DEVELOPMENT OF PROCEDURES FOR THE IMPLEMENTATION OF THE NATIONAL RIVER HEALTH PROGRAMME IN THE PROVINCE OF MPUMALANGA

DJ Roux

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DEVELOPMENT OF PROCEDURES FOR THE IMPLEMENTATION OF THE NATIONAL RIVER HEALTH PROGRAMME IN THE PROVINCE OF MPUMALANGA

edited by

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EXECUTIVE SUMMARY

BACKGROUND AND MOTIVATION

The design of the national River Health Programme (RHP) was initiated in 1994 by the Department of Water Affairs and Forestry (DWAF). The overall goal of the RHP is to collect and make available ecological information on river ecosystems in order to support the rational management of these resources. During the design phases of the programme, a model of shared ownership has been advocated to ensure that a critical level of institutional participation is achieved. Subsequently, the Department of Environmental Affairs and Tourism(DEAT) and the Water Research Commission (WRC) became, together with the DWAF, joint national custodians of the programme. At a provincial and local level, Provincial Champions and Provincial Implementation Teams (PITs) became responsible for operational and implementation initiatives.

Although several scientific components have been developed during the design of the RHP, most of these required further testing and verification. It was hoped that regional implementation initiatives would facilitate the required testing and refinement. However, it became apparent that a pilot-scale implementation project was needed to demonstrate to PITs how to go about implementation in their regions. Such a pilot project would:

- allow testing and refinement of programme components;
- allow integration of programme components;
- facilitate the identification of additional developments that may be required;
- demonstrate the worth of the programme; and
- provide broad guidelines to facilitate the eventual implementation and maintenance of the programme.

A project was proposed to the Water Research Commission for conducting pilot implementation of the RHP. The project would aim at developing procedures which will eventually help to, at a national level, bridge the gap between the conceptual design of the RHP and the operational maintenance thereof. This project would essentially be used to facilitate the translation of new knowledge and insights related to the RHP into new ways of doing.

The Province of Mpumalanga has been proposed as an appropriate test ground, primarily because of competencies and capacity that existed within the provincial institutional infrastructure, and a pro-active approach adopted by key institutions within the province towards implementation of the RHP.

The main participating organisations (DWAF, DEAT, the Mpumalanga Parks Board, Kruger National Park and CSIR) were to each contribute to the project in terms of providing manpower, funding, equipment and/or training opportunities. While external expertise may be required during the duration of the project, the aim should be to establish regional expertise and capacity which can ensure regional autonomy in maintaining the programme. It would, therefore, be important that the programme get the buy-in of both the officialdom and the people of the region where it is to be implemented.

TERMS OF REFERENCE

The overall aim of the project was to develop and implement procedures which would ensure sustainable maintenance of a long-term biomonitoring programme within the Mpumalanga geographic area, in such a way that the information generated by the programme satisfy the requirements of the national, provincial and regional institutions involved.

Specific objectives of the project were:

- *To tailor and establish the monitoring network, addressing aspects such as selection of monitoring sites, frequency of sampling and selection of monitoring indicators.*

- *To develop and establish protocols for the storage, transfer and management of data.*

- *To develop the formats, techniques and procedures for the assessment of data and the dissemination of the resulting information.*

- *To establish the necessary know-how, infrastructure, capacity and coordinating functions to ensure maintenance of the programme after completion of the project.*

SUMMARY OF ACHIEVEMENTS

At a national level, five alternative Biomonitoring Protocols (BPs) were proposed for the provincial implementation of the RHP. These protocols ranged in complexity and resource requirements, from the use of a single biological index to the use of several biological and non-biological indices at a site. Biomonitoring Protocol 3 (BP3) was used as a benchmark for the implementation of the RHP in the Province of Mpumalanga. This meant that a certain minimum suite of tools and methods were required. Some of these were fully developed and tested at the inception of the study, while others still required development. Several new developments were facilitated within this study. The following table indicates the developmental status of the related methods and tools, at commencement and conclusion of the project respectively:

BP3 products and processes	Developmental status	
	At project commencement	At project conclusion
IHI	developed and tested; application well established; adopted without a requirement for further development	
SASS	fourth developmental prototype used widely as biological index of water quality in rivers; development of this index preceded the initiation of the RHP, and did not necessarily adhere to the scope and specifications of the RHP; further research on aspects such as the spatial variation of SASS scores; determination of area-specific reference conditions and the relationship between SASS and habitat condition is required to improve SASS assessments in the RHP context	further research was viewed as a national responsibility; initiatives to coordinate such research was initiated and contributed to; to date no project has been initiated
HQI	developed by Peter McMillan; widely used locally; the need for further development and improvement recognised.	separate research project resulted in alternative system called Integrated Habitat Assessment System (IHAS) (McMillan, 1999); IHAS used parallel with HQI during latter part of project
FAII	formerly known as Fish Community Integrity Index (FCII); early stages of development	refined through application and testing; can be applied with confidence on the rivers of Mpumalanga; needs adjustment for rest of the country
RVI	no suitable index available; development was taken on as part of pilot project	through development by application a prototype RVI has emerged; in present form can be applied on rivers of Mpumalanga; requires further development and testing

Table Continued

BP3 products and processes	Developmental status	
	At project commencement	At project conclusion
Site Selection	a spatial framework (bioregional) for site selection available (Brown *et al.*, 1996); untested protocol for selection of monitoring and reference sites available (Eekhout *et al.*, 1996); practical application and testing required	alternative spatial framework (ecoregional) adopted following national developments in water resources management; site selection within ecoregional context done in a pragmatic fashion (considering accessibility, suitability, availability of historical data, etc.)
Reference Condition Derivation	development of the SASS technique did not specifically address assessment in the context of regional reference conditions; research project required to develop protocol for invertebrates	IHI, FAII and RVI have assessment against reference condition as build-in function; DWAF funded research project initiated for SASS - to determine ecoregional reference conditions for aquatic invertebrates (Dallas, 1999)
Data Management	creation of management system for biological and habitat data/information required; structures for data storage under development by IWQS/DWAF; procedures and mechanisms for transfer and retrieval of data under development by IWQS/DWAF	IWQS/DWAF product still in developmental phase; accept DWAF funded development of Rivers Database to provide regional data management platform; interfacing ability between Rivers Database and IWQS/DWAF system important; Rivers Database available for provincial application - will be refined while applied
Information Dissemination	formats for presenting biological and habitat information under development - especially by IWQS; information packaging for different target groups needs to be demonstrated	a popular brochure (State of the Crocodile River, 1998), poster (Roux *et al.*, 1997) and technical paper on river health in the context of the Water Act (Roux *et al.*, 1999) were produced; two exploratory web pages were developed (DWAF & CSIR) - these still require optimisation
Procedures for Quality Assurance and Control	developmental project required	framework developed as part of Mpumalanga project; requires application, testing and refinement

More detailed progress are presented under the summaries of each of the chapters.

CONTENTS OF THIS REPORT

This is the first of a series of reports forthcoming from the project, and focuses primarily on processes, guidelines and understanding which are required for sustainable implementation of the RHP. This report presents a number of new concepts and tools that were developed as part of the study:

- preliminary procedures for quality control and quality assurance;
- social tools for addressing the socio-cultural and knowledge gap between RHP proponents and communities living in catchments;
- a procedure for the adaptive assessment and management of river ecosystems;
- an understanding of the legal and institutional issues relevant to RHP implementation;
- a model to guide national implementation of the programme.

The development of the Riparian Vegetation Index (RVI) and the Fish Assemblage Integrity Index (FAII) was also supported by this project, but are reported on separately. Similarly, an inventory format for sampling sites is the topic of a separate report. A last report deals with the assessment of the state of the three river systems as based on the South African Scoring System (SASS) invertebrate index.

Following is the complete series of reports that resulted from this study:

Report 1: Development of Procedures for the Provincial Implementation of the National River Health Programme

Report 2: Inventory of RHP Monitoring Sites on the Crocodile, Sabie and Olifants Rivers

Report 3: Development of a Riparian Vegetation Index

Report 4: Assessment of the Biological Integrity of the Crocodile, Sabie and Olifants Rivers Based on Attributes of Fish Assemblages

Report 5: Assessment of the State of the Crocodile, Sabie and Olifants Rivers Based on the SASS Invertebrate Index

Chapter 2 - Capabilities and Limitations

In addition to serving the primary objectives of the programme, information generated by the RHP may also assist resource managers to respond to a number of water resource/catchment management responsibilities. However, there would also be certain information needs for which the RHP would not be able to provide answers. To prevent unrealistic expectations and wrongful application of RHP information, it is necessary to be explicit about the capabilities and limitations of the monitoring and assessment techniques associated with the programme. In this chapter, the potential application of information generated by the RHP is assessed in relation to some actual environmental management responsibilities, activities or agendas.

The information generated by the RHP are assessed in the context of:

- *Environmental impact assessment*: The objectives of a specific monitoring programme direct its technical specifications, such as site selection, sampling frequency, geographic area to be covered and level of biological organisation appropriate to scrutinise; hence making the resulting data fairly specific in terms of its impact assessment potential. The RHP is geared to assess the general ecological state and associated long-term changes over river reaches. This assessment is cumulative as it integrates the effect of all stressors, and the programme is not intended to link specific stressors to specific effects. Qualitative and coarse links may, however, be made between biological responses and types of disturbances such as habitat degradation, flow alteration or water quality deterioration.

- *State of environment reporting*: The RHP would allow reporting on the ecological state of all rivers that are included in the programme. Reporting could range in scale from "state-of-the-nation's rivers" to the state of a specific river or river reach.

- *Addressing issues of sustainability*: Three broad components are considered here, namely ecological integrity and sustainable development, sustainability indicators and performance indicators. The RHP uses the concept of ecological integrity as its theoretical foundation. With the application of professional judgement, results generated by the programme can be translated into sustainable and unsustainable groupings. Indicators developed within the RHP generally meet the criteria for good sustainability indicators. Results from the RHP can also be used as performance indicators, where actual measures of ecological integrity relates to the targets or objectives established by resource managers and policy makers. This would help people to evaluate progress (or the lack of it) towards sustainable goals.

- *Setting of Resource Quality Objectives (RQOs)*: In order to give practical meaning to the concept of an ecological reserve for water resources, response monitoring and assessment must form an integral part of a future water resource management approach. The availability of quantitative and qualitative information on ecological reference conditions as well as the current ecological state of a river, as collected by the RHP, will contribute towards setting realistic and ecologically sound RQOs.

- *Responding to monitoring results*: The output of the RHP can and should be used, at national, provincial and local levels of responsibility regarding the management of aquatic ecosystems. The programme is not designed to give early warning of potential impact, but it is most suited for pointing out areas which have degraded most and need priority management intervention. Also, through linking with policy goals and measurable RQOs, the ongoing data collection of the RHP will provide an opportunity to build a long-term data base which would facilitate adaptive management of water resources.

It is concluded that the design of the RHP is tailored in response to specific information needs, namely *to quantify the ecological state and track the overall response of riverine ecosystems* in relation to all the anthropogenic disturbances affecting them. Application of information resulting from the RHP should be guided by the objectives and technical specifications underpinning the monitoring design.

Chapter 3 - Quality Control and Assurance

This chapter provides a practical and affordable preliminary framework for Quality Control and Quality Assurance (QC/QA) within the South African River Health Programme (RHP). The framework aims to ensure that the natural variability within and between rivers, biomonitoring methods, the personnel involved, as well as the needs of the end users, are taken into consideration when biomonitoring results are interpreted and presented. The framework is in accordance with the requirements of the National Water Act (Act No 36 of 1998, Chapter 14, Section 137(2) and Section 143).

The suggested framework is based on seven guiding principles as follows:

- All aspects of the RHP, from programme design, field and laboratory activities, data storage and analysis through to data presentation, should be subject to QC/QA procedures.

- The effort taken to implement QC/QA procedures should be appropriate to the resolution of the data. This means that QC/QA procedures should aim to ensure that the results are within limits of reliability that are considered acceptable by the proposed Quality Assurance Portfolio.
- Different aspects of QC/QA procedures may have to be developed for activities at the national and regional scales. Auditing at the national scale should involve monitoring the overall activities of the RHP, with the emphasis on programme design, planning, training and data base management. Auditing at the regional scale should involve monitoring individual performance, with emphasis on detecting problems at an early stage, introducing remedial action before the programme is detrimentally affected, and editing of reports and other outputs to ensure that they are appropriate for their intended uses.
- QC/QA should be an ongoing process, requiring continual evaluation. A large component of QC/QA should therefore focus on continual monitoring of data quality, with constructive and timeous remedial action where and when necessary.
- QC/QA should be approached in a spirit of constructive engagement and cooperation, rather than a top-down, policing approach.
- Biomonitoring data collected during, or shortly after, high-flow conditions can be unreliable. It is therefore suggested that sampling should be restricted, when possible, to low-flow periods.
- Approximately 10% of the field data should be audited by Regional Auditors.

The proposed management hierarchy for QC/QA operates at two levels: national and regional. At the national level, the hierarchy consists of a proposed Quality Assurance Portfolio within the existing National Coordinating Committee (NCC), and a Quality Assurance Portfolio Manager. The function of the Quality Assurance Portfolio should be to critically review the overall activities and services of the RHP on an annual basis, and endorse the detailed protocols for each biomonitoring index. The Quality Assurance Portfolio Manager is the person who should be responsible for coordinating all QC/QA activities of the RHP at a national level. It is suggested that 5-10% of the RHP annual budget should be allocated to QC/QA.

At the regional level, the suggested management hierarchy consists of Regional Auditors and individuals who collect, analyse, interpret and report data, referred to in this report as "Biomonitors". The functions of Regional Auditors are to monitor and critically review the biomonitoring activities of Biomonitors so as to detect problems at an early stage, recommend remedial action before the programme is detrimentally affected, and edit reports and other outputs. Regional Auditors should be experts in their field, and so different auditors will be required for invertebrates, fish, riparian vegetation etc.

Biomonitors are the people who collect, analyse, interpret and report biomonitoring data. Since the collection of biomonitoring data requires fewer skills than analysis, interpretation and reporting, it is suggested that a distinction should be made between junior and senior Biomonitors. Both junior and senior Biomonitors should attend and successfully complete a certified course in biomonitoring. Separate courses should be held for each biomonitoring Index. Senior Biomonitors should, in addition, be qualified with a university level degree in an appropriate field.

It is recommended that an initial biomonitoring training/certification course should be run for Regional Auditors. The training course should aim to standardise protocols for each biomonitoring index. The protocols will need to define sampling procedures, data storage techniques, data analysis methods, appropriate presentations and safety procedures for each index. The protocols will need to be reviewed and approved by the proposed Quality Assurance Portfolio.

Chapter 4 - Social Tools

The Department of Water Affairs and Forestry (DWAF) - through resource-directed measures - is clear in its intention to protect national water resources on an ecosystem basis. The establishment of habitat and biotic integrity objectives is an essential aspect of the protection and maintenance of healthy aquatic ecosystems. The River Health Programme (RHP) was designed to enable monitoring related to such ecological integrity objectives.

Government is not ignorant of the social factors that contribute to the depletion of the resource, hence the establishment of the Reserve for basic human needs, and the commitment to providing 25 litres of water per person per day, within 20 metres of the household. However, the complexity of the situation cannot be addressed simply by implementing these measures. The situation can be effectively addressed if government simultaneously and holistically addresses past social and environmental imbalances.

There are important measures that need to be dealt with before stakeholders - especially those who have not been part of the development planning - can participate effectively. However, on the flip side of the same coin, those who have already been part of the development process and still continue to be part of it, need to be realistic regarding prevailing circumstances. Water ecologists and resource managers need to develop social and cultural awareness of local people's circumstances on the ground. They need to be sensitive and empathetic in dealing with local people so that a mutually beneficial relationship can be developed. Social skills are what these experts need to develop as tools to afford them a harmonious relationship with the community - and this will enhance the protection of the water resource.

Case studies, focussing on three communities, were undertaken to develop a better understanding of the situations within communities. It became clear that the main concern in all three communities is livelihood security. These people need water, irrespective of its quality. According to the communities, it is only those who have an abundance of resources who concern themselves with the condition of living organisms in the water.

Two key considerations that determine the involvement of local people in conservation programmes such as the RHP are:

- the socio-cultural gap that exist between local communities and proponents of the programme; and
- the extreme knowledge differential inherent between less sophisticated communities and resource managers.

The perceptions and worlds of water resource managers/scientists and that of people living in these rural communities can only be reconcile through interaction. Based on the case studies, a number of guidelines are provided for approaching and working with communities. These guidelines are for the identification of a target community, making contact and consulting with the selected community and how to follow local rules and customs.

Chapter 5 - Adaptive Assessment and Management

This chapter proposes a procedure which enables managers to respond to the results of the RHP. The procedure is demonstrated by applying existing data, obtained through pilot application of the RHP on the Crocodile and Elands Rivers. The procedure is based on the theory of adaptive environmental assessment and management (AEAM), whereby the need for flexibility, ongoing learning and associated adaptation is emphasised.

The AEAM procedure which was developed for application in the RHP context consists of three broad components:

- monitoring (data collection by means of the RHP),
- assessment (information generation),
- management (making and execution of decisions).

The monitoring results obtained from using three biological indices (fish, macroinvertebrates and riparian vegetation) were used to test the procedure. The assessment component deals with interpreting the data which were collected during monitoring. In order to assess the collected data relative to a reference state, homogeneous river segments were identified. Each of the segments was classified in terms of its relative ecological integrity, based on the three biological indices used.

The river segments are also suggested as ecological management units. Therefore, a management goal and quality objectives must be determined for each of the identified river segments. This was done by means of an ecological importance and sensitivity estimation for each segment. The assessments of current integrity could then be compared with the management goals and quality objectives for different segments. This indicated areas where quality objectives are met or where management action is required to ameliorate undesirable conditions. Finally, river segments were ranked in terms of priority for receiving management attention, and an example is given of formulating appropriate management actions for addressing a high priority need.

The proposed AEAM model is an attempt to formalise the dependancies between monitoring, assessment and management of aquatic ecosystems. It provides a systematic procedure which links the collection and assessment of biological data, the setting of goals and quantifiable objectives for managing the integrity of rivers, and the prioritisation of management actions. The balance between the protection and utilisation of aquatic ecosystems can be negotiated and hopefully optimised by following this iterative cycle, while also focussing on continuous imposement of the component protocols.

Chapter 6 - Legal and Institutional Arrangements

The role of a monitoring programme in the current water management system would be optimally expedient if it receives statutory recognition, and if the statutory decision-makers could be bound by its products. By establishing the River Health Programme as a statutory national monitoring system in terms of the National Water Act of 1998, the necessary legitimacy is attached to the programme. However, it will then still be necessary to develop statutory procedures and mechanisms to integrate the monitoring programme into the decision-making process, and to bind the decision-makers to the accommodation of monitoring data during the decision-making process which is aimed at the achievement of resource quality objectives.

However, because of the cumbersome procedure to amend the conditions of existing entitlements, even maximum delegated decision-making powers and statutory status of the monitoring programme will still not optimize the achievement of resource quality objectives. The ultimate responsibility for fulfilling the purpose of the Act, which is to manage water resources in an integrated way for the benefit of all and for sustainability, vests in the Minister's overriding powers to issue regulations to which all water use will be subject. This power cannot be delegated, and no delegate or assignee in terms of the Act may, to protect resource quality, impair on permissible water use, except by temporary measures, expropriation or the revision of licence conditions.

Although the new water law has therefore taken a huge step towards environmentally sustainable water management, it is not as yet institutionally geared to integrate its management systems with other systems (developed from other than water management-oriented sources) towards integrated environmental management. The ideal positioning of the River Health Programme would therefore be as an official national monitoring system of which the results, in terms of official procedures, should bind the Minister to take the necessary steps by way of the publication of regulations, to enforce the use of water in such a way as to achieve the resource quality objectives.

Because water is a natural resource of which the management should strictly fall under the scope of environmental management, there is a need for the establishment of structures and mechanisms which would effectively draw water management under the wings of environmental management, towards integrated resources control for sustainability. The objectives and fundamentals of the new environmental management legislation, contained in the National Environmental Management Act of 1998, are comprehensive and futuristic, and it is expected that the eventual implementation thereof will facilitate integrated resources management towards sustainable environmental development. But although the mechanisms envisaged in this Act provide the desired framework for integrated resources management, especially by binding all resources management institutions to the procedures and criteria to be developed under the Act, there remains a need to give flesh to these bones. Environmental monitoring and other programmes should be engaged as far as possible to fulfill this task. The establishment of the River Health Programme as an environmental management tool to dictate the implementation of procedures for environmental decision-making, which, according to the Act, will bind all activities and functions which may affect the environment, could well be the basis for structured water management in line with environmental principles.

Once the RHP is an official river health monitoring programme used in the implementation of the National Environmental Management Act, the water management institutions under the

National Water Act will be statutorily bound to the data and monitoring results. This will, in turn, facilitate the admission thereof in the structures of statutory water management. It could even become the very programme to dictate Ministerial regulations in terms of the National Water Act to control the exercise of water use entitlements, which is the strongest mechanism in the Act towards sustainable utilization and development.

Chapter 7 - Strategies for Implementation

This chapter documents the process and strategies that are being followed to grow the RHP from a mere idea to a national initiative. The development and implementation models that are being followed, and the lessons that emerge from these, are discussed. Emphasis is on obtaining an understanding of some of the critical issues that affected the transition from the creation to the application of the RHP.

Several concepts from the field of technology management are used to develop a model for successful national development and provincial implementation of the RHP. These include:

- the relationship between the creation and application of technology,
- technology maturation and competitive impact,
- profiles in the adoption of new technologies,
- product versus process innovations.

Four key components of the RHP are analysed, namely (a) the guiding team, (b) concepts, tools and methods, (c) infra-structural innovations and (d) communication. These key components evolved over the broad life stages of the programme, which are called the design, growth and anchoring stages.

During the design phase the guiding team consisted of a few individuals who shared a vision. This vision was triggered by a worldwide trend towards the use of biological indicators in the monitoring and management of water resources. Recognition was given to the fact that both the information requirements and the technical and practical feasibility surrounding the vision will change with time, and that the final product itself should not be static.

The initial guiding team ascertained themselves with the concepts related to the design of monitoring programmes, biological monitoring and indicators, and ecological integrity and ecosystem health. Through discussions with potential end-users of a national river monitoring programme, the definition of and specification for the programme started to take shape.

An audit of required and available resources and skills made it evident that a programme of this nature could only be successful if competencies and resources could be harnessed across organisational boundaries. This motivated tactical communications with selected end-users and stakeholders of the programme.

During the growth phase of the programme, a number of technical experts and provincial implementation agents became part of the guiding team. A National Coordinating Committee (NCC) was formed to act as central body for strategic planning, knowledge sharing and providing guidance regarding technical developments. Through representation on the NCC, several provincial implementation agents started to experiment with the tools that were developed for the RHP. This allowed small-scale demonstration of the worth of the programme, which led to further buy-in and an increase in the programme's circle of influence.

The NCC facilitated coordination of activities, and a dominant design started to emerge for the RHP. It became important to build the capacity and support base to implement this dominant design on a national basis. Communication strategies for this included the publication of a newsletter and several promotional pamphlets and brochures.

The anchoring phase is characterised by provincial implementation initiatives which are coordinated and driven by Provincial Implementation Teams (PITs). This must eventually lead to provincial and local independence regarding the maintenance of the RHP, while ongoing development will still be coordinated at a national level.

The anchoring stage requires an approach of learning and development by application. It is suggested that implementation agents focus on, and master, one step at a time. The anchoring phase will be completed when the RHP becomes part of "the way we do things here". However, issues such as the financial considerations, political endorsement, and capacity requirements needs to be addressed before the RHP can achieve this level of technological maturity.

Chapter 8 - Business Plan

The Province of Mpumalanga is the leading province in South Africa regarding the implementation of the RHP. In order for Mpumalanga to remain a leading role player in developments regarding the RHP, the provincial programme needs to successfully mature from an externally funded pilot project to an internalised operation. A business plan was compiled with the aim of ensuring this transition. The business plan focuses on four critical issues, namely a common purpose and direction, selection and application of technical protocols and methods, institutional connectivity through collaboration and networking, and capacity requirements.

A vision was formulated for the RHP implementers in Mpumalanga, namely ***to maintain a model for the regional implementation of the RHP that serves as a national example***. This vision implies adherence to the national objectives of the RHP. However, at the provincial level it can also be decomposed into the following operational objectives:

- *To understand and satisfy the dynamic information needs of stakeholders*: The success of the RHP will ultimately be determined by the degree to which it satisfies the information needs of its multiple stakeholders. This can only be achieved by developing a deep understanding of the programme's stakeholder segmentation and the evolving information needs within each segment.
- *To achieve ongoing development and improvement of programme components*: The technical composition of the RHP will have to continuously evolve and improve to effectively respond to improved understanding and changing needs. The Mpumalanga implementors must contribute to these improvements, and strive to lead the way in certain developmental areas.
- *To refine and optimise monitoring, assessment and reporting operations*: This project has provided a platform for the effective monitoring, assessment and reporting of river health. However, it should be an ongoing aim to improve overall operational efficiency.
- *To positively impact on the management of water resources*: Results from the RHP must directly contribute to decision making regarding water resources and the programme must be perceived as an essential tool in support of implementing the national Water Act.
- *To demonstrate leadership*: New insights and knowledge gained within the province must be actively transferred to the rest of the country.

In terms of technical considerations, Biomonitoring Protocol 3 will remain the primary focus of the RHP initiative in Mpumalanga. However, developments regarding implementation tools and guidelines will be tracked and new tools will be incorporated where necessary. The experience that was gained during surveys on the Crocodile, Sabie and Olifants Rivers will be used as the basis to continue implementation according to an "adaptive RHP implementation cycle". This cycle includes a number of activities, namely data collection, data capturing, health assessment, information dissemination and reflection. Each of these activities must be completed before the next cycle can be entered into. It is proposed that the duration of each cycle be limited to 18 months and that the information dissemination component should preferably be completed 12 months after data have been collected.

The river systems dealt with in this pilot project are shared by three provinces and two proposed water management areas, and a number of institutions have an interest in biomonitoring activities in this region. To achieve shared custodianship and responsibility for implementing the RHP in Mpumalanga, it is suggested that the relevant institutions collaborate in the context of a community of practice (COP). Within the COP, institutions can either take part as members of a core guiding team, or as strategic or tactical partners.

The pilot project has facilitated significant capacity building of human resources within Mpumalanga. However, human resource development is an ongoing activity and each participating organisation should also assess its own position and respond to expertise gaps within its own staff profile. To assist with this process, a three-stage assessment matrix is proposed. In terms of financial resources, a cost-per-sampling-site approach is proposed to allow the notion of adoption of a sampling site. This provides a basis for finding financial owners for the maintenance of the RHP for certain sites. As an example, national government may have an interest in maintaining monitoring at reference sites and a private sector company may have a responsibility to implement monitoring at certain impacted sites.

Chapter 9 - Conclusion and Recommendations

During the design phases of the RHP it became evident that good intentions and sound methods and tools are not sufficient to ensure widespread adoption and successful implementation of a new monitoring programme. The feasibility and worth of the programme first need to be demonstrated. In this regard the Mpumalanga pilot study played a significant role to facilitate the maturation of the RHP from a vision to a national initiative. The knowledge and products that were generated through the practical application of the RHP in Mpumalanga provide a basis for other provinces or water management institutions to become part of a national network of standardised river health monitoring.

The Mpumalanga pilot project has facilitated significant capacity building of human resources, primarily within the province but also nationally. Through the various field surveys, technologies and skills were actively transferred from various specialists to members of the participating organisations from Mpumalanga and neighbouring provinces. Many people from other parts of the country, both from private and public sector organisations, also visited during these surveys and benefited from the exchange of knowledge. Apart from the practical field work, the participating Mpumalanga institutions were exposed and acquired competence in the development of the Rivers Database, assessment of the data collected by the RHP and developing various formats for the presentation of river health information. At the conclusion of this project, the implementation agents for the RHP in Mpumalanga are essentially self sufficient regarding the technical expertise required to maintain the programme.

The following high-level recommendations can be drawn from this report:

- Two areas of future research regarding indices for the RHP were identified, namely:
  - *further development related to the SASS invertebrate index*
  - *development of a water quality index*

- The procedures that were developed for quality control and quality assurance requires practical testing and refinement. This will form the main drive towards standardisation of sampling procedures, data storage techniques, data analysis methods, information presentation formats and appropriate safety procedures for each index. A national initiative is needed to ensure definition and reporting of these protocols and techniques, and the nation-wide adoption and implementation thereof.

- The grassroots communication component of this study provided new perspectives on the social challenges that await implementers of environmental programmes. This work was exploratory in nature, and there is a strong need to build on these preliminary findings. A follow-up project is recommended that specifically evaluates and develops mechanisms and methods for addressing the socio-cultural gap and knowledge differential between grassroots communities and water resource scientists and managers.

- The adaptive environmental assessment and management (AEAM) model that was developed for the RHP should be further tested and refined. Refinement should also consider compatibility with the concept of an ecological reserve. A final product could be a user-friendly decision support system that links the results of river health monitoring with river management options.

- Water, environmental and land laws have all been subject to substantial revisions in recent years. An important issue that was touched upon in the chapter on legal and institutional issues is the ideal of streamlining and integrating natural resources laws. It is envisaged that the new environmental law will champion a process towards integrated resources management, and that legislation will eventually be streamlined accordingly. The legal investigation undertaken as part of this study focussed on river ecosystems as one component of natural resources. The insights that were gained can contribute meaningfully to the process of legal-institutional development towards a system of integrated resources management. To achieve this, the current study needs to be continued as the legal and institutional environment in South Africa is still fast evolving.

- The RHP can not yet be regarded as anchored in the cultures of all the relevant water management institutions in the country. To achieve this, an "anchoring phase" needs to be initiated and championed at a national level. Such a phase should focus on the processes that determine the effectiveness of implementation.

- The business plan presented in this report will only result in the desired outcome if all the relevant institutions will accept joint responsibility, at both the technical and management levels, for implementing the RHP. The formation and formalisation of a Mpumalanga community-of-practice is still in an experimental stage. It is recommended that this process be facilitated from a national level to ensure that this model evolves into a practical arrangement for shared custodianship of the RHP with relatively generic application in South Africa.

ABBREVIATIONS

CEC	Committee for Environmental Coordination
CMA	Catchment Management Agency
CRDC	Community Reconstruction and Development Committee
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EIP	Environmental Implementation Plan
EMCA	Environmental Management Cooperation Agreement
EMP	Environmental Management Plan
FAII	Fish Assemblage Integrity Index
GCEE	Grassroots Communication and Environmental Education
HQI	Habitat Quality Index
IEM	Integrated Environmental Management
IHI	Index of Habitat Integrity
ISO	International Standards Organisation
IWQS	Institute for Water Quality Studies
KNP	Kruger National Park
MPB	Mpumalanga Parks Board
NCC	National Coordinating Committee (of the RHP)
NEAF	National Environmental Advisory Forum
NEMA	National Environmental Management Act
NGO	Non-governmental Organisation
NMS	National Monitoring System
NWRS	National Water Resource Strategy
PIT	Provincial Implementation Team (of the RHP)
QAP	Quality Assurance Portfolio
QC/QA	Quality Control and Quality Assurance
RHP	River Health Programme
RQO	Resource Quality Objectives
RVI	Riparian Vegetation Index
SASS4	South African Scoring System, Version 4
SoE	State of Environment
WCS	Water Classification System
WMA	Water Management Area
WMI	Water Management Institution
WRC	Water Research Commission
WUA	Water User Association

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CHAPTER 1 - THE MPUMALANGA PILOT PROJECT

DJ Roux

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1.1 BACKGROUND

1.1.1 The Use of Biomonitoring

Effective environmental decision-making, and thus natural resource management, is entirely dependant on the information provided by appropriate and proper resource monitoring. As such, the development and application of monitoring techniques play a critical role in the ongoing process of balancing economic development, human welfare and ecological protection. A recent trend worldwide is the introduction of in-stream biological response monitoring to water resource management. This type of monitoring, commonly referred to as biomonitoring, is increasingly being recognised as an important component of the overall monitoring and assessment of water resources.

Resident aquatic communities integrate and reflect the effects of chemical and physical disturbances occurring over extended periods of time. Assessments of biological communities such as fish and macro-invertebrates can therefore be used to provide an integrated measurement of the overall integrity of aquatic ecosystems.

Aquatic biomonitoring programmes are developed for various purposes, including:

- surveillance of the general ecological state/integrity of aquatic ecosystems;
- assessment of impacts (before and after an impact or upstream and downstream of an impact, both for diffuse and point-source impacts);
- audit of compliance with in-stream ecological objectives or regulatory standards; and
- detection of long-term trends in the aquatic environment as a result of any number of impacts.

When designing a biomonitoring programme, attention should be given to aquatic community components that are representative of the larger ecosystem and are practical to measure. In determining the taxonomic group(s) appropriate for a particular biomonitoring situation, the advantages of each group must be considered along with the objectives of the programme. The taxonomic groups may also vary depending on the type of aquatic ecosystem being assessed. For example, benthic macro-invertebrates and fish are often used as taxonomic groups to assess flowing waters, while plants are used in wetlands and algae and zooplankton in lakes and estuaries.

In order to index biological integrity, appropriate attributes of a selected aquatic community need to be tested and linked to measuring units or metrics. The information provided by a number of community attributes can be integrated into one biological index. The output format of such a biological index is usually numeric.

1.1.2 Design of the River Health Programme

During 1994, the Department of Water Affairs and Forestry (DWAF) initiated the design of a biomonitoring programme for assessing the ecological integrity of rivers in South Africa. This programme is referred to as the River Health Programme (RHP), and has the overall goal of expanding the ecological information on aquatic resources in order to support the rational management of these systems (Roux, 1997).

A phased approach was adopted for the design to facilitate the development of a design framework, conceptualisation and testing of programme components, and formulation of implementation structures and mechanisms. These design phases would allow for a gradual move towards full-scale implementation.

During the first phase, the information expectations and requirements related to monitoring of river ecosystems were assessed. The information needs of water resource managers were then reconciled with the degree to which a national programme can produce the required information. Based on these assessments, the scope and objectives of the RHP was specified in a framework document (Hohls, 1995). The objectives of the RHP centre around the assessment of the ecological state or integrity of rivers and streams.

The second design phase saw the conceptual development of programme components. The specifications for these components were directed by the programme objectives. The conceptual design addressed aspects such as the selection of monitoring sites (Eekhout *et al.*, 1996), indices for measurement and monitoring frequency (Uys *et al.*, 1996), data management procedures, reporting formats and a strategy for national deployment of the programme (Roux, 1997). Biological indicators (e.g. fish, aquatic invertebrates, riparian vegetation) are the main focus of the RHP. However, to provide a framework within which to interpret the biological results, some abiotic indicators (e.g. geomorphology, habitat, hydrology, water quality) have also been selected. Measurement indices for some of these indicator groups have been developed, tested and are applied widely in South Africa, while others still need considerable development and testing.

Although the design of the RHP was initiated by the DWAF, this national department does not have the regional infrastructure and expertise to implement and maintain the programme on a national basis. During the final design phase a model of shared ownership has been pursued to ensure a critical level of institutional participation. At the national level, the Department of Environmental Affairs and Tourism (DEAT) and the Water Research Commission (WRC) became, together with the DWAF, joint custodians of the programme.

Also, the geographic framework for decision-making in South Africa is changing from the national level to provincial and more local levels of government. To ensure the successful implementation and long-term maintenance of the programme, it will be necessary to involve regional stakeholders. As such, a model of national coordination (R&D, standardisation, quality control) and regional implementation and maintenance (data collection and ownership, coordination amongst regional stakeholders, ongoing learning and improvement) was adopted. At a provincial level, Provincial Champions and Provincial Implementation Teams (PITs) became responsible for implementation and operational initiatives (DWAF, 1996).

1.2 THE MPUMALANGA PILOT PROJECT

Although several scientific components had been conceptualised during phase two of the RHP design, most of these required further testing and verification. It was envisaged that regional implementation initiatives would facilitate the required testing and refinement. However, it became apparent that a pilot-scale implementation project would be needed to demonstrate to PITs how to go about implementation in their regions. Such a pilot project would:

- allow testing and refinement of programme components;
- allow integration of programme components;
- facilitate the identification of additional developments that may be required;
- demonstrate the worth of the programme; and
- provide broad guidelines to facilitate the eventual implementation and maintenance of the programme.

A project was proposed to the Water Research Commission for conducting pilot implementation of the RHP. The project would aim at developing procedures which will eventually help to, at a national level, bridge the gap between the conceptual design of the RHP and the operational maintenance thereof. This project would essentially be used to facilitate the translation of new knowledge and insights (related to the RHP) into new ways of doing (for implementation agents).

Demonstration projects are regarded as appropriate mechanisms for creating, acquiring and transferring knowledge, especially in times of fundamental change, as these projects seek to move from superficial knowledge to deep understanding. Common virtues of demonstration projects are that (Garvin, 1998):

- They are usually the first projects to embody principles and approaches that the organisation hopes to adopt later on a larger scale. For this reason, they are more transitional efforts than endpoints and involve considerable "learning by doing". Mid-course corrections are common.
- They implicitly establish policy guidelines and decision rules for later projects.
- They are normally developed by strong multi-functional teams reporting directly to senior management.
- They can have significant impact on the rest of the organisation if they are accompanied by explicit strategies for transferring learning.

The Province of Mpumalanga has been proposed as an appropriate test ground, primarily because of competencies and capacity that exist within the provincial institutional infrastructure, and a pro-active approach adopted by key institutions within the province towards implementation of the RHP.

The main participating organisations (DWAF, DEAT, the Province of Mpumalanga, KNP and CSIR) were to each contribute to the project in terms of providing manpower, funding, equipment and/or training opportunities. While external expertise may be required during the duration of the project, the aim should be to establish regional expertise and capacity which can ensure regional autonomy in maintaining the programme. It would, therefore, be important that the programme get the buy-in of both the officialdom and the people of the region where it is to be implemented.

1.3 GOAL AND OBJECTIVES

During 1996, even before the formal commencement of Mpumalanga pilot project, a number of work sessions were held with key stakeholders in the province. This was done to reach consensus regarding the way in which the RHP should be implemented for the rivers of Mpumalanga. The aim with these work sessions was to identify the research and operational components which needed to be addressed, and an appropriate time frame for doing so, in order to implement the RHP.

At the time, the Institute for Water Quality Studies (IWQS), Mpumalanga Parks Board (MPB) and the Kruger National Park (KNP) were all involved in biomonitoring on the rivers flowing through Mpumalanga. It made sense for these organisations to join forces and to optimise the benefits from their respective monitoring efforts. The RHP provides a mechanism for linking and standardising their current activities and for formalising cooperation.

As a first step, a goal statement was formulated to reflect the desired outcome of the collaborative implementation project:

By the year 2000, the Mpumalanga Province, through its provincial and local authorities, has the necessary procedures, capacity and institutional arrangements in place to accept custodianship and responsibility for effective operation and maintenance of the RHP in the province.

The goal statement directed the compilation of a project plan. This plan consists of a number of key intermediate objectives which must be reached before the project goal can be realised (Figure 1.1).

The content of each intermediate objective is summarised below:

Intermediate Objective 1 - Identify and Develop Missing Technical Components
It is necessary to identify the minimum suite of protocols and procedures that would be required for implementation of the RHP in Mpumalanga. Those protocols and procedures which are already developed and available for use can be adopted, while those remaining will have to be developed as part of the implementation project.

