 Provincial Task Team (PTT)

Role

The PTT has the overall responsibility of implementing, improving and maintaining the Programme in its particular province or region. Participating organisations show commitment to this responsibility by including biomonitoring in their business plans and supporting and endorsing the involvement of their staff members (Roux, 1997; Mangold, 2001).

Composition

Provincial Task Teams are usually represented by individuals from DWAF Regional Offices, provincial and local government, conservation agencies, NGOs, and universities that have a mandate or interest in water resources protection and conservation. The composition and size of these teams are determined by available capacity within a particular province and typically include a provincial champion, managers and scientists, technical and field workers and professional service providers.

Responsibilities

- Institutionalising the Programme within participating institutions and organisations in the relevant geographic area in terms of budgets, resource development priorities, policy planning, etc;
- Implementing the RHP according to available capacity and expertise and provincial requirements;
- Managing operational resources and infrastructures, including human capacity creation, hardware, software, and equipment;
- Developing and implementing funding models, specifically regarding provincial and local sources of funding;

- Researching biomonitoring needs and requirements;
- Identifying important rivers for the RHP;
- Selecting provincial monitoring and reference sites, while maintaining the responsibility for national sites in the catchment;
- Coordinating the Programme and liaising with relevant authorities;
- Obtaining support for the RHP from major stakeholders in the province such as government, river fora, industry, NGOs, farmers and local communities;
- Training of monitoring personnel;
- Promoting the RHP in the province / CMA;
- Setting of objectives of rivers being monitored;
- Quality assurance and control;
- Storage and management of information;
- Analysing results and detection of environmental trends;
- Disseminating information and reporting to stakeholders, government and CMAs;
- Management actions within the catchment; and
- Communication between RHP initiatives in other provinces.

PTT meetings

Provincial Task Team meetings are held annually or as required for representatives of participating organisations in the province. They are coordinated by or through the Provincial Champion. The overall purpose of these meetings is to plan and coordinate the execution of RHP monitoring and reporting in the province / region.

Participation

Participants in the PTT meetings include the Provincial Champion, members of the PTTs, DWAF Regional Office representatives, scientists, and where necessary, professional service providers involved in RHP and related projects from organisations in a province.

5.4 CORPORATE GOVERNANCE

Unique DWAF elements

Every organisation that participates in the RHP needs to incorporate the Programme within their internal business processes. This is referred to as corporate-level RHP governance. However, while certain generic guidelines may apply, DWAF, because of its leading role in the RHP, has some unique elements that are critical to the success of the Programme. These are summarised as follows (Roux, 2005).

Political endorsement and accountability

It is essential that DWAF ensures and visibly demonstrates support for the RHP from the highest possible level.

Technical leadership and communication

In order to maintain their leadership role within the RHP community, DWAF must have a certain level of competence credibility regarding the basics of RHP monitoring and reporting. This does not mean that DWAF needs to self-sufficient in everything that needs to be done. However, they should be in a position to effectively coordinate, integrate where necessary, and evaluate various technical inputs from several sources.

Capacity and skills

It is important that DWAF knows exactly where they would like to be in terms of technical competencies, where they are at present, and what needs to be done to close any gaps. An assessment of the current as well as desired competencies within each of the participating organisations is a basic prerequisite for effective participation.

5.5 NETWORK GOVERNANCE

5.5.1 Overview

Three recommenda-tions

Three areas are recommended for future attention for governing the national network of RHP practitioners and participating organisations (Roux, 2005):

- A performance management system for a cluster of participating organisations at the spatial scale of a province or Water Management Area (WMA);
- A community of practice to foster inter-organisational learning and knowledge sharing; and
- A national research and development programme to ensure dynamic development and scientific credibility of the Programme.

5.5.2 Cooperation & performance management

Mutual reinforcement

Cooperation and performance management can be used as two mutually reinforcing strategies to promote network governance. Performance management motivates organisations to work together to achieve collective goals and encourage partners to adhere to agreements developed using collaborative processes. On the other hand, the interactive nature of cooperative processes promotes information sharing and encourages the development of performance measures to enhance accountability (Imperial, 2004).

