THE KRUGER NATIONAL PARK

RIVERS RESEARCH PROGRAMME

FINAL REPORT

Incorporating the Contract Report and the Review Report

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CONTRACT REPORT OF THE KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME (KNPRRP)

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PREFACE

The Kruger National Park Rivers Research Programme was subject to external review on completion of the third phase. To enable readers to benefit from the work of the programme and the perceptions of the reviewers, this Final Report is in two parts: Contract Report and Review Report.

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ACRONYMS

ACRU	Agricultural Catchment Research Unit
APNR	Associated Private Nature Reserves
ARC	Agricultural Research Council
ARCVIEW	GIS Software
BASINS	Better Assessment Science Integrating Non-point and Point Sources
BEEH	Bioresources Engineering and Environmental Hydrology
BLINKS	Linking of Abiotic and Biotic Prediction Capabilities
BWB	Bushbuckridge Water Board
CALSITE	Name of a Simulation Model
CCWR	Computing Centre for Water Research
CMA	Catchment Management Agency
CMC	Catchment Management Committee
CWE	Centre for Water in the Environment
DEAT	Department of Environmental Affairs and Tourism
DALA	Department of Agriculture and Land Affairs
DSOH	Desired State Objectives Hierarchy
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry
FRD	Foundation for Research Development
GenScn	Tool for the Generation and Analysis of Model Simulation Scenarios for Watersheds
GIS	Geographic Information System
HBU	Historically Black University
HSPF	Hydrological Simulation Programme Fortran
HYDROCOM	Company Name
GMS	Goal Maintenance System
ICIS	Integrated Catchment Information System
ICM	Integrated Catchment Management
IFR	Instream Flow Requirement
IGS	Institute for Groundwater Studies
IM&F	Information Management and Facilitation Subprogramme
INR	Institute of Natural Resources
IRMP	Integrated River Management Subprogramme
IUCN	International Union for the Conservation of Nature
IWQS	Institute for Water Quality Studies
IWR	Institute for Water Research
KNP	Kruger National Park
KNPRRP	Kruger National Park Rivers Research Programme
KOBWA	Komati Basin Water Authority
MPB	Mpumalanga Parks Board
NPB	National Parks Board - now South African National Parks (SANP)
NPDALE	Northern Province Department of Agriculture, Land and Environment
NRF	National Research Foundation
NRI	National Rivers Initiative
ORF	Olifants River Forum
PC	Policy Committee
PDMC	Programme Development and Management Committee
QRBM	Quantitative Rule Based Model

ACRONYMS (Continued)

RCHRES	Reach or Reservoir Segment of a River
RHP	River Health Programme
SAFCOL	South African Forestry Company Ltd
SAM	Strategic Adaptive Management
SANP	South African National Parks
SAPPI	South African Paper & Pulp Industry
SASAQS	Southern African Society of Aquatic Scientists
SASS	South African Scoring System
SEDFLO	Sediment Flow Model
SIDA	Swedish International Development Agency
SRWG	Sabie River Working Group
TPC	Threshold of Probable Concern
UCI	User Control Input
UCT	University of Cape Town
UNP	University of Natal, Pietermaritzburg
UNITRA	University of Transkei
UFS	University of the Free State
USAID	United States Agency for International Development
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UV	University of Venda
UZ	University of Zululand
WATERLIT	Water Literature Database
WDM	Watershed Data Management System
WRC	Water Research Commission

ACKNOWLEDGEMENTS

The Kruger National Park Rivers Research Programme was conceptualised and has been conducted as a collaborative joint venture between researchers, stakeholders, resource managers and funders. All have had their roles to play and none is more or less important than another. It has been gratifying that all have identified with the Programme and its cause, and each of us has brought individual expertise, wisdom and effort to the greater initiative. It has been most rewarding to experience the benefits of generative learning focused around an issue which has been on the centre stage of developing policies, legislation and strategies led by the Department of Water Affairs and Forestry.

For a research programme the goals were ambitious. Researchers were required to extend into unknown domains, far beyond their areas of expertise and comfort. They could not have done so without the support and understanding of those who motivated and funded the Programme, the WRC, DWAF and the KNP. There were difficult times when delivery seemed not to match expectation, but they continued to demonstrate confidence in the research team. We hope that your support has been justified.

On a personal note, I wish to express thanks to my colleagues in Phases II and III. It has been a most rewarding experience.

C M Breen
Programme Managing Director

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Water abstraction upstream of the Kruger Park has exacerbated drought conditions. In 1987 the Levuvu River stopped flowing (top, Freek Venter) and large areas of Fig forest died (bottom, Freek Venter).

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Rivers of the Kruger Park are variable and complex. Nine different channel types are recognized on the Sabie River. The pool-rapid channel type on granitic landscapes (top, Kevin Rogers) and the anastomosing channel type on Rhyolites of the Lebombo range (bottom, Kevin Rogers) are two examples.

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The wide range of river conditions found in the Kruger Park is exemplified by the contrast of a reeded pool-rapid section on basalt of the Sabie River (top, Kevin Rogers) and a wide, sandy, braided section of the Letaba River (bottom, Freek Venter).

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The extreme floods of February 2000 markedly changed the character of the Sabie River. The forested section of anastomosing channel in the Sabie River gorge before (top, Kevin Rogers) and after (bottom, Freek Venter) the floods.

EXECUTIVE SUMMARY

The Kruger National Park Rivers Research Programme is a co-operative undertaking by resource-use managers, funding agencies and researchers. It addresses the water quality and water quantity requirements of the natural environments of rivers, particularly those flowing through the Kruger National Park.

The Programme, envisioned at a workshop convened by the Department of Water Affairs in March 1987, was initiated in December 1988 jointly by the government Departments of Water Affairs and Environment Affairs, the Foundation for Research Development (now National Research Foundation), the National Parks Board (now South African National Parks), the Water Research Commission and various research institutions and provincial nature conservation authorities.

There have been three phases. The first can be broadly described as 'scientific research'. A comprehensive review of Phase I acknowledged the high quality of science and recommended that in the event of a second phase, management should be strengthened. Phase II was initiated in 1994 after preparation of a comprehensive Programme Description.

A fundamental difference between Phase I and Phase II was recognition that:

> "*Decisions on management options need to be made in the context of historical and prevailing circumstances as to optimise conservation of the natural environment of rivers. The basis for achieving this is our ability to predict the behaviour of these systems under changing circumstances. This acknowledges that as trade-offs continuously have to be made, there can be no absolute amount for water quality and quantity to sustain the natural environment indefinitely*".

Recognition of this Focused Phase II on enhancement of predictive capabilities and contextualising these within the management process so that decision-making could be supported.

Phase II was completed at the end of 1996. A decision was made to extend the Programme for a third phase. This would enable the research team to complete the development of first-generation procedures and technologies necessary for promotion of strategic adaptive management of rivers; to engage managers and stakeholders and promote information and technology transfer; and to promote corrective action whereby people from previously marginalised sectors were enabled to participate. Phase III also started with a comprehensive Programme Description.

Phase II had two goals and a third was added for Phase III. These were made into subgoals which were more precisely defined and measurable.

1. To achieve a common understanding of the water quality and quantity requirements to sustain the natural environments of rivers which flow through the Kruger National Park.

2. To develop, refine and implement methods for predicting and monitoring the responses of the natural environment of rivers flowing through the Kruger National Park to fluctuating flow and variable water quality.

3. To achieve corrective action through enhancing individual and institutional capacity in the conceptualisation, implementation and management of trans-disciplinary research on river systems.

Our commitment to informing management necessitated that the researchers understood clearly which component of the management process their research was to inform. It was, therefore, necessary to define the management process before identifying research needs and priorities. The process was also to serve as a framework into which research findings from Phase I could be integrated.

The process was considered to be as important as the components of the process. Research was, therefore, required to develop understanding and technology and to integrate these into the management process. This, in turn, required us to test the research products in a management environment and to promote their adoption by stakeholders.

Four fundamental principles are embodied in the process:

- Management should be directed towards achieving a desired state;
- Management decisions should be informed by predictions about what might result from a particular action or lack of action. Inherent in this is the necessity of being able to measure river conditions and optimise water allocation trade offs;
- River systems are dynamic and are in a continual state of flux. It is therefore necessary to continuously monitor river conditions and to revisit management objectives;
- River systems have characteristics of 'common property'. This, together with the scarcity of water and the need for determining equitable allocation, necessitates that the process is interactive with stakeholders.

It is important to appreciate that Phases II and III were designed to synthesise what was already known. This was to serve several purposes: to increase our ability to predict; to enable us to better design and conduct research; and to improve focus, cost effectiveness and efficiency. This would in turn enable us to support strategic adaptive management. Thus, only a part of the Programme was research in the more traditional sense. Much attention was given to information and technology transfer and active engagement with stakeholders and resource managers. The budget for Phases II and III was conservative and each phase was equivalent to an average large project funded by the Water Research Commission.

Research was conducted in discrete projects, each of which was supported by way of a steering committee. Project managers had to report separately to the steering committee and funding agency. The Kruger National Park Rivers Research Programme was the 'nerve centre' and the interface between research and implementation. This report does not, therefore, consider the detail of

individual projects. The reader is directed to project reports for such information. This report is the 'end-of-contract' report for the Programme, with particular emphasis on Phase III, because an end-of-contract report was prepared and accepted for Phase II.

The Contract Report is presented in three parts. Part 1 is an overview which provides context and an assessment of achievements, strengths and weaknesses. Part 2 comprises reports by the Subprogramme managers. Part 3 comprises statements by the partners and a statement by Kruger National Park Management of their perceptions of the Programme. This is because KNP has delegated responsibility for managing parts of the rivers and was, therefore, a primary target for the services and products of the Programme.

The report concludes that the Programme has:

- been innovative in its design and operation;
- delivered science of high quality;
- been cost effective;
- contributed meaningfully to policy and legislation review and to strategy development;
- contributed meaningfully to the process of establishing user interest groups (forums) and Catchment Management Agencies. These effects will endure;
- contributed practically to the adoption of strategic adaptive management principles and practices;
- promoted a culture of collaboration and generative learning;
- promoted individual and institutional growth in collaborative trans-disciplinary research;
- promoted the establishment of a National Rivers Research Initiative.

A number of weaknesses are acknowledged. These include:

- being overly ambitious, particularly in respect of engaging stakeholders in the prevailing dynamic socio-political situation in South Africa. This had origins in our deliberate intention to stretch participants to targets which would draw them out of their narrow professional domains and extend their learning experiences;
- simplistic assumption that what we perceive to be the compelling logic of installed modelling systems with high levels of inter-operability would prevail in other groups;
- assumption that organisations, e.g. KNP, were, or would quickly become transformed to use and implement procedures and technologies developed;
- we did not achieve as much as we had hoped with corrective action;
- we did not achieve our intentions in respect of water quality;
- we did not interact as well as we could have with the reserve development process of the new Water Act.

Recommendations are made which address:

- generative learning and knowledge management;
- trans-disciplinary research programmes;
- installed modelling systems;

- water quality;
- data and information.

Information on the programme is available on the website: http://www.ccwr.ac.za/knprrp/index.html

Water abstraction upstream of the Kruger Park has exacerbated drought conditions. In 1987 the Levuvu River stopped flowing (photograph top) and large areas of Fig forest died (photograph bottom).

OVERVIEW

HISTORICAL PERSPECTIVE

The Kruger National Park Rivers Research Programme (KNPRRP) was envisioned at a workshop convened by the Department of Water Affairs in March 1987. It was initiated in March 1988 jointly by the government Departments of Water Affairs and Environment Affairs, the Water Research Commission, the Foundation for Research Development (FRD) (now National Research Foundation (NRF)), the National Parks Board (now South African National Parks (SANP)) and various research institutions and provincial nature conservation authorities.

In 1986 the Department of Water Affairs declared its intent to allocate water to sustain the natural environment. Thus came the need to determine the water quantity and quality requirements of the natural environment. Consumptive demands for water were increasingly creating conditions in river systems which prejudiced their integrity. Given the complex nature of river systems it was evident that a co-operative interdisciplinary undertaking was required to determine the water quantity and quality requirements. The rivers of the Kruger National Park were selected as the focus because of both the urgent need to address the deteriorating situation in the rivers of the country's best-known Park and because of growing tensions between various demand sectors.

The Programme was engaged with considerable enthusiasm and vigour. However, whilst much progress was made, it became apparent that the activities lacked the integration necessary to achieve the desired outcomes. Phase I came to a close with a comprehensive evaluation (Görgens and Lee, 1992). The reviewers, whilst complimenting the scientists on the quality of their research, indicated the need for a more structured Programme. They proposed that, in the event a second phase was considered, a Programme Managing Director should be appointed to provide direction and management. This recommendation was accepted and a Programme Managing Director was appointed to oversee the development and implementation of Phase II, and this was carried through to Phase III.

INTRODUCTION TO PHASES II AND III

Phase II

Phase II started with preparation of a Programme Description (Breen, *et al.*, 1994) which would direct the research and guide management. The document was published in August 1994 but the Programme was launched earlier that year on the basis of a draft of the final Programme Description.

A fundamental difference between Phase I and Phase II was recognition that:

> "*Decisions on management options need to be made in the context of historical and prevailing circumstances as to optimise conservation of the natural environment of rivers. The basis for achieving this is our ability to predict the behaviour of these systems under changing circumstances. This acknowledges that, as trade-offs continuously have to be made,*

there can be no absolute amount for water quality and quantity to sustain the natural environment indefinitely".

Recognition of this focused Phase II on enhancement of predictive capabilities and contextualising these within the management process so that decision-making could be supported.

Phase II therefore had:

- a conceptual focus on decision support and development of predictive capabilities;
- a geographical focus on the Sabie River in particular;
- a research focus whereby the best expertise and other resources could be brought to bear on the same conceptual and geographic focus;
- a capacity building focus whereby capacity was enhanced in different parts of the country through participation in the Programme.

The goals of Phase II were explicitly stated (Box 1)

Box 1 : Goals of Phase II

- To inform researchers, system managers and stakeholders about the water quality and quantity requirements to sustain the natural environments of rivers which flow through the Kruger National Park.
- To develop, test and refine methods for predicting and monitoring the responses of the natural environment of rivers flowing through the Kruger National Park to fluctuating flow and variable water quality.

These primary goals were to be achieved through the following subsidiary goals:

- to develop, refine and maintain decision support systems for responding to the information needs of managers, stakeholders and researchers concerned with the natural environment of rivers flowing through the Kruger National Park;
- to establish an interdisciplinary team (a consortium), the members of which share common principles, goals and commitment to design, guide and evaluate the Programme, thereby ensuring it achieves its principal goals;
- to develop the understanding of the functioning of the natural environment of rivers required for predicting their responses to changing conditions in both catchments and rivers;

- to develop methods for assessing the perceived value (asset value) of the natural environment of rivers and evaluating the acceptability of changes in asset value;

- to implement and manage a cost-effective research Programme in which research priorities are defined precisely; technology and information are managed properly and transferred to stakeholders; the human resources required are developed and the achievements are evaluated properly.

Phase III

Phase II was comprehensively reviewed by O'Keeffe and Coetzee (1996). They identified notable achievements (Box 2) and concluded that the goals had, by and large, been met.

Box 2 : Notable achievements identified by O'Keeffe and Coetzee (1996)

- Existing information on the rivers of the Kruger National Park has been synthesised and can now be accessed by all potential users through a project directory and a data catalogue and information system.
- A decision support system has been developed which can provide users with an information pathway to assist in management decisions, or in explaining and motivating environmental water use.
- Protocols for defining desired state and representative river reaches have been drawn up.
- Predictive capabilities for biotic modelling have been enhanced.
- Linkages between abiotic (hydrology, hydraulics, geomorphology) and biotic (fish and vegetation) predictive models have been developed.
- An Integrated Catchment Information System has been developed and is being adopted by user agencies.
- Detailed inventories and the status of the following components of the Sabie River are available: riparian vegetation, fish, invertebrates, large aquatic animals, geomorphology and sediment transport, water quality, hydrology and channel hydraulics.
- The Programme has advanced the approach to rivers research in South Africa and has pioneered the development of an explicit hydrology-hydraulics-geomorphology-biotic response framework.
- The Programme has made significant contributions to assessment of instream flow requirements of rivers through both the development of new methodologies (e.g. desired state) and enhanced predictive capabilities (responding to 'what if?' questions).

The Contract Report for Phase II acknowledged a number of weaknesses. Perhaps the weakest point was its failure to effectively engage the government Departments of Water Affairs and Forestry (DWAF) and Environmental Affairs and Tourism (DEAT). This may at least in part be attributed to the changing environment in government and the consequent lack of capacity. Another contributing factor was that government, particularly DWAF, had a tradition of managing water resources. River systems (ecosystems) were not acknowledged as resources. Consequently, the structure of government departments did not facilitate river system management. Government expectations were not sufficiently met.

Weakness was also evident with communication both internally and externally.

The intention to initiate research on water quality and to link this to predictive modelling was not effectively engaged. This can be partly attributed to the generally good quality of water in the Sabie River which was the chosen study site. Research on toxicology was, however, promoted within the Programme.

The failure to effectively engage other interested researchers (particularly Professor Stewart and Dr King) meant that certain expectations and envisaged activities were not realised. This resulted in conceptual differences which remained unresolved.

Phase II explicitly set out to build on existing knowledge, understanding and experience. A consequence was that human and financial resources were directed to analysis and synthesis and not to numerous new projects. It achieved this but at the severe cost of limited development of new capacity. This makes the strengths gained vulnerable in some areas.

Although a decision-making hierarchy was used to prioritise research projects it was insufficiently precise to present a clear picture as to how priorities were determined. This was not enhanced sufficiently during the Programme and it led to a degree of confusion and discontent amongst some participants.

With this in mind and in anticipation of the progress towards constituting Catchment Management Agencies (CMAs) the goals and objectives defined for Phase II were revisited and revised.

Box 3 : Goals of Phase III

- To achieve a common understanding of the water quality and quantity requirements to sustain the natural environments of rivers which flow through the Kruger National Park.
- To develop, refine and implement methods for predicting and monitoring the responses of the natural environment of rivers flowing through the Kruger National Park to fluctuating flow and variable water quality.
- To achieve corrective action through enhancing individual and institutional capacity in the conceptualisation, implementation and management of trans-disciplinary research on river systems.

An essential difference between Phase II and Phase III of the Kruger National Park Rivers Research Programme was the focus on broadening the base of understanding to River Forums and other stakeholders, and on the application of the knowledge, understanding and tools to the management of river systems (Breen, *et al*, 1997).

Subsidiary Goals

The above primary goals were to be achieved through addressing the following subsidiary goals:

- scientifically based and jointly developed strategies and action plans for the integrated management of at least three rivers providing flow into the Kruger National Park (Sabie, Olifants, Crocodile or Letaba rivers);

- improved understanding and application of ecological, social and economic principles in the management of the natural environment of rivers flowing through the Kruger National Park;

- strategies developed and action plans implemented for meeting national obligations and emerging policy (e.g. Convention on Biological Diversity, Helsinki Rules, Agenda 21) on at least three systems (Sabie, Olifants, Crocodile or Letaba rivers);

- an effective communication strategy which will support the Programme through regular interaction and exchange of information and understanding between stakeholders;

- partnership programmes developed and operationalised with two historically Black universities (HBUs);

- previously marginalised researchers working in partnership with experienced Subprogramme managers;

- an effective education programme which promotes the transfer of expertise and understanding generated in the Programme to resource managers, researchers and stakeholders;

- river monitoring programmes for at least three rivers which enable stakeholders to evaluate whether goals and objectives are being achieved;

- the sharing and exchange of principles and techniques derived in the Programme with other regions and river basins in southern Africa;

- the formation of a Southern African Rivers Network to share information and exchange expertise;

- the hosting of a conference on Integrated River Management in southern Africa.

DESIGNING THE RESEARCH PROGRAMME

Our commitment to informing management necessitated that the researchers understood clearly which component of the management process their research was to inform. It was, therefore, necessary to define the management process before identifying research needs and priorities. The process was also to serve as a framework into which research findings from Phase I could be integrated. Thus, at the start of Phase II, the process illustrated in Figure 1 was adopted by researchers and the Programme management structures.

Four fundamental principles are embodied in the process:

- Management should be directed towards achieving a desired state;
- Management decisions should be informed by predictions about what might result from a particular action or lack of action. Inherent in this is the necessity of being able to measure river condition and optimise water allocation trade offs;

- River systems are dynamic and are in a continual state of flux. It is therefore necessary to continuously monitor river condition and to revisit management objectives;
- River systems have characteristics of 'common property'. This together with the scarcity of water and the need for determining equitable allocation, necessitates that the process is interactive with stakeholders.

The process was considered to be as important as the components of the process. Research was, therefore, required to develop understanding and technology and to integrate these into the management process. This, in turn, required us to test the research products in a management environment and to promote their adoption by stakeholders.

For management to be interactive, it was necessary for us to make sure that it was possible to support decision-making at each of the steps in the sequence illustrated in Figure 1. This led to conceptualising the following research needs:

- **Desired State**. Since Desired State must reflect the vision stakeholders hold for a particular river, or part thereof, and because it is necessary to be able to measure and monitor progress to Desired State, vision building and monitoring were an integral part of this project;

- **Representative reaches**. The need to be able to measure state introduces the issue of where should state be monitored and how should representative sites be identified. Thus, establishing criteria for delineating representative reaches was a pre-requisite for defining a Desired State;

- **Prediction**. The interactions between river flow and local geology and geomorphology create the physical templates for the biota. As the biota colonise these templates they, in turn, change hydraulics and hydrology. A highly dynamic feedback system results. It was necessary therefore, to be able to develop and link physical and biotic predictive capabilities;

- **Integrated modelling.** Catchment run off is the driving force of rivers. What happens at any particular reach is a product of what is delivered to it from upstream and how local conditions affect this. Consequently it was necessary to 'install' an integrated modelling system to model the run off (quantity and quality) and the transformations in the channel. Scale (spatial and temporal) is a central issue which had to be resolved in order to permit integration of predictive models;

- **Information.** Integrated modelling draws information from many sources. Some of the information is in the form of data, some might be in interpretation of data (e.g. rules), and some might be as output from modelling. Since information and expertise are spread across the country (and further afield) it was necessary to develop an information database (a meta database) and an information management system at the catchment scale (Integrated Catchment Information System, ICIS);

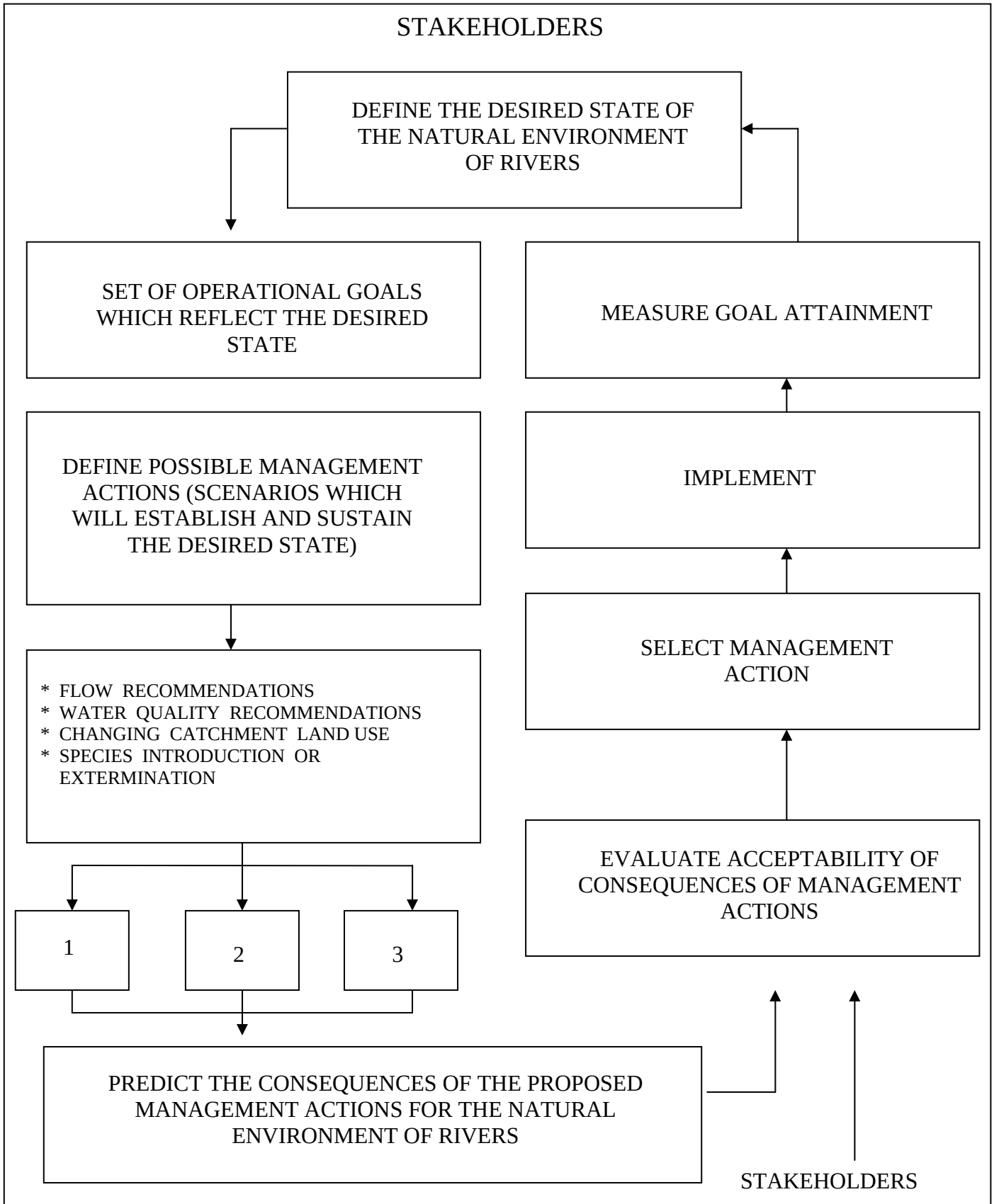


FIGURE 1 **MANAGEMENT PROCESS ADOPTED IN PHASE II**

- **Water quality.** This is one of the parameters defining Desired State. Whilst quantity can be modelled without reference to water quality, the reverse is not the case. It was therefore decided to concentrate on quantity and then address quality. To prepare for this it was necessary to seek an integrated modelling system which had water quality capabilities;

- **Monitoring and auditing.** Strategic Adaptive Management (SAM) requires comparing the current situation with envisioned future situations. This cannot be achieved in the absence of effective monitoring and auditing.

Success was dependent upon collaboration between scientists with quite different expertise and (as it turned out) who were drawn from different parts of South Africa. The Programme structure for Phase II is shown in Figure 2 and the responsible officers in Box 4. As the team had never worked together before, and because of the need to focus so that we would talk to each other about the same system, and therefore have to resolve issues such as scale, it was decided to focus on the Sabie River system. We therefore had a philosophical focus (decision support) and a physical focus (Sabie River).

KEEPING ABREAST OF CHANGE

The Programme was designed in anticipation of change. The inevitability of change in river systems responding to global climatic changes and to human influences was acknowledged. Also anticipated was the inevitability of having to determine and manage, in an integrated manner, the allocation of water for maintaining the environmental integrity (Desired State) of rivers.

Whilst Phase I was intended to provide the scientific information for the then Department of Water Affairs to enable them to manage for environmental integrity, Phase II foresaw the increasing involvement of stakeholders in this. The intention was to inform and empower this broader sector in integrated river system management. We were, therefore, prepared for and contributed to the changes in policy and legislation which are promoting the establishment of Catchment Forums and Catchment Management Agencies.

Several important changes were introduced for Phase III (Figure 3):

- In order to be able to inform all steps of the management process (Figure 1, subsequently modified Figure 4) it was necessary to address monitoring. The Desired State research had developed protocols for monitoring which were structured around Thresholds of Probable Concern (TPC). There was clearly a need for thoughtful analysis and debate around these in the context of monitoring procedures and indexes being developed and applied in the National River Health Programme (NRHP) and in Instream Flow Requirements (IFRs). A Monitoring Subprogramme was established;

Rivers of the Kruger Park are variable and complex. Nine different channel types are recognised on the Sabie River. The pool-rapid channel type on granitic landscapes (photograph top) and the anastomosing channel type on Rhyolites of the Lebombo range (photograph bottom) are two examples.

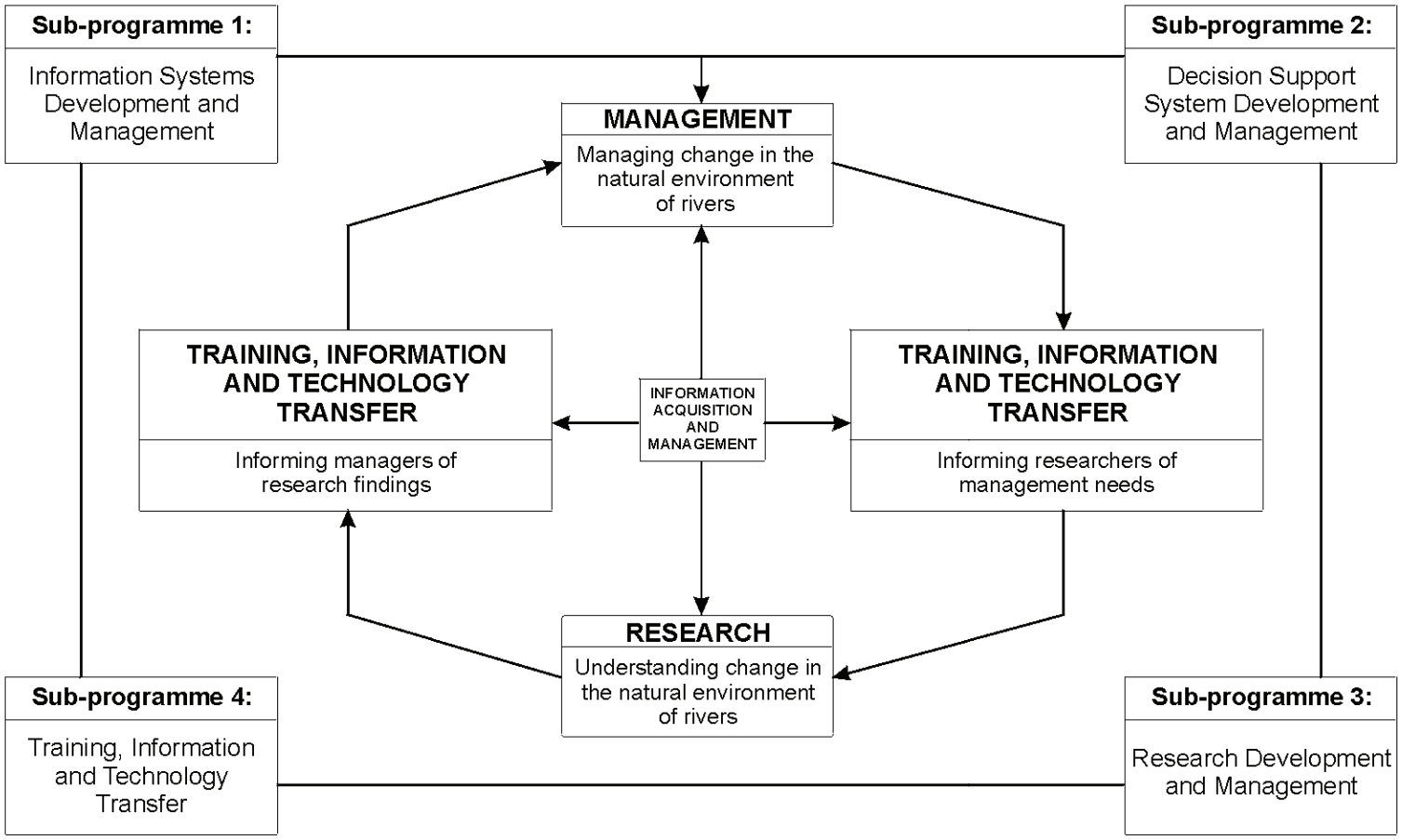


FIGURE 2 | **STRUCTURE OF PHASE II OF THE KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME**

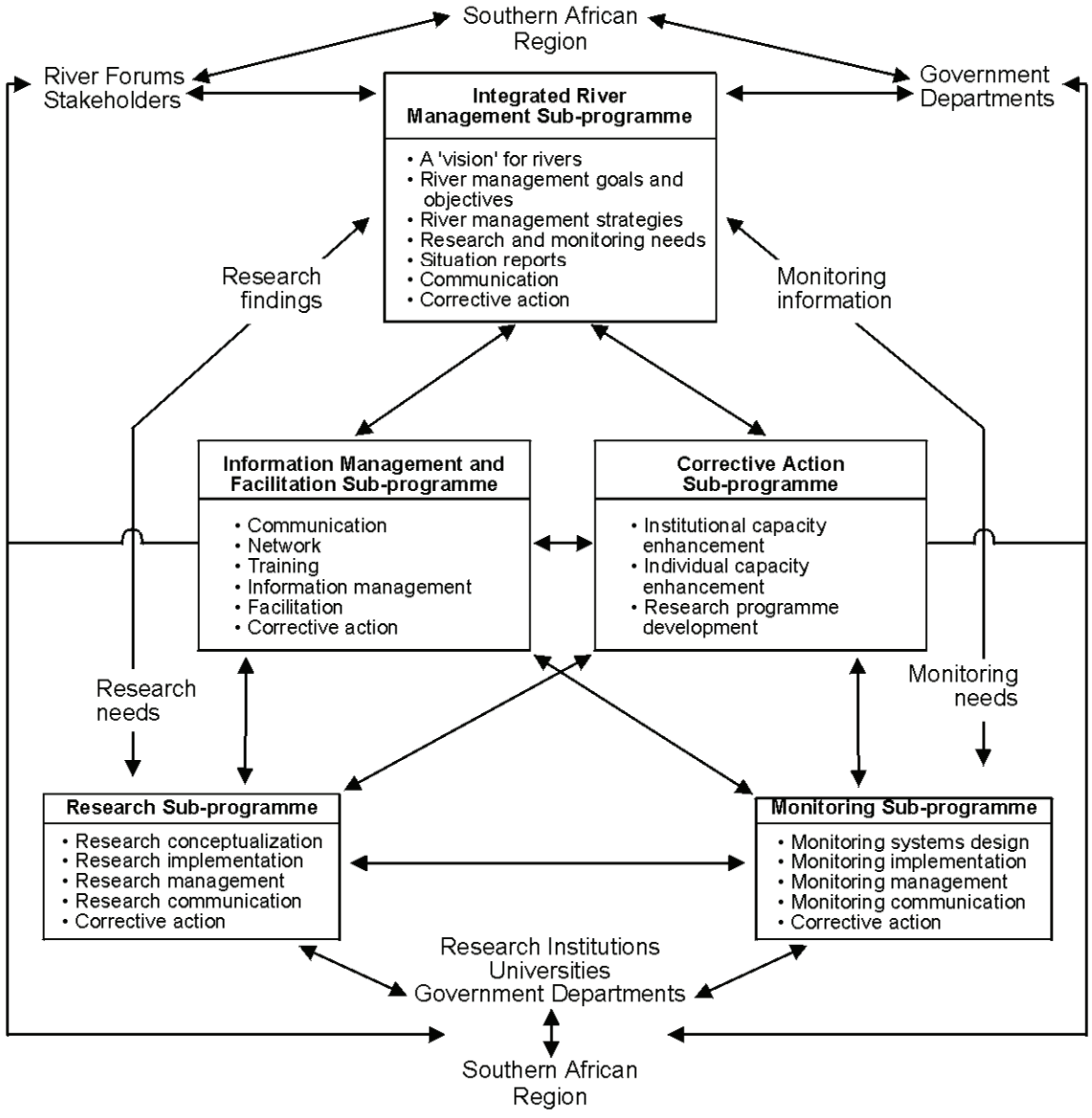


FIGURE 3 — **STRUCTURE OF PHASE III OF THE KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME**

- Policy and legislation review was promoting Integrated Water Resources Management (IWRM) – as anticipated at the start of Phase II. To support this it was decided to place more effort in using the Desired State procedures to promote integrated river management (IRM). A new Subprogramme was established to achieve this;

- The failure of Phase II to address corrective action effectively led to this being identified as a special initiative and elevated to the level of a Subprogramme.

In the 1970s the Department of Water Affairs promoted the determination of the water requirements of the Pongola River Floodplain (Heeg and Breen, 1982). Since then, considerable progress has been made in the determination of instream flow requirements (King and Louw, 1998). Phase II was designed to support these developments by:

- enhancing our ability to define river reaches, and to quantify Desired State;
- enhancing monitoring to measure achievement of Desired State;
- enabling account to be taken of the dynamic nature of river systems when defining and determining Desired State;
- enhancing our ability to predict change and to incorporate this into an integrated modelling system;
- incorporating the various components of the IFRs into a management process.

Central to all of this was the belief that notwithstanding the determination of IFRs, there is no absolute quantity of water for the environment, and that allocation and management of its delivery will require continual negotiation and trade off. This is particularly so where rivers are shared by different countries. In anticipation of this, the Programme sought to establish contact and collaboration with colleagues in Swaziland and Mozambique. A collaborative Programme (Shared Rivers Research Joint Venture) was established in 1999, funded by the Swedish International Development Agency (SIDA). The first phase of this initiative is structured to achieve a common level of understanding and skills in river health, decision support systems, socio-economic principles and procedures, and institutional organisation and functioning. Once this has been achieved a collaborative research programme will be developed. South Africans from all over the country are participating.

The democratisation of South African society has raised awareness of the urgent need for corrective action. Whilst it was intended to address this in Phase II, it did not occur. Mitigating factors were that senior researchers had enough of a challenge learning to work together, and insufficient resources were available to support the involvement of additional people. The imperative was acknowledged at the start of Phase III and a ‘partner’ approach was adopted to provide opportunity for individuals from previously marginalised sectors to associate with managers in their activities at all levels.