Intermediate Objective 2 - Use Prototyping in the Development, Testing and Demonstration of the RHP
This step accepts that not all of the technical components of the RHP will be fully developed and tested by the time the implementation initiative is launched. This necessitates the application of the latest prototype of each required protocol or procedure to facilitate interaction between different programme components and to demonstrate the results of the programme. This approach recognises that a monitoring programme should always remain dynamic and allow for modifications as, for example, new findings become available.

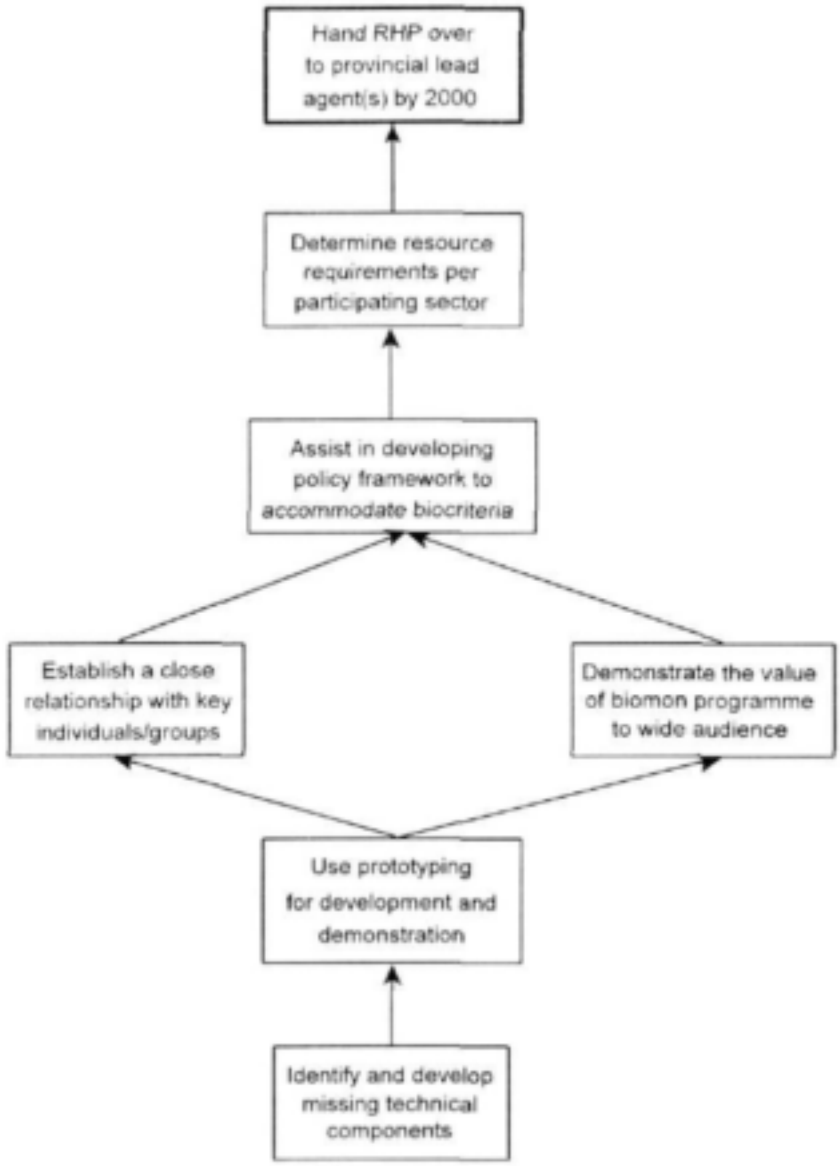

Figure 1.1 The objectives tree, showing intermediate objectives that need to be achieved in order to reach the project goal, and the chronological relationships between these objectives.

Intermediate Objective 3 - Demonstrate the Value of the RHP to a Wider Audience

One of the key components of any monitoring programme is the ability to capture and report on the information that result from assessing the data collected by the programme.

Demonstration of the value of the programme is crucial for gaining the necessary support to ensure ongoing improvement and maintenance thereof. This implies a need for packaging the information obtained from applying the programme prototypes in such a way that key user groups will be empowered to utilise the information. Key target audiences include political, operational (water resource managers) and grassroots communities.

Intermediate Objective 4 - Establish a Close Relationship With Key Individuals and Groups
The institutional framework (responsibilities and accountabilities) of role players in the province is not yet resolved, and this process is likely to take some time. Close relationships need to be established with key individuals and groups in order to streamline the process of transferring operational ownership of the RHP to the appropriate provincial and local lead agents. The task of identifying appropriate groups for participation, and shaping the responsibilities of these groups, is ongoing.

Intermediate Objective 5 - Assist in Developing a Provincial Policy Framework to Accommodate Output from the RHP
As the RHP is new, existing policy and legal frameworks do not automatically utilize the information produced by the programme. The project team needs to become involved with appropriate national and provincial initiatives in the development of a legal and policy framework which would accommodate and support biological data for rivers.

Intermediate Objective 6 - Determine Resource Requirements and Developmental Needs Per Participating Sector
It is necessary to conduct a proper resource audit and needs assessment of the infrastructure, equipment, hardware and software, competencies, numbers and types of people and financial resources that will be required by the different participants to implement and maintain the RHP.

The intermediate objectives essentially provided a framework for identifying project activities and developing a project plan.

1.4 SUMMARY OF PROGRESS MADE

Intermediate Objective 1
Biomonitoring Protocol 3 (BP3) was used as a benchmark for identifying and developing missing technical components.

> *Five alternative Biomonitoring Protocols (BPs) were proposed to accommodate a range of regional requirements, capabilities and available resources. The options range from the use of a single biological index and an associated habitat index, to the use of several biological and non-biological indices at a site (Uys et al., 1996).*

By adopting BP3 as a first aim for rivers in Mpumalanga, the implementation team committed to implementing a certain minimum suite of tools and methods. The following products are associated with the effective implementing of BP3:

- the Index of Habitat Integrity (IHI) (Kleynhans, 1996) based on an aerial video recording;
- the South African Scoring System (SASS) based on aquatic macro-invertebrates (Chutter, 1998);
- the site-based Habitat Quality Index (HQI) - used in association with SASS;
- the Fish Assemblage Integrity Index (FAII) (Kleynhans, 1999);
- a Riparian Vegetation Index (RVI);
- a site selection protocol;
- protocol for determining reference conditions;
- a data management system;
- formats for disseminating information;
- quality control and assessment procedures.

At the inception of this study, some of these methods and tools were fully developed and tested while others still required development. It was attempted to facilitate as many of the developmental needs as possible within the study, while some developments were supported but took place outside of the pilot project (Table 1.1).

Table 1.1 The developmental status of each of the BP3 methods and tools, at commencement and conclusion of the project respectively.

BP3 products and processes	Developmental status	
	At project commencement	At project conclusion
IHI	developed and tested; application well established; adopted without a requirement for further development	
SASS	fourth developmental prototype used widely as biological index of water quality in rivers; development of this index preceded the initiation of the RHP, and did not necessarily adhere to the scope and specifications of the RHP; further research on aspects such as the spatial variation of SASS scores; determination of area-specific reference conditions and the relationship between SASS and habitat condition is required to improve SASS assessments in the RHP context	further research was viewed as a national responsibility; initiatives to coordinate such research was initiated and contributed to; to date no project has been initiated
HQI	developed by Peter McMillan; widely used locally; the need for further development and improvement recognised.	separate research project resulted in alternative system called Integrated Habitat Assessment System (IHAS) (McMillan, 1999); IHAS used parallel with HQI during latter part of project
FAII	formerly known as Fish Community Integrity Index (FCII); early stages of development	refined through application and testing; can be applied with confidence on the rivers of Mpumalanga; needs adjustment for rest of the country
RVI	no suitable index available; development was taken on as part of pilot project	through development by application a prototype RVI has emerged; in present form can be applied on rivers of Mpumalanga; requires further development and testing

Table 1.1 Continued

BP3 products and processes	Developmental status	
	At project commencement	At project conclusion
Site Selection	a spatial framework (bioregional) for site selection available (Brown *et al.*, 1996); untested protocol for selection of monitoring and reference sites available (Eekhout *et al.*, 1996); practical application and testing required	alternative spatial framework (ecoregional) adopted following national developments in water resources management; site selection within ecoregional context done in a pragmatic fashion (considering accessibility, suitability, availability of historical data, etc.)
Reference Condition Derivation	development of the SASS technique did not specifically address assessment in the context of regional reference conditions; research project required to develop protocol for invertebrates	IHI, FAII and RVI have assessment against reference condition as build-in function; DWAF funded research project initiated for SASS - to determine ecoregional reference conditions for aquatic invertebrates (Dallas, 1999)
Data Management	creation of management system for biological and habitat data/information required; structures for data storage under development by IWQS/DWAF; procedures and mechanisms for transfer and retrieval of data under development by IWQS/DWAF	IWQS/DWAF product still in developmental phase; accept DWAF funded development of Rivers Database to provide regional data management platform; interfacing ability between Rivers Database and IWQS/DWAF system important; Rivers Database available for provincial application - will be refined while applied
Information Dissemination	formats for presenting biological and habitat information under development - especially by IWQS; information packaging for different target groups needs to be demonstrated	a popular brochure (State of the Crocodile River, 1998), poster (Roux *et al.*, 1997) and technical paper on river health in the context of the Water Act (Roux *et al.*, 1999) were produced; two exploratory web pages were developed (DWAF & CSIR) - these still require optimisation
Procedures for Quality Assurance and Control	developmental project required	framework developed as part of Mpumalanga project; requires application, testing and refinement

Intermediate Objective 2

The Mpumalanga pilot project has followed an approach of learning while doing. River surveys were conducted using the latest available methods and tools, while recognising that development will be ongoing and improved versions may be available for the next survey. At the same time, practical experience obtained during surveys stimulated integration and influenced the direction of various local and national developments. Surveys on the Crocodile, Sabie and Olifants Rivers were used to facilitate this process of development by application.

Intermediate Objective 3

Various initiatives were used to communicate the value of the RHP to as wide a stakeholder audience as possible. The specific capabilities and limitations of the RHP were made explicit (Chapter 2), and a primary school and two communities were used to develop an understanding of the requirements for successful grassroots communication and awareness creation (Chapter 4). Results collected during the Crocodile River survey were used to compile a popular brochure on the State of the Crocodile River. This brochure was used as a RHP promotional item and was distributed widely within Mpumalanga as well as nationally and internationally. In addition, the Crocodile River results were packaged into an adaptive assessment and management framework that supports the making and implementation of resource management decisions (Chapter 5).

Intermediate Objective 4

The success of the project was always dependent on the degree of buy-in and participation that could be achieved amongst stakeholder institutions. This has been one of the strengths of the project, in that many individuals and institutions became intimately part of the knowledge network that implemented the RHP in the Province of Mpumalanga. The business model for inter-institutional collaboration that is proposed in Chapter 8 testifies of the inclusiveness of the participating community, either as part of the guiding team, or as strategic or tactical partners.

Intermediate Objective 5

The legal and institutional standing of the RHP has been analysed in some detail (Chapter 6). In the changing environment of environmental policy development, this provides a valuable perspective on the legal implications and institutional responsibilities regarding sustainable implementation of the RHP.

Intermediate Objective 6

The resource requirements and developmental needs within the province are addressed through the compilation of a business plan for the implementation and maintenance of the RHP in Mpumalanga (Chapter 8). In addition, a study was done to better understand the mechanisms and dynamics that drive the maturation of a technological product so that it can become a truly operational programme. Concepts and principles from the field of technology management were used to build an implementation model for the RHP (Chapter 7).

1.5 STRUCTURE OF REPORT

This is the first of a series of reports forthcoming from the project:

Report 1: Development of Procedures for the Provincial Implementation of the National River Health Programme

Report 2: Inventory of RHP Monitoring Sites on the Crocodile, Sabie and Olifants Rivers

Report 3: Development of a Riparian Vegetation Index

Report 4: Assessment of the Biological Integrity of the Crocodile, Sabie and Olifants Rivers Based on Attributes of Fish Assemblages

Report 5: Assessment of the State of the Crocodile, Sabie and Olifants Rivers Based on the SASS Invertebrate Index

The development of specific protocols are addressed in reports 3 to 5. This report focuses primarily on processes, guidelines and understanding which are required for sustainable implementation of the RHP.

Chapter 2 of this report was compiled in response to the identified need to explore the complementarity between the RHP and other programmes, agendas and responsibilities regarding environmental monitoring and management. This section provides some perspective on the capabilities and limitations of the RHP in relation to environmental impact assessments, state of the environment reporting, sustainability indicators, management objectives, and supporting environmental decision-making.

Chapter 3 provides a preliminary and generic framework for quality control and quality assurance (QC/QA)for biomonitoring in the context of the RHP. Five fundamental problems that may result in poor quality are discussed. General principles and an organisational structure for QC/QA are suggested.

Chapter 4 explores ways of involving non-technical people in the RHP by means of three community-based case studies. A set of social "tools" are presented which water resource managers may use in the implementation of the RHP.

Chapter 5 deals with the development of an adaptive assessment and management procedure for linking the monitoring outcomes of the RHP with water resource management decisions. The potential of such a procedure is demonstrated using data that have been collected through application of the RHP on the Crocodile and Elands Rivers.

Chapter 6 presents the complex legal and institutional environment within which the RHP has to function as a management tool to influence decision-making. Suggestions are made as to how water and environmental policy could best support the RHP in influencing decision makers.

Chapter 7 explores the strategies that were, and are being, used to facilitate the transition from scientific development to operational application of the RHP. Theoretical models from the field of the management of technology are used to provide insight into the dynamics that influence the relationship between the creation and application of environmental programmes, and the RHP in particular. Four key components of the RHP development are analysed, namely the (a) guiding team, (b) concepts, tools and methods, (c) infra-structural innovations, and (d) communication. These key components evolved over three broad life stages of the programme, which are called the design, growth and anchoring stages.

Chapter 8 presents a business plan for Mpumalanga. The aim is for the provincial implementation initiative to successfully mature from an externally funded pilot project to an internalised operation. The business plan focuses on four issues critical to this transition, namely purpose, technological considerations, connectivity and capacity.

Chapter 9 ends this report with concluding remarks and recommendations.

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CHAPTER 2 - CAPABILITIES AND LIMITATIONS OF THE RHP AS A TOOL IN THE MANAGEMENT OF WATER RESOURCES

DJ Roux

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2.1 INTRODUCTION

No single monitoring programme can meet all the information expectations of water resource managers. The primary intention with the RHP is to provide a source of information on the overall response of aquatic ecosystems to multiple stressors. As a result, the RHP essentially focuses on biological response or effects monitoring. Selected attributes of aquatic communities are monitored in an attempt to characterise the response of the ecosystem to a disturbance(s). The rational is that the status of biological communities provides the most direct and holistic measure of the integrity or health of their associated ecosystem as a whole. The ultimate goal of such biomonitoring is to measure, evaluate and quantify the consequences of human activities on riverine systems (Karr and Chu, 1997).

A further important aspect is that the RHP was design for national application. Its objectives are stated as to, at a national level:

- 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; and
- identify and report on emerging problems regarding the ecological state of aquatic ecosystems in South Africa (Roux, 1997).

In addition to serving the primary objectives of the programme, information generated by the RHP may also assist resource managers to respond to a number of water resource/catchment management responsibilities. However, there would also be certain areas of information need for which the RHP would not be able to provide answers. To prevent unrealistic expectations and wrongful application of RHP information, it is necessary to be explicit about the capabilities and limitations of the monitoring and assessment techniques associated with the programme.

In this chapter, the potential application of information generated by the RHP is assessed in relation to some actual environmental management responsibilities, activities or agendas.

2.2 ENVIRONMENTAL IMPACT ASSESSMENT

Four of the most common types of environmental impact assessments required by water resource managers are:

- temporal impact assessments (e.g. before and after the construction of a dam);
- spatial impact assessments (e.g. upstream and downstream of a source of impact);

- cumulative impact assessments (integrating the effects of multiple stressors); and
- causal impact assessments (to be able to predict the nature and degree of impact that will result from certain stressors, i.e. to establish cause-effect relationships).

The specific nature of the impact will determine the information required to do a proper assessment. The appropriateness of the information can generally be described in terms of the breadth and detail of the data that are available or should be collected.

"Breadth" depends on the number of ecosystem processes and components (indicators) that are included in the data. "Detail" refers to the frequency at and degree to which each ecosystem indicator is measured and analysed. The more detailed the available data, the better the insight that can be obtained about the functioning of the ecosystem, i.e. the interrelations among ecological components as well as their relationship to stressors (Nip and De Haes, 1995).

Breadth is often at the expense of detail. A broad approach can be sensitive to all kinds of stressors, however, subtle responses may not be detected. Similarly, detail is at the expense of breadth. Although predictive capacity depends on the detail of information, the evaluation may become too narrowly focused, with an increasing risk that important effects on other ecosystem components can be overlooked (Nip and De Haes, 1995). Ultimately, the breadth and detail of design specifications need to be tailored according to specific monitoring objectives.

The RHP, operating at a national scale, is designed to measure and assess the general state and annual changes over river reaches, rather than to provide day-to-day operational answers or for measuring exact river conditions at any specific site. The programme focuses on breadth rather than detail. A representative spectrum of ecological indicators are monitored at a coarse level (e.g. *community attributes of the biological indicator groups*), at a low frequency and a low resolution of monitoring sites spread across all major rivers of the country.

2.2.1 Temporal Impact Assessment

Regarding assessment of impacts over time, the RHP is designed to reflect change in ecological condition over years, rather than over different seasons within one year or directly before and after a pollution incident. This implies that the RHP needs to be in existence for a few years before it would allow the detection of temporal trends that would provide an ability to quantify improvement or deterioration. Establishing such long-term trends may then allow the qualitative prediction of further improvement or deterioration.

From the time-integrating nature of biological indicators, a much lower monitoring frequency is required for indicators of the RHP than is usually the case for programmes focussing on chemical water quality variables. The optimum sampling frequency will also vary for different biological indicators, for example invertebrates (with relatively short life spans) will be sampled more frequently than fish (with longer life expectancies). Similarly, the non-biological indicators, such as for habitat and geomorphological characteristics, would be monitored at a frequency concurrent with the time scales in which change in that specific component of aquatic ecosystems is likely to occur. Furthermore, for any programme operating at a national scale, resource (funds, manpower, equipment) realities must be considered.

Frequencies of sampling events for indicators of the RHP is, therefore, determined by ecological factors and pragmatic considerations rather than specific impacts anticipated or experienced. The sampling frequencies proposed for the RHP typically range from twice per year to once every five to ten years.

2.2.2 Spatial Impact Assessment

Results from the RHP are intended to provide insight in the relative degree of impairment of, or impact on, aquatic ecosystems in the context of a catchment or river reach as an ecological unit. As examples, the Index of Habitat Integrity operates on the basis of five kilometre segments along the length of the river (Kleynhans, 1996), and the Fish Community Integrity Index describes a reference condition per "fish segment" of the river. Each segment represents a reach in which the fish community would, under unimpaired conditions, remain generally homogenous due to the relative uniform nature of the physical habitat (Kleynhans, 1999). However, the invertebrate index (South African Scoring System or SASS) (Dallas, 1997) could potentially be used to determine impacts at much smaller spatial scales, e.g. for a particular site on a stream or a specific biotope such as a riffle or a sandy patch within a stream.

In terms of site selection, the RHP focuses primarily on general state of the environment reporting, as opposed to specific monitoring of problem areas (impact assessment). The emphasis on long term state of the environment monitoring necessitates a network of sites which are representative of the full range of variation in character of rivers within the country.

These sites should ideally be selected in an objective or random fashion. However, in practice it became evident that site selection is often also influenced by accessibility to the river, suitability of the habitat for a particular type of sampling, and the historic use of certain sites which provide more data to assist interpretation of new results. Nevertheless, sampling sites adopted for the RHP may not necessarily overlap with sites that are ideal for assessing specific impacts on a river system.

2.2.3 Cumulative Impact Assessment

Biological communities inhabit rivers continuously, and hence possess a broad-based ability to integrate the effects of chemical, biological and physical influences occurring over extended periods of time. Structural and functional attributes of these communities would reflect, for example, the overall decline in the condition of a water resource as caused by the combined effect of chemical contamination, loss and fragmentation of physical habitat, invasion by alien species, excessive water withdrawals and over harvesting of riparian zones. Biological responses can thus be used to monitor the cumulative effects of multiple stressors (upstream of the point of monitoring) on the aquatic environment.

The level of biological organisation focussed on in a specific monitoring design is very significant in terms of the required response time, sensitivity of the test and ecosystem relevance (Figure 2.1). The RHP, which aims to identify long-term trends and assess ecosystem level change, primarily focus on measuring biological community attributes.

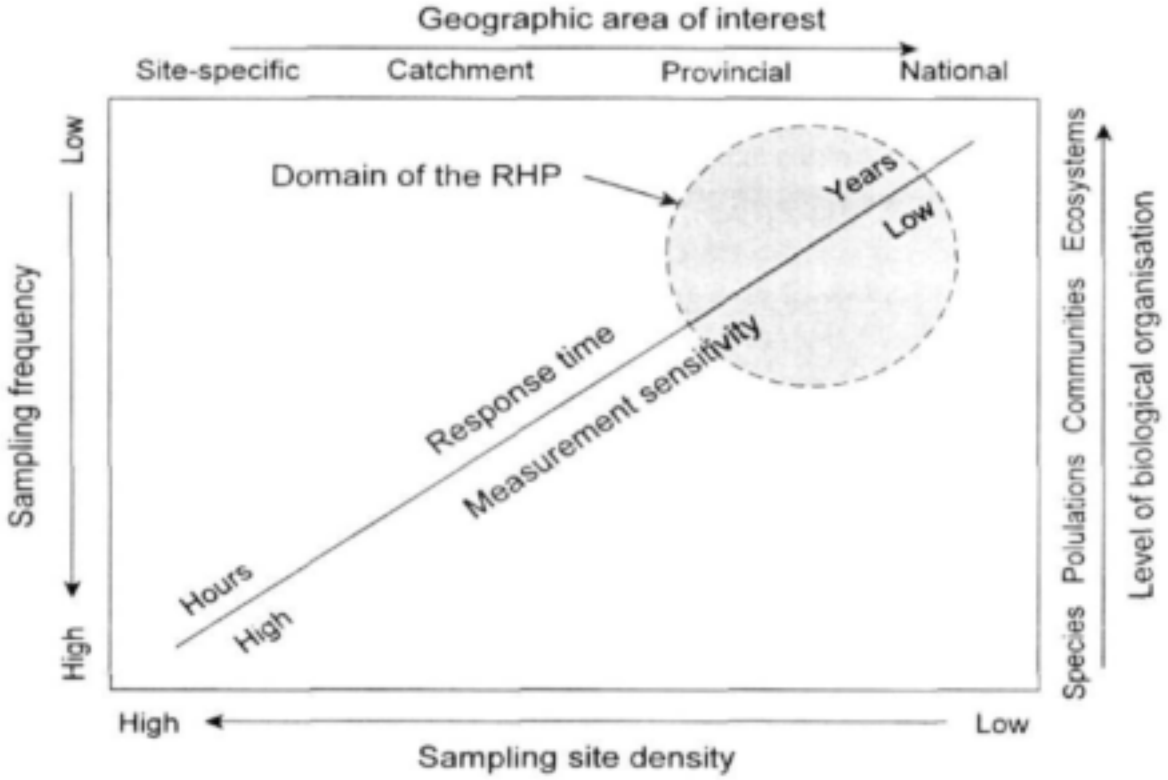

Figure 2.1 The objectives of a monitoring programme direct its technical specifications.

2.2.4 Causal Impact Assessment

Community-level response monitoring, as employed by the RHP, tends to be diagnostic in that it indicates that something is wrong in terms of an ecological component. On its own, this approach cannot indicate why something is wrong, as this ability relies on knowledge of the relevant cause-effect relationship(s). The data collected through a national programme are unlikely to be sufficiently detailed to establish causal relationships with a high level of confidence, i.e. providing quantitative links between the presence of a stressor or disturbance and the resulting biological response.

In cases where the RHP indicates that something is wrong, the national programme may feed into region- or site-specific biomonitoring programmes. Such programmes could be tailored around the particular problem experiences. More detailed and frequent monitoring can be instituted to provide insight into possible causality. An example is where the extent to which the quality of an effluent discharge must be improved in order to achieve a specified in-stream biological integrity. It may be appropriate to employ different types of biological monitoring, such as laboratory-based toxicity tests.

2.3 STATE OF ENVIRONMENT REPORTING

National monitoring for state of environment (SoE) reporting necessitates a network of monitoring sites which are representative of the full range of variation in character of rivers within the country. An established approach for the selection of representative sites is through regional classification of riverine ecosystems. In this approach, riverine ecosystems are grouped geographically on the basis of similarity between their catchments. This concept is based on the assumption that waterbodies reflect the catchments they drain and therefore, catchments with similar characteristics should result in similar waterbodies.

In the United States, regions of similarity in terms of their waterbodies have been termed ecoregions. Biological and physical characteristics of rivers would be expected to differ among ecoregions but be relatively similar within any given ecoregion. Therefore, the different ecoregions can be used as a template for site-selection to support SoE reporting. This is exactly what the RHP aims to do.

The development of a spatial classification scheme for the RHP has evolved from bioregions (Brown *et al.*, 1996) to ecoregions (Louw, 1998; Kleynhans *et al.*, 1998). The delineation of ecoregions allows the establishment of ecological reference conditions for each ecoregion. These reference conditions define the best physical habitat, water quality and biological parameters that can be expected to occur in a particular ecoregion. Reference conditions may be determined by means of:

- monitoring relatively unimpacted sites within an ecoregion;
- using historical (pre-disturbance) data;
- applying system specific knowledge and expert opinion;
- a combination of the above.

Comparison of the current conditions at each monitoring site with the reference condition for the associated ecoregion is used to determine the degree of change that can be attributed to anthropogenic causes. For the RHP, this process essentially constitutes the assessment of the current ecological state of riverine environments.

The design specifications of the national RHP allows for a number of hierarchical levels of reporting on the state of aquatic ecosystems. One possibility is based on political boundaries, e.g. from a metropolitan area to a province to the whole country. Another is based on natural (ecological) boundaries, e.g. from secondary catchments within one primary catchment, to primary catchments within one sub-continent, to the whole of southern Africa. An example of such a report in a catchment context is provided by the brochure on the ecological state of the Crocodile River, Mpumalanga (State of the Crocodile River, 1998).

2.4 ADDRESSING ISSUES OF SUSTAINABILITY

Apart from using the data generated by the RHP to determine the ecological state of aquatic ecosystems, and recording associated temporal and spatial trends, it is important for resource managers to know when the condition of a system is acceptable and when unacceptable. However, determining a cut-off point between acceptable and unacceptable degrees of change is technically problematic and politically controversial.

A potential way of overcoming these difficulties is to view acceptability in the context of environmentally sustainable development. Although there is no clear consensus in detail as to what constitutes sustainable development, most views build on the Brundtland definition: "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1997). This very broad definition can be decomposed into various components within which research and common understanding can be facilitated. Three such components are considered here:

- Ecological integrity and sustainable development;
- Sustainability indicators;
- Performance indicators.

2.4.1 Ecological Integrity and Sustainable Development

Sustainability definitions in general emphasise the holistic treatment of three subsystems of the environment, namely ecological, economic and social (socio-political-institutional). The ecological subsystem is concerned with the need to maintain ecological structures and functioning or ecological integrity (Simonovic, 1996).

The RHP uses the concept of ecological integrity as its theoretical foundation. With the application of professional judgement, results generated by the programme can be translated into river integrity classes. These classes can potentially translate into sustainable and unsustainable groupings (Table 2.1).

Table 2.1 A simple river integrity assessment system.

River Integrity Class	Assessment/Management Perspective
A - No measurable modification	falls within the range of natural and measurement variability; represent the best condition to be expected
B - Largely unmodified	Conditions are acceptable (sustainable)
C - Moderately modified	
D - Largely modified	marginal conditions
E - Seriously modified	unacceptable conditions (essentially unsustainable)
F - Critically modified	

2.4.2 Sustainability Indicators

In general, decision makers need information that is accurate, integrated, succinct and representative, and that allows some play for alternative scenarios and customising for national or local conditions. Sustainability indicators are intended to assist in this process. These indicators need to be "developed to provide solid bases for decision making at all levels and to contribute to the self-regulating sustainability of integrated environmental and development systems" (Agenda 21 - Chapter 40).

Many criteria have been published for good sustainability indicators. In essence, sustainability indicators should be simple, quantifiable and easy to communicate. Sustainability indicators should also be developed in close collaboration with those who will use them (Murray *et al.*, 1998). When evaluating the RHP against these criteria, we find that:

- During development of the RHP, the need for relatively simple and rapid techniques was emphasised.
- The programme was required to produce quantifiable results that could be used to communicate statistical, scientific and technical information to non-technical user groups.
- Ecological indices/indicators of the RHP were, and are being, developed in collaboration with water resource managers at national, provincial and local spheres of government.

In view of the above, the indicators developed within the RHP generally comply with the criteria for good sustainability indicators.

2.4.3 Performance Indicators

A primary purpose of indicators of sustainable development is to help people measure progress (or the lack of it) towards sustainable goals. A simple classification system such as presented in Table 2.1 allows for results from the RHP to be used as performance indicators, where actual measures of ecological integrity relate to the targets or objectives established by policy makers. Once indicators are routinely used in the context of sustainability, they will become vital forms of information to shape policy decisions. This information tend to flow in two primary directions, namely:

- to policy makers, who it is hoped will react to the warning signs and make adjustments; and
- to citizens and nonprofit organisations, who use the information to influence public policy (Chiras and Corson, 1997).

2.5 SETTING RESOURCE QUALITY OBJECTIVES

The national Water Act (Act No 36 of 1998) makes a commitment to the sustainable utilisation of water resources in South Africa. There are two separate but interdependent components related to the proposed strategy for sustainable resource utilisation, namely:

- protection of water resources in order to ensure their capability to support utilisation for the benefit of current and future generations, and
- utilisation of water resources in the most efficient and effective manner, within the constraints set by the requirements for protection.

Depending on the level of protection which is acceptable or desirable for a specific water resource, the degree of utilisation that may be allowed can vary from extensive to none. It is envisaged that, under a national classification system for rivers, all water resources will be grouped into classes representing different levels of required protection. This provides a nationally consistent basis and context for deciding on an acceptable level of short-term utilisation, balanced against the requirements for long-term protection of a water resource.

For water resources which are especially important, sensitive, or of high value, little or no utilisation would be acceptable, and they would be assigned a high protection class. In other cases, the need for short to medium term utilisation of a water resource may be more pressing. Such a resource would still be protected, but would be assigned a class which reflect higher risk to its integrity.

Classification of rivers represents a vision of how people feel their water resource should be managed in terms of resource quality. However, to give operational meaning to a qualitative vision, different resource classes need to translate into measurable and verifiable management objectives. These objectives are referred to as Resource Quality Objectives (RQOs), and are numerical or sometimes descriptive statements of the conditions which should be met in order to ensure that the water resource is protected according to an assigned protection class. RQOs comprise four critical components, to cover each of the aspects necessary for protection:

- requirements for water quantity, stated as flow requirements for a river reach or estuary, and/or water level requirements for standing water or ground water, and/or requirements for groundwater level in order to maintain spring flow and base flow in rivers and other ecological features;
- requirements for water quality (chemical, physical, and biological characteristics of the water);
- requirements for habitat integrity, which encompass the physical structure of in-stream and riparian habitats, as well as the vegetation aspects;
- requirements for biotic integrity, which reflect the health, community structure and distribution of aquatic biota.

The RHP will play an important role in specifying RQOs for habitat and biological components of aquatic ecosystems. Through the RHP, assessments can be made regarding the ecological state of an aquatic ecosystem in terms of:

- the current ecological state (where are we now);
- ecological reference condition (where could we potentially be); and
- setting of ecologically sound and feasible RQOs (where do we want to be).

2.6 ENVIRONMENTAL DECISION MAKING

Responding to the results of environmental monitoring programmes and instituting management action are important in terms of timing (early warning system), priority (where attention is most needed), and making use of the most recent knowledge for implementing the most appropriate actions (adaptive management).

2.6.1 Early Warning Systems

Early warning systems usually refer to response indicators which have been developed for on site and continuous monitoring of, for example, an effluent stream. These behavioural toxicity assays explore sub-lethal effects by looking at the behaviour of certain organisms when exposed to low levels of stress. The observable behavioural responses can be avoidance, swimming behaviour, ventilation rates, feeding activity, photosynthetic activity, sub-cellular responses and locomotory activity. These assays are often automated by linking them to a computer which records such variables as respiration and heart beat. The organisms react to environmental stress by rapid alteration in their normal behavioural or physiological patterns, and this is picked up by the monitoring equipment.

The main advantage of early warning systems is that they are capable of detecting pollution almost immediately, and on a continuous basis. This allows remedial actions to be taken before the most severe effects of a sudden pollutant loading can occur. Such quick and continuous results are not possible with field bio-assessment protocols, as employed by the RHP. The RHP with its diagnostic nature will report on the effects of a pollution incident after it has happened.

2.6.2 Focus Attention Where it is Most Needed

Prioritised and effective responses require robust monitoring systems and the willingness to alter human behaviour and practices, sometimes on short notice. Ideally, this alteration should be instituted before ecosystems have suffered acute adverse consequences (Cairns, 1997). As indicated by the objectives of the RHP, the national assessments would help to identify areas which need attention most. The national ecological surveys of the RHP should allow the detection of unacceptable change at a coarse scale. This would allow for area-specific activities to be prioritised and limited resources to be used optimally by focussing on specific problem areas.

However, more detailed area-specific surveys would be required in order to quantitatively and confidently link specific causes to any unacceptable change that is identified through the national programme. Although area-specific monitoring activities are not addressed as part of the national programme design, such monitoring initiatives will be essential to complement the national information and hence to optimise decision-making competence. Provision must, therefore, be made for feedback-loops between bio- and other monitoring programmes operating at different spatial scales. Area-specific monitoring programmes include those instituted by provinces, sectors (e.g. for a conservation area, land-use area) or catchment-based agencies.

2.6.3 Adaptive Management

As there are many uncertainties and a high degree of unpredictability involved with ecosystems management, choosing the most appropriate intervention to an identified problem is often very difficult. Because of the dynamic nature of ecosystems, and to ensure that resources are invested in those actions that would provide the best returns, there is a need to constantly review and revise restoration and management approaches. This problem can be addressed through the adoption of an adaptive management approach.

Adaptive management is a process whereby the limits of our knowledge and experience is recognised, yet it helps us to move towards goals in the face of uncertainty. The premise is that, as we increase our understanding of ecosystem structure and function, and their relationship to management actions, we need also to adjust our actions accordingly. When new information becomes available, a decision is made whether and how to adjust the management strategy and actions. Management decisions are thus viewed as experiments subject to modifications, rather than as fixed and final rulings.

A critical prerequisite to the successful application of adaptive management is a long-term commitment, also in terms of legislation, to maintaining a certain standard of monitoring (see Chapter 6). As a national programme, the RHP provides an opportunity for establishing the monitoring support that would be required for adaptive management to have an impact on water resources management. In essence, adaptive management of the state of riverine ecosystems would have the following components (see Chapter 5):

- management goals (RQOs) are set;
- restoration or management measures are implemented to achieve goals;
- monitoring is conducted to audit goal achievement;
- feedback is provided based on new insights gained; and
- adjustments are made to management measures.

2.7 CONCLUSION

The RHP is being designed in response to a specific information need, namely to quantify the ecological state and track the overall response of riverine ecosystems in relation to all the anthropogenic disturbances affecting them. The RHP is not intended to replace any existing water quality monitoring approach, but rather to expand on the approaches currently in use. Implementation of the RHP would provide a substantial broadening of the traditional water quality monitoring and assessment focus. It would provide for a far more integrated collection and analysis of data, as well as the assessment of new types and combinations of data.

Application of information resulting from the RHP should be guided by the philosophy and technical specifications underpinning the monitoring design. Following is a summary of the application potential in some areas of water resources management:

- *environmental impact assessment* - The objectives of a specific monitoring programme direct its technical specifications, such as site selection, sampling frequency, geographic area to be covered and level of biological organisation appropriate to scrutinise; hence making the resulting data fairly specific in terms of its impact assessment potential. The RHP is geared to assess the general ecological state and associated long-term changes over river reaches. This assessment integrates the effect of all stressors, and the programme is not intended to link specific stressors to specific effects. Qualitative and coarse links may, however, be made between response and types of disturbances such as habitat degradation, flow alteration or water quality deterioration.
- *state of the environment reporting* - The RHP would allow reporting on the ecological state of all rivers that are included in the programme. Reporting could range in scale from a "state-of-the-nation's rivers" report to a report on the state of a specific river or river reach.
- *addressing issues of sustainability* - Indicators that are used or developed for inclusion in the RHP fall within the ecological subsystem of the environment. These indicators also meet the criteria as good indicators of sustainable development. The RHP, once in operation, would provide guidance as to the trajectory (up or down) of rivers in terms of sustainability.
- *setting of RQOs* - In order to give practical meaning to the concept of an ecological reserve for water resources, response monitoring and assessment must form an integral part of a future water resource management approach. The availability of quantitative and qualitative information on ecological reference conditions as well as the current ecological state of a river, as collected by the RHP, will contribute towards setting realistic and ecologically sound RQOs.
- *responding to monitoring results* - The output of the RHP can and should be used, at national, provincial and local levels of responsibility regarding the management of aquatic ecosystems. The programme is not designed to give early warning of potential impact, but it is most suited for pointing out areas which have degraded most and need priority management intervention. Also, through linking with policy goals and measurable RQOs, the ongoing data collection of the RHP will provide an opportunity

to build a long-term data base which would facilitate adaptive management of water resources.

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CHAPTER 3 - PRELIMINARY PROCEDURES TO ENSURE QUALITY CONTROL AND ASSURANCE IN THE RIVER HEALTH PROGRAMME

RW Palmer

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3.1 INTRODUCTION

The national River Health Programme (RHP) uses various indices to assess the condition or "health" of rivers in South Africa. The indices include one based on the composition of aquatic invertebrates (Chutter, 1998), the expected composition and health of fish species (Kleynhans, 1999), the condition of the riparian vegetation (Kemper, 1999), the condition of the fluvial geomorphology (Rowntree and Ziervogel, 1999), and the condition of the instream and riparian habitats (Kleynhans, 1996). The results obtained by applying these indices are likely to contain various errors which arise from five fundamental problems as follows:

Variable rivers

- Rivers vary naturally in space, time and size, making direct comparison of results difficult.
- The sites selected for biomonitoring may not be representative of the area.
- The biotopes sampled may not be representative of the area.
- The number of sites sampled may be too few to adequately describe river conditions.

Variable methods

- Standard data sheets may not be used.
- Data sheets may be poorly designed and promote transcription errors.
- Samples may be muddled through unmethodical protocol or inadequate labelling.
- Samples may be inadequately stored or preserved.
- Methods of entering and storing data may differ.
- Data may be inadequately stored for easy retrieval.
- Data may not be verified.
- Data may be analysed and interpreted in different ways.
- Important details may be overlooked. For example, linkages with hydrological data may not be made.

Variable personnel

- Standard protocols may not be followed.
- Standard equipment may not be used.
- Data may be analysed and interpreted in different ways.
- Taxa may be incorrectly identified.

Variable enthusiasm

- Agencies or individuals may not recognise the need for independent and routine

QC/QA auditing.

- The intensity of sampling may vary. For example, hunger, fatigue and time constraints can significantly affect results.
- Equipment may be poorly maintained.
- Data sheets may be inadequately completed.
- Errors may be made when entering data into computer files.

Variable users

- The objectives for biomonitoring may be variously defined.
- Results may be reported in an inadequate or inappropriate format for users.