Examples

In the context of the RHP, performance management relates to issues such as setting a goal in terms of the health of a river, objectives for various indices, and responsibilities in terms of sampling frequency, data management, reporting, and implementing various water resource management actions.

5.5.3 Communities of practice

Bridging boundaries

Bridging organisational, disciplinary, cultural and functional boundaries is central to promoting learning and knowledge sharing within the social system of the RHP. We essentially learn through our participation in communities made up of people with whom we interact on a regular basis. These "communities of practice" (CoPs) are mostly informal and distinct from organisational units for example a peer group representing a field of study.

Negotiate mutual relevance

Communities of practice are by their very nature horizontal structures that enable peer-to-peer learning among practitioners. Participants engage in the negotiation of mutual relevance of different forms of knowledge. This is critical to the production and transfer of knowledge and the ultimate building of institutional capability (Wenger, 1998). A number of specialised CoPs are already functioning within the broader RHP community, for example around the use of fish communities as an indicator of river health.

Knowledge enrichment

By actively participating in a community, the knowledge of an individual is enriched as a result of diverse perspectives and experiences, in turn a function of the disciplinary and cultural heterogeneity in the community. Knowledge is analysed, contextualised and reviewed at the community level. Useful knowledge then becomes part of community norms. Community members tend to automatically transfer this knowledge to their home organisations, where it can be adopted and further diffused.

5.5.4 National R&D programme

Scientific credibility

An effective R&D programme would promote the continuous development of scientific credibility of the RHP. Such a programme should be more than a mere collection of independent R&D projects. It must also cater for learning interdependence among multiple components. By following a learning-by-doing approach, an R&D programme would facilitate a partnership between those involved with development of new concepts and those responsible for operational application of those concepts (Roux *et al.*, 2005).

Projects and programmes

The following differences between R&D projects and R&D programmes highlight some of the design criteria for programmes (after Roux *et al*. 2005):

- *Levels of participation*. Programmes should cater for multiple levels of participation, *e.g.* from a core group that provides direction, to peripheral or occasional participants. The less-active members are important for cross-boundary stimulation and transfer of messages and may gradually become more involved as they acquire related knowledge and develop confidence. Conventional project teams have little tolerance for such marginal involvement.
- *Outputs versus outcomes*. Projects are strongly output oriented, where certain tangible products need to be delivered by a certain date. Programmes have a stronger emphasis on intangible value creation, such as development of relationship and knowledge sharing. Programmes therefore tend to enable achievement of desirable outcomes more than is the case with most projects.
- *Effectiveness and efficiency*. Projects are commonly managed to achieve cost and time efficiencies. However, learning has to take place effectively to deliver its full value. Programmes provide the space to balance efficiency with effectiveness.

- *Flexibility to alter course*. Where projects have pre-determined objectives that can rarely be changed or expanded on, programmes allow ongoing adaptations to the overall course.
- *Catering for diversity*. Effective teams often self-organise around personal networks and in their early stages display relative cultural homogeneity. Over time, these teams tend to get demographically more diverse in composition. Programmes with their longer time frames cater better for this diversification of participants than projects.
- *Time frames and cost*. Given the above, it must be realised that programmes typically have to operate at longer time frames (ten years) than what we are accustomed to in a project-driven world. There are also costs associated with running effective programmes that are difficult to account for since many of the necessary outcomes, such as trusting relationships, are intangible.
- *Leadership style*. Successful "programme leadership" requires a different set of skills to "project management". These leaders are also referred to as developmental leaders, contagious leaders or generative leaders, and must have intrinsic legitimacy in the programme.

Responsibility

Who should be responsible for maintaining an R&D programme for the RHP is an open question. One can argue that DWAF, as a leading partner, and the Water Research Commission have clear mandates for supporting such a programme. Involving a few additional partners could benefit the objective of creating learning interdependency among key partners. Care should be taken to ensure appropriate support, communication channels, and distribution of risk and benefits.