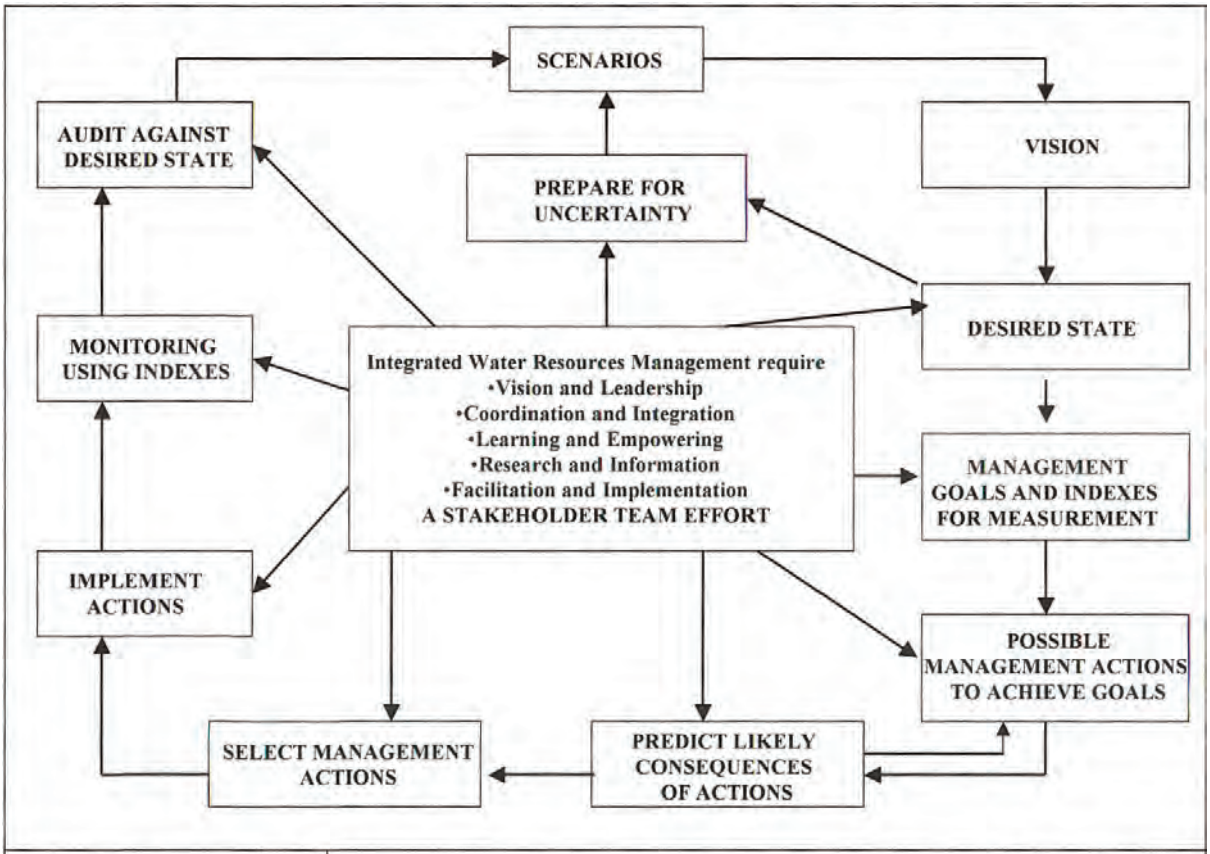


FIGURE 4 | **REVISED VERSION OF THE MANAGEMENT PROCESS ADOPTED DURING PHASE III**

MANAGEMENT

A review of Phase I by Görgens and Lee (1992) identified a need for the Programme to be under the control of a manager. Because of the decision to make a greater commitment to informing management it was decided to appoint Subprogramme managers for each of the main thrusts of the Programme. The scientific teams assembled to lead Phases II and III are shown in Box 4.

Box 4 : The scientific team assembled to lead Phases II and III

Phase II

- Managing Director: Professor C M Breen, Institute of Natural Resources, University of Natal
- Subprogramme Managers:

  Decision Support Systems Development & Management :
  Professor A H M Görgens, Faculty of Engineering, University of Stellenbosch

  Information Systems Development and Management :
  Dr H Biggs, National Parks Board (now South African National Parks)

  Research Development and Management :
  Water Quantity : Professor K H Rogers, Centre for Water in the Environment, University of Witwatersrand
  Water Quality : Professor J H O'Keeffe, Institute for Water Research, Rhodes University

  Training, Information and Technology Transfer :
  Dr M C Dent, Computing Centre for Water Research, University of Natal

Phase III

- Managing Director: Professor C M Breen, Institute of Natural Resources, University of Natal
- Subprogramme Managers:

  Integrated River Management :
  Dr F J Venter, South African National Parks

  Information Management and Facilitation :
  Dr M C Dent, Computing Centre for Water Research, University of Natal

  Research:
  Professor K H Rogers, Centre for Water in the Environment, University of the Witwatersrand

  Monitoring:
  Professor J H O'Keeffe, Institute for Water Research, Rhodes University

  Corrective Action:
  Professor C M Breen, Institute of Natural Resources, University of Natal

Managers received an annual grant to enable them to initiate and develop their Subprogramme activities. The Water Research Commission held a 'Block Grant' to be available for projects. The management team met three times each year and decided priorities at the end of each year. Researchers were also encouraged to seek grants from other agencies such as the Department of Environmental Affairs and Tourism (who supported the Desired State project) and the Foundation for Research Development (now National Research Foundation).

Two committees (Boxes 5 and 6) were constituted to provide guidance and support. In determining the membership of these committees emphasis was placed on those who might be 'clients' for products emanating from the Programme and those who could provide scientific, policy and financial support.

Box 5 : Members and affiliation of the Programme Management and Development Committee. Membership changed during Phase II. Only members current at the end of Phases II and III are shown.

Phase II	
Mr D S van der Merwe	Water Research Commission (Chairman)
Professor C M Breen	Institute of Natural Resources, University of Natal
Dr S A Mitchell	Water Research Commission
Mr N J van Wyk	Department of Water Affairs and Forestry
Mr W S Rowlston	Department of Water Affairs and Forestry
Mr J L J van der Westhuizen	Department of Water Affairs and Forestry
Dr F J Venter	South African National Parks
Dr H Biggs	South African National Parks
Professor K H Rogers	Centre for Water in the Environment, Wits University
Professor J H O'Keeffe	Institute for Water Research, Rhodes University
Dr M C Dent	Computing Centre for Water Research
Professor A H M Görgens	Ninham Shand Inc. and University of Stellenbosch
Dr J M King	Department of Zoology, University of Cape Town
Mr G I Cowan	Department of Environmental Affairs and Tourism
Mr J Engelbrecht	Mpumalanga Parks Board
Mr J Pauw	National Research Foundation
Ms G C Rolando (Secretariat)	National Research Foundation
Phase III	
Mr D S van der Merwe	Water Research Commission (Chairman)
Professor C M Breen	Institute of Natural Resources, Institute of Natural Resources
Dr S A Mitchell	Water Research Commission
Mr N J van Wyk	Department of Water Affairs and Forestry
Dr L Braack	South African National Parks
Dr F J Venter	South African National Parks
Dr H Biggs	South African National Parks
Professor K H Rogers	Centre for Water in the Environment, Wits University
Professor J H O'Keeffe	Institute for Water Research, Rhodes University
Dr M C Dent	Computing Centre for Water Research
Mr K Legge	Department of Water Affairs and Forestry
Mr G I Cowan	Department of Environmental Affairs and Tourism
Mr J Engelbrecht	Mpumalanga Parks Board
Mr J Pauw	National Research Foundation
Ms G C Rolando (Secretariat)	National Research Foundation

Box 6 :	**Members and affiliation of the Programme Policy Committee. Membership changed during Phase II. Only members current at the end of Phases II and III are shown.**
Phase II	
Dr G A Robinson (Chairman)	South African National Parks
Mr H Braack	Kruger National Park
Dr C Cameron	Department of Environmental Affairs and Tourism
Mr S A Gerber	Department of Environmental Affairs and Tourism
Mr T M Sokutu	Department of Water Affairs and Forestry
Mr W van der Merwe	Department of Water Affairs and Forestry
Dr C S Blignaut	Department of Agriculture
Dr M B Molope	Department of Agriculture
Mr P E Odendaal	Water Research Commission
Dr G von Gruenewaldt	Foundation of Research Development
Mr S Wolff	Mpumalanga Department of Environmental Affairs
Mr J C Mhlongo	Mpumalanga Department of Environmental Affairs
Dr G Batchelor	Mpumalanga Department of Environmental Affairs
Mr D S van der Merwe	Water Research Commission
Professor C M Breen	Institute of Natural Resources (Programme managing Director), University of Natal
Phase III	
Mr R D Parris (Chairman)	South African National Parks
Dr P Novellie	South African National Parks
Dr P Nevhutalu	National Research Foundation
Mr S A Gerber	Department of Environmental Affairs and Tourism
Dr M B Molope	Department of Agriculture and Land Affairs
Mr P E Odendaal	Water Research Commission
Mr JLJ van der Westhuizen	Department of Water Affairs and Forestry
Mr J Botha	Northern Province Department of Land, Agriculture and Environment
Mr A van Wyk	Mpumalanga Parks Board
Dr G Batchelor	Mpumalanga Department of Environmental Affairs
Mr D S van der Merwe	Water Research Commission
Professor C M Breen	Institute of Natural Resources (Programme Managing Director)

The wide range of river conditions found in the Kruger Park is exemplified by the contrast of a reeded pool-rapid section on basalt of the Sabie River (photograph top) and a wide, sandy, braided section of the Letaba River (photograph bottom).

PROGRESS

The overall emphasis in Phases II and III was on scientific and facilitation support for management of river systems. The management process depicted in Figure 4 was used to structure endeavour and to direct effort towards holistic integrated support. Strategic Adaptive Management (SAM) is the descriptor generated during Phases II and III to describe the integrated management process. Contributions to scientific and facilitation support for river system management are considered in relation to the SAM process and scientific understanding although separation is not always distinct. Within each of these individual contributions are considered in relation to perceived need, nature of the tool or process and its application, and the way forward.

1. Strategic Adaptive Management (SAM) process

Need: A theory of science/management partnerships in which science has an explicit process of testing its findings against both theory and practical need, and management has a process for translating policy into achievable and scientifically defensible operational goals. Management also needs a defined process for auditing outcomes against societal value systems.

Tool: A comprehensive set of interactive components which are organised into three subsets. An "Operational Framework" (to develop and evaluate attainable goals which reflect a desired state, and to select appropriate actions to achieve that state); a "Predictive Modelling Framework" (to predict the consequences of management actions); and a "System Response Framework" (monitor and audit system response to management actions).

Transfer: The process was used to define a new management strategy and process for implementation for the Kruger National Park, including its rivers. It has also been used by Northern Province Department of Environment Affairs for the same purpose. A simplified version is being applied to estuary management in the Eastern Cape.

Way forward: The process is, by its very nature, evolutionary and is enhanced each time and place it is used. The main challenge now is to incorporate SAM into Catchment Management. A pilot project is under way on the Crocodile River. Overcoming institutional inertia particularly in the public sector which has little previous experience of managing ecosystems before (e.g. DWAF) is the main obstacle to wide implementation of this tool.

1.1 Sub-component tools

1.1.1 Process to Define a Desired State of the Environment

Need: A process for achieving consensus on the future state of the environment for which management should strive.

Tool: The Desired State is defined by an Objectives Hierarchy which provides a vision of the future and operational goals that are acceptable to, and achievable by, a particular management institution. The Objectives Hierarchy maps out a credible future for the ecosystem (including people) to be managed, and reflects both societal value systems and scientific rigour.

Transfer and Way forward: As for SAM (Section 1.0 above).

1.1.2 Process for Development, Use and Auditing of Goals for Environmental Management

Need: Environmental management has largely been a reactive process directed towards maintaining nature in balance. There was a need to translate the Desired State into achievable goals which reflected the reality of nature in flux. Monitoring programmes usually become ends in themselves rather than means to a defined end. There was a need to develop goal orientated monitoring which precipitated strategic rather than reactive management actions.

Tool: Goals are defined as "Thresholds of Probable Concern". They are integrated into a structured process of: (i) research to identify agents of change and indicators of system response; (ii) modelling to predict system response to management actions; (iii) monitoring of indicators and auditing of goals; (iv) feedback to operational management. They are structured into the three frameworks of SAM.

Transfer and Way forward: As for SAM (Section 1.0 above).

1.1.3 Adaptive Knowledge-based Modelling Approach

Need: Traditional modelling approaches are mathematically intense, requiring considerable data for development. There was a need to adopt a modelling approach that would facilitate the development of predictive tools, and yet not require exhaustive amounts of data first. There was also a need for this approach to effectively utilise the wealth of expert knowledge that was available, often in the absence of empirical data.

Tool: A knowledge rule-based modelling approach was adopted and refined. This approach develops and utilises rules that are based on empirical data where available, and expert knowledge and assumption where they are not. Uncertainty is explicitly incorporated in this approach, and assumptions are transparent to users. Object orientated design results in interactive interfaces for users.

Transfer and Way forward: This approach is generally accepted as effective for modelling in data-poor environments, but also where there is a need for pragmatic models which address specific management goals, such as TPCs. The approach was successfully used in the BLINKS project (Section 1.2.3.2) and for the *Breonadia* model. It has gained favour among researchers and modellers and development is proceeding.

1.1.4 Adaptive Knowledge-based Model of Vegetation Response

Need: There was a need for the development of predictive tools for SAM. One of the primary concerns of river managers was the response of riparian vegetation to changes in hydrology and geomorphology. There was also a need for models to enable adaptive refinement within the SAM process.

Tool: A rule-enhanced, matrix population model was developed using the adaptive knowledge-based modelling approach outlined above. Thresholds of Probable Concern were set and modelled for the *Breonadia salicina* population, which is an indicator of bedrock within the macro-channel floor. Population response is primarily determined by hydrological regime, geomorphological change (in the form of sediment dynamics) and vegetation density dependence.

Transfer: The model was coded and packaged in Visual Basic, and transferred to managers in the KNP, as a self-installing and stand-alone executable, requiring only the Windows environment to operate. Meetings were held with potential model users, where the model was displayed, explained and tested for operation on various PCs.

Way forward: The *Breonadia* model requires additional testing and refinement as it is used by managers. The user agency (KNP) has begun a monitoring programme to provide independent data sets for its improvement and verification.

1.1.5 Design Concept for Institutionalising SAM

Need: Adaptive management is recognised all over the world as the appropriate approach to natural resource management. The biggest obstacle to its implementation is that it requires redesign of institutional purpose, structure and process. This is primarily because organisations, and indeed society at large, are insufficiently and inappropriately organised to utilise the information and knowledge at their disposal, and translate this into effective decision making.

Tool: A concept design for integrating generative knowledge management into resource management organisations.

Transfer: Currently in the very early stages of exposing SANP and DWAF to the concept. Both have expressed real interest in its continued development.

Way forward: This is an essential tool for effective form and function in the new CMAs. There is a need for DWAF and others to seriously engage these concepts if the Reserve is to be effectively managed within CMAs. It has general relevance in the operation of the CMAs.

1.1.6 Develop a Common Vision, Desired Future State and River Management Objectives and Goals for Selected KNP Rivers

Need: Catchment stakeholders to establish a Common Vision, Desired Future State and River Management Objectives and Goals for selected KNP rivers.

Tool: Desired State Objectives Hierarchy process.

Application: The process was used to engage stakeholders from both the Sabie and Olifants River catchments and to produce common visions and sets of management goals for the respective rivers as seen by the catchment stakeholders. The process worked better for the Olifants River than for the Sabie River mainly due to perceived representation problems in the Sabie River stakeholder group. The process was also hampered by rapid changes in catchment management structures and the establishment of Catchment Management Committees which pushed the importance of the river forums into the background. However, the DWAF is applying the products which are the outcome of this process in the Ecological Water Requirement Assessment process for the Olifants River which is currently in progress.

Way forward: The process to establish CMAs in the catchments of the Inkomati and Olifants rivers focuses primarily on establishing the CMA structures needed to take the process forward. Much effort is presently put into getting the

CMAs established and functioning, and the proposal to the Minister for the establishment of the Inkomati CMA is nearing completion. Once the CMAs have been established and the need arises for the development of Catchment Management Strategies (CMS) in the different rivers of the Water Management Areas covering the KNP, the DSOH process will undoubtedly play a major role in setting appropriate common visions and management goals.

1.1.7 Enhancing Capacity of River Forums

Need: To enhance the capacity of river forums to engage integrated river management.

Tool: Formal participation in catchment management activities of the river forums, especially using the Desired State Objectives Hierarchy processes to give more structure to their activities.

Application: The process was hampered by other developments (establishment of Catchment Management Committees as a prelude to the formation of CMAs) in these catchments, which caused the role of the river forums to change. They were drawn into new bodies and temporarily lost some of their identity and status as catchment management forums. However, their continued valued contributions in the CMCs establishment process demonstrated the capacity already gained by being involved in earlier activities described above.

Way forward: The Forums are re-defining their roles and responsibilities. They will need to review their goals for which the DSOH process will be useful.

1.1.8 Monitoring Liaison Committee

Need: To integrate and promote the various monitoring activities on KNP rivers.

Process: Committee organised under the auspices of the KNPRRP, including members of DWAF, provincial conservation agencies, forestry, KNP, WRC and researchers. Meets 3 times a year.

Application: Progress reports, initiating monitoring development and projects, developing a comprehensive monitoring plan for the Lowveld rivers.

Transfer: This is an integral part of the committee's activity, since the management agencies are represented on the committee.

Way forward: The committee has agreed to continue beyond the Programme's end and is now officially constituted as the WRC steering committee for the IFR monitoring project.

1.2 Fluvial geomorphology and its role in aquatic ecosystem management

1.2.1 Classification of KNP Rivers

Need: To extrapolate information from the Sabie River (the focus of our research), to the other rivers of the Park.

Tool: A classification framework, based on physiographic and biological criteria, to assess the similarities and differences between the various river zones.

Application: Development of the tool is not completed. It is aimed at facilitating the choice of sites, methods for monitoring, and interpretation of monitoring data to facilitate comparison and extrapolation.

Transfer: Tool is incomplete.

Way forward: Awaiting the outcome of the proposal submitted to the WRC for the completion of the tool.

1.2.2 Process for Hierarchical Definition of Representative Reaches

Need: Evaluating the physical and ecological response of the Kruger National Park rivers to changes in water quality and quantity was a vital but complex task. A detailed study of the entire length of the rivers within the Kruger National Park was logistically and economically impossible, and therefore a process to categorise a river system by identifying "typical" reaches for study and monitoring was needed.

Tool: A method for the definition and characterisation of Representative River Reaches was developed and tested. This provided a method by which a river could be zoned. A hierarchical geomorphological classification system was developed for characterising the complex mixed bedrock/alluvial geomorphology of the Kruger National Park rivers. It has now been developed to a state where it can be applied to any river.

Transfer: The hierarchical geomorphological classification system developed on the Sabie River has been successfully applied and used on the Letaba and Olifants rivers. The representative reach concept of identifying sensitive channel types has also been used in the IFR workshops for the Sabie, Letaba, Luvuvhu, Olifants and Mooi rivers.

Way forward: The representative reach concept and methodology provides a way in which to reduce monitoring by directing focus to critical sections of the river which are most susceptible to change. However, our understanding of medium-to long-term channel change (>50 years) is poor and more in depth studies are needed to contextualize episodic events such as the recent floods.

1.2.3 Models of Geomorphological Change

1.2.3.1 Model to predict river response to change in flow and sediment supply

Need: A model to predict morphological change in rivers in response to natural and anthropogenic changes in flow and sediment supply regimes.

Tool: The model predicts changes in sediment storage in a sequence of cells representing selected channel types. Simulation is by sediment budget on a daily basis, using daily flows and sediment supply as input. Sediment transport through cells is computed according to the Ackers and White (1973) model, with calibration through the energy gradient.

Application: The model has been applied, using IFR specifications at sites on the Sabie River, to demonstrate the progressive accumulation of sediment associated with upstream abstraction and flow regulation.

Transfer: Model is complete and available through the CCWR/KNPRRP.

Way forward: Complete. Although the model is very useful the overall approach has limitations for further development. Other approaches are now under investigation (see also 1.2.3.3).

1.2.3.2 Rule based model (BLINKS)

Need: To relate aquatic biotic response to abiotic catchment conditions and the allied need to foster links between scientific disciplines researching these.

Tool: A suite of inter-linked models which consists of an hydrology model and two Qualitative Rule-based Models (QRBMs), known as the Abiotic-Biotic link (BLINK) models, which describe the geomorphic function and fish response of the Sabie River.

Transfer: A number of workshops were attended by programme leaders, developers, modellers and KNP staff. Models were developed in conjunction with potential users and within an interdisciplinary forum. All data, rules and models were made available to sponsors and the KNP. The suite of models is structured to facilitate understanding of the systems under consideration rather than too produce definitive solutions. As such, they form an important means of communication between scientists and managers alike. The broad operational scales used have been selected to optimally integrate the various process and observation scales involved. The models are incorporated in the KNPRRP ICIS.

Way forward: Refinement of the BLINK models is ongoing through separately funded WRC projects. Refinement is focused on the conceptualisation of the models, in particular the fish and geomorphology models and the assumptions therein. A further, and equally important focus is the alignment of model's output with their respective TPCs. More detail is given in the following sections.

1.2.3.3 Geomorphology Rule Based Model

Need: To predict geomorphological response to changing flows and sediment input because of well-defined responses of fish to channel geomorphology. A model of geomorphological change was a critical need, not only to understand geomorphological dynamics better, but also in predicting biotic responses in rivers.

Tool: Knowledge-based rules have been developed to control the response of geomorphic units within a selected river reach depending upon incoming flow and sediment. The model is designed to accept discharge and sediment data for any point on the Sabie River in the form of a daily averaged flow and sediment load. Input is obtained either from the ACRU model simulation, or from observed data if available. Modules of the geomorphology model served as template predictors for both the fish and riparian vegetation models.

Transfer: Model output is presented in a user-friendly graphical form. Model output is used directly as input to the fish model.

Way forward: The geomorphology model has provided a coarse template, which, in conjunction with hydrological input, is critical to the further development of the BLINK models. However, there are known areas of concern in the conceptualisation of the geomorphology model. Model refinement will require further assessment and re-analysis of baseline data. Although some of this work will form part of the WRC funded BLINKS III project, there is limited capacity for geomorphological analyses in South Africa and the

research will rely heavily on UK partners. There is a critical need to develop expertise in this field, within South Africa.

1.2.3.4 The Fish Model

Need: To relate the response of specific fish groups of the Sabie-Sand river system, in the short term (seasonally), to varying flow conditions and in the medium and long term, to changes in channel composition.

Tool: A QRBM in which the abundance of each fish group is predicted according to a set of "rules" based on expert knowledge of the fish response to hydrological and geomorphological variation in the Sabie River. Input to the model is provided by parameters describing the hydrological status of the preceding season (e.g. number of days of zero flow, flood events, etc.) and a description of the available fish habitat provided by the geomorphology model by way of a Habitat Suitability Index.

Transfer: Model output is presented in a graphical form consisting of a hypertext trace of the rules invoked at each time step and links to their explanation, and an output file of the abundance of each fish group for each time step. The files are presented to the user using a hypertext browser, in the case of the rule trace, and a colour area graph in the case of the fish abundance information. The graphs enable the user to assess the impacts of the model scenario with relative ease, while the hypertext trace ensures that assumptions made in model development are transparent. The models are incorporated in the KNPRRP ICIS.

Way forward: The fish model is currently undergoing major revision through a separate WRC project. It is intended that this project will allow for in-depth analysis of conceptual issues regarding the development of the model, as well as ensure its alignment with the TPCs set for fish, according to the SAM approach. It is envisaged that this process will also include refinement of the existing TPCs for fish.

1.2.3.5 Knowledge-based Model for Morphological Change

Need: A model to predict morphological changes in rivers that accounts for sediment-vegetation interactions and non-quantifiable knowledge about the system.

Tool: A rule-based model that predicts changes in sediment storage in a sequence of cells, including descriptions of the dynamics of reed beds and their interaction with sediment storage and movement.

Transfer and
Way Forward: This is a novel approach to morphological modelling that requires development of new formulations and new types of information. Currently being pursued in projects investigating sediment-bedrock and sediment-vegetation interactions.

1.2.3.6 Patterns and Process of Change in Geomorphology: Implications for IFR/Reserve Determination.

Need: Particular channel types, which are thought to be insensitive to changes in flow/sediment supply, and are associated with sensitive biota, are chosen for monitoring the condition of a river and for establishing IFRs/the reserve. However, our knowledge of the stability of these channel types has been non-existent and the assumptions of stability untested.

Tool: Recent studies of aerial photographs suggest that these channel types are in fact highly sensitive, fluctuating widely in the space of ten years or less. Choosing such sensitive sites for monitoring purposes will not lead to effective river management. Results provide the basis for choosing more stable sites.

Transfer: This project has not yet been completed.

Way forward: The IFR process does not seem to be equipped to incorporate new information or revise previously developed methodology. Better understanding of channel type stability and clearer application of this new information for river management will improve this situation.

1.3.5 Sediment Supply Prediction

Need: Spatially explicit technology is required for predicting sediment supply from catchments to rivers as an important input for morphological modelling, and for effective management of the catchments to control erosion.

Tool: A GIS-based model (CALSITE) was modified to be applicable under South African conditions.

Application: The model has been used to predict catchment sediment yield for the subcatchments contributing to the Sabie River in the Kruger National Park.

Transfer and
Way Forward: Complete. Modifications incorporated in HR Wallingford's CALSITE model, Donald, van Niekerk and James (1995).

2. River Hydraulics

2.1 Stage-discharge Relationships

Need: Synthesis of stage-discharge relationships from local stage and remote discharge measurements. Stage-discharge relationships are often required at remote locations where stages can be recorded automatically, but stream gauging is not possible because of inaccessibility during short events.

Tool: Procedure for relating discharges measured at established gauging stations to simultaneous short-term stage measurements at the remote site. This uses non-linear Muskingum routing to optimise parameters of a rating function.

Transfer: Published in Journal of Hydrology, Birkhead and James (1998).

2.2 Interaction between river flow and bank storage

Need: Storage dynamics in river banks determines water availability to riparian vegetation. The response of bank storage to fluctuating river levels needs to be described to enable the response of riparian vegetation to upstream river control to be predicted, and to manage this control.

Tool: A numerical model has been developed to describe the water balance of the bank storage zone. This accounts for unsteady unsaturated and saturated flow in 2 dimensions, with extension for quasi 3-dimensional application.

Application: The model has been applied to demonstrate the role of river level fluctuations in determining the availability of water to riparian vegetation, the role of bank storage on the passage of flood waves down rivers, and the dependence of bank storage on the non-linear characteristic of rating relationships.

Tool: A graphical method has been developed for determining the maximum rise in phreatic surface in response to flow events of varying magnitude and duration.

Application: This method provides a simple means for quantifying the bank storage response to flow events, and hence for determining reservoir release policies for managing riparian vegetation through controlling water availability.

Transfer and Way forward: Development completed. Publication in preparation.

Vegetation has important feedback effects on hydraulics and geomorphology. Trees, such as the Mingerhout (*Breonadia salicena)* establish in cracks on rocks (photograph above) and reeds colonise sand bars (photograph below). The resistance provided by tree and reed stems reduces flow rates and promotes sedimentation.

2.3 Relating local hydraulics to discharge

Need: Instream flow requirements and sediment dynamics in rivers are established through quantification of local hydraulic variables, such as flow depth and velocity. Management is effected through control of discharge. There is therefore a need to link managed discharges to local hydraulic variables. Such capability is particularly deficient for low flows in complex, bedrock-influenced channel types.

Tool: A procedure for determining flow resistance in alluvial and bedrock-controlled river reaches, such as found in the rivers in the Kruger National Park. This method allows assumption of a transversely horizontal water surface, for alluvial reaches, or a non-horizontal water surface, such as occurs in bedrock-controlled distributaries.

Application: The procedure has been applied to determine resistance characteristics of representative reaches in the Sabie River.

Transfer and Way forward: Published in Earth Surface Processes and Landforms, Broadhurst and Heritage (1998). The concept proposed could be developed and refined for more general application.

3. Integrated Modelling System

Need: To integrate existing predictive capabilities in hydrology, hydraulics, sediment production and transport, water quality, channel morphology and ecological functioning to form a modelling system appropriate to the aims of the KNPRRP, and thus provide the ability to predict responses to different development scenarios and provide managers, and stakeholders alike, with a means of assessing the impact of potential change on components of the catchment system.

Tool: A loosely integrated suite of models in which time-series of hydrology and sediment yield models are used as input to qualitative rule-based models (QRBM) for geomorphology, fish and riparian vegetation.

Transfer: Models and time-series of results of various potential catchment development scenarios are available through the KNPRRP ICIS. The ICIS has been widely demonstrated and serves as a platform for stakeholder interaction with the models.

Way forward: Future integrated catchment modelling exercises should adopt the idea of a core catchment hydrology model with basic water quality functions, which

may be coupled with a suite of pragmatic models, governed by some form of filter represented by management needs. "Traditional" modelling paradigms are not always appropriate to this approach. Thus the use of Qualitative Rule-based Models is recommended where appropriate.

3.1 Linked ACRU-HSPF Modelling System

Need: To integrate simulations of streamflow and sediment, according to catchment physiographic conditions and hydrodynamic tools to move these downstream through the river channel system. The focus of this integration is the interface between catchment and river channel on the Sabie River rather than the links with the BLINK models.

Tool: The ACRU Agrohydrological Modelling system was used to simulate the land surface processes, and the HSPF (Hydrological Simulation Program – Fortran) models the in-channel hydraulic and water quality processes. The link between ACRU and HSPF is made in series. Daily streamflow and sediment values computed at each of 56 Sabie subcatchments are produced by the ACRU model in its native binary time series storage format and then converted into the WDM format for use by HSPF. A reach of river for each subcatchment is created to represent the channel component of each subcatchment. A HSPF User Control Input (UCI) file is created for the HSPF components of the simulation which then operates on each reach of river.

Transfer: Time-series of model input and output are available through the KNPRRP ICIS. These data are also used as input to the BLINK models. Inadequate input data in other catchments may restrict transfer of the system.

Way forward: There is consensus among researchers and the Programme management that installed modelling systems of the ACRU and HSPF type are essential for the strategic adaptive management approaches advocated by the KNPRRP. In order to increase the capabilities of such installed systems it will be necessary to increase the modelling capabilities as well. There are many substantial potential benefits in linking the ACRU and HSPF modelling systems. Thus despite the complexities of this task one view in the KNPRRP is that the ACRU-HSPF link should be pursued. Another view is that the ACRU model should be enhanced to include the capabilities which are at present in HSPF but not in ACRU.

This difference in views has not been resolved in the KNPRRP and it remains a task in the future to consider these separate pathways. The issue will inevitably come down to a question of financial and human resources and

time. The KNPRRP believes that it is healthy to hold these two views in tension and believes that the debate surrounding them should continue.

3.2 The ACRU Agrohydrological Model

Need: To predict streamflow on a daily basis for a range of potential development scenarios in the Sabie River catchment.

Tool: The ACRU model is a multi-purpose and multi-level integrated physical conceptual model that can simulate streamflow, total evaporation, and land cover/management and abstraction impacts on water resources at a daily time step. For the purposes of this exercise, the Sabie catchment was further divided into 56 subcatchments in order to account for heterogeneity of catchment rainfall, land cover and soils and to facilitate output requirements at specific sites within a catchment, such as dams, weirs or representative reaches.

Transfer: Phase II model output is available through the KNPRRP ICIS. Phase III updates available through the School of Bioresources Engineering and Environmental Hydrology (BEEH) have been loaded into GenScn and are awaiting transfer to the ICIS. The BLINK models utilise model output directly. In Phase III, BEEH have interacted closely with catchment stakeholders such as the Save the Sand initiative, AWARD, Sellick and associates, etc.

Way forward: Updating of the catchment landuse and model input will continue through the BLINKS III (WRC project K5/1065) project.

3.3 Sediment supply prediction

Need: Prediction of changes in the geomorphological template, requires estimates of sediment production. In addition spatially explicit tools are required for predicting sediment supply from catchments to rivers as an important input for geomorphological modelling, and for effective management of the catchments to control erosion.

Tool: The ACRU Agrohydrological model provides a subcatchment-based prediction of sediment supply catchments to the Sabie and Sand rivers. The model utilises the Modified Universal Soil Loss Equation (MUSLE) to predict sediment supply, and as such is sensitive to land management practices and landuse, as well as rainfall intensity, soil characteristics and slope, all of which play a role in the production of sediment.

Application: The model has been used to predict subcatchment sediment yield for the subcatchments contributing to the Sabie River upstream of the Mozambique border. Model output has been used in both the SEDFLO and BLINKS geomorphology models.

Transfer: Phase II model output is available through the KNPRRP ICIS and Phase III updates through the School of Bioresources Engineering and Environmental Hydrology have been transferred to GenScn and are awaiting transfer to the ICIS.

Way forward: Updating of the catchment landuse and model input will continue through the BLINKS III project (WRC project K5/1065).

3.4 HSPF Model

Need: Prediction of hydrodynamic and water quality variables at a coarse (subcatchment) scale.

Tool: The Hydrological Simulation Programme – Fortran (HSPF) is a comprehensive water quantity and quality modelling tool. For the purposes of the Integrated Modelling System, hydrodynamic components of the model (RCHRES module) were linked to the ACRU model to provide estimates of river channel sediment movement and water temperature.

Application: The model has been used to estimate water temperature and sediment load in the river reaches upstream of the Mozambique border. Different views are held within the team on the approach used and the consequent simulations of water temperature, and, to a lesser extent, sediment load.

Transfer: The model output is available through the KNPRRP ICIS.

Way forward: The exceptional functionality of the HSPF modelling system and the support that its ongoing development is receiving in the USA by the US Geological Survey, the US Environmental Protection Agency, numerous catchment management authorities comprising multiple stakeholders, academic researchers and practitioners leads the KNPRRP Management to believe that it is a candidate to play a significant role in the "installed modelling systems" of the future in SA.

4. Integrated Catchment Information System (ICIS) and Related Programmes

Needs: The need for an affordable, customisable and yet world-class integrated catchment information system for use in the KNPRRP, was expressed early in the Programme. In the interest of cost effectiveness, speed, product quality, affordability, future maintenance and reducing competitiveness in the development of the system, a principal decision was taken to use existing and preferably public domain software where possible.

The system needed to have capabilities in GIS; model execution; meta data storage and display; time series management; Internet connection; remote application triggering; hypertext; connection to other world class software with complementary capabilities and client server application mode.

The software needed in addition to have solid alignment and connection to efforts at institutions whose commitment would endure beyond the end of the KNPRRP.

Tools: The inter-operable suite of programmes commonly known as the Integrated Catchment Information System (ICIS) was developed primarily in the KNPRRP with considerable assistance from the Computing Centre for Water Research (CCWR).

The system includes the ARCVIEW software and numerous coverages of the Sabie River, the Riparian Vegetation Model, the Geomorphological model and the Abiotic-Biotic link model for fish. These are mentioned in more detail elsewhere in this section. The Hydrolocial Simulation Programme Fortran (HSPF) and Agricultural Catchments Research Unit (ACRU) models were also configured and run for the Sabie River as part of the KNPRRP. These models also linked their output to the ICIS.

In addition all the other needs expressed above were met in this tool.

Application: The application linked the efforts of no fewer than 14 institutions within the RSA and also those of the US Geological Survey (Water Resources Division) and the US Environmental Protection Agency who produced " A Tool for the Generation & Analysis of Model Simulation Scenarios for Watersheds (GENSCN)" and the "Better Assessment Science Integrating Point & Nonpoint Sources" software respectively. The application became commonly known as ICIS. It has been installed at 19 different sites throughout South Africa and training has been given with each installation. The application is installed on computers at the SANP Scientific Services at Skukuza and training has been given.

The software has also been promoted through workshops and information sessions at the DWAF.

Way forward: It is confidently anticipated that the ICIS developed in the KNPRRP, with its close links to GenScn and BASINS will become a feature in the software systems required by Catchment Management Agencies (CMAs). The developments using these systems which were started during the KNPRRP have been taken up by other groups and organisations and their sustained enhancement and use seems assured.

5. Energising and Operationalising SAM

It is one thing to develop tools and processes to support integrated management of river systems, and quite another for them to be adopted and activated with energy understanding and commitment.

Research programmes consider the unknown. The first target for new knowledge and understanding is the Core Team. From this it is diffused outwards, the rate being determined to a significant degree by the commitment of the researchers and their resources to this diffusion process. This is not unique to research programmes. It is an established feature of transformation in business.

There is an inevitable lag between the generation of new knowledge and understanding and its adoption and use. In the KNPRRP, as will be discussed in subsequent sections, progress with achieving knowledge diffusion and adoption of new practices did not proceed as quickly as was hoped. Why was this? In this section we consider how this process could be energised and operationalised more effectively.

Needs: * **Need to envisage latent needs**

The greatest needs from the KNPRRP were to envisage latent needs in the processes of integrated river management and to develop research products, processes and capabilities to deal with these when the roleplayers in the catchment recognised and felt a need for them. This is the essence of generative leadership and of proactive research. We believe that the KNPRRP did envisage current and future needs wisely, as far back as the beginning of Phase II. That the outputs may not yet have been fully adopted illustrates the inevitability of the lag referred to in Figure 5.

* **Need to learn to deal with complexity**

Integrated river management decisions take place in a complex, integrated, inter-disciplinary, inter-organisational, international environment and the DSS tools and processes must be commensurate with this complexity. Simplistic tools and processes are just that, simplistic, not realistic. The KNPRRP, whilst not becoming over-complex did strive to develop processes to accommodate complexity rather than to avoid it.

* **Need to recognise the power of the business environment**

The KNPRRP could not control the business environment. The environment is still evolving and maturing. Many of the processes developed in the KNPRRP have not yet been perceived to be important by many of the stakeholders and sponsors.

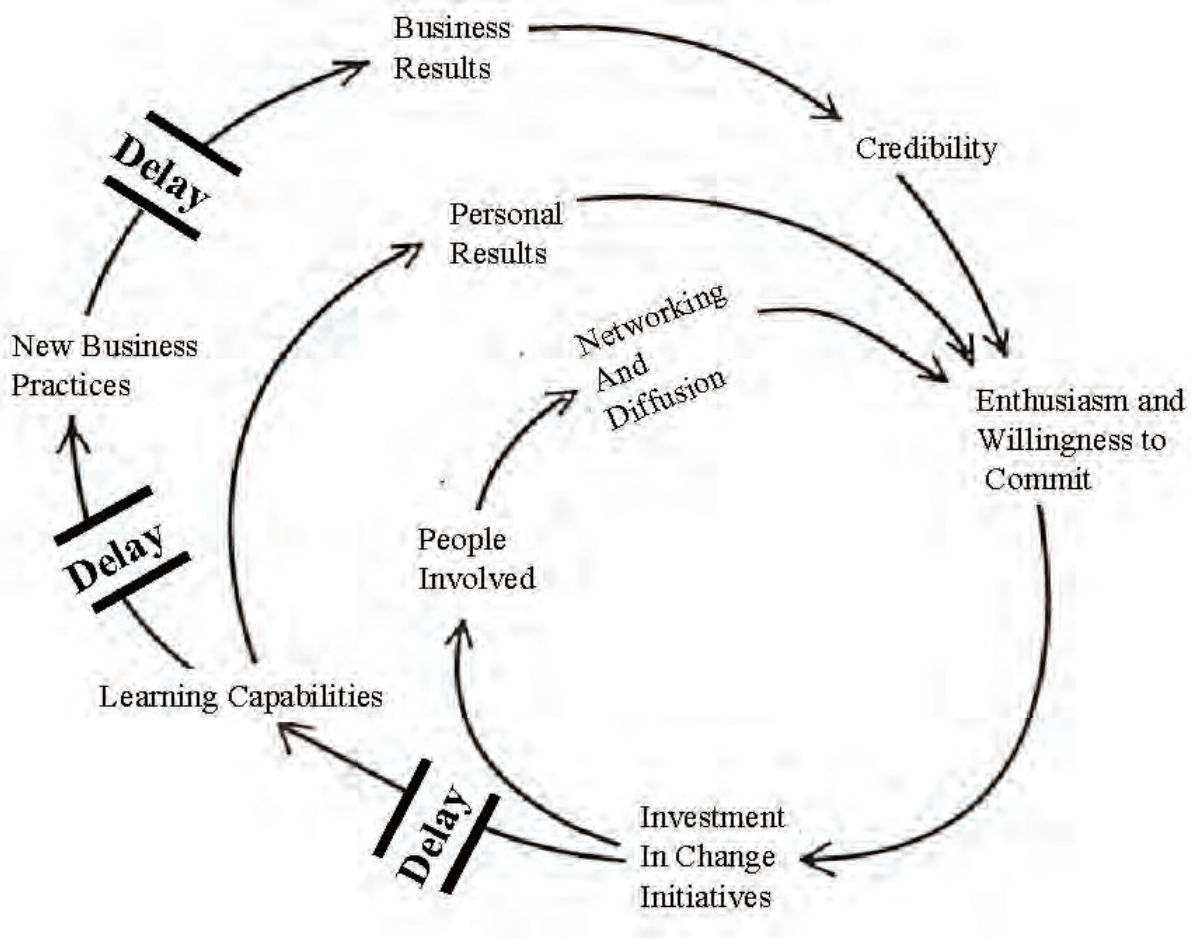
In order to properly judge the appropriateness of the DSS, we need to either be patient and wait for the predicted conditions upon which the research directions were predicated to arrive, OR we need to perform business analyses which will more accurately predict the sort of conditions into which we are delivering research products and processes. Thereafter, develop strategies to hasten the arrival of such conditions. The KNPRRP has undertaken a number of initiatives to stimulate the latter. For example:

* the successful workshops on the Objectives Hierarchy with the SANP and many catchment stakeholders;
* the energetic and successful propagation of the Strategic Adaptive Management (SAM) concepts and process;
* the Monitoring Liaison Committee for the KNP rivers;
* the promotion of the business context surrounding the ICIS development to the many catchment forums throughout SA;
* the active engagement of the KNPRRP researchers with the development of the new water law in general and the environmental reserve in particular.