These problems highlight the need to develop mechanisms to ensure Quality Control and Quality Assurance (QC/QA) within the RHP. This document provides a generic framework for QC/QA which is intended to cater for all biomonitoring indices within the RHP. The document is also in accordance with the National Water Act (Act No 36 of 1998 - Chapter 14, Section 137(2) and Section 143).

This document is not concerned with the details of QC/QA, as these will be described in the protocols developed for each biomonitoring index. Instead, this document suggests a framework for QC/QA, and identifies important actions and responsibilities within the framework. The suggestions are a compromise between reliability, cost and available skills. For this reason, no attempt was made to follow the International Standards Organisation (ISO) guidelines for QC/QA. However, a meeting of SASS4 specialists in December 1998, which was attended by the forestry industry and other biomonitoring agencies which require ISO accreditation, recommended that a study should investigate the possibility of developing biomonitoring procedures which are ISO compatible.

3.2 GUIDING PRINCIPLES

The following principles are suggested as a basic framework for QC/QA within the RHP.

- All aspects of the RHP, from programme design, field and laboratory activities, data storage and analysis through to data presentation, should be subject to QC/QA procedures.
- The effort taken to implement QC/QA procedures should be appropriate to the resolution of the data. This means that QC/QA procedures should aim to ensure that the results are within limits of reliability that are considered acceptable by the

proposed Quality Assurance Portfolio.

- Different aspects of QC/QA procedures may have to be developed for activities at the national and regional scales. Auditing at the national scale should involve monitoring the overall activities of the RHP, with the emphasis on programme design, planning, training and data base management. Auditing at the regional scale should involve monitoring individual performance and collection methods, with emphasis on detecting problems at an early stage, introducing remedial action before the programme is detrimentally affected, and editing of reports and other outputs to ensure that they are appropriate for their intended uses.
- QC/QA should be an ongoing process, requiring continual evaluation. A large component of QC/QA should therefore focus on continual monitoring of data quality, with constructive and timeous remedial action where and when necessary.
- QC/QA should be approached in a spirit of constructive engagement and cooperation, rather than a top-down, policing approach.
- Biomonitoring data collected during, or shortly after, high-flow conditions can be unreliable. It is therefore suggested that sampling should be restricted, when possible, to low-flow periods.
- Approximately 10% of the field data should be audited by regional auditors.

3.3 THE MAIN PROBLEMS

3.3.1 Variable Rivers

Rivers are highly variable in space, time and size. This means that biomonitoring results which differ do not necessarily indicate that river conditions are significantly different. One of the aims of QC/QA is to develop mechanisms which can easily and reliably identify results which are significantly different to what would be expected at a particular place, time or scale. A component of QC/QA procedures should therefore focus on ensuring that the natural variability in results are quantified (where possible) and taken into consideration when the results are interpreted.

Monitoring is usually aimed at answering questions on much larger temporal and spatial scales than the scales at which the samples were collected (USEPA, 1997). This problem is compounded by the highly variable nature of river systems, making data verification difficult. It is therefore important that samples are representative of the area and time in which they are sampled. Critical evaluation of site selection, sampling methods, sampling frequency and periodic auditing of field operations is therefore essential if the results of the RHP are to be of any use.

Although the biomonitoring indices used by the RHP are specifically designed to minimise the effects of natural spatial and temporal variation, it is impossible to eliminate this variation. For example, a recent flood or drought or specific event, such as upstream construction, may affect the river significantly. It is therefore important that the temporal context in which a sample is taken is recorded and considered when interpreting biomonitoring results. It is suggested that significant events should be described and quantified in terms of magnitude as well as the time elapsed before sampling.

Sampling during or shortly after high-flow conditions is often problematic. This is because habitats are often inaccessible during high-flow conditions, and the composition and abundance of biota is often significantly affected. Biomonitoring data collected during, or shortly after, high-flow conditions is therefore often unreliable. The best way of avoiding this problem is to restrict sampling to low-flow periods.

It is also important that specific features of the biotopes sampled should be recorded. For example, sampling invertebrates on bedrock-in-current may give different results to sampling cobbles-in-current, where the surface area of substrate sampled and the variation in the flow conditions are significantly greater.

Another important consideration concerns selecting representative sites. For example, a road crossing may be situated in a narrow rocky area which may not be representative of the river reach as a whole. This highlights the importance of clearly defined protocols for defining the biotopes sampled and procedures for delineating the boundaries of sampling sites.

3.3.2 Variable Methods

The importance of standard protocols in ensuring QC/QA cannot be overestimated. At present, various agencies are conducting biomonitoring activities, and each have wittingly and unwittingly developed their own, slightly different, approaches. This is partly because user agencies usually have different requirements. For example, site selection and sampling frequency to meet national objectives, such as monitoring long-term trends, are likely to be different to regional or site-specific objectives, such as monitoring the downstream impacts of a dam. Likewise, monitoring the impacts of industrial effluent on river health may require a monitoring protocol with a lower taxonomic resolution and higher sampling frequency than that required for recommending Ecological Flow Requirements. Consequently, the results may not be comparable. This highlights the need to screen biomonitoring results which form part of the RHP. A large component of QC/QA should therefore focus on ensuring that the data are comparable. This may be achieved by developing standard protocols, and checking that the protocols are adhered to. It is not the intention of this document to define what the protocols should be, or what the limits of data reliability should be, because these should be included as part of the protocols for each biomonitoring index.

Despite the importance of recording various details, it is important that only data which are relevant to the interpretation of biomonitoring results, and which can be entered into a database and easily analysed, should be recorded. Furthermore, the way in which data are recorded must be compatible with the structure of the data base. Carefully planned data sheets and data base are therefore an essential component of QC/QA.

One of the concerns of the SASS biomonitoring method is taxonomic accuracy. It is commonly known that field identifications of aquatic invertebrates are less accurate than laboratory identifications. The protocol which has been developed for SASS4 requires identification of taxa in the field (Chutter, 1998). This raises a problem for QC/QA because taxonomic accuracy may only be verified when Auditors accompany Biomonitors in the field. The disadvantage of this method is that the Biomonitors know when they are being audited, and this is likely to bias the auditing results. Another problem is that Auditors are also likely to make identification errors because some taxa can only be identified with certainty with a microscope. It is therefore suggested that invertebrates from each site-visit should be collected and preserved. Specimens can also be kept alive for several days for laboratory examination by pouring off the water and placing them on ice.

The advantages of collecting and preserving invertebrate specimens are that identifications are likely to be more accurate, specimens would be available should identifications need verification, and identifications can be verified in the laboratory by Regional Auditors from random samples. This would ensure that Biomonitors are kept on their toes because they would not know which of their samples would be audited. Furthermore, specimens would be available should taxa need to be identified to a higher resolution, for whatever reason. To increase objectivity, the procedure could be structured so that the Auditors do not know where the samples are collected from, or who collected them. Standard procedures, with set fees, are recommended for this. The disadvantage of this method is the extra time and cost (both financial and logistic) in preserving and curating samples and mailing them to Auditors. More importantly, this auditing procedure is extremely boring, and Auditors are unlikely to sustain an interest in their work, and this could defeat the aim of the exercise.

Another shortcoming related to QC/QA of the SASS4 method concerns the identification of taxa and delineation of biotopes. Various user agencies and individuals have developed their own guides to the identification of SASS4 taxa and biotope delineation, but there is no standard field guide available. The Water Research Commission is currently funding a project which will provide a series of identification keys, but these are likely to be too detailed for SASS purposes and use in the field. It is suggested that the reliability of SASS4 results could be improved significantly by producing a standard, good quality illustrated field guide to SASS4 taxa and aquatic biotopes.

3.3.3 Variable Personnel

The RHP involves a large number of people and organisations, each with their own skills and interpretation of biomonitoring protocols. Inexperienced staff may overlook important details, such as the calibration of equipment, or they may conduct inappropriate analyses and interpret results incorrectly. On the other hand, experienced staff may disregard standard protocols because they are accustomed to collecting and analysing data in their own particular way. Indeed, it has been shown that standard protocols tend to be interpreted differently, no matter how clearly defined the protocols may be (Storey and Humphrey, 1997; USEPA, 1997). This highlights the need for initial training of Biomonitors, irrespective of their experience. A large component of QC/QA should therefore focus on continual monitoring of data quality, with constructive and timeous remedial action where and when necessary.

The number of people sampling may also affect results. For example, the results of a fish survey undertaken by one person are not comparable to that of a large team over the same time. *It is therefore important to standardise the number of people involved in sampling.*

3.3.4 Variable Enthusiasm

One of the main problems with biomonitoring and implementing QC/QA procedures is that enthusiasm can vary greatly - hunger, sampling fatigue, time constraints and boredom can affect results significantly. Added to this is the fact that large government programmes, such as the RHP, inevitably create opportunities for individuals and agencies to hitch "free rides". Consequently, the enthusiasm for biomonitoring and QC/QA can be highly variable, even within a day. One of the aims of QC/QA should therefore be to ensure that the RHP remains interesting and stimulating, particularly for those who are collecting and analysing data. It is also important that the time taken for sampling is standardised.

One way of preventing boredom is to ensure that Biomonitors and Auditors are interested in what they are doing. This could be achieved by encouraging Biomonitors and Auditors to learn more about the systems on which they are working. Periodic courses could be held on various aspects, such as river and wetland rehabilitation, life history of riparian vegetation, taxonomy etc. Although such courses would not benefit the RHP directly, the indirect benefits are likely to be significant. It is proposed that courses should be funded by the RHP.

3.3.5 Variable Users

The results of the RHP are primarily intended to meet the information needs of water resource managers, but they are also likely to be used by non-government organisations, academic institutions and other interested and affected individuals and organisations. Consequently, the way in which data are presented should vary according to the target audience. Data should not be presented merely as listings of variables and their results. Instead, data should be interpreted, recommendations for management action should be made, and the results presented in an appropriate format. A glossy brochure may be suitable for the general public, but is of little use to scientists looking for hard data. An inappropriate format may quickly lead to the perception that the data are unreliable, and that the programme is not meeting its objectives. Reports and publications should therefore be critically reviewed before they are distributed. It is recommended that for each biomonitoring index, results should be classified according to the six point scale (A-F) used by the DWAF to classify water resources. Furthermore, raw data should be readily available for re-analysis by QC/QA Auditors or use by others as required.

3.4 ORGANISATIONAL STRUCTURE AND RESPONSIBILITIES

The proposed management hierarchy for QC/QA within the RHP is shown in Figure 3.1. At the national level, the hierarchy consists of a proposed Quality Assurance Portfolio (QAP) within the existing National Coordinating Committee (NCC), and a Quality Assurance Portfolio Manager. At the regional level the hierarchy consists of Regional Auditors and individuals who collect the data, referred to in this report as "Biomonitors". Regional Auditors and Biomonitors would be required for each biomonitoring index. The functions, responsibilities, methods of appointment and the information flow between these components are discussed below.

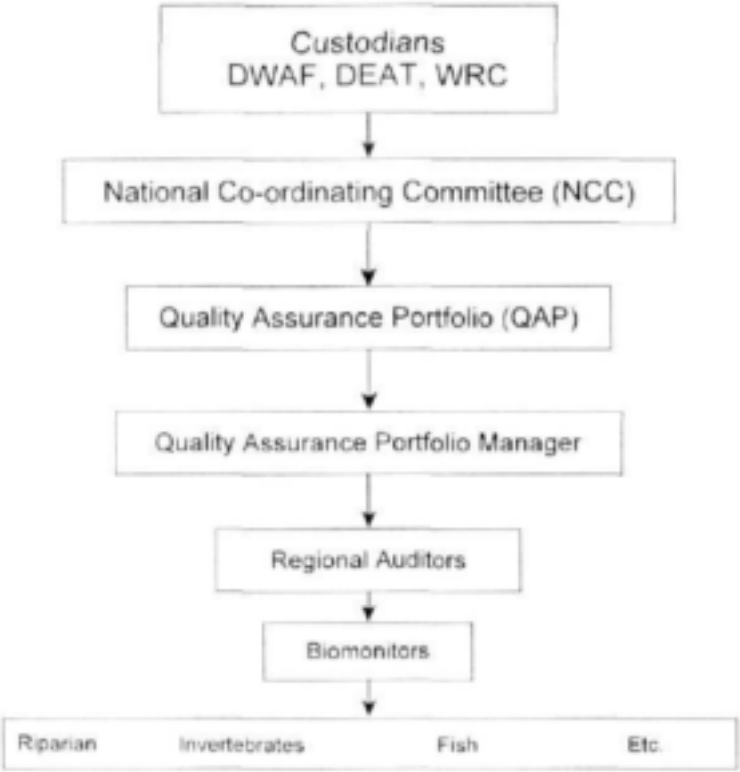

Figure 3.1 Organisation chart for Quality Control and Quality Assurance in the RHP.

3.4.1 Quality Assurance Portfolio (QAP)

The existing National Coordinating Committee (NCC) consists of custodian representatives (DWAF, DEAT, WRC), Provincial Champions, Portfolio Managers and Scientific Advisors. It is suggested that an additional portfolio, the Quality Assurance Portfolio (QAP), should be established within the NCC. It is suggested that the portfolio should consist of no more than eight people, and should include a specialist representative for training, sampling design, data storage and analysis, and reporting. Appointments should be based on experience in monitoring and management. The QAP should have the following responsibilities:

General

- Reviewing and endorsing the initial protocols for training, sampling, data storage, data sheets, data analysis, data quality objectives, guidelines for presentation and safety procedures, developed for each biomonitoring index.
- Reviewing the activities and services of the RHP annually, including a critical assessment of whether the recommended protocols for each biomonitoring index are being followed. The group may make suggestions for changing specific procedures or

organisation structures.

- Appointing a Quality Assurance Portfolio Manager, in consultation with the Custodians (DWAF, DEAT & WRC).
- Advising and supporting the Quality Assurance Portfolio Manager when required.
- Endorsing the final draft of this document.

Training

- Appointing, in consultation with the QAP, a Service Provider/s to run an initial biomonitoring training/certification course for Regional Auditors. The training course should aim to standardise procedures, and should include all field and laboratory tasks such as standardised biotope assessments, sampling methods, taxa identification, data storage, data analysis, data presentation and safety procedures. It is recommended that an overseas expert on QC/QA in biomonitoring should be invited to attend and contribute towards the initial training course.
- Appointing, in consultation with the QAP, a Service Provider/s to run periodic biomonitoring training/certification courses for Biomonitors. Each course should include a generic component which deals with aspects of biotope assessment, data storage and reporting, and separate components for invertebrates, fish and riparian vegetation biomonitoring etc. To promote consistency, it is important that these training courses should, as far as possible, be run by the same people and organisation/s from year to year.
- Appointing, in consultation with the QAP, a Service Provider/s to develop a standard, illustrated text to the identification of SASS4 families. The identification guide should be endorsed by the QAP.
- Maintaining a register of certified Biomonitors.
- Although not a priority, it is suggested that a training video for biomonitoring would help to standardise protocols. The training video could be developed by students of journalism as part of their training.

Sampling design

- Providing technical support regarding location of suitable and representative sampling sites, reference conditions, sampling procedures, frequencies and intensities.

Data storage and analysis

- Assisting with the development of a standardised database. Although the development of a database does not form part of QC/QA procedures, certain aspects need to be considered. For example, the database must be compatible with the data sheets. Furthermore, the database should include a system of flagging results which are outside the expected ranges. This would help to reduce errors arising from inaccurate typing. Initial checks on data could include bivariate checks for outliers, and checking that the recorded station exist in the list of recorded stations. Missing data need to be identified, and a policy to deal with missing data adopted (either by deletion of records or by estimating the missing value).

- Checking that regular backups of data are indeed made.
- Selecting performance criteria on which data are accepted or rejected. To prevent false alarms, the performance criteria should be readily available to Auditors.
- Ensuring that expected spatial and temporal variability in biomonitoring results at each site are readily available. This will require the development of standardised statistical analyses for comparative purposes, particularly as time-series data sets are built up.

Reporting

- Critically reviewing Biomonitoring Reports. It is recommended that various reporting formats should be developed to suite different user requirements. The recommended reporting formats should be readily available, preferably on the Internet. Any alterations should be communicated to all interested and affected parties, including Regional Auditors and Biomonitors.

3.4.2 Quality Assurance Portfolio Manager

The success of implementing QC/QA procedures will depend on the coordinating abilities and drive of a suitable manager. The appointment of a competent Quality Assurance Portfolio Manager is therefore critical to the success of the RHP. The Quality Assurance Portfolio Manager should be responsible for coordinating all QC/QA activities of the RHP at a national level. The person should be appointed by the Custodians and the proposed Quality Assurance Portfolio. The appointment should be based on experience in project management and biomonitoring. The Quality Assurance Portfolio Manager should have the following responsibilities:

- Coordinating the QA/QC activities of the RHP at the national level.
- Appointing and coordinating the activities of the Regional Auditors.
- Performing periodic cross-checks with Regional Auditors to promote regional consistency and verify that protocols are followed.
- Designing standard field data sheets and sampling protocols for use by Biomonitors.

Only data which are directly relevant to the biomonitoring indices and their interpretation should be collected. The data sheets and sampling protocols should be endorsed by the QAP. The data sheets and protocols should be readily available, preferably on the Internet. Alterations to these sheets should not be undertaken unless absolutely necessary. Alternations should be communicated to all interested and affected parties, including all registered Regional Auditors and Biomonitors.

- Designing standard auditing sheets to be used by Regional Auditors in their evaluations of the performance of Biomonitors. The auditing sheets should be endorsed by the QAP.
- Testing biomonitoring protocols by using different experts to assess the conditions at the same site and time, and then comparing the results.
- Promoting and coordinating studies to test the performance criteria of different biomonitoring methods and protocols. Performance criteria include precision, accuracy, bias, sampling effort, performance range and resolution. For example, a comparison of SASS4 results obtained from live-sorting and laboratory sorting would allow either protocol to be used to suite different user objectives.
- Keeping records of auditing activities.
- Reporting QC/QA activities, together with recommendations for remedial action, at least annually to the QAP, Regional Auditors and Biomonitors. The report should include all changes in procedure. The report should be critically reviewed by the QAP before distribution.

3.4.3 Regional Auditors

The functions of Regional Auditors are to monitor and critically review the biomonitoring activities of Biomonitors so as to detect problems at an early stage, recommend remedial action before the programme is detrimentally affected, and edit reports and other outputs. Regional Auditors should be experts in their field, and so different auditors will be required for invertebrates, fish, riparian vegetation etc. Auditors who are also registered Biomonitors should have their biomonitoring activities monitored by Auditors from other regions. Regional Auditors should be accountable to the Quality Assurance Portfolio Manager. The appointment of Regional Auditors should be based on the successful completion of a biomonitoring course. Regional Auditors should have the following responsibilities:

- Keeping records of the activities and performance of Biomonitors. Particular attention should be paid to the efficiency of different operators in selecting representative sites, sampling representative biotopes and adhering to standard protocols.

- Undertaking periodic field audits to check on sampling methods, sampling effort, efficacy, data recording, equipment calibration, state of equipment and accuracy of taxonomic identifications, filing methods, accuracy of data storage, methods of analysis and data presentation. It is suggested that 10% of samples collected by each Biomonitor should be audited. The final scores produced by the Auditor and the Biomonitor should not differ by more than a certain percentage, stipulated in the protocols for each biomonitoring index.
- Quantifying the taxonomic accuracy of field identifications by measuring the frequency of missed taxa or taxa incorrectly identified. This would entail sampling the same areas as sampled by the Biomonitors, and comparing results.
- Recommending remedial action in cases where the performance of Biomonitors is sub-standard. Typical remedial actions include training in the identification of certain taxa, training in collection of samples, renewal of equipment, reworking some or all of the samples, scrapping some or all of the data or flagging data to indicate that their quality is low.
- Undertake spot checks to ensure that raw data are correctly transcribed to data bases.
- Tagging data in database as being quality controlled.
- Editing reports and other outputs produced by senior Biomonitors.
- Reporting the results of audits to Biomonitors and the Quality Assurance Portfolio Manager. The reports should include recommendations of appropriate remedial action in the event of data quality rejections.

3.4.4 Biomonitors

Biomonitors are the people who collect, analyse, interpret and report biomonitoring data. Since the collection of biomonitoring data requires fewer skills than analysis, interpretation and reporting, it is suggested that a distinction should be made between junior and senior Biomonitors. Both junior and senior Biomonitors should attend and successfully complete a certified course in biomonitoring. Separate courses should be held for each biomonitoring Index. Senior Biomonitors should, in addition, be qualified biologists, with a university level degree. Biomonitoring should therefore be undertaken only by individuals which are certified by the QAP to do so. This means that experienced biologists who have not completed a certified biomonitoring training course should not be able to undertake biomonitoring for the RHP. Prerequisites for attending a biomonitoring course should include good eyesight, legible hand writing, a driver's license and ability to swim.

It is recommended that withdrawal of a biomonitor's certification should be considered following gross misconduct, such as fraudulence, or if remedial action recommended by the regional auditor fails to improve data quality. Expulsion should be decided in a disciplinary hearing attended by one or more Regional Auditors, a representative of the QAP and the "accused" biomonitor. Suggested responsibilities of Biomonitors (junior and senior), on which they should be evaluated, are listed below.

- Adhering to biomonitoring protocols recommended by the QAP.
- Planning field trips and communicating intention to sample to the Regional Auditor well in advance so that Regional Auditors can plan schedules for auditing.
- Selecting biotopes which are representative of the river in the area or zone being sampled.
- Following standard protocols regarding sampling effort.
- Following standard protocols regarding biotope assessment.
- Using approved equipment.
- Maintaining and calibrating equipment (eg fixing nets with holes).
- Preserving, labelling and storing samples adequately for auditing purposes and later reference.
- Using standard data recording sheets, and completing data sheet adequately, including additional information that may be important for data interpretation (eg recent hail storm, floods etc).
- Identifying taxa correctly.
- Communicating biomonitoring activities and results to the Regional Auditors on a regular basis.
- Assisting Regional Auditors in locating stored specimens, data files, equipment and other items required for auditing purposes.
- For SASS4 biomonitoring, samples from each site-visit should be retained for auditing purposes. In the absence of preserved samples there is no way of verifying results, and no way of identifying at which point problems may have occurred. It is not necessary for each specimen to placed in a separate bottle - it is sufficient that all specimens from a single biotope and site can be placed together in a sealed and labelled plastic bottle or envelope.
- For SASS4 biomonitoring, voucher specimens for each region should be kept. Voucher specimens may not be needed from sites that are sampled regularly and where the fauna is well known. Initially, the responsibility for curating and cataloguing voucher samples will reside with biomonitors. However, it is recommended that samples should be transferred from time to time to central sites, such as the Albany Museum, for permanent curation.

Senior Biomonitors only

- Storing data for easy retrieval by others.
- Using appropriate methods for data analysis.
- Interpreting data.
- Linking results to hydrological and water quality data.
- Reporting biomonitoring results to relevant parties, including Regional Auditors, in a format appropriate to suite user requirements.
- Coordinating Intra-laboratory Proficiency Testing, in which sites are re-sampled by a different Biomonitors within 48 hours, and the results compared.
- Raw data should be made available for reanalysis by Regional Auditors and for use by others as required. (Appropriate formats should be developed by the Quality Assurance Portfolio Manager).

3.5 ACKNOWLEDGEMENTS

The chapter is based on the guidelines for QA developed by the US Environmental Protection Agency (USEPA, 1995), the Australian Monitoring River Health Initiative (Storey & Humphrey, 1997), a review of QC/QA procedures used for biomonitoring in other parts of the world, as well as correspondence with various experts on the subject. In particular, I thank Drs Richard Norris, Chris Humphrey (Australia) and Micheal Barbour (USA) for their suggestions and access to reports, and the following for their comments on an earlier draft of this report: Dr Mark Chutter (AfriDev Consultants), Dr Jenny Day (University of Cape Town), Dr Chris Dickens (Umgeni Water Board), Mr Gerhardt Diedericks (Environmental Biomonitoring Services) and Dr Dirk Roux (CSIR).

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CHAPTER 4 - DEVELOPMENT OF SOCIAL TOOLS FOR THE RIVER HEALTH PROGRAMME

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4.1 INTRODUCTION

Water is a natural resource that filters through all aspects of human life (DWAF, 1997). Different sectors of society use water for diverse applications, including social (drinking, sanitation, etc.), economic (farming, industrial, etc.) and environmental. Many communities situated within catchment areas depend entirely on the rivers for their water needs. But the use of the resource often has negative impacts on its physical, chemical or biological properties, thus rendering it less fit to sustain other lives. Most noteworthy is the negative effect that such use can have on the aquatic ecosystem; altering the habitat of a variety of fish species, amphibians, aquatic plants, invertebrates and micro-organisms.

Though the initiative to protect the aquatic ecosystem is intended to involve a wide and diverse group of people - from river ecologists, water resource managers and industrialists, through to communities situated in priority catchments - it remains an ambiguous concept to many communities. The challenge facing everyone responsible for protecting this resource lies in ensuring its sustainable use and management. Coupled with this is an understanding of the variables that contribute to the modification of the resource.

Not everyone shares the understanding that water is a non-renewable resource that must be safeguarded - not only against pollution but against stress also. Such understanding, or lack of understanding, is a product of the social circumstances in which individuals or groups of people find themselves. The purpose of this chapter is twofold, namely:

- to provide an overview of the processes followed to establish the role that the River Health Programme (RHP) is likely to play in local circumstances where the scientific and technical knowledge is limited; and
- to use the lessons emanating from community-based activities undertaken as part of the development of an information management system for the implementation of the RHP. Specifically, these lessons were used to:
    - develop "social tools" for use by water resource managers during the implementation of the biomonitoring programme;
    - suggest biomonitoring and other interventions that are likely to raise the awareness of local communities and motivate them to participate in the conservation of the aquatic ecosystem.

4.2 A COMMUNITY-BASED PROJECT

4.2.1 Background

The Sabie River catchment in Mpumalanga Province and the Sand-Vet catchment in the Free State Province were selected as the priority catchments within which to establish community-based RHP projects and to gather information on local circumstances so as to enhance the implementation of the biomonitoring programme. Towards the end of 1997 a working group was established to determine the scope of work for the project. At the time, most of the RHP activities were gaining momentum in Mpumalanga Province. Although it was anticipated that the outcome of the project would form part of the national programme, for practical reasons the working group was drawn from organisations participating in the Mpumalanga RHP pilot project, and it was also among these that the greater portion of the community-based project activities were established.

Members of the working group were chosen from the Mpumalanga Department of Environmental Affairs and Tourism (Environmental Education Section - DEAT/EE), the Mpumalanga Parks Board, the Kruger National Park (Social Ecology Section - KNP/SE), the CSIR (Environmentek), the DWAF's Institute for Water Quality Services (IWQS) and Manyaka Greyling Meiring (Pty) Ltd. The project was named "Grassroots Communication and Environmental Education" (the GCEE).

The goal of the GCEE is to develop appropriate means of associating the technically oriented biomonitoring approaches (top-down) with community-based methods of conservation (bottom-up) so as to advance the RHP.

Immediate objectives of the GCEE are to:

- identify and link up with communities situated in priority catchments to inform them about the RHP;
- interact with these communities in order to gain a first-hand understanding of the relationship between these communities and the catchment;
- use the lessons learned from these interactions to develop appropriate interventions to be used in the implementation of the programme.

4.2.2 Information Gathering Through Case Studies

The establishment of the GCEE was preceded by a search for, and appraisal of, literature on local community-based biomonitoring projects. Although the literature search was not by any means exhaustive, no information on successfully implemented local community-based water resource management projects was to be found. Information gathered from other countries was useful in comparing the local situation with other similar circumstances elsewhere in the world. Thus was a need for more local information on the use and protection of the water resource identified.

Three communities were identified and selected as case studies for the project. One in the Sabie River catchment and the other two in the Sand-Vet catchment. A participatory mapping approach was employed to introduce the RHP and to gather information related to the local use of the water resource. A participatory mapping exercise is a comprehensive, multifaceted situational analysis exercise whereby participants validate local information through graphic illustrations (IIED, 1995). It starts of with the determination of the boundaries separating the participating community from the neighbouring communities. After confirming the demarcations, the group carrying out the exercise identifies all assets and natural resources, physical features, infrastructure and other utilities within its community. Finally, the group identifies and prioritises community needs. An important rule of the exercise is that it is conducted by the local people themselves and no decision on the inventory is passed without sufficient consensus from all participants. All information must reflect the true status of the community.

Cork Trust community

Cork Trust community is predominantly rural. It is located on the border of the Northern Province, approximately 15km from the Kruger National Park's Skukuza Gate and about 30km from Hazyview in Mpumalanga Province. It has a population estimated at 11 700 people hailing from approximately 1 300 households, with an average of nine people per household. Out of the total estimated population, the youth between the age of eight and 19 years are estimated at 4 000, while pensioners are estimated at 500 (Table 1). The level of unemployment is estimated at 70%. The majority of those working are employed in the public and private sector. The percentage of those employed in the private sector could not be established, but there is a significant dependence on remittances from the migrant labour system. The literacy level is also very low. A predominant skill is teaching, followed to a lesser extent by nursing. A very small percentage of people are employed in the KNP. There is a substantial pool of youth at pre- and post-matriculation level and who have no immediately applicable skills nor any source of employment.

Like many rural communities, the Cork Trust community is lacking in essential infrastructure in the form of roads, communication, commercial services, health care facilities and education. There are two pre-primary schools, two primary schools and one secondary school. The community gets its food supplies from four local restaurants. There is a motel which is hardly utilised, either by the locals or by tourists in transit to the KNP (Table 2).

Table 4.1 Social inventory of Cork Trust community.

Households and people	Numbers
Number of stands/sites	1300
Total population	11700
Average number of people/household	9
The population figure includes ±4 000 youths between the age of 8 and 19 who are school attenders and ±500 pensioners.	

Table 4.2 Physical infrastructure.

Infrastructure	Numbers
Schools: Primary Schools High School Pre-Schools	212
Restaurants	4
Motels/Hotels	1

(NB: Information in the two tables was generated by the CRDC through the participatory mapping exercise)

Members of the working group consulted with the main tribal authority in the region and permission was granted to consult with the selected community through the local headman. He was approached and the RHP concept was introduced to him. He advised the group to consult with community-based coordinating structures in the form of the Community Reconstruction and Development Committee (CRDC), a body where all community-based structures are represented.

A series of meetings took place with the Cork Trust CRDC, firstly to develop a relationship between the CRDC and the working group, and secondly to inform them and discuss the programme and its objective with them. At the participatory mapping sessions and other workshops information was disseminated and members of the CRDC were given an opportunity to ask questions on issues they did not understand. Furthermore, the CRDC participated in, and was exposed to, biomonitoring activities (SASS in particular).

Dinabo and Bloudrif communities

Dinabo and Bloudrif are very small communities situated in the Sand-Vet catchment and having a combined population of fewer than 200 households. The socio-economic and cultural aspects of the two communities differ considerably from those of Cork Trust community. A comprehensive profile of these communities could not be established, primarily because it was difficult to identify legitimate community leaders with whom to discuss the project. Secondly, people in both communities were unreceptive. Unlike the Cork Trust community these communities are not permanent rural communities and do not, therefore, have security of tenure. Community members can, in fact, be classified as labour tenants because the land they occupy belongs to white farmers and, apparently, each household pays rental. Thirdly, most of the people living in the two communities are migrant labourers from Lesotho. A good number are without work permits and do not, therefore, speak openly to strangers.

4.2.3 Situation Analysis

In the 1970s and 1980s South Africa witnessed the rise of a plethora of non-governmental organisations (NGOs) and a spate of "integrated rural development" projects in the former homelands and self-governing states. Most of the NGOs were opposed to what was perceived as an anti-social, imposed, and top-down development approach by government officials. They demonstrated their opposition by adopting a hard-line approach towards them. Government-initiated projects were accused of lacking an understanding of, and an empathy with, local people's circumstances (social, economic and political). Most were accused of being biassed towards the aesthetic value of the natural resource, including water, and not towards the needs of the people using it. The NGOs argued that the philosophy underlying government's approach was that "water as a public good is best served by being protected", even if this meant setting limitations on its use (Pimbert *et al.* 1995). As a result, most NGOs vilified government and research organisations for their approach of protecting the resources while giving no due consideration to the people who depend on them.

In contrast, the NGOs' approach to community development was bottom-up; mobilising and involving target communities in the planning and implementation of own development projects. Unfortunately, and due to their focus being on social development, most of the NGOs lacked conservation skills. As a result, the enthusiasm with which they implemented community projects failed to address water resource management issues at local level. Whereas grassroots communities exploit natural resources (food, energy, farming, etc) for their livelihood, community development facilitators' predominant attitude was that these resources must be used unreservedly to benefit the communities.

Communities' response to the RHP

The River Health Programme (RHP) was the first DWAF project to be introduced to the communities of Cork Trust, Dinabo and Bloudrif. The communities' first reaction was joyful in that they thought the programme would supply them with water. However, when it was discovered that the programme is not about water supply, a feeling of disappointment set in and many community concerns regarding past experiences with other projects were raised. The CRDC posed a fundamental question: How different is the RHP from past projects introduced to the community? Because of the poor reception and the suspicions, members of Dinabo and Bloudrif communities were fearful to speak openly to strangers about the local situation. Thus it was difficult to assess the communities' perception of the RHP. We were also cautious not to force them to speak to us since this would have ruined whatever chance we had of establishing a relationship with them.

The following were the main issues of concern that were raised, mainly by the Cork Trust CRDC:

- what benefit will the community reap from its involvement in the RHP?
- will the programme provide the community with water?
- will the programme create jobs for local people?

Communities' use of the water resource

Through the interaction with all three communities we succeeded in establishing each community's use of the river. Although their water needs and uses are not different from those stated in the National Water Act (DWAF, 1998), there are other interesting uses of the rivers that have not been captured in the National Water Act and which need to be considered in future.

Cork Trust community derives 80% of its water needs from the Sabie River while the Dinabo and Bloudrif communities depend entirely on the Sand River. Water from these rivers is used by the community for consumption. The communities also use the river for recreation and for small-scale farming. Local women use the river for domestic washing. These communities are not the only communities that use the Sabie and Sand rivers - communities upstream and downstream also use the resource. The activities of upstream communities pose problems for these communities equally as much as their own activities present health and environmental problems to communities down stream.

The following are problems experienced by these communities with regard to access to the resource:

- The Sabie River is infested with crocodiles. The CRDC reported that a number of people had lost their lives to the crocodiles. Victims are both men and women attacked when fetching water or bathing in the river. The river is also a source of water and a grazing area for domestic animals, and they too fall prey to the crocodiles.
- Often the communities would come across excrement in the river. In the Sabie river the community lays the blames for this on the Sewage Works at Mkhuhlu. They allege that water containing raw sewage is often released into the river and flows downstream.
- The Sabie River is a source of income and food to those families that do not have an alternative source of livelihood. This was demonstrated by the negative reaction of the CRDC when members of the technical team requested that the community report any dead fish floating in the river to the local environmental officer. The CRDC made it clear that, by the time the officer received such a report, the dead fish would already have been eaten. A dead fish represents food to the community - irrespective of the circumstances surrounding its death. It was clear to the scientists that no normal member of the community would choose to starve because of need to establish the cause of death of a fish.
- The CRDC indicated that the Sabie river is often infested with mosquitoes, especially during summer. It is common knowledge that certain mosquito bites causes malaria - a disease that is common near the Kruger National Park.

Unconstituted use of water

The Sand River has a special significance to the Bloudrif and Dinabo communities. It is not only used to meet the normal needs for washing, bathing and farming, but also to meet the community's religious and spiritual needs. This is an important water use that Chapter 4 of the National Water Act has not sufficiently prescribed. Various community groupings in the two communities use the Sand River for religious worship, traditional rituals and cultural devotions.

Traditional communities believe in the powers of ancestral spirits, and that their lives are influenced and determined by the spirits of departed family members. They believe that the deceased spirits are watching over them and react to incidents resulting from their behaviour on earth. Furthermore, it is believed that the spirits have the power to impose their wishes on the living souls. It is believed, for example, that the spirit of an ancestor who was a "sangoma" might wish that one of his or her grandchildren also become a "sangoma". Should the grandchild not fulfil the ancestral wish, he or she may not prosper in his or her work, or a bad spell may befall him or her. The bad spell would be lifted only when he or she has fulfilled the ancestral wishes.

According to the different traditions, satisfying the wishes of the spirits could range from a simple gesture of respect and appeasement to actually becoming the person the spirits want one to be, for example a sangoma or witchdoctor. One of the ways in which these communities appease the spirits is by throwing money, ornaments and traditional accessories into the river. It is believed that when this is done the spirits become satisfied.

A common religious activity is baptism in the river. However, in some cases religious garments and other paraphernalia are left in the river. In one section of the Sand River members of the community have left religious crosses, copper coins, candles and other accessories that suggest that the particular spot is used for both religious worship and for traditional rituals.

4.3 BENEFITS AND LESSONS DERIVED FROM THE INTERACTION

In view of the fact that the RHP will neither provide the community with water nor create jobs for them, the working group suggested to the CRDC other options for meeting community needs. At the meetings held with the CRDC, potential spinoffs from this programme were investigated and a number of alternatives were suggested. Although the interaction could not produce tangible benefits, there are things that the CRDC has learned. Through the participatory mapping exercise, the CRDC:

- was assisted with the amendment of its constitution, thus ensuring that it is in line with the development mandates that it has received from the community;

- was assisted to develop a community profile, to identify and prioritise the community's needs;
- was taught the basic skills behind writing proposals and developing budgets, as well as skills on how to implement, monitor and evaluate community development projects;
- had its awareness of the RHP raised through exposure to the biomonitoring programme and tools such as SASS.

What we have learned from the interaction with communities is that there are two key considerations that determine the involvement of local people in conservation programmes such as the RHP. The first of these is the socio-cultural gap that exists between local communities and proponents of the programme. The second consideration is the extreme knowledge differential inherent between less sophisticated communities and resource managers (Thompson and Joyce, 1997). These are illustrated in Figure 1. Section B in Figure 1 shows the outcome of the interaction with communities in both catchments. In section B a clear distinction is made between the social and economic circumstances that determine the value systems between the local communities and the proponents of the RHP.

The programme needs to be sensitive to the local level concerns reflected in section B to be able to provide (scientifically) relevant information for the management of aquatic ecosystems (section C). What section B shows is that issues relating to the aquatic ecosystem - as dealt with in the RHP - are not a priority to the local people. The main concern in all three communities is livelihood security. That is, the need for water (quantity) irrespective of its quality, and not the impact that the use of the resource has on water organisms. According to the communities, it is only those who have an abundance of resources who concern themselves with the condition of living organisms in the water.