5.6 CAPACITY BUILDING

True engagement

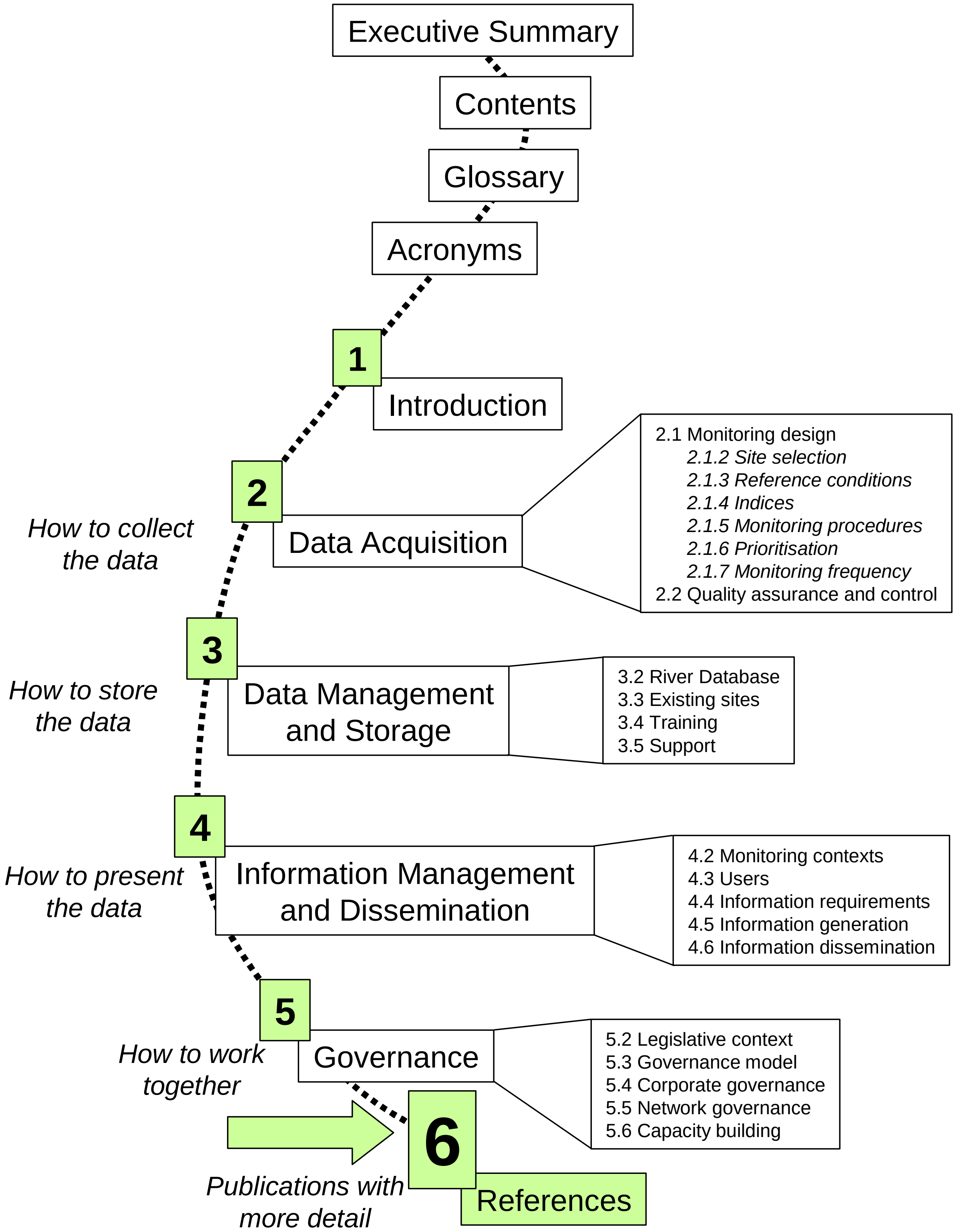
A key challenge of the RHP remains to build and sustain a critical capacity to implement and maintain the Programme at both national and provincial levels. Sustainability of the RHP requires that capacity building should go beyond the traditional top down approach of enhancing skills and knowledge through training alone. It should focus on enhancing true engagement of partner organisations in all facets of the Programme.