* **Need to clarify who the "stakeholders, managers, decision makers" are**

One of the prime needs was/is to envisage who the stakeholder/managers/decision makers are. What are the likely influence groupings and skills that we are aiming to address with the DSS? Like all products and processes it cannot be all things to all people. Focus on a wisely anticipated and clearly articulated target is essential. The KNPRRP was partially successful in this. However, the exceptionally dynamic nature of the structure and operation of the water sector during the study, made it very difficult to fix a focus and stay with it.

Figure 5: Setting the processes of profound change in motion (adapted from "The Dance of Change" by Senge *et al.*, 1999)



* **Need to consider other organisational paradigms**

Decisions take place in an organisational environment. We focused perhaps too much on one organisational interaction paradigm and were not responsive enough to the business dynamics of the situation to be well informed on other possible paradigms. To be more specific we implicitly viewed the CMAs as advisors for DWAF, which in turn would carry on with business as usual. We could have engaged in more serious discussion on bargaining/negotiation paradigms that direct fundamental shifts in the mind set and concrete actions on the part of all role players.

Process: It is useful to consider the relationship between the KNPRRP management diagram (Figure 4), the Strategic Adaptive Management Process (SAM) and the Integrated Catchment Information System (ICIS) which calls the models into action. The least important aspect of the DSS process is the current content of the ICIS. ICIS is merely there to serve the DSS processes embodied in the KNPRRP Management diagram and in the SAM process involving Thresholds of Probable Concern (TPC). These processes were all well conceived and the tools well developed within the KNPRRP. However, with the exception of the Strategic Adaptive Management (SAM) and Objectives Hierarchy Process within the SANP in the KNP, they delivered into an organisational system which was not ready to receive them. It required the organisation/s to invest in change (Figure 5). Although this investment has started, there are inevitable delays as individuals and organisations change. Conditions in the wider organisational spheres are vital to the successful diffusion of the processes and products developed in the KNPRRP. The development of such conditions is a process over which the KNPRRP does not have much influence at all but which it has followed with great interest. We believe that the KNPRRP processes and products are appropriate to the emerging conditions.

Application: Although the Objectives Hierarchy leading to the Desired State, the SAM process and TPCs have been developed for the KNP and its rivers, these have yet to be fully incorporated into focused monitoring and modelling in the KNP.

Thus, although these developments are encouraging, we cannot say that the complete system of processes and products developed in the KNPRRP is being used in the KNP or in the stakeholder interactions in the catchment.

The critical mass of energy and leadership required (outside of the KNPRRP) for these applications to be taken up in practice is not yet present. We still hear (on a daily basis) statements to the effect, "How does one know what CMAs will need, they haven't been formed yet?"

The idea that the KNPRRP has been building the “installed modelling systems” which the CMAs would need, has not yet been applied seriously.

Transfer: The external organisational environment in which the KNPRRP found itself meant that unfortunately we were often constrained by the old paradigm thinking concerning practices surrounding technology transfer. With some notable exceptions (i.e. SAM and Objectives Hierarchy workshops) we focused on reports, conference papers and short courses. Throughout we implicitly assumed a target market which with the wisdom of hindsight is proving to be inappropriate except in some cases.

We also implicitly assumed that the co-ordination required to use these tools and processes could be developed with little practice.

Way forward:

- Clearly identify the stakeholders who will have the desire and the capability to use the KNPRRP DSS products.
- Approach the organisational and individual behavioural issues surrounding integrated river management in a professional manner.
- Thoroughly explore the implications of the move from Rights-based to Interest based paradigms of bargaining and exploit those implications which are in favour of equity, openness, sharing and ongoing relationship building.
- Clearly identify the stakeholder interest groups and analyse how they are likely to pull together to inform themselves and fight for the interests of their group.
- Explore the national implications of such tendencies.
- Assumptions which are not made explicit confound progress. Care should be taken to explore and state assumptions in an unambiguous manner.
- Progress is critically dependent upon "champions". It is necessary to identify, engage and support this champion in different stakeholder sectors. They are the pioneers of change.
- "If the business case for change is not clearly articulated, people do not connect with the aim of the changes and a commitment gap results. People may participate because they have to, but there will be little investment and learning."

6. Subsidiary Goals for Phase III

It is informative to consider progress for each of the eleven Subsidiary Goals for Phase III before evaluating goal attainment according to the criteria set in the Programme Description.

6.1 Action plans and strategies for river management

Scientifically based and jointly developed strategies and action plans for the integrated management of at least three rivers providing flow into the Kruger National Park (Sabie, Olifants, Crocodile or Letaba rivers).

There have been two major thrusts in our efforts to achieve this Subsidiary Goal: testing and promoting application of the technology and process for Desired State Objectives Hierarchy (DSOH); and promoting the adoption of an integrated modelling system approach and the concept of installed modelling systems.

Although the DSOH was developed with integrated management of river systems in mind, its first application in the Kruger National Park led to its use for the whole Park (aquatic and terrestrial). Its impact has been considerable. It was also used with the Sabie River Working Group (SRWG) and the Olifants River Forum (ORF). With the SRWG the stakeholder involvement process soon highlighted the need for a more fully representative forum. This was taken up with the provincial office of DWAF and we anticipate that once this has been achieved it will revisit the DSOH process.

The ORF used the DSOH process very effectively to reach consensus on the Desired State and is currently using this in the process of determining the environmental reserve.

Experience gained in the Programme and the associated capacity developed in the KNP and the various forums, has been an important element in the progression towards establishing CMAs in the Lowveld. The beneficial consequences will endure in the long term.

The DSOH approach (in an abridged form) is being applied to the Eastern Cape Estuaries Management Project. It was used successfully in reaching consensus amongst a group who were previously antagonistic to one another, and with a second estuary stakeholder group drawn from widely differing backgrounds.

Dr Nick Schofield's comment in the Australian publication *Rivers for the Future* (Schofield, 1999) provides a view on the relevance of the DSOH and the KNPRRP in a wider context (Box 11). He arranged for the KNPRRP to be invited (all expenses paid) to make a presentation at the River Festival Conference in Brisbane. Dr Dent presented the paper.

The complexity of river systems is such that integrated management must inevitably be founded on integrated modelling. The Integrated Catchment Information System (ICIS) developed in the Programme focuses primarily on developing inter-operability between components of the overall software systems being developed within the KNPRRP and elsewhere (Box 7).

The KNPRRP has no coercive power to cause stakeholders and authorities to adopt the philosophies, concepts and technology it has developed. It has been particularly pleasing therefore, to experience the interest in the work of the KNPRRP and to see the direct and indirect influences it is having in both the private sector and Government (Box 8). The influence of these interactions on integrated river management will be realised in the short to medium term.

Box 7 : Software Linking

The following systems were linked into the ICIS shell which included linking the time series to the Water Resources Division US Geological Survey's watershed data management system (WDM) and the ARCVIEW GIS package :

- Breonadia Model
- Geomorphology Model
- Fish Model
- Sediment Flow Model (SEDFLOW)
- ACRU System output
- WISH System (Geohydrology).

Several international systems were also linked in the ICIS concept. These were the Hydrological Simulation Program Fortran (HSPF), the generalised scenario generator and information display shell (GenScn), the better assessment science integrating point and non-point sources (BASINS2.0) all from the USGS and the US EPA.

Box 8 : Parties with whom there has been active engagement in respect of ICIS

Government

- DWAF Chief Directorate Scientific Services
- DWAF Institute for Water Quality Studies
- DWAF Directorate of Hydrology
- DWAF Gauteng Region
- DWAF Eastern Cape Region
- Cape Town Metropolitan Council
- North West Province Department of Environment Affairs

Parastatal organisations

- South African National Parks
- Umgeni Water

Universities

- University of Zululand
- Universitate Eduardo Mondlane
- University of Cape Town
- University of the Orange Free State
- University of Potchefstroom
- University of Natal
- University of Venda

Private sector

- Olifants River Forum
- Waterval Forum
- SASOL
- AMCOAL
- Greater Edendale Environmental Network
- CSIR
- Sabie River Working Group

Presentations or training courses have been delivered to those who have requested them.

6.2 Improved understanding

Improved understanding and application of ecological, social and economic principles in the management of the natural environment of rivers flowing through the Kruger National Park.

There are four principal areas in which improved understanding has been developed.

In Phase I the Centre for Water in the Environment initiated studies directed at developing our understanding of how the physical template was shaped and how this varied over time. These studies were carried through Phases II and III and led to predictive capabilities, particularly in respect of bedrock controlled river systems such as the Sabie River. In Phase III these capabilities were used effectively in determining physical TPCs and ultimately indicating that unless there was concerted effort to reduce sediment loading into the river, it would be impossible for the KNP to achieve its management objectives for the Sabie River.

Phase II and III also focused on the further development of riparian vegetation studies by the CWE and the CSIR. Of particular relevance was the enhancement of predictive capabilities in respect of *Breonadia*, a tree colonising rocky sills in the KNP rivers. These sites are vulnerable under high sediment loads. This model provides biotic TPCs which are an expression of the interactions between fluvial geomorphology and vegetation. The linking of physical (hydrology, hydraulics and geomorphology) and biotic predictive capabilities (riparian vegetation and fish) has provided the system whereby scenarios can be developed which enable the KNP (and others) to envisage possible future states and test corrective action. This, for the first time in South Africa, has provided river system managers with a capability for strategic adaptive management, i.e. instead of reacting (adapting) to a changed state, they can now also act strategically. This is particularly important given the uncertainty which attends rainfall and water demand.

The third area of emphasis has been the 'transferability' of concepts to other types of river. The central component is the development of a river classification system. This project has, however, not made the progress we had hoped for although it is under way now. A number of studies in the fluvial geomorphology and riparian vegetation of other rivers (particularly the Levuvhu and Olifants) are also currently under way.

In anticipating greater stakeholder involvement in water allocation, Phase II recognised a need for improving our understanding of socio-economic aspects of river systems. Two projects were initiated in Phase III, both of which have been slow to start. One focuses on the incorporation of economic considerations into management of the environmental reserve. The second addresses the incorporation of societal needs and values (particularly of previously marginalised people) into the objectives of catchment forums. It is anticipated that these studies will enhance understanding of the socio-economic context in which integrated water resources management occurs.

6.3 Meeting national obligations

- Strategies developed and action plans implemented for meeting national obligations and emerging policy (e.g. Convention on Biological Diversity, Helsinki Rules, Agenda 21) on at least three systems (Sabie, Olifants, Crocodile or Letaba).

Phase II anticipated meaningful devolution of resource management and a growing influence of stakeholder groups. This combined with a conviction that environmental sustainability rests ultimately on individual behaviour, led us to focus at a 'local institutional' level, i.e. on catchment forums, sectoral authorities (such as the KNP) and stakeholder groups (e.g. forestry and mining).

Perhaps naively we had anticipated a much more structured institutional system than has emerged to date. This has meant that the 'targets' with whom we intended to develop these action plans and strategies have been in a process of 'institutional change' – in essence there has not been the necessary stability for engagement.

The striking exception has been the KNP where we have been able to 'test our products in the market place'. The results, as indicated earlier, have been very encouraging. But even here, the institutional transformation necessary to implement river management has not been forthcoming. Ironically this is despite the KNPRRP being motivated on concerns about environmental sustainability of river systems. With hindsight it may not be too surprising because their 'solution' was simplistically envisaged as water – if water was provided environmental sustainability would be secured without management intervention. There are encouraging signs that the need for institutional reform is acknowledged. This is evidenced clearly in reorganisation and ongoing requests for facilitation, advice and support.

Rivers have never been managed in South Africa – except as conduits of water. We underestimated the complexity of transformation. It will be some time before the institutions being set up and those which already have responsibilities for contributing to river management have made the conceptual and organisational transformations which are required to effectively engage strategic adaptive management of river systems.

6.4 Communication strategy

An effective communication strategy which will support the Programme through regular interaction and exchange of information and understanding between stakeholders.

It was the specified intention at the start of Phase II to conduct collaborative, integrated research and to influence stakeholders with interests and responsibilities for river management. This required effective communication among scientists and stakeholders.

Communication is not simply the passing of information from one to another. Rather, it is meaningful conversation and learning. We tried to establish a culture of learning among scientists and with stakeholders. We committed ourselves to engaging others.

There can be no doubt that within team learning has been substantial. Each member of the team during Phases II and III brought new insights, concepts and communication to the table. These were frequently introduced in a 'language' not previously encountered by colleagues. These have been difficult lessons in listening, hearing and learning, and of engaging differences openly and constructively. Human behaviour has changed significantly. Researchers are less defensive and are much more open to having their views questioned.

There have been six important determinants of this change:

- the philosophical and geographical focus;
- the emphasis given to developing predictive capabilities;
- the linking of abiotic and biotic predictive models;
- the empowering of team members by allocating roles and responsibilities and promoting accountability;
- developing a sense of commitment to the Programme and not only to the project of individual interest;
- supportive management and leadership.

At the start of Phase II the focus was 'inward'. We felt it was essential to learn to communicate amongst ourselves before focusing 'outwards' to stakeholders. Hence external communication became a strong focus in Phase III. This is reported elsewhere in the Subprogramme manager reports in Part 2.

6.5 Partnership programmes with historically Black universities (HBUs)

- Partnership programmes developed and operationalised with two HBUs.

Various government departments and research funding agencies are promoting activities to strengthen research capabilities at the HBUs. We intended to support these initiatives by developing research collaboration. Three HBUs were targeted.

The University of the North was chosen because Mr Ndlovu was the Research Subprogramme Partner. His field is Human Geography and a project on stakeholder perceptions was conceptualised but never implemented. The National Research Foundation is promoting 'Research Thrusts' at HBUs. We have supported those at the Universities of Venda (UV) and Zululand (UZ) as both have interests in river systems. The UV was developing its Programme and Dr Dent has participated in several workshops directed at developing the structure and defining the projects. The UZ has strong research groups in hydrology and estuary ecology. We have contributed in a meaningful way to the design of the research Programme and to support with ICIS and HSPF. We have also set up a joint project on riparian area rehabilitation.

There has been considerable frustration along the way. We have felt that if the process of developing the Thrusts had been better organised we would have made more meaningful contributions. We have also suggested, on several occasions, that it is our opinion that HBUs could have benefited from dedicated mentorship in preparation of these Programmes. We believe that the concern that we might impose our will is not well founded. This is because, as pointed out above, we have developed a culture of listening, hearing, learning and being supportive.

6.6 Previously marginalised researchers

- Previously marginalised researchers working in partnership with experienced Subprogramme Managers.

The failure of corrective action in Phase II led us to set up a 'twinning' arrangement. All managers had to have a partner drawn from the previously marginalised sectors. Short reports by each partner are included in Part 3. Dr Jaganyi was also supported in her application to spend four months attending a course on biodiversity in the USA. The following extracts from Subprogramme partner reports indicate the value of the approach adopted.

Box 9 : Quotes from Programme partners

'I shall not hesitate to join such Programmes of national interest in future, should I be invited to do so'.
Madikizela

' …….. afforded me this really good capacity building exercise and learning experience. The project has, in some ways, also contributed to my new promotional post ……'

Maganbeharie

'My association with the KNPRRP has truly empowered me and built a capacity within me ……..'

Jaganyi

6.7 Effective education programme

- An effective education programme which promotes the transfer of expertise and understanding generated in the Programme to resource managers, researchers and stakeholders.

Section 3 of the Information Management and Facilitation Subprogramme report which is included in Part 2 of this report, addresses the issue of who are 'the Stakeholders' and how they relate to 'the Managers' and 'the Decision Makers'. This understanding is important because it directs the structure and context of education.

The view which has emerged strongly in Phases II and III is that congruent with the growing importance of allocation of water has come a redistribution of 'intellectual power' in the water sciences field. Inevitably industries such as forestry, sugar, irrigation, mining and conservation, to name a few, will channel their efforts through top class cadres of water science consultants who will specialise in the interests of their members. This will create enormous *de facto* forces for inter-operability standards within and between industries on water modelling issues.

We have appreciated, therefore, that in developing and distributing 'intellectual power' in the KNPRRP it is imperative to do so in the context of inter-operability. The 'environmental' management issues have to be addressed as part of a 'macro' system which allows interoperability

with other 'non-environmental' issues. This explains the rationale for our search for a 'core' modelling system with a proven track record and which is user friendly and affordable. Hence our choice of HSPF.

There have been three main thrusts in our 'education programme'. We have focused on stakeholder groupings, especially in the catchment of the Sabie and Olifants rivers. This had a twofold intention of introducing and supporting a process of setting management goals and objectives; and of introducing them to HSPF, ICIS and the importance of inter-operability standards. We have also done this with government with the specific intention of encouraging adoption of a consistent national approach. This is important since the same stakeholder interests will inevitably be represented in widely separated catchments. Given the scale of this challenge relative to our resources, and given the state of flux in constitution of CMAs and stakeholder groupings, we believe that we have played a formative role (refer to report on Subsidiary goal 6.1).

In the context of the rivers flowing through the KNP there is currently one institution which has delegated authority for river management. This is the SANP operating the KNP. The DSOH approach has been utilised effectively for the whole of the KNP, providing for the first time a strategic adaptive approach to management. In addition considerable effort has been expended to transfer skills and expertise. The single most limiting factor remains the lack of an institutional structure to efficiently and effectively internalise the information, skills and technology.

There has been a deliberate strategy of building research capacity, particularly amongst young researchers. This should not be measured in numbers because the KNPRRP had a commitment to focused research and not an expansive approach to the subject. It should rather be measured in progress towards collaborative, integrated research. There has been very substantial growth in interdisciplinary collaborative research (Box 10). This has been extended beyond South Africa through the Joint Venture with Mozambique and Swaziland (Subsidiary goal 6.10). We envisage that the beneficial effects will be felt for many years to come. This is particularly so since the WRC has acknowledged that the KNPRRP has encouraged them to allocate more of their funding to collaborative research programmes.

Box 10 : Researchers whose approach to research has been materially affected

Regina Bestbier	Andrew Birkhead
Mark Botha	Lucy Broadhurst
Andrew Deacon	Marc de Fontein
Paul Donald	Joan Jaganyi
Graham Jewitt	Angelina Jordanova
George Heritage	Bruce Kelbe
Jackie King	Karen Kotschy
Delana Louw	James Mackenzie
Bonani Madikizela	Moeti Makoa
Ara Monadjem	Asaph Ndlovu
Craig Nicholson	John Odiyo
Nevil Quinn	Mark Rountree
Dirk Roux	Ian Russel
Gert Steyn	Alan van Coller
Andre van Niekerk (deceased)	Johan van Vuuren
Inga Vogt	Dez Weeks

6.8 River monitoring

- River monitoring programmes for at least three rivers which enable stakeholders to evaluate whether goals and objectives are being achieved.

The Desired State Objectives Hierarchy enables stakeholders to set measurable and achievable objectives and goals. Whether goals are being achieved or not is assessed by way of TPCs. Thus monitoring is structured around the TPCs.

The determination of the instream flow requirements and the environmental reserve require definition of the Desired State (or at least a Management Class). And, the National River Health Programme monitors river health in relation to a 'pristine' state.

At least six organisations are involved with monitoring the Lowveld rivers. There was clearly a need to seek congruence between their monitoring approaches and needs in order to avoid confusion and to enhance efficiency and cost-effectiveness. This was the focus of activities in the Monitoring Subprogramme set up in Phase III.

A Monitoring Liaison Committee was established and this formed the hub for integrating monitoring. It will continue beyond Phase III as it assumes a life of its own.

Success has been achieved in establishing and testing a set of monitoring indices. These are linked to innovative systems for focusing monitoring and linking monitoring to the management system developed in Phase II and modified in Phase III. Stakeholders and resource managers are now included to address the process and each of the steps illustrated in Figure 4. They can also feel confident that whilst doing so their actions are consistent with determining and managing the environmental reserve and monitoring river health.

Although some training has been provided much more needs to be done. We envisage this being linked to commercial opportunities (IWR Environmental, CSIR and probably others). Sustainability is probable through the statutory requirements for monitoring which are devolved to provincial government and parastatal agencies, particularly CMAs and water boards, e.g. KOBWA.

The intention to develop a comprehensive strategy for monitoring the Lowveld rivers has not yet been achieved. This was, in part, due to the cascading effect of the slower than anticipated progress with establishment of CMAs.

6.9 Sharing and exchange of principles and techniques

- The sharing and exchange of principles and techniques derived in the Programme with other regions and river basins in southern Africa.

It will be evident from the preceding sections of this report that considerable effort has been directed towards achieving this Subsidiary goal. We believe our commitment to this is unique in the history of aquatic research in South Africa; and we believe that our influence has been far-reaching. Further we anticipate that the effects will be influential for many years to come.

Our commitment to integrating science and management has led us to propose that in addition to the usual Programme and project reports, and refereed publications, we should publish a synthesis. We are currently planning to publish a book provisionally entitled 'Integrating Science and River Management'. We believe such a text, emphasising South/southern African experience, will provide a valuable reference for professionals and students concerned with water resources management.

Box 11 : Dr Nick Schofield writing in the Australian publication - Rivers for the Future

The Kruger Rivers Study, now in its final year, is the most comprehensive and in-depth project undertaken in South Africa, and is probably unique worldwide. Perhaps the most valuable aspect of this work for Australia is the protocol development for holistic river management that has now become a template for management and restoration of South African rivers. Some of the features of this protocol include:

- Development and application of Strategic Adaptive Management (SAM);
- Visions and goal setting protocols (including translating vision into goals into operational level objectives);
- Protocol for goal maintenance;
- Objectives hierarchy of rivers management (including nested patch hierarchy dynamics);
- Strengths, determinants, threats and constraints analysis;
- Development of the concept of 'Thresholds of Probable Concern' (TPCs);
- Process for dealing with conservation, institutional and ecological paradigms;
- Use of prediction tools to evaluate management options;
- Integration of ecological, biological and hydrological disciplines;
- New approaches to addressing problems of scale;
- New protocol for identifying agents of change, indicators of change, response indicators, and decision support to respond to violation of TPCs, and
- Move from ecological balance theories to flux basis to maintain heterogeneity and biodiversity (in the broad context of this term).

As the above points suggest, the methodology has progressed substantially further than anything similar in Australia, particularly including recent ecological theory, scale theory, objective setting protocols (visions to operational), disciplinary integration and a complete and tested framework involving full stakeholder participation which is now in use. The different role by stakeholders at different steps in the process was a notable outcome.

6.10 Southern African Rivers Network

- The formation of a Southern African Rivers Network to share information and exchange expertise.

Strong emotions attend the broader involvement of South Africa in co-ordination within southern Africa. We have had to proceed cautiously with, for example the establishment of the Shared Rivers Initiative. Our intention has been to establish collaboration before setting up the Rivers Network. An additional motivation is that the activity creates information and an interest for such a network.

The matter of the network was discussed at the recent inception meeting of the Shared Rivers Research Joint Venture Core Team. It has been agreed to establish a network but clearly there are still difficulties to be overcome, particularly as Mozambique for example has difficulty engaging the Internet. Nevertheless we have agreed to set up a web site and to support this with limited hard copy circulation of information. This should be operational during the first half of 2000.

There has been some exchange of expertise through a training course delivered at the University Eduardo Mondlane and during a visit of Professor Matondo (Swaziland University) to the CCWR.

A training course followed the conference (see below). Participation (35 people) was drawn from South Africa, Mozambique, Zimbabwe and Malawi. It was not possible in the time available to provide more than an introduction to the concepts and technology developed in the KNPRRP, but by and large comment on the Programme was very positive.

6.11 Conference

- The hosting of a conference on Integrated River Management in southern Africa.

The conference was held on 10 and 11 August 1999. There were seventy-one participants and twenty seven papers were delivered. The proceedings are available on CD from the CCWR and on the KNPRRP web page.

There was general consensus that the conference was worthwhile and enabled participants to learn more of the KNPRRP and to exchange experiences. It did not, however, achieve all that we had in mind. There were several contributing factors. We had made somewhat slower progress than had been envisaged with the River Forums and emerging CMAs, so these ‘targets’ were not as well represented as we had hoped; we had not got the Shared Rivers Initiative under way, so much of the talk of collaboration lacked substance; and we had not established the network. The indirect effect of the conference following six weeks after the Southern African Association of Aquatic Scientists (SASAQS) conference in Swakopmund was also evident. There was a clear indication of interest in a future conference focusing on river management.

6.12 Evaluating goal attainment

In the Programme Description it is stated that the achievements and success of the Programme will be determined by the extent to which ten criteria are met. Each is considered briefly.

(i) Stakeholders, particularly those previously excluded, are contributing effectively to the implementation of action plans in at least one river system.

- This has been achieved very effectively with the SANP for the Sabie River within the KNP, but not to the same extent in the river as a whole. It has yet to be extended to rivers other than in the KNP.
- First steps have been successful with the Olifants River Forum.
- Less success in other systems.

(ii) Resource managers, stakeholders and researchers who have reached an understanding of the water quality and water quantity requirements for sustaining the natural environment of rivers flowing through the Kruger National Park.

- Clearly understood within KNP.
- Broadly understood in the Sabie and Olifants River systems. There is agreement on requirements and these are defined by way of IFRs.
- Not well understood or accepted in the Letaba River.
- We underestimated the lead-in time for establishment of representative forums and CMAs.
- We underestimated the workload relative to our resources.

(iii) Researchers, resource managers and stakeholders are able to use their knowledge, understanding and techniques to develop strategies and action plans for the management of rivers.

- This has been vastly improved by way of improved understanding, processes, communication, technology and training.
- We underestimated the institutional reform process and, therefore, the lead-in time for these organisations to be in a position to develop strategies and action plans.

(iv) Resource managers are able to make better, cost-effective decisions about the water quality and quantity requirements of rivers.

- The technology and scientific expertise has been vastly improved.
- Technology and expertise transfer has occurred to a number of stakeholder groups. Much more work is, however, required.
- The slow evolution of management structures has meant that these targets have not been addressed.

(v) River Forum and Working Group members have the capacity to set environmental goals and objectives and to use research and monitoring expertise effectively.

- We misjudged the target. It would probably have been better to direct efforts to the stakeholder groups.
- We were successful with KNP, and partially successful with ORF. Early signs of success in extension to estuary management.
- Quite a number of individuals have gained new capacity which they can use either within Forums and Working Groups or to facilitate the work of such groups.

(vi) Researchers have, through a directed research programme achieved enhanced understanding and predictive capability.

- Vastly improved with important implications for the design and operation of research.

(vii) Enhanced research capacity in previously disadvantaged students.

Acknowledged highly beneficial impact but for a small group.
Disappointing spread into Historically Black Universities.

(viii) Enhanced Programme development and management capacity in at least two HBUs.

Yes, but the real potential was not realised.
A more structured mentorship process would be required to achieve this.
There has been too much emphasis on the preparation of the Thrust proposals and too little on the process leading up to and following on the proposals.

(ix) Staff and researchers from HBUs participating in integrated transdisciplinary research programmes.

- Achieved with the University of Zululand although there has been insufficient facilitation and management of integration. There is a risk of talking integration but not practising it.
- Some prospect with the University of Venda.
- The KNPRRP, probably quite correctly, has had no coercive power. This should, however, come via the funding agencies in a more committed way than it appears to have.

(x) Partners trained to take responsibility for future management of the Programme.

- The KNPRRP is a very complex Programme both conceptually and in its organisation. It was naïve of us to imagine that young researchers after three years could take responsibility for management of the Programme.
- There is certainly considerable enhanced understanding, leadership and management capabilities. Partners could take responsibility for components of a Programme, once it had been conceptualised.
- A new programme directed at understanding management implications of episodic events is being developed. It will be operated by young researchers under mentorship from experienced researchers.

The extreme floods of February 2000 markedly changed the character of the Sabie River. The forested section of anastomosing channel in the Sabie River gorge below (photograph above) and after (photograph below) in the floods.

STRENGTHS OF THE PROGRAMME

South Africa has been predicted to 'reach the limits of its economically usable, land-based fresh water resources during the first half of the next century' (Department of Water Affairs and Forestry, 1999). Water allocation becomes the central process under conditions of such scarcity. Superimposed on this is the changing nature of our world. The challenges we face are to provide insight into change in complex natural systems and to manage allocation equitably, efficiently and sustainably in the midst of scarcity and change.

Complex problems require complex solutions. A strength of the KNPRRP has been its acknowledgement of complexity and its commitment to developing complex but user-friendly solutions. In doing so, we have also appreciated that in South Africa, as in other southern African countries, we have to be able to 'do more with less.' This has required us to develop ways of harnessing expertise and resources spread across the country, and we have been required to construct, and maintain interdisciplinary teams.

Another strength has been the emergence of a new culture (See Senge, 1994, Pascale *et al.*, 1997 and Prokesch, 1997). We have demonstrated:

- how to create an identity so that individuals have identified with the Programme and not only with their professional area of competency;
- how to handle conflict constructively. Conflict is inevitable and healthy - it provides a fertile ground for learning;
- how to promote organisational learning, including communication.

It has been important that the WRC has invested in organisational development and management and not simply in the products of research projects.

We believe a strength has been the 'Core Grant' system whereby the WRC allocated funds 'up front' for which we made annual applications. This encouraged us to do what was necessary when it was necessary and not to commit ourselves too far ahead. In essence we practised our philosophy of strategic adaptive management. The result was a conservative use of human and financial resources - doing more with less.

Finally we believe our commitment to information and technology transfer, to user-friendly products and processes, has been an important strength.

WEAKNESSES

These are considered from two aspects: internal and external to the Programme.

Internal

Several areas of weakness can be identified:

- We failed to effectively address the issue of water quality. Casual factors were that we did not have much strength on which to build; we decided to place it on hold until we had greater capabilities on the quantity side; and we did not define clearly enough what we should do e.g.: use the basis of HSPF which has water quality capabilities to provide a research framework. Also, our geographic focus on the Sabie River was on a system experiencing few water quality problems;
- We did not engage sufficiently strongly with the ongoing research and development of IFRs. We could have benefited from much more direct involvement. This would have helped to promote discussion around some of the philosophical differences. That there are differences is a strength;
- We were overly ambitious. This resulted in a degree of 'over-sell' and, probably unfulfilled expectations. Adding resources is not always a good solution because it can dilute focus and increase management load;
- We were only partially successful with corrective action within the Programme. The partner concept, whilst sound in principle, is based on the assumption that partners will have time to allocate to their Programme activities. In most cases this was not so and despite enthusiasm for participation it had to be fitted in with other activities - for which the incumbents were paid. Corrective action requires considerably more investment in money and time than we were able to provide;
    - We believe there is a general weakness in project management in South African research. The KNPRRP is not an exception. It might be appropriate for research funding agencies to set up a national initiative directed at improving project development and management skills;
    - We did not take sufficient advantage of the opportunities of national and international conferences e.g.: SASAQS to present the Programme, in addition to the individual components.

External

These are weaknesses over which the team has limited influence:

- Progress with policy and legislation reform, and the devolution of authority created a 'moving target' which made it very difficult to achieve our intentions in technology and information transfer;
- River systems have never been managed in South Africa (except as conduits for water). Thus, even organisations such as KNP who most wanted the KNPRRP, have yet to reorganise to deliver effective river management. This has made it difficult for the KNPRRP to 'transfer the baton' as it winds down;
- Two potential funding agencies, the NRF (formerly FRD) and DEAT, did not engage Phases II and III with any real commitment conceptually or financially. They, therefore, have probably not benefited to the extent they could have from the Programme;
- Stakeholder groups and resource managers were requested to state their expectations. These were largely presented in such broad terms as to be of little real help to researchers. This may reflect that managing rivers has not traditionally been part of their responsibilities and they are not organised to address it effectively. Much greater commitment to effective communication is required from this sector;

- In government (national and provincial) there was insufficient co-ordination and focus on river management, as distinct from managing IFR or the environmental reserve. This is illustrated by the KNPRRP research on the Sabie River. The evidence shows that the critical intervention required is to reduce sediment entering the river. This is a Department of Agriculture and Land Affairs responsibility. Who has the responsibility of bringing together DWAF, DEAT, DALA and KNP to achieve this? Too much reliance is placed on the researchers who have no coercive influences.

CONCLUSIONS

We believe that the KNPRRP has been unique, at least in South Africa, in its concomitant delivery of top class research, integration, team building and information and technology transfer.

The complexity of managing natural systems for sustainable use is such that it will not be achieved until there is a high level of co-ordination and collaboration among scientists, stakeholders and managers. The KNPRRP, despite its weaknesses, provides a framework for establishing and managing such initiatives. It shows that with focus and commitment to collaboration we can achieve a lot with relatively little. This is a *sine qua non* for southern Africa.

River systems are highly integrated systems, bringing together land and water in highly variable space and time. They are also critical components of private and common property assets. There needs to be much greater commitment to river system management. This is particularly so since the countries of southern Africa share so many rivers.

Two quotes eloquently convey the success of the KNPRRP:

"……the methodology has progressed substantially further than anything similar in Australia, particularly including recent ecological theory, scale theory, objective setting protocols (visions to operational), disciplinary integration and a complete and tested framework involving full stakeholder participation……"
Schofield (Australia)

"The Programme has advanced the approach to rivers research in South Africa."
O'Keeffe and Coetzee (South Africa)

RECOMMENDATIONS

The recommendations made here are of a broad and general nature. More specific recommendations are given in the Subprogramme reports.

(i) Generative learning and knowledge management.

Typically society has more knowledge and wisdom than it is organised to use. We generally do not use or generate knowledge efficiently. Worldwide this has been shown to reflect inadequate commitment to organisational culture and learning processes. It is simply not possible to cope with the uncertainty of the future unless we focus strongly on promoting a culture of generative learning. This requires us to manage knowledge more effectively. We must move beyond the simple linear process of acceptance of a proposal, 'Project Steering Committee' and 'Final Report', and even beyond 'cradle to grave' as this suggests management as being bounded in time. We require an iterative process of continuous learning through envisioning the future, auditing where we are and adapting strategies accordingly in a process of strategic adaptive project management.

South Africa and its neighbours cannot afford inefficient and ineffective learning and generation of knowledge.

We recommend a fundamental review of the manner in which we intend to generate learning and manage knowledge to improve efficiency and effectiveness.

(ii) Trans-disciplinary research programmes

Natural systems are inherently complex. This complexity is increased by the growing wish of stakeholders to participate in and influence the manner in which these systems are used. There is no alternative to trans-disciplinary research. We recommend that:

- the complexity of trans-disciplinary research must be acknowledged in design, implementation and management;

- much more emphasis must be given to organisational planning, problem and solution analysis, the preparation of research 'business plans' (not simply research proposals). This accords well with generally accepted stages of project development including prefeasibility and feasibility analysis;

- much more emphasis must be placed on process, particularly on participation, agreement on procedures and products and acknowledgement of responsibility for transfer and use of research products, and explicit management feedback to maintain adaptive and generative learning cycles;

- new procedures must be established which enable a logical sequence of steps (Box 12) in the design and solution of research Programmes to keep the process innovative and adaptive but not self- perpetuating;

- new procedures for appraisal and reward are required;

- research funders should promote organisational and generative learning in addition to the usually anticipated products and outcomes;

- funding agencies should provide support for researchers to receive training in programme and project management, communication and conflict management and partnership building.

Box 12 : Envisaged steps for designing, establishing and managing trans-disciplinary research programmes which, by definition, are strategic in nature.

(i) Continuous low-level analysis of trends and formulation of scenarios.
(ii) Identification of strategic needs.
(iii) Prefeasibility analysis
- Characterisation of needs
- Characterisation of probable solutions
- Synthesis in context of research theory and practice
- Identification of research needs
- Assessment

(iv) Feasibility analysis
- Research business plan
- Information and technology transfer plan
- Management plan
- Feasibility report
- Assessment

(v) Implementation
- Constitute management team and establish process
- Constitute research team
- Call for proposals
- Assessment and award
- Implement project monitor and audit
- Adapt as required
- Co-ordinate and synthesise
- Transfer information and technology

(vi) Review and evaluation

(iii) Installed modelling systems

The term modelling here refers to a structured process rather than the technology. Modelling is a means to an end – not an end in itself. It allows us to consistently envisage the future and apply strategic adaptive management.

The emphasis in water resource management has shifted from supply to allocation. This brings with it strong interest from stakeholders. Most of the user sectors are universally distributed. The implication is that these sectors will draw on scientific and other expertise to represent their interests

consistently across catchments. We envisage that they will use generic modelling systems customised for each catchment. There is compelling logic that these should be 'installed' so that all user groups use the same systems to analyse their needs and to evaluate the likely consequences of allocation scenarios.

These installed systems may be complex but user-friendly and suited to South African conditions. They should be able to model quantity and quality. They must be affordable.

We recommend that:

- the principle of installed modelling systems be evaluated at the national scale;
- if appropriate, criteria for installed systems should be established and a suitable system(s) should be selected;
- training should be provided in the use of the preferred modelling system(s).

(iv) Water Quality

Approaches to water quality management in South Africa have focused largely on achieving discharge standards and on monitoring river health. There has been little attempt to develop predictive capabilities for integrated water quality management in river systems (including estuaries). This is despite the use of models such as HSPF for water quality management in, for example, the catchments of Chesapeake Bay and Sydney Harbour. The need for integrated modelling of water quality will increase.

We recommend that:

- the principle of integrated water quality modelling be evaluated at a national scale;
- if appropriate, criteria for modelling systems be established and that a suitable model and/or suite of models should be selected;
- training should be provided in the use of the preferred modelling system.

(v) Data and information

Strategic adaptive management (SAM) is a process founded on the use and development of knowledge and wisdom. To achieve this it must envisage what data and information will be required in the future, and it must continuously interrogate the data and information to update the vision of probable future states.

The implication is that data and information collection should be structured to meet the requirements of the SAM process. The various modelling and knowledge management systems used to envisage trends and future states provide both direction for design of monitoring programmes, and the mechanisms for interrogating the data and information gathered. A more 'purposeful' approach to monitoring is required. In this way monitoring becomes a means to an explicit end.