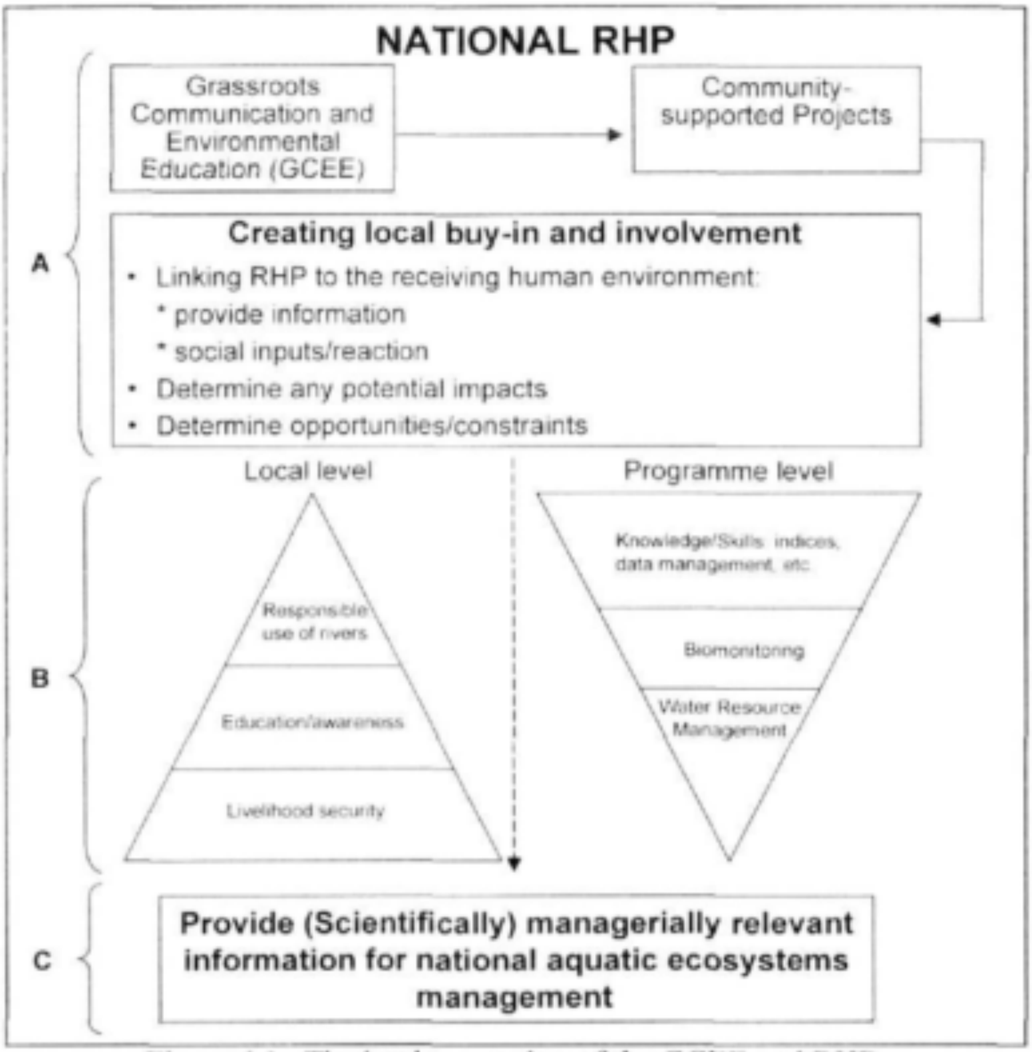

Figure 4.1 The implementation of the GCEE and RHP.

This tells us that, despite the fact that communities living within a catchment have a significant impact on the river, it is not every community that will welcome the River Health Programme. Communities that would participate in the programme without realising some immediate benefit are often difficult to find. This is because communities' interpretation of "projects" and "programmes" is strongly associated with spinoffs such as jobs and other resources. When a project is introduced in an area communities immediately think of the possible jobs that are likely to be generated by the project. Communities find it hard to believe that an organisation can start a project in a community if firstly, it does not have the financial muscle to sustain the project, and secondly, if it is not going to reap large benefits from the project. These perceptions are motivated by the socio-economic conditions that many communities, especially rural ones, find themselves in.

4.4 SKILLS REQUIRED FOR APPROACHING AND WORKING WITH COMMUNITIES

Sustainability and equity are fundamental principles that underpin the protection, use, development, conservation, management and control of the water resource (DWAF, 1998). These are principles that must be upheld and implemented by all users. Because of the disparities of the past, there are other fundamental issues that need to be dealt with before an appreciation of the above principles can be established in some people's minds. In the case of community involvement in the RHP, a relationship must first be established. An RHP-community relationship begins the day a water resource manager is appointed to manage a catchment. A harmonious and sustainable relationship between the community and the water ecologists or water resource manager will be determined by the approach and attitude displayed towards the two parties.

4.4.1 Identify the target community

The following criteria may be used in the identification and selection of a suitable community to implement the biomonitoring programme with. This approach is followed with the view that, should the community become involved, it will serve as a model community to other neighbouring communities:

Close proximity to a river

Only those communities closest to a chosen river may be identified and screened for the programme. The one community closest to the river may be selected and negotiations with the local leadership undertaken. The rationale behind selecting the community closest to the river is that:

- this community is the one likely to be using the resource more than the others and is the one which has far-reaching impacts on the resource;
- it will be cost effective to get members of the community to the river during field visits or other biomonitoring-related activities.

Willingness and ability to participate

In the discussions with the legitimate community leadership it is important to establish its willingness and ability to participate in the programme. The willingness and ability to participate in the programme can be determined only in the initial stages of contact and consultation with the community, especially during the introductory stages.

4.4.2 Contact and Consult with Selected Communities

Acquiring the necessary "social skills" to interact with communities before and during the implementation of the RHP is essential. Without a knowledge of the socio-cultural traits of communities in the priority catchment, as well as their concerns and fears, water resource managers may unintentionally provoke conflict and give rise to negative consequences for all parties (Thompson and Joyce, 1997). It is always important to remember that, although these communities may be less sophisticated, they still have their community pride and this should be respected. Their rights, both real and perceived, must be recognised.

The following are some of the tools resource managers need to have with them when approaching and dealing with local communities:

Introductory stage

At this stage the water ecologist or resource manager will have identified and selected the community closest to the river. An important principle to always remember is that you are an *outsider. Therefore you do not have local knowledge of the area and its conditions. The* following are guidelines on how to liaise and consult with the target community:

- Identify legitimate leaders, consult with them and listen with an open mind to their concerns (e.g., women's concerns about water), fears (e.g., death by crocodiles and restrictions), and their local circumstances (environment and development). It is only by accepting how communities think and what they value, and understanding what kind of environment the people aspire to, that you will be able to design a programme that will be sensitive to those aspirations.
- Let your hosts introduce you to the community leadership. After you have been introduced, wait to be given an opportunity to speak. Introduce yourself and your organisation properly. Raise your voice and do not speak fast. If you cannot speak the local language, have someone interpret for you. Be composed and never be overly friendly.
- Explain in detail the objectives of your visit and why you have chosen this community in particular.

- Explain the difference between biomonitoring and water supply. Most importantly, explain what will happen to the resource if the community does not use it responsibly. Be genuine about this, but without imposing.
- Enquire about other community-based structures that may not be represented on the leadership structure. It is important that the resource manager establish the presence of any minority or subservient group such as women and youth groups.
- Inform the community leaders that you are not here to create a rift but to introduce a programme that will help them conserve an important resource that everyone depends on. Remember that the community will be expecting tangible benefits such as jobs. If the programme is not likely to offer these, state this up front so that you do not create unrealistic expectations.
- Explain the approach that will be followed in the programme and how the community will fit in and become involved.

Consultation stage

At this point you will be in your second or third meeting with the community leadership. By now you will have a good sense of the leadership's attitude and whether it is willing to become involved. After the second meeting you can raise the following aspects:

- Propose the establishment of a (voluntary) working committee to advice on community involvement in the programme. Emphasise that the body should be representative of all community structures and have a good gender balance. Propose that it be inclusive of the youth and disabled persons.
- On agreement, jointly develop a work programme for the establishment of the group and its capacity building. A series of meetings will be required to establish the correct understanding of the programme so as to avoid confusion and conflict later in the programme.
- Suggest a series of workshops, training sessions and site visits to familiarise the group with the concept and issues it addresses.
- Allow the group to set up protocol and guidelines.
- Establish other requirements before commencing with the biomonitoring programme.
- Let the community know that you can contribute by linking them up with other programmes within the DWAF, such as Water Supply and Sanitation, to help them in the area of water supply.
- On the first day any female field workers or researchers should refrain from wearing trousers. At this meeting ask if it will be acceptable for female workers to wear

trousers and give reasons why this is advisable and/or necessary.

Before commencing with the implementation, suggest that one or two broader community meetings be held so that you can establish contact with the community. These meetings must be arranged and coordinated by the committee. The committee must advise on suitable days, times and venues. Such meetings must, however, be held in the village. As a matter of principle:

- Adhere to all agreements and guidelines;
- Establish and maintain a good relationship between yourself, your organisation and the community;
- Involve the working committee in specific biomonitoring issues of relevance to the community, and empower the working committee to play a meaningful role;
- Keep the traditional leadership and working committee informed of the development;
- Discuss any change in the scope of work with the working committee and the traditional leadership. Should a need arise to start work earlier than planned, inform the leadership and committee in advance;
- Announce the arrival of the technical teams and also the work that they are coming to perform. Inform the traditional authority and working committee and discuss with them the significance of what the teams are coming to do. Inform them of the time envisaged as necessary for them to do what they have to do.
- Arrive at committee or community meetings on scheduled days, on time and not before or after. Announce your arrival to the working committee or the local headman with full knowledge of the committee. Do not make any promises that you may not be able to fulfil within the scope and limitations of the programme.

4.4.3 Follow local rules and customs

Acquiring and implementing the above skills provides one with a good understanding of the local circumstances and affords one an opportunity to be objective when dealing with local people. Not only does one become aware of tribal and cultural differences within the community, but one also appreciates the differences between one's own community and the community being studied.

By following the rules and protocols set for the programme one remains objective and is unlikely to be seen as having taken sides should a conflict arise in the committee or community.

By working closely with the community - and not showing an attitude that might suggest that one shuns them - one will learn a lot about the traditional and customary ways of conserving the natural resource. A harmonious relationship will develop and from this the community will acquire a basic knowledge of the aquatic ecosystem.

4.5 CONCLUSION

In rural areas there is a strong attachment to rivers and catchments because these are sources of livelihood. However, such areas are characterised by poverty and environmental degradation. Due to the levels and extent of poverty in the rural areas, it is only logical to say that the need for water supply in these areas overwhelms the need to preserve the resource. Throughout the entire consultation process, female members of the communities intimated that they would support and participate in the RHP only if it were to provide them with water. The women were clear in their requirements and they used this argument to negotiate their involvement in the programme. The people did not, and still do not, understand why the government should invest resources in the protection of water resources for the benefits of "insignificant" aquatic animals, rather than in the development of people. A clear message from the communities is that they would not care for the lives of water insects and animals when their own human survival was at stake. It would therefore be naive and irresponsible of the RHP to expect local communities to participate in the programme without their being benefits in it for them.

The White Paper on a National Water Policy for South Africa states that, of all natural resources, water is without doubt the one that permeates most deeply into all aspects of our life (DWAF, 1997). Water resource managers cannot successfully manage the resource by themselves. Local communities as stakeholders must be involved right from the beginning; from the planning stage to the implementation stage. In order to bring a holistic approach to the programme, traditional, community-based and scientific resource management techniques must be infused. This will ensure that the responsibility and accountability of managing the resource rests not only with the water resource managers alone, but also with all stakeholders in the area (Pimbert *et al.* 1995). Such sharing of responsibility will mean that the local stakeholders are introduced to the existing technical and scientific means of managing the resource.

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CHAPTER 5 - ADAPTIVE ASSESSMENT AND MANAGEMENT OF RIVERINE ECOSYSTEMS: THE CROCODILE/ELANDS RIVER CASE STUDY

DJ Roux, CJ Kleynhans, C Thirion, L Hill, JS Engelbrecht, AR Deacon and NP Kemper

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5.1 INTRODUCTION

For the RHP to become truly operational as a management information system, a step-wise procedure must be in place for linking the collected data and derived information with management actions. Therefore, in addition and parallel to protocols for site selection and indices with which to measure ecological condition, mechanisms must be developed for assessing the monitoring results in the context of management objectives, as well as for deciding on appropriate management activities.

To facilitate these parallel and interdependent initiatives, prototypes of both the monitoring methods and the step-wise procedure need to be tested in pilot exercises. By generating real data through pilot applications, a high degree of alignment and synergy between technical programme components can be encouraged. Such data are also essential for the construction of a systematic procedure for linking monitoring, assessment and management outputs.

Considerable attention has and is being given to the conceptual development and practical testing of the technical components of the RHP. Examples include the development of a protocol for the selection of monitoring sites (Eekhout *et al.*, 1996), indices for assessing the condition of communities of fish (Kleynhans, 1999) and riparian vegetation (Kemper, 1998), as well as for establishing natural baseline conditions for aquatic invertebrates (Dallas, 1999). However, no formal procedure has been suggested for linking the information output of the programme with management decisions.

Note that the word procedure, as used in this chapter, refers to a set of steps that needs to be performed in order to achieve a certain outcome. The outcome is to establish a closed loop between the monitoring, assessment and management of the ecological state of riverine ecosystems. Each step may consist of one or more protocols or methods.

This chapter proposes a procedure which enables managers to respond to the results of the RHP. The procedure is demonstrated by applying existing data, obtained through pilot application of the RHP on the Crocodile and Elands Rivers (Mpumalanga). Emphasis is on the links between the different steps and the continuity provided by the overall procedure, rather than on the detail of protocols used within each step. Prototype outcomes of each step are, however, used for demonstrative purposes.

5.2 THE ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (AEAM) APPROACH

5.2.1 Theory of Adaptive Environmental Assessment and Management

Managers of natural resources are confronted with the complexity of ecosystems, including long-term ecological processes, unpredictable natural disturbances and human influence. Even with the best available science, complete answers to all management questions will not be attainable. In fact, every change in environmental policy and management action presents a perturbation experiment with highly uncertain outcome. Thus, in no place can we claim to predict with absolute certainty either the ecological impact of cumulative stresses, or the efficacy of most measures aimed at regulating these stresses (Walters and Holling, 1990).

It follows that the management of ecosystems involves unpredictability and uncertainty. A given of modern living is that resource managers must make decisions despite incomplete information about how ecosystems function and react. They manage under uncertainties, which inevitably leads to some mistakes being made. The essential point is that dynamic resource management systems and policies are required to effectively react to our continually improving understanding of evolving ecosystem conditions; thereby providing flexibility for adapting to change and surprises (Holling, 1995).

The need for flexibility, in terms of ongoing learning and associated adaptation, in natural resource management led to the notion of adaptive environmental assessment and management (AEAM) (Holling, 1978). AEAM implies that successful ecosystem management depends on learning about the system while managing it.

In applying AEAM, resource management is essentially treated as an adaptive learning process where management activities themselves are viewed as the primary tools for experimentation. AEAM is an iterative process that includes collecting data, setting goals, modelling the effects of management options on ecological and social attributes, monitoring outcomes, and revising the management plan. When properly integrated, the process is continuous and cyclic; components of the adaptive management model evolve as information is gained and social and ecological systems change (Haney and Power, 1996).

5.2.2 A Procedure for Adaptive Assessment and Management of Aquatic Ecosystems

The concept of AEAM was used as the basis for developing a systematic procedure for responding to the monitoring results of the RHP (Figure 5.1). The step-wise procedure links the collection and assessment of data through the RHP, in a structured and consistent way, with water resource management decisions. The overall goal of the procedure in this context is to facilitate environmentally sustainable development of riverine ecosystems at a high level, in line with the National Water Act (Act No 36 of 1998).

Effective implementation of the RHP design will provide for the ecosystem monitoring (data collection) (Figure 5.1). The remainder of this chapter is concerned with developing the links between monitoring and ecosystem assessment (information generation) and ecosystem management (making and execution of decisions). The nature of the outputs required from, as well as the links between, individual steps shown in Figure 5.1 are demonstrated through applying the RHP survey results from the Crocodile and Elands Rivers.

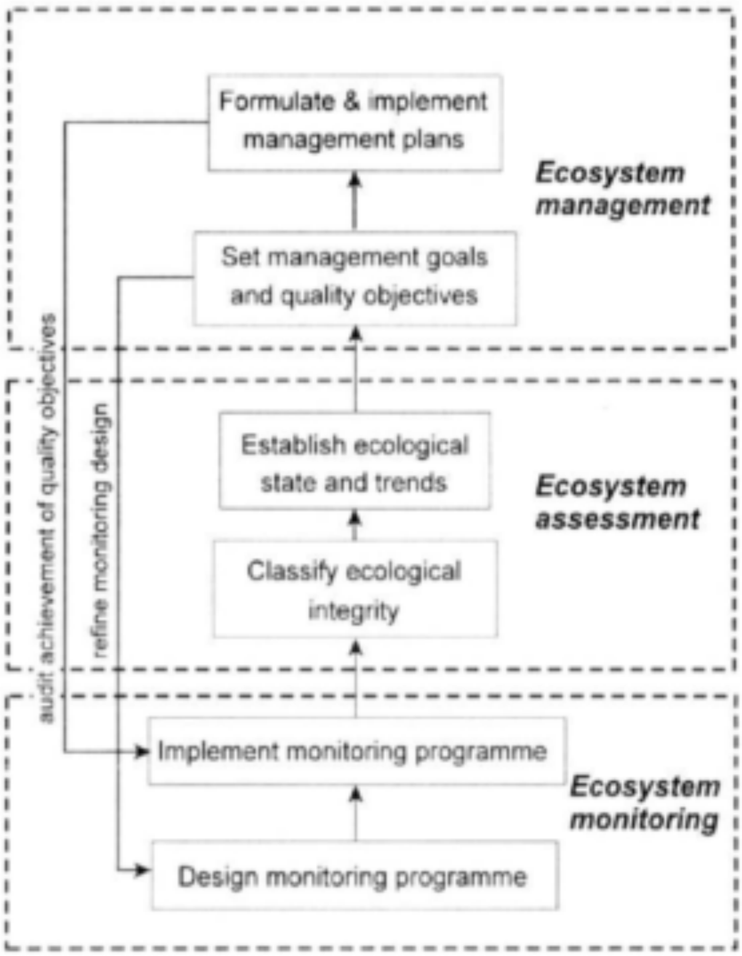

Figure 5.1 The AEAM procedure, as developed for application in the RHP context.

5.3 STUDY AREA AND BIOLOGICAL INDICES USED

5.3.1 Study Area

The Crocodile River is, from an ecological point of view, one of the most important rivers in the country. The river is characterised by a broad range of riverine habitats, ranging from cold mountain streams in the Drakensberg to the slow flowing warm waters where the river meanders through the Lowveld. As a result of the diverse habitats, the river is also one of the most biologically diverse systems in South Africa, with at least 49 fish species occurring here (State of the Crocodile River, 1998). Apart from its ecological importance, the Crocodile River is also one of the most economically productive catchments in the country (DWAF, 1995).

Figure 5.2 Map of the study area.

The Crocodile River catchment has an area of 10 440 km² (Figure 5.2). The river rises at an altitude of approximately 2 000 m a.s.l. near Dullstroom in the Steenkampsberg Mountains. The upper catchment consists of steep-sided valleys, often with sharply defined cliff slopes on the eastern edge of the escarpment. From the escarpment, the Crocodile River levels out into the basin of the Kwena Dam. Downstream of Kwena Dam, the river winds along the valleys of the Drakensberg Mountains (Schoemanskloof) to Montrose Falls and the confluence of the Elands River.

The Elands River, a tributary of the Crocodile River, rises in a gently sloping Highveld zone near the town of Machadodorp. Downstream of its source, the Elands River has a steeper gradient for most of its length, and is characterised by exceptional riffle and rapid habitats. It joins the Crocodile River 2 km downstream of the Montrose Falls.

Between Montrose Falls and Nelspruit, the Crocodile River is slightly incised into a broad, flat-bottomed valley. Further downstream, steep-sided river banks are densely colonized with riparian vegetation and reedbeds, before the river flows through a gorge immediately upstream of the confluence with the Kaap River. Downstream of its confluence with the Kaap River, the gradient of the Crocodile River flattens out until its confluence with the Komati River at the town of Komatipoort. In this zone the Crocodile River forms meanders, incised into a wide sandy river bed. In other sections the river flows through multiple bedrock channels. From the town of Malelane and further downstream, the river also forms the southern boundary of the Kruger National Park.

5.3.2 Biological Indices Used

Indices were used to measure community attributes of fish, aquatic invertebrates and riparian vegetation on the Crocodile River.

Fish Assemblage Integrity Index (FAII) - This index is based on a categorisation of a fish community according to an intolerance rating which takes into account trophic preference and specialisation, habitat preference and specialisation, requirement for flowing water during different life-stages, and association with habitats with unmodified water quality. Results of the FAII are expressed as a ratio of observed conditions versus condition that would have been expected in the absence of human impacts (Kleynhans, 1999).

South African Scoring System (SASS) - This index, based on the presence of families of aquatic macroinvertebrates and their perceived sensitivity to water quality changes, is currently in its fourth stage of development (Chutter, 1998). SASS has been tested and is used widely in South Africa as a biological index of water quality (e.g. Dallas, 1997 and Thirion, 1998). SASS results are expressed both as an index score (SASS score) and the average score per recorded taxon (ASPT value).

Riparian Vegetation Index (RVI) - This index is under development, and the prototype used for this survey represents a slight modification from the method developed by Kemper (1994). The RVI determines the status of riparian vegetation within river segments based on the qualitative assessment of a number of criteria (vegetation removal, cultivation, construction, inundation, erosion/sedimentation and exotic species) in the riparian zone.

5.4 ECOSYSTEM ASSESSMENT

The ecosystem assessment component of the AEAM framework deals with interpreting the data which were collected during monitoring (Figure 5.1). In the context of the RHP, these assessments aim at expressing the degree of modification to the ecological integrity that exists in a particular section of a river.

The assessment component consists of two steps, namely:

- to classify ecological integrity - establish a reference classification for varying degrees of modification to the integrity of the ecosystem(s) to be assessed, and
- to establish ecological state and trends - determine the present degree of modification to the integrity of each ecosystem in relation to the reference classification.

5.4.1 Classify Ecological Integrity

Demarcating riverine ecosystems

The biological and habitat information generated by the RHP allow the classification of riverine ecosystems, based on the degree of modification relative to natural benchmark conditions. The natural benchmark, per ecological indicator group, is defined as the set of conditions which can be expected in the absence of human impacts. This definition is compatible with the concept of ecological integrity (Kleynhans, 1996), and implies that benchmark conditions are specific to a particular riverine ecosystem. The benchmark condition does not imply a stable state, and should reflect natural variation over time.

The spatial scale selected for distinguishing between different riverine ecosystems will depend on the specifications of the monitoring programme of concern. In other words, two neighbouring pools in a river can be regarded as separate ecosystems, or two neighbouring river systems can be regarded as separate ecosystems. Results from the RHP are intended to provide insight into the relative degree of impairment of, or impact on, a section of a river as an ecological unit. The delineation of such homogeneous sections needs to be defined in a sound and systematic manner.

A multi-level hierarchical system is being developed for the typing of rivers in South Africa (DWAF, 1998; Kleynhans *et al.*, 1998c; Kleynhans *et al.*, 1998d; Louw, 1998). The principle of river typing is that rivers grouped together at a particular level of the hierarchy will be more similar to one another than to rivers of other types. This typing procedure was followed by Kleynhans *et al.* (1998b) to group the streams of the Crocodile River catchment to the second hierarchical level. Within these river types, a further segmentation of the river channel was based on broad geomorphological characteristics of the river (Figure 5.3 and Table 5.1). These geomorphological river segments form ecological management units for which natural benchmark conditions can be defined.

Figure 5.3 Map indicating preliminary geomorphological segments for the Crocodile and Elands Rivers.

Table 5.1 Broad description of the river segments identified for the Crocodile and Elands Rivers.

River segment	General characteristics
Crocodile River	
C1	1 to 2 m wide; small rocky pools with riffles; steep slope; wetland and grassland dominated
C2	5 to 10 m wide; rocky pools and runs with occasional riffles and some small waterfalls; steep slope; grassland with scattered woody component and scrubs
C3	10 to 15 m wide; rocky pools and runs with occasional riffles; steep slope; change from afromontane forest to grassland and woody component to grassland
C4	Kwena Dam; grassland dominant with woody component
C5	15 to 20 m wide; large rocky pools interspersed abundantly with riffles and rapids; steep slope; riparian forest
C6	20 to 30 m wide; large rocky pools and runs with occasional rapids; riffles rare; moderate slope; change from mountain riparian forest to foothill riparian forest
C7	30 to 40 m wide; large rocky pools and runs with occasional rapids; riffles very rare; moderate slope; change from mountain riparian forest to anastomosing lowveld riparian forest with reeds
C8	20 to 30 m wide; rocky pools and runs with cobbles and boulders, rapids and riffles abundant; steep slope; gorge riparian forest
C9	30 to 40 m wide; rocky and sandy pools and runs with riffles and rapids; moderate slope; lowveld riparian forest
C10	40 to 50 m wide; mostly large sandy pools with occasional rapids; riffles very scarce; gentle slope; lowveld riparian forest
C11	40 to 50 m wide; mostly large sandy pools with occasional rapids; riffles very scarce; gentle slope; lowveld basalt riparian thicket (basalt bedrock limited)
C12	40 to 50 m wide; mostly large sandy pools with occasional rapids; riffles very scarce; gentle slope; Lebombo riparian thicket (rhyolite bedrock limited)
Elands River	
E1	1 to 2 m wide; small pools; gentle slope; grassland
E2	1 to 2 m wide; small pools with occasional riffles; moderate slope; grassland with scattered woody component
E3	5 to 15 m wide; large rocky pools with riffles and rapids; moderate to steep slope; grassland with scattered woody component
E4	15 to 20 m wide; large rocky pools with abundant riffles and rapids; steep slope; change from mountain riparian forest to foothill riparian forest to mountain riparian forest

Establish reference classification

Natural benchmark conditions were derived for each of the biological indicator groups for each identified river segment. Benchmark conditions for the FAII were based on a combination of historical evidence of the distribution of fish species as well as professional judgement. The best SASS index scores, usually obtained at the least impacted site, were regarded as the benchmarks for particular segments. This was both for the SASS index score and the average score per taxon (ASPT value). Expert opinion was used to define the RVI for each segment.

The natural benchmark conditions, as determined for each biological index for each river segment, were used for calibrating the degree of modification to ecological integrity. A six class division was used, to be compatible with other complementary initiatives, for example a classification system for habitat integrity (Kleynhans, 1996) as well as for the protection of water resources in South Africa (DWAF, 1998). In the classification scheme for ecological integrity of riverine ecosystems, Class A represents the natural benchmark state and Class F a state of critical modification (Table 5.2). These classes will be referred to as River Integrity Classes (RICs).

The way in which the divisions between the different RICs are defined (percentage cut-offs in Table 5.2), is based on professional judgement and may differ for the different biological indicator groups. A classification scheme (Table 5.2) allows for standardisation of the assessment process to a degree where different people using the same measured data will consistently arrive at the same RIC. In some instances, this statement will be an oversimplification, as expert judgement and system specific knowledge often form part of the assessment rules for the respective ecological indicator groups.

The rules defining the ranges within different classes (Table 5.2) need not change between river segments, but the benchmark values will change to reflect the natural variation in ecological parameters over space and time. For example, a benchmark value for the SASS index score may be 200 for one river segment and 70 for a river segment in another part of the country. Similarly, the benchmark ASPT values for the SASS index may differ between the mentioned segments. These benchmark values will form the basis for translating SASS data, measured at any particular point in time at the mentioned segments, into RICs.

Table 5.2 The classification of ecological integrity of riverine ecosystems used for the assessment of RHP results.

River Integrity Class (RIC)	FAII as % of natural benchmark (Kleynhans, 1999)	SASS as % of natural benchmark (Thirion, 1998)		RVI as % of natural benchmark (Kemper, 1994)
		SASS score	ASPT value	
A - No measurable modification	≥90	≥90 70 to 89	variable ≥90	≥90
B - Largely unmodified	80 to 89	80 to 89 70 to 79	<90 80 to 89	80 to 89
C - Moderately modified	60 to 79	60 to 79 70 to 79	variable <80	60 to 79
D - Largely modified	40 to 59	40 to 59	variable	40 to 59
E - Seriously modified	20 to 39	20 to 39	variable	20 to 39
F - Critically modified	0 to 19	0 to 19	variable	0 to 19

5.4.2 Establish Ecological State and Trends

The present ecological status of the respective river segments was defined by applying the results for the biological indices, obtained during the survey of the Crocodile and Elands Rivers, to the ecological integrity classification scheme (Table 5.2). The present ecological state for each river segment was thus defined as an integrity class per biological indicator group (Table 5.3).

Table 5.3 Present ecological state, expressed as an integrity class, of the river segments identified for the Crocodile and Elands Rivers

River Segment	River Integrity Class (RIC)		
	FAII	SASS	RVI
Crocodile River			
C1	A	B	B
C2	B	A	C
C3	B	A	D
C4	NA	NA	D
C5	B	B	C
C6	C	B	C
C7	D	D	C
C8	C	C	C
C9	C	C	D
C10	C	B	D
C11	C	D	D
C12	C	A	D
Elands River			
E1	NA	NA	D
E2	A	A	D
E3	A	A	D
E4	A	A	C

NA - not available

A low monitoring frequency is prescribed by the national RHP objectives. This frequency varies among the different biological indicators in accordance with differences in life-cycle durations and associated response times. Monitoring of fish and riparian vegetation is likely to take place once in three years, and the invertebrates once per year (Uys *et al.*, 1996). Over time, it would be possible to detect temporal trends for the relevant river segments and biological indicator group(s). The results (Table 5.3) clearly show spatial trends in the ecological state/integrity of river segments.

5.5 ECOSYSTEM MANAGEMENT

The ultimate aim of accurate ecosystem assessment is the dynamic and effective management of water resources. At the high level of the AEAM procedure, resource management consists of two steps, namely firstly to set management goals and associated quality objectives, and secondly to make management decisions. Management goals are viewed as broad qualitative statements which reflect some foresight and commitment from policy makers and managers, and incorporate societal values, as to the condition in which an ecosystem should be maintained. In order to give operational meaning to these goals, they should be translatable into measurable scientific end-points, referred to here as quality objectives. Where the goals consist of a qualitative vision for the river, the quality objectives are quantitative values or ranges of values that can be used to monitor, manage for and audit attainment of the goals.

In the context of the RHP, the management goals and quality objectives define desired characteristics of ecological values to be protected. The management goal is the same as the "desired state" of an ecosystem, as referred to by some authors (e.g. Rogers and Bestbier, 1997). Management decisions refer to determining the means for achieving the management goals. In other words, appropriate management plans must be formulated and implemented.

The separate river segments are suggested as ecological management units. Therefore, a management goal and quality objectives must be determined and a management strategy must be formulated for each of the identified river segments.

5.5.1 Set Ecosystem Management Goals and Quality Objectives

Management goals

In the assessment component of the AEAM procedure (Figure 5.1), degrees of ecological impairment have been quantified per river segment or aquatic ecosystem. Ecological management goals must be set to judge the acceptability of these levels of impairment. However, the quantification of ecological goals for aquatic ecosystems is both technically complex and politically controversial. Such goals need to be ecologically sound and sustainable, but at the same time allow for some desired degree of socio-economic development.

The decision on the ecological management goal for a particular aquatic ecosystem requires the achievement of a balance between three aspects:

- The ecological importance and sensitivity of the resource, which includes biodiversity, rarity, uniqueness and fragility from habitat, species and community perspectives. The intrinsic ecological value of the resource and its importance to the functioning of neighbouring ecosystems are the main concerns.
- The strategic importance of the resource for human use, which refers to the water requirement for various economic sectors (such as agriculture, industry and mining), and for basic human and social needs (such as recreation, tourism and religion).
- The current as well as reference ecological integrity of the resource. The availability of quantitative or qualitative information on the reference biological integrity and the current biological integrity of a river will contribute towards setting realistic and ecologically sound management goals.

Consideration of all of the above aspects should ideally be part of the process of goal setting. The outcome would be a negotiated decision, where human values and stakeholder participation would have played important roles. Such a consultative management process has been developed to support the conservation policy of the Kruger National Park (Rogers and Bestbier, 1997). This methodology may need some modification before it can be applied in the context of the national Water Act.

To demonstrate the overall AEAM procedure, the ecological importance and sensitivity of the respective ecosystems were considered in deriving broad ecological management goals for the Crocodile and Elands Rivers. The strategic importance of the resource for human use was not considered, as such an assessment has not been done for the rivers of concern and could not be undertaken within the scope of this study.

Ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales (Kleynhans *et al*, 1998a). Ecological sensitivity (or fragility) refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (resilience) (Resh *et al.*, 1988 and Milner, 1994).

Kleynhans *et al.* (1998a) suggest the following ecological aspects be considered as the basis for the estimation of ecological importance and sensitivity:

- The presence of riparian and in-stream biota, in terms of
  - rare and endangered species

  - unique (endemic, isolated, etc.) species and communities
  - intolerant species
  - overall species diversity and richness
- The presence of riparian and in-stream habitats, in terms of
  - diversity of types
  - providing refuge areas
  - providing connectivity between neighbouring reaches or systems, i.e. providing a migration route or corridor for species
- The presence of conservation or natural areas, such as national parks, nature reserves and wilderness areas

A scoring system, which integrates the relative importance of the above issues, has been developed by Kleynhans *et al.* (1998a). This system is intended as a guideline for the professional judgement of relevant specialists familiar with the study area. As the authors represent extensive experience of the relevant ecological attributes of the Crocodile River system, their combined judgement was deemed sufficient to provide a valid outcome in terms of the ecological importance and sensitivity ratings for the identified river segments.

The ecological importance and sensitivity scoring system was tailored to present the results as one of six classes (A to F). The class obtained in the present evaluation was considered to be equivalent to the ecological management goal for the relevant segment. The goals for the Crocodile and Elands Rivers are presented in Table 5.4.

Table 5.4 Ecosystem management goals for the Crocodile and Elands River segments.

River Segment	Ecological Management Goals
Crocodile River	
C1	A
C2	B
C3	B
C4	B
C5	B
C6	B
C7	C
C8	B
C9	B
C10	A
C11	A
C12	A
Elands River	
E1	C
E2	B
E3	B
E4	A

Ecological Quality Objectives

Whereas the management goal reflects the ecological values that we seek to protect, these values need to be translated into measurable ecological quality objectives (EQOs) in order to become operational. Once consensus is reached on a management goal for a particular river segment, and if this goal can be expressed in terms of a specific RIC (Table 5.2), then EQOs can be allocated per ecological indicator group. Thus, the range of index scores coinciding with the desired integrity class for each biological indicator group becomes measurable and auditable quality objectives. Figure 5.4 shows how such a goal statement can be translated into EQOs.

A comparison of the set management goal and the determined current RIC of each river segment will indicate which EQOs are met and where management action is required to ameliorate undesirable conditions. However, this comparison will not always be straightforward and simple. In instances where the RIC differs among the indicator groups, an expert system may have to guide decisions regarding compliance with the set management goal. Such rules are currently being developed for the implementation of resource-directed measures for the protection of aquatic ecosystems, as specified under the National Water Act (DWAF, 1998), and fall outside the scope of this study.

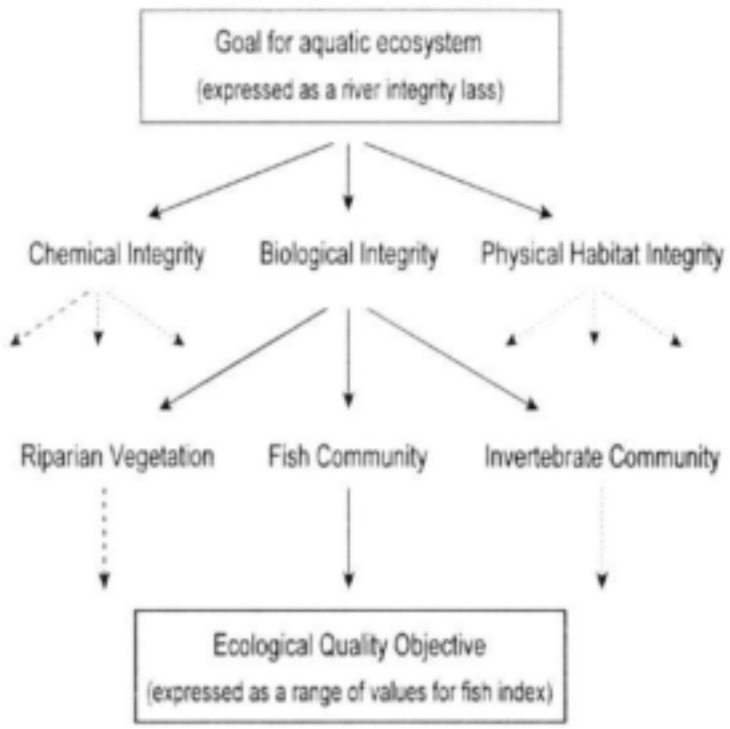

Figure 5.4 Integrating human values and scientific endpoints in setting visionary management goals and measurable quality objectives for riverine ecosystems.

5.5.2 Formulate and Implement Management Plans

Ranking ecosystems for management action

Threats to achieving or maintaining the set goal for a river segment may vary in type, severity, extent and imminence. Amidst this variability, resource managers need to rank ecosystems at risk in order to set priorities for management action. Such prioritisation would allow them to focus their resources at areas where the need is most urgent.

There are three basic types of methods for ranking ecosystems at risk; negotiated consensus, voting and formulae (EPA, 1993 as cited in Gonzalez, 1996). Gonzalez (1996) proposes a three-dimensional ranking system which makes use of negotiated consensus along with a simple additive formula. This relatively simple ranking system consists of the following three components:

- category of threat,
- level or class of threat, and
- distance from desired future condition (i.e. distance from the management goal).

A description of how each of these components contribute to the ranking system, as modified from Gonzalez (1996), follows.

- *Category of threat to ecosystems:* Threat to any ecosystem of concern can be grouped into three broad categories:

  Category 1 ecosystem degradation - occurs mainly through pollution, but could also be from selective removal of species (e.g. overfishing);

  Category 2 alteration - major physical changes (such as dredging, water diversion, impounding) and major removal of species (i.e. extinction); and

  Category 3 removal - highest level of alteration (e.g. destruction of wetlands due to urbanisation, conversion of forest to cropland, etc.).

- *Level of threat to ecosystems:* Four levels of threat to ecosystems are proposed:

  Level 1 Without intervention, the ecosystem's integrity will be largely unchanged three to five years from now;

  Level 2 Without intervention, ecosystem status will have declined somewhat three to five years from now [the ecosystem is likely to drop one integrity class];

  Level 3 Without intervention, ecosystem status will have dramatically declined, perhaps resulting in ecosystem disappearance three to five years from now [the ecosystem is likely to drop two integrity classes]; and

  Level 4 Collapse or disappearance of the ecosystem is imminent in less than three years [the ecosystem is likely to drop three integrity classes].

- *Distance from the management goal:* Four "distances" from the management goal can be distinguished:

  Distance 1 In the same RIC as the management goal

  Distance 2 One RIC away from the goal

  Distance 3 Two RICs away from the goal

Distance 4 Three RICs away from the goal

Gonzalez (1996) suggests that ecosystems could be prioritised for receiving management action, by giving numeric weights to the different categories, levels and distances and summing them. Decisions on the category of threat and level of threat, could be made by an expert panel consisting of scientists, conservationists, resource managers and stakeholder groups. The qualitative determinations would represent a negotiated consensus of expert judgement based on both qualitative and quantitative information (Gonzalez, 1996).

The distance from that management goal, however, is a more objective assessment. It could be determined mechanistically for each river segment using the river integrity classification system (Table 5.2), the present RICs (Table 5.3) and the management goals/classes (Table 5.4). To demonstrate the concept of ranking ecosystems, only the distance component was considered for ranking segments of the Crocodile and Elands Rivers for management action. The following simple formula was used:

$$D = RIC_{Goal} - (RIC_{FAII} + RIC_{SASS} + RIC_{RVI} \ldots RIC_i)/n \qquad \ldots\ (1)$$

where D is the distance from the management goal

RIC_{Goal} is the management goal expressed as a RIC (Table 5.2)

RIC_{FAII} is the current RIC according to the FAII

RIC_{SASS} is the current RIC according to the SASS

RIC_{RVI} is the current RIC according to the RVI

n is the number of ecological indices for which a current RIC has been determined

and where Class A equals 6 and Class F equals 1 numeric unit.