Different forms

Capacity building can occur in a variety of ways and contexts:

- Communities of practise;
- Field work;
- Workshops;
- Meetings and symposia;
- In-house training;
- Coaching and mentoring;
- Research and development (DWAF, 2004b);
- Education and awareness creation among stakeholders enabling stakeholder participation in decision-making processes that don't necessarily relate to the RHP (Strydom *et al.*, 2007).

Manual Roadmap



SECTION 6: REFERENCES

Some of the reports below are available from the River Health Programme website: http://www.csir.co.za/rhp/.

Archibald, C.G.M. and J.C. Taylor. 2007. The assessment of diffuse pollution from acid mine drainage using an updated and revised diatom assessment procedure as an added value bio-monitoring tool. *Water Science & Technology* **55**(3): 151–160.

Australian Guidelines for Water Quality Monitoring and Reporting. 2000. *National Water Quality Management Strategy. No 7a. Australian Guidelines for Water Quality Monitoring and Reporting.* 2000. Australian and New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand.

CEMAGREF. 1982. *Etude des méthodes biologiques quantitatives d'appréciation de la qualité des eaux*. Rapport Division Qualité des Eaux Lyon – Agence Financière de Bassin Rhône-Méditerranée- Corse. Pierre-Bénite.

Chutter, F.M. 1972. An empirical biotic index of the quality of water in South African streams and rivers. *Water Research* **6**: 19-30.

Chutter, F.M. 1998. *Research on the rapid biological assessment of water quality impacts in streams and rivers*. WRC Report No 422/1/98. Water Research Commission, Pretoria, South Africa.

Cyfernet. 2008. Internet: http://cyfernet.org/ncsu_fcs/beyonddata/present.htm. Accessed: 20 February 2008.

Dallas, H.F. 1997. A preliminary evaluation of aspects of SASS (South African Scoring System) for the rapid bioassessment of water quality in rivers, with particular reference to the incorporation of SASS in a national biomonitoring programme. *Southern African Journal of Aquatic Sciences* **23**(1): 79-94.

Dallas, H.F. 2000. *The derivation of ecological reference conditions for riverine macroinvertebrates*. National Aquatic Ecosystem Biomonitoring Programme Report Series No.12. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Dallas, H.F. 2002. *Spatial and temporal heterogeneity in lotic systems: implications for defining reference conditions for riverine macroinvertebrates*. Water Research Commission Report No.KV138/03, Water Research Commission, Pretoria, 218pp.

Dallas, H.F. 2004(a). Spatial variability in macroinvertebrate assemblages: comparing regional and multivariate approaches for classifying reference sites in South Africa. *African Journal of Aquatic Science* **29**(2): 161 – 171.

Dallas, H.F. 2004(b). Seasonal variability of macroinvertebrate assemblages in two regions of South Africa: implications for aquatic bioassessment. *African Journal of Aquatic Science* **29**(2): 173-184.

Dallas, H.F. 2005(a). *Inventory of National River Health Programme Monitoring Sites, Volume 1*. Prepared for Environmentek (CSIR) and Resource Quality Services River Health, Department of Water Affairs and Forestry. The Freshwater Consulting Group, Cape Town, South Africa.

Dallas, H.F. 2005(b). *Inventory of National River Health Programme Monitoring Sites, Volume 2*. Prepared for Environmentek (CSIR) and Resource Quality Services River Health, Department of Water Affairs and Forestry. The Freshwater Consulting Group, Cape Town, South Africa.