We recommend that:

- river system monitoring should be reviewed and restructured to better service strategic adaptive management;
- the emphasis in monitoring be shifted from data gathering to generation of information and knowledge which is used to test hypotheses (TPCs);
- knowledge management systems should be established to service strategic adaptive management.

BUDGET AND ALLOCATIONS

The WRC was the principal funder of Phases II and III. It supported the core of the Programme.

Each participating institution contributed much in cash and kind; and agencies such as WRC, DWAF, DEAT and the NRF (FRD) funded individuals and projects external to the core grant. These are addressed in the individual project reports.

The WRC budget and allocation for Phases II and III are set out in the following tables. The allocations are conservative and each phase was equivalent to an average large project funded by the WRC.

KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME
PHASE II BUDGET (IN RANDS)

	1994 (R)		1995 (R)		1996 (R)	
	Requested Budget	**Allocated Budget**	**Requested Budget**	**Allocated Budget**	**Requested Budget**	**Allocated Budget**
Programme Management						
Managing Director	64 000	40 000	40 000	40 000	50 000	42 000
Subprogramme Managers						
Information Systems	31 500	20 000	33 000	20 000	36 000	21 000
Decision Support Systems	31 500	20 000	20 000	20 000	20 000	21 000
Research (Quantity)	36 500	32 000	34 000	20 000	38 000	21 000
Research (Quality)	36 500	35 000	38 000	20 000	41 000	21 000
Training, Information & Technology Transfer	20 000	20 000	20 000	20 000	20 000	20 000
TOTAL	**220 000**	**167 000**	**185 000**	**140 000**	**205 000**	**147 000**
Secretariat						
Remuneration & operating costs	96 000	68 000	74 000	72 000	94 100	74 100
Workshops						17 000
TOTAL	**96 000**	**68 000**	**74 000**	**72 000**	**94 100**	**91 000**
Projects						
Representative River Reaches: Prof Görgens	52 500	55 000				
Common currency for integration of results: Prof van Riet	120 000	59 000	25 000	44 500		
Integrated modelling system: Prof Görgens	90 000	78 000	90 000	93 000	90 000	90 000

	1994 (R)		1995 (R)		1996 (R)	
	Requested Budget	**Allocated Budget**	**Requested Budget**	**Allocated Budget**	**Requested Budget**	**Allocated Budget**
Information Management System: Dr Biggs	95 000	74 000	90 155	102 000	100 000	100 800
Hydrology and Hydraulics: Prof Rogers			79 000	62 000		
Desired State: Prof Rogers & Prof Görgens			100 000	150 000		
KNPRRP Status Report: Prof O'Keeffe			68 000	5 500		62 400
Collaborative proposal: BLINK					253 000	253 000
TOTAL	**357 500**	**266 000**	**452 155**	**457 000**	**443 000**	**506 200**
GRAND TOTAL	**673 500**	**501 000**	**711 155**	**669 000**	**742 100**	**744 200**

KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME
PHASE III BUDGET (IN RANDS)

		1997 (R)		1998 (R)		1999 (R)	
		Allocated Budget	**Requested Budget**	**Allocated Budget**	**Requested Budget**	**Allocated Budget**	**Requested Budget**
Managing Director ♣		48 000	48 000	50 800	53 000	55 900	58 000
Secretariat ♦		83 000	83 000	103 000	92 000	107 000	102 000
Subprogramme Managers ♣	IM&F	20 000	20 000	22 000	22 000	24 000	24 000
	IRM	20 000	20 000	22 000	22 000	24 000	24 000
	Research	20 000	40 000	22 000	44 000	24 000	48 000
	Monitoring	20 000	30 000	22 000	33 000	24 000	36 000
Kruger National Park Rivers Research Programme ♣	IM&F Dent (Meta data catalogue) Dent (Information Management System)	15 000	15 000	16 000	16000	46 900 75 000	46 900 75 000
	IRM Research proposal pending – Venter						100 000
	Research Rogers (Prediction of flow modification effects – Blinks extension) Rogers (Interaction methodologies) Schulze (Environmental reserve) Breen (Economic evaluation) O'Keeffe (Rule based modelling of fish) Rogers (Strategic Adaptive Management)	50 000 -- --	50 000 48 500 --	200 000 157 000	151 500 207 000	95 000 -- 170 000 210 000 98 600	95 000 -- 281 000 100 000 180 000
	Monitoring O'Keeffe (Classification System and	37 000	63 000	26 000			

		1997 (R)		1998 (R)		1999 (R)	
		Allocated Budget	**Requested Budget**	**Allocated Budget**	**Requested Budget**	**Allocated Budget**	**Requested Budget**
	Analysing trends) O'Keeffe (Classification System)					46 000	46 000
	Corrective Action ♠						
Total		**313 000**	**417 500**	**640 800**	**640 500**	**1 000 400**	**1 215 900**

♦ Budget allocated from WRC and FRD
♣ Budget allocated from WRC
♠ Budget allocated; no proposals submitted within available time

KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME
PHASE III REQUESTED RESEARCH BUDGET

		1997 (R)	1998 (R)	1999 (R)
		Phase III Original Requests	**Phase III Original Requests**	**Phase III Original Requests**
KNPRRP ♣	IM&F	80 000	88 000	97 000
	IRM	80 000	88 000	97 000
	Research	200 000	220 000	241 000
	Monitoring	140 000	154 000	170 000
	Corrective Action ♠	200 000	220 000	
Total		**700 000**	**770 000**	**605 000**

♣ Budget allocated from WRC
♠ Budget allocated; no proposals submitted within available time

KNPRRP: PROJECT DATABASE

Phase II

Title **A description of the Kruger National Park Rivers Research Programme (Second Phase)**

Researchers

Coresearcher

Funding

Start **Report**

Finish **Available from** Waterlit, WRC, (012) 330 0340

Publications/ Papers Breen, C.M., Quinn, N.W. and Deacon, A. (1994). A Description of the Kruger National Park Rivers Research Programme (Second Phase). Foundation for Research Development, Pretoria.

Title **Abiotic-biotic links in the Sabie River: The responses of riverine biota to changing hydrology and geomorphology (Blinks I)**

Researchers Görgens, A.H. M. Professor, University of Stellenbosch; Jewitt, G. P.W. Dr, University of Natal

Coresearcher

Funding Water Research Commission

Start January 1996 **Report** Final Report available

Finish December 1997 **Available from** WRC Librarian; (012) 330 0340

Publications/ Papers Jewitt, G.P.W., Heritage, G., Weeks, D., Mackenzie, J., Görgens, A.H.M., O'Keeffe, J. and Rogers, K.H. (1998) Modelling Abiotic-Biotic Links in the Sabie Rivers. Report to the KNPRRP and Water Research Commission. WRC Report 777/1/98. ISBN: 186 845 309X.

Title **An integrated modelling system for predicting for rivers of the Kruger National Park the impact, on their ecological functioning, of changes in water quantity and quality brought about by upstream development**

Researchers Görgens, A.H. M. Professor, University of Stellenbosch; Jewitt, G. P.W. Dr, University of Natal

Coresearcher

Funding Water Research Commission

Start April 1994 **Report** Final report available

Finish December 1996 **Available from** WRC Librarian; (012) 330 0340

Publications/ Papers Jewitt, G.P.W. and Görgens, A.H.M. (in prep). An Integrated Modelling System for the Rivers of the Kruger National Park. Water Research Commission, Pretoria. WRC Report 627/1/00 ISBN 186 845 598X.

Jewitt, G.P.W. (1998) Resolution of Scale Issues in an Integrated Modelling System for the Rivers of the Kruger National Park. Unpubl. PhD dissertation. Department of Civil Engineering, University of Stellenbosch.

Invited paper: Jewitt, G.P.W. and Görgens, A.H.M. (1995) An integrated Catchment Management System for Rivers of the Kruger National Park, South Africa In: Proceedings of MODSIM '95 Conference, Dec. 3-5, 1995. University of Newcastle, Newcastle, Australia.

Jewitt, G.P.W., Görgens, A.H.M., Horn, M., Dent, M.C. and Dutlow, R.M. (1998) Integrated catchment management and integrated decision support tools: A South African example. In: Proceedings of WISA98. May 3-7, 1998, Water Institute of South Africa, Cape Town, RSA.

Jewitt, G.P.W., Horn, M., Dent, M.C. and Görgens, A.H.M. (1997) An integrated Catchment Management System (ICIS) for southern African rivers. In: Proceedings of the Eighth South African National Hydrological Symposium. Nov. 17-19, 1997, Water Research Commission, Pretoria, RSA.

Jewitt, G.P.W. and Görgens, A.H.M, 1995. An Integrated Catchment Management System for Rivers of the Kruger National Park In: Proceedings of the Seventh South African National

Title **Designing, developing and implementing an information management system for the Kruger National Park Rivers Research Programme**

Researchers Biggs, H. Dr, Kruger National Park; Coetzee, Y. Mrs, Kruger National Park
Coresearcher
Funding Water Research Commission
Start January 1994 **Report** Available on World Wide Web site http://ccwr/ac/za
Finish ongoing **Available from**
Publications/ Papers Biggs, H., Freitag, S., Uys, M., van der Merwe, M., Coetzee, Y. and Lefothlha, W. (1995). Data Catalogue (with interactive digital version). Kruger National Park Rivers Research Programme. Foundation for Research Development, Pretoria. Also on World Wide Web Site http://www.ccwr.ac.za. WRC Report 655.883/1-5/00. ISBN: 186 845 567X

Title **Development of a water quality and quantity modelling system which will provide a common currency for communication between researchers in the Kruger National Park Rivers Research Programme**

Researchers Van Riet, W. Professor, University of Pretoria; Dent, M.C. Dr, University of Natal
Coresearcher
Funding Water Research Commission
Start April 1994 **Report** Final report available
Finish March 1995 **Available from** WRC Librarian; (012) 330 0340
Publications/ Papers Van Rensburg, J.D.J. and Dent, M.C. (1997) Development of a water quality and modelling system which will provide a common currency for communication between researchers in the KNPRRP. WRC Report 654/1/97. ISBN 186 845 214X.

Title **KNPRRP: A Situation Statement and Management Assessment**

Researchers Görgens, A.H. M. Professor, University of Stellenbosch; Lee, J. Dr, Ninham Shand Consulting Engineers
Coresearcher
Funding Water Research Commission
Start 1992 **Report** Final report available
Finish **Available from** WRC Librarian; (012) 330 0340
Publications/ Papers Görgens, A.H. and Lee, J. (1992) KNPRRP: A situation statement and management assessment. Unpublished Report. Water Research Commission, Pretoria.

Title **KNPRRP: Annual Report 1993**

Researchers **Breen, C.M., Biggs, H., Dent, M.C., Görgens, A.H.M., O'Keeffe, J. and Rogers, K.H.**

Coresearcher
Funding **Water Research Commission**
Start 1993 **Report**
Finish 1993 **Available from** Waterlit, WRC, (012) 330 0340
Publications/ Papers

Title **KNPRRP: Annual Report 1994**

Researchers **Breen, C.M., Biggs, H., Dent, M.C., Görgens, A.H.M., O'Keeffe, J. and Rogers, K.H.**

Coresearcher

Funding

Start 1994 **Report**

Finish 1994 **Available from** Waterlit, WRC, (012) 330 0340

Publications/ Papers

Title **KNPRRP: Annual Report 1995**

Researchers **Breen, C.M., Biggs, H., Dent, M.C., Görgens, A.H.M., O'Keeffe, J. and Rogers, K.H.**

Coresearcher

Funding

Start 1995 **Report**

Finish 1995 **Available from** Waterlit, WRC, (012) 330 0340

Publications/ Papers

Title **KNPRRP: Phase II (1994-1996) Final Contract Report**

Researchers **Breen, C.M., Biggs, H., Dent, M.C., Görgens, A.H.M., O'Keeffe, J. and Rogers, K.H.**

Coresearcher

Funding

Start 1996 **Report**

Finish 1996 **Available from** Waterlit, WRC, (012) 330 0340

Publications/ Papers

Title **Status report on the Kruger National Park Rivers Research Programme: a synthesis of results and assessment of progress**

Researchers O'Keeffe, J.H. Professor, Rhodes University; Coetzee, Y. Mrs, Kruger National Park

Coresearcher

Funding Water Research Commission

Start January 1995 **Report** Final report available

Finish December 1995 **Available from** WRC Librarian; (012) 330 0340

Publications/ Papers O'Keeffe, J.H. and Coetzee, Y. (1996). Status report on the Kruger National Park Rivers Research Programme: a synthesis of results and assessment of progress to January 1996. Pretoria: Water Research Commission. WRC Report 711/1/96. ISBN 1 86845 242 5.

Title **The definition and characteristics of representative river reaches for river management**

Researchers Rogers, K.H. Professor, University of the Witwatersrand; James, C. Professor, University of the Witwatersrand

Coresearcher Heritage, G. Dr (Univ. of the Witwatersrand)

Funding Water Research Commission

Start 1995 **Report** Final Report available

Finish 1997 **Available from** WRC Librarian; (012) 330 0340

Publications/ Papers Heritage, G.L, Broadhurst, L.J., van Niekerk, A.W., Rogers, K.H. and Moon, B.P. (1999). The Definition and Characteristics of Representative Reaches for River Management. Water

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Researchers Rogers, K.H. Professor, University of the Witwatersrand; Bestbier, R. Ms, University of the Witwatersrand

Coresearcher

Funding Department of Environmental Affairs & Tourism

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Coresearcher Heritage, G. Dr (Univ. of the Witwatersrand); Van Niekerk, A. Mr (Univ. of the Witwatersrand)

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University of Natal

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University of Natal

Hassan, R. Dr
University of Natal

Coresearcher

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Researchers Dent, M.C. Dr
University of Natal

Coetzee, Y. Mrs
Kruger National Park

Coresearcher

Funding Water Research Commission

Start January 1999 **Report** Progress reports available (WRC Project K5/1096)

Finish December 1999 **Available from** WRC Librarian; (012) 330 0340

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Researchers **Breen, C.M., Dent, M.C., O'Keeffe, J., Rogers, K.H. and Venter, F.**

Coresearcher

Funding **Water Research Commission**

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Researchers

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Researchers Rogers, K.H. Prof
University of the Witwatersrand

Birkhead, A. Mr
University of the Witwatersrand

Coresearcher

Funding Water Research Commission

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Title **Rule based modelling of fish: facilitating Strategic Adaptive Management of the KNP rivers through model development and technology transfer**

Researchers O'Keeffe, J.H. Professor & Weeks, D. Mr — Rhodes University; Jewitt, G. Dr — University of Natal
Coresearcher Biggs, H. Dr; Heritage, G. Dr
Funding Water Research Commission
Start July 1999 **Report** Progress reports available (WRC Project K5/1065)
Finish June 2002 **Available from** WRC Librarian; (012) 330 0340
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Title **The development of a classification system for rivers of the KNP, and a model for analysing trends in the conditions of these rivers**

Researchers O'Keeffe, J.H. Professor — Rhodes University; Rogers, K.H. Professor & Bestbier, R. Ms — University of the Witwatersrand
Coresearcher Scherman, P. Dr; Palmer, R. Dr
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Researchers Weeks, D.C. Mr — Rhodes University; Jewitt, G. P.W Dr — University of Natal; Heritage, G. L. Dr — University of Salford, UK
Coresearcher
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SUBPROGRAMME REPORTS

INFORMATION MANAGEMENT AND FACILITATION SUBPROGRAMME

M.C. Dent and J. Maganbeharie

Table of Contents

1. Executive Summary

Several products and outcomes (listed below) have been achieved by the Information Management and Facilitation (IM&F) Subprogramme.

Products

- A strategic **plan**, software and network capability for information generation and management by researchers, managers, stakeholders and decision makers during and after Phase III.

- A maintained and enhanced Information Generation and Management **System** which incorporates links between several modelling systems (e.g. fish, riparian vegetation, geomorphology, hydrology, instream water quality, catchment river network management, groundwater) and to information management systems such as WATERLIT.

- A strategy and action **plan** for facilitation of KNPRRP Subprogramme and stakeholder interaction, communication and marketing.

Outcomes

- A cost-effective **testing ground** for the Integrated River Management (IRM) Subprogramme & alignment was developed with organisations who could assist. Part of this process involved the development of the electronic network capability of the researchers and stakeholders.

- An integrated river management system which **serves the process** of strategic adaptive management (SAM) and also the concept of generative leadership.

- Implementation of a facilitation, communication and marketing **strategy** to assist the social process of water allocation, which is central to river management.

2. Stakeholders, Managers and Decision Makers

Who are "the Stakeholders" and how do they relate to "the Managers" and "the Decision Makers"?

The term "Stakeholders" is used frequently in all the documents and discussions involving the KNPRRP and indeed in all documents relating to the implementation of the New Water Law. If one looks at the KNPRRP management diagram (which has been a key to the success of the KNPRRP), the terms "stakeholders", "managers" and "decision makers" are in the centre of that diagram. (From now on we shall just use stakeholders but imply "managers" and "decision makers" as well).

It is important not to gloss over the question, "Just who ARE these stakeholders?". Within the body of the KNPRRP formed by the Managing Director, Subprogramme managers and the PDMC members there are differing ideas on who these stakeholders are and how they will interact with the KNPRRP's **products** and **outcomes.** Each is partially correct. The fact that we do not share a coherent vision on who the stakeholders are and how they are likely to interact is a symptom of a deeper underlying cause. It is likely that the cause is that we do not share a collective vision on how

the “stakeholders/managers/decision makers” in the CMAs will engage the complexity of the issues which they will face.

What is the context in which Stakeholders will operate?

One of the significant effects of the rising value of water has been a redistribution of intellectual power in the water science field. Twenty-five years ago most of the water resources science and management intellect resided in state departments. Such an intellectual power setting was adequate to cope with the “get more water” and the “use water more efficiently” eras. Today a significant intellect resides with stakeholder groupings who are in contention for water resources. This shift in the balance of intellectual power holds important strategic implications for the development and use of integrated water resources modelling systems which are used in the prediction phase of the social process of water allocation. The KNPRRP management diagram indicates this prediction phase clearly and it has been one of the cornerstones of our scientific focus in the programme. The above paragraph introduces/raises the first paradox. Is DWAF a stakeholder OR is it “above” the stakeholders and therefore responsible for ensuring fair play between the stakeholders? We believe the answer is both yes and no! This is paradoxical and confusing for communication unless the paradox is specifically acknowledged.

There are enormously powerful business forces driving the move to the “allocation era”. These are well described, *inter alia*, in the KNPRRP Phase III Description (Breen *et al.*, 1997). The responses by organisations to these forces have in turn created secondary forces. It is necessary to look at the changes induced by these forces to get a better picture of the stakeholders, who they are and how they are likely to behave in the negotiations over water allocation. Only then will we begin to know what sort of scientific input the stakeholders will require and hence who they are likely to be and what scientific products and processes they can master. The real target market for the products and processes of the KNPRRP will then emerge.

In South Africa the water law has been changed in recognition of the above forces and the law itself has thus become an important secondary driving force on the water resources modelling industry. South African Water Law makes provision for the state to share the responsibility for managing water resources with Catchment Management Agencies (CMAs). The exact nature of representation on CMAs, as well as their structure, functions and responsibilities has not yet been finalised. The latter are not strategically significant for water and river resources modelling (or in other words predictive capability). One of the key focii of the KNPRRP has been to develop appropriate predictive capability. The terms modelling and predictive capability will be used synonymously and interchangeably in this report.

What is highly significant for the modelling industry is the manner in which these CMAs will be informed on the science and systems of the water which they will be managing in co-operation with the state. The forces on and responses by these intellectual groupings are going to be vital in determining the strategic direction of water resources modelling in southern Africa.

It is important to pause for a moment to consider these forces and likely responses by the top level scientific consultant groups which will inevitably emerge to advise various stakeholder groupings. It is here that the scientific, computer, business and social science worlds will integrate to form the new paradigms.

It is inevitable that industries such as forestry, sugar, irrigation, mining and conservation, to name a few, will channel their efforts through top class cadres of water science consultants who will specialise in the interests of their members. This will immediately create ties which cut across catchment boundaries as many of these industries span large geographic areas. They will create enormous *de facto* forces for inter-operability standards within and between industries on water modelling issues. They will greatly elevate the level of intellectual input into water allocation decisions as only the best in each disciplinary area will suffice. The above hold major strategic implications for water and river resources modelling (prediction).

It is important to be pro-active and forthright in conveying this vision since it will:

- concentrate people's minds on the question of who can intellectually and institutionally utilise the products and outcomes of the predictive capability that the KNPRRP has adopted or developed;

- show why it is necessary for each industry (stakeholder grouping) to develop a top class cadre of scientific consultants who can span both their own industry and also develop the inter-operability standards to interact meaningfully with other industry stakeholders;

- show why the generic components of the products and outcomes of the KNPRRP are so very important to scientific consultants and stakeholders in the rest of southern Africa.

In short, an appropriate cognition with regard to stakeholders is vital to the success of the KNPRRP's technology and process transfer efforts.

3. Overview

It is necessary to re-emphasise that the strategy being pursued, by the KNPRRP in general and the IM&F in particular, pre-supposes that the Sabie River is NOT the only river of concern to the many organisations involved. This means that these organisations would be seeking products, processes, technologies and strategies which could also be applied to many other rivers in southern Africa for which they have some aspect of responsibility. This explains why the IM&F Subprogramme activities have ranged far beyond the borders of the Sabie River. This also forms a useful bridge between the current KNPRRP Phase III activities and future National Rivers Initiative activities.

3.1 Software linking

3.1.1 South African systems

The following systems were linked into the ICIS shell which included linking the time series to the Water Resources Division US Geological Survey's watershed data management system (WDM) and the ARCVIEW GIS package: -

* *Breonadia* Model,
* Geomorpology Model,
* Fish Model,
* Sediment Flow Model
* ACRU System output,
* WISH System (Geohydrology),

3.1.2 International systems

Several international systems were also linked in the ICIS concept. These were the Hydrological Simulation Program Fortran (HSPF), the generalised scenario generator and information display shell (GenScn), the better assessment science integrating point and non-point sources (BASINS2.0), all from the USGS and the US EPA.

3.2 Networking initiatives with Stakeholders within the KNP rivers System

3.2.1 Forums

Presented strategies, software systems and processes to the Sabie River Working Group and the Waterval Forum (part of Olifants River Forum) and also worked more closely (short courses and follow-up interaction) over a longer period with some key stakeholders in each. This also included work with the DWAF.

3.2.2 National Rivers Initiative

The Policy Committee of the KNPRRP pursued the strategy of preparing to extend the lessons learned in the KNPRRP to other systems in South Africa through the National Rivers Initiative. The IM&F was deeply involved in implementing a conference and workshop in June 1998 and convening a working group which was active for the last 6 months of 1998 to pursue this initiative to the stage of a plan which was tabled to and accepted by the Policy Committee early in 1999.

3.2.3 International Contact

The IM&F Subprogramme, with the help of the Computing Centre for Water Research, has actively engaged our downstream neighbours Mozambique through courses and a follow-up joint effort with the CCWR. This contact was in line with

the urging of Minister Asmal, near the end of Phase II, when he referred to the KNP rivers as our eastern international rivers and said that, instead of looking upstream in anger, we should look downstream in humility.

The IM&F Subprogramme Manager represented the KNPRRP at the Second International Rivers Festival in Brisbane, Australia in 1999 and presented an overview paper on the KNPRRP, authored jointly by the Managing Director and the Subprogramme managers (Dent *et al.,* 1999).

3.2.4 Integrated Management of River Ecosystems Conference & Course

The IM&F Subprogramme organised the Integrated Management of River Ecosystem Conference and Course held in August 1999. It achieved some measure of success in attracting delegates from Mozambique, Zimbabwe and Malawi.

3.2.5 International Shared Rivers Initiatives

Specific actions by the IM&F Subprogramme were to assist in an approach to the USAID to develop a southern African Research Programme involving primarily SA, Swaziland and Mozambique, and a similar proposal to the Swedish International Development Agency (SIDA). These proposals involved at least 6 South African research groups and a number of groups from Swaziland and Mozambique. The IM&F Subprogramme worked very closely with the KNPRRP's Managing Director in both of these efforts.

3.2.6 Historically Disadvantaged Universities

Dr Dent accepted an invitation from the WRC to serve on the University of Zululand's WRC-funded project which aims to create a management decision support system for the Mhlatuze catchment. They are incorporating much of the experience and modelling systems as well as ICIS, GenScn & BASINS2 which have been passed on by the IM&F Subprogramme from the KNPRRP and with the assistance of the CCWR.

Through his involvement with the KNPRRP, Dr Dent was invited to take part in an FRD (now NRF) sponsored workshop at the University of Venda to develop an integrated water/environment related programme which the FRD would support. The process of evaluating and refining the proposal is still ongoing between the NRF and the University of Venda. The IM&F Subprogramme through the person of Dr Dent is still deeply involved.

3.2.7 Facilitation for Integrated Water Resources Systems at DWAF

Through experiences and involvement with the KNPRRP Dr Dent was invited to facilitate a seven-day process stretched over four months to develop a Strategy proposal for the Chief Directorate Scientific Services in the Department of Water Affairs and Forestry. The aim of the strategy was to enable Scientific Services to fulfil its responsibility to deliver water resources information to the public of South Africa.

The facilitation process was successful and a proposal containing many of the lessons learned in the KNPRRP was accepted by the directors within Scientific Services, DWAF. The workshop was conducted at Director and Deputy Director level.

3.2.8 Water Resources Management Forums beyond the KNP Rivers

The strategic view of the major sponsors of the KNPRRP was that the Sabie project was a *de facto* pilot project with the main aim being to transfer the lessons of the KNPRRP beyond the KNP to serve southern Africa. The NRI and the International Shared Rivers initiative which the KNPRRP supported is indicative of this. The IM&F played its part in addition to the items reported above by engaging the four forums that make up the Mooi River Forum (Gauteng), the Eastern Cape, DWAF through the University of Zululand/WRC initiative, and the emerging Mhlatuze Forum, and Umgeni Water.

4. Specific Objectives and Tasks

Introduction

The sequence of objectives and tasks as set out in the Phase III Programme Description (Breen, *et al.*, 1997), is followed in order to facilitate auditory control of this Subprogramme.

Before detailing the progress on each of the tasks it is deemed necessary to comment briefly on the purpose and power of the Information Management & Facilitation (IM&F) Subprogramme.

Purpose

The purpose of the Information Management & Facilitation (IM&F) Subprogramme is to ensure that the information and understanding acquired and technology developed within the Programme is shared effectively within the programme and with resource managers, researchers and stakeholders in the catchments.

There was a reciprocal obligation on the other Subprogrammes in the KNPRRP to feed the IM&F with relevant information and to interact with it.

To fulfil this purpose the IM&F Subprogramme has four main objectives detailed below.

However, before detailing the progress which follows for each objective it needs to be stressed that the iterative and continuous nature of this work meant that these objectives and tasks were carried out simultaneously, each informing and in turn being informed by the other. It is also in the nature of the KNPRRP, as a whole, that in order to develop a process which was affordable and sustainable, the tasks had to be aligned to a large degree to other commissioned work of the Subprogramme managers, e.g. the SANP Integrated River Management work of Dr Venter; National River Health Programme work of Professor O'Keeffe; research work of Professor Rogers, which is funded by other sources; and the mission and work of the Computing Centre for Water Research (CCWR).

Furthermore, it was important to note that the KNPRRP, and therefore also the IM&F Subprogramme of the KNPRRP did not have the reward or coercive power to force stakeholders to interact with the programme or with each other. The required "force" had to come from a series of factors which were external to the KNPRRP and which are totally beyond its control. The challenge to the KNPRRP was to utilise the technologies and processes which it had developed to influence the stakeholders to follow the route of science, interaction, analysis, reason, dialogue and consensus. The IM&F made every endeavour to influence stakeholders to follow this path which we believe is wise. However, at the end of the day, if the stakeholders and researchers were not ready to interact or unwilling to interact, the IM&F Subprogramme was not able to play a role.

The new water law came into effect on 1 October 1999. There will soon be legally constituted CMAs with whom to interact and they in turn will be looking for products and processes to assist them in their complex and integrated tasks. The driving forces in the business environment of which the KNPRRP has been aware, for the past 10 years, will this year become widely apparent to many more river stakeholders.

Objective 1

- Develop a strategic plan for information management for the duration of Phase III.

Task 1.1

- Develop a cost-effective testing ground for the Integrated River Management (IRM) Subprogramme.

Report for Task 1.1

One of the key aspects that water resources stakeholders will be required to decide on is the expected consequences of current and future actions. Prediction through simulation modelling is one of the major strategic actions chosen by the KNPRRP to fulfil this need. To accomplish this task it was planned to work closely with the various modelling efforts which are funded by KNPRRP and associated projects, e.g. hydrological modelling and the delivery of IFR requirements project (School of Bioresources Engineering & Environmental Hydrology (BEEH), University of Natal); Riparian

vegetation modelling project (Centre for Water in the Environment (CWE), Wits); Fish modelling extension (Institute for Water Research (IWR), Rhodes University and Umgeni Water). The objective of working closely with these projects was to assist in linking their efforts into the ICIS and thereby to make them more accessible to the stakeholders. The above names and projects will not be repeated in all the progress listed below, however, close liaison with them was sought in many of the actions.

The Rogers and Bestbier (1997) report on "Development of a protocol for the definition of the desired state of the riverine systems in South Africa" has been translated into hyper text format, by the IM&F Subprogramme and included in the Sabie River integrated catchment information system (ICIS).

The IM&F Subprogramme Manager served on the WRC Steering Committee for the Riparian Vegetation Modelling project and arranged for the CCWR staff to be available to assist with any computer architectural or programming requirements to link the considerable conceptual progress in this project to the KNPRRP's ICIS system. The Riparian Vegetation Modelling Project (CWE, Wits) co-operated with the IM&F Subprogramme in the spirit of an integrated programme and has produced excellent concepts and software as reported by Mackenzie, *et al.*, (1999).

Version 1 of the fish modelling system is linked into the Sabie River ICIS. The IM&F Subprogramme contributed to a workshop on the future of the fish modelling project (commonly referred to within the KNPRRP as biotic-abiotic linking project BLINKS).

Every effort has been made to stay close to developments in the hydrological modelling for the delivery of an environmental reserve project undertaken by the School of Bioresources Engineering & Environmental Hydrology, University of Natal. The latter have maintained a strong independent stance in their interpretation and conduct of their project and will be reporting directly to their Steering Committee constituted by the WRC.

Task 1.2

- Develop alignment with organisations who can assist.

Report for Task 1.2

Many of the interactions have not yet borne tangible fruit. This is regretted. However, it is in the nature of relationships that they take time to form in integrated work.

The alignment between the aims of this Subprogramme of the KNPRRP and those of the CCWR (both groups funded by the WRC) was critical to the success of this Subprogramme. The above two WRC initiatives were fortunately well aligned. One of the CCWR's prime functions is also to seek and develop alignment between the software systems which are being used by organisations to perform various scientific aspects of river analysis for management purposes. A central theme of all the work is to seek and develop alignment between all potential contributors to the process.

Department of Zoology, UCT

The water quality component of the environmental flow has not been neglected. Good interaction has been fostered between the researcher (Mrs H Malan) on a WRC-funded project at the University of Cape Town and the Project Leader, Dr J. Day and Dr A Bath of Ninham Shand (now emigrated). Mrs Malan attended the seminar in Stellenbosch given by Prof Johanson, at which the ICIS was also represented. Dr Dent and others from the CCWR have been in constant communication with Mrs Malan both before and after the HSPF seminar. The ACRU system does not have any instream water quality capability and therefore this was a major reason to develop the synergy with HSPF software.

Groundwater Studies, University of the Free State

A most productive meeting was held with Professor F. Hodgson and his colleague, Mr E. Lukas at the Institute for Groundwater Studies, UOFS, in January 1997. They had completed a WRC-funded project on groundwater GIS and graphical analysis software development (WISH). This software is a successor to the popular HYDROCOM package which is used extensively in the mining and groundwater industry. The meeting yielded an exchange of the software which we already have working on each other's computers and also an agreement to develop interoperability between the two packages, in addition to a clear agreement as to the route to follow to develop such interoperability. This development will be of great significance in the Olifants River Forum and hence the desired alignment is being achieved.

Waterval Forum

Further preliminary “alignment work” has been done through a presentation to the Waterval Forum (upper Olifants River near Secunda). The processes and technology developed in the KNPRRP were presented to this forum. They resolved to continue our discussions and to begin to use some of the technology developed within the KNPRRP. The Waterval Forum which covers part of the Vaal Catchment and part of the upper Olifants River has representation from SASOL, Evander Goldmine, organised agriculture, the local irrigation board, DWAF, Rand Water and local communities. They already have strong links with the Institute for Groundwater Studies (IGS) and were therefore particularly pleased to see the ICIS / WISH link developing. Two members of SASOL attended the one-day seminar on HSPF and ICIS at the WRC during the visit of Professor RC Johanson. Two members from SASOL attended the Integrated Management of River Ecosystems Conference and Course in the KNP, 10-13 August 1999.

SASOL, Secunda and AMCOAL, Anglo-American Corporation

Six members from AMCOAL (Witbank and Head Office) attended a one day seminar on ICIS and HSPF in 1997. On two occasions five members from SASOL attended one-day workshop/training courses at the CCWR on ICIS and HSPF and they have now been introduced to the GenScn and BASINS2.0 software.

Institute for Water Research, Rhodes University

A visit to the research groups of Professor Hughes and Professor O'Keeffe at the IWR, Rhodes University on 12 June 1997, coincided with a presentation to approximately 17 senior officials of the DWAF, Eastern Cape, in King William's Town. This presentation followed an invitation from the DWAF, Eastern Cape. The ICIS developed primarily within the KNPRRP was the focal point of the discussions which centred on software and processes to support future CMAs.

Hydrology Department, University of Zululand

Dr Dent accepted an invitation from the WRC to serve on the University of Zululand's WRC-funded project which aims to create a management decision support system for the Mhlatuze catchment. They have incorporated much of the experience gained by the IM&F and the CCWR during the KNPRRP. The HSPF and ICIS systems are central features in this installed system. A total of five days of intensive training has been given and they are in daily contact with the CCWR for advice. This followed ongoing discussions over several years and the attendance by Professor Kelbe at a one-day course given by the late Professor Johanson (senior author of HSPF).

Statistics Department, UCT

An interesting development has been the link to the Save the Sand feasibility study mentioned in the progress statement for Task 4.3 and other tasks. One of the components of the latter project is the work and current involvement of Professor T. Stewart, UCT, who is applying some of the multi-criteria decision support tools and processes which he developed on an earlier WRC-funded project. The IM&F Subprogramme facilitated a link between Ms A. Joubert of Professor Stewart's team and Professor Schulze's team who worked on hydrological scenarios for different land use options in the Sand River Catchment.

School of Bioresources Engineering & Environmental Hydrology (BEEH), University of Natal

A closer working relationship between the ACRU (Agricultural Catchments Research Unit modelling system, BEEH, University of Natal) and HSPF (Hydrological Simulation Programme Fortran of the US Environmental Protection Agency and the Water Resources Division of the US Geological Survey) was sought. The potential of this synergy was enormous.

Task 1.3

- Develop the electronic network ability of the researchers and stakeholders.

Report for Task 1.3

In view of the discussion in Section 2 on Stakeholders, Managers and Decision Makers and in view of the need for future expansion out of the KNP, such networking extended beyond the Sabie River. This did not involve installing hardware but did involve offering technical advice and training

wherever needed. This initially required travel to stakeholder's sites. However, one of the prime reasons for wishing to develop such a network is to reduce the travel costs in future. The networking and associated software will only replace much of the travelling if it is affordable, inclusive, inter-operable with existing software systems investment and relatively easy, cheap and fast to develop. These criteria were followed at all times.

Save the Sand

A day and a half training session on ICIS and networking was held in Skukuza at the end of November 1997. This involved three researchers from the SANP in Skukuza and Ms Pollard who is working on the Save the Sand project mentioned above. The latter project has extensive connections with developing communities and it was therefore considered to be important in terms of networking. Further training was given during a working visit to Skukuza by Dr Dent and Mr Nundlall (CCWR) in March 1998.

Developing Communities

Through alignment between the CCWR and KNPRRP endeavours the IM&F was involved at the periphery of the International Development Research Centre (IDRC) funded project undertaken by the Institute of Natural Resources (INR) in the Msunduzi catchment. This project involved networking with developing communities. The aim of our involvement in this project was to gain experience with the technical and organisational issues involved in such networking.

SA National Parks (SANP), Phalaborwa

Development of such communication networks in the Sabie for the KNPRRP has been slow due to the limited networking capability (in some areas) of the institutions involved. The delay in the SANP link to Phalaborwa has been particularly unfortunate.

Mrs Coetzee (Skukuza) was trained on the ICIS system and has introduced researchers in the SANP to the software. She was involved in a KNPRRP funded sub-project of the IM&F to extend this work.

The IM&F has also been involved to a lesser degree with the SA Sugar Association, the Forestry industry through the Institute for Commercial Forestry Research and Mondi, the CSIR, Swaziland University and various organisations in Mozambique in particular the University Eduardo Mondlane. Some of these networking activities are reported elsewhere in this report.

Task 1.4

- Establish strategies and methods for updating data sets in the current, medium and long term e.g. those of the Monitoring Subprogramme.

Report for Task 1.4

The IM&F Subprogramme was continually open and available to receive these data and to store and present them in appropriate forms. This was one of the many tasks which was going to require the reciprocal co-operation particularly of the Monitoring Subprogramme. The other Subprogrammes also had reciprocal tasks of this nature built into their objectives and tasks. Without this reciprocity the IM&F could not be effective in this sphere. In the medium and long term it was envisaged that this updating will be the task of the Catchment Management Agencies (CMAs) and hence the urgency for engaging the top level scientific advisors of stakeholders in the Sabie River Catchment in 1999.

The ICIS system was installed at the SANP Scientific Services offices at Skukuza and at the Institute for Water Research at Rhodes University. It is therefore available to receive the data from the Monitoring Subprogramme. Two sets of telephonic discussions were held with Mr D. Hohls, Environmentek, CSIR who had been commissioned by the IWQS, DWAF to write a graphical user interface for the bio-monitoring data sets, and he agreed to liaise closely with the IM&F Subprogramme of the KNPRRP. It was envisaged that because of the progress on the TPCs it would then be possible to compare the TPCs with the monitored and the model predicted values in those cases where modelling and/or monitoring was carried out. Due to complex issues within the River Health Programme and the DWAF, the database release was too late for the KNPRRP.

A member of Dr Venter's Integrated River Management (IRM) team, Mr Jacque Venter (SANP, Phalaborwa) undertook several working sessions with Mrs Kruger of Dr Bigg's department (SANP) to learn about the ICIS system. During 1998 the SANP (KNP) made the appointment of a resource manager, Dr S Freitag (SANP, Skukuza), who has partial responsibility for rivers.

Task 1.5

- Identify the means and process for incorporating new information, understanding and decision support capabilities which will be developed in the Research and Monitoring Subprogrammes during Phase III of the programme.

Report for Task 1.5

The ICIS and the philosophy and process which drives its development, was the primary means and process chosen to achieve this task. The ICIS concept focuses primarily on developing inter-operability between components of the overall software systems being developed within the KNPRRP and elsewhere. As such the IM&F Subprogramme was one of a number of organisational role players who are continually seeking to develop interoperable links between existing and proposed software developments. The overall ICIS architecture strove to minimise restrictions on flexibility and to maximise the opportunities for creativity, and as such was a key component of the work plan. This process of developing linkages in a creative manner could only be founded on a growing base of common understanding which in turn will contribute in a practical fashion to decision making.