Formula (1) is suggested strictly as a mechanism for the ranking of river segments in terms of their need for receiving management attention. It should not be used to assess compliance with a set goal, as a wider set of variables needs to be considered for this (explained under *Ecological Quality Objectives*). Similarly, it can also not be used to argue the case that the river has additional capacity that can be used for development (e.g. in cases where the current RIC is higher than the management goal).

The distance values (Table 5.5) provide the outcome of applying formula (1) to the present ecological state (Table 5.3) and management goal (Table 5.4). In practice, the response of managers to these distance values depends on the philosophical debate of whether river segments which shows the highest or lowest distance values should receive priority attention. It could be argued that the first priority is to maintain the integrity of those segments already meeting the management goal; or that the segments that deviate most from the goal should receive priority to improve their state. To demonstrate the concept of prioritisation, it is assumed that the larger the numeric value the more urgent the need for management action in a specific segment.

It is possible to devise management guidelines based on the outcome of Table 5.5. For example, a distance above one implies a need for management action, above two a serious need and above three a critical need. A distance of four or higher would probably imply that management intervention in the form of ecological restoration is required. Although these cut-offs may seem arbitrary, the idea behind AEAM is to have and apply preliminary rules which can be improved as experience and knowledge is gained. In other words, not to wait with management action until complete certainty is obtained, as such a situation may never materialise. Instead, management action becomes part of the process of gaining evidence that would allow managers to shape and improve prototype rules in an ongoing fashion.

Where a current RIC for only one indicator was available (e.g. segment E1), the result should be viewed with lower confidence than where the results of three indicators were used. The use of more ecological indicators, for example the inclusion of the Index of Habitat Integrity (Kleynhans, 1996), would allow a more comprehensive assessment of ecosystem state and more confidence could be linked to the outcome.

Table 5.5 The distance between the ecological management goals and current ecological state for each river segment, as determined by equation (1) and where zero is the closest and five the furthest.

Riverine Segment	Distance from management goal
Crocodile River	
C1	0.7
C2	0
C3	0.3
C4	2
C5	0.3
C6	0.7
C7	0.7
C8	1
C9	1.3
C10	2
C11	2.7
C12	1.7
Elands River	
E1	1
E2	0
E3	0
E4	0.7

Formulate management actions

Once ecosystems have been priority ranked, the actual management plans for high ranking segments need to be established. In the example used here, segment C11 ranked worst. By referring back to the original data collected, and observations during the field survey, it will often be possible to identify the likely stressors that resulted in the high ranking. However, this may not always be obvious, and additional and more intense monitoring and observation may be required to establish such links for the river segment(s) of concern.

The stressors that could be linked to the undesirable ecological condition of segment C11 are presented in Table 5.6.

Table 5.6 Stressors potentially responsible for the undesirable ecological condition in river segment C11.

Biological Index	Stressors
FAII	- primarily a flow-related problem, due to the regulation of discharges from Kwena Dam and excessive water abstraction for irrigation purposes in the middle and lower parts of the Crocodile River. This results in habitat loss which adversely impacts on the fish community in this segment (particularly during periods of drought). - water quality deterioration, mainly as result of irrigation return flows and associated nutrient enrichment and algal growth - presence of exotic aquatic macrophytes, mainly hyacinth (*Eichhornia crassipes*), resulting in habitat alterations (especially during low flows).
SASS	- water quality deterioration, mainly as a result of irrigation return flows and associated nutrient enrichment and algal growth - loss of stable riffle habitat at some long-term monitoring sites due to sedimentation and sand cover
RVI	- vegetation removal on the southern bank, due to the construction of roads, pump houses, tourist lodges, etc.

Based on the knowledge of the main stressors which are having an effect on the integrity of segment C11 (Table 5.6), it is relatively simple to recommend management options which would assist improvement of ecological conditions towards the management goal for this segment. The authors felt that three broad management options would result in an improvement over time:

1. The determination of the in-stream flow requirement (King and Louw, 1998) in order to meet the management goals at the lower parts of the Crocodile River (segments C10 to C12), and associated operational management of water releases from Kwena Dam.
2. Restoration and or proper management of the riparian zone on the southern bank of segments C10 to C12, to form an effective buffer area against erosion and leaching of nutrients from irrigation activities.
3. The control of water hyacinth.

The example of segment C11 is relatively straightforward. However, it is possible that multiple or alternative management options could be identified for another situation. Here another prioritisation procedure will be required, as most often more than one management activity may result in a similar effect. Haney and Power (1996) suggest an implementation index to prioritise various management options on the basis of their political and technical feasibility and perceived efficacy.

They assigned a rating to each management option based on political feasibility (PF), technical feasibility (TF) and efficacy (E), with a value of 1 being the least acceptable and 5 being the most acceptable. These values were combined to yield an implementation index (I), where:

$$I = (PF + TF)(E) \qquad \text{..... (2)}$$

By applying the implementation index to all possible options, the most feasible and efficient management option can be determined in a fairly structured way.

The only way to verify that the chosen management plans result in the specified management goal, is by ongoing monitoring of those end-points (quality objectives) with which the goal is being described. This feedback to ongoing monitoring closes the loop between monitoring and management (Figure 5.1). Monitoring data would then show whether chosen management actions result in progress towards management goals (Haney and Power, 1996). Modifications to the monitoring design may be required to properly audit performance relative to specified goals (Figure 5.1). This would be particularly relevant when additional management actions or modified goals are suggested, or when new or refined relationships between stressors and environmental responses emerge.

To truly audit the adaptive relationship between a monitoring design and the setting of management goals, the AEAM system needs to be operational for a number of years. As the RHP does not provide such an example, the feedback from management to monitoring discussed above is hypothetical.

5.6 DISCUSSION

The output of monitoring programmes such as the RHP must be used, at national, provincial and local levels of responsibility, in the management of aquatic ecosystems in southern

Africa. As it stands, the RHP provides the methodology to monitor changes in the ecological state of aquatic ecosystems, but not a framework for responding to the results. In the absence of such a framework, the RHP will have little further influence on how its results enter the management arena, if at all.

The AEAM model proposed in this chapter is an attempt to formalise the dependancies between monitoring, assessment and management of aquatic ecosystems. It provides a systematic procedure which links the collection and assessment of biological data, the setting of goals and quantifiable objectives for managing the integrity of rivers, and the prioritisation of management actions. The balance between the protection and utilisation of aquatic ecosystems can be negotiated and hopefully optimised by following this iterative cycle, while also focussing on continuous improvement of the component protocols (Figure 5.1).

Lessons from the development of this AEAM framework can be summarised as follows:

- The AEAM model ensures that recognition is given to the need for ongoing learning and adaptation. No prototype assessment method or management decision is ever the ultimate, but just the best that is available for now. Commitment to the AEAM process will avoid a situation where complacency with the familiar is an obstacle to future improvement of ecosystem monitoring, assessment and management.

- The AEAM procedure provides for the semi-quantitative assessment of the overall response of aquatic ecosystems to cumulative disturbances, in relation to both a natural benchmark condition and ecological management goals. Such assessments facilitate measurement of goal achievement, deciding on management actions and auditing management performance.

- The higher the number of ecological indicators used in the RHP, the more comprehensive an assessment of ecosystem condition will be possible, and the more confidence could be linked to resulting management decisions.

- The strong emphasis in the AEAM procedure on the results obtained through the various ecological indices, may drive a behaviour where the respective index scores become the sole management focus and where the holistic ecosystem perspective is diluted. It should be stressed that these ecological indices, although orders of magnitude more relevant than measuring only chemical concentrations, are still surrogate measures of ecosystem condition.

- The classification and rating techniques built into the AEAM framework would ensure a high degree of standardisation in the processing of RHP data. However, as professional judgement and system-specific knowledge are required inputs to certain components, absolute standardisation cannot be guaranteed - nor is this absolute rigidity necessarily desirable. Variability in the outcomes obtained from applying the AEAM procedure can only be limited by increasing the exposure of technical specialists and managers to the procedure.

- Although a consensus goal is not a prerequisite for making management decisions, a goal-oriented approach to resource management has the following advantages:
  - A defined goal provides the platform for strategic or proactive management, whereas the absence of a goal often encourages a wait-and-see approach and reactive management.
  - Measurable goals will allow an audit of management performance, which is in line with the greater emphasis on accountability of the custodians of natural resources.
  - Stated goals will increase transparency and encourage participation to incorporate the desires and expectations of more stakeholders.
  - The process of goal setting, if done in a transparent and participatory way, will acknowledge and consider the value systems of society.
  - The process of defining a goal will result in continuity regarding the rationale behind decision-making.

- Conceptualising the entire AEAM procedure provides an important perspective for the ongoing development and improvement of the individual protocols of which it is composed. By developing the process and its links in parallel with the separate technical components, improvement and functionality achieved over time can be optimised.

- The principles of the AEAM procedure are sufficiently generic to be applicable to other response monitoring programmes focussing on rivers and other natural resources. The national RHP is concerned with relatively coarse changes in the ecological status of rivers and river reaches over long time periods. A monitoring programme focussing on the consequences of a certain type of impact (cause-effect relationship) in one part of a catchment may employ more detailed biological indices at a higher sampling frequency. More specific management direction would flow from such a programme. Lastly, a programme designed to assess the local effects of a site specific stressor may be based on biotoxicological assays. An example of such a programme is to monitor the response of aquatic species to an effluent discharge, where management actions may relate to a specific constituent of the effluent. A challenge would be to interlink the response frameworks of monitoring programmes with national, regional and local objectives in a complementary fashion and thus coming close to covering all spatial and temporal scales relevant in the management of aquatic ecosystems.

- It is acknowledged that the setting of ecological management goals and the identification of management options would not automatically result in the implementation of management actions (Walters, 1997). These goals need to be institutionalised to ensure maintenance of the AEAM procedure (Rogers and Bestbier, 1997; Rogers, 1998). When institutionalising goals, one needs to address aspects of responsibilities, time-frames, required capacities, etc., relevant to the various institutions mandated with aquatic ecosystem management.

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CHAPTER 6 - LEGAL AND INSTITUTIONAL ARRANGEMENTS

M Uys

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6.1 WATER RESOURCES MANAGEMENT IN SOUTH AFRICA

In South Africa, water resources are managed in terms of a management system which is separate from the environmental management system : not only is the governance separated into two different government departments, but water resources are managed according to legislation separated from the environmental management legislation. In view of modern environmental perspectives aimed at the integrated management of natural elements for sustainable development, this separation is somewhat artificial and rather complicating as far as the attempt to develop an integrated environmental management system is concerned. As will be seen from this report, much streamlining among water resources and environmental management policies and legislation is necessary before management tools such as the RHP can be employed effectively and implemented smoothly under the wings of all applicable laws.

Water resources are managed according to a codified system, contained in the Water Act of 1956 (hereafter the 1956 Act) and the National Water Act of 1998 (hereafter the 1998 Act). The last-mentioned Act is intended to entirely replace the 1956 Act in due course. In terms of this legislation and the official water management Policy, National Government is the public trustee of the nation's water resources, with the duty to ensure that water is managed for sustainability and in an equitable manner for the benefit of all and in accordance with its constitutional mandate.[1]

A National Water Resource Strategy (NWRS), in accordance with which all water resources must be protected, used, developed, managed, conserved and controlled, must be established by the Minister after public consultation.[2] This will set the strategies, objectives, plans, guidelines and procedures which will bind all water management institutions (including the Minister) in the performance of water management duties aimed at achieving the purpose of the Act.[3] The NWRS has not as yet been established.

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1 Section 3.

2 Section 5.

3 Sections 6, 7. In as far as the NWRS is therefore developed in accordance with the purpose of the Act, it will bind officials, but the extent to which the strategies will be formulated to achieve the purpose of the Act, is in the discretion of the Minister. This means that the Minister is bound to the purpose of the Act only in as far his interpretation of the practical meaning and application of section 2 stretches.

A water resource is defined in the 1998 Act as including a watercourse, surface water, estuary or aquifer, while a watercourse is defined as a river, spring, natural channel in which water flows, wetland, lake or dam into which or from which water flows, and any collection of water declared by the Minister to be a watercourse, including beds and banks.[4] The definition does not include the entire aquatic system which naturally encompasses the riparian ecosystem, but is intended to refer to the water mass only. The Act thus envisages managing the use, development and conservation of *water* only, and not of the aquatic ecosystem. However, management of the water must be in a way which will take the protection of aquatic and associated ecosystems and their biological diversity into account.[5] It is clear from the purpose of the Act that the management of the aquatic ecosystem is regarded an object of management separate from the water mass itself, and that the responsibility for management of this is excluded from the responsibilities of water management institutions, and rather within the management sphere of environmental laws. However, water is included in the National Environmental Management Act's definition of the environment, which is defined as the surroundings within which humans exist, including the land, *water* and atmosphere of the earth. This means that water is subject to the management systems of both water and environmental law, while the aquatic ecosystem is subject to environmental law only. This, and the resulting question as to which law has the overriding power as far as water management is concerned, is one of the complexities resulting from the separation of control.

To compensate for this withdrawal from one of the environmental elements from the environmental management system for independent additional control, various control measures have been built into the water management system to secure the management of water against environmentally unsound decision-making, which measures are aimed at promoting environmental values,[6] but are not necessarily streamlined with environmental laws and policies. On the other hand, all scheduled government departments (which include DWAF) are, in terms of the National Environmental Management Act (hereafter NEMA), bound to exercise all their functions - which may significantly affect the environment - in accordance with the statutory environmental management principles.[7] They are, moreover, bound to develop environmental management and implementation plans to which all decision-making will be subject. The control measures to which decision-making by water

[4] Section 1(xxiv) and (xxvii).

[5] Section 2(g).

[6] Section 3(2).

[7] Section 2(1) of NEMA.

management institutions is subject, are therefore originating from both laws, but are not converged, which could once again complicate the environmental management system to some extent.

As the *RHP* is aimed at the biomonitoring and assessment of river health in a structured way to act as a management tool to influence decision-making, the question arises as to what decision-making and by which authorities the Programme envisages to influence, and where this Programme should be based in the complex legal and institutional collaboration of water and environmental management attempts, to serve the best purpose and to attain optimal management results.

6.2 THE RHP AND WATER LAW

6.2.1 Water Management Principles

The fundamental principles underlying the statutory water management system have been published in 1997 as part of the National Water Policy.[8] Those principles relating to environmentally sound water management, include the following :

- The objective of managing the quantity, quality and reliability of the nation's water resources is to achieve optimum, long term, environmentally sustainable social and economic benefit for society from their use.[9]
- The quantity, quality and reliability of water required to maintain the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long term sustainability of aquatic and associated ecosystems.[10]
- Water quality and quantity are interdependent and shall be managed in an integrated manner, which is consistent with broader environmental management approaches.[11]

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[8] White Paper on a National Water Policy for South Africa G.P.-S. April 1997.

[9] Principle 7.

[10] Principle 9.

[11] Principle 15.

- Water quality management options shall include the use of economic intives and penalties to reduce pollution; and the possibility of irretrievable environmental degradation a result of pollution shall be prevented.[12]

- Water resource development and supply activities shall be managed in a manner which is consistent with the broader national approaches to environmental management.[13]

- The right of all citizens to have access to basic water services necessary to afford them a healthy environment on an equitable and economically and environmentally sustainable basis shall be supported.[14]

It is clear from these principles that human benefit is primarily envisaged as a result of the water management system, yet in a way that will promote sustainable development.

The purpose of the 1998 Act, is more specifically aimed at the management of water for environmental sustainability:

- The purpose of the Act is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled to, *inter alia*, meet human needs, promote efficient, sustainable and beneficial use of water in the public interest, facilitate social and economic development, *protect aquatic and associated ecosystems and biological diversity, reduce and prevent pollution and degradation of water resources,*[15] and to establish suitable and representative institutions for this purpose.[16]

- National Government is the public trustee of the nation's water resources, with the duty to ensure that water is managed for sustainability and in an equitable manner for

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12 Principle 16.

13 Principle 17.

14 Principle 25.

15 My italics.

16 Section 2.

the benefit of all and in accordance with its constitutional mandate.[17]

Unfortunately, decision-making by water management institutions are not bound to this purpose in any direct manner. The actual mechanisms which bind these decision-makers are those which must be developed in terms of the provisions of the Act.[18]

6.2.2 Water Management Mechanisms

6.2.2.1 The National Water Resource Strategy

A National Water Resource Strategy (NWRS), in accordance with which all water resources must be protected, used, developed, managed, conserved and controlled, must be established by the Minister after public consultation.[19] This will set the strategies, objectives, plans, guidelines and procedures which will bind all water management institutions (including the Minister) in the performance of water management duties aimed at achieving the purpose of the Act.[20] It must provide for at least the requirements of the Reserve and identify water resources from which particular requirements must be met; it must contain estimates of present and future water requirements and state the available water in each water management area; it must state the water quality objectives to be achieved through the classification system; and it must promote the management of catchments within a water management area in a holistic and integrated manner. The NWRS may be phased in, and must be reviewed at least every five years.

6.2.2.2 The Water Classification System

A water classification system (WCS) must be prescribed by the Minister, who may establish procedures to determine the Reserve for each water resource class and which may determine

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17 Section 3.

18 These mechanisms are described and discussed in 9 hereunder.

19 Section 5.

20 Sections 6, 7. In as far as the NWRS is therefore developed in accordance with the purpose of the Act, it will bind officials, but the extent to which the strategies will be formulated to achieve the purpose of the Act, is in the discretion of the Minister. This means that the Minister is bound to the purpose of the Act only in as far his interpretation of the practical meaning and application of section 2 stretches.

allowable activities in respect of water.[21] All significant water resources will be classified according to this system.

6.2.2.3 *The Resource Quality Objectives*

Resource quality objectives (RQO's) will be determined for each water resource, aimed at balancing the need for protection and use of each resource. RQO's may relate to, *inter alia*, the Reserve, instream flow, water level, the presence and concentration of substances in the water, the quality and characteristics of the water and the habitat, the distribution of aquatic biota, and the regulation of water-related activities.[22] All water management institutions are bound to the classes of water resources and the RQO's, when performing their duties in terms of the Act.[23]

6.2.2.4 *The Reserve*

When a water resource class has been determined in accordance with the classification system, the Minister must determine a Reserve[24] for each water resource, in accordance with which all water management institutions must exercise their powers.

Although provision is made in the Act for the preliminary determination of resource classification or RQO's and the Reserve, no provision is made for the revision of the final classes and quality objectives once these have been fixed. It is submitted that this should be reconsidered, as river health as well as other considerations might from time to time necessitate a revision of resource quality objectives, river classification or the Reserve. As water use licences and authorizations, and permissible water use in general, is dependent on these factors and must be in line with this, some flexibility should be allowed. The implications of this fixed and inflexible nature of river classification, the RQO's and the Reserve, is discussed hereunder.

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21 Section 12.

22 Section 13.

23 Section 15.

24 A Reserve is defined as the quantity and quality of water required to satisfy basic human needs and to protect aquatic ecosystems.

6.2.2.5 *Water Use Entitlements*

Water use is allowed only in terms of a licence or general authorization or as a continuation of an existing lawful use or for reasonable domestic purposes.[25] The quantity of water in respect of a resource for which licences or authorizations may be issued by a responsible authority, is determined by the Minister.[26]

Once the NWRS, the Resource Class and RQO's, and the Reserve for a resource have been determined, a responsible authority is bound to issue licences and authorizations for water use in accordance with these criteria, but until then, none of these criteria bind discretion, and only the conditions set out in section 27 are binding : in terms of this section, a responsible authority must, *inter alia,* take into consideration efficient and beneficial use of the water in the public interest and the likely effect of the proposed use on the resource and on other users, as well as the quality of the water which will probably be required for the Reserve.

Conditions relating to the protection of the resource, as well as water management conditions, *inter alia* specifying management practices, general requirements and conservation measures and requiring monitoring and analysis and recording procedures, *may*[27] be attached to licences and authorizations.[28] Compliance with sound environmental management principles is therefore, in this case, left to the discretion of the responsible authority, and not prescribed by the Act.

6.2.3 Water Management Institutions

A Water Management Institution (hereafter WMI) is defined in the Act as a Catchment Management Agency, a Water User Association, a body responsible for international water management or any person who fulfils the functions of such institutions.[29]

25 Section 22 and Schedule 1.

26 Section 23.

27 My italics.

28 Section 29.

29 Section 1(1)(xxvi).

6.2.3.1 The Minister

As custodian of the nation's water resources, National Government (acting through the Minister) has the ultimate responsibility to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, for the benefit of all persons and in accordance with its constitutional mandate, and that water is used beneficially in the public interest, while promoting environmental values. He also has the power to regulate the use, flow and control of all water in the Republic.[30]

This is a dominant and overriding administrative discretion, to which the powers of all other institutions will be subject, justified by the public interest, which is an undefined term of which the interpretation is probably in Ministerial discretion.[31]

The Minister may delegate some of his powers[32] to government officials or WMI's.[33] When he so delegates his powers, he may do it subject to conditions or limitations, and it does not prevent him from exercising the power or performing the function himself.[34]

In emergency situations, or in cases of urgency where the protection of a water resource or the environment requires it, the Minister may dispense with the requirements regarding prior publication, public consultation notice periods or time limits. In such a case, the decision must be withdrawn or repealed within two years after the urgency has ceased to exist.[35]

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30 Section 3.

31 There are various possible legal discrepancies regarding Ministerial powers, eg. a question as to what would happen if the Minister regards it necessary in the public interest to make a decision which is not in line with the National Strategy (although the Strategy is, in general, not against the public interest) will he be bound to the Strategy, or will his ultimate powers in the public interest prevail? May he interfere in or override administrative decisions of other water management institutions? It is submitted that the Act was developed to leave room for centralized power structures, while simultaneously catering for partial decentralization, yet subject to central control - this could lead to much debate and uncertainties.

32 Section 63(2) excludes some of his powers from delegation.

33 Section 63.

34 Section 159.

35 As urgency refers to a condition, it is difficult to say when an urgency ceases to exist : it could well be that the instrument issued to remedy the urgency, is the only measure which will do so : if the instrument is withdrawn, the urgency will arise again. Under section 9A of the 1956 Act, the intended temporary measures provided for use in emergency situations, were often

Catchment Management Agencies (CMAs) are established at the discretion of the Minister, and he may do so out of own initiative or on application.[36] He also has the power to determine the water management area[37] for the jurisdiction of the CMA, which does not necessarily have to be a natural catchment, although in determining it, he has to take into account the watercourse catchment boundaries, together with other factors such as the social and economic development patterns, efficiency considerations and communal interests.[38]

If the Minister does not establish a CMA, all powers and duties of CMA's vest in him, and if he does establish a CMA, he has a discretion as to what powers to assign to it, to which assigned powers he may attach conditions, while those not assigned remain vested in himself.[39]

The Minister may give directives to all WMI's in relation to the exercise of any of their functions, to which it must give effect. Although directives relating to their powers and duties should be published and subjected to comment, non-compliance with this does not deprive the directive of its validity, and neither does it relieve the WMI from having to comply with it.[40]

6.2.3.2 Catchment Management Agencies

Catchment Management Agencies (CMA's) are established at the discretion of the Minister, and he may do so out of own initiative or on application.[41] He has the power to determine the water management area for the jurisdiction of the CMA.

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used as permanent measures to compensate for over-exploitation of resources, by merely repeating the use thereof for the same areas in a continuous way. It is submitted that this section allows for similar misuse, in that the definition of urgency is open for arbitrary administrative discretionary definition and interpretation.

36 Section 78.

37 A Water Management Area is defined as an area established as a management unit in the NWRS, within which the CMA will conduct the protection, use, development, conservation, management and control of water resources (Section 1(1)(xxv)).

38 Section 6(2).

39 Section 73.

40 Section 74.

41 Section 78.

A catchment is defined in the Act as the area from which any rainfall will drain into a watercourse through surface flow.[42] A Water Management Area (WMA) is an area established as a management unit in the NWRS.[43] Nothing in the Acts binds the Minister, when developing the NWRS, to establish management areas on catchment boundaries,[44] although he must take water course catchment boundaries into account together with social and economic development patterns, efficiency considerations and communal interests in the area.[45] This fragmented nature of the previous water management system was criticized from environmental viewpoints for this lack of recognition of the integratedness of water resources within catchments, and the strive towards environmentally sound water management will probably in due course result in a proper catchment management system being implemented.[46]

If a CMA is established by the Minister, he may assign to it any power or duty of a responsible authority,[47] and any power listed in Schedule 3, yet subject to the conditions and limitations which he deems necessary.[48] In terms of Schedule 3, a CMA may exercise any of the powers in the Schedule which have been assigned to it, as well as well as any other powers or duties necessary or desirable in order to ensure compliance with the Act, but subject to the extent and limitations of the assignment. The scope of possible powers include the following:

- to manage and monitor permitted water use;
- *to conserve and protect water resources and quality;*[49]
- to develop and operate waterworks;
- to implement the catchment management strategy;
- to limit Schedule 1 permissible water use;

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42 Section 1(1)(iii).

43 Eighteen Management Areas have been proposed recently (GN 1697 GG 19641 31December 1998).

44 In terms of s 6(1)(c), all that is required of the Minister is to establish WMA's "and determine their boundaries".

45 Section 6(2).

46 This seems likely from the proposed management areas referred to in 43

47 While a Responsible Authority is defined as either the Minister himself or a CMA to which a power has been delegated.

48 Section 73.

49 My italics.

- to make rules to regulate water use;
- to require from users the establishment of management systems such as monitoring devices, water use and storage and abstraction recording systems, etc.;
- to control and direct alterations to waterworks;
- to temporarily control, limit or prohibit water use during shortage periods.

The initial functions of a CMA are, *inter alia*, to investigate and advise interested persons on the protection, use, development, conservation, management and control of water resources in the WMA, to develop a catchment management strategy, and to promote community participation in the protection, use, development, conservation, management and control of water resources in the area.

The protection and conservation of water resources and water quality, which may be delegated to a CMA, is a function which can hardly be properly exercised unless this WMI also receives the power to control the allocation and revision of water use entitlements. Although a certain extent of resource protection can be achieved by a WMI by ensuring strict compliance by users with their entitlement conditions, and even by temporary use restrictions during periods of resource stress, the ultimate control of water use is required to effectively protect and conserve the resource.

6.2.3.3 Water User Associations

Water User Associations (WUA's) are localised co-operative bodies of individual water users who wish to undertake water-related activities for their mutual benefit. They may be established by the Minister on own initiative or on application by interested parties, but nothing binds him to the establishment thereof.

The powers of a WUA are not set out in the Act, but may include any of the following, which may be supplemented by the WUA when preparing its constitution:

- to prevent water waste;
- *to protect water resources;*[50]
- to prevent unlawful water use;
- to remove unlawful obstructions in watercourses;
- to prevent any unlawful Act likely to reduce water quality;
- to exercise general supervision over water resources;

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[50] My italics.

- to regulate flow;
- to investigate and record the quantity of water at different levels of flow in a watercourse and the times and places of permissible water use;
- to construct or acquire waterworks;
- to regulate water distribution;
- to provide management services, training and support to rural communities and water services institutions, and to provide catchment management services on behalf of responsible authorities.[51]

It is submitted that the purpose of WUA's is to represent specific water users relating to specific water use activities, and not to undertake overall water resources management aimed at sustainable catchment or resources development, as set out in sections 2 and 3 of the Act.

6.2.4 The RHP under the National Water Act

6.2.4.1 RHP: Objectives

The RHP is a scientific programme for the biomonitoring and assessment of river health, aimed at measuring, assessing and reporting on the ecological state of aquatic ecosystems; at detecting and reporting on spatial trends in the ecological state of aquatic ecosystems; and identifying and reporting on emerging problems regarding the ecological state of aquatic ecosystems.

The Programme envisages, by way of a national monitoring programme that focuses on the ecological condition of riverine ecosystems, to develop a management information system which will support the rational management of water resources.[52]

6.2.4.2 RHP: Goals

As far as water management is concerned, the RHP envisages two main goals, being:

- "to play an important role in determining the ecological reserve and in specifying

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[51] Schedule 5, ss4-5.

[52] Roux 1998.

measurable and auditable scientific end points for RQO's";[53] and

- "to assist in the implementation of water quality objectives in a water resource management context, where it is alleged that it will be necessary, in the course of water management, to decide on a time frame to achieve the objectives, to implement actions to achieve these, and to implement and maintain monitoring programmes to audit performance".

In short, the products gained from the Programme are therefore to be used to formulate, implement and audit RQO's.

First Goal: Influence the determination of Reserve and RQO's

As far as the first and short-term goal is concerned, the Minister has the statutory duty to determine the Reserve and RQO's for resources, and he may do so at his discretion (subject to certain prescriptions regarding the invitation and consideration of comment).[54]

The systems and criteria which he regards necessary to employ in order to determine these, are according to his preference, as long as these can be justified in terms of the purpose of the Act, as well as the environmental considerations which bind him in terms of the NEMA.

The involvement of the RHP or the use of its data in this determination is therefore in Ministerial discretion, and nothing in law can force him to accommodate this or any other programme in his determination process. As the establishment of the RHP was, however, initiated by the Department of Water Affairs, and as the RQO's should relate, *inter alia*, to instream flow, the Reserve, the water level of the resource, the presence and concentration of particular substances in the water, the characteristics and quality of the water resource and the instream and riparian habitat, and the characteristics and distribution of aquatic biota, the RHP is an ideal programme to assist in the determination of RQO's. There is thus little doubt that the data and systems developed by the RHP will extensively be utilized to determine the RQO's ans resource Reserves, and the continuation of this utilization is dependent on the standard and dynamics of product delivery which the RHP can maintain, as well as the direction in which the determination process grows.

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53 Roux 1998.

54 Sections 13-18.

However, it is submitted that some statutory legitimacy be granted to the Programme, to ensure that the scientific measures developed by it, form an integral and official and enforceable and binding criterion which will provide some legal certainty as to the scientific basis of the Reserve and the RQO's, and remove the possibility of arbitrary and political decision-making during the process of development of these instruments.

This submission is made in close coherence with the submission that the inflexible and fixed and final nature of the RQO's, the resource classification and the Reserve be softened to a system where these instruments are due for regular revision. In this way, it is submitted, there will be room for the changeability and the unpredictability of natural systems, which cannot be bound by strict and fixed management measures, while at the same time the rich source of scientific research and monitoring will be effectively and consistently utilized to provide flexible yet reliable management measures and criteria.

In terms of Chapter 14 of the Act, the Minister is compelled to establish National Monitoring Systems (NMS) on water resources as soon as practicable.[55] These systems must provide for the collection of data and information necessary to assess, *inter alia*, quantity, quality and use and rehabilitation of water resources; compliance with RQO's, the health of aquatic ecosystems and atmospheric conditions which may influence water resources.[56] He must also establish mechanisms and procedures to co-ordinate the monitoring of water resources. As no procedure is prescribed for the official establishment of a national monitoring system, eg. by declaration in the Gazette, it is submitted that the appointment of the RHP as an official NMS in terms of the Act should be negotiated and formalized, to give statutory effect to its activities. Mechanisms and procedures for the co-ordination of the various aspects of monitoring should also be negotiated, to fix the parametres of the statutory duties of the RHP, its cooperation with other monitoring and information systems,[57] and the extent to which the Minister will give effect to its data during the exercise of his functions in terms of the Act and aimed at achieving the purpose thereof. It is submitted that the establishment of a NMS, and the appointment of the RHP to undertake this function, should either be gazetted or contracted, to provide legal certainty.

55 Section 137.

56 Section 137(2).

57 The Act also compels the Minister to establish National Information Systems, which may overlap or function parallel with monitoring systems (s 139).

Second Goal: to assist the implementation of RQO's

All decision-makers in terms of the Act are statutorily bound to give effect to the RQO's when performing their functions.[58] From this follows that, as far as its second and longer-term goal is concerned, the RHP will have to become established as an official management tool which decision-makers are statutorily bound to use : it will have to acquire some statutory recognition as a legitimate criterion for decision-making :

RHP as NMS

As the Act does not prescribe the extent to which decision-makers are bound to any national monitoring system established in terms of Chapter 14, the mere engaging of the the RHP as a NMS will not necessarily guarantee that the monitoring data is effectively used during the decision-making process, which could negate the effort.

It will be necessary for the mechanisms and procedures (developed in terms of section 137(2) to co-ordinate monitoring), to be developed in such a way as to bind decision-making by all WMI's to the *RHP* products, similar to it being bound by the *RQO's*. *In* simplified terms, the procedure should therefore be:

RHP ASSESSMENT → DECISION → IMPLEMENTATION OF DECISION → RQO ACHIEVEMENT

Only if this fixed function could be fulfilled by a statutory monitoring system, will decision-making really be effectively guided by river health. If decision-makers could attempt to achieve RQO's on discretionary resources assessment or on arbitrary advice, little structured progress can be expected.

RHP and CMA's

The purpose of the development of RQO's, in terms of the Act, is to establish a set of criteria, based on the class in which the specific resource has been placed within the classification system, according to which resource use must be administered. It may be seen as the standard which will have to be complied with in the resource management process.

The requirements for achieving these objectives are published with the objectives, and developed according to the guidelines set by the NWRS.

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[58] Section 15.

While "Resource Quality" is defined as "the quality of all the aspects of a water resource including the quantity, pattern, timing, water level and assurance of instream flow; the water quality, including the physical, chemical and biological characteristics of the water; the character and condition of the instream and riparian habitat; and the characteristics, condition and distribution of the aquatic biota",[59] the RQO's relate to the Reserve; the instream flow; the water level; the presence and concentration of substances in the water; the characteristics and quality of the water resource and the instream and riparian habitat; the characteristics and distribution of aquatic biota; and the regulation and prohibition of instream or land-based activities which may affect resource quality.

These quality standards, together with the requirements which have been published to achieve them, are fixed statutory standards which bind all management institutions, including the Minister and the state, when performing their duties under the Act.

In terms of the Act, as discussed above, CMA's have statutory powers relating to the administration of permitted water use, including a duty to conserve and protect water resources and resource quality in the management area. This duty, *inter alia*, must be exercised in a way that aims at achieving the RQO in accordance with the requirement. In order to do this, constant monitoring of all the factors to which the RQO's relate, will be necessary, and this is where the RHP, preferably as a national monioring system, will play an important role.

It is submitted that steps to perform a duty to protect resource quality according to statutory requirements aimed at achieving fixed RQO's, can hardly be performed by an institutional body who does not have the responsibility to control the apportionment of water and the allocation of use rights in respect of the resource. The mere power to administer the utilization of existing water use entitlements, is insufficient to effectively achieve RQO's. The ideal level to implement measures which would comply with the requirements for achieving the RQO's, would be on the level where the apportionment of the resource and the allocation of licences and authorizations are controlled, as the exercise of these entitlements are the actual determinants of whether or not the requirements for the RQO's can be met.

It is therefore submitted that river health monitoring and assessment will optimally assist the implementation of RQO's in the water resources management process only in as far as the management institution responsible for water management in the area is empowered to

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[59] Section 1(1)(xix).

effectively control water use, and especially to control the apportionment of water. As water entitlements must be issued in accordance with the RQO's, the responsibility to comply with the requirements for RQO's lies in the responsible authority, who must ensure that such entitlements are made subject to those conditions and limitations which will meet the requirements for the RQO's. In the event of the misuse of entitlements, the WMI, such as the CMA or WUA will be empowered to take the necessary steps to force the holder of such entitlement to return to the authorised use and to obey the conditions of his entitlement, but in the event where monitoring of the resource indicates that the RQO's are not achieved because the fixed requirements are not complied with, the responsibility will lie with the responsible authority to get the entitlements in line with the RQO's.

It follows that the RHP will have limited value for purposes of the administration of the use of entitlements, which are the primary tasks of the WMI's at catchment and lower levels. As the responsible authority, which is the Minister or any of the institutions to which he may delegate the power to act as responsible authority, is in charge of issuing entitlements which must meet the RQO's, the RHP may serve, in his discretion, as a guideline to indicate to him the need to change water use in respect of the resource.

It is therefore submitted that the RHP should, in its long term goals, rather aim at receiving statutory recognition as the official mechanism implemented to determine the need for revision of the entitlements, which is the responsibility of and in the control of the responsible authority, than at playing a role in the ground-level and *ad hoc* administration of the use of entitlements. Although this lower-level role could be handy for a management institution to have his decision-making facilitated as to implement measures (and especially emergency-measures) to ensure strict or restricted compliance with entitlements, these measures cannot be used to achieve the RQO's, unless the entitlements are, by the responsible authority, brought in line with the RQO requirements. The RHP on the lowest water management level should then rather be aimed at assisting the WMI within a WMA to advise the responsible authority on the amendment of entitlements to ensure compliance with RQO requirements.

This positioning of the RHP as a NMS in the water management structure is important for effective implementation of the RQO's, and it is submitted that during the development of mechanisms and procedures for the coordination of monitoring systems, which ought to be done in terms of section 137(2), the RHP should strive at influencing the development of a mechanism where it is positioned at the effective decision-making level, that is at the level where water use entitlements are controlled.

RHP and RQO's

It was said above that the Act makes no provision for the revision of RQO's: they are attached to the class in which the resource is classified, and the requirements to achieve them are similarly published once.

The ideal would be that the particular and unique characteristics of a specific resource, combined with the land-use patterns in its catchment and other environmental factors, would over time dictate the standards according to which the resource should be managed. These unpredictable and dynamic resource characteristics should motivate the need to revise the standards from time to time, and the effectiveness of management should also be able to lead to the possible upgrading of these standards.

And as the standards of required resource management are reflected in the RQO's, the implication is that these RQO's should be somewhat more flexible than is currently provided for in the Act.

However, this not being the case, the question is whether a biomonitoring and resource health assessment mechanism would serve any further purpose than to indicate to the responsible authority that some revision or control measures in respect of the existing entitlements in the WMA is required, and if this is the only purpose, whether the effort is worthwhile.

In the discussion above, it was submitted that, besides its short-term goal, the RHP could have a longer-term goal of assisting in post-RQO-establishment resource management, being (a) to indicate to the responsible authority the need to change entitlements to ensure compliance with the RQO requirements, and (b) to assist a WMI in taking the necessary steps within its scope of powers to ensure that permitted users are exercising their entitlements within limits, or to restrict them temporarily hanging improvement in the river health, or at least to advise the responsible authority of the need to change entitlements:

Although (b) seems the most realistic effect, in that RHP could play an important role in providing early symptoms of resource quality (as defined), which could facilitate prompt remedial actions by the WMI, the question is whether the time, cost an effort of implementing the RHP as a formal and an official biomonitoring programme within WMA's is justified in view of the limited effect which it will most probably have on this level.

On the other hand, (a) is the ideal, but not an easy process, because the amendment of entitlements is not a simple procedure, as existing and beneficial use could be affected to the detriment of the lawful user:

> The RHP could indicate that the IFR, to which the RQO for that resource relates, is not met. As temporary restrictions on use will not remedy this problem, the responsible authority, who cannot alter the Reserve or the RQO, has only one choice for permanent correction to achieve the RQO, being to change or suspend the entitlements or their conditions.
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> In terms of the Act, a licence may be reviewed only at the time periods stipulated for that purpose in the licence (which must be a maximum of once every five years).[60] On reviewing, the responsible authority may amend any of the conditions of the licence if it is necessary to prevent deterioration or further deterioration of water resource quality, or if there is insufficient water in the resource to accommodate all authorised uses after allowing for the Reserve and international obligations, or if it is necessary to accommodate demands brought about by changes in socio-economic circumstances and it is in the public interest to meet those demands.[61]
>
> An amendment may only be made if the conditions of all other licences are similarly and equitably amended, and after the holder of the licence have been heard. If the amendment of the licence condition severely prejudices the economic viability of any undertaking, the holder of the licence may, by way of the Water Tribunal, claim compensation for consequential financial loss, which compensation is determined in accordance with section 25(3) of the Constitution. However, in determining compensation, any reduction in the permitted water use may be disregarded if this reduction was done to provide for the Reserve, to rectify an over-allocation of water from the resource, or to rectify unfair or disproportionate water use.[62]
>
> This means that the responsible authority is empowered, for purposes of the above example, to amend the conditions of licences in order to reduce permissible water use in favour of the Reserve without having to compensate. However, he may not

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60 Section 49(1).