Dallas, H.F. 2005(c). *River Health Programme: Site characterisation field-manual and field-data sheets.* National Aquatic Ecosystem Biomonitoring Programme Report Series No 18. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Dallas, H.F. 2007(a). *River Health Programme: South African Scoring System (SASS) data interpretation guidelines (Draft report)*. Prepared for the Institute of Natural Resources and the Resource Quality Services River Health, Department of Water Affairs and Forestry. The Freshwater Consulting Group, Cape Town, South Africa.

Dallas H.F. 2007(b). The influence of biotope availability on macroinvertebrate assemblages in South African rivers: implications for aquatic bioassessment. *Freshwater Biology* **52**: 370-380.

Dallas, H.F and J.A. Day 2007. Natural variation in macroinvertebrate assemblages and the development of a biological banding system for interpreting bioassessment data – a preliminary evaluation using data from upland sites in the south-western Cape, South Africa. *Hydrobiologia* **575**(1): 231-244.

Dallas, H.F., A. Molteno, J. Ewart-Smith and P. Janssens. 2007. *Rivers Database Version 3: User Manual*. Report for the Department of Water Affairs and Forestry River Health Programme. Prepared by The Freshwater Consulting Group in association with Soft Craft Systems. 71pp.

de la Rey, P.A., J.C. Taylor, A. Laas, L. van Rensburg and A. Vosloo. 2004. Determining the possible application value of diatoms as indicators of general water quality in the Mooi River (North West Province): a comparison with SASS 5. *Water SA* 3: 325-332.

Denisov, N. and L. Christoffersen. 2001. *Impact of environmental information on decision-making processes and the environment*. UNEP/GRID-Arendal Occasional Paper 01. Arendal, Norway.

Department of Water Affairs and Forestry. 2004(a). *Strategic Framework for National Water Resource Quality Monitoring Programmes* DC Grobler and M Ntsaba. Report No. N/0000/REQ0204. ISBN 0-621-35069-9. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry. 2004(b). *National Water Resources Strategy*. First Edition, September 2004. Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry. 2007(a) *Rivers Database for the National Aquatic Ecosystems Health Monitoring Programme (RHP)*. Prepared by The Freshwater Consulting Group, Cape Town, Pretoria, South Africa.

Department of Water Affairs and Forestry. 2007(b). *Quality Assurance for the National Aquatic Ecosystems Health Monitoring Programme (RHP)*. Prepared by the Institute of Natural Resources for DWAF, Pretoria, South Africa.

Dickens, C.W.S and P.M. Graham 2002. The South African Scoring System (SASS) version 5 Rapid Bioassessment Method for Rivers. *African Journal of Aquatic Science* **27:** 1-10.

Elzinga, C. L., D. W. Salzer and J. W. Willoughby. 1998. *Measuring and Monitoring Plant Populations*. Bureau of Land Management Technical Reference 1730-1, BLM/RS/ST-98/005+1730.

Harding, W.R., C.G.M. Archibald and J.C. Taylor. 2005. The relevance of diatoms for water quality assessment in South Africa: A position paper. *Water SA* **31**(1): 41-46.

Hill, L, C. J. Kleynhans and J. Moolman. 2008. *Prioritising National River Health Programme Sites for Monitoring*. Internal Document. Resource Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Hughes, D.A. 2005. *Spatsim, an integrating framework for ecological reserve determination and implementation*. WRC Report No: TT 245/04, Water Research Commission, Pretoria, South Africa

Imperial, M.T. 2004. *Collaboration and Performance Management in Network Settings: Lessons from Three Watershed Governance Efforts*. IBM Center for The Business of Government, Washington, DC.

Kleynhans, C.J. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). *Journal of Aquatic Ecosystem Health* **5**: 41-54.

Kleynhans, C.J. 1999. The development of a fish index to assess the biological integrity of South African rivers. *Water SA* **25**: 265-278.