Task 1.6

- Identify the manner in which the Information Management System will be reviewed in response to the achievements of the Programme, the needs of researchers and stakeholders and the availability of resources.

Report for Task 1.6

There are a number of indicators by which the IM&F Subprogramme and its main technology concept, the ICIS, may be reviewed.

These are:

- the number of sub-systems which interoperate to form the ICIS. At present there are the:
  - meta-database (KNPRRP)
  - fish model & associated graphics & hypertext links (KNPRRP)
  - riparian vegetation model (KNPRRP)
  - geomorphology model (KNPRRP)
  - Sediment Flow Model (SEDFLOW)
  - links to HSPF model output
  - links to ACRU model output
  - numerous GIS coverages
  - Ninham Shand Inc. plotting routines
  - spatially linked picture catalogue interrogation
  - range of time series plots including spatial animation on a map of the catchment
  - multi-media capability
- GenScn
- BASINS 2
- WISH
- the number of sites which are equipped with the ICIS and which are networked to each other
- the levels of use of the ICIS within the KNPRRP and in other organisations who formed part of the outreach programmes of the KNPRRP (e.g. University of Zululand, Mhlatuze and soon possibly, the University of Venda).

Task 1.7

- Present strategy, review and finalise.

Report for Task 1.7

The strategy was presented in the Tasks discussed in this report. It was reviewed continuously as progress evolved. It is acknowledged that certain aspects of the strategy could have progressed better. These are mentioned at various points in the report.

It is necessary to re-emphasise that the strategy being pursued presupposes that the Sabie River is not the only river of concern to the many organisations involved. This means that these organisations would be seeking products, processes, technologies and strategies which could also be applied to many other rivers in southern Africa, for which they have some aspect of responsibility. This explains why the IM&F Subprogramme activities have ranged far beyond the borders of the Sabie River in the period under review. This also forms a useful bridge between the current KNPRRP Phase III activities and future National Rivers Initiative activities.

Objective 2

- Maintain and enhance the Information Management System.

Task 2.1

- Develop links with other information management systems such as WATERLIT, and the Department of Water Affairs and Forestry's GIS, WATERMARQUE, and National River Health Programme systems.

Report for Task 2.1

The good working relationship with WATERLIT continued and appropriate information was transferred to that system. The meta data base developed in Phase II and completed in Phase III, has been placed now on the KNPRRP web site and searches can be done by anyone on the Internet using their web browser. The WATERLIT database is now accessible on-line through the Internet and certain appropriate information sets from the KNPRRP have been placed in the WATERLIT database.

Discussions with the Institute for Water Quality Studies with regard to closer interoperability between ICIS and the DWAF's WATERMARQUE and particularly the ARCVIEW version of WATERMARQUE were in progress. Similar approaches were made to the software developers within the National River Health Programme, as reported under Task 1.4. Neither of these efforts yielded progress.

It is postulated that the perceived "distance" between the KNPRRP and DWAF approaches at present reflect their different roles and responsibilities, and also their differing views on the role and functioning of integrated river management and CMAs in the future.

A successful presentation was given at the DWAF by KNPRRP Managing Director, Professor Breen and Dr Dent. The presentation was attended by 35 people drawn from Data Management;

Engineering Services; Information Services; Water Resources Studies; Geomatics-GIS Data Management; Data Quality.

Task 2.2

- Maintain and enhance the ICIS system to accommodate the needs of researchers and stakeholders.

Report for Task 2.2

Mention has been made on several of the above tasks of enhancements to the ICIS system and the promotion and training on this system for stakeholders and researchers in the Sabie, Olifants, and Mooi Rivers (Gauteng and North West Province), Mhlatuze River, Eastern and Western Cape, Umgeni and Umkomaas rivers.

The IM&F Subprogramme was expecting to become much more involved in the data management and graphical user interface aspects of the monitoring programme but after discussions with the Monitoring Subprogramme it was decided to await the delivery of the National River Health Programme's information system.

Task 2.3

- Link the outputs of simulation modelling systems developed by researchers to the ICIS system.

Report for Task 2.3

The Riparian Vegetation Model (Mackenzie, *et al.,* 1999) is being linked to the ICIS time series management systems at present. Training of researchers in Professor Schulze's team on the ICIS has taken place. They are now in a position to use the ICIS system for the Sabie River. They have also been introduced to GenScn and BASINS2.0.

The groups involved in extending the fish model, a component of the "BLINKS" model, decided not to extend the computer coding on this endeavour but rather to spend time on conceptual aspects. The fish model has featured prominently in all presentations on ICIS as an example of the benefits of multi-disciplinary and multi-organisational co-operation.

Task 2.4

- Review progress.

Report for Task 2.4

The structure of this section of the final report is the same as the tri-annual reporting to the Programme Development and Management Committee. The structure of the report is designed to facilitate the review and auditory control of each task.

The IM&F Subprogramme participated fully in the preparation for the complete review of the KNPRRP held in November 1999.

Objective 3

- Develop a strategy and action plan for facilitation, communication and marketing.

Task 3.1

- Identify an approach for the facilitation of effective reciprocal links between the Subprogrammes and activities within Subprogrammes.

Report for Task 3.1

The approach identified was to seek real problems which stakeholders have in the catchment and which are of a nature which requires an integrated process approach to their management. It was anticipated that these problems would inevitably be surfaced through the work of the Integrated River Management Subprogramme and more particularly in 1999 as the new water law become reality.

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Only when such real problems involving interdependency are tackled, will meaningful reciprocal links be forged and tested effectively. A number of areas of linkage have been mentioned in the work reported above.

The implementation of the new water law is at present focusing on institutional structures and legal arrangements with respect to rights, responsibilities and power relationships. Stakeholder attention has thus not yet turned to ways in which integrated science can assist CMAs in understanding the complexities of the catchment systems which they are required to manage. The IM&F's key strategic action in this regard has been to illustrate the business forces driving stakeholders needs in the direction of the KNPRRP management process. The discussion on stakeholders in Section 2 is an example of the reasoning which has been employed to extend people's vision.

Task 3.2

- Facilitate effective links between the Subprogrammes and activities within Subprogrammes.

Report for Task 3.2

The ICIS embodies the results of many of the endeavours of the KNPRRP. It therefore forms an ideal medium through which to channel linking activities. Training courses were therefore held to

encourage more widespread use of ICIS among research groups who are contributing to the KNPRRP and among catchment stakeholders.

Implicit in the above is the use of a common time series storage and manipulation system and also the linking of the efforts of various modelling groups. In the fish and riparian vegetation areas co-operation was good. Co-operation with the hydrological and water quality modelling area, as well as the monitoring, did not reach its potential.

Task 3.3

- Identify stakeholders and beneficiaries.

Report for Task 3.3

The discussion in Section 2 of this Report illustrates the IM&F Subprogramme's view on this Task. The actions in this regard are described throughout the Report. Unfortunately one of the issues which retarded progress on this Task was the pre-occupation within the Sabie and other catchments with functions, powers and representivity within future CMAs. The focus has not yet shifted to what these CMAs are actually going to do to understand the systems they will be called upon to manage, in partnership with the State, represented primarily by the DWAF.

The anticipated stakeholder alignment predicted in Section 2 has not yet fully materialised and they have therefore not yet articulated their needs.

Task 3.4

- Transfer information and technologies.

Report for Task 3.4

Since the ICIS represents an interrelated repository for most of the information and technologies training in the use of the ICIS, it formed the major action under this task. Progress on this has been reported in many of the tasks above.

ICIS training courses were arranged with any and all stakeholders who requested such. The technologies and information developed within the KNPRRP were mostly linked into ICIS in an appropriate fashion. There was a reciprocal responsibility on each Subprogramme (as listed in their Objectives & Tasks) to work with the IM&F Subprogramme to achieve this.

ICIS presentations or training courses were delivered to groups listed below.

Freshwater Research Unit, University of Cape Town
Institute for Water Research, Rhodes University
Civil Engineering, Stellenbosch University
Botany Department, University of the Witwatersrand
Civil Engineering, University of the Witwatersrand

Agricultural Engineering, University of Natal (now Bioresources Engineering & Environmental Hydrology)
SA National Parks, Skukuza
Umgeni Water
Computing Centre for Water Research
Department of Water Affairs and Forestry
Institute for Commercial Forestry Research
SA Sugar Association Experiment Station
Indumiso Teachers Training College
Department of Environmental Affairs and Tourism, Pretoria
Environmentek, CSIR
Ninham Shand Inc.
Geography Department, Potchefstroom University
Wates, Meiring and Barnard Inc.
Randfontein Estates Gold Mine, JCI
Goldfields SA, Environmental Division
Hydrology Department, University of Zululand
Institute for Groundwater Studies, University of the Free State
Institute of Natural Resources, University of Natal
Universidade Eduardo Mondlane, Mozambique
Pulles Howard and De Lange, Consultants
Water Resources Planning, Consultants
Cape Town Metropolitan Council

Task 3.5

- Establish a network.

Report for Task 3.5

The success of Task 3.4 (and many of the other tasks) is very dependent on the establishment of this network. Every effort was made to do so, but in the final analysis it was up to the stakeholders and the other KNPRRP Subprogrammes to also make their contribution. The aim of the IM&F Subprogramme was to have the SANP at Skukuza established as the hub of the network for the Sabie River. The key software will no longer reside on the CCWR computer. The UNIX-based server containing ACRU, HSPF and the other shared software has been installed at Scientific Services, SANP, Skukuza.

Task 3.6

- Solicit sponsorship.

Report for Task 3.6

The IM&F Subprogramme was deeply involved in three major initiatives in this regard. These are the National Rivers Initiative (NRI); a proposal to the USAID to perform a KNPRRP type project on the Inkomati system; a similar proposal to the Swedish International Development Agency (SIDA). These latter proposals involved at least six South African research groups and a number of groups from Swaziland and Mozambique. The IM&F Subprogramme worked very closely with the KNPRRP's Managing Director in all of these efforts.

Task 3.7

- Identify marketable products and the timing of their delivery.

Report for Task 3.7

The whole process in which the KNPRRP was involved is very marketable to the emerging CMAs. The external forces which are beyond the control of the KNPRRP are what will energise the market. The products and process which the KNPRRP has to "sell" will then have a good chance to steer the market in a direction that ensures that rivers are managed in a manner which seeks their ecological health. Stakeholder responses to the external environmental forces have not developed as fast as anticipated. The work of the KNPRRP will have to wait for a while until its relevance is appreciated more widely.

It is the understanding of the IM&F Subprogramme that the KNPRRP's ICIS embodies the systemic summary of the knowledge gained during the KNPRRP's Phases II and III. This, along with the human intellect which has been honed by six years of practice in an integrated research programme, forms the core of the marketable products.

The conference and courses organised for 10-13 August, 1999 at Berg-en-dal was a major marketing effort under this task.

Task 3.8

- Demonstrate the economic benefit of the Programme to the region.

Report for Task 3.8

In view of the comments above it is premature to pronounce on the economic benefits of the programme to the region. Demonstration of these will have to come later. However, the actions reported under many of the other tasks (in this report) do indicate that deep down in the "soul" of water resources management in the region something is stirring and saying to people that this work is of substantial significance in economic as well as other terms.

The demonstration of these benefits will not be easy. The reason for this is that the true costs of the current lack of co-ordination and lack of integration are hidden in numerous forms within the budgets of the whole range of stakeholders within the catchment. To point out these costs to them at present would probably just lead to anger and resentment. However, once the "new game" is being played, it has been shown in numerous industries throughout the world that the stories of savings and other benefits begin to emerge and help to reinforce the successes of truly integrated efforts. As with Task 3.7 the IM&F Subprogramme is optimistic that we are approaching a watershed time for these developments and is planning to take advantage of the opportunities.

Two key actions in this regard have been the National Rivers Initiative (NRI) Consultative Conference and the Conference and Course held in August 1999.

Task 3.9

- Document the process for transfer of information and technologies.

Report for Task 3.9

The process lives in the training given and in the interactions between the stakeholders. It will be important to document and analyse the reasons for both successes and failures in these endeavours. Much can be learned from the discipline and rigour of documenting these stories. However, as pointed out in Table 3.8 the stories are still very sensitive and documentation will certainly not be well received by all the parties concerned.

One of the early "lessons" that the IM&F Subprogramme has learned is that in the process of relationship building, during joint work, it is important to manage expectations. Mismanagement of expectations can lead to unfortunate and unnecessary disillusionment. A second lesson is to take up opportunities for co-operation when the "energy" exists in one or more of the groups. This means that uni-laterally prepared timing schedules may have to be altered. Flexibility (without being exploited) is important. Constant, open and frank communication can greatly facilitate these two processes. A third lesson is that ***alignment*** is essential. All the large stakeholders in the rivers of the KNP are very busy and have responsibilities in many other river systems. It is therefore natural that they would seek to develop and find, in the KNPRRP, processes and products which are more generally useful to them. The KNPRRP itself has also always been perceived as a crucible for developing generic (as well as specific) processes and products for deployment in other catchment situations in southern Africa. The NRI and the SIDA programme are tangible proof of this.

Objective 4

- The phased implementation of a facilitation, communication and marketing strategy.

Task 4.1

- Transfer understanding and products to all Subprogrammes and participants.

Report for Task 4.1

The enhanced ability to communicate through e-mail, ICIS and the web site should help this process but at the end of the day it was the human enthusiasm for the function of sharing on a regular and unsolicited basis that was vital. The IM&F Subprogramme encouraged this at every opportunity. A number of the tasks discussed above address this point.

Task 4.2

- Distribute continually updated data catalogues and programme directory.

Report for Task 4.2

The meta data updating project is complete. The data catalogue on the web site has been updated. The programme directory is kept on the KNPRRP website.

Task 4.3

- Enhance the capacity of stakeholders and river forums in co-operation with the other Subprogrammes.

Report for Task 4.3

The IM&F's primary technology for achieving this was the ICIS. Training courses will continue to be given on the use of the ICIS to enhance both information dissemination, interaction and understanding. The success of this task (with regard to the IM&F Subprogrammes efforts) depended on the extent of commitment to making contributions to the ICIS by the other Subprogrammes and by stakeholders. This task extends to groups at the HBUs who are involved in integrated river management, e.g. Universities of Zululand and Venda.

Actions in this regard at the University of Zululand have been reported above where progress has been made in the conceptual thinking. Top-level scientific advisors to stakeholders were targeted as they will most probably be the focal point of scientific debate with respect to water resource allocation.

Task 4.4

- Training in the use of the ICIS and other computer-based information management systems.

Report for Task 4.4

As mentioned under several of the tasks above, this process was ongoing in a number of cases and was considered a key focus of the IM&F Subprogramme.

The ICIS is not just one computer programme or approach, it is a combination of programmes and systems which are interoperable. The ICIS is more than just software. It is in fact an embodiment of the concept of a combination of interoperable systems. This combination also strives to be affordable, flexible, inclusive, usable and responsive to the reasonable needs of stakeholders who interact regularly with it. These have been reported on in many of the Tasks above.

5. Academic Papers

The following papers have been strongly influenced by the authors' involvement with the KNPRRP:

Biggs, H.C., Coetzee, Y and Dent, M.C., (1999) Development of a meta database to support a multi-organisational, multi-disciplinary river ecosystem research and management initiative: – experiences from the Kruger National Park Rivers Research Programme. In Press. Submitted to *Water SA* June 1999.

Breen, C.M., Dent, M.C. and Mander, M., (1998) The Pongola River and its People - past, present and future. Salzburg Seminar, Session 353, Sustainable Rural Community Development. Salzburg.

Breen, C.M., Mander, M. and Dent, M.C., (1998) Companies and the beneficial use of natural resources. Paper presented at the Environmental Imperatives for Directors, Conference. Institute of Natural Resources, University of Natal. Occasional Paper OP189.

Dent, M.C., (1997) Individual and organisational behavioural issues relating to water resources simulation modelling and its role in integrated catchment management in southern Africa. Paper presented at the Eighth South African National Hydrology Symposium. Pretoria. November.

Dent, M.C., (1998) Reflections on the phenomenon and management implications of integration. Presented at National Rivers Initiative Conference, University of Natal, Conference organised by SA Society of Aquatic Scientists and the Kruger National Park Rivers Research Programme.

Dent, M.C., (1999) The role of integrated information systems in river management processes. Paper presented at the Integrated Management of River Ecosystems Conference, Kruger National Park, Conference organised by the Kruger National Park Rivers Research Programme, August 1999.

Dent M.C., (1999) Strategic issues in modelling for integrated water resources management in South Africa. In press for the *Journal of Hydrology,* (Special edition on Southern Africa).

Dent, M.C., (1999) Available modelling technologies to support Catchment Management Agencies (CMAs) in implementing the New Water Act. Paper presented at a workshop organised and hosted by DWA&F to discuss and assess available modelling technologies for the management of water resources on a catchment basis,

Dent, M.C., (1999) Installed water resources modelling systems for Catchment Management Agencies. Paper presented at the Ninth South African National Hydrology Symposium, November 1999, Cape Town.

Dent, M.C., Breen, C.M., O'Keeffe, J., Rogers, K., Venter, F., (1999) The Kruger National Park Rivers Research Programme. Paper presented at Second International River Management Symposium, River Festival Brisbane, Australia.

References

Dent, M.C., Breen, C.M., O'Keeffe, J., Rogers, K.H. and Venter, F., (1999) The Kruger National Park Rivers Research Programme. Paper presented at Second International River Management Symposium, River Festival, Brisbane, Australia.

McKenzie, J.A., Van Coller, A.L., Rogers, K.H., (1999) Rule-based modelling for management of riparian systems. WRC Report No 813/1/99.

Rogers, K.H. and Bestbier, R. (1997) Development of a protocol for the definition of the desired state of riverine systems in South Africa. Department of Environmental Affairs & Tourism, Pretoria. ISBN: 0-621-27824-6.

RESEARCH SUBPROGRAMME

K. H. Rogers and A. Ndlovu

Purpose

The purpose of the Research Subprogramme is to provide, in an efficient and cost- effective manner, the information, understanding and methodologies required to make better decisions about the water quality and quantity requirements of the rivers flowing through the Kruger National Park.

Objective 1

- Identify and prioritise research needs.

Task 1

- Collaborate with Mozambique and river forums.

Efforts by the Managing Director to set up a "Shared Rivers Initiative" between the RSA, Mozambique and Swaziland have been successful. Professor Rogers participated in workshops to set this up and is a member of the first phase Shared Rivers team. No new projects or programmes have emerged from the extensive contact with forums. Their needs are in some cases too poorly articulated but mostly they are not of a research nature. As the transformation to CMAs takes place we can expect this to change. The Strategic Adaptive Management (SAM) project (See Objective 5) has had spin-offs for this Task in that Professor Rogers gave a Key Note address at a DWAF CMA workshop on contrasts of Command and Control Management, Adaptive Management and Generative Knowledge Management.

Task 2

- Further development of Desired State Objectives Hierarchy (DSOH).

Two main projects were conceptualised. The first, Development of a Prototype Goal Maintenance System (Objective 2 Task 5a), was initiated. The second, A Protocol for Incorporating Societal Needs and Values into the Process (Objective 2 Task 5b), was not implemented.

Task 3

- Introduce DSOH concept and process into forums.

Two workshops have been held with each of the Olifants River Forum and the Sabie River Working Group, facilitated by Dr Biggs and Prof Rogers respectively. The Olifants Forum has taken the process further in an additional workshop and the results are being used in the process to determine the ecological reserve for this river. The Olifants River exercise can be seen as the first full-scale implementation of the environmental aspects of the new Water Act. Engaging the forums in an explicit exercise to reach consensus on a Desired State has highlighted the fact that the Sabie River

Working Group (SRWG) needed to formalise the development of a more representative forum. This process is well under way, sponsored by the DWAF (Mpumalanga Province), and it is expected that the forum will return to the DSOH process once it has a new identity.

We believe the DSOH process has served its function very well in giving forums consensus on direction and goals. Even in the case of the SRWG the process was instrumental in exposing a fundamental problem which was holding it back from fulfilling its potential in the new South Africa, even though it was functioning well on the surface. There seems to be a growing expectation that the process or at very least the concepts it embodies, could serve the future CMAs.

Objective 2a

- Assist other Subprogrammes to meet overall programme objectives.

Task 1

- Contribute to programme development at HBUs.

Mr A Ndlovu (University of the North) has participated as a Subprogamme manager "partner" with Professor Rogers. It has been very useful interacting with Mr Ndlovu, who is a social geographer, as he has been able to impart a fresh perspective to the Subprogramme. Time has been too short and interaction too intermittent for the relationship to really gel but it has nevertheless been mutually beneficial and served the purpose of exposing Mr Ndlovu to the programme.

Prof Rogers was invited to review a submission by the University of Venda for FRD funding but had to decline because of teaching commitments.

Task 2

- Interaction with National Biomonitoring (River Health) Programme.

Progress on this front is very encouraging. A very constructive and interactive relationship has developed as a consequence of regular meetings under the auspices of the KNPRRP Monitoring Subprogramme and Professor Rogers' involvement with the steering committee of the National initiative. Professor Rogers is particularly impressed by the efforts of Dr Dirk Roux (CSIR) to consider, expand and integrate concepts and protocols from KNPRRP into the National system. Dr Roux and Professor Rogers have interacted very closely on the SAM project and much integration of the River Health and KNPRRP perspectives has enriched the development of the SAM process.

There has been little progress with the riparian index being developed by Mr Nigel Kemper, so Professor Rogers's role as reviewer of the process and product has been limited.

Task 3

- Development of a Goal Maintenance System (GMS).

A draft final report has been delivered to the KNP. Transfer of the protocol to KNP has been hampered by resignation of the staff member in charge of Alien Control in KNP and the researcher who developed the GMS. Both have now been replaced and the process is back on track.

Task 4

- Transfer of DSOH to forums.

See Objective 1, Task 3 above.

Task 5a

- Goal Maintenance System.

See Objective 1, Task 3 above.

Task 5b

- Societal needs and values.

This project was to be undertaken by Mr Ndlovu. It was initially delayed by illness and has subsequently been terminated.

Task 5c

- Water quality action plan.

It took some time to find and constitute a committed group which can both develop this plan and have the potential to follow it through at a later stage. Dr Henk Bouwman and Mr Hendrick Smith of the Agricultural Research Council (ARC) were enthusiastic researchers. This team also brought new and broad perspectives to water quality issues by linking land care/management issues to the conventional instream approach of dealing with industrial, urban and mining influences on water quality. This is particularly important in the KNP rivers where increasing sediment supply is a major agent of change in biodiversity. A final report has been delivered to WRC and it is unfortunate that formal interaction will come to an end just as this initiative is beginning to bear fruit.

Task 5d

- Training programme for DSOH.

This programme is under development. A short version was presented at the International River Management conference in Kruger National Park in August 1999. It appears to have been favourably received. A final report is expected in early 2000.

Task 5e

- Response of Olifants River to floods.

An MSc. student, Mark Rountree (University of the Witwatersrand), has taken on this project under funding from the Mellon Foundation (USA). This funding has allowed Rountree to spend five months in Britain with Dr Heritage absorbing the expertise Dr Heritage took back to the UK with him when he left the KNPRRP. This opportunity to build capacity in a local student of fluvial geomorphology is extremely useful and should re-establish the expertise we have lost from this Programme.

Objective 2b

- Meeting stakeholder needs.

Task 1

- Support FRD endeavours with HBUs.

Apart from the University of Venda initiative, it seems that the FRD (NRF) process has not got off the ground so there has been little to support. The FRD commitment to them was reaffirmed at the November 1998 KNPRRP Policy Committee meeting.

Task 2

- Enhancement of DSOH for DEAT.

See Objective 2a Task 3, Task 5a and Task 5b.

Task 3

- Promote visionary research and project management for WRC and FRD.

The following projects and products are managed for WRC and FRD.

1. Representative Reaches. The final report has been submitted and is being published. CWE for WRC.
2. Scenario Modelling. Final report submitted by CWE to WRC.

3. BLINKS Modelling. The final report has been published by WRC, Weeks, IWR Rhodes and Jewitt UNP. A proposal to WRC for upgrading the fish and geomorphology BLINKS models to make them more compatible with the TPC approach to management was successful. The new project was initiated in July 1999. A brief report on the project in which the proposal was developed has been submitted to WRC.
4. Goal Maintenance System for alien vegetation which will provide a template for other such systems. CWE Wits for WRC. See Objective 2, Task 3.
5. Improved capability for predicting, in terms of TPCs, riparian response to changing catchment conditions. BLINKS extension project. The final report is in press. A follow-up proposal to the WRC which will ensure effective transfer and development of the model was successful and research began in July 1999. CWE for WRC.
6. An action plan to promote water quality studies on the KNP rivers. Final report submitted. ARC for WRC. See Objective 2a, Task 5c.
7. Improved understanding of flood response of Sabie River and its invasion by alien plant species. A useful Honours level study was completed in 1997. (CWE for FRD).
8. A training programme and associated materials for transfer of Desired State Objectives Hierarchy to interested parties. (CWE for WRC.) Final report due late 2000. See Objective 2a, Task 5d.
9. Improved understanding and predictive potential of reed/sediment interactions and their influence on geomorphology. An MSc project (CWE for FRD) began in May 1998.
10. Improved potential to model riparian water balance with particular reference to reed transpiration. WRC project conducted by Dr C Everson (CSIR) is in progress.
11. Influence of reeds on fluvial geomorphology. WRC project conducted by Prof. C James (CWE Wits) is under way.
12. Understanding and model of the influence of closure of waterholes on elephant impacts on the riparian zone of ephemeral rivers with particular reference to establishing TPCs (Wits CWE/Centre for African Ecology for FRD) is under way.
13. Improved understanding and predictive potential of flood response in the Olifants River. See Objective 2a, Task 5e.
14. Riparian forests of the Levuvhu River. Mark Botha UCT for WRC is under way.
15. Incorporation of economic considerations into management of the environmental reserve. This project is not under our control but is under way. INR (UNP) for WRC.
16. Developing protocols for ICM for the Sabie River Catchment. Joint venture between Working for Water, CSIR and KNPRRP funded by WRC is under way.
17. Classification of KNP rivers, is under way. (IWR Rhodes for WRC) See Monitoring Subprogramme report.

Task 4

- Promotion and development DSOH and TPCs for SANP.

All DSOH activities discussed above fall under this task and SANP staff are involved in them all. Professor Rogers gave a presentation on this subject at the annual KNP research symposium which

exposed a large number of postgraduate researchers, from a wide range of disciplines and institutions, to the concept and river examples. All research projects under our management are encouraged to contribute to the development and testing of KNP TPCs.

Task 5

- Extension of rivers research in KNP.

All projects reported on above fall under this task. A particular effort has been made to bring Mark Botha (UCT) closer to the fold by ensuring his participation in the KNP research meeting and having some of my own students accompany him on field trips. He remains on the fringe but his work is potentially useful.

Professor Rogers contributed to a ground water day organised by Dr Biggs and believes there is a real need to connect rivers and ground water research in the Park.

Professor Rogers is "honorary" rivers research manager for the KNP and participates in internal project co-ordination.

Professor Rogers and KNP (Biggs) have received funding from the Andrew Mellon Foundation to establish a programme of research into riparian upland interactions across a range of rivers from perennial to seasonal. Three American Institutions (University of California, Berkely; University of Washington and Institute of Ecosystem Studies, New York) collaborate in the research and student exchange of this four-year programme.

Objective 2c

- Meeting new programme objectives.

See Objective 2a, Tasks a, b, c, d, e and Objective 2b, Task 3.

Objective 3 and 4

- Research strategy, implementation and management.

See Objective 1, Task 1; Objective 2a, Tasks a, b, c, d, e and Objective 2b, Task 3.

Objective 5

- Product transfer and generating commitment of stakeholders.

Professor Rogers presented a paper and participated at the National Rivers Initiative Working Conference in June 1998. See also Objective 1, Task 3; Objective 2a, Tasks 1-5.

Professor Rogers is also on the review panel for the Olifants Ecological Reserve determination exercise and serves on many WRC steering committees.

A major product during this phase was the report on Scenario Modelling of Geomorphology which has clearly indicated that the IFR flows for the Sabie River will result in progressive sediment storage. Thus, the study provides the prediction that IFR flows will not achieve the desired geomorphological state which is expressed as "no directional loss of bedrock influence over a twenty-year prediction period". This is a very significant finding because the whole rationale for defining the desired state in geomorphological terms is based on the hypothesis that decreased sediment transport capacity in the Sabie River will result in a loss of bedrock influence and thus reduced habitat and species diversity.

This finding prompted the KNPRRP PDMC to commission Professor Rogers to conduct a project entitled: **"Operationalizing multi-party Strategic Adaptive Management (SAM) of the Sabie River"**. The purpose of the project is to close the loop between research, monitoring, management and decision making for the Sabie River, using particular TPCs as examples or vehicles for closing the loop.

Two very constructive workshops have been held and considerable progress made. The main contributors have been Dr Dirk Roux (CSIR, River Health Programme) and Dr Harry Biggs (KNP). Other enthusiastic participants at a meeting in the KNP were Dr Leo Braack, Dr Willem Gertenbach, Dr Stephanie Freitag, Dr Freek Venter, and Ms. Antionette van Wyk, all of the KNP. Dr Henk van Vliet (Director Scientific Services DWAF) was to have brought more detailed DWAF perspective at one meeting but was unable to attend at the last minute.

The internationally recognised problem of institutionalizing adaptive management has been highlighted as an important issue in ensuring effective river management and decision making for the Sabie River and RSA in general. Adaptive management is not an approach which has been used within DWAF, nor is it explicitly incorporated within proposals to implement the new Water Act. There are, of course, people who recognise the need for it. Strategic Adaptive Management is the explicit philosophy of the KNP and major strides have been made to implement it, but there is some way to go before it is fully understood, internalized and institutionalized across the ranks.

Two documents which arise from these workshops are in circulation and beginning to elicit response. The first was an open submission to KNP management and research sections in July 1999, entitled **The desired state of the Sabie River will not be met: What now?!** It was designed to; (1) document the history of research findings preceding and subsequent to the setting of the Sabie River geomorphology and vegetation (*Breonadia*) TPCs; (2) outline the predictions that they will not be met and relate the perceived shortfall in management response to rivers problems to analogous terrestrial issues which apparently received disproportionate attention.

The second document was entitled **The challenge for catchment management agencies: What can we learn from bureaucracies, business and conservation?** It highlights the need for a generative and strategic form of adaptive management to replace the command and control style of bureaucracies

if water is to be properly managed as a resource dependent on functional ecosystems. The document reached Mr Haroon Karodia (DWAF) who is responsible for development of Catchment Management Agencies. He has shown considerable interest in our work and Professor Rogers delivered a starter presentation on this subject at a workshop on how to manage CMAs.

Central to the philosophy of the KNPRRP and SAM is a generative style of leadership and consensus building among stakeholders which we believe is essential in promoting resource management in South Africa. Developing a clear, innovative vision for stakeholders is, in turn fundamental to building consensus and generative leadership. Professor Rogers, and Drs Roux and Biggs have submitted a manuscript to the online Journal *Conservation Ecology* entitled: "The value of vision and art of visionaries". A copy follows in this report.

Significant progress in Phase III

Consolidation of the Desired State Objectives Hierarchy approach into the process now known as Strategic Adaptive Management. This has taken a number of forms. Publication in *Freshwater Biology*, transfer to forums (especially the Olifants River Forum), transfer to the River Health Program through involvement of Dr Dirk Roux, explicit modelling to serve the riparian vegetation TPCs and monitoring, and transfer to a wider audience in the August conference and course. The whole SAM concept and approach as outlined in the *Freshwater Biology* paper has received much acclaim from Australian ecologists and managers.

Modelling. Completion of the geomorphology scenario modelling which demonstrated that the rivers will experience continued sediment storage and the geomorphology TPC will be exceeded.

Development of a second generation vegetation model (The *Breonadia* model) which explicitly services the TPC philosophy and approach of SAM. Mr James MacKenzie delivered an invited paper at the American Ecological Society Conference in August and received excellent feedback and interest. So much so, that he was invited to give a day-long seminar/course on his model and the modelling approach to an Environmental Science class at the University of York, Toronto in November.

Extension to other rivers and upland linkages. The Mellon Program and work on the Olifants River both extend the Sabie River work and provide some continuance of the KNPRRP. Establishment of collaboration with governmental agricultural sector through the Water Quality Action Plan represents an important extension of the research to capture catchment/river linkages.

Operationalizing SAM. This project is ongoing but represents an important step in our understanding of what it takes to get research products fully integrated into management and indeed to revolutionize management through research. The project to develop protocols for

Catchment Management on the Sabie will extend the SAM approach into CMAs and also represents an important step in the extension of the focused KNPRRP.

Shortfalls

1. It takes longer to do everything than planned. We are at times too ambitious given our resources.

2. The partner Programme could have had more substance. The main problem is that in our case Mr Ndlovu was already committed to other efforts and could not switch allegiance within the time frame. A project was designed to bring him closer to the fold, but this was never implemented.

3. There are a number of initiatives which will not be complete by the end of this phase. That may have good and bad sides to it. The good is that the Programme influence will not come to an abrupt end. The bad is that these initiatives will not benefit fully from the KNPRRP spirit and spin-offs.

THE VALUE OF VISIONS AND ART OF VISIONARIES

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A group of ecologists and managers sitting in the Kruger National Park workshopping an adaptive management process find themselves in awe of the value of the vision they sketched with stakeholders a few years ago. It has provided excitement and stimulus as they build and shape the process to fit unique and changing circumstances in South Africa.

Holling's (1999) editorial provided a jolt! Suspicion of people with visions came as a surprise. Are we missing something that lies behind the editorial? Are we "blind" and "deaf" too? We think not, and share here our experience and excitement in the spirit of what *we* see as Holling's *vision* for Conservation Ecology.

Our excitement comes from the value a vision can provide as a listening device, an integrator of conversations, a means to converge dreams with reality. We see this emerging in our work and this is why we get excited about vision.

It is also why we are confused by the apparent contradiction we see in Dr Holling's editorial. No vision for Conservation Ecology? We are excited by the prospects of a journal that provides a listening device for quiet voices masked by the noise of crusades, dogma and parochial self-confidence - the voices from less developed nations or circumstances, the young dreamer, or anyone whose experience is off the mainstream thinking circles. They may not be heard simply because they do not couch their tale in the buzz words of the "noise". A noble and selfless vision which we can see providing boundless opportunity for enriching the global science and management of ecosystems.

But perhaps Holling's suspicion comes from a different use of "vision" from ours. We can imagine a vision which is used to further ambition becoming a disruptive force, or a vision which is not allowed to evolve inclusively becoming stagnant, even bigoted. But we see immeasurable value when vision is used with reticence, humility, even altruism, to bring people together and create a better future.

Let us develop an analogy using Holling's sculpture to illustrate how visions work for us.

Although his ideas are hazy before he starts they must surely be collected into a form of "consensus" when he decides where the first cut should be - a humble cut made in anticipation of the potential latent in the wood. This is the sort of vision of which we speak. The wood grain is the reality with which this vision will converge. The first cut is the first step in that convergence. Thereafter the artist is the generative power which molds the vision of "hazy" but creative, ideas in harmony with the reality of the grain. The sculpture is a self-fulfilling prophecy.

If the artist is blind to the surprises and deaf to the voices of the grain, he and the wood are not in harmony but conflict. The product is more a result of ambition (self-centered and selfish) than of vision. The altruistic vision on the other hand can be integrative, open to other voices, to other influences and to learning by doing.

What if there were many artists all trying to sculpt the same piece of wood? Then perhaps the process of deriving vision is more important than the vision itself. Holling hints at how his Adaptive Management workshops have evolved to "let the voices speak". Undoubtedly this draws out their expectations, a form of vision.

Similarly, we have found that the process of developing a collective vision, and seeking its expression in reality, is central to Adaptive Management. Vision provides the first step in integrating social values, scientific knowledge and management experience in a multi-party system (Rogers and Bestbier, 1997). The first step in developing the common purpose and knowledge base on which consensus thrives. In collectively exposing disparate mental models (Senge, 1990) to achieve consensus on ecological and management end points.

Given adequate consensus and some artistry, the vision and reality converge over time to shape each other in a self-fulfilling prophecy; an expression of the latent wisdom and desires of the participants: Provided of course, that the vision does not represent someone's ambition and its convergence with reality is coaxed with humility and goodwill.

Visions for ecosystem management must be developed and used with reticence and humility. Vision is a valuable tool for converging energies (Senge, 1990) but its value depends on how well it is translated into reality. This is a tricky task and requires a facilitator skilled at negotiating consensus, rather than compromise. Because it is so essential we have purposefully incorporated a process for generating a consensus vision (Rogers and Bestbier, 1997) into adaptive management exercises.

Our process is based on the remarkable negotiations which led to peaceful change from apartheid to democracy in South Africa (Fig. 1). This process is geared to avoid the conflict which comes with seeking compromise between party specific problems and solutions, as in western democracies. Instead the focus is on making the problem a common problem. But, rather than seeking solutions to the immediate problem, the vision of a better common future is achieved by focusing on common values and future needs. The common values and needs are latent in the participants, as is the grain of the wood. The facilitator carefully extracts them in the same way the sculptor exposes the grain. When everyone is focused on the common needs and values embodied in a broad consensus vision, the template for converging it with reality exists.

Our process of convergence is one of developing an Objectives Hierarchy which decomposes the vision into achievable ecosystem targets or end points (Rogers and Biggs, 1999). The cascading linkages provide increasing detail of explanation of what the world should look like. Each step in the hierarchy is developed by the same negotiation process as the vision. The facilitator helps the parties whittle away at the vision (wood) exposing the needs (grain) in ever-increasing detail. The realities of what can and can't be done are merged with what needs to be done to achieve the better future. The vision provides an anchor or reference point which, like the block of wood, holds the potential which the parties have for achieving it. In the hands of the right person the vision encourages the voices to speak!

When used in this way a common vision pre-empts and dissipates conflict in a remarkable way. Witness the transformation in South Africa - a country so rich in cultural diversity that it has eleven official languages. So much potential for conflict yet so much potential for achieving Nelson Mandela's vision.

Verwoerd took the autocratic, command and control approach to his "wood". He knew the shape he wanted apartheid to take. When the shape would not emerge the hacking began to destroy its potential. Mandela's vision is forgiving, inclusive and inspirational, encouraging the sculptors to forge a new nation themselves. Peter Senge (1990) suggests that the USA was the first nation built on vision. Perhaps South Africa will be the first to also hear the silent voices.

If vision can work for nations then surely it must have the potential to solve environmental conflicts, the potential to hear the quiet voices above the noise.

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INTEGRATED RIVER MANAGEMENT SUBPROGRAMME

Freek Venter and Maritza Uys

SUMMARY

The purpose of the Integrated River Management Subprogramme (IRMP) was to promote the process of Integrated Catchment Management and the sustainability of river systems by acting as a catalyst in the participative development of a strategy and action plan for integrated river management. At the beginning of the third phase of the KNPRRP it was decided to focus attention on two river forums, namely the Sabie River Working Group (SRWG) and the Olifants River Forum (ORF). This was done because these river forums were actively involved in catchment management activities.