61 Section 49(2).

62 Section 22(6)-(10) read with section 49(4).

suspend the licence altogether,[63] and he may not alter the entitlement itself, but only the conditions thereof.

Moreover, he may only amend these conditions once the revision time has come, and not earlier, irrespective of the need to do so, and he must do the same with all the other licences, whose revision times may differ. It is, moreover, not possible to implement temporary measures until such time as all entitlement conditions can be amended, because the WMI's powers in terms of section 6 of Schedule 3 are limited to placing water restrictions on users in times of water shortages or threatening shortages: this function does not empower the WMI to restrict certain users in favour of other water user sectors or even the Reserve.[64]

It is therefore a rather cumbersome procedure to amend licence conditions, which can hardly be regarded as a system which can complement the RHP inputs or even make the efforts worthwhile : Although the RHP might therefore provide early symptoms of water quality or other resource problems, the statutory mechanisms created in the Act to fix these, are administratively inappropriate to give effect to the need for effective solutions.

RHP and WMA's

It seems as if the formal implementation of the RHP on ground-level, ie. within WMA's, is not justifiable per se, unless as an integrated and sub-section of the national programme, aimed at high-level decision-making.

However, the most suitable management level for the RHP to be employed to influence ground-level resource administration, would nevertheless be the WMA, and therefore the WMI responsible for a WMA should also be responsible for or bound by or at least influenced by the data provided by the area-specific biomonitoring programme.

It is submitted that the effort which will be required from the RHP within a WMA, will probably, except for lesser and *ad hoc* situations and resource quality problems, only be a

63 The termination or suspension of licences may only take place in prescribed instances, see ss50-55.

64 Although, in the event of a shortage, the maintenance of the Reserve must receive preference when restrictions on users are considered. This does not, however, mean that circumstances which indicate over-exploitation of the resource may be rectified by supplying the Reserve with water deprived from other users.

worthwhile exercise if the management level at which it is aimed, is the Minister himself, who is acting as the custodian of water resources, and in whom vests the ultimate responsibility to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable manner:

The practical distinguishing status between the powers of the Minister and those of any other WMI, irrespective how wide the range of powers which has been delegated or assigned to it, is the non-delegateable and extensive power of section 26, being the power to make *regulations on* water use. The *regulations* which *he may make*, *include extensive measures* to limit or restrict the purpose, manner or extent of water use, and to regulate or prohibit any activity in order to protect a water resource or instream or riparian habitat. These regulations need not be subject to existing rights or permissible water use or entitlements, but they must, *inter alia,* be aimed at promoting the economic and sustainable use of water, at conserving and protecting water resources or instream and riparian habitat, and at preventing wasteful water use. The possible effect of these regulations may impair on water use rights, and should reflect the highest level of management powers, viz. to exercise the kind of control which will ensure that water resources management can and will achieve the purpose of the Act.

It is submitted that, in order to make a monitoring programme effective on a catchment or WMA level, the Minister will have to use his powers to make regulations which will bind all lawful water user in the exercise of their entitlements. Moreover, he will have to establish NMS's and develop mechanisms and procedures in terms of section 137(2) to position these NMS's in such a way as to bind all decision-makers to its products.

6.2.5 Conclusion

From the above, it may be concluded that the National Water Act, as it currently stands on the statute book, and as the official water resources management system valid in South Africa, has taken a huge step towards environmentally sustainable water management, but it is not as yet institutionally geared to integrate its management systems with other systems, developed from other than water management-oriented sources, towards integrated environmental management.

The role of a monitoring programme in the water management system would be optimally expedient if those decision-makers who are empowered to impact on water use entitlements, could be bound by its products. If the power to allocate and revise water use entitlements could be delegated or assigned to WMI's on catchment or regional level, regional monitoring could be useful as a basis for the apportionment and revision of entitlements, and the conditions attached to those. This will, however, be effective only if these decision-makers are statutorily bound to use the monitoring data as a basis for decision-making, which is possible only if legitimacy is attached to the monitoring programme. By establishing the programme as a NMS in terms of Chapter 14 of the Act, the necessary legitimacy is attached to it, but then it will remain to develop statutory procedures and mechanisms to integrate the monitoring programme into the decision-making process, and to bind the decision-makers to the accommodation of monitoring data during the decision-making process which is aimed at the achievement of the RQO's.

However, even in a case where CMA's are established for all catchments, and all possible powers in terms of section 73 have been assigned to such CMA's, including the power to act as responsible authorities, then the achievement of RQO's is nevertheless complicated because of the cumbersome procedure to amend the conditions of existing entitlements. The ultimate responsibility for fulfilling the purpose of the Act, ie. to manage water resources in an integrated way for the benefit of all and for sustainability, will remain with the Minister, which overriding power vests in his power to issue regulations to which all water use will be subject. This power cannot be delegated, and no delegate or assignee in terms of the Act may, to protect resource quality, impair on permissible water use, except by temporary measures, expropriation or the revision of licence conditions.

It is therefore submitted that the ideal positioning of the RHP would be as an official NMS of which the products, in terms of official procedures, should bind the Minister to take the necessary steps by way of the publication of regulations, to enforce the use of water in such a way as to achieve the RQO's.

It is, however, submitted that this positioning should be evaluated against environmental law and principles.

6.3 THE RHP AND ENVIRONMENTAL LAW

6.3.1 Environmental Law Principles

The National Environmental Management Act of 1998[65] was promulgated on 27 November

[65] Act 107 of 1998.

1998,[66] to provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of the state.

The statutory environmental principles[67] apply to all actions of all organs of state, and serve as guidelines to which any organ of state must exercise any function when taking any decision concerning the protection of the environment.[68]

The statutory environmental principles include:

- Although development must be socially, environmentally and economically sustainable, environmental management must place human requirements at the forefront;

- Sustainable development encompasses:
  - The avoidance of the disturbance or loss of ecosystems and biological diversity;
  - The avoidance of pollution and environmental degradation;
  - The responsible and equitable use and exploitation of non-renewable natural resources;
  - The development, use and exploitation of renewable natural resources and the ecosystems of which they are part not to exceed the level beyond which their integrity is jeopardized ;
  - The avoidance of negative impacts on the environment and the environmental rights of people.

- Environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated, and it must take into account the effects of decisions on all aspects of the environment and all people in the environment by pursuing the selection of the best practicable environmental option.

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66 GN 1540 GG 19519 of 27/11/98.

67 Set out in s 2 of the Act.

68 Section 2(1)(c).

- Responsibility for the environmental health and safety consequences of a policy, programme, project, product, process, service or activity exists throughout its life cycle;

- The social, economic and environmental impacts of activities, including disadvantages and benefits, must be considered, assessed and evaluated, and decisions must be appropriate in the light of such consideration and assessment;

- There must be intergovernmental co-ordination and harmonisation of policies, legislation and actions relating to the environment;

- The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage.

6.3.2 Environmental Law Mechanisms

The mechanisms which the Act provides for, include procedures for co-operative governance, fair decision-making and conflict management and integrated environmental management.

6.3.2.1 Environmental Implementation Plans and Environmental Management Plans

Co-operative governance is strived at by the obligation which scheduled national government departments (which exercise functions which could affect the environment) have to draft environmental implementation plans (EIP's) and environmental management plans (EMP's).

The purpose of these plans is to co-ordinate and harmonize the environmental policies, plans, programmes and decisions of organs of state which exercise functions affecting the environment, aimed at the achievement, promotion and protection of a sustainable environment, in order to promote consistency in the exercise of functions that may affect the environment.[69]

Every organ of state must exercise every function thereof which may have a significant effect on the protection of the environment, substantially in accordance with its EIP or EMP.[70] This

[69] Section 12.

[70] Section 16.

need to comply with the EMP's and EIP's is subject to a prescribed checking procedure.

6.3.2.2 Integrated Environmental Management

Integrated Environmental Management (IEM)[71] is aimed at promoting the application of appropriate environmental management tools in order to ensure the integrated environmental management of activities.[72]

In order to promote the integration of principles of environmental management into the making of all decisions which may have a significant effect on the environment, and to identify, predict and evaluate the actual and potential impact on the environment, and to ensure that the effects of activities on the environment receive adequate consideration before actions are taken in connection with them,[73] the potential impact on the environment of activities which require permission, must be considered prior to their implementation, and procedures for this consideration process may be prescribed by law.[74]

6.3.2.3 Pollution and Environmental Degradation Control

Any person who causes pollution or significant degradation of the environment mus take reasonable measures to stop or minimize or rectify it, and the Director-General may direct measures to be taken to do so.[75]

6.3.2.4 Environmental Management Cooperation Agreements

The Minister or any organ of state may enter into Environmental Management Cooperation Agreements (EMCA's) with any person or community for the purpose of promoting compliance with the principles of the Act.

EMCA's may contain:

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[71] As provided for in Chapter 5 of the Act.

[72] Section 23(1).

[73] These are some of the objectives of IEM listed in s 23(2).

[74] Section 24.

[75] Section 28.

- an undertaking by the person or community concerned to improve on the standards laid down by law for the protection of the environment which are applicable to the subject matter of the agreement;
- a set of measurable targets for fulfilling the undertaking, including dates for the achievement of such targets; and
- the measures to be taken in the event of non-compliance with commitments in the agreement, including where appropriate penalties for non-compliance and the provision of incentives to the person or community;
- provision for periodic monitoring and reporting of performance against targets; independent verification of reports; regular independent monitoring and inspections; and verifiable indicators of compliance with any targets, norms and standards laid down in the agreement as well as any obligations laid down by law.[76]

6.3.2.5 Other Ministerial Discretions

The Minister may purchase or expropriate any property for purposes of the implementation of the Act.[77]

The Minister may make regulations in order to ensure compliance with the purpose of the Act, and these regulations may differ in respect of different activities, provinces, geographical areas and owners or classes of owners of land.[78]

6.3.3 Environmental Management Institutions

6.3.3.1 National Environmental Advisory Forum

A National Environmental Advisory Forum is established in terms of section 3 of the Act, aimed at informing the Minister, in general, on environmental management and governance, and specifically the setting and achievement of objectives and priorities for environmental governance. The Minister appoints the members of the NEAF, lay downs rules for the functioning thereof, fund it and audit its work.

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[76] Section 35.

[77] Section 36.

[78] Section 44.

6.3.3.2 Committee for Environmental Coordination

The Committee for Environmental Coordination is established in terms of section 7 of the Act, to promote the integration and coordination of environmental functions by the relevant organs of state, and to promote the achievement of the purpose and objectives of EIP's and EMP's.

The functions of the Committee include:

- scrutinising, reporting and making recommendations on EIP's;
- investigating and making recommendations regarding the assignment and delegation of functions between organs of state under any law affecting the environment, and regarding the practical working arrangements between the organs of state;
- investigating and recommending the establishment of mechanisms in each province for providing a single point in the province for the receipt of applications for authorisations, licences and other permissions required for activities under legal provisions concerned with the protection of the environment where such authorisations, licences or permissions are required from more than one organ of state, and procedures for the co-ordinated consideration of such applications by the organs of state concerned;
- making recommendations to co-ordinate the application of IEM, including cooperation in environmental assessment procedures and requirements;
- making recommendations aimed at securing compliance with the environmental management principles and national norms and standards contemplated in section 146(2)(b)(i) of the Constitution;
- making recommendations regarding the harmonisation of the environmental functions of all relevant national departments and spheres of government;
- advising the Minister on providing guidelines for the preparation of EIP's and EMP's.

The CEC consists of representatives of specific national departments, specific provincial heads of departments, and other members whom the Director-General may appoint.

6.3.4 The RHP under the National Environmental Management Act

Although the RHP was primarily a DWAF initiative, it was submitted above that the new statutory water law is not yet properly geared for incorporating the RHP to the extent of optimal utilization of its products. In order for the RHP to have a significant effect on decision-making, it will be necessary to grant some flexibility to RQO's, or to interfere in lawful water use entitlements by Ministerial regulation.

What is necessary, is some mechanism which will legitimately bind all water users and decision-makers to river health, as presented by the RHP. Even the establishment of the RHP as an official national monitoring system, will not solve the problem, unless this formal connection is secured.

In view of this, it was submitted that the effect which the RHP could optimally have within the water management system, should be advanced by its establishment as a structure within environmental law, where new legislation was developed to have substantial overriding and binding powers as far the performance of all other government functions which might have an effect on the environment, is concerned.

6.3.4.1 RHP as an Environmental Management Institution

The NEAF is intended to advise the Minister on matters which would advance the achievement of the environmental principles. As the status sought for the RHP is rather of having some binding effect on decision-making, it is submitted that an advisory status will not assist towards its optimal purpose. Being an advisory organization leaves the ultimate discretion in the hands of the Minister, to implement the steps recommended by such a structure. Moreover, the Act does not make provision for Programmes, in stead of persons, to be appointed as members. It is submitted that the RHP is not suited to fit into the environmental management system as part of the NEAF.

As the CEC is aimed at administering the mechanisms provided for in the Act and discussed above, it is submitted that the RHP is neither structured for this slot, although it could be used valuably if co-opted to attend meetings and influence the decisions for administration of the Act which are being taken by the CEC. It is submitted that the statutory status sought for the RHP is not one of an Environmental Management Institution, but rather of a statutory Programme which is co-opted and to which decision-makers and administrators of the Act are bound when executing the mechanisms of the Act to attain its purpose of sustainable environmental management.

6.3.4.2 RHP as an Environmental Management Mechanism

RHP and EIP's/EMP's

EIP's and EMP's are aimed at establishing a blueprint with guidelines which will bind all organs of state when functions affecting the environment are performed.

These Plans must contain descriptions of the procedures which the relevant Departments will commit to, in order to ensure that their activities are exercised with a view to achieve the purpose of the Act and to comply with its principles.

The Plans are submitted to the CEC for approval and streamlining with the Plans of other Departments, and then Gazetted. Thereafter the relevant organs of state are bound to conduct their activities in strict accordance with these Plans. Compliance with the Plans is monitored by the Director-General, and each Provincial Government must ensure that all municipalities comply with the Plans.

It is submitted that EIP's and EMP's, in the description of procedures and policies which will bind the departments in the undertaking of their activities, should include proper resource health monitoring programmes. In as far as river health is concerned, the RHP could become one such a monitoring programme to which all organs of state are bound in the attempt to ensure that they comply with the purpose and principles of the Act, and which is written into their Plans. This could either be attained by negotiation with the CEC or the relevant Departments, and especially DWAF, or by having it enforced by way of regulation.

The ideal is to eventually establish the RHP as the official monitoring programme to ensure compliance with the Act, and to which not only water managing institutions, but all resource management institutions should be bound. This status is, for the long term, a much more extensive positioning than having it established as a monitoring system in terms of the National Water Act, while supporting the effort towards integrated resource management.

RHP and IEM

The IEM procedure may largely be developed and prescribed by regulation. The Minister and every MEC may, *inter alia,* prepare compilations of information and maps that specify the attributes of the environment in particular geographical areas, including the sensitivity, extent, interrelationships and significance of such attributes which must be taken into account by every organ of state charged with permitting activities which may affect the environment.[79] The investigation, assessment and communication of the potential impact of activities must take place in accordance with prescribed procedures, which include investigation of the environment likely to be affected, the potential impact, its effects and significance, mitigation

[79] Section 24(2)(e).

measures, as well as the formulation of arrangements for the monitoring and management of impacts, and the assessment of the effectiveness of such arrangements after implementation.[80]

It is submitted, without stepping into too much detail, that the role of the RHP in the IEM procedure should be investigated, especially as far its establishment as the official criterion for the consideration of the permission of activities is concerned. It is suggested that a monitoring programme as a guide to integrate environmental management activities could substantially contribute towards sustainable development.

RHP and EMCA's

EMCA's may be concluded to promote compliance with environmental management principles, and it may be concluded by the Minister, MEC or a municipality with any person or community. It may, inter alia, provide for regular independent monitoring of progress towards the purpose.

It is submitted that the RHP could well become the official programme used for monitoring progress relating to EMCA's, as far as river ecosystems are involved. A recognized or official monitoring programme will contribute towards integrated environmental management, and in the long run will stabilize the fundamental substructure which will guide environmental management towards sustainable development. This possibility should be investigated in further depth.

6.3.5 Conclusion

The purpose and principles of environmental management legislation are comprehensive and futuristic, and it is expected that the eventual implementation of the mechanisms of the Act should facilitate integrated resources management towards sustainable environmental development.

The establishment of the RHP as an environmental management tool (at first only in so far as river health aspects are concerned), to dictate the implementation of procedures for environmental decision-making, which, according to the Act, will bind all activities and functions which may affect the environment, could well be the basis for structured water management in line with environmental principles.

80 Section 24(3) read with (7).

Because, as was submitted earlier, water is a natural resource of which the management should strictly fall under the scope of environmental management structures and mechanisms, there is a need for the establishment of structures which would effectively draw water management under the wings of environmental management, towards integrated resources control for sustainability.

Although the mechanisms envisaged in the NEMA provide the desired framework for integrated resources management, especially by binding all resources management institutions to the procedures and criteria to be developed under the Act, there remains a need to give flesh to these bones, and sound environmental monitoring and other programmes should be engaged as far as possible to fulfill this task.

The drafting and streamlining of EIP's and EMP's for all affected organs of state, promises to be an extensive process, and the implementation of these to achieve decision-making which will comply with the statutory principles, will require expert input as far as environmental processes are concerned.

It is therefore submitted that environmental monitoring programmes such as the RHP should be considered as a standard programme to guide the implementation of EIP's and EMP's, but also other mechanisms of the Act, including the processes to monitor the progress towards the goals of EMCA's and the identification and evaluating of activities to be regulated by the IEM processes.

The RHP, to be accepted as an official environmental management tool, preferably by regulation, the product of which all environmental managers will be bound to while performing their functions in line with the EIP's and EMP's, should become involved in negotiations on all levels of environmental governance to achieve this status.

Once the RHP is the official river health monitoring programme used in the implementation of the of the National Environmental Management Act, the Minister and WMI's in terms of the National Water Act will by statute be bound to the data and monitoring results, which will, in its turn, facilitate the admission thereof in the structures of statutory water management. It could even become the very programme to dictate Ministerial regulations in terms of the NWA to control the exercise of water use entitlements, which is the strongest mechanism in the NWA towards sustainable utilization and development.

6.4 RECOMMENDATIONS FOR REGIONAL IMPLEMENTATION OF THE RHP

In view of the above, it is submitted that the following aspects regarding the positioning of the RHP should be negotiated with the relevant authorities, in order to legitimize it as a lawful structure in terms of the official water and environmental management systems:

- The establishment of the RHP as a National Monitoring System in terms of the NWA;
- The development of procedures and mechanisms for the implementation of NMS's within the entire scope of water management and decision-making, which will ensure that such NMS's receive the status of binding decision-making criteria, which will bind WMI decision-making towards achieving the RQO's, but also influence the publication of Ministerial regulations regarding the control of conditions of water use;
- The delegation of water apportionment powers to catchment or regional level, to facilitate the achievement of RQO's by WMI decision-making, but subject to RHP guidance;
- The establishment of the RHP as an official criterion for the drafting of EIP's and EMP's, and especially as a binding procedure to guide the performance of the functions of all organs of state;
- The acceptance of the RHP as an integral criterion for the IEM procedure, according to which the authorization of activities will be considered and reviewed;
- The acceptance of the RHP as one of the official mechanisms to monitor the progress in EMCA's, and to be included as a standard condition of such EMCA's.

Although the basic negotiations for the positioning of the RHP for these functions in the water and environmental management systems, are at national level, its eventual effect would be on regional level, where WMI's and provincial governance would eventually be responsible for the implementation of the mechanisms established by national governance in terms of law. It is therefore probably worthwhile to commence negotiations regarding the incorporation of the RHP into the management structures, at regional level, and especially to undertake case studies under the auspices of regional governance. This will facilitate national negotiations.

It is submitted that both the applicable Acts are relatively new, and have not as yet been tested against practical requirements. This will necessitate the further development of mechanisms to make these pieces of legislation practically applicable, in which process the RHP should intervene to ensure its admission from the earliest phases of implementation.

CHAPTER 7 - STRATEGIES TO GUIDE NATIONAL IMPLEMENTATION OF THE RIVER HEALTH PROGRAMME

DJ Roux

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7.1 INTRODUCTION

It is in the interest of sustainable development that relevant scientific advances be passed on to the operational managers of natural resources. This is especially important where scientific progress relate to the monitoring, assessment and management of these resources. Unfortunately, the good intentions and sound scientific principles that may be used by developers of environmental monitoring and management programmes provide no guarantee that such programmes will be adopted by the intended end-user community. Apart from the design specifications, critical levels of technical expertise, institutional arrangements, financial resources and political support are required to turn the programme into an operational system which will achieve its objectives.

Certain mechanisms and dynamics are known to drive the transition of technology from scientific concepts to operational products and programmes (e.g. Steele, 1989 and Rogers, 1995). An understanding of these mechanisms and dynamics is usually associated with the discipline of technology management, and commonly falls outside the realm of environmental researchers. However, the effective transfer and implementation of environmental technologies can only benefit from such an understanding.

This chapter explores the transition from development (creation) to adoption (application) of an existing environmental monitoring programme, using the South African River Health Programme (RHP) as a case study. The RHP focuses on measuring, assessing and reporting on the ecological state of riverine ecosystems. This programme has the overall goal of expanding the ecological information available for rivers, in order to support the rational management of these systems (Roux, 1997). The RHP has largely progressed from its conceptual and technical design phases to widespread adoption by end users. As such, the development of the RHP, and implementation initiatives to date, are generally perceived as a success story.

This chapter documents the process and strategies that were followed, often unknowingly or intuitively at the time, to see the RHP grow from a mere idea to a national initiative. The development and implementation models that were, and are being, followed, and the lessons that emerge from these, are discussed. Emphasis is on obtaining an understanding of some of the critical issues that affected the transition from the creation to the application of the RHP. Although this chapter focuses strongly on the example of the RHP, several of the models used are generic to the management of technology. Developers of environmental technologies/programmes in general could benefit from taking cognisance of the experience gained through the design, growth and early anchoring stages of the RHP in South Africa.

7.2 BACKGROUND TO THE CREATION AND ADOPTION OF TECHNOLOGY

7.2.1 Relationship Between the Creation and Application of Technology

The planning, development and implementation of appropriate technological capabilities are prerequisites for accomplishing strategic and operational objectives related to water resources management. Having a continual supply of the right kind of technologies is strongly dependant on the deliberate coordination of research and development (R&D) with associated application and service functions. Marketing, financial and human resources considerations form an integral part of this process. The overall process falls within the domain of technology management.

Technology management can be broadly divided into **creation** and **application** of technology. Creation consists of basic and applied research as well as the development of the technology. Application contains functions or disciplines such as design, production, quality control, application, integration (e.g. with information systems and decision making processes) and product service.

The two broad technology compartments and even their sub-components each represent a field of specialised activity. Many of these specialised activities are characterised by specialised language and skills and operate in different time frames. All of this commonly results in the fragmentation of the different activities or functions, and too little recognition of an interdependent relationship between the compartments of creation and application (Steele, 1989).

In order to ensure the required coordination and integration between the two technology compartments, the creation of technologies should ideally be initiated by real operational needs with end-user involvement all along the way. It follows that R&D should be a means to an end, and that the application of technology should be influenced, in an ongoing and pro-active manner, by the results of R&D activities (Van Vliet and Gerber, 1992).

The relationship between the creation and the application of technologies essentially comes down to an interplay between (Figure 7.1):

- developing relevant technologies (technology development route), and
- applying these technologies in the appropriate way (technology transfer route).

Figure 7.1 Progression from business, to technology, to R&D strategies; where technology strategy is a subset of business strategy and R&D strategy in turn is a subset of technology strategy (from van Vliet and Gerber, 1992).

In the context of the national water resources management function in South Africa, the business strategy is reflected by the development and acceptance of policy related to the management of water resources. This strategy stipulates the broad future direction to be followed, of which the integrated management of water resources and the adherence to the principles of sustainable development are examples (South African National Water Act; Act No 36 of 1998). The business strategy provides the framework for the development of a technology strategy. A technology is seen as the process of applying scientific and engineering knowledge to achieve a practical result (Roussel *et al.*, 1991). In the water resources context, this may include ways of collecting data, of processing information, or of taking decisions. The R&D strategy should facilitate the development and testing of the concepts, tools and methods that are necessary to give effect to the broad technologies specified by the technology strategy.

Few people, no matter how competent, have the ability to conceptualise the combined developmental and operational worlds of creating and applying new technologies. This is understandable, as the working cultures between the creators and appliers of technology differ. Creators commonly accept change, innovation and risk taking as necessary conditions for sustained viability and survival of the technology that is being developed. Appliers, on the other hand, usually desire stability, rigour and discipline in their day-to-day operational management (Steele, 1989). These differences may easily result in misunderstandings or misconceptions, which will detract from aligning business, technology and R&D strategies.

A number of potential misconceptions can lead to the wrong assumptions about the actual rate, direction and character requirements of a new technology. As examples, creators of capability are often guilty of the following misconceptions, as based on Steele (1989):

- *Best possible should determine the choice of a technology:* In reality, social, economic and user considerations determine the criteria and the level of performance required for the application of a technology. In the real world, "good enough" is commonly the basis for choice.
- *The choice of technology result from rational analysis:* Most often, choice is strongly influenced by convention and past practice/experience. Also, a change in values or of policy will result in a change of perceived priority needs and associated budget allocations. These budget allocations may ultimately reflect perceived technology needs and hence direct R&D activities.
- *Technological advances or discoveries usually are adopted eventually:* In fact, most new developments never succeed. One reason for this is that the socio-technical system is immense, intricate, highly interdependent, and exceedingly demanding. Any newcomer technology is faced by a multitude of social, cultural and financial barriers. The result is that only technologies that really offer substantial advantages are likely to be adopted and incorporated into systems.
- *Technological advances have intrinsic value:* The customer, through acceptance and application of a technology, determines value.
- *The power of a new technology determines its success:* The reality is that the infrastructure required to support the implementation of a technology is often the determining factor. In addition, appropriate user-skills and logistical support, and a sufficiently knowledge-intensive environment must be in place before a new technology can be deployed successfully.

7.2.2 Technology Maturation and Competitive Impact

Each new technology is exposed to a certain maturation sequence during its developmental and applied life cycle. Roussel *et al.* (1991) describe four sequential stages of technological maturity, namely the embryonic, growth, mature and aging stages (Figure 7.2).

Technological maturity is intrinsic to any technology, and is not dependant on ways and scale of application (Roussel *et al.*, 1991).

The initial or embryonic stage of a programme will be characterised by the existence of little more than a vision of its possible application. In the growth stage of maturity, the accumulation of knowledge has led to a much more realistic picture of its application potential. Although much of the uncertainty has been removed, considerable potential for R&D advance still lies ahead. With continued generation of knowledge through R&D, the technology advances into the mature stage, where the pace of advance in understanding slows. With time, technologies advance to the aging stage, characterised by substantial completion of scientific and engineering advance (Roussel *et al.*, 1991).

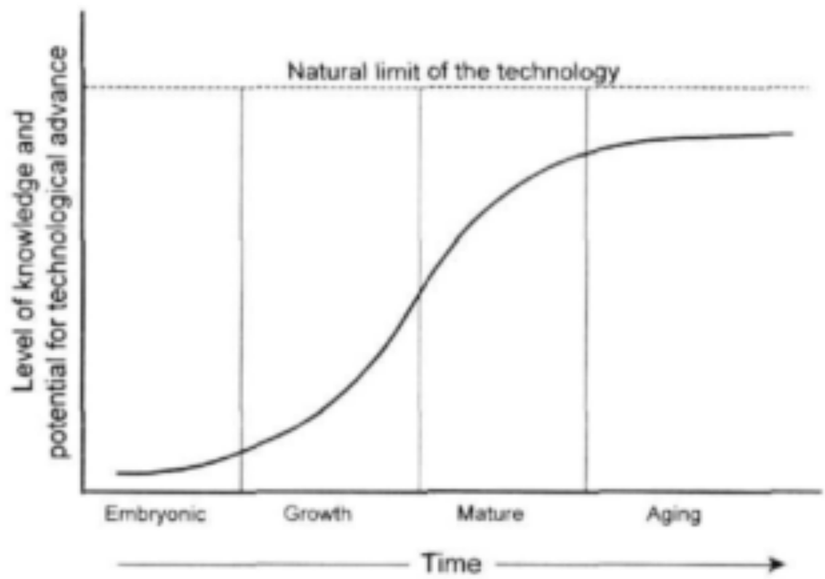

Figure 7.2 The technology maturation sequence (from Roussel *et al.*, 1991).

A further concept of relevance is that of the competitive impact of technologies. The competitive impact of a technology is extrinsic and closely dependant on the community that applies it. There is a natural progression in the competitive impact of technologies, typically progressing from pacing (potential to change technological competition), to key (embodied in products and processes used by leading groups), to base technologies (essential, and known and practised by all relevant groups). Where the maturity of technology provides insights into the potential for future technological advances, their competitive impacts indicate the differences that such advances might make to a relevant field of application (Roussel *et al.*, 1991).

In the above context, there are several mature technologies to be used for the biological monitoring of rivers. However, when these technologies are packaged into a monitoring programme with a specific purpose, the programme itself starts as both an embryonic and pacing technology. The embryonic programme will mature as knowledge and understanding of the functioning and integration of its components (e.g. sampling, data assessment, information dissemination) are accumulated through R&D. However, the programme also has to find its way into an intended market, which will be determined by the ability of the programme to satisfy an existing need. As the value of applying the programme becomes clear, its impact will progress from where it is viewed as something with potential (pacing technology), through a stage during which its usefulness is demonstrated (key technology) to where it becomes a "commodity" which is used by virtually all relevant parties (base technology).

With the increase in the complexity and severity of human-induced pressures on water resources, there is an ever-changing need for different types of management information and associated monitoring programmes. Once developed, new monitoring programmes are used to generate new kinds and combinations of information, which increase our knowledge and understanding of a particular situation. New kinds of information usually also highlight new problem areas and make associated uncertainties visible. As such, the development and application of monitoring programmes follow, but often lag behind, the challenges and insight characteristic of a specific era. Hence the feeling that we never or rarely have sufficient information and knowledge to make proper decisions (Van Vliet and Roux, 1996).

It follows that an important task in effectively managing a suite of monitoring programmes is to always maintain some sort of dynamic balance between continued concentration on conventional monitoring technologies while diverting some effort to the development of new monitoring technologies to supplant it (Steele, 1989). Implicit in this balance between old and new is the existence of effective programmes in each category of work. There can be no progress if all the effort is devoted to conventional or existing technologies, with no recognition of the role of appropriate replacements. If a programme's dynamic nature does not keep up with the rate of change in information requirements (which may shift quickly and substantially due to, for example, a change in resource management policy), the programme will inevitably have to be replaced by one that addresses the actual questions of the time.

7.2.3 Innovators and Laggards

Several factors may play a role in determining the competitive impact of a new technology. One aspect that provides an important perspective on the likely nature of the transition between the creation and the application of a technology, is the process of technology adoption (Figure 7.3). The following brief description for each of the adopter categories is from Rogers (1995):

- *Innovators*: This group is characterised by venturesomeness and is responsible for launching the new idea into a system (e.g. an organisation or country). Innovators must be able to cope with a relatively high degree of uncertainty. Often the control of substantial financial resources is required to counter the risk of failure of a new innovation.
- *Early adopters*: This adopter category usually has the greatest degree of opinion leadership in most systems. Potential adopters look to early adopters for advice and information about a new technology. Early adopters know that to continue to earn this esteem of colleagues, they must make judicious innovation decisions. They decrease the uncertainty about a new idea by adopting it and then conveying a subjective evaluation to peers.
- *Early majority*: The early majority adopt new ideas just before the average member of a system. They may deliberate for some time before completely adopting a new idea. The thinking of this group is well described by the quote: "Be not the first by whom the new is tried, nor the last to lay the old aside" (Alexander Pope, *An Essay on Criticism*, Part II). Although the early majority may interact frequently with their peers, they seldom hold positions of opinion leadership in a system.
- *Late majority*: The relatively scarce resources of this group mean that most of the uncertainty about a new idea must be removed before they will feel that it is safe to adopt. Adoption by this sceptical group is often as a result of economic necessity or increasing network pressure from peers.
- *Laggards*: Laggards are the last in a social system to adopt a technology, and they possess almost no opinion leadership. Laggards tend to be suspicious of new technologies. Their resistance to adoption may be entirely rational from a laggards' viewpoint, as their economic position is often precarious.

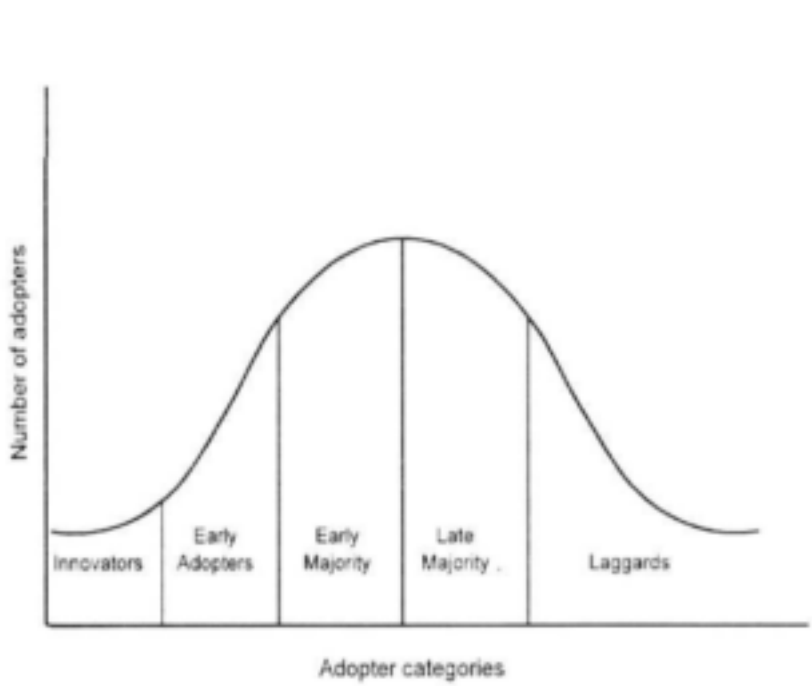

Figure 7.3 Categories of adopting new technologies (from Rogers, 1995).

7.3 ARCHITECTURAL MODEL FOR DEVELOPING THE RHP

The above background to the creation and adoption of technology provides the context for analysing the transition from development to initial application of the South African RHP. To facilitate this analysis, the development of the RHP is conceptualised in terms of key architectural components and life stages. Firstly, the key components that are used in this chapter to investigate the factors that influenced the development of the RHP are (Figure 7.4):

- *Guiding Team*: The leadership who provides the vision and drive which guides the future development of the programme.
- *Concepts, Tools and Methods*: To make the monitoring programme functional, it needs appropriate concepts and sound technical tools and methods, e.g. for conducting monitoring and assessing the resulting data.
- *Infra-structural Innovations*: Once the programme has been designed, certain individuals and organisations will be required to implement, maintain and improve the programme over time. The appropriate infra-structural arrangements would ensure that the programme design becomes operational and remains sustainable.
- *Communication*: Internal communication is the glue that aligns the different

components, and keeps the overall programme together and on track. External communication presents the programme to, and obtain feedback from, the user-community and relevant stakeholders.

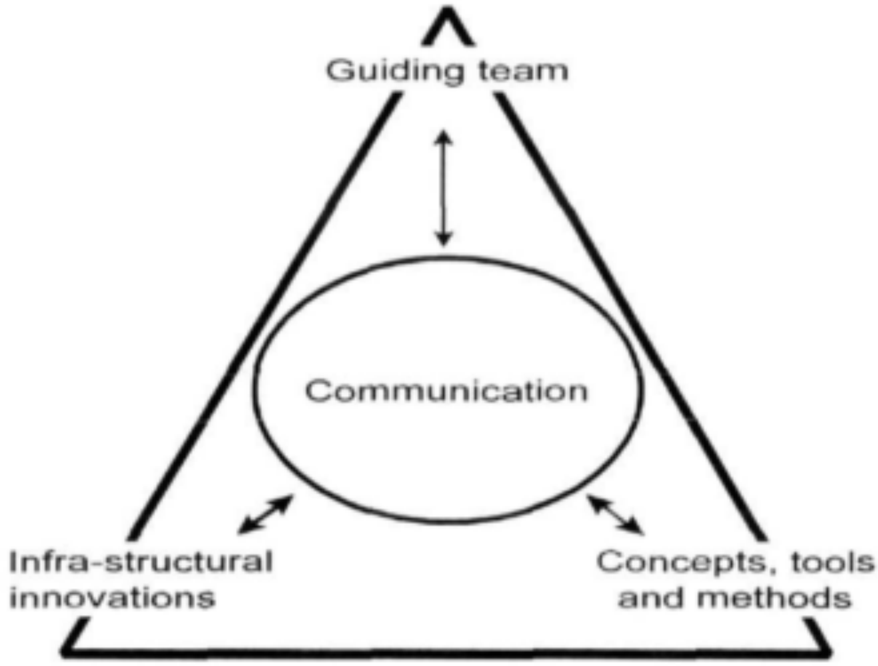

Figure 7.4 The key components focussed on in the design of the RHP, modified from the "architecture" of a learning organisation as presented by Senge *et al.* (1994).

Secondly, three broad life stages are used within which to assess the development of the RHP to date. These stages are referred to as the design, growth and anchor stages. The key architectural components, and how these relate to each of the sequential life stages, are the focus of the remainder of the chapter.

7.4 DESIGNING THE RHP

The realisation of the need for a new type of management information regarding water resources, and thus a new type of monitoring capability, led to the DWAF initiating the design of the RHP (Hohls, 1996). A phased approach included phases for formulating a design framework, the conceptual development and testing of the programme within that framework, and specifying structures for the implementation of the programme. This design process is summarised by Roux (1997).

7.4.1 Guiding Team

The RHP started as an idea shared by a small group of scientists and managers. This idea was triggered by a worldwide trend towards the use of biological indicators in the monitoring and management of water resources. The idea developed into a vision, based on a shared knowledge and understanding of why the programme was needed, where the programme should take water resources management, and what is required to make the programme a reality. Recognition was given to the fact that both the information requirements and the technical and practical feasibility surrounding the vision will change with time, and that the final product itself should not be static.

The small group of individuals that developed the vision of a RHP represented the early guiding team for the design of the programme. The guiding team for the development of a relatively small and simple technology may consist of one individual. However, a large and complex capability such as an environmental monitoring programme intended for national application, requires a guiding team consisting of a number of individuals. In the case of the RHP, some members of the guiding team were from the relevant creator field (researchers), and others were from the relevant applier field (water resource managers). However, a general characteristic of members of the early guiding team was that they were visionary, conceptual and systemic in their thinking.