Kleynhans, C.J. 2007. *Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2)*. Water Research Commission Report No. TT 330/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

Kleynhans, C.J. and M.D. Louw. 2007(a). Module A: *EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2)*. Water Research Commission Report No. TT 329/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

Kleynhans C.J. and M.D. Louw. 2007(b). *River reach demarcation, delineation and site suitability*. Appendix A in: Department of Water Affairs and Forestry, South Africa. 2007. *Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the Inkomati Water Management Area, Mpumalanga. Sabie and Crocodile Systems: Resource Unit Delineation*: Prepared by Water for Africa, authored by Louw, MD. Report no. 26/8/3/10/12/006

Kleynhans, C.J, M.D. Louw and M. Graham. 2007(a). *Module G: EcoClassification and EcoStatus determination in River EcoClassification: Manual for Index of Habitat Integrity*. Water Research Commission Report No. TT XXX/08 (In Prep). Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

Kleynhans, C.J., M.D. Louw and J. Moolman. 2007(b). *Reference frequency of occurrence of fish species in South Africa*. Joint Water Research Commission and Department of Water Affairs and Forestry report. Water Research Commission Report No. TT 331/08, Pretoria, South Africa.

Kleynhans, C.J., J. Mackenzie and M.D. Louw. 2007(c). *Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2)*. Water Research Commission Report No. TT 332/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

Kleynhans, C.J., C. Thirion and J. Moolman. 2005. *A level I River Ecoregion classification system for South Africa, Lesotho and Swaziland*. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, C.J, C. Thirion, J. Moolman and L. Gaulana. 2007(d). *A level II River Ecoregion classification system for South Africa, Lesotho and Swaziland*. Report No. N/0000/00/REQxxxx. (In Prep). Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Mangold,S. 2001. *An Implementation Manual for the River Health Programme - a hitch hiker*s guide to putting the RHP into action*. NAEBP Report Series No 15. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Midgley, D.C., W.V. Pitman and B.J. Middleton. 1994. *Surface Water Resources of South Africa 1990, vols. I-VI*. Water Research Commission Reports No. 298/1.1/94 to 298/6.1/94, Pretoria, South Africa.

Murray, K.1999. *National Aquatic Ecosystem Biomonitoring Programme: National Implementation Assessment*. NAEBP Report Series No 8. Institute for Water Quality Studies, Department of Water Affairs and Forestry. Pretoria, South Africa.

Ollis D.J. 2005. *Rapid bioassessment of the ecological integrity of the Lourens, Palmiet and Hout Bay rivers (South Western Cape, South Africa) using aquatic macroinvertebrates*. MSc. Thesis, University of Stellenbosch, 192pp.

Republic of South Africa (RSA). 1971. *Water Research Act (Act 34 of 1971)*. Government of the Republic of South Africa, Pretoria.

Republic of South Africa (RSA). 1996. *Constitution of SA (Act No. 108 of 1996)*. Government of the Republic of South Africa, Pretoria.

Republic of South Africa (RSA). 1998. *National Environmental Management Act (Act No. 107 of 1998)*. Government of the Republic of South Africa, Pretoria.

Republic of South Africa (RSA). 1998. *National Water Act, 1998 (Act No 36 of 1998)*. Government of the Republic of South Africa, Pretoria.

Republic of South Africa (RSA). 1998. *National Environmental Management: Protected Areas Act (Act No 57 of 2003)*. Government of the Republic of South Africa, Pretoria.

Republic of South Africa (RSA). 1998. *National Environmental Management: Biodiversity Act (Act No. 10 of 2004)*. Government of the Republic of South Africa, Pretoria.

River Health Programme (RHP). 2005. *State-of-Rivers Report: Monitoring and Managing the Ecological State of Rivers in the Crocodile (West) Marico Water Management Area*. Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Rosenberg, D.M. and V.H. Resh. 1993. *Freshwater biomonitoring and benthic macroinvertebrates*. Chapman & Hall, New York, U.S.A.

Round, F.E., R.M. Crawford and D.G. Mann. 1990. *The Diatoms: Biology and Morphology of the Genera*. Cambridge University Press, Cambridge, United Kingdom.