Subsequent to the initiation of the third phase of the KNPRRP the new National Water Act was promulgated. Water Management Areas (WMA) were established and the Department of Water Affairs and Forestry (DWAF) started to establish Catchment Management Agencies in the appropriate WMAs. The river forums were used as a platform for this process and played an important initial role in facilitating these activities, but their importance faded as the newly formed bodies (Catchment Management Steering Committees or CMCs) came into operation. As a consequence of these changes that were taking place it was difficult for the IRMP to remain focused on the objectives set for it at the onset of Phase III. Much more effort was therefore redirected towards influencing the establishment of CMCs as they were very much in a developmental phase and were breaking new ground in the history of South African river management. In this process it was possible to represent the KNPRRP on the forerunners of CMAs of the KNP river catchments and to influence the thinking and direction they were taking.

An important direct product of the IRMP is a draft Desired State Objectives Hierarchy for the Olifants River. This is currently used by the DWAF for the establishment of a future desired state of the Olifants River, and by the Olifants River Forum for management planning in the Olifants River Catchment. More abstract products include the capacity that was built inside the SANP for conceptualizing and dealing with Integrated River Management (IRM).

Stakeholders of river catchments were able to develop a common vision for the rivers of the Lowveld and capacity was established for IRM. They were influenced to realize that rivers should be managed as ecosystems and not merely as conduits for water and that provision is made for this in the National Water Act. The implications of such a management style by CMAs were emphasized.

Purpose

The purpose of the Integrated River Management Subprogramme is to promote the process of integrated catchment management and the sustainability of river systems by acting as a catalyst in the participative development of a strategy and action plan for ***integrated river management*** *of the rivers providing freshwater inflow to the Kruger National Park.*

INTRODUCTION

During the first phase of the KNPRRP much attention was given to basic research and understanding the river systems that flow through the Kruger National Park (KNP). The second phase was more focused on addressing specific gaps and concentrated on the development of tools such as Data Catalogues, Decision Support Systems and tools for the determination of the Desired State of river systems. It was at one stage thought that the Programme might end after Phase II, but the KNP motivated for an extension of the Programme to implement the products developed. The rationale behind the request for an implementation phase was that the KNP felt that the Programme developed excellent tools but that they were not yet implemented in the management of the KNP rivers. A third phase of the Programme was therefore initiated.

The Integrated River Management (IRM) Subprogramme was added to the KNPRRP in Phase III as a new Subprogramme. Its purpose was to promote the process of Integrated Catchment Management and the sustainability of river systems by acting as a catalyst in the participative development of a strategy and action plan for integrated river management. To be able to achieve this it was decided that the IRM Subprogramme should focus on the two most active river forums in the catchments of the rivers that flow through the KNP, namely the Olifants River Forum and the Sabie River Working Group. The IRM Subprogramme was to act as a link between the KNPRRP and these river forums.

The objectives of the IRM Subprogramme were specifically aimed at equipping the river forums with the capacity to achieve effective integrated river management for their specific rivers through the application of products developed by the KNPRRP. However, as Phase III of the KNPRRP progressed, other exciting developments took place in the river management scene in South Africa that made the achievement of many of these objectives less relevant in their original form. The new National Water Act was promulgated, Water Management Areas (WMAs) were established and the Regional Office of the Department of Water Affairs and Forestry (DWAF) at Nelspruit took actions towards establishing Catchment Management Agencies in the appropriate WMAs. Although the river forums were used as a platform for this process and played an important initial role in facilitating these activities, their importance receded as the newly formed bodies (Catchment Management Steering Committees – CMCs) came into operation. It also became evident that it would not be appropriate at this time to apply the objectives set for the IRM Subprogramme directly to the CMCs as they were preoccupied with attaining representivity and determining structures for the CMAs in the Olifants and Inkomati (including the Sabie River) CMAs.

However, energy in the Programme was redirected at influencing stakeholders represented on the CMCs towards IRM as well as the **(Freek to complete)**

It is therefore important to view the following discussion of the objectives of the IRM Subprogramme in this light.

Objective 1

- Develop a strategy and action plan for IRM.

Task 1

- Develop a common vision and desired future state for two selected rivers.

A Desired State Objectives Hierarchy (DSOH) has been developed for the Olifants River (and partly for the Sabie River) during several workshops held with the forums and other stakeholders, and by using the methodologies developed during Phase II of the KNPRRP. Inherent to the DSOH process was the development of a common vision and the setting of objectives, sub-objectives, goals, etc. for the catchments of the Sabie and Olifants rivers, with specific reference to and focus on the rivers as resources.

A product of this task is the document "Towards a Management Plan for the Olifants River".

An important outcome is that both Mr Beyers Havenga of the DWAF and the Olifants River Forum are using the document for the Ecological Water Requirements Assessment of the Olifants River that is currently being done under the auspices of the DWAF, as well as for future management planning of the Olifants River. The process is continued for the Olifants River through an Environmental Water Requirements study (formerly called an IFR study). The Department of Water Affairs and Forestry (DWAF) has appointed BKS (PTY) Ltd as consultants for the determination of the Environmental Reserve, and the objectives hierarchy developed for the Olifants River is being used in this regard.

Task 2

- Develop river management objectives and goals for two selected rivers.

A process by which the objectives hierarchy is being simplified and rearranged to make it more user-friendly for all stakeholders in the catchment was initiated in conjunction with Messrs Beyers Havenga of DWAF and Martin van Veelen of BKS. This will be followed up as the Olifants River Study proceeds, probably also after the KNPRRP has terminated officially.

Task 3

- Develop river management strategies and action plans.

This task was not addressed due to changing circumstances in the catchments. The CMAs of the respective rivers will develop a Catchment Management Strategy (CMS) for their respective rivers as soon as the CMAs are in place. The DSOH will serve as a framework for the development of CMSs by the CMAs.

Task 4

- Identify relevant research and monitoring needs.

The task was addressed indirectly by communicating on PDMC meetings and by participating in the Monitoring Liaison Committee and research-oriented workshops.

Objective 2

- Implement the IRM strategy and action plan.

Task 1

- Enhancing capacity of river forums

Active participation in river forum activities continued. Both the Olifants River Forum and the Sabie River Working Group (LSRWG) have restructured to adapt to the new situation with regard to the National Water Act. The SRWG initiated the formation of the Sabie and Sand Rivers Steering Committees that are active in the process of the formation of a Catchment Management Agency for the Inkomati River Basin. As the role of the River Forums receded, energy was directed towards the newly formed CMCs. An environmental lobby was formed in the Crocodile River catchment (the Crocodile River Environmental Group) which consisted of the KNP, conservancies, Mpumalanga Parks Board, DEAT and other interested groups to balance strong lobbying from other prominent water user sectors, notably irrigated agriculture and forestry.

Task 2

- Establishing the Desired Future State for selected catchments.

Completed, at least in provisional form, for the Olifants and Sabie rivers according to the Desired State Objectives Hierarchy process (see Objective 1).

Task 3

- Participating in the determining of Instream Flow Requirement studies and determining the environmental reserve.

The IRM Subprogramme was actively involved in the Olifants River Environmental Water Requirements (formerly IFR) study (see Objective 1), which is facilitated by the Olifants River Forum. The products (objectives hierarchy developed for the Olifants River entitled Towards a Management Plan for the Olifants River) of the IRM Subprogramme are being used by DWAF in the development of a catchment management strategy and establishing the future desired state for the Olifants River. This document is currently in the process of being updated, simplified and restructured (in consultation with DWAF and BKS) to ensure that it fits the model developed by BKS for the Olifants River. This is also done to ensure that catchment stakeholders buy into the process and end product.

The process for the Olifants River will link water quantity and quality - a first for South Africa.

The IRM Subprogramme actively participated in the revision of the IFR for the Luvuvhu River. This included drafting a statement to DWAF regarding the future management of the Luvuvhu River and raising concerns regarding future impacts of the Mutoti Dam on the floodplain of the Luvuvhu River.

Objective 3

- Building a common understanding and vision for IRM

Significant progress in this regard was made directly via the attainment of Objectives 1 and 2. Whereas CMCs were initially not concerned with environmental needs and regarded these needs as being addressed as long as there is water in the river, acceptance and sympathy for the need to supply the Environmental Reserve and to manage rivers in a sustainable way were achieved within the CMCs. We contributed to this in a large way by making written statements as well as oral presentations to CMCs on various matters.

Objective 4

- Building capacity for IRM.

Task 1

- Involving DWAF in the activities of the Subprogramme.

Several senior persons within DWAF and persons doing consultancy work for DWAF that are involved with the development of the CMAs have been directly involved in the activities of the IRM Subprogramme. Others were involved by entering into discussions with them regarding ICM, the Reserve and providing for the needs of the natural environs of the rivers flowing through the KNP.

Dr Magda Ligthelm of DWAF	Heading up the establishment of CMAs in the Inkomati and Olifants Rivers
Mr Beyers Havenga of DWAF	Heading up the Environmental Water Requirement Assessment of the Olifants River
Dr Phillip Woodhouse from the UK	Consulted by DWAF to evaluate the implementation of the National Water Act
Prof André Görgens and Dr Guy Pegram	Both on the team of consultants appointed by DWAF to develop a protocol for the establishment of CMAs and WUAs
Mr Haroon Karodia of DWAF	Heading up the establishment of CMAs on a national level
Mr Hadley Kavin of DWAF	One of the main drafters of the National Water Act
Mr Bill Rowlston of DWAF	A member of the SC to develop a protocol for the establishment of CMAs and WUAs
Mr Hubert Thompson of Thompson & Thompson	One of the main drafters of the National Water Act
Ms Eustathia Bofilatos	A member of the Steering Committee to develop a protocol for the establishment of CMAs and WUAs
Dr Ben Dyer of the Murray Darling Basin Commission in Australia	Visited SA and the KNP as a guest of DWAF
Dr Heather McKay of DWAF	Responsible for providing protocols for the establishment of the Reserve, Resource Quality Objectives and the classification of rivers

Some of the discussions also revolved around the feasibility of establishing an environmental WUA to ensure compliance with the environmental reserve. A steering committee for the development of a protocol for the establishment of CMAs and WUAs was created and on which we were represented. As it was resolved at a meeting of the Steering Committee that an environmental WUA was not the answer in this regard, the IRM Subprogramme was invited to propose a possible structure. A document is being prepared.

Task 2

- Sustained interaction with established river forums.

Contact was maintained and involvement sustained with the following forums:

- Sabie River Working Group
- The newly formed Sabie-Sand River CMA Steering Committee
- Sabie River Co-ordinating Committee
- Save the Sand River Project
- Olifants River Forum
- Olifants River Ecological Water Requirements Assessment Task Group

- Phalaborwa Waste Reduction Committee
- Phalaborwa Environmental Policy Committee
- Upper Olifants Catchment consultation planning meeting for initiating the establishment of a Catchment Management Agency for the Loskop Dam Catchment
- Maputo Iron and Steel Project Environmental Impact Assessment
- Palaborwa Mining Company Decommissioning and Closure Stakeholder Committee
- Groot Letaba River Water Development Steering Committee
- Klein and Middle Letaba Water Development Stakeholder Committee
- Luvuvhu River Water Development Steering Committee
- Lower Mutale River Forum
- Lower Crocodile River Environmental Group
- Crocodile River Catchment Management Agency Steering Committee
- Steering Committee for the development of a protocol for the establishment of CMAs and WUAs.

Most of the activities of these forums are directed towards the process of establishing CMAs for specific Water Management Areas, developing structures along the lines of the National Water Act, and determining the functions of the different structures. Although the process is steered by DWAF to a large extent, the involvement of the KNPRRP as an active participant in this process was valuable in influencing ideas and changing mindsets.

Task 3

- Develop consensus on roles and responsibilities of river forums in relation to government departments and parastatals.

This task is also partly completed. During several meetings with ORF and SRWG and in letters to the Minister, from both forums requests were made to transform them into CMAs. It has emerged that river forums will not be transformed into CMAs directly. Forums may be important vehicles for the formation of CMAs and their experience and expert input would be used throughout the formation process. The river forums will have no legal standing in the new dispensation. They may, however, continue to play an important role in organising local level input to CMCs and CMAs.

Task 4

- Design an education programme to enhance the capacity of river forums.

An education programme was not designed, mainly due to the changing circumstances with regard to the river forums. This task forms part of the objectives for the different rivers and will probably best be addressed by the CMAs, once established. However, contributions to informal education were made by having information sessions with river forums and by continuously raising the importance of meeting the needs of the natural environment in the face of strong lobbies from other sectors.

Task 5

- Transfer techniques for determining Desired Future State to river forums.

This has been achieved through objectives hierarchy workshops conducted with the forums and may be further pursued by the CMAs, once established.

Task 6

- Facilitate the formation of a Water User Association (WUA) for the environment to lobby for the provision of the Environmental Reserve in rivers flowing through the KNP.

This task was added to the IRM Subprogramme recently. Several meetings and workshops were held and attended to investigate the suitability of a WUA for the natural environment. In the development of protocols for the establishment of WUAs no clear guidelines exist for the accommodation of environmental needs at this level. It was established that the route of ensuring the delivery of the Environmental Reserve and monitoring the effectiveness of the Reserve in meeting the needs of the environment was much more appropriate than forming an environmental WUA. Senior personnel within DWAF still differ strongly with some agreeing that an Environmental WUA is feasible, while others reject the idea. The reason for the latter is that water for the environment will be catered for at ministerial or CMA level and not at the operational level of WUAs. It was resolved that a WUA is probably not a suitable vehicle for ensuring compliance with the environmental reserve. It was appreciated that this task would require specific and expert knowledge and expertise. The IRM Subprogramme was invited to make proposals to the Steering Committee tasked with the development of a Protocol for the Establishment of CMAs and WUAs.

Task 7

- Building capacity through corrective action.

Ms Maritza Uys has been involved in the IRM Subprogramme as the programme Manager's partner. She has attended workshops and meetings of the Subprogramme and the PDMC and has made a valuable contribution especially with regard to matters pertaining to the National Water Act.

Objective 5

- Consolidating principles and methodologies for IRM.

Task 1

- Identifying a process for developing river management plans for the rivers within the KNP.

Developing river management plans should be an integrated process involving all stakeholders to ensure buy-in. The DSOH process was found to be highly effective in achieving this.

Several 'first generation' river management plans had been developed for rivers in the KNP before the onset of the Phase III of the KNPRRP. One such plan was developed in conjunction with the Sabie River Working Group to manage the Sabie River during the drought of 1992. It was used to manage abstraction from the Sabie River so as to maintain flow through the KNP and was further developed by the SRWG in subsequent years. A similar management plan was developed for the Groot Letaba River in conjunction with the Groot Letaba Major Irrigation Board for the maintenance of minimum flows in the Letaba River during droughts.

Inputs were recently made for the development of Operating Rules for the Injaka Dam presently under construction in the Maritsani River (a tributary of the Sabie River) with regard to meeting the IFR for the Sabie River in the KNP. Mr Charles Sellick is developing these Operating Rules for the DWAF.

A 10-point plan for the management of the sedimentation problem in the Sabie River was developed for the KNP and was accepted by management in the KNP. This undoubtedly signals a move from *ad hoc* or crisis management to strategic river management of the KNP rivers.

Until now river management plans tended to focus on the Sabie River. There is wide recognition that they need to be improved and extended to other rivers. Some river management plans will need to be generic while others will need to be river specific.

Task 2

- Reviewing short-, medium- and long-term assessment methodologies for water quantity and quality.

Contributions were made by the IRMP with regard to the determination and revision of IFRs, the development of the River Health Programme and the determination of the Environmental Reserve. An extensive revision of water quality standards that should provisionally apply to the KNP rivers was completed. It supported the water quality monitoring programme in the KNP and was embedded in Thresholds of Probable Concern (TPC) in the Management Plan for the KNP.

Task 3

- Establishing the process to determine the environmental reserve.

The IRM Subprogramme is intimately involved in the process of determining the Environmental Water Requirements for the Olifants River. The first phase of this project, namely determining the Present Ecological State, has been completed. Currently the determination of Management Classes for all the different sectors of the Olifants River is being done. A preliminary Reserve was also determined for the Crocodile River.

Task 4

- Implementing and testing ICIS and DSS developed in the Programme.

ICIS was installed on computers in the KNP and several SANP staff members and others attended courses presented by members of the CCWR. It is intended to transfer the water quality and hydrological data bases maintained by the KNP to ICIS to facilitate decision making and auditing.

PRODUCTS AND OUTCOMES

The product (objectives hierarchy developed for the Olifants River entitled "Towards a management plan for the Olifants River") of the IRM Subprogramme is being used by DWAF in the development of a catchment management strategy and future desired state for the Olifants River. This document is currently being updated, simplified and restructured (in consultation with DWAF and BKS) to ensure that it fits the model developed by BKS for stakeholder consultation in the Olifants River catchment. This is also done to ensure that catchment stakeholders buy into the process and end product.

A similar product was being developed for the Sabie River but the process was stalled due to perceived representivity disparities among working group delegates.

Other more abstract products were also brought about. The involvement of the IRM Subprogramme in the activities of the Catchment Management Committees of the Crocodile, Sabie, Sand and Olifants rivers, and submissions made to the committees, has had a significant effect on the course deliberations were making. For example, a major effort by the irrigation section to replace the CMC for the Crocodile River with a WUA under their auspices was successfully opposed by the environmental lobby, which was moulded into an effective group by acting in unison to achieve alternate joint solutions.

Most of the activities of the CMCs are drawn into the process of establishing CMAs for specific Water Management Areas, developing structures along the lines of the National Water Act, and determining the functions of the different structures. Although the process is steered by the DWAF to a large extent, the involvement of the IRM Subprogramme as an active participant in this process, has significantly influenced the process of establishing CMAs and the way in which they will function.

During recent deliberations with the DWAF regarding the suitability of a WUA as a vehicle for ensuring compliance with the environmental reserve, it emerged that a WUA would not serve these goals. It was appreciated that this task would require specific and expert knowledge. The IRM Subprogramme was

therefore invited to make proposals to the Steering Committee tasked with the development of a Protocol for the Establishment of CMAs and WUAs. Developing such a proposal is in the process but will probably only be finalized after the KNPRRP has been formally completed.

EVALUATION

The rapid changes that were taking place with regard to river management and river forums in the catchments of the rivers flowing through the KNP made it difficult for the IRM Subprogramme to remain absolutely and specifically focused on the objectives set for it at the onset of Phase III. Some of these objectives were therefore not met. The river forums that were initially targeted by the Programme for capacity building and to be equipped to efficiently manage the rivers and their catchments, were subsequent to the initiation of the Phase III gradually superseded by other forums (at a later stage called Catchment Management Steering Committees or CMCs) for the establishment of CMAs. It also happened that the Olifants River Forum and the Sabie River Working Group were initially selected for specific attention, but most of the initial CMC activity and development took place in the Crocodile River Catchment. Much activity therefore followed initially in the catchment of the Crocodile River, and later also in the Sabie, Olifants and Sand rivers.

As these changes also reflect in a positive way that progress was rapidly being made with regard to the implementation of the new National Water Act, a redirection in the IRM Subprogramme was made. It was decided to spend considerable time with the activities of the CMCs and to attempt to amplify the energy that was being produced in these forums. The CMCs were very much in a developmental phase and were breaking new ground in the history of South African river management. However, there was strong lobbying from other water user sectors and determination and commitment were often needed from the environmental lobby.

In this process it was possible to represent the KNPRRP on the forerunners of CMAs of the KNP river catchments and to influence the thinking and direction they were taking. The experience gained by being involved with the KNPRRP played a significant role in promoting IRM principles and ensuring that the importance of river ecosystem conservation is understood.

IMPLICATIONS FOR MANAGING RIVERS

The implications for managing rivers are that other stakeholders over a wide front (i.e. representatives on the CMCs), the regional members of the DWAF and consultants in the process are beginning to realize that rivers should be managed as ecosystems and not merely as conduits for water. Provision is made for this in the National Water Act. The implications of such a management style by CMAs were outlined as follows:

- Rivers should first and foremost be managed (including water released from dams) to maintain habitats in rivers and not only to satisfy the needs of other water users.
- There is a great need to appoint or access experts on river ecology and management on CMAs to fulfil this function. It should not merely be left to the water quantity or quality managers. The

task is not limited to ensuring that the Environmental Reserve is supplied, but more importantly to evaluate the long-term effect of the Reserve on the river ecosystem. A Reserve Manager will be able to keep his finger on the pulse of the river to monitor the health of the river and detect subtle changes that can drastically affect the condition of the river over the long term. Close co-operation with the River Health Programme and other initiatives is needed.

- There is therefore by implication also a need to reserve an amount of water (contingency water) in case it is found that the reserve does not meet the needs of the environment of the river.
- Due to the potential impact of different kinds of land use in the catchment of rivers on river ecosystems, strong linkages with other departments will have to be pursued. Since the responsibility to sustain the natural environs of rivers rests on the shoulders of the CMA it will have to take the initiative in this regard (commit the necessary human and other resources to this end) to ensure that sustainable land use becomes a priority. This includes the need for strong links with other ICM projects as well as the Landcare initiative.

The fact that it was possible to make apparently valuable inputs into the deliberations of the CMSs is to the credit of the KNPRRP which provided expert knowledge and decision support tools.

CONCLUSIONS

The IRM Subprogramme provided a link between catchment stakeholders of some rivers flowing through the KNP and the KNPRRP and many positive outcomes were thus achieved. Although it was not possible to fully implement all the products developed by the KNPRRP, or to meet all the objectives set for the IRM Subprogramme in the appropriate time frame, valuable inputs regarding sustainable river management could be made at CMC level. It therefore partly succeeded in promoting Integrated Catchment Management and the sustainability of river systems by acting as a catalyst in the development of a strategy and action plan for integrated river management of the rivers flowing through the KNP.

RECOMMENDATIONS

It is recommended that the following aspects receive focused attention:

1. completion and finalization of the Olifants River Desired State Objectives Hierarchy;
2. submitting a proposal to the steering committee tasked with the development of a protocol for the establishment of CMAs and WUAs regarding the management of the Environmental Reserve by CMAs;
3. that the energy for IRM created by the KNPRRP be taken forward by the KNP within the CMAs upon termination of the KNPRRP and establishment of CMAs; and
4. that continued research and development of DSS products be promoted.

PROJECTS RELATED TO THE IRM PROGRAMME

Title: Towards a management plan for the Olifants River.

Aim: To promote the development of a strategy and action plan for the integrated management of the Olifants River.

Objectives:
- Enhancing capacity of river forums.
- Establishing a Desired Future State for the Olifants River.
- Setting appropriate objectives and goals for the management of the Olifants River.

Agencies involved:
- Kruger National Park Rivers Research Programme
- Olifants River Forum
- Department of Water Affairs and Forestry
- Kruger National Park.

Funders:
- Kruger National Park Rivers Research Programme
- Kruger National Park.

Current status: Completed.

Products:
- Venter, F.J., Biggs, H., Bestbier, R., Kruger, J., Havenga, B. and Freitag, S., (1997) Towards a management plan for the Olifants River. Unpublished proceedings of a workshop, Skukuza, Kruger National Park.
- Venter, F.J., Biggs, H., Bestbier, R., Kruger, J., Havenga, B. and Freitag, S., (1999) Towards a management plan for the Olifants River. Unpublished poster paper presented at the 36th SASAQS Conference, Swakopmund, Namibia.

Title: Towards a management plan for the Sabie River.

Aim: To promote the development of a strategy and action plan for the integrated management of the Sabie River.

Objectives:
- Enhancing capacity of river forums.
- Establishing a Desired Future State for the Sabie River.
- Setting appropriate objectives and goals for the management of the Sabie River.

Agencies involved:
- Kruger National Park Rivers Research Programme
- Sabie River Working Group
- Department of Water Affairs and Forestry
- Kruger National Park.

Funders:
- Kruger National Park Rivers Research Programme
- Kruger National Park.

Current status: Incomplete.

Products:
- Venter, F.J., Rogers, K., Bestbier, R. and Kruger, J., (1997) Towards a management plan for the Sabie River. Unpublished proceedings of two workshops, Skukuza, Kruger National Park.

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MONITORING SUBPROGRAMME

J. H. O'Keeffe and B. R. Madikizela

SUMMARY

- At least six organisations are involved with the monitoring of the Lowveld rivers, and the main responsibility of the KNPRRP Monitoring Subprogramme was to integrate and co-ordinate monitoring activities.
- The KNPRRP's Monitoring Liaison Committee became the hub of Lowveld river monitoring integration, and was able to take important new initiatives, such as the implementation of IFR monitoring. It will continue to operate after the Programme ends.
- Most of the objectives of the Subprogramme have been achieved, and additional activities were also undertaken, such as an identification of the similarities and differences between the KNP rivers, and the IFR monitoring.
- In association with the national River Health Programme, a set of monitoring indices have been developed and tested.
- Good progress has been made with training and capacity-building, with two trainee/researchers employed from the University of the North, and a Subprogramme partner from the University of Transkei.
- Mainly through the initiative of Kevin Rogers (Research Subprogramme) and Harry Biggs (KNP), innovative systems for focusing monitoring (Objectives Hierarchy and Thresholds of Probable Concern) and linking monitoring to management processes have been developed and are being tested.
- The chief criticism of the Subprogramme would be an inability to develop a consistent strategy and plan for a monitoring programme for all the rivers of the Lowveld. This was in part due to the diversity of organisations involved, and the need for urgent implementation of particular activities such as the IFR monitoring.
- The activities of the Subprogramme will continue after the end of the KNPRRP:
  - Short term (1 year): The similarities and dissimilarities of rivers of the KNP.
  - Medium term (3 years): Training and development for IFR monitoring.
  - Long term (indefinite): The River Health Programme, and the continuance of the Monitoring Liaison Committee.

Purpose

The purpose of the Monitoring Subprogramme is to design and implement a comprehensive monitoring strategy and action plan which achieves compatibility between river management goals, the development of predictive capabilities, research and monitoring.

INTRODUCTION

The rationale for a Monitoring Subprogramme in the third phase of the KNPRRP was: "to ensure that the objectives of Integrated Catchment Management are being achieved, and that the objectives for river management are being met. Monitoring is also required to support and validate understanding developed within the Research Subprogramme" (Breen *et al.*, 1997).

Within the rivers of the Lowveld which flow through the Kruger National Park there are a number of agencies with responsibilities for managing and monitoring, and a considerable amount of monitoring activity was already under way prior to the third phase of the KNPRRP:

- The River Health Programme (RHP) (part of the National Aquatic Ecosystems Biomonitoring Programme). This is a national initiative aimed at providing long-term information on the state of the rivers. A pilot project on the Sabie, Crocodile and Olifants rivers was launched in 1996. The RHP has been responsible for the development and testing of monitoring indices for fish, invertebrates, riparian vegetation, (all with associated habitat assessment methods), and for geomorphology. Indices for hydrology and water quality are at early stages of development.
- Mpumalanga Parks Board carry out an ongoing rivers monitoring programme, also concentrating on biomonitoring, and linked to the RHP.
- Northern Province Department of Agriculture and Environment also undertakes an ongoing biomonitoring programme on the province's rivers.
- The Kruger National Park has a biomonitoring programme on the reaches of river within the Park.
- The Department of Water Affairs and Forestry continuously monitors flow, and 'discretely' monitors water quality at more than thirty sites in the Lowveld rivers.
- SAFCOL has initiated a biomonitoring programme in the upper afforested catchments of the Lowveld rivers.

It was therefore important that the KNPRRP did not attempt to reinvent the wheel, but rather to help co-ordinate and improve the existing monitoring programmes to provide a comprehensive picture of the state of the rivers.

An aspect of monitoring in general which emerged during phase III is that monitoring programmes are often conducted in isolation from management, with the result that the methods are often ill-suited to the management requirements, and the results of the monitoring may never be used to inform or influence management. The need to "close the loop" between monitoring and management became a major focus of the KNPRRP during the third phase of the programme.

STRUCTURE AND PLAN FOR THE SUBPROGRAMME

The Phase III Programme Description (Breen *et al.*, 1997) assigned the purpose, objectives and tasks of the Monitoring Subprogramme at the start of Phase III of the KNPRRP, but these have been

modified in detail, particularly in relation to monitoring activities listed in the Introduction which were already being implemented. The changes in the purpose and objectives of the Monitoring Subprogramme reflect a need to synergise with these other initiatives, and to avoid duplication of effort, rather than to "design and implement a comprehensive monitoring strategy and action plan" in the words of the original Subprogramme description.

The purpose, objectives and tasks of the Subprogramme, listed below, are therefore a modification of the original brief, although they remain substantially similar. The following report is not restricted to activities that have been solely the responsibility of the KNPRRP, but includes many activities in which the KNPRRP has been involved, but which have essentially been the responsibility of other agencies. This is a necessary and desirable aspect of the Monitoring Subprogramme, that it has been primarily a co-ordinating, supporting and integrating exercise, seeking to cooperate with and add to existing activities as much as to develop new activities.

OBJECTIVES OF THE SUBPROGRAMME

- To develop a strategy and action plan for training and capacity building in monitoring;
- To identify monitoring needs and prioritise requirements for effective monitoring;
- To establish links with current monitoring programmes;
- To review current approaches to monitoring;
- To refine techniques and adapt methodologies, developing new techniques for integration into decision support systems; and
- To develop strategy and action plans for implementing a comprehensive monitoring programme for the KNP rivers.

This report will deal with each of the objectives in turn, reporting on the progress achieved and the remaining needs for each of the identified tasks within each objective.

Objective 1

- To develop a strategy and action plan for training and capacity building in monitoring.

Task 1.1

- Education of stakeholders to appreciate the relevance and importance of monitoring.

One of the first initiatives of the Subprogramme was to organise a Monitoring Liaison Committee. It has met twice a year to co-ordinate monitoring activities, to initiate the development of methods and training of personnel, and to disseminate information to stakeholders. The constitution and responsibilities of the committee are listed under Objective 3.

Among the achievements of the committee have been:

- initiation of a monitoring and training programme for instream flow requirements in the Luvuvhu and Sabie rivers;
- initiation of a project to describe the similarities and differences between the rivers of the KNP.
- Co-ordination of monitoring activities in the Lowveld. At the penultimate meeting of the committee within the KNPRRP, the members decided that so much benefit had been gained from the organisation that it should be maintained beyond the end of the Programme. From the year 2000 the committee will become known as the "Lowveld Rivers Monitoring Liaison Committee", and Professor O'Keeffe has undertaken its coordination.

Task 1.2

- Designing a regional training programme in monitoring techniques.

Under the auspices of the DWAF and the CSIR, a series of monitoring training courses has been run by members of the RHP. The course has now been conducted three times, and has received over 90 participants. The last course was organised by the Institute for Water Research (IWR), and a further course is planned for February 2000, also organised by the IWR.

Task 1.3

- Mechanisms for providing assistance to neighbouring countries.

The Shared Rivers Initiative, a joint river research and management programme between South Africa, Swaziland and Mozambique, will begin in 2000, and will have a substantial monitoring component, to develop methods and initiate training.

Task 1.4

- Participation of universities and technikons.

Professor O'Keeffe has initiated a project funded by the WRC, to train personnel from local universities and technikons in the Lowveld in monitoring techniques and management. The WRC has made funding available for three years, and the main aim is to prepare trained personnel to take over the management of DWAF river monitoring for IFRs in the Sabie and Luvuvhu Rivers. The training will be conducted by Andrew Deacon (KNP), Johan Engelbrecht (Mpumalanga Parks Board), Mick Angliss (Northern Province Nature Conservation), Dr Wynand Vlok (University of the North) and Prof Jay O'Keeffe (Rhodes University).

The project was initiated at the beginning of September 1999, and two trainees have been appointed. They are Jennifer Newenham and Support Shabalala, both part-time Honours students from the University of the North.

Mr Bonani Madikizela, MSc, a Research Officer from the Department of Zoology at the University of Transkei, was appointed Subprogramme partner for Monitoring. He has attended the PDMC and Monitoring Liaison Committee meetings, and has been included in a training capacity in the Olifants River Ecological Reserve Project, together with Mr Thobile Bokwe, also from UNITRA.

Objective 2

- To identify monitoring needs and prioritise requirements for effective monitoring.

Task 2.1

- Identify monitoring needs in IRM, Research and IM&F Subprogrammes.

The Subprogramme managers attended meetings of the Monitoring Liaison Committee and outlined their needs to the members. From these meetings it was agreed that the relevant members of the committee would assist Mark Dent and Yvette Coetzee to identify and collate information on the Sabie River for incorporation in ICIS.

Task 2.2

- Prioritise requirements.

An initial meeting of members of the RHP and the KNPRRP was held in October 1997 to identify monitoring priorities nationally for the Subprogramme. The following list is a summary of the identified priorities, with generic time-scales for achievement:

- develop expertise in different provinces (Long term);
- conformity at the national level (Long term);
- site selection and reference conditions (Long term);
- low-tech/high info indices and methods (Long term);
- further development of SASS (Short term);
- development of data storage/retrieval/analysis/presentation technology (Should begin immediately, but long term to achievement);
- regionally applicable fish and riparian vegetation indices (Short term for river/province applicable indices, but long term for regionally applicable indices);
- indices for geomorphology, hydrology, and water quality (Rough indices available, need short term development and testing, but long term to final development);
- training - partner/manager; technicians for routine monitoring; partnerships between research institutions (Immediate start, but long term to achieve results);
- archiving of biological materials (Long term).

It was felt that the development of usable indices should be the single most important research and development priority. To date the following developments have been achieved:

- geomorphology (Index developed under the auspices of the RHP, and has now been published as Volume 7 of the RHP series. Testing continues and funding has been made available for the production of a photographic guide and manual);
- riparian vegetation (Index being developed under the auspices of the RHP. A report on the index was delivered by Nigel Kemper in August 1999. Testing continues);
- upgrade of SASS Index (Workshop held under the auspices of the RHP in November 1998, and a proposal for further development has been written and submitted to the WRC);
- hydrology (Index developed in concept under the auspices of the RHP. Funding has been made available for further development and testing in 1999);
- fish (FCII Index developed for lowveld rivers by Dr Kleynhans of the IWQS, DWAF).

Objective 3

- To establish links with current monitoring programmes.

Task 3.1

- Identify regional initiatives.

Accomplished (see 3.3 below).

Task 3.2

- Identify national initiatives.

Accomplished (see 3.3 below).

Task 3.3

- Establish Technical Co-ordinating Group to facilitate communication between other monitoring efforts.

The Monitoring Liaison Committee continues to co-ordinate all the monitoring activities in the lowveld rivers. The committee includes members from:

- KNPRRP;
- South African National Parks;
- CSIR;
- DWAF;
- Mpumalanga Parks Board;

- Northern Province Department of Agriculture, Land and Environment;
- SAFCOL.

The Committee has undertaken the following tasks:

- reports on monitoring activities in lowveld rivers;
- review of progress on KNPRRP projects;
- co-ordination of monitoring development in the lowveld;
- determination of development priorities;
- initiation of the IFR monitoring on the Sabie and Luvuvhu rivers;
- training of monitoring personnel;
- in addition, the committee will link to the new task identified for the Integrated River Management Subprogramme, to form Water User Associations.

Task 3.4

- Utilise electronic networks for updating stakeholders and interested parties.

This task was not addressed in detail.

Objective 4

- To review current approaches to monitoring, with a view to identifying techniques and methodologies which may be appropriate.

This objective has been continuously addressed in co-operation with the RHP. Among the intermediate objectives of the RHP are:

- a technical specification for the RHP;
- a version/prototype of each of the technical components exists;
- technical training is available;
- information is in a useful format that can be used by water management agencies.

The achievements of the KNPRRP Monitoring Subprogramme are being fed into the RHP strategy, and the activities of the Subprogramme have been designed to achieve a number of these objectives.

Objective 5

- To refine techniques and adapt methodologies, developing new techniques for integration into decision support systems.

Task 5.1

- Monitoring indices for riparian vegetation.

A report on the method has been presented by Nigel Kemper (IWR Environmental) in August 1999, and the method is being tested, in particular in the Luvuvhu and Sabie Catchments. Nigel Kemper presented a training course to the lowveld conservation agencies in November 1999.

Task 5.2

- Monitoring indices for hydrology.

Funding has been made available for further development and testing by Professor Denis Hughes (IWR) by the RHP, for the present financial year.

Task 5.3

- Developing a link to the "Desired Future State" goals.

The further development and implementation of Thresholds of Probable Concern (Rogers and Bestbier, 1997) is continuing. Their incorporation in an objectives hierarchy for all the different aspects of the KNP, including the rivers, is part of the strategy of the KNP. The monitoring programme in the KNP rivers still needs to be fully directed at the measurement of trajectories towards TPCs.

Task 5.4

- Assessing the success of an IFR in estimating the requirements of a desired future state.

The Monitoring Liaison Committee, in association with the Social and Environmental Studies Directorate of the DWAF, has devised a plan and timetable for the implementation of the baseline monitoring phase of the Sabie IFR recommendations. Funding has been provided by the WRC to help with some aspects of the monitoring and to train monitoring personnel (see Task 1.4).

Task 5.5

- Incorporating bioaccumulation techniques in the monitoring programme.

This task has not been addressed by the Subprogramme.

Objective 6

- To develop strategy and action plans for implementing a comprehensive monitoring programme for the KNP rivers.

Task 6.1

- Provide regular reports on monitored components.

Progress reports have been provided for the PDMC meetings, as well as minutes of the meetings of the Monitoring Liaison Committee. In addition, Dr Andrew Deacon of the KNP continues to produce editions of a newsletter entitled *State of the Rivers: Kruger National Park* which will be sent to stakeholders and interested parties, providing a graphical and simple explanation of the status of the rivers.

Task 6.2

- Compare monitored components with predicted values from models.

The WRC funded a three year project for a second phase of the BLINKS model, linking the effects of changing flow regimes to the effects on habitat diversity and availability, and therefore to key elements of the biota.

Task 6.3

- Provide feedback to the Research, IRM and IM&F Subprogrammes.

Feedback has been provided in terms of the PDMC meetings and progress reports, and the Monitoring Liaison Committee meetings and reports.

Task 6.4

- Provide data on monitored components for integration into ICIS.

At the April 1999 meeting of the Monitoring Liaison Committee, members of South African National Parks and Mpumalanga Parks Board agreed to provide monitoring data for inclusion in ICIS. Yvette Coetzee is co-ordinating data input to ICIS and will train National Parks personnel in its use.

Task 6.5

- Provide for regular review of progress.

Regular report-backs and reviews continue to be held via the PDMC meetings and the meetings of the Monitoring Liaison Committee.

Task 6.6

- Provide regional assessments which contribute to the national context.

The RHP, regional monitoring initiatives and the KNP monitoring programme continue to provide updates on monitoring activities through the Monitoring Liaison Committee.

ADDITIONAL TASKS IDENTIFIED AND CARRIED OUT DURING PHASE III

The above section reports on the objectives and tasks which were initially identified for the Subprogramme. This section addresses additional tasks which became apparent during Phase III and which were added to the objectives for the Subprogramme.

IFR monitoring in the Sabie and Luvuvhu Rivers:

In 1996 the instream flow requirements were set for the Sabie and Sand rivers, in response to the building of the Injaka Dam on the Marite tributary of the Sabie River. In 1997 the DWAF organised a workshop to design a monitoring programme to:

- provide baseline information, mainly at the IFR sites, on pre-impoundment conditions against which to judge the effects of subsequent IFR flows;
- monitor whether the recommended flows were being provided at the IFR sites;
- monitor whether the IFR flows provide for the conditions in the rivers for which they were designed.

By the beginning of 1999 the monitoring programme had not been implemented by the DWAF, and the situation was becoming urgent because the construction of the Injaka Dam was advanced and the opportunity for pre-impoundment monitoring was being lost.