An important factor for creating an environment where the thinking processes within the creator and applier communities can be harnessed in a complementary fashion, is to nurture the right type of relationship between these groups. The initial guiding team was brought together by means of a once-off and relatively short-term contractual arrangement between the DWAF (applier) and the CSIR, a research organisation (creator). However, it was soon realised that the extent of this programme would require a different type of thinking, where much longer time-frames and more frequent sharing of ideas need to be catered for. The

DWAF has responded by funding a multi-year arrangement between them and a consortium of creators, which allowed for the creator-applier relationship to develop into a strategic partnership. The security of a long-term relationship supported freedom of thinking and creativity during the design stage of the RHP.

7.4.2 Concepts, Tools and Methods

The guiding team visualised the process of creating and implementing a national programme for monitoring the integrity or health of riverine ecosystems. They were then able to break the process down into parts and to identify the types of expertise that would be required for developing each part. Once these parts have been identified, relevant specialists were involved in order to develop technical specifications for each part. At the same time, resource mangers at national and regional (provincial and local) spheres of government were consulted in order to align the available technical capabilities with their information needs. During this stage, the guiding team essentially formed an interface between the larger creator and applier communities. As their knowledge and understanding increased, they shaped the overall vision and at the same time conceptualised the links for integrating the different parts into one programme.

An important outcome of the framework design was to define the objectives of the programme. These are to: (a) measure, assess and report on the ecological state of aquatic ecosystems, (b) detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems, and (c) identify and report on emerging problems regarding the ecological state of aquatic ecosystems in South Africa. The set objectives directed the conceptual design of the programme, in terms of the required tools and methods. It allowed specifications to be defined for the methods and tools, so that the product resulting from the design would both fulfill the objectives set by the guiding team, and be feasible in terms of available resources and capabilities.

The concept of integrity, as developed for riverine biota (e.g. Karr *et al.*, 1986) and for in-stream and riparian habitats (Kleynhans, 1996), was adopted as the basis for measuring and assessing the ecological state of aquatic ecosystems. This essentially means that the condition of an ecosystem is assessed relative to how that system would function within its hypothetical natural state. Any reduction in the natural abilities of an ecosystem is viewed as a reduction in integrity.

As the main purpose was for the programme to serve as a source of information regarding the overall ecological integrity of riverine ecosystems, the RHP would essentially rely on the use of biological indicators (e.g. fish communities, riparian vegetation, invertebrate fauna) of river condition. The rationale for using biological monitoring is that the integrity of biota inhabiting riverine ecosystems provides a direct, holistic and integrated measure of the integrity of the river as a whole. (e.g. Karr and Chu, 1997).

To implement the concept of biological monitoring, various methods and tools are needed to, for example, conduct biological measurements, interpret these measurements and package and disseminate the resulting information. The conceptual design phase dealt with defining the underlying technical specifications of the various components of the programme (such as selecting monitoring sites and ecological indicators to measure, deciding on monitoring frequency and creating management systems for data and information). To accommodate a range of regional requirements, capabilities, and the availability of resources, alternative monitoring protocols were proposed. The options range from the use of a single biological index to the use of a comprehensive suite of biological and non-biological indices (Uys *et al.*, 1996).

7.4.3 Infra-structural Innovations

Good guiding ideas and sound methods and tools are not sufficient to ensure the successful implementation of a monitoring programme. Infra-structural mechanisms must be developed and improved to ensure the long-term feasibility of the programme in terms of required resources: political and management support, expertise, money, equipment, people, time, etc. Such mechanisms are most likely to be achieved through organisational arrangements for co-participation and coordination in the development and implementation of the monitoring programme.

It was recognised that the DWAF, even with the assistance of its regional offices, did not have the infrastructure and expertise to implement the RHP nationally. It was thus necessary to specify an institutional design that would allow the practical and sustainable implementation and maintenance of the programme. As this would require infrastructures at the river, catchment and provincial levels, it was proposed that the operational responsibilities and ownership of the programme be devolved to appropriate institutions within provinces. In order to optimise the coordination and maximise the resources available for implementation of the RHP, a model of national coordination (custodianship) and provincial and local implementations (ownership) was proposed (Roux, 1997).

7.4.4 Communication

During the design stage, the composition of the guiding team was exclusive. An advantage of this exclusivity was that interaction among individuals in the guiding team was characterised by a natural cohesion and synergy. Communication within the team was personal and easy, characterised by mutual trust, a shared vision and matching work ethic and values. During this stage, communication within the guiding team was important for shaping the vision and developing sufficient understanding and clarity of the future role of the RHP. External communication was limited to selected specialists or resource managers whose opinions were sought.

7.5 GROWING THE RHP

The design of a monitoring programme represents a mere plan on paper. Even though the plan should present all the specifications to allow one to visualise the complete programme, it still needs to grow through research results, testing, demonstration and implementation, before it can be regarded as a fully operational monitoring programme. However, the rate of growth may be dependant on many factors, of which some may be very concrete and some of a more subtle nature.

The growth stage of the RHP saw the expansion of the guiding team and a strong emphasis on developing, testing and selecting tools and methods for the programme. Provincial stakeholders started to implement the programme on a pilot scale, and communication regarding the programme reflected the growing network of interested parties.

7.5.1 Guiding Team

During the growth stage of the RHP, the nature, size and composition of the guiding team changed radically from the small nucleus that it was during the design stage. This change resulted from weighing up two basic scenarios for continued R&D of methods and tools for the RHP and a decision to follow the more inclusive option (Roux, 1997).

The first option was to develop the methods and tools within a relatively small project team until the scientific validity and technical detail of all programme components could be specified with considerable certainty. Such an approach would most likely focus on one geographic area for development and testing. An implementation manual would then have to be produced to prescribe in detail the techniques and protocols to be followed to implement the RHP in other parts of the country.

The advantages of conducting R&D within a small group are that this option will only require a moderate degree of coordination, will probably result in a product of considerable scientific standing (technical quality), and will allow available funds to be focussed. A limitation of this approach is that there will be a very limited degree of exposure among political, managerial and operational stakeholders. As a result, a relatively long transitional phase may be required between design and full-scale implementation of the RHP, to transfer the technology to relevant groups.

The second option was to conduct research and development in collaboration with virtually all the groups, organisations and authorities which would ultimately be involved with, or responsible for, the implementation and maintenance of the RHP. This approach would spread developmental activities, in varying intensities, over the whole of the country. This would result in an operational manual shaped through the experiences and involvement of a large and diverse group of stakeholders.

The approach of wider collaboration will have the advantages of:

- fostering a natural progression from involvement in development to involvement in implementation of the RHP by participating groups;
- highlighting, at an early stage, the real-world realities relevant to the implementation of a national monitoring programme;
- gradually creating the capacity for each participating region(e.g. province), and upgrading participation as capacity and more techniques become available;
- institutionalising the RHP in terms of budgets, policies, priorities and workloads at an early stage; and
- mobilising a wider resource base and creating a richer variety of ideas.

On the down side, the latter option will require strong coordination, as its success will largely depend on the level of support volunteered by the relevant organisations and authorities, and a limited pool of funds will have to be distributed among more participants. A further limitation of this option is that standardisation may be hampered by allowing separate developments (Roux, 1997).

Through a process of consultative planning with national, provincial and local stakeholders, it became apparent that the option of wider participation was the desired way ahead. Indications were that there was sufficient support from relevant provincial departments, Water

Boards, Parks Boards etc., to continue confidently with as wide an involvement as possible (DWAF, 1996).

Adoption of the inclusive option for the development of the methods and tools paved the way for inclusive institutional collaboration. Part of the resulting arrangements was that two national statutory bodies, the Department of Environmental Affairs and Tourism (DEAT) and the Water Research Commission (WRC), have together with the DWAF become joint custodians of the programme. This provided considerable weight and credibility to the programme. Furthermore, to facilitate the provincial branching of the RHP, a Provincial Champion was elected for each province.

The DWAF provided the funding which allowed the establishment of a National Coordinating Committee (NCC), consisting of representatives of the national custodian organisations, the Provincial Champions, a number of specialist contributors and advisors, specialist portfolio managers (e.g. for communication and fund raising), and a secretariat. The NCC became the new guiding team, to oversee the development, testing and selection of tools and methods. This structure was seen as a sufficiently powerful and representative body to guide the introduction of the RHP, as a major new technology, into its intended market.

7.5.2 Concepts, Tools and Methods

Balance coordination and freedom

It was recognised that the design of the RHP represented the beginning of a new line of thinking for water resource managers and aquatic scientists. In general, any new line of thinking is characterised by a variety of product features and types (methods and tools) from different contributors. With time, a dominant configuration of product features and attributes will emerge (Figure 7.5). This is a natural process of selection, that will ensure the strongest possible final product (Steele, 1989). It is unlikely that the same final product will be achieved where individual effort and ideas are inhibited for the sake of standardisation, especially during the early phases of a new development. As an example, Rogers (1995) stated that due to standardisation of study approaches in diffusion research, workers started to limit the ways in which they approached their research and that this has constrained the intellectual progress of the particular discipline.

In view of the above, the approach adopted by the NCC during the growth stage of the RHP was to be explicit about the desired capabilities of the methods and tools required for the programme, yet to follow an inclusive approach for considering what was on offer. In other words, relatively strong coordination was exercised regarding the vision, scope and objectives of the programme, and sufficient time, freedom and flexibility were allowed for the best tools to emerge from research, development and testing. The ideal scenario is where "natural selection" over time, within practical boundaries, becomes the mechanism of standardisation.

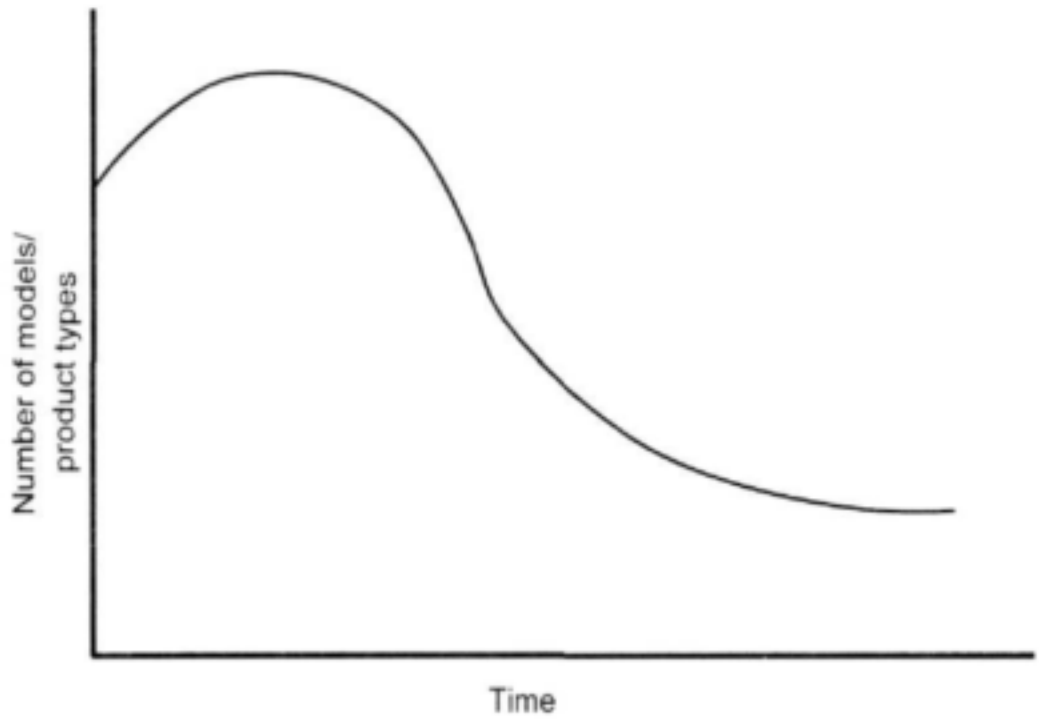

Figure 7.5 The route from allowing flexibility of product types at the initiation of a new capability, to standardising on those tools and methods which prove to serve the intended capability best (from Steele, 1989).

Apply prototyping

A basic principle of allowing a natural selection of tools and methods, is that they should be subjected to constant testing and review to ensure their practical relevance. This was achieved through prototyping, which means that you apply, accept and use the results from the most current developmental prototype, until such time as an improved version is available. This is done even when you know further development and testing will be required to the prototype. Prototyping was found to be invaluable for rapid learning and coordination. This sentiment is shared in the 400 BC quote from Sophocles: "One must learn by doing the thing, for though you think you know it, you have no certainty until you try" (from Rogers, 1995).

Leonard-Barton *et al.* (1994) stated that effective development teams build prototypes, often and early, to learn rapidly, minimize mistakes and successfully integrate the functions of the many components involved in the project. These authors list the virtues of prototypes as:

- providing a common language and focal point for people from a wide variety of disciplines;
- helping each group understand how its work affects the work of other groups;
- enabling the team to spot problems that require cross-functional solutions;
- providing a powerful mechanism for focussing a development team's efforts;
- enabling management to review progress, assess what remains to be done and consider what alternative paths should be taken to complete the effort;
- enabling products to be developed and launched more quickly;
- enabling the development of products that are both higher quality and more effective in fulfilling their intended purpose in the market place.

Prototyping also facilitated interaction between managers and researchers, to ensure that the final product will be relevant in terms of the information requirements of resource managers, the scientific validity of the methods and tools, and the feasibility of implementing the programme at a national level. Prototyping was also valuable for developing the links between different programme components, for example, the different ecological indices used for monitoring, procedures for assessing the collected data, mechanisms for storing and sharing the data and formats for disseminating the information resulting from the programme. As a result, a high degree of synergy was experienced within the overall project, even though several different developmental teams from different backgrounds and disciplines participated.

7.5.3 Infra-structural Innovations

Appropriate institutional and infra-structural arrangements are necessary to provide the environment within which a new technology can grow to maturity. In this regard, the NCC provided a platform from which to penetrate government and other relevant institutions at both national and provincial/local levels. The custodians represented organisations responsible for natural resource management at national level, and the Provincial Champions were to transfer the monitoring capability to organisations and institutions with a similar responsibility, but at provincial and local (e.g. catchment) levels. The latter would be accomplished through the creation of provincial consortia of owners, referred to as Provincial

Implementation Teams (PITs).

The NCC's vision was to increase the RHP's circle of influence systematically - from the guiding team responsible for the design to the critical mass of people required for ensuring successful application and long-term maintenance of the programme. It was important to realise that not all provinces would adopt the RHP right from the start, and it was necessary to make decisions regarding which provinces to invest in initially.

In analogy with the technology adoption model (Figure 7.3), Figure 7.6 shows the steps that have been, and are being, taken to increase the RHP's circle of influence. The following discussion of the steps is partly factual (developments to date: STEPS A to D) and partly hypothetical (possible future scenario: STEPS E to G):

STEP A: This step represents the start of the RHP, when it was a mere idea shared by a small number of people (the initial guiding team). The DWAF was an important part of this guiding team, as it provided the funding that allowed STEP B to take place.

STEP B: Members of the initial guiding team shared their vision with researchers and managers who were perceived as potential role players in the design of a RHP. As a result of further buy-in to the idea, the guiding team grew to include individuals able to develop conceptual methodologies to form the scientific basis of the programme, as well as individuals familiar with the management needs and implementation requirements associated with such a programme. This larger guiding team developed a conceptual programme design, again with the financial support of the DWAF.

STEP C: The conceptual design was demonstrated to a larger group of possible stakeholders, during a "consultation planning meeting" (DWAF, 1996). This demonstration led to further support for the vision of a RHP, and the NCC was established. The NCC was comprised of a representative(s) from the three custodian organisations, a champion for each of the country's nine provinces, and the scientists and resource managers that were responsible for the conceptual design.

STEP D: While the NCC continued to develop methods and tools, as well as the vision of the RHP, each provincial champion started to develop a vision for implementing the programme in his/her province. The NCC invested, through another custodian member (the WRC) in one province to further develop, test and fine-tune the conceptual programme design. The Province of Mpumalanga was selected because of considerable capacity and keenness from within organisations within the province. These groups, notably the Mpumalanga Parks Board and the Kruger National Park, formed the core of the PIT. With the assistance of external funding, and specialist input, this province started and progressed rapidly with their implementation initiative. This demonstration of commitment, from both the NCC and Mpumalanga, was followed by similar initiatives from early adopter provinces. These early adopters had to source their own funds and expertise for their initiatives. STEP D reflects the approximate status of the RHP at the time of writing this chapter.

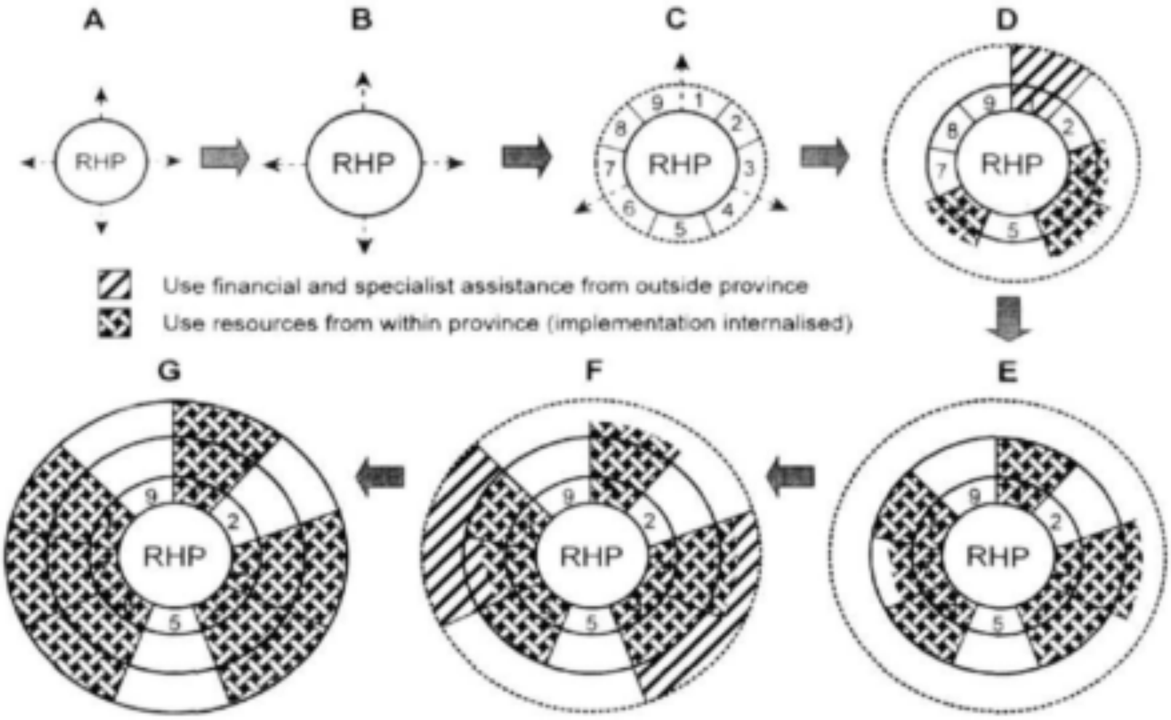

Figure 7.6 Model by which the circle-of-influence of the RHP was, and is being, increased through strategic involvement and investment.

STEP E: This hypothetical step shows how the early adopter provinces have grown their influence, in terms of awareness (among scientists, resource managers, politicians and the public at large), experience, and skills in applying the RHP methods and tools. As these provinces do not receive much help from outside, they have to institutionalise their efforts to build a sustainable basis for long-term maintenance and improvement of their monitoring programmes. Because of this, it is possible that these provinces may in due course exceed the progress by Mpumalanga.

STEP F: The transfer of technology and exchange of experience between provinces have resulted in considerable expansion of the national programme. Yet, it may be necessary for the NCC to become involved again in funding the development of tools with which to bridge the gap between just monitoring and actively making use of monitoring results in the management of water resources. Such tools may include a national database and data management procedures, quality control and assurance procedures, and formats for the dissemination of river health information. It may be necessary to select a province(s) as a test ground for these developments. Again the perceived return from the investment may be the basis for choice (i.e. the province(s) that will use the new tools and demonstrate to other provinces how it should be done). Demonstration of how the monitoring results can be used to support decision-making regarding water resource management, will convince even more provinces to implement the programme.

STEP G: This step represents a pragmatic vision of a mature RHP. Stakeholders in the majority of provinces are participating, at provincial and catchment levels, in implementing and maintaining the RHP. The programme operations are fully institutionalised within these stakeholder groups, and every participating group uses the national methods and tools. Whereas the RHP is firmly established in most provinces, there may be two or three provinces that can be classified as laggards (Figure 7.3). However, the national programme can be regarded as successfully implemented at this stage. The lagging provinces may have such limiting resources and expertise that it would be inappropriate to interpret their lack of participation as failure of the programme. These provinces may still, through some future intervention, become part of the programme; or they may miss out on this wave of technology altogether.

7.5.4 Communication

Demonstration-for-resource-allocation spiral

To grow a new technology, the objectives and priorities of the management of the target applier community (often non-technical) need to be influenced. A new technology is rarely recognised and accepted without some demonstration of its worth. The NCC viewed demonstration as an iterative process of actively packaging the results obtained through prototyping, in ways that would clearly demonstrate the potential of the relevant technology. Thus, demonstration was seen as an essential part of the communication process.

It is important that what is demonstrated reflects what top management is likely to want, namely realism, pragmatism, value for money, technical vision and acceptability of associated risk and uncertainty (Steele, 1989). If the demonstration convinces the appliers that the new capability will get them closer to where they want to be, their initial resistance to change is likely to turn into momentum towards change.

The demonstration model employed by the RHP can be called the "demonstration-for-resource-allocation spiral" (Figure 7.7). Small-scale demonstration of the role of biological monitoring in water resource assessment and management has led to a recognition of the usefulness of this type of monitoring. This recognition, and the acceptance of a need for the monitoring capability, resulted in the allocation of the resources (financial and human) which made the framework and conceptual design of the programme possible. The conceptual design is a further demonstration of the potential worth of the programme to South Africa, which has resulted in considerable recognition of the need for, and acceptance of, the programme (e.g. the buy-in of all 9 provinces through their relevant authorities - DWAF, 1996). Results from pilot testing of the RHP in the Province of Mpumalanga have been used to demonstrate the value of the programme for the purpose of state-of-the-environment reporting (State of the Crocodile River, 1998), which assisted in leveraging resources to conduct similar work in other provinces.

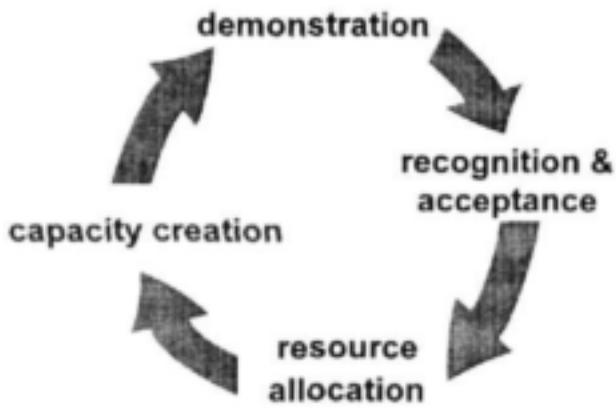

Figure 7.7 The reinforcing "demonstration-for-resource-allocation" spiral.

In general, it was experienced that demonstrating how the RHP can address a specific need, led to increased support for the programme by those experiencing the need. Effective demonstration thus has a reinforcing effect on recognition and acceptance, resource allocation and capacity creation (Figure 7.7).

Coordination through the NCC

The NCC had to promote the national interest through marketing the programme, yet be sensitive to local needs and constraints in order to develop a sufficiently pragmatic programme to ensure adoption and ongoing maintenance. One mechanism for achieving this was to organise NCC meetings, generally twice per annum. These meetings would usually carry a theme, for example to do strategic planning for the year ahead, or to deliberate technical components of the programme (during which, for example, field demonstrations may be held). These meetings provided a forum that supported various types of communication needs, for example:

- national custodians report on progress regarding R&D activities as well as funding opportunities, being coordinated at the national level;
- Provincial Champions report on practical problems (equipment, political support, funding, etc.) experienced as well as successes in terms of pilot application of the programme;
- future work programmes could be coordinated to foster technology transfer (e.g. where inexperienced technicians would join an experienced field team during a biological survey of a river) and optimal use of limited resources.

These NCC meetings have proved to be a critical success factor in facilitating communication and understanding between creators and potential appliers, in order to develop a needs-driven, practical, as well as technically sound RHP.

Printed communication was a further medium that was expanded during the growth phase of the RHP. Apart from a technical report series, a newsletter was instituted and the printed media was selectively targeted to reach a much wider audience than those directly involved with the development or implementation of the programme. Furthermore, a series of fact sheets, produced in several languages, was used to communicate the RHP to audiences with lesser skills levels. Also, an experimental project is being directed at schools and riverside communities, to investigate the potential of using the RHP as a tool in environmental education and awareness creation.

The communication component of the RHP became relatively expensive, but was viewed as a critically important injection to ensure strong growth of the programme.

7.6 ANCHORING THE RHP

A single application of the RHP on the rivers of a province is still one step short of success. Monitoring, and the use of the resulting information, need to become a routine activity over the long term before the programme can live up to its objectives. However, Kotter (1996) warns that, until a new technology becomes "the way we do things around here," it will remain fragile and subject to regression. The new way of doing things must be reflected in the organisational structure, the expertise and skills of associated human resources, budget allocations, etc. (Kotter, 1996).

Rogers (1995) quotes Edward H. Spicer as follows: "Changing people's customs is an even more delicate responsibility than surgery". Clearly, focussed and dedicated efforts over an extended period of time will be required to entrench a national programme such as the RHP into the cultures of relevant institutions at national, provincial and local levels of government. At this stage of pilot implementation of the programme, there is still the risk that the critical momentum can be lost and regression may set in. In order to support the eventual firm anchoring of the RHP in the country, certain strategies can be followed. Some factors that are, or likely to be, playing a role in the anchoring of the RHP in South Africa, are discussed in the following section.

7.6.1 The Guiding Team

The NCC will remain relevant as a coordinating body. However, the nature of its coordination will gradually shift from the R&D of technical products, to the processes used to apply the final products. Increasingly, the PITs will develop their separate visions for the implementation and maintenance of the programme and become a network of guiding teams in the country. Required levels of standardisation in the application of the national programme will be achieved through their representation on the NCC.

Provincial Champions are primarily from organisations with a) an interest in, or perceived responsibility to, implement the RHP; and b) some capability and capacity, in terms of human and financial resources and equipment, to apply the minimum suite of tools and methods that would constitute the RHP. It is the responsibility of each champion to institutionalise the RHP in his/her province, in terms of budgets, resource development priorities, policy planning etc. Therefore, the PITs need to be sufficiently representative and powerful to achieve this anchoring of the programme in their regions. Each PIT would essentially become a guiding team for RHP-related activities in its region of concern.

7.6.2 Concepts, Tools and Methods

Ongoing testing and review of the RHP and its individual components will ultimately stabilise the programme design. Once the RHP has matured to a stage where it is evident that a dominant design has emerged, it would be increasingly difficult to make further technical advances to the RHP or to its underlying tools and methods. At this stage, contributions to improve the application of the programme will become increasingly important. The focus will shift from what to do (product innovation), to how to do it (process innovation) (Figure 7.8).

Process innovations would largely determine the operational effectiveness of the RHP; this in turn will determine the success of adoption and maintenance among the applier communities. In the context of the RHP, process innovations would include:

- procedures for quality control and assurance (under development - Palmer, 1998);
- an implementation manual which spells out what to do (tools and methods), how to do it (procedures) and who should do it (roles, responsibilities and functional interaction) in the RHP (under development - Murray, 1999);
- simplification of monitoring protocols and automation of data assessment procedures to allow more people than a few specialists to be able to do the work;
- procedures for the storage, management and transfer of data (under development - Dallas, University of Cape Town, Pers. Comm.)
- formats for disseminating information to different target groups (politicians, resource managers, public at large);
- formal links between the monitoring programme and the decision-making process of water resource managers, in order for the RHP to have an impact on the health of rivers and not to stop at just collecting data (e.g. Roux *et al.*, 1999); and
- reduction of cost.

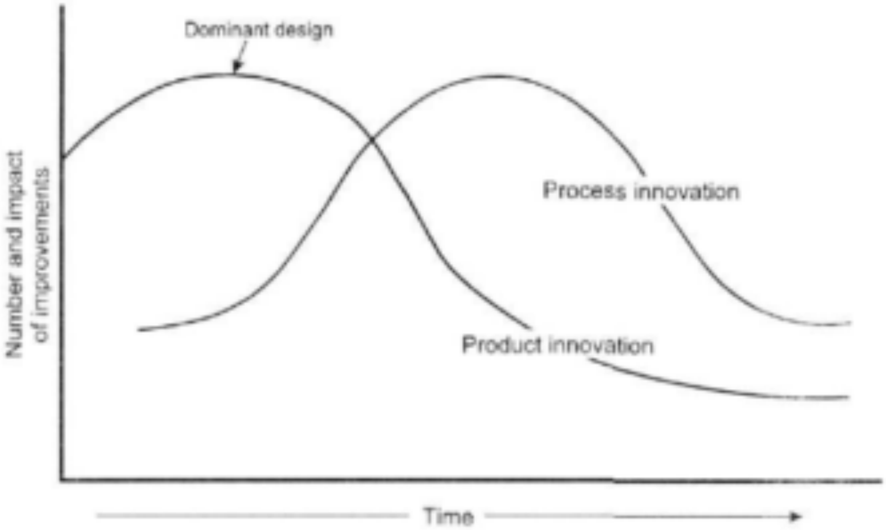

Figure 7.8 The relationship between product and process innovation (from Utterback, 1994).

The end result of proper process development is that biomonitoring, as packaged in the RHP, will have become a "commodity", which could be applied by all organisations who desire or need to do so. The programme will no longer be perceived as a competitive advantage to those organisations applying it, but as a competitive necessity for conducting effective assessment and management of water resources.

7.6.3 Infra-structural Innovations

The fact that the elected Provincial Champions were from different types of organisations, including a Provincial Parks Board, University, Water Board, Provincial Department of Nature Conservation, and a regional office of the DWAF, resulted in a varied nature of the PITs within the different provinces. Also, the theme of reasonable freedom and flexibility was followed in the creation of PITs. Where one PIT would consist mainly of conservation agencies, another will have strong representation from the industrial sector or regulatory agencies. This freedom in organisational composition was viewed as a way to accommodate the skew geographic distribution of resources and appropriate capacity across South Africa. It was also seen as a potential strength, in that the number of implementation scenarios and associated mistakes, victories and lessons, would be maximised.

Each PIT would bear the overall responsibility for implementing the RHP in its region. The PIT will, for example, have to attain the appropriate political endorsement of RHP activities in its region. This is essential to ensure the sustainability of the programme in terms of having sufficient resources allocated for maintenance and improvement of the programme. Members of the PIT need not, however, conduct all the work associated with RHP implementation. As the programme has (at this stage) to a large extent been commercialised, specialist service providers will increasingly offer cost-effective services to the PITs. These services may include data collection through to the compellation of reports on the health status of certain rivers.

A best-case implementation scenario is where a province has an active PIT, political endorsement, sufficient resources and skilled service providers to execute certain specialised components of the RHP. However, even under such a scenario, it must be realised that anchoring of the RHP is a process and not a single event. An important concept here is that a process consists of sequential steps, and that successful completion of the process may require considerable time. Kotter (1996) says that anchoring a new approach requires that sufficient time be taken to ensure that the next generation of leaders/champions/management really does personify the new approach.

By focussing on, and securing, one step at a time while keeping the ultimate destination in mind, a team can experience a sense of achievement and motivation. The motivated team would be able to progress from step to step and will ever get closer to their destination. This can be called the mountaineering approach (Figure 7.9), and is the approach of choice for moving towards national anchoring of the RHP.

However, when the team only focusses on the final destination, they may become disheartened when it seems as if they will never reach this goal. This may cause the team to surrender or to lower their vision of what should be achieved. This is called the "big jump" approach (Figure 7.9).

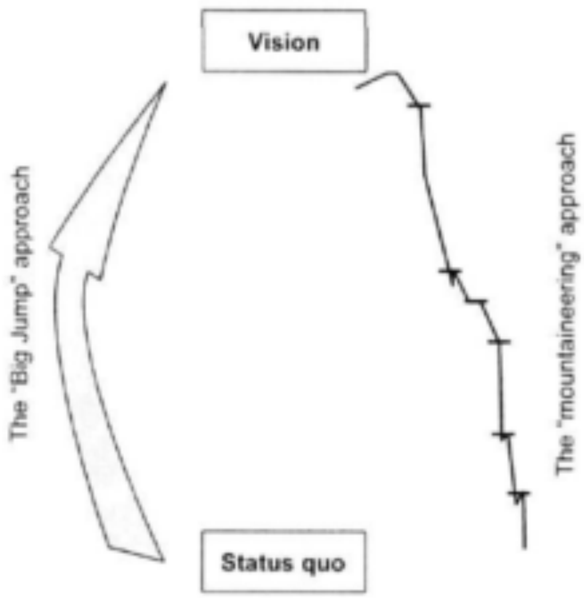

Figure 7.9 The "big jump" versus "mountaineering" approaches for progressing towards anchoring the RHP.

Following either the big jump or mountaineering approach will determine how much regression is likely to set in when given an opportunity. With the mountaineering approach, every step (for example: compilation of a sampling manual; establishment of a PIT; completion of a monitoring exercise; each report, publication or brochure) represents a tangible gain. Consolidation of all the gains achieved to date will provide a strong basis from which to approach the next step. Proper consolidation will also make it unlikely that a specific implementation effort can regress from the furthest step that was secured. However, when following the big jump approach, any regression that sets in is likely to have a much more severe effect. In other words, the big jump may be followed by a "big fall".

Further advantages of the mountaineering approach are that taking one step at a time is less threatening to those who still stand sceptical of the new technology, and it also allows more opportunity for other people to become involved and to participate in the process.

6.4 Communication

During the anchoring stage, the NCC remains responsible for communication regarding aspects in the national interest. This may include information on:

- the progress of a state-of-the-rivers report for the country;
- a national quality control workshop;
- research findings that are relevant to implementation initiatives in general; and
- certain procedures that would encourage standardisation.

However, the main emphasis of communication activities shifts to the provincial level, where it serves the purpose of enabling the networks of PITs and service providers to run the operations of implementing the RHP. Apart from the coordination required to do the practical work, ongoing and focussed communication will be required to obtain the full support of the relevant political and managerial groups, as well as the public at large. To achieve the latter, the demonstration-for resource-allocation spiral (Figure 7.6) will become increasingly relevant for anchoring the RHP at the provincial level.

The PIT will have to demonstrate the advantages or strengths associated with the RHP clearly, to all the relevant target audiences. Again this communication function may be performed by a specialist service provider. The importance of this communication component should not be underestimated, as new approaches usually sink into a culture only after it is very clear that they work and are superior to old methods (Kotter, 1996). The ability, and sometimes capacity, to demonstrate the strengths of the RHP may determine whether the attempt at introducing the programme will succeed in the long run (Steele, 1989). In this context, ongoing demonstrations will:

- provide evidence that sacrifices are worth it, e.g. by showing a product to justify the short-term costs involved;
- undermine cynicism and make it difficult for people to block the implementation initiative;
- keep managers on board, and stimulate confidence in the product that would benefit adoption;
- build momentum, and turn neutrals into supporters, reluctant supporters into active helpers, etc (from Kotter, 1996).

7.7 SUMMARY AND FUTURE CHALLENGES

The development of the RHP has seemingly escaped the common trap of ambitious environmental monitoring and management programmes, namely to remain programmes in concept or design only and not to become operational realities. This chapter explores the design, growth and anchoring stages that characterise the life cycle of the RHP for lessons that can be linked to successful implementation. Table 7.1 provides a summary of the main issues that emerge from this case study.

Challenges regarding the implementation of the RHP that will have to be faced in the future, and which have not been addressed in detail, include:

- The relatively high degree of political flux, especially at provincial level, that prevails in the country has a negative impact on continuity. Mandates, roles and responsibilities change more rapidly than desirable. As a result, key individuals and groups need to be identified and relationships need to be established on an ongoing basis.
- As the focus of activities moves from the national to more local levels, the future roles and responsibilities of the national custodians will need to be clarified. To date these custodians were an essential source of funding and high-level political support. From a national perspective, their continued and active involvement in certain functions and processes of the RHP will remain important. The development of a complementary and mutually beneficial relationship between the national custodians and the provincial implementers will be a critical success factor for maintenance of the programme.
- To date the RHP has relied heavily on the commitment and enthusiastic contributions of a number of individuals. As activities regarding the programme changes from a predominantly developmental mode to a more routine and operational nature, equally committed and enthusiastic people, but with different skills, will have to emerge to become key players in the RHP. The fact that any long-term programme will experience turnover of role players must be recognised and managed for.
- The final test of the RHP will be in the degree to which information resulting from it will become part of the decision-making process in water resources management. In other words, the RHP should become an essential tool to achieve better understanding and management of riverine ecosystems, and not a programme which conducts monitoring for monitoring's sake (e.g. Gunderson *et al.*, 1995).

Table 7.1 Characteristics of the architectural components of the RHP over the three life stages of the programme.

Components of the architectural plan		Life stages in the creation and application of the RHP		
		Design	Grow	Anchor
Guiding team		*Committed nucleus* - benchmarking - pro-active/visionary - conceptual/systemic - willing to experiment - freedom	*National Coordinating Committee* - implementers/change agents - pragmatic but assertive - technical detail - coordination - integration	*Provincial Implementation Teams* - managers - builders/finishers - operational rigour - maintenance - standardisation
Concepts, tools and methods	Concepts	- design of monitoring programmes - biological monitoring and indicators - ecological integrity and ecosystem health - technological maturation and competitive impact	- demonstration through prototyping - technology adoption - increase the circle of influence - technological maturation and competitive impact	- secure one step at a time - ongoing learning and improvement - technological maturation and competitive impact
	Tools and Methods	*Product definition* - dialogue between creators (developers) and appliers (end-users) - audit available expertise, resources, tools - develop underlying technical specifications	*Product innovation* - develop and refine the design - balance coordination and freedom - emergence of dominant design - prototyping	*Process innovations* - project management - efficiency - quality control and assurance - de-skill/commoditise programme
Infra-structural innovations		*Specify future institutional design* - explore potential for inter-institutional collaboration - recognise need for harnessing competencies across organisational boundaries	*Design becomes operational* - reflects multiplicity of skills and input - gain political support - integrate multiple skills and perspectives - resource key functions - build capacity for future service providers	*Programme is internalised* - network of service providers - implement with political endorsement - flexible to reflect local resource realities
Communication		*Tactical to win alliances* - exclusive - trust and open sharing within small group - mainly internal to nucleus, but "lobby" outside - listen to selected end-users and stakeholders	*Strategic to establish networks* - controlled, but increasingly inclusive - personal within increasing group size and diversity - increasing external focus	*Practical within networks* - diminishing control - emphasis on external environment

7.8 ACKNOWLEDGEMENTS

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CHAPTER 8 - BUSINESS PLAN FOR IMPLEMENTING THE RHP IN THE PROVINCE OF MPUMALANGA

DJ Roux

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8.1 INTRODUCTION

The Province of Mpumalanga is the leading province in South Africa regarding the implementation of the RHP. This came about as a result of:

- technical expertise that existed within the provincial institutional infrastructure;
- a pro-active approach adopted by key institutions within the province towards implementation of the RHP;
- pooling of resources through institutional collaboration, technology transfer, capacity building and rapid learning that resulted from the WRC implementation project.

In order for Mpumalanga to remain a leading role player in developments regarding the RHP, the provincial programme needs to successfully mature from an externally funded pilot project to an internalised operation. The business plan presented here focuses on four issues that will be critical to this transition:

- *Purpose* - A common purpose and direction must guide the agents that will be responsible for implementing and maintaining the RHP in the province. This common purpose and direction should be facilitated by a shared vision and operational objectives for the provincial RHP.