Roux, D.J. 1997. *National Aquatic Ecosystem Biomonitoring Programme: Overview of the design process and guidelines for implementation*. NAEBP Report Series No 6. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Roux, D.J. 2004. *From Monitoring Design to Operational Program: Facilitating the Transition under Resource-Limited Conditions*. In: Wiersma, G. B. (Ed.). *Environmental Monitoring*. CRC Press, Boca Raton, pp 631-648 (ISBN: 1-56670-641-6).

Roux D J. 2005. *Governance of the South African River Health Programme*. Prepared for the Institute of Natural Resources and the Resource Quality Services River Health, Department of Water Affairs and Forestry. CSIR, Natural Resources and the Environment, Pretoria.

Roux, D.J., P.L. Kempster, C.J. Kleynhans, H.R. van Vliet and H.H. du Preez. 1999. Integrating stressor and response monitoring into a resource-based water-quality assessment framework. *Environmental Management* 23(1): 15-30.

Roux, D.J., H.M. MacKay and L. Hill. 2005. *Consolidation and Transfer of Knowledge and Experience Gained in the Development and Implementation of Water and Related Policy in South Africa*. WRC Report No 1295/1/04, Water Research Commission, Pretoria.

Rowntree, K.M. and R.A. Wadeson. 1999. *A hierarchical framework for categorising the geomorphology of selected South African rivers*. Water Research Commission Report No. 497/1/99. Water Research Commission, Pretoria, South Africa. 333pp.

Saywell, D.L. and Cotton A.P. 1999. *Spreading the word. Practical guidelines for research dissemination strategies. Interim Findings*. Water, Engineering and Development Centre. Loughborough University, United Kingdom.

Strydom, W.F. 2003. *Compiling State-of-Rivers Reports and Posters: A Manual*. River Health Programme Report Series No 17. Available online:

http://www.csir.co.za/rhp/reports/reportseries17.html

Strydom W.F., L. Hill and E. Eloff. 2007. *The Role of Communication in Governance: The River Health Programme as a Case Study*. In: AR Turton, J Hattingh, GA Maree, DJ Roux, M Claassen and WF Strydom (Eds), *Governance as a Trialogue: Government-Society-Science in Transition.* Berlin: Springer-Verlag. Pages 281-304. [ISBN: 3-540-46265-1]

Taylor J.C., W.R. Harding and C.G.M. Archibald.. 2007(a). *A methods manual for the collection, preparation and analysis of diatom samples*. Report to the Water Research Commission of South Africa. WRC TT281/07. (Includes DVD video).

Taylor, J.C., M.S. Janse van Vuuren and A.J.H. Pieterse. 2007(b). The application and testing of diatom-based indices in the Vaal and Wilge rivers, South Africa. *Water SA* **33**(1): 51-60.

Taylor, J.C., J. Prygiel, A. Vosloo, P.A. de la Rey and L. van Rensburg. 2007(c). Can diatom based pollution indices be used for bio-monitoring in South Africa? A case study of the Crocodile West and Marico water management area. *Hydrobiologia* **592**: 455-464.

Taylor, J.C., W.R. Harding, C.G.M Archibald and L. Van Rensburg. 2005. Diatoms as Indicators of Water Quality in the Jukskei-Crocodile River System in 1956 And 1957, A Re-Analysis of Diatom Count Data Generated by Dr. B. J. Cholnoky *Water SA* **31**(2): 237-246.

Thirion, C. 2007. Module E: *Macroinvertebrate Response Assessment Index. In River EcoClassification: Manual for EcoStatus Determination (version 2)*. Water Research Commission Report No. TT 333/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

Thompson, M. 1996. A standard land-cover classification scheme for remote-sensing applications in South Africa. *South African Journal of Science* **92**: 34-42.

Wenger, E. 1998. *Communities of Practice: Learning, Meaning and Identity*. Cambridge University Press, New York.

Wikipedia. 2008. Internet: http://en.wikipedia.org/wiki/Memorandum_of_understanding. Accessed on: 3 March 2008.