The Monitoring Liaison Committee took the initiative to find funding and personnel to initiate the IFR monitoring programme. The WRC agreed to provide funding, primarily for training and method development, and the project began in September 1999.

Two trainees have been appointed, and a programme of monitoring tasks has been agreed on with the KNP, Mpumalanga Parks Board, and the Northern Province Department of Agriculture and Environment. The project will last for three years, after which the plan is to provide the catchment management authorities with trained personnel capable of managing and implementing an effective biomonitoring programme aimed at assessing the effectiveness of IFRs in the Lowveld rivers.

Operationalising monitoring data

Ensuring effective communication of monitoring results and implementing management responses are essential for the effective use of a monitoring programme, but these vital links are often missing. The result is that monitoring information is either stored ineffectively until some crisis occurs, or inappropriate information is collected. The KNPRRP has made several highly successful contributions to this process of "closing the loop" between the monitoring of systems and their management.

The development of an objectives hierarchy leading to the identification of Thresholds of Probable Concern (TPCs) (Rogers and Bestbier, 1997) has been a very effective method in focusing monitoring into detailed and auditable methods which are aimed at identifying the components of a system which best indicate any trajectories of change. These methods have now been adopted for the terrestrial as well as the aquatic components of the KNP, and have resulted in a fundamental shift in the management processes for the Park. Where previously data were collected in vast amounts without careful consideration of their purpose and relevance, the new monitoring programmes are being designed to minimise monitoring effort while optimising the information gained. All the TPCs are designed to contribute to the assessment of whether Park Management is achieving its objectives, which are now carefully articulated from the broad level of the vision for the Park, through different levels of resolution to the state or condition of individual components.

The next contribution of the Programme is to design and put in place management procedures which will ensure that the results of the monitoring are fed through the system to contribute to the management of the Park. Professor Kevin Rogers has articulated a conceptual system linking the aims, design and analysis of monitoring programmes to research output on one hand and to management decision making, implementation, and auditing on the other. The components feed back to each other, so that, for example, if a monitoring report indicates a problem (such as the imminent exceeding of a TPC), there are automatic pathways to management response and to feed into research needs.

EVALUATION OF THE ACHIEVEMENT OF THE OBJECTIVES

To develop a strategy and action plan for training and capacity building in monitoring

The WRC project for IFR monitoring, the communication and discussion through the Monitoring Liaison Committee, and the involvement of Mr Madikizela as Subprogramme partner have all been successful attainments in relationship to the above objective. However, much of this activity has been developed *ad hoc*, rather than as the result of a carefully designed strategy.

To identify monitoring needs and prioritise requirements for effective monitoring

These were identified at the beginning of Phase III, and the main objectives, such as the development of monitoring indices, were achieved with the co-operation of the RHP.

To establish links with current monitoring programmes

The Monitoring Liaison Committee proved a most effective forum for linking the various Lowveld monitoring activities. This, with Professor O'Keeffe's involvement on the committee for the national RHP, as well as with the development of implementation methods for the Ecological Reserve under the new Water Act, has meant that there has been very close and effective interaction between the KNPRRP and the other monitoring programmes countrywide.

To review current approaches to monitoring

This is an ongoing priority of the RHP, and the KNPRRP was able to feed developments into this process. Because of the diversity of different organisations involved in monitoring in the Lowveld rivers and nationally, it has sometimes been difficult to implement the developments of the KNPRRP nationally. For example, the process of setting objectives for monitoring through an objectives hierarchy and the setting of TPCs has clearly been very successful in focusing the monitoring strategy of the KNP, but is only gradually being appreciated elsewhere.

To refine techniques and adapt methodologies, developing new techniques for integration into decision support systems

Once again the objectives hierarchy methods, and the project to "close the loop" between monitoring and management (championed by Professor Rogers and Dr Biggs) have been the major developments of the Programme. In general, the monitoring techniques and methodologies have been developed under the auspices of the RHP with some input from the KNPRRP.

To develop strategy and action plans for implementing a comprehensive monitoring programme for the KNP rivers

This has to some extent been achieved, but without the *a priori* planning which was initially envisaged. There are two main reasons for this:

- the number of monitoring activities (under the control of different organisations) which were already operating in the Lowveld rivers before the start of the KNPRRP monitoring Subprogramme. Each of these organisations have their own aims and agendas, and a fully integrated programme will take some time to be achieved. Considerable progress in co-operation and communication has, however, been achieved;
- the failure of the DWAF to implement IFR monitoring in the Sabie and the Luvuvhu rivers, in both of which major water resource developments are being constructed, left the KNPRRP and provincial conservation agencies with the need to activate a "fire-fighting" policy, rather than to develop an integrated plan with all the responsible agencies.

IMPLICATIONS FOR MANAGING RIVER SYSTEMS

The monitoring programme for the Lowveld rivers is intended to provide managers with accessible up-to-date information on the state of the rivers. Within the KNP, this information is being linked to specific objectives which will identify when trajectories of change in the rivers are approaching undesirable conditions, and to a management system which will automatically audit the information and take the appropriate action. As yet this comprehensive monitoring/management approach has not been adopted by the other agencies (DWAF and the provincial nature conservation agencies). They are well aware of the development of the KNP systems, and will hopefully see the advantages of this holistic approach when it is fully implemented. At present, however, the other agencies are more allied to the national RHP approach, which is more aimed at general state of the environment reporting rather than at specific problem identification.

The KNPRRP has substantially contributed to providing the tools for integrating monitoring into the management process, and the river monitoring programme for the Lowveld rivers is the most sophisticated and effective in the country.

CONCLUSIONS

Overall, the Monitoring Subprogramme has achieved most of its objectives, and has gone considerably beyond those originally envisaged. The Subprogramme has interacted well with the other Subprogrammes, and the Research Subprogramme in particular has provided very innovative developments in focusing monitoring processes and the integration of results into the management process. The Subprogramme has also been flexible in its approach to problem solving, and has been able to take the initiative in implementing urgent IFR monitoring on the Sabie and Luvuvhu rivers. Considerable training and capacity-building, particularly among the formerly disadvantaged Universities of the North and Transkei, has been achieved and will continue to grow with the WRC project on IFR monitoring.

A criticism of the Subprogramme would be that, although many of the individual objectives have been achieved beyond the original expectations, an overall strategy has yet to be developed and implemented. As discussed above, this is partly associated with the number and diversity of the management agencies involved in monitoring.

RECOMMENDATIONS

Continuing from the previous section, the advantage of the diversity of organisations and programmes involved in monitoring is that there is plenty of scope for the continuation of the Subprogramme's initiatives beyond this millennium, when the KNPRRP officially ends.

The main recommendation would be that these initiatives continue to be pursued. The Subprogramme manager, Professor O'Keeffe, has undertaken to co-ordinate the continuation of the Subprogramme's activities:

- in the short-term (the next year), the project to determine the similarities and differences of the KNP rivers will continue (as long as the expected funding is provided);
- in the medium term (the next three years), the IFR monitoring project will continue to train personnel and develop the techniques for this specialised form of monitoring;
- in the long-term (indefinitely), the River Health Programme will continue to gather momentum, and will be expanded to many other rivers. A major effort should be continued to incorporate the developments of the KNPRRP into this national initiative;
- the Monitoring Liaison Committee will continue to meet, under its post-KNPRRP name (the Lowveld Rivers Monitoring Liaison Committee), and will act as a hub for discussion, development of techniques, and dissemination of information.

PROJECTS RELATED TO THE MONITORING SUBPROGRAMME, INITIATED DURING PHASE III

Title: To identify similarities and differences between the rivers of the Kruger National Park, towards the design and testing of a classification framework to aid management of the KNP rivers by contributing to effective monitoring.

Commencement date and project duration: This project is being conducted in 2 parts, Phases I and II; Phase I has been completed. A proposal has been submitted for Phase II of the project to run from September 1999 to June 2000.

Funding agency: Water Research Commission.

Responsible research organisation: Institute for Water Research, Rhodes University.

Project aims:

The aims of the project (Phases I and II) are to:

- collate available (current and historical) information concerning selected physical and biological variables for the Crocodile, Sabie, Olifants, Letaba and Luvuvhu rivers;
- extrapolate knowledge from data-rich (*e.g.* Sabie River) to data-poor rivers or sections of rivers, by finding similarities and differences between the selected rivers or sections of rivers;
- assist in establishing expected natural conditions and biota;
- produce an index or matrix of similarity or dissimilarity in order to produce a classification framework for the KNP rivers;

- determine how different the rivers are, in order to manage and optimize monitoring programmes for these differences.

The first and fourth aims were addressed and funded in part by Phase I.

Current status and products. Phase I lasted for a year and finished in December 1998. Progress was hampered by the resignation of the main project worker in the middle of Phase I, and it was only possible to identify new workers, bring them up to speed in the project aims and methods, and produce a plan for Phase II. The final report on Phase I and a proposal for Phase II was submitted to the WRC in July 1999.

Title: The development of monitoring methods for the Ecological Reserve (quantity) for rivers (also known as IFRs)

Commencement date and duration: May 1999, until December 2001.

Funding agency: Water Research Commission.

Proposer and responsible organisation: Institute for Water Research (IWR), Rhodes University.

Collaborating organisations:

- Department of Water Affairs and Forestry;
- South African National Parks;
- Mpumalanga Parks Board;
- Northern Province Department of Agriculture, Land and Environment.

Aim: To develop and test monitoring methods that will a) check that the recommended ecological flows are being delivered to the different reaches of the river and b) assess whether the recommended flows are achieving the objectives for which they were designed.

Objectives:

- To design an IFR monitoring programme that will achieve the aim with the minimum costs and resources.
- To test the programme on two rivers.

Current status: The project was begun in September 1999. Two trainee researchers have been appointed, and development of the monitoring programme will commence in October.

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CORRECTIVE ACTION SUBPROGRAMME

C. M. Breen and J. Jaganyi

INTRODUCTION

The democratisation of South Africa has exposed just how marginalised sectors of society were. The need for corrective action was urgent. A consequence of marginalisation is the gap in experience and understanding which exists between those who were marginalised and those who were not. The challenge is to close the gap quickly and efficiently. This requires committed effort from those who are ahead and those who are behind. It is the synergy between these groups which advances the speed at which corrective action occurs. The statement of purpose for this Subprogramme was founded on the philosophy that marginalised individuals and institutions should be brought into working contact with the KNPRRP thereby enabling them to contribute to and benefit from the Programme.

The purpose of the Corrective Action Subprogramme is to use the experience and activities of the Programme to enhance the capacity of HBUs and previously marginalised people to enable them to provide leadership in river research.

There is potential tension between the need to deliver products and outcomes which advance understanding and technology and the need to achieve corrective action. A balance is required whereby the front moves forward and the gap is narrowed. There is also potential tension when progress with corrective action is measured in numbers of individuals. This is because the greater the effort directed to increasing depth of understanding the more specialist knowledge is required and the fewer people are able to engage the endeavours.

Purpose

Progress is evaluated against each of the objectives defined in the Phase III Programme Description.

Objective 1

- The development of a strategy and action plan for training and corrective action.

The strategy required:

- specialist engagement by appointing Subprogramme manager partners and involving them in management of the Programme;
- institutional engagement by identifying 'target' historically Black universities and supporting the FRD (now NRF) in their efforts to promote trans-disciplinary research at these institutions;
- providing training opportunities by way of a training course based on technologies and understanding developed during the KNPRRP;

- building the capacity of stakeholders by engaging and supporting interest groups, particularly the emerging river forums, in promoting river management, using technology and expertise developed in the KNPRRP;
- fostering relationships with researchers and resource managers in Swaziland and Mozambique with a view to enhancing their capacity in river system management.

Objective 2

- The phased implementation of a training and corrective action plan.

The first action was to appoint Subprogramme partners, taking account of race and gender. The following were appointed:

- Joan Jaganyi - biologist
- Josh Maganbeharie - hydrologist/GIS
- Asaph Ndlovu - social geographer
- Bonani Madikizela - biologist
- Maritza Uys - lawyer

Towards the end of Phase III, Maganbeharie took up a new appointment which precluded his further involvement with the KNPRRP. Beason Mwaka (hydrologist) joined the team from the University of Zululand.

The views of the Subprogramme partners concerning their experiences are reported independently later in this report.

We provided additional support for partners by:

- delivering a presentation to Maganbeharie's colleagues at DWAF;
- enabling Jaganyi to attend a biodiversity management course in the USA. She achieved excellent marks and we anticipate that her experience will be put to good use in a number of areas of natural resource management;
- enabling Madikizela and a colleague, Bokwe, to be included in a training capacity building exercise on the Olifants River Ecological Reserve Project.

The second step was to develop institutional links with HBUs.

Objective 3

- Institutional links with two HBUs.

The Water Research Commission and the Foundation for Research Development (now the National Research Foundation) are committed to enhancing research capacity at historically Black universities. The intention was to build on these, particularly the NRF efforts to promote research 'thrusts' at these

institutions. We also intended that experience gained by those research partners drawn from HBUs would feed back into these institutions. Initially three HBUs were identified; the University of the North because Mr Ndlovu from the Department of Geography accepted the invitation to serve as a Subprogramme partner, and the Universities of Venda and Zululand because they were developing thrusts in which river systems were to feature prominently.

We envisaged 'institutional links' between the KNPRRP and the thrust teams which were being facilitated by the NRF. The notion of developing these links independent of these thrusts seemed to us to be counterproductive. We, therefore, anticipated using the momentum of the NRF process to direct interaction with KNPRRP. This proved to be very frustrating. Our vision was a close association – perhaps even a mentoring role, in the development of the thrusts, or at least that component which addressed river research. We suggested this several times, especially when our interaction with the process of thrust development at their institutions suggested to us that it could benefit from more dedicated support and interaction with experienced researchers.

The NRF policy is one of facilitating 'in house' development of the thrusts with infrequent interaction, during workshops, with experienced researchers, in our case Drs Dent, Rogers and Breen. Thus, close frequent contact, review and mentorship were not facilitated. A formal institutional association was not promoted by the NRF.

During the term of Phase III, Mr Madikizela from the University of Transkei was appointed as the partner in the Monitoring Subprogramme. This enabled us to interact with the University of Transkei. Formal links were, however, not pursued.

Objective 4

- Transfer of information, understanding and technology to HBU team.

Attempts to transfer information, understanding and technology via the teams set up by the NRF to formulate thrusts was only marginally successful. We were able to influence the University of Zululand team to consider a more integrated approach than the ''cluster' of projects they originally had in mind. We believe, however, that the complexity of integration (see David R. Dent, 1997, Box 13) and the consequent requirement for dedicated management (experience from the KNPRRP) are neither sufficiently understood nor appreciated.

In an effort to provide a 'backbone' for integration, Dr Mark Dent and colleagues from the CCWR, have focused on information and technology (ICIS and HSPF) transfer to Professor Kelbe's hydrology group. This has been well received and we envisage an enduring and expanding influence on the furtherance of river system research at the University of Zululand.

We have been less successful with engaging the University of Venda. Here our contribution has been restricted to influence during a number of workshops organised by the NRF and to comment on thrust documents. We view this as a lost opportunity.

Involvement of Mr Madikizela and a colleague, Mr Bokwe, in the work of the Monitoring Subprogramme has had an institutional influence in the Department of Zoology at the University of Transkei.

Objective 5

- Partners in research development and management.

The intention here was to:

- become thoroughly familiar with current activities, strengths, weaknesses, opportunities and threats to establishment of trans-disciplinary programmes at each HBU;
- build vision and design an appropriate programme;
- obtain resources to implement the programme;
- monitor participants and progress.

Box 13: Strategic Management in an Olive Integrated Pest Management Programme (Dent 1994).

"In terms of scientific management, multidisciplinary research is highly demanding. This is due to the difficulties associated with bringing together scientists from different disciplines to formulate and implement a research strategy, and in the process integrate the various individual components to produce a unified IPM system. This is not an easy task. Strategic management provides a framework around which Programmes can be designed, in order to overcome some of the difficulties of collaborative multidisciplinary research.

Strategic management may be defined as an integrating pattern of activities that concentrates resources into those areas which offer the best prospects of obtaining specified goals (Karlof, 1987). In the modern business world it takes into account social attitudes, legal structures, markets, resources, technologies, organisation and management; the whole system that involves the customer, the business and the world from which the business derives its resources (Sanders and Bradman, 1991).

As has been explained earlier the NRF chose to 'drive' the initiative without promoting external mentorship. Whilst this certainly has the advantage of requiring the local institution to organise itself to deliver the Thrust proposal, it has the disadvantage that a weak institution does not have support and adequate facilitation. In our opinion this is reflected in the quality of the plan underpinning the thrusts and in the individual proposals. A surprising anomaly is that evaluation forms for project proposals emanating from these institutions specifically require comment on whether the proposer could benefit from mentorship.

Anticipating that river systems will have to be managed in an integrated manner, from source to sea, we engaged colleagues in the Universities of Swaziland and Mozambique. The result has been a joint proposal funded by SIDA. The specific intention of the proposal is to develop partnerships in research development and management and to build capacity in universities in neighbouring countries.

Evaluation and Conclusion

The value of the 'partner' initiative was acknowledged by participants as providing valuable growth and development in the organisation and management of integrated trans-disciplinary research. That similar partnerships were not promoted by NRF within the thrusts initiative contributed to the low level of success achieved with HBUs. Despite this there has been sufficient interaction with the Universities of Zululand and Transkei for an enduring beneficial effect.

Building relationships is a slow process because it requires first that trust is established between potential partners. This has been clearly demonstrated in our efforts to develop a joint venture with colleagues in Mozambique and Swaziland.

One cannot achieve corrective action in a vacuum. By definition corrective action requires opportunities and enabling processes to engage the opportunities successfully. The importance of identifying the opportunities unambiguously and of establishing the required process should not be underestimated. If it were simple it would happen spontaneously. That it does not attests to the difficulties which have to be overcome. Far too little attention is given to organisation, planning and management. This is not a peculiarly South African issue (Dent 1994; 1997). A much more strategic and dedicated approach will be required if capacity for trans-disciplinary research on any significant scale is to be institutionalised at our universities, whether they be HBUs or not.

Recommendations

It is strongly recommended that a much more strategic approach to corrective action is adopted. This will require greater attention to:

- organisational structure,
- processes including planning, appraisal and reward, and
- resources, human and financial.

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THE PERCEPTIONS OF THE KRUGER NATIONAL PARK AND PROGRAMME PARTNER REPORTS

The Influence of the KNPRRP on Processes and Approaches in Ecosystem Management in the Kruger National Park

Freek Venter, Harry Biggs and Leo Braack

Intensified land use in the catchments of the rivers flowing through the Kruger National Park (KNP) during the past half century has caused degradation of the rivers to the point where biodiversity loss has become a major undermining factor to the conservation goals of the KNP. The South African National Parks (SANP), as legal custodian of the KNP, embraces the goals of the IUCN for national parks. The KNP's own conservation goals make provision for the conservation of biodiversity, the provision of human benefits and the preservation of wilderness qualities.

The degradation of the KNP rivers was further amplified by the droughts experienced in the early 1980s, which triggered national interest in the KNP rivers and led to the establishment of the Kruger National Park Rivers Research Programme (KNPRRP) in 1988. Although the KNPRRP focused mainly on one or two of the KNP rivers at a time, its products could eventually be applied to the other rivers as well. It has even found non-riverine applications in the KNP and has penetrated the realms of science, monitoring, decision-making and management of terrestrial systems.

The KNPRRP represented a collaborative initiative which involved several KNP researchers, and an important opportunity for these KNP researchers to become involved in far larger, national teams functioning in an inter-disciplinary, integrated manner. These methodological insights have found fertile ground and are also being incorporated in non-riverine KNP planning and management processes.

Focused research, guided by a national team of inter-disciplinary, multi-organizational participants, led to a clearer understanding of the key factors influencing riverine conditions. The KNPRRP facilitated the formulation of desired states expressed as clear objectives, an integrated approach of how to achieve the desired state, an understanding of the processes whereby this should be achieved and a monitoring system to keep track of riverine system changes. It also provided a Decision Support System with appropriate loops to accommodate technical input and management feedback and to ensure information flow and appropriate reaction to address changes occurring in the system. Most recently it has explicitly encouraged Strategic Adaptive Management by developing specific mechanisms to accomplish this effectively.

The interactive process of clear problem and goal definition, clear goal measurement parameters (e.g. Thresholds of Probable Concern), together with effective feedback between research and management which has emanated from the KNPRRP, has perhaps been one of its greatest achievements in terms of potential benefit to ecosystem management within the KNP. These more intangible products are now

being integrated into the approaches of emerging Catchment Management Agencies as well as that of KNP ecosystem managers.

The KNPRRP built tremendous capacity both within and outside the KNP in river research and management. One area where it made its influence felt was in the ability of KNP rivers researchers to participate in Instream Flow Requirement assessments and thus to "bargain for water" for the KNP rivers on scientific grounds. The Programme also entrenched an understanding of the importance of KNP rivers in the view of other stakeholders in the river catchments. No meeting in the catchments or elsewhere concerning rivers of the KNP is held nowadays without seeking the presence of KNP staff. SANP views are taken very seriously, especially by the DWAF. Several proposed developments with potential impacts on the KNP rivers were shelved because SANP officials were unhappy about their potential impacts on the KNP.

The KNPRRP had a notable, albeit indirect, influence on the shaping of the new National Water Act and on the eventual inclusion of the Reserve idea in the Act. Based on provisions made for the Reserve in the Act, the KNP is in the process of securing adequate flows for the KNP rivers.

The KNPRRP has also:

- built capacity for interdisciplinary work (especially biophysical-engineering/hydrology/ hydraulics) but also some in the ecological-economic field;
- strengthened surrounding community perceptions of the ecological needs of our rivers;
- led to some of the ecological needs of KNP rivers being met (as a result of liaison and goodwill) even before legislation was updated;
- built capacity for participation in legal processes;
- promoted the cause of environmental water in South Africa by drawing attention to the plight of the KNP rivers;
- brought terrestrial and aquatic scientists closer together.

One of the most important outcomes of the KNPRRP is the recognition that rivers are extremely complex systems which require complex management systems. There are no easy answers for managing rivers and the continued input of high-quality research products is therefore of the utmost importance.

The KNPRRP has made a significant impact on science and management in the KNP. History will tell whether the impact of the KNPRRP will be looked back on as a discrete, important contribution not only to river management but also more generally to processes and approaches in the KNP.

CORRECTIVE ACTION: J. JAGANYI

STATEMENT OF ASSOCIATION WITH KNPRRP

Prof. Charles Breen recruited me into the KNPRRP in March 1998. I was then in the final stage of completing my PhD in Entomology at the University of Natal-Pietermaritzburg. The project title was, "Response of CARABID and CICINDELID beetles to various types of landscape disturbances (forests, grasslands, agriculture) ". Since then, the KNPRRP has enabled me to get academic and professional exposure in river research and management at national and international levels.

Specifically, the KNPRRP made it possible for me to attend the biodiversity Conservation Planning Course, at the University of Illinois, Chicago, USA, sponsored by USAID (August 1998 - December 1998), where I acquired skills relating to the management of whole ecosystems (i.e. Integrated Catchment Management) to achieve sustainable development.

The Subprogramme manager's meetings and the PD& M committee meetings have been an on-going learning experience, particularly in the style and manner of their operations. The research findings and resource materials produced within each Subprogramme provide extremely useful reference and learning material.

Specifically, my association as Partner to Prof. Charles Breen has given me a ‘quantum leap’ and a focused direction in my professional career. Prof. Breen has made it possible for me to reach and release the potential power to engage in river research and natural resource management. In addition to exposing me to key role players in water research and management in South Africa, he taught me how to write proposals and budgets for funding, networking skills and to be confident. My association with the KNPRRP has truly empowered me and built a capacity within me to undertake water research and management. For instance, a water research proposal looking at rural community needs and dependencies on river system resources and how these affect the ecological reserve has been funded for the year 2000 and 2001 by the Water Research Commission.

I am happy and grateful to be associated with KNPRRP.

MONITORING: B. MADIKIZELA

A SUMMARISED REPORT ON THE EXPERIENCE GATHERED DURING THE LAST PHASE OF THE KNPRRP

Joining

I joined the KNPRRP late (October) in 1998 through persuasion by Professor J.H. O'Keeffe (Rhodes-IWR). By that time the Programme was mid-way or more into its final phase (Third Phase).

Participation, experience and benefits

In less than a year of my involvement, I have gathered very helpful information through participation in meetings both in Pretoria and at Skukuza (KNP). In Skukuza meetings were focusing on monitoring (my Subprogramme), river classification and IFRs. Through my involvement with KNPRRP, I was also invited (by Dr C. Palmer, IWR) to participate and prepare a report on PES of the middle-reaches of the Olifants River, Mpumalanga, with a colleague from IWR (Dr P. Scherman) and Mr N Roussow (Ninham Shand Inc.). I was also invited to attend a workshop on IFR in Grahamstown by Ms Delana Louw (IWR) and Professor J. O'Keeffe.

I also attended a Biomonitoring course in Grahamstown (IWR) which improved my participation in the KNPRRP.

The experience I gathered also helped me in my project (Umzimvubu Catchment Project) on water quality and faunal studies, as well as tolerance tests (using kaolin as silt or test material on selected macro-invertebrates). The report will be submitted (Final report) in November 1999 to the WRC, the funders.

Generally, I gathered a lot of information through meeting with various specialists in the field of freshwater ecology - a wonderful opportunity.

I shall not hesitate to join such programmes of national interest in future, should I be invited to do so!

INFORMATION MANAGEMENT & FACILITATION: J. MAGANBEHARIE

During mid-1997, my supervisor informed me of a capacity building post within the KNPRRP. In October 1997 I was appointed as Deputy Subprogramme Manager: Information Management and Facilitation under the supervision of Subprogramme Manager Dr Mark Dent. The purpose of the IM&F Subprogramme was to maintain and develop the Integrated Catchment Information system (ICIS) and to ensure that the information and understanding acquired, and technology developed within the Programme was shared effectively between resource managers, stakeholders and researchers.

Although the primary function of my association with the project was capacity building, I also had to promote both awareness of the project and the Subprogramme product, viz. the Integrated Catchment Information system (ICIS). To enable capacity building, I had to attend quarterly meetings of the Subprogramme managers and the Programme Management and Development Committee (PDMC).

The meetings of the Programme managers were very informative from a capacity building point of view. It was extremely useful to see how such a large-scale programme was to be effectively managed. The managers had to have detailed strategic work plans developed that took into consideration the project as a whole. There was a lot of emphasis on alignment between the different Subprogrammes and the Programme managing director, Professor Charles Breen was phenomenal in keeping the project on track and absolutely relevant. Often in such projects the issue of "scope creep" sidetracks and hinders the project, however a good leader can often "pull" the project in the correct direction. I must confess that I learnt a lot from Prof Breen's managing style by just listening to him. Dr Mark Dent was also quite instrumental in helping to build my capacity. Dr Dent used many principles from his recent Masters in Business Leadership studies for his Subprogramme work. I have used on many instances in my own job issues that I learned in the KNPRRP. My work plans and ways of dealing with issues now reflect a lot on the experiences gained from the project.

On the promoting side, I successfully arranged a workshop and demonstration for the interested parties at my work environment. There was relatively good attendance of the workshop and many new contacts were made. GIS people were quite impressed by the amount of work that had gone into the ICIS development and were amazed at the functionality of the Arcview GIS package. I too would have liked to get into the development of ICIS since I have some experience in Arcview, however, my current work obligations did not allow for this. Learning from real software experts such as Rajesh Nundlall and Mike Horn was also very interesting to me. I used their expertise in my own work tasks as well.

The KNPRRP also afforded me the opportunity to meet various people that I gained a lot of insight from during the meetings and workshops. I was delighted to be able to actually visit the Kruger Park through the project. It was my first experience of the Park and the visit suddenly put a lot of perspective on my view of the project. It certainly gave a more realistic feel to the project. I feel that perhaps more field visits should be encouraged in projects such as the KNPRRP. The social function arranged by Dr Leo Braack was superb both as a team-building exercise and social occasion.

The KNPRRP project was divided into three phases together with different Subprogramme managers at different phases and different members at different stages of the Programme Development Committee. I feel that perhaps the project should have used a more graphical tool to illustrate both progress and tasks of the entire project. There was perhaps a good reason not to use something like Microsoft Project to handle project management because people were not too familiar with the concepts of the package. As the tool becomes more widely acceptable I feel that managers should switch over to using it. The saying that a picture says a thousand words is indeed true.

Finally I would sincerely like to thank Dr Mark Dent and Professor Breen, as well as all the other Subprogramme managers who afforded me this really good capacity building exercise and learning experience. The project has in some ways also contributed to my new promotional post in the civil service and I am very grateful for that as well.

I would also like to thank the KNP secretary for her extreme competence and professionalism in the project. We have also become quite good friends as a result of my association with the KNPRRP.

INTEGRATED RIVER MANAGEMENT: M. UYS

I regard myself as very privileged to have been part of the KNPRRP from its very early stages, where I researched water law aspects, and to these final phases. I have also for a short time been involved in data management aspects (for Dr Biggs) during 1993-1994.

Of course, my involvement as a partner to the ICM Subprogramme was of much lesser intensity than my involvement as researcher and database developer during the earlier stages of the Programme. From this viewpoint, I was in a sense disappointed in what was expected of me. I soon realised that I was no longer a main role player in the Programme, but merely an assistant! I was now here to support my Subprogramme, and to benefit from the course of the Programme.

As a supporter, I feel that I could have done much more : I was rather excited about the idea of integrating the new Water and Environmental Law mechanisms with the Programme, but I soon realised that this was premature: the institutional arrangements and the mechanisms for water resources management under the new legislation were far behind in comparison to the well-developed views on ICM developed in the Programme: it will take many years for the new laws to become practically applicable to effectively integrate the management systems for water and other natural resources. I still believe that the establishment of an environmental WUA is essential for future water management, especially in the more important and agriculturally-dominated river systems and catchments. I was, however, outvoted here, and my support role did not allow me to press the issue further.

Merely reading reports and attending meetings and speaking to Dr Venter, was an enriching experience, and although I was often lost in that I was not always sure whether I understood what was happening in the other Subprogrammes, I picked up important knowledge, for which I am appreciative.

In short, I think that I could have been involved more extensively in the matters where I could have contributed, because I do have a good knowledge of water and environmental laws, which could have facilitated ICM. As I was restrained by budget time and my support role, I could, however, not push issues too far.

I thank you for involving me.

REVIEW OF THE KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME (KNPRRP)

26 November 1999

Pretoria
South Africa

REVIEW PANEL:

Dr P J Ashton, CSIR, South Africa (Convenor)

Dr J Seager, Environment Agency, United Kingdom

Dr H M MacKay, Department of Water Affairs and Forestry, South Africa

Dr T J Ruredzo, Commonwealth Science Council, United Kingdom

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REVIEW OF THE KRUGER NATIONAL PARK RIVERS RESEARCH PROGRAMME

EXECUTIVE SUMMARY

1. The Review Panel was asked to evaluate Phases II and III of the Kruger National Park Rivers Research Programme (KNPRRP) and, in particular, to examine the achievement of objectives and to identify its successes and failures, the lessons learnt and future opportunities. The Review Panel was given access to the main reports arising from the Programme and conducted a wide range of interviews with key staff in the research teams, management organizations and stakeholder groups. The Review Panel also took part in field visits to gain an understanding of some of the projects within the Programme. We were asked to concentrate on strategic issues and this we have done, but in the short time available to conduct the review we have not carried out a detailed examination of the scientific methodologies and outputs from the Programme.

2. The Review Panel has conducted an analysis of the Programme's strengths and weaknesses and future opportunities and threats as a central part of the assessment (appended). Our main findings are summarized below.

3. The KNPRRP has made a significant contribution to the understanding of the functioning of river ecosystems and the consequences for the management of South African rivers. It is original in concept and has broken new ground in generating new knowledge of natural processes and in stimulating new thinking in integrated environmental management approaches. It has been a considerable learning experience and all parties involved appear to have benefited from this experience.

4. The Programme management structure introduced in Phase II and carried into Phase III brought new direction and promoted an objective–led approach. The Programme structure is well defined and focused. In particular, the inter-disciplinarity within research teams was perceived to be a major benefit and helped to produce an integrated problem–solving approach. The programme management provided an important framework for the research without interfering with innovation and personal initiative. However, some interviewees expressed a perception of exclusivity and a 'club' appearance of those involved with the Programme. Self-evaluation and tracking of progress were done by the Programme Development and Management Committee of the KNPRRP as well as individual project steering committees. A wider ranging mechanism for this may have been desirable in view of the changing political emphasis and priorities that occurred during Phases II and III.

5. The KNPRRP has undoubtedly raised the profile of river ecosystem science both nationally and internationally. This has resulted in significant interest within the scientific community and has also attracted new and substantial funding from other sources. It has provided good opportunities for research students of contributing universities to take part in a new and expanding inter-disciplinary field and allowed them to grow personally from this. The

scientific approach in the core Programme has concentrated on characterization of river systems through survey and monitoring and much of this centered on one river, the Sabie. This was partly because of lack of prior knowledge about the basic characteristics of the rivers. However, the Review Panel feels that insufficient emphasis was given to experimental testing of specific hypotheses that could have helped to improve understanding of the dynamic processes in rivers and enhanced the predictive capability of the modelling approaches. We recognize that this is now being addressed in projects related to the core Programme that will extend beyond Phase III.

6. A major success of the Programme is that it has developed new thinking on strategic adaptive management of ecosystems. This approach has been adopted by the Kruger National Park and other agencies and has resulted in a major reorientation of conservation management strategies. This now needs to be followed through and translated into proactive management action.

7. It is evident that there are different perceptions from scientists, managers and river users over what the Programme should and could deliver. Some managers expressed frustration that practical questions, such as those related to hydrological management, were not being answered. On the other hand, the research teams felt that the questions being asked were too simplistic and did not take account of the complexity and dynamics of river ecosystems. We conclude that this mis-match of expectations was due to poor communication by partners within the Programme. The Policy and Management Committees should have debated and resolved this issue at an early stage. One of the consequences of the differing expectations was a lack of precision in the framing of the Programme objectives.

8. The objectives hierarchy approach adopted to define primary goals and sub-goals was good practice and brought focus to the design of the work programme and prioritization of its projects. Most of the agreed goals were addressed to differing extents. The Review Panel concludes that the wide range of sub-goals set, particularly for Phase III, was overly ambitious with respect to the limited resources and time available. Some important areas, and in particular the water quality component of the goals, were not addressed in the core Programme. Although we were given reasons for this, there are fundamental research questions to be answered on the effects of water quality on river ecosystems, and the decision not to address these issues was disappointing. Other areas, including the transfer of knowledge and technology to end-users and corrective action initiatives envisioned for Phase III were only partly addressed.

9. The Programme was severely constrained by the early decision to concentrate on those parts of the river catchments that lie within the Kruger National Park boundaries. The main advantage of this was that it focused the limited resources available to a specific area, bearing in mind the practical and logistical problems of dealing with vast geographic scale. However, it was recognized that the causes of ecological problems in rivers within the Park clearly lay in catchment areas upstream and that they could only be realistically solved through the

development of integrated catchment management approaches. This issue only began to be addressed in the later stages of the Programme.

10. Many of the catchment stakeholders and river users consider that the management approaches and tools developed through the Programme have the potential for wider application to underpin catchment management planning. There has been some communication with various river user groups during the Programme and this has helped to raise awareness and to stimulate action to help alleviate the impact of human uses on the rivers. Some important river users, such as water supply organizations were not drawn into the Programme and we found some potentially useful stakeholders who were completely unaware of the Programme. This could have been more effectively addressed through the communications strategy which was one of the goals of the Programme. As yet, there is no evidence of any tangible improvement in the state of the Lowveld rivers as a consequence of the Programme.

11. The potential benefits of the products of the Programme to river users have yet to be fully realized. This will require a structured process of transfer of knowledge and technology and this should have been addressed earlier in the Programme. As Phase III nears completion, products with considerable potential practical application and particularly the Integrated Catchment Information System (ICIS) have yet to be fully completed and handed over to users. Without further funding and management there is a risk that this transfer process will not take place and the potential benefits of the Programme will not be delivered.

12. Some products are of particular relevance to the operation of the future Catchment Management Agencies (CMAs). It is important that the momentum of knowledge transfer is maintained in the immediate interim period before the CMAs are fully operational. Otherwise, there is a risk that the tools will not be progressively developed to support emerging management needs and will eventually become obsolete, and that alternative technologies to support catchment management will continue to be developed and used.

13. The objective added later in the Programme to implement corrective action policies and to create capacity as part of the Programme was only partly addressed. Difficulties were reported by the research team in finding candidate students. However, the Review Panel considers that there were missed opportunities and found evidence of individuals who would be good candidates to take part in different ways, with whom capacity could have been created and who could have served as champions in stimulating interest in the wider application of the Programme, thereby adding value to it.

14. There are considerable opportunities to take forward the experience and knowledge gained in the Programme and extend it more widely into other research programmes (such as the National Rivers Programme, and the Shared Rivers Initiative), into wildlife management and into integrated catchment management via the future CMAs. This will require cohesion between relevant funding bodies to ensure that the potential benefits are fully realized by end-users.

Table 1: Review Panel's SWOT analysis of the KNPRRP

STRENGTHS	WEAKNESSES
• Strong focus on river management issues: - ecological functions/processes - impacts of users • Stimulated inter-disciplinarity, particularly in Phase III • Improved intra-team communications • Programme management structure well-defined and focused, yet allowed innovation and initiative • Delivered good science and raised profile of South African aquatic science internationally • Strong influence on new water-related policy and legislation • Delivered a new resource management approach which has been taken up and implemented within KNP • Provided good training base for students in the participating universities • Extended scientific base of aquatic sciences in South Africa • Helped to bridge gaps between engineers - science, and management – science • Promoted problem-solving approaches and expertise • Promoted originality in South Africa in river ecological modelling • Extensive use of information technology approaches to disseminate products	• Mismatch of expectations on what the Programme could and should deliver has not been fully resolved • Programme objectives were not sufficiently precise • Some objectives not addressed and others not addressed adequately • Absence of structured communications strategy with external users • Self-evaluation within the Programme did not always ensure alignment with end-user needs and expectations in the light of the changing political emphasis and priorities which occurred during Phases II and III • Little evidence of regular self-evaluation within the Programme to ensure alignment with end-user needs and expectations • Opportunities for corrective action and capacity creation missed • Apparent lack of cohesion between funding agencies • Inadequate communication with catchment stakeholders and some stakeholder groups not engaged • Interaction between KNP managers and KNPRRP not sufficiently developed at an early enough stage • Technology transfer issues not addressed early enough and potential benefits to users not yet fully realised • Lack of clarity among researchers over who end-users are and how products would be used • No apparent criteria for judging efficiency and effectiveness of Programme • Heavy reliance on field survey/monitoring approaches; insufficient emphasis on experimental approaches and hypotheses testing within the core programme • Inadequate emphasis on socio-economic linkages
OPPORTUNITIES	**THREATS**
• Programme has provided scientific platform for underpinning integrated catchment planning and mobilising capacity in South Africa • Stakeholders have indicated their willingness to interact with and participate in the Programme • Stakeholder involvement can add value to the programme • Programme structure offered sound framework for effective corrective action • Changing political environment in South Africa • Achieving added value by attracting other major sources of funding and students • Scientific achievements provide foundation for directed research in the future • Experience gained in KNPRRP can be transferred to other research programmes • Promotion of joint projects with neighbouring states • Fundamental re-orientation of management approach in KNP • Potential credibility and economic opportunities through application of Programme products outside the research sector • Knowledge gained in the Programme provides a platform for future long-term ecological research in KNP	• Lack of ownership of Programme products by catchment stakeholders through inadequate involvement and communication • Reduced uptake of research outputs because of perceptions of exclusivity in Programme team who developed concepts and products • Lack of funding and co-ordination to finalise product refinement and extension to users • Reduced opportunities due to failure to implement corrective action • Inadequate technical/scientific support for emerging CMAs • Strong possibility that alternative technologies to support catchment management will continue to be developed and used. • Possible rejection of Programme products by Government authorities • Mismatch between expectations / needs of stakeholders and Programme products • Many stakeholders do not understand potential value of available Programme products • Many stakeholders are not in a position to exploit Programme products

1 INTRODUCTION AND BACKGROUND INFORMATION

1.1 Origins of the Kruger National Park Rivers Research Programme (KNPRRP)

The Kruger National Park Rivers Research Programme (KNPRRP) was first envisioned at a workshop convened by the Department of Water Affairs in March 1987. The driving force for formation of the KNPRRP was defined by the need expressed by the Department of Water Affairs to determine the quantity and quality of water required to sustain the rivers that flow eastwards through the Kruger National Park (KNP) into Mozambique (Breen *et al*., 1999). Steadily declining flows and a progressive deterioration in the quality of the water in these rivers emphasised the urgent need to derive quantifiable and defensible estimates of the water requirements for aquatic ecosystems.