- *Technological considerations* - The technical protocols and methods which constitute the RHP are primary enabling factors allowing the breakthrough to a new dimension in the assessment and management of riverine ecosystems. Selection, expansion and mastering of these tools, and their ongoing improvement, is necessary for sustained relevance of the RHP.

- *Connectivity* - Institutional collaboration and networking are key factors in providing the cohesion to hold individuals and organisations together as one virtual implementation agent for the province. Existing or perceived barriers to such collaboration must be overcome to enable people that are organisationally or physically separated to interact as members of the same team. The concept of a "community-of-practice" is suggested as the mechanism for allowing mutually beneficial collaboration across boundaries.

- *Capacity* - The availability of human and financial resources must match the vision for implementing the provincial programme. An assessment of current and desired competency levels provide guidance for career development strategies and required personnel profiles. An estimation of the cost associated with maintaining the RHP provides a financial perspective and paves the way for alliances with funding partners.

The chapter is concluded by describing four possible scenarios for the future of the RHP in Mpumalanga.

8.2 PURPOSE

In terms of the competitive impact of the RHP, it would be in both the national and provincial interest if Mpumalanga maintains and capitalises on its current strong position regarding implementation of the programme. As such, the following vision was formulated for the RHP initiative in Mpumalanga:

To maintain a model for the regional implementation of the RHP that serves as a national example.

This vision implies adherence to the national objectives of the programme, namely (Murray, 1999):

- To measure, assess and report on the ecological state of aquatic ecosystems;
- To detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- To identify and report on emerging problems regarding the ecological state of aquatic ecosystems in South Africa; and
- To ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

In order to ensure common purpose and direction among institutional participants in Mpumalanga, the vision was translated into a number of high-level but more tangible provincial objectives:

- *Understand and satisfy the dynamic information needs of stakeholders:* The RHP has been designed to primarily address the information needs of water resource managers. However, it has become clear that the stakeholders of the programme also include political, private sector and public groupings. The success of the RHP will ultimately be determined by the degree to which it satisfies the information needs of its multiple stakeholders. It is thus of critical importance to develop a deep understanding of the programme's stakeholder segmentation and the evolving information needs within each segment.

- *Achieve ongoing development and improvement of programme components:* The technical composition of the RHP will have to continuously evolve and improve to effectively respond to improved understanding and changing needs. The Mpumalanga RHP initiative must contribute to these improvements, and strive to lead the way in certain developmental areas. In this regard, the Province is in a position to contribute to the ongoing development of especially the indices used for the assessment of fish communities and riparian vegetation. The development of these indices were pioneered in Mpumalanga, and the competencies required to continue this trend has been internalised.

- *Refine and optimise monitoring, assessment and reporting operations:* During the pilot project a substantial amount of learning and technology transfer was part of every river survey, assessment exercise, or reporting action. With time, operational activities should improve in terms of overall efficiency. Complexity and cost must decrease and the expertise must be in place to make the implementation of the RHP a relatively simple and routine function.

- *Impact positively on the management of water resources:* The RHP is intended to provide information that will assist in making rational decisions regarding river management. This should always be kept in mind as the overall goal - and never to surrender to the "monitoring for the sake of monitoring" syndrome. To positively impact on water resources management, the RHP must be perceived as an essential tool in support of effective implementation of environmental policies. This can only be achieved if river health information is creatively packaged and actively disseminated into the arenas where decisions are made.

- *Demonstrate leadership:* To live up to the stated vision, Mpumalanga must actively demonstrate its leadership in implementing the RHP. It is important to transfer new insights and knowledge gained within the province to the rest of the country. This can be achieved by regularly reporting on progress through the national coordinating committee (NCC) and the existing communication mechanisms (e.g. newsletter) of the RHP.

8.3 TECHNOLOGICAL CONSIDERATIONS

8.3.1 Protocol Selection

The suite of tools and methods that were initially adopted for the Mpumalanga study will remain the primary focus of the ongoing initiative. These are:

- the Index of Habitat Integrity (IHI) (Kleynhans, 1996) based on an aerial video recording;
- the South African Scoring System (SASS) based on aquatic macroinvertebrates (Chutter, 1998);
- the site-based Habitat Quality Index (HQI) or Integrated Habitat Assessment System (IHAS) - used in association with SASS (McMillan, 1999);
- the Fish Assemblage Integrity Index (FAII) (Kleynhans, 1999);
- the Riparian Vegetation Index (RVI) (Kemper 1999);

To effectively apply the above tools and methods, it is important to also be aware of, incorporate and integrate the latest:

- guidelines for site selection;
- procedures for determination of reference conditions;
- mechanisms and structures for data storage and management;
- formats for disseminating information;
- quality control and assessment procedures.

The intention is to, as a first priority, master and effectively apply the above products and procedures. Where possible, contributions will be made to the ongoing development of these products and procedures. As a second priority, further indices could be incorporated once such indices are added to the pool of developed and tested products. These may include a Geomorphological Index, a Hydrological Index and a Water Quality Index.

8.3.2 Adaptive RHP Implementation Cycle

The Mpumalanga initiative has followed an approach of learning while doing. River surveys were conducted using the latest available methods and tools, while recognising that development will be ongoing and improved versions may be available for the next survey. At the same time, practical experience obtained during surveys had a positive effect on the direction and integration of various developments. Surveys on the Crocodile, Sabie and Olifants Rivers were used to facilitate this process of development by application.

It is suggested that the application of the products and procedures selected for Mpumalanga continue to operate in an adaptive mode. A number of distinct components of an "adaptive RHP implementation cycle" can be identified, namely data collection, data capturing, health assessment, information/knowledge dissemination and reflection (Figure 8.1). Each of these components must be executed properly in order to effectively complete an adaptive implementation cycle, and the learning must be transferred to the next cycle. A test of proper execution is that every cycle should be an improvement (technically and operationally) over the previous cycle.

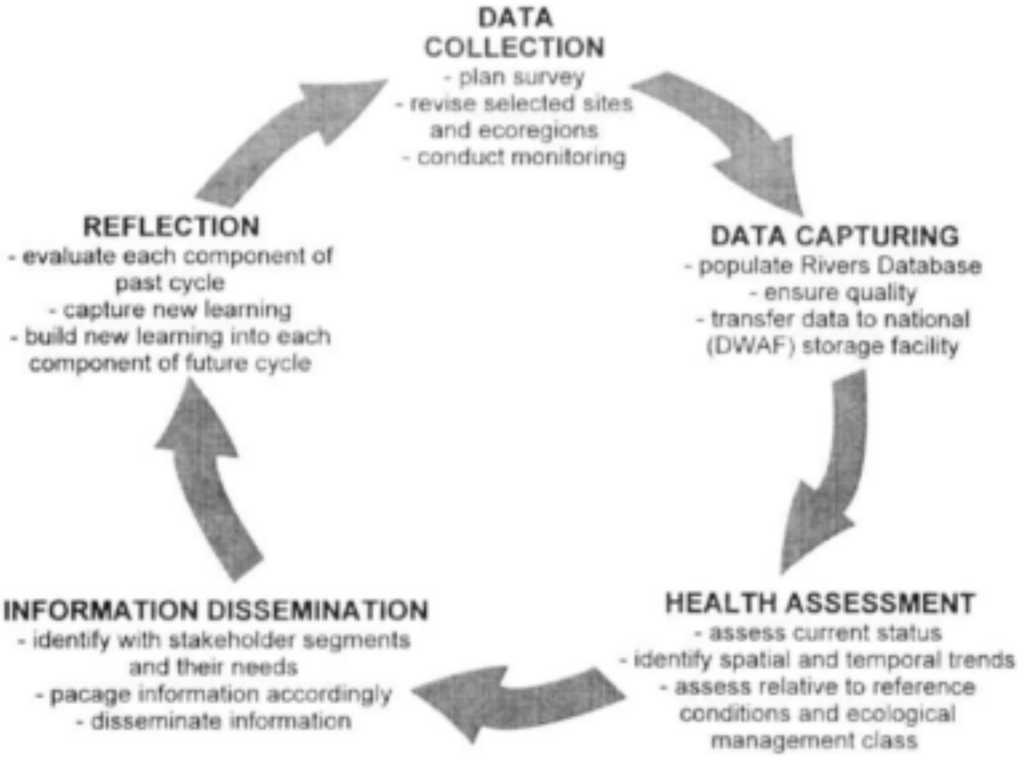

Figure 8.1 The adaptive implementation cycle for the RHP.

The duration of each cycle should not be longer than 18 months, and the information dissemination component should preferably be completed 12 months after data have been collected.

The Mpumalanga pilot project focussed on three river systems: the Crocodile, Sabie and Olifants Rivers. A routine of surveying one river per year has been adopted, which will result in the future work schedule shown in Table 8.1.

Table 8.1 Broad work schedule for the next few years.

2000		2001		2002		2003	
	Crocodile River Implementation Cycle						
			Sabie River Implementation Cycle				
					Olifants River Implementation Cycle		
							Croc ...

The above work programme does not imply that, for example, no monitoring or related work will take place on the Crocodile River during 2002. It merely suggests that the bulk of implementation activities for each river will be focussed over a dedicated time period. The start of this time period corresponds with the three-yearly monitoring frequency that was adopted for the national programme in Mpumalanga. It is possible that the provincial and local needs will require a higher frequency of monitoring, especially for the SASS index. These additional data should then be incorporated with the next adaptive implementation cycle conducted under the national programme.

8.4 CONNECTIVITY

8.4.1 Current Reality

The river systems dealt with in this pilot project are shared by three provinces: Mpumalanga, Northern Province and Gauteng. These systems can also be divided into two proposed Water Management Areas, the Incomati and the Olifants. The following institutions were involved in this study, and can be expected to remain involved with, or stakeholders of, biomonitoring activities in the Incomati-Olifants region:

- Mpumalanga Parks Board
- Kruger National Park
- Department of Water Affairs and Forestry - National as well as regional office in Nelspruit
- Mpumalanga Department of Environmental Affairs and Tourism
- Gauteng Department of Agriculture, Conservation and Environment: Directorate Nature Conservation
- Northern Province Department of Environmental Affairs
- University of the North
- Institute for Water Quality Studies
- Environmental Biomonitoring Services (for the forestry sector: Sappi, Mondi &

SAFCOL)

During the three year pilot project, a model of informal networking has evolved between participating individuals and institutions. However, the effective and efficient implementation of the RHP in Mpumalanga will require an across-the-board organisational commitment over an extended period of time. It is not the norm for such a diverse grouping to engage in a long-term commitment for collaboration, and a number of substantive and procedural barriers may potentially hamper inter-institutional collaboration:

- Different institutions may be unwilling or unable to commit to the long-term investment of personnel and resources.
- Physical distance may be a problem in terms of logistics and communication, although information technologies can potentially make distance irrelevant.
- Organisational goals and cultures may differ significantly. Difference in corporate culture among participants may pose a challenge to coordination, integration and standardisation.
- Each organisation have its own stakeholders, which may result in differences in desired ways of participation and products to be produced.
- Legal issues may stand in the way to allow separate legal entities to operate as if they were a legal unit (for example regarding the protection of participants' proprietary information).

There is no simple recipe for joining the resources of multiple institutions behind one vision. As such, the potential coalition will have to be prepared to deal with setbacks and frustrations that will inherently be part of a collaborative venture. However, the gains in terms of learning and capacity utilisation is likely to far outweigh the growing pains that will be experienced. Also, the informal collaboration that has occurred during the pilot study has been significant and provides a strong foundation to work from.

8.4.2 A Model for Inter-institutional Collaboration

The concept of "communities-of-practice" (COP) provides some insight in how informal networking can be applied in support of a formal initiative. Essentially a COP is a group of people or institutions related by processes or needs, rather than by formal structural or functional relationships, to solve a common problem. Within such communities, people freely share their individual knowledge to enhance the speed and quality of the learning that takes place in the group. Each individual then return to his/her organisation where newly acquired knowledge is internalised. As such, the formation and maintenance of such communities represent an important link between individual and organisational learning (Tidd, 1997).

Networking through a COP provides an opportunity for accumulating knowledge from outside the organisation, share it widely within the organisation, and store it for future use (Nonaka and Takeuchi, 1995). It is, however, important that every partner must contribute knowledge or resources to the overall process.

As a collaborative arrangement for implementing the RHP, networking by means of a COP includes some advantages:

- The COP brings together individuals from different organisations and with different backgrounds and competencies. This provides an environment conducive to the transfer of technology, sharing of knowledge, and fast and ongoing learning.
- The collective body of river health information "owned"by the members of the COP can be used to improve reporting, decision making and water resource management within the specific context of each participating institution.
- Existence of a COP enables the sharing of human resources (skills and experience), equipment and information. This reduces the investment that each participating organisation must make in order to benefit from an operational RHP;
- The COP makes it possible to deliver the best possible product or service since it allows selection of participants from across traditional structural boundaries. The value lies in the integration of the core competencies of the participating institutions.

There are, however, a number of preconditions to the successful existence of a COP (from Christie and Levary, 1998):

- *Focus on stakeholder/customer requirements*: By definition, the COP consists of organisations and individuals who share a common purpose. This purpose must be based on meeting stakeholder requirements. All the efforts of the COP must be driven by the need to intelligently forecast or discern these requirements and to meet them timely, for their collective as well as individual stakeholders related to river management.

- *Choice of right partners with right core competencies*: The structure of a COP follows competency needs (form follows function), rather than convenience of location, cost etc. Core competencies represent the most important factor for success or failure. This type of networked partnership forms an environment that necessitates teamwork.

An ability to contribute in a team context should be a prerequisite for membership.

- *Win-win outcome for all participating organisations and individuals*: It is important to harness the collaboration and cooperation of each partner, while ensuring that each partner also gains through participating and with the achievement of the final outcome.

- *Trust and sharing*: While a COP is build on core competencies, these are cemented with trust. Participating organisations and individuals must have total trust in each others ability to deliver on brief and on time. As participating groups will have access to each other's technology, data and skills, they need to be comfortable with transparency and sharing. Enthusiastic sharing must replace the "this-is-our-product" syndrome.

- *Communication and power of information*: The success of a COP depends on its ability to handle flow of information, including to acquire, store, analyse and distribute information. The population and maintenance of a shared database will be a key feature. Furthermore, real-time communication technologies such as electronic mail, video conferencing and intra- and extra-webs will enhance the power of communication and information within the COP.

- *Leadership*: According to Tom Peters, the only constant that correlates with success is top leadership. The leadership role that is required is one of providing vision and leading by example. Such leadership must have passion for the product or service being advocated.

8.4.3 A Community-of-practice for the RHP in Mpumalanga

The COP suggested for Mpumalanga allows three distinct "positions" within the community that participants can occupy (Figure 8.2 and Table 8.2):

- The *guiding team* essentially fulfills the leadership function and consists of the drivers or lead agents of the initiative. As a result these are also the relatively permanent members of the COP.
- The *strategic partners* constitutes those individuals and organisations with whom a long-term relationship will be mutually advantageous.
- The *tactical partners* would have a relatively short residence time in the community, based on the requirement of a specific expertise. This section of the community

provides operational flexibility since tactical partners can be changed readily. These partners may be professional service providers or consultants and would typically be used where a temporary or longer-term expertise-gap exists, for example in project coordination, selection of reference sites, management of data or compilation of a report.

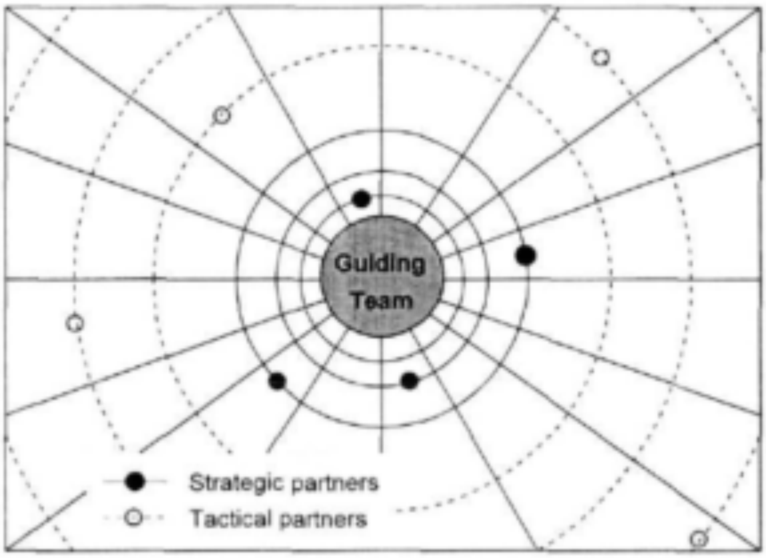

Figure 8.2 A community-of-practice for implementing the RHP in Mpumalanga.

Table 8.2 Suggested population of the COP for implementing the RHP in Mpumalanga.

Community Position	Institution	Contact Person
Guiding Team	– Mpumalanga Parks Board: Aquatic Research Unit - Lydenburg – Kruger National Park: Scientific Services - Skukuza – DWAF - Nelspruit Regional Office*	Dr Johan Engelbrecht Dr Andrew Deacon Dr Magda Lighthelm
Strategic	– Mpumalanga DEAT – Northern Province Department of Environmental Affairs – Gauteng Department of Agriculture, Conservation and Environment: Directorate Nature Conservation – University of the North – Institute for Water Quality Studies – Kwazulu/Natal Provincial Champion	Dr Garth Batchelor Mr Mick Angliss Mr Mukhetho Neluvhalani Dr Wynand Vlok Dr Neels Kleynhans Dr Chris Dickens
Tactical	– Environmental Biomonitoring Services – CSIR – Manyaka Greyling Meiring – Southern Waters – Any other organisation or individual that may be required to perform a specific function	Ms Felicity Weir Dr Dirk Roux Mr Solly Manyaka Ms Justine Fowler

* Catchment Management Agencies, once in operation, would also form part of the guiding team, probably in the place of the current DWAF regional office.

8.4.4 Operational Roles and Responsibilities

As with "membership" of the COP, roles and responsibilities will be highly dynamic. Basic roles and responsibilities can, however, be identified for the guiding team. These are:

- to provide leadership in terms of the stated vision and operational objectives;
- to ensure coordination within the network through ongoing communication;
- to plan operational activities in detail and in advance;
- to facilitate the execution of operational activities, including data collection, data

capturing, health assessment, information dissemination and reflection;
- to report to the National Coordinating Committee of the RHP, on a regular basis, regarding activities and advances within the Mpumalanga COP.

The guiding team essentially replaces the concept of a provincial implementation team (PIT) that has previously been proposed (Roux, 1997). Institutions that form part of the guiding team must be prepared to make a long-term commitment to the maintenance and ongoing improvement of the RHP in their mandated areas of responsibility. This includes a commitment to the creation of the capacity required to fulfil this function. The Provincial Champion may act as the chairperson of the guiding team - this responsibility may even be carried on a rotational basis.

8.5 CAPACITY

There are two main problems impending regional implementation, namely lack of accountability and resource constraints (Murray, 1999). As discussed in Chapter 6, there is a lack of statutory accountability for implementing the RHP. However, during the Mpumalanga pilot project it became clear that the organisations that make out the guiding team of the provincial COP are committed to maintaining the monitoring programme. This is directly as a result of them perceiving the RHP to be adding value to their respective line responsibilities in natural resource management. Although this commitment is not the same as formal accountability, it is probably the best scenario that can be hoped for within the current legal environment. Also in terms of available resources the Province of Mpumalanga is relatively well-off. This was the case even before the commencement of the pilot project.

8.5.1 Human Resources

The pilot project has facilitated significant capacity building of human resources. Through the various field surveys, technologies and skills were actively transferred from various specialists to members of the nucleus organisations. Apart from actual monitoring activities, competence is also required in the areas of data management and information presentation. In this regard, the nucleus organisations were exposed to or involved in:
- the development of the Rivers Database for data storage and management;
- the compilation of a popular brochure based on the results of a RHP survey (Sate of the Crocodile River, 1998);
- the preparation of a technical paper on the application of RHP results in adaptive management of water resources (Roux *et al.*, 1999 - see Chapter 5).

Collectively, the COP for implementing the RHP in Mpumalanga is essentially self sufficient regarding the technical expertise required to maintain the RHP. Human resource development is, however, an ongoing activity and each participating organisation should also assess its own position and respond to expertise gaps within its own staff profile. A simple assessment of the current capabilities in terms of the basic competency requirements, within each of the guiding team organisations, is presented in Table 8.3. A three stage competency scale is used, where:

Stage 1 - indicates that an organisation still depends on assistance from outside to conduct the particular activity;

Stage 2 - reflects an ability to competently do the work independently;

Stage 3 - implies that the organisation is providing national leadership in the particular field.

Table 8.3 Competency assessment matrix.

Institution	Competency Stage					
	SASS	FAII	RVI	IHI	Data Manage.	Reporting
MPB	1	3	3	2	1	1
KNP	2	3	1	2	1	2
DWAF*	1	1	1	1	1	2

* Only the Mpumalanga regional office is assessed, recognising that at a national level the DWAF enjoys Stage 3 competency in all the mentioned areas.

This simple competency assessment matrix can also be used to set career development and staff profiling goals, and to monitor progress regarding human resource development within an organisation. For example, the MPB should ideally improve its competency in SASS, data management (referring to the use of the Rivers Database) and reporting to at least Stage 2. The KNP needs to improve its competency regarding data management and the use of the RVI to Stage 2, and the regional office of DWAF should ideally develop Stage 2 competencies in data management and the use of SASS, FAII, RVI and IHI.

8.5.2 Equipment, Hardware and Software

Sampling equipment

In terms of sampling equipment, both the MPB and the KNP were well equipped before the initiation of the pilot project. During the pilot project the need to standardise on equipment and methodologies used amongst participating institutions was identified as an important issue. This need was considered during the ongoing maintenance and improvement of equipment, and when additional equipment was obtained. As a consequence, the degree of standardisation on sampling techniques and the availability of appropriate equipment within the Mpumalanga Guiding Team are at present very satisfactory.

For standardisation at the national level, the equipment prescribed by the developers of the various indices should be used as a guideline. This is not always readily available, and the *compilation of user-friendly manuals that would facilitate national standardisation on the* equipment and methodologies used in the implementation of the RHP should receive priority attention.

Communication and information technologies

The institutions constituting the Mpumalanga Guiding Team are all very much part of the information society. Excess to appropriate hardware and software is not a limiting factor. However, the potential of electronic communication has not been explored or fully harnessed for connecting the RHP COP in the province. In this regard, the implementation of an electronic discussion group and an extraweb (that can be accessed and contributed to by a number of organisations - as opposed to an intraweb) could prove to be valuable "connectors" of the members of the COP.

The Rivers Database is anticipated to become the primary data storage and management mechanism to be used at regional levels. This will require that at least one person in the Guiding Team, and preferably one person from each of MPB, KNP and DWAF, master the use of Rivers Database and associated Microsoft Access. Each of these organisations has already identified such a person.

The use of Geographic Information System (GIS) technology is most suited for presentation of river health information. This technology and the capability to use it is available within the Mpumalanga Guiding Team. Various examples of presentation formats exist. The existing GIS capability and available presentation templates should be used as a basis for expanding the provincial competency in reporting, and hence satisfying the information needs of stakeholders.

8.5.3 Financial Considerations

The organisations that constitute the Guiding Team of the Mpumalanga COP all have a line interest in maintaining the RHP. These organisations should make provision for salaries and other expenses associated with implementing the RHP. However, in order for the RHP to be truly sustainable, funds will be required to ensure:

- effective participation of some strategic and most tactical partners;
- that appropriate equipment, hardware and software can be obtained;
- that expenses for travel, accommodation and subsistence can be met;
- that personnel can attend training courses and engage in further education;
- the ability to produce professional communication products (slides, brochures, posters, etc.).

In this relatively early stage of RHP implementation, it is difficult to suggest how much ongoing maintenance and improvement will cost. Murray (1999) provides a provisional budget for the provincial implementation of the RHP, as well as approximate monitoring costs for reference and monitoring sites. Using these figures and the experience that was gained during the pilot project, a sliding scale has been developed to provide some perspective on the financial implications of RHP implementation (Figure 8.3). The cost reflected on this sliding scale does not include salaries of personnel from organisations with a line responsibility for natural resource management, for example public sector departments and nature conservation institutions. Only the "visible" costs that is in addition to these salaries are indicated.

The estimated cost per sampling site includes expenses for logistics, data collection and management, information dissemination and coordination to complete the RHP implementation cycle (Figure 8.1). The figures have been estimated in the broadest context of the implementation initiative - to cover the three relevant rivers systems over a period of three years. It should not be interpreted as costs associated with sampling one site in isolation.

Based on the approximately 200 sites that have been selected and sampled during the pilot study, the lowest cost scenarios where primarily public sector and nature conservation groups conduct all the work implies a visible cost of R120 000 over a period of three years. Where all of the implementation of the RHP is contracted out, the visible cost can be as high as R1 200 000 over a three-year period. Neither of these options is recommended. It is suggested that the COP for a province includes participants from across the board to achieve the best balance between cost effectiveness, technological efficiency and the introduction and internalisation of new knowledge. For such a COP, costs per site are likely to range between R2000 and R4000, which translates into R400 000 and R800 000 respectively for completing the three-year implementation cycle.

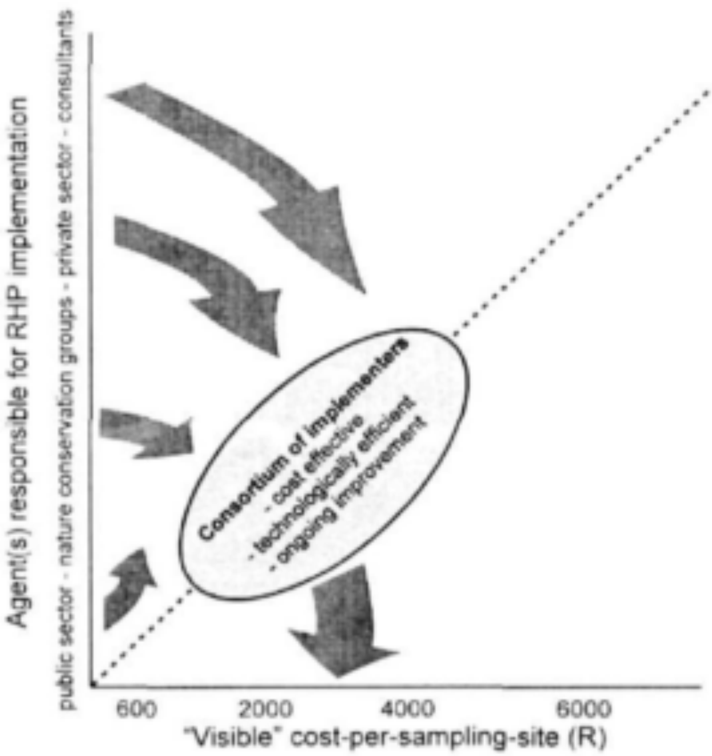

Figure 8.3 Estimates of cost-per-sampling-site based on different implementation agents.

A cost-per-sampling-site approach is used to allow the notion of adoption of a sampling site. It provides a basis for finding financial "owners" for certain sites. As an example, national government may have an interest in maintaining monitoring at reference sites and a private sector company may have a responsibility to implement monitoring at certain impacted sites.

8.6 TRAJECTORY TO SUSTAINABLE IMPLEMENTATION

Scenario refers to a description of a possible situation in the future, based on a number of influence factors. Two main influence factors are considered here, namely the scientific soundness and technical relevance of the RHP and the degree to which the programme addresses and satisfies stakeholder needs (Figure 8.4).

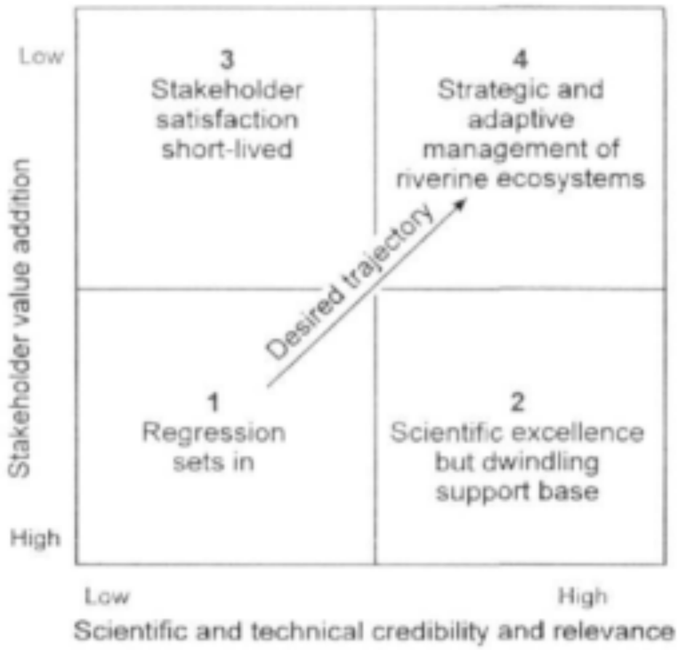

Figure 8.4 Scenarios for RHP implementation.

Scenario 1: Regression Sets In

If both the scientific and technical credibility and the value that the RHP presents to its stakeholders are low, then the RHP has no future. Increasing regression will eventually lead to the disappearance of the programme and more relevant options will be adopted by water management institutions. However, this scenario is very unlikely as the philosophical foundation and the tools and methods of the RHP have been build on sound scientific principles. Also, stakeholder requirements were always considered as primary guiding factors during the design phases of the RHP.

Scenario 2: Scientific Excellence But Dwindling Support Base

The second scenario is where the RHP is recognised for its scientific and technical excellence, but stakeholders are not really experiencing the benefits of the programme. The resources available for the programme are directed primarily towards technical improvement through research and development. Too little attention is given to understanding and satisfying the needs of the non-technical stakeholder community. These end users of river health information lose their enthusiasm for the RHP and redirect their support to other initiatives that show better promise of addressing their needs. Under such conditions the RHP will largely remain of academic interest and will not become a sustainable operational programme.

Scenario 3: Stakeholder Satisfaction Short-lived

Scenario 3 represents a future where all attempts are made to understand and satisfy stakeholder needs but insufficient resources are allocated to technical development and improvement. Initial support by stakeholders is replaced by scepticism as the gaps in the programme's science-base become evident. The end result of scenario 3 is very similar to that of scenario 2.

Scenario 4: Strategic and Adaptive Management of Riverine Ecosystems

In this scenario the influence factors of adding real value to stakeholder needs and remaining technically and scientifically relevant are recognised and pursued with sufficient resources. As a result the various stakeholder segments (natural resource managers, private sector, relevant politicians, public at large) are satisfied and supportive of the programme and the scientific credibility of the RHP is demonstrated through appropriate research and application outputs. This scenario is characterised by constant interaction between scientists, managers and policy makers. The reflection stage of the adaptive RHP implementation cycle (Figure 8.1) provides the ideal context and opportunity for such interaction. The aims of this interaction should be to:

- facilitate reconciliation of perspectives;
- develop a deep understanding of each other's needs and limitations;
- learn across disciplines, cultures, etc.;
- adaptively improve over time to ensure continued scientific and managerial relevance.

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CHAPTER 9 - CONCLUSION AND RECOMMENDATIONS

DJ Roux

Following a global trend, the new policy direction of the Department of Water Affairs and Forestry emphasises the need to protect rather than to use the ability of aquatic ecosystems to recover from disturbances. Implementation of this policy direction necessitates the adoption of response monitoring and assessment techniques in order to allow quantification of ecological condition and change. The RHP addresses this need and is well positioned to support the implementation of the current Water Act.

However, during the design phases of the RHP it became evident that good intentions and sound methods and tools are not sufficient to ensure widespread adoption and successful implementation of a new monitoring programme. The feasibility and worth of the programme first need to be demonstrated. In this regard the Mpumalanga pilot study played a significant role to facilitate the maturation of the RHP from a vision to a national initiative. The knowledge and products that were generated through the practical application of the RHP in Mpumalanga provide a basis for other provinces or water management institutions to become part of a national network of standardised river health monitoring.

Apart from practical learning that was gained through field surveys, new concepts and tools were developed as part of this study: These include:

- preliminary procedures for quality control and quality assurance;
- social tools for addressing the socio-cultural and knowledge gap between RHP proponents and communities living in catchments;
- a procedure for the adaptive assessment and management of river ecosystems;
- an understanding of the legal and institutional issues relevant to RHP implementation;
- a model to guide national implementation of the programme.

The development of the Riparian Vegetation Index (RVI) and the Fish Assemblage Integrity Index (FAII) was also supported by this project, but are reported on separately. Similarly, an inventory format for sampling sites is the topic of a separate report. A last report deals with the assessment of the state of the three river systems as based on the South African Scoring System (SASS) invertebrate index.

The Mpumalanga pilot project has facilitated significant capacity building of human resources, primarily within the province but also nationally. Through the various field surveys, technologies and skills were actively transferred from various specialists to members of the participating organisations from Mpumalanga and neighbouring provinces. Many people from other parts of the country, both from private and public sector organisations, also visited during these surveys and benefited from the exchange of knowledge. Apart from the practical field work, the participating Mpumalanga institutions were exposed and acquired competence in the development of the Rivers Database, assessment of the data collected by the RHP and developing various formats for the presentation of river health information. At the conclusion of this project, the implementation agents for the RHP in Mpumalanga are essentially self sufficient regarding the technical expertise required to maintain the programme.

The following high-level recommendations can be drawn from this report:

- A number of biological and non-biological indices have been used in this study, and more non-biological indices are being developed (for geomorphological and hydrological assessment). Two areas of future research and development were identified, namely:
  - *further development related to the SASS invertebrate index* - this index was not specifically developed for application in the RHP context, and it is uncertain whether or how this index supports the objectives of the RHP.
  - *development of a water quality index* - physical measurements and chemical analyses are conducted for each biomonitoring site and each sampling event, but this data is not currently applied in RHP reporting nor for investigating the relationship between water quality and biological condition.

- The procedures that were developed for quality control and quality assurance requires practical testing and refinement. This will form the main drive towards standardisation of sampling procedures, data storage techniques, data analysis methods, information presentation formats and appropriate safety procedures for each index. A national initiative is needed to ensure definition and reporting of these protocols and techniques, and the nation-wide adoption and implementation thereof.

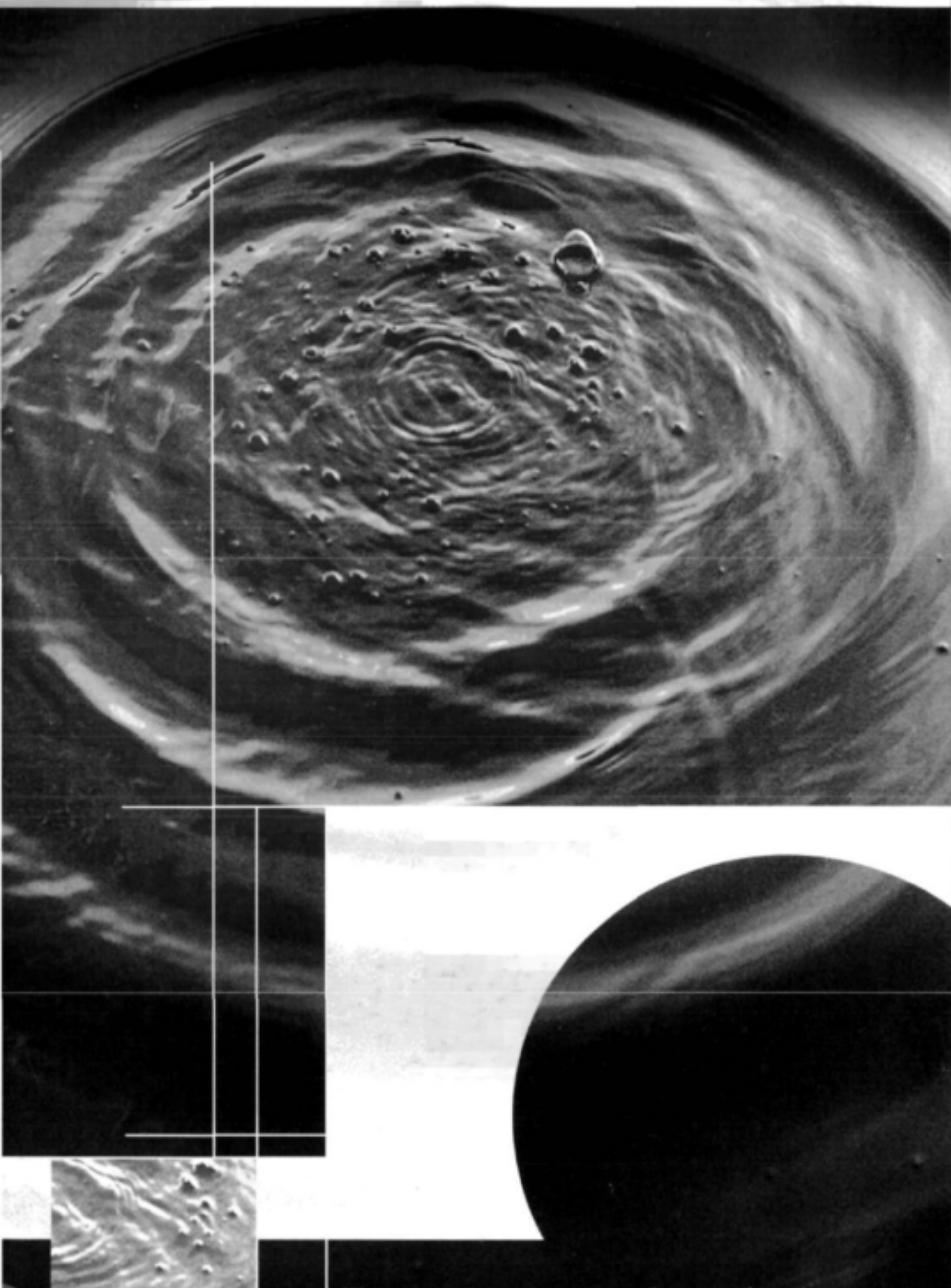
- The grassroots communication component of this study provided new perspectives on the social challenges that await implementers of environmental programmes. This work was exploratory in nature, and there is a strong need to build on these preliminary findings. A follow-up project is recommended that specifically evaluates and develops mechanisms and methods for addressing the socio-cultural gap and knowledge differential between grassroots communities and water resource scientists and managers.

- The adaptive environmental assessment and management (AEAM) model that was developed for the RHP should be further tested and refined. Refinement should also consider compatibility with the concept of an ecological reserve. A final product could be a user-friendly decision support system that links the results of river health monitoring with river management options.

- Water, environmental and land laws have all been subject to substantial revisions in recent years. An important issue that was touched upon in the chapter on legal and institutional issues is the ideal of streamlining and integrating natural resources laws. It is envisaged that the new environmental law will champion a process towards integrated resources management, and that legislation will eventually be streamlined accordingly. The legal investigation undertaken as part of this study focussed on river ecosystems as one component of natural resources. The insights that were gained can contribute meaningfully to the process of legal-institutional development towards a system of integrated resources management. To achieve this, the current study needs to be continued as the legal and institutional environment in South Africa is still fast evolving.

- The RHP can not yet be regarded as anchored in the cultures of all the relevant water management institutions in the country. To achieve this, an "anchoring phase" needs to be initiated and championed at a national level. Such a phase should focus on the processes that determine the effectiveness of implementation.

- The business plan presented in this report will only result in the desired outcome if all the relevant institutions will accept joint responsibility, at both the technical and management levels, for implementing the RHP. The formation and formalisation of a Mpumalanga community-of-practice is still in an experimental stage. It is recommended that this process be facilitated from a national level to ensure that this model evolves into a practical arrangement for shared custodianship of the RHP with relatively generic application in South Africa.



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