The KNPRRP was formally initiated in 1989 as a joint enterprise by the government departments of Water Affairs and of Environment Affairs, the then National Parks Board, the Water Research Commission (WRC), and the then Foundation for Research Development (FRD), and was further supported by various other institutions. The primary focus of attention was on the river systems within the Kruger National Park. It was anticipated that the research would later be extended to the upper catchments of the KNP rivers and, ultimately, expanded further afield to the other river systems in South Africa.

The first phase of the KNPRRP extended from 1987 until 1993. A formal review of Phase I revealed the wide extent of the scientific achievements and recommended greater focus on structured management of the research before the programme was extended. The programme was refocused accordingly and the second (1994-1997) and third (1997-1999) phases were launched. The primary and secondary objectives of these two phases are detailed by Breen *et al*., (1999).

As their primary goal, the second and third phases of the KNPRRP strove to inform those individuals and agencies who are responsible for or who have a direct interest in the management of the natural environment of river systems. This was approached through a structured research process, which was designed to promote a strategic resource management process and, wherever possible, to underpin and support this through the development, transfer, and application of the necessary procedures and technologies to water resource managers and other stakeholders.

1.2 Reasons for the review of the KNPRRP

The standard research management procedures employed by the Water Research Commission (WRC) consist of regular peer review of research proposals and research projects at steering committee level and by the National Research Foundation (NRF) and include regular peer review of research projects, external evaluations of individual researchers and independent

reviews of larger research programmes. This practice is in line with research management practices used elsewhere in the world and enables funding agencies and research management organisations to evaluate progress against specific objectives. Such reviews then form the basis for management decisions on individual performance, future research directions and funding priorities.

This review of the KNPRRP was deemed to be necessary by the WRC and the NRF because the research programme is nearing the end of the third (final) phase and decisions must now be made as to what future research priorities require support. In this context, it is important that the lessons learnt during the KNPRRP should be available for transfer and adoption by continuing and future research projects and programmes.

2 TERMS OF REFERENCE FOR THE REVIEW PANEL

A comprehensive document that outlines the formal Terms of Reference for the Review Panel has been provided to each member of the panel; a copy of this document has been attached to this report as **Appendix 1**. The Water Research Commission (WRC) and National Research Foundation (NRF), two of the key funding organisations that have supported the KNPRRP from its inception, formulated this document. These Terms of Reference were ratified and approved by the Policy Committee of the KNPRRP; all the organisations involved in directing and guiding the KNPRRP are represented on this committee. The formal Terms of Reference provide a firm and unequivocal basis for the scope of activities to be undertaken by the Review Panel. The WRC and the NRF have declared themselves to be jointly responsible for the costs of this evaluation.

2.1 Scope of the review

The Review Panel was instructed by the WRC and the NRF that this review should focus primarily on the second and third phases of the KNPRRP, whilst appreciating that many of the research thrusts had their origins in Phase I. In particular, the Review Panel were required to provide a strategic-level overview and assessment of the following key issues:

- the quantity, quality and appropriateness of the specific research achievements in relation to the series of objectives originally set for the KNPRRP,
- the ability of the KNPRRP to adapt its focus and activities to meet changing needs and objectives in the external environment,
- the extent of commitment and support from external stakeholders,

- the efficiency and effectiveness of the KNPRRP structure, management and administration, as well as the monitoring and marketing of the Programme's products,

- the degree to which the research programme is aligned with world trends, and

- the identification of those key learning points from the KNPRRP which can be recommended for transfer to, and adoption by, future research programmes and initiatives.

In addition, the WRC and the NRF requested the Review Panel to provide a specific evaluation of the degree to which the KNPRRP had been able to create additional research capacity and the extent to which corrective action imperatives had been achieved during the second and third phases of the programme.

2.2 Limitations of the review

The Review Panel were instructed to complete their review of Phases II and III of the KNPRRP within a period of seven working days from inception. This time limit constrained the range of organisations and individuals that could be consulted, and limited the extent to which the Review Panel were able to evaluate the appropriateness and applicability of specific KNPRRP products. In particular, the Review Panel were not able to scrutinise the specific details of each individual project within the KNPRRP.

However, despite the strict time limitations, the Review Panel members concur that they have been able to develop a sound strategic overview of the KNPRRP and the activities that have been undertaken during the second and third phases of the research programme.

2.3 Assumptions made during the review process

The Review Panel have assumed that the objectives of the review process could be achieved most effectively by an examination of the documentation and software produced during the second and third phases of the research programme, supported by a series of interviews with key stakeholders and participants in the KNPRRP.

3 APPROACH ADOPTED DURING THE REVIEW

In view of the short time available for the review process, the Review Panel requested the NRF Secretariat staff to draw up a formal schedule of activities as a structured framework for gathering the necessary information on which to base this review. The schedule included interviews with KNPRRP participants and representatives of stakeholder groups in Pretoria

and Skukuza, field visits to specific project sites in the Sabie River and in its upper catchment, as well as evaluations of documentation and software produced by the KNPRRP research team. The programme of activities undertaken by the Review Panel is attached to this report as **Appendix 3**.

3.1 Evaluation of Programme products

The Review Panel examined the various technical reports and scientific publications that have been produced during the second and third phases of the KNPRRP. In addition, Review Panel members also examined a selection of papers published as conference proceedings, as well as the final progress reports for Phases II and III. Review Panel members also accessed the KNPRRP website and attempted to examine the ICIS modelling system. KNPRRP members provided the Review Panel with specific documentation and copies of publications describing the Strategic Adaptive Management (SAM) approach to resource management that was developed during the course of the KNPRRP. The evaluation of the KNPRRP "products" was based on our professional judgement and formed the basis for many of the questions that the Review Panel posed to the KNPRRP members and stakeholders who were subsequently interviewed.

3.2 Interviews with stakeholders and Programme members

A central part of the information-gathering process consisted of a series of structured interviews with a wide range of potential stakeholders and participants in the KNPRRP. These interviews were held with the participants and key stakeholders identified by researcher managers within the KNPRRP. After examination of the list of names prepared by the KNPRRP, the Review Panel recommended the inclusion of a few additional individuals so that the Panel could interact with a broader spectrum of stakeholders.

A full list of the individuals who were interviewed by the Review Panel is attached to this report as **Appendix 2**, whilst the programme of interviews and activities is attached as **Appendix 3**.

3.3 Structure of this report

The next section of this report lists the Review Panel’s opinions on the degree to which the KNPRRP has been able to meet the objectives that have been set for it. Whilst the format in which our opinions are expressed does not strictly match the same sequence of itemised objectives listed in the Review Panel’s Terms of Reference, they cover all the issues that were raised in that document (**Appendix 1**).

The subsequent sections of this report contain the conclusions of the Review Panel, as well as our recommendations for future action.

Four appendices are attached to this report. These provide supplementary information on the Review Panel's Terms of Reference (**Appendix 1**), the names and affiliations of all the individuals who were interviewed (**Appendix 2**), the schedule of activities undertaken by the Review Panel (**Appendix 3**), and a complete listing of all information sources that were consulted by the Panel (**Appendix 4**). A list of important abbreviations and acronyms used in this report is provided in **Appendix 5**.

4 REVIEW PANEL'S FINDINGS AND EVALUATION

4.1 Achievement of Programme objectives

The design of the Programme adopted an objective hierarchy approach that provided a sound basis for setting out specific goals and sub-goals. The primary goals stated for Phase II were:

- to inform researchers, system managers and stakeholders about water quality and quantity requirements to sustain the natural environments of rivers which flow through the Kruger National Park, and

- to develop, test and refine methods for predicting the responses of the natural environments of rivers flowing through the Kruger National Park and in southern Africa to changing water quality and patterns of supply. Some specific subsidiary goals were defined to support the primary goals.

A third primary goal was added in Phase III:

- to achieve corrective action through enhancing individual and institutional capacity in the conceptualisation, implementation and management of trans-disciplinary research on river systems.

The Review Panel's overall assessment is that good progress was made in the characterisation of the Sabie River within the Kruger National Park. This provided new and important understanding of the interactions between river hydrology, the in-stream aquatic ecosystem and associated riparian habitats. This knowledge was applied effectively to help define the water quantity requirements and, in particular, the identification of Threshold of Potential Concern (TPC) for river flow and sedimentation.

This new knowledge also supported the development of new methods for monitoring and of a suite of predictive models that were built using a rule-based approach. The Review Panel did not carry out a detailed assessment of these products because of the short time available, but gained the impression through discussions with the research teams that the approach adopted was sound. The planning of future catchment management solutions will clearly depend upon the ability to predict 'what if' scenarios in evaluating management options.

One apparent weakness in the scientific method is that it relied heavily upon basic survey and monitoring of systems. Insufficient emphasis was placed on the generation of conceptual models and hypotheses and the experimental testing of hypotheses. This could have provided more insight into the processes of ecosystem functioning and helped to improve the predictive capability of the modelling approaches. The Review Panel accepts, however, that this basic survey work was a necessary pre-cursor as so little prior knowledge existed about the rivers in

the Kruger National Park. There is evidence of a more process-driven approach in some of the related projects to the core Programme that will extend beyond the lifetime of Phase III.

It is disappointing that the water quality component of the primary goals was not addressed in either Phase II or III. The reason given for this was that it was necessary to obtain an understanding of the hydrology of the systems first and that there were no significant water quality issues in the river chosen for study, the Sabie River. However, there are other rivers in the Kruger National Park in which water quality is a significant consideration and this could have been addressed.

The primary goal to inform researchers, system managers and stakeholders was achieved with varying degrees of success. In general, communication within the research community appeared to be satisfactory, although some interviewees commented that the Programme was exclusive and had a 'club' appearance. Effective links were created with environmental managers in the Kruger National Park and this resulted in a fundamental re-orientation in management strategy based upon the Strategic Adaptive Management (SAM) approach. However, the influence of the programme on other system managers outside the Kruger National Park appears to be quite limited at present. The extent to which the Programme was able to inform stakeholders is dealt with in **Section 4.7**.

The achievement of the third primary goal related to corrective action had only limited success in the Programme. This is discussed in more detail in **Section 4.4**.

In general, the Review Panel feels that the range of sub-goals set for the work programme was too ambitious bearing in mind the limited resources and time available. This was particularly so for the sub-goals in Phase III which concentrated on the communication of knowledge and transfer of technology to end-users; some of these were only partly addressed.

4.2 Programme Management

The Programme management structure initiated in Phase II provided coherence and direction to what appeared to be a previously disparate collection of projects conducted during Phase I. This brought new focus in prioritising and aligning specific projects to the agreed goals. The appointment of a Programme Director was critical to this process and the division of the Programme into Subprogrammes with dedicated managers was sensible. The adoption of the management principles developed through the Programme (i.e. objective hierarchy and the SAM approach) to the design of the Programme itself is to be commended. The management process that emerged from this thinking was sound and produced clear benefits, particularly in the close relationship with Kruger National Park staff who were able to transfer this process into conservation management. In view of the diversity of the work programme and the large number of participants, based in different parts of South Africa, the Review Panel concludes that the programme management was generally sound.

The Review Panel found some lack of clarity on what aspects of the work were within the core Programme itself and what projects were related to it, but funded from other sources. The Review Panel was given a breakdown of the budget allocations for the Subprogramme areas, but did not have access to information on actual expenditure and how the variances with respect to budget were actually managed. It was reported to us that not all the funding allocated was actually spent because of the rigour applied in the selection of projects against the Programme goals.

All of the staff involved, including the Programme Director were working on the Programme on a part-time basis. This was intended and common practice in South Africa. However, bearing in mind the scope, size and breadth of the Programme, the appointment of a full-time staff member would have provided focus and continuity within the work programme. It would also have helped the communication process, particularly with the wide range of catchment stakeholders which is both time-consuming and requires an established point of contact.

4.3 Capacity creation

4.3.1 Capacity creation within the KNPRRP - researchers

The KNPRRP has been successful in building a core of experienced aquatic scientists within the programme itself. Several senior researchers who were or have been members of the KNPRRP have contributed their specialist expertise as individuals, outside the core activities of the KNPRRP, to other processes and projects such as

- the national River Health Programme;
- development of the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1997);
- development of methodologies for determination of the ecological Reserve;
- a number of DWAF studies to determine Instream Flow Requirements for rivers within the KNP and elsewhere in South Africa.

The core team of KNPRRP researchers have developed strong inter-disciplinary research skills, and the ability to design and execute integrated research projects to investigate ecological processes and cause-effect relationships in aquatic systems. This was evident in discussions with the researchers in the field during this review, and from perusal of the research reports. Particular mention should be made of the development of new thinking and specialist expertise in low-flow river hydraulics and predictive ability related to geomorphological processes.

The Review Panel also believes that the Subprogramme managers and their partners have developed skills in research co-ordination and management as a result of their work in the KNPRRP with its well-defined management structure.

4.3.2 Capacity creation within the broader scientific community in South Africa

Discussions were held with several aquatic scientists associated with the KNPRRP and other parallel national initiatives as part of this review process. It appears that the thinking and research approaches of many South African aquatic scientists outside the KNPRRP have been positively influenced by the increased awareness of the need for an integrated ecosystem approach to both research and resource management, and hence broadened scientific debate and research effort around these aspects. While it is difficult to quantify the direct influence of the KNPRRP in this respect, informal interactions between KNPRRP researchers and their colleagues in other programmes and fora appear to have contributed significantly.

The ICIS modelling system appears to have been widely demonstrated to diverse groups of researchers, scientists and water resource managers around South Africa, but the Review Panel did not have sufficient information to judge whether these groups actually developed increased expertise and capacity as a direct result of ICIS demonstrations and training courses. In interviews with scientists outside the KNPRRP, only scientific staff of SANP in the KNP felt confident in their current ability to use and derive benefit from ICIS.

Communication between the KNPRRP and the broader scientific community was considered to be generally satisfactory. The KNPRRP could have been more effective in directly transferring their research expertise and capacity to the wider community of established aquatic scientists in South Africa, with respect to the adoption of and ability to use, refine or further develop specific tools and methodologies produced by the KNPRRP. The reasons for this are considered to include the following:

- A relatively small number of senior South African researchers were directly involved in core KNPRRP activities during Phases II and III. This was a natural consequence of the directed and focused approach to research in these phases.

- While ICIS appears to have been the subject of a number of presentations, there was only limited and infrequent interaction with scientists outside the KNPRRP core team through training courses and/or workshops that were directly related to the KNPRRP research products. Budgetary constraints may have played a role here. The conference on integrated river management, held under the auspices of the KNPRRP in August 1999, might have contributed to increased interaction of the KNPRRP core team members with a wider group of aquatic scientists. This was not as well attended as had been hoped, perhaps due to its being scheduled very close to the annual conference of the Southern African Society of Aquatic Scientists.

- There appears to have been a lack of structured and sustained engagement of the KNPRRP with the Southern African Society for Aquatic Scientists, although many individual members of the KNPRRP participated in Society activities. This represents something of a missed opportunity in terms of both dissemination of KNPRRP research products and contribution of the KNPRRP to building research capacity in South Africa.

4.3.3 Capacity creation within the KNPRRP - students

Research projects associated with the KNPRRP have provided opportunities for a number of graduate students in the aquatic sciences. Several former students have gone on to become respected practitioners in aquatic ecology, hydraulics and hydrology. It was the opinion of several people interviewed by the Review Panel that many students or former students associated with the KNPRRP display strong problem-solving and integrative skills, a good grasp of the detail and complexity of their subject matter, as well as maturity and sound scientific judgement. This matched the view of the Review Panel members, who were able to interact intensively in the field with two former students during the review process.

The Review Panel found that the KNPRRP displayed strengths in areas that supported the development of high-caliber students:

- Through the KNPRRP, students have had opportunities to interact with a multi-disciplinary group of experienced researchers from universities and from a resource management agency, specifically SANP in the KNP.

- Student research projects associated with the KNPRRP have promoted practical work, field observation and field data collection, which provided opportunities to understand the complexity of real ecosystem processes, relating to both the measurement and management of ecosystems.

- Some people felt that students within the KNPRRP had a tendency to take longer on average to complete their studies. This was considered by the Review Panel to be a potential strength, in that those students who had valid reasons for doing so could spend more time developing understanding based on their own observations and results. They then had the benefit of a longer period of direct supervision by a senior researcher, within a larger well-structured programme.

There was potential for more students to have been able to work within the KNPRRP, through NRF funding of student research projects. However, because only one KNPRRP researcher has a current NRF rating and hence access to NRF funding for students, this potential was not fully realized.

4.3.4 Capacity creation within resource management agencies

The Review Panel found that there has been significant development of capacity and expertise within the scientific staff of SANP in the KNP as a direct result of the KNPRRP:

- Several stakeholders commented in interviews on the positive contribution of KNP staff to increased general awareness and understanding of river management issues, through their interactions with river fora and sectoral groups.

- The ability of the KNP scientific staff to meet their responsibilities in terms of research and scientific support for management appears to have been enhanced through their participation in the KNPRRP.

- Understanding of ecosystem complexity and processes, generated through the KNPRRP, appears to be filtering through to the KNP conservation staff in the field.

Other resource management agency representatives who were interviewed were of the opinion that there had been only limited building of capacity in their scientific staff that could be specifically attributed to the activities and the products of the KNPRRP. However, it was clear that the awareness and understanding of river ecosystem issues among the senior managers in these agencies have been greatly influenced, albeit indirectly, through their exposure to discussions around the water quantity and quality requirements of rivers and the setting of management objectives for ecosystems.

Links between the KNPRRP and the forestry sector in the Sabie River catchment appear to have been beneficial in supporting scientific staff of this sector with information and expertise, and there is the potential to expand this role to other water user sectors.

4.3.5 Capacity creation within stakeholder groups in the catchments of KNP rivers

The Review Panel interviewed representatives of various stakeholder groups in the Sabie and Olifants River catchments. In general, these groups felt that they would like to have had more interaction with the KNPRRP. They felt the KNPRRP had the potential to assist greatly in increasing awareness and capacity among water and land users of the impacts of their activities, and to provide valuable information to support catchment management.

Individual members of the KNPRRP, mainly KNP staff members, had fairly frequent interactions with stakeholder groups in the form of field days and short training exercises. These were considered to have been highly beneficial to the stakeholder groups. It was not clear to the Review Panel how much of this "extension" activity was carried out as a core activity of the KNPRRP and how much was linked to other initiatives such as the River

Health Programme. However, there was little doubt that the KNP staff had developed their own capacity considerably through their links with the KNPRRP, and that this enabled them to contribute to capacity development in stakeholder groups.

The Review Panel found evidence of several individuals within stakeholder groups in the Sabie/Sand and Olifants catchments who had the potential for significant development at the technical and scientific level, but these people were not identified and brought into a structured training initiative by the KNPRRP. This could have provided a valuable opportunity for building capacity for river management outside the KNP, especially since these individuals were already working within stable community structures, which would have allowed rapid dissemination of information to the community level.

The importance of incorporating local and traditional knowledge into the KNPRRP was highlighted by several stakeholders during interviews. These interviewees felt that the KNPRRP members could have been more proactive in accessing such knowledge, and that this would have enhanced the capacity of the researchers themselves to understand ecological processes and cause-effect relationships in the catchments of the KNP rivers.

4.4 Corrective action

In the planning of Phase III, corrective action was identified as a 'mainline' activity within the KNPRRP, and this proposal was accepted and implemented.

It was intended that at least two historically Black universities (HBUs) would have benefited from association with the Programme and would have operational river research programmes under their own direction and management by the end of Phase III. The purpose of the Corrective Action Subprogramme was to use the experience and activities of the Programme to enhance the capacity of HBUs and previously marginalised people to enable them to provide leadership in river research.

The objectives of the Subprogramme were: the development of a strategy and action plan for training and corrective action; the phased implementation of a training and corrective action plan; [development of] institutional links with two HBUs; transfer [of] information, understanding and technology to HBU team; and [further development of] partners in research development and management.

The Review Panel is satisfied that the Programme did indeed develop a strategy for corrective action that was based on institutional links with HBUs. We welcome the successful linkage of the Hydrology Department of the University of Zululand with the Programme. We also welcome the development of links between the KNPRRP and a staff member of the University of Transkei. We note the training of four previously disadvantaged students on the Programme. The Programme successfully implemented its 'partners in research development

and management' initiative and we would like to congratulate them for this innovative approach to corrective action given the relatively short time available for implementation.

The Review Panel was informed by Programme Management that relationships with the University of Venda and the University of the North did not succeed due to lack of capacity in these two institutions and that this was a constraint on the corrective action Subprogramme as a whole. This perception was shared by most of the KNPRRP staff, though this view was not shared by most of the other people who were interviewed by the Review Panel. There was an overwhelming feeling among most of the people interviewed that the KNPRRP did not do enough to implement corrective action mainly due to the fact that this has not been pursued forcefully enough. People from NGOs, water boards and community groups, some operating within the programme area, expressed their enthusiasm and willingness, as well as suggesting ways in which they could have been engaged. Some of these potential partners would have enabled the Programme to leverage additional funding but they did not even know of the Programme until they were invited to meet the Review Panel.

We believe the major constraint to the implementation of corrective action was in the strategy of the Subprogramme itself, which relied heavily on interacting with existing research capacity in HBUs at a formal institutional level. It was generally accepted by most of the people we interviewed, including members of the KNPRRP, that the HBUs still have very little research capacity especially in the natural sciences. It was also generally agreed that person-to-person interactions are usually more successful in these circumstances than institution-to-institution linkages. We believe the KNPRRP did not adequately seek out individuals with potential among students and lecturers alike and did not take advantage of its multi-disciplinary nature to engage potential researchers from disciplines other than natural scientists and engineers and from institutions other than universities. For example, social scientists would have added considerable value to the output of the KNPRRP. The KNPRRP programme therefore lost a valuable opportunity to engage other institutions such as NGOs, community groups and water boards which would have welcomed working with the Programme and would have brought in natural corrective action components.

The Review Panel would like to emphasise that the door is not closed and these opportunities still exist. We strongly recommend that the KNPRRP should take advantage of the list of organisations contacted for the purpose of this review to engage some of these groups.

4.5 Quality and quantity of research

Only a limited number of research reports arising from core KNPRRP activities were provided to the Review Panel. It is assumed that the scientific peer review process has been adequately applied in evaluation of individual research products, and only a general overview is given here.

During Phases II and III, the work of the KNPRRP has been aligned within a definite hierarchical framework, namely:

- the provision of decision support tools and systems;
- the development of models related to various ecosystem components, which are nested within these decision support systems;
- focused research projects aimed at providing data and understanding of ecological processes in order to develop and strengthen models;
- information management systems that can serve all the above levels.

In general, interviewees agreed that the scientific research emanating from or associated with the KNPRRP was of a very high standard and could hold its own internationally. The Review Panel shared this view.

The various Subprogramme teams within the KNPRRP have all been involved in research, development and application to greater or lesser degrees, and it is difficult to separate clearly the products of any one Subprogramme from the others. This fact in itself is a mark of the integration within the KNPRRP team. The Review Panel also found it difficult to clearly distinguish between research products wholly delivered by the KNPRRP directly, and those that were influenced by or influenced other related research within South Africa. Again, this can be viewed as a strength since the KNPRRP was able to connect with a network of research capacity in South Africa in order to generate maximum benefit from limited funding and personnel.

Several key stakeholders appear to have had expectations about the final form and output of the research products that were not met. This mismatch in expectations is addressed elsewhere in the report, but the Review Panel considers that the KNPRRP researchers and the research products might have benefited from closer involvement of the technical staff of various resource management agencies in the actual research. Where this involvement did occur, as with scientific staff of SANP in the KNP, the synergy was apparent and the research products appear to be well tailored to resource management needs.

4.5.1 Decision support tools and processes

These are considered to include the Desired State Objectives Hierarchy approach (DSOH), and the Integrated Catchment Information System (ICIS). Both of these products are high-level integrative tools which can support the decision-making process.

The DSOH approach represents practical operationalisation of the philosophy of adaptive environmental management. A strength of the DSOH approach is that it provides a structured

process for translating complex narrative goals into fairly simple, measurable, verifiable resource management objectives that have a sound scientific basis. The KNPRRP has generated new ideas and thinking around strategic adaptive management, and this has been captured in a tool whose potential for wide application in natural resource management has already been demonstrated through its adoption by SANP and other nature conservation agencies. Several interviewees from the water sector, who had been exposed to the DSOH process, considered it to be a very useful product that could support the process of integrated catchment management and be a valuable tool for use by catchment management agencies.

The ICIS is a system that is designed to underpin catchment management processes and decision-making. A presentation on ICIS was made to the Review Panel, but we were unable to fully assess the tool in a working demonstration. ICIS appears to have considerable potential to serve as a framework for scenario testing and evaluation in a catchment management context, but its ultimate value will depend on the willingness and capacity of a catchment management agency to populate the system with adequate information, models and data for their own catchment. The system itself is not yet particularly friendly for non-specialist users.

4.5.2 Models and modelling systems

One of the key Phase II goals of the KNPRRP was to set up an installed catchment model for the Sabie River, which could address water quantity and water quality, and be linked to ecological models. The Hydrological Simulation Programme Fortran (HSPF) model was selected and has been successfully parameterised for the Sabie catchment. Linkage with the Agricultural Catchments Research Unit Modelling Systems (ACRU) model has provided capability to address groundwater and surface water in an integrated way, particularly important since the new National Water Act recognises that the hydrological cycle must and will be managed as an inter-connected whole.

From the Review Panel's point of view, some questions remain on the applicability of the HSPF-ACRU models to other rivers in the KNP and beyond. While the model output is at quite a high resolution, set-up and calibration of the model requires a significant amount of data and expertise. The resolution, and the model itself, may not be appropriate for all situations or for all aspects of water resource management, and its specific applicability as one of a suite of available modelling tools should be established.

The rule-based ecological models, which have been linked to the hydrological model via the Biotic-abiotic Links Project (BLINKS), are derived from empirical relationships observed in the Sabie River. The models provide the capability to predict, on a semi-quantitative basis, the response of fish and vegetation to changes in flow and sediment regimes. Direction of change rather than rate of change in response to biophysical drivers is the emphasis of these models. The rule-based models provide practical, cost-effective tools for evaluating the

relative acceptability of different change scenarios. However, because they are built on empirical relationships, they remain very specific to the Sabie River.

Most members of the KNPRRP research team were of the opinion that the models can probably be applied successfully to other KNP or Lowveld rivers, but little attention has yet been given to verifying this. Other scientists who were interviewed felt that the empirical rules could probably not be extrapolated to other biogeographical regions beyond the Lowveld. More attention to rigorous testing of hypotheses and underlying processes would strengthen the rule-based models, and the Review Panel notes that ongoing research projects will address this issue after Phase III, especially for channel hydraulics and for vegetation-water interactions. The proposed follow-up work to re-survey the Sabie River and test the model suite's predictive capability is a necessary exercise if the models are to be accepted and taken up by resource managers.

4.5.3 Research projects

In general, the research projects carried out within the core KNPRRP or in association with the KNPRRP are clearly defined studies, usually aimed at answering specific questions that are generated in development and/or application of the modelling systems. Much of the research in Phase II focused on collection of baseline data in a survey approach, which was necessary since little data were available with which to calibrate the models. In Phase III, the emphasis shifted more to understanding processes within the ecosystem, through field and laboratory work. However, the more process-oriented research is slower to deliver results, and work will necessarily carry on in various research projects after Phase III. The Review Panel has some concern that if the decision support tools and models are not fully taken up by resource management agencies and implemented in the short term, the impetus for co-ordinated, directed research may be reduced when core KNPRRP funding is terminated at the end of Phase III.

Research into water quality-related aspects was not adequately addressed in the KNPRRP, although it was one of the objectives of the Subprogramme (**Section 4.1**).

The final report indicates that there are associated projects in progress related to socio-economic and economic aspects but no products of this research were available to the Review Panel. This was considered by many stakeholders to be an area that has received inadequate research attention from the KNPRRP in the past.

4.5.4 Information management and custodianship

Considerable effort went into the establishment of the metadata base in Phase II, and its improvement in Phase III. This has provided a useful facility, which is easy to access and search via the Internet. The KNPRRP is to be commended on the energy and efficiency with which they have gone about this task.

The more specialised aspect of time series data management is being addressed, and will be a challenge for the future if the information is to be taken up and applied beyond the scientific research community.

4.6 Uptake and transfer of research outputs

The Review Panel interviewed a wide range of actual and potential end-users of the Programme outputs, including others in the aquatic science community, resource managers and catchment stakeholders. The general impression gained was one of variable uptake and transfer of the research outputs. The Kruger National Park was clearly a major beneficiary of the Programme that has directly influenced adaptive conservation management strategies. The new knowledge generated from the research projects and disseminated through reports, scientific papers and electronic outputs has directly benefited the freshwater science community in South Africa and internationally.

The main area of weakness, particularly in Phase III, was the transfer of knowledge and technology to non-scientific end-users, in particular to resource managers in national government and provincial departments and to different catchment stakeholder groups. The Review Panel concludes that more emphasis should have been given to this issue at an early stage in the Programme. This should have involved more dialogue with these groups to establish a clearer undertaking of their needs and how the products of the Programme could have been developed and tailored to meet these different needs. The Programme has generated an expectation by some end-users that the products can help them in some way, but they are either unaware of what the products are, or, where they are aware, they feel that they are too technical and detailed for their specific needs. This is particularly the case for the Integrated Catchment Information System (ICIS) which is potentially a tool of considerable value in helping to underpin integrated catchment management decision-making, but in its present form is only usable and meaningful to a limited technical audience.

This issue should have been given more emphasis with regard to a central part of the communications strategy. What is required is a properly managed process of knowledge transfer to different end-users. The question of the extrapolation of the products generated in the Kruger National Park section of the Sabie River to its wider catchment and to other catchments in South Africa needs to be properly addressed. Consideration should be given to what kinds of skills are needed to do this and how it should best be funded. There is an immediate risk, as Phase III comes to completion, that without further funding the potential benefits will not be realised and the products themselves will become rapidly obsolete.

4.7 Involvement of stakeholders and degree to which expectations have been met

One of the nine specific statements of purpose of the KNPRRP is ‘to generate awareness, participation and commitment among stakeholders at local, national and international levels,

of the issues and how they can be addressed'. All the Subprogrammes of the KNPRRP have tasks to identify, engage, accommodate and transfer technology to stakeholders. The Review Panel is satisfied that its members discussed the KNPRRP with representatives of all the major stakeholders except KwaZulu Natal Conservation Services and the National Department of Agriculture. (See **Appendix 2** for the list of persons interviewed and their organisations).

There was overwhelming agreement among the stakeholders that the KNPRRP has contributed enormously to the appreciation of the issues involved in river management. Stakeholders from the research community concurred that the scientific work carried out in the KNPRRP was of good international standard. Scientists and students who worked on KNPRRP projects appreciated the unique value of working in this multi-disciplinary team and the way in which it helped to build their own capacity. Some water-user stakeholders such as the river forums attributed their formation, bringing together unlikely partners, to the KNPRRP. The Review Panel was very pleased to hear of the general feeling of awareness of river and catchment issues that were directly or indirectly attributed to the KNPRRP by stakeholders. The Review Panel took note of the activities of river forums that are now actively engaged in more environmentally friendly activities in catchment areas.

The stakeholders felt that the KNPRRP published useful products targeted at the scientific community and at management level in stakeholder organisations. They commented positively on the website but we did not find stakeholders who frequently visit the website for information. Review Panel members visited the website of the KNPRRP and are satisfied that it is a suitable vehicle for dissemination of programme information to the research community and other interested parties. We are also satisfied that, as indicated by stakeholders who commented, "*River News*", the newsletter of the KNPRRP, which has a circulation of 200 and increasing, is suitable for informing the general public about river issues and is effective in raising awareness.

However, most potential clients of the KNPRRP products did not feel adequately consulted during the conceptualisation of the products to declare ownership. We believe ownership is a prerequisite to acceptance and adoption of these products and that the KNPRRP should take immediate action to address this oversight. Major clients in DWAF and the water boards felt the KNPRRP did not address their immediate concerns adequately and are seeking in-house solutions to their problems.

We found no evidence that the KNPRRP is keeping the senior officials responsible for the establishment of Catchment Management Authorities informed of their activities in order to ensure that these authorities would seek to use some of the products of the KNPRRP. Some potential clients of the KNPRRP in one river forum, were not clear about the exact nature of the tools the KNPRRP was developing and had expectations of computer-based tools that would solve most of their catchment management and water allocation problems. We believe these expectations did not match the tools under development through the KNPRRP, ICIS,

since ICIS is a specialised tool that will be useful to researchers and is of limited use to non-scientists in its present form.

Stakeholders from river boards, river forums and one from an NGO in the catchment areas of the KNPRRP did not feel the Programme was doing enough to engage them and did not feel that they were an integral part of the KNPRRP. One river board and an NGO in the KNPRRP catchment areas were not aware of the project until they were approached to take part in the review. These river boards and NGOs not only suggested ways in which they could benefit from the KNPRRP but also ways in which the Programme could have benefited from their knowledge and that of the communities in the area, and even budgetary advantages from joint activities.

Some community-based members of the Olifants River Forum expressed their strong belief that the KNPRRP could have benefited from working with them to capture some of the local knowledge about the rivers in their catchment. We believe the KNPRRP could have taken the opportunity to gather some of this knowledge for posterity.

The Review Panel recommends that the KNPRRP take immediate steps to improve stakeholder participation in their activities. The KNPRRP should take advantage of the list of stakeholders met by the Review Panel to directly engage them in KNPRRP activities and to target them for distribution of *River News* and other publications. We would like research team members to take greater advantage of *River News* to inform non-scientific stakeholders of the potential application of their products. As emphasised in the recommendations, ICIS should be completed and customised at different levels according to the needs of different end-users.

4.8 Cohesion in funding strategy

The Review Panel has examined the available budgetary information contained in KNPRRP documentation and minutes of the Policy Committee. We have also raised questions related to funding with individual researchers and research managers. Overall, there were clear indications that, given the amount of funding, the objectives set were very ambitious (**Section 4.1**).

Stakeholder organisations that made monetary or ‘in kind’ contributions to the Programme were the Department of Water Affairs and Forestry, the Water Research Commission, the National Research Foundation, South African National Parks and the Department of Environmental Affairs and Tourism. Each of these organisations was represented on both the Policy Committee and the Programme Development and Management Committee of the KNPRRP.

However, the Review Panel members recognise that there are some uncertainties regarding the overall cohesiveness of the funding strategy for the KNPRRP. In particular, we are aware of the relatively narrow approach followed by the NRF where financial support is only provided to

those researchers who have obtained an NRF rating or to graduate students at an approved tertiary educational institution. As a result, the WRC became the major source of the direct funding required to support the central project components of the KNPRRP. The direct support of the WRC for the KNPRRP was further extended by the adoption or inclusion of other WRC-funded projects under the overall "KNPRRP umbrella". This could have led to the perception that the WRC was the major Client for products emanating from the KNPRRP.

We believe that this situation has led to some confusion among external Stakeholders regarding the overall Programme funding effort and differing perceptions as to which specific projects were directly or indirectly included in the Programme. In turn, this appears to have contributed to the concerns expressed by some stakeholders that the KNPRRP might not adequately have addressed their specific needs.

We believe that the two research funding agencies (WRC and NRF) have funding strategies that are strongly complementary. However, it is our opinion that the lack of cohesion that appears to have been caused by each organisation addressing the funding needs of projects and researchers separately has meant that the full potential of this complementarity was not realised in the KNPRRP.

4.9 Guidance provided by Policy Committee and Management Committee

The Review Panel was given information on the role and composition of the Policy and Management Committees that respectively provide strategic guidance and management direction to the Programme. We are of the opinion that this division of responsibilities is sensible and provides a good framework for relevant organisations to interact with and steer the Programme. We cannot comment on the appropriateness of individuals representing the different organisations, as that is a matter for those organisations themselves. However, the Review Panel was surprised that local catchment stakeholder groupings were not represented on these committees, as they are both important water users and potential end-users of the research outputs.

Throughout the interviews it became apparent that there were different expectations of what the Programme could and should deliver and this prevailed throughout the Programme. Some resource managers, and in particular those in DWAF, expressed a clear view that the Programme should have been orientated to provide answers to specific management questions related to in-stream river flow needs. The research group expressed the opinion that the questions being asked were not the right ones because they were too simplistic and did not take account of the natural dynamics and variability of river ecosystems. This appears to have led to frustration in both parties. There is a risk that the outputs from the Programme will not be taken up because alternative approaches have been developed and are being applied by resource managers as they feel that their questions were not properly addressed.

The Review Panel is of the view that this mis-match in expectations has resulted from poor communication and a lack of understanding of both management needs and what research programmes are capable of delivering. This issue had been repeatedly debated at the Programme Development and Management Committee (PDMC) but unfortunately consensus could not always be reached. There are ways in which this frequently encountered dilemma can be addressed. For example, it might have been possible to include a member on the research team with expertise and experience in resource management to help stimulate thinking on how the research could be better orientated to meet specific management needs.

4.10 Links with, contributions to, and influence on National policy and legislation

In attempting to review this component of the KNPRRP, the Review Panel felt it important to recognise that the South African community of aquatic scientists and water resource managers is very small. As a consequence of this, it is inevitable that the KNPRRP would have influenced, and had been influenced by, parallel developments in policy and legislation within the country. Given the often complementary research directions of other programmes and research initiatives, and the involvement of many researchers on more than one of these initiatives, it is difficult to disentangle the inter-relationships and define the precise extent to which the KNPRRP has contributed to or exerted an influence on these activities. In several, if not all the cases examined, the influence has often been bi-directional.

Nevertheless, the Review Panel felt it important to recognise that there are specific National initiatives in the policy and legislative arena where KNPRRP researchers and/or their "products" are widely recognised to have played an important role, though this role may not necessarily have been unique, pivotal or even distinct. It is also true to say that it is difficult to distinguish where individual researchers contributed in the personal capacity or as representatives of the KNPRRP. The specific examples we have below demonstrate those important arenas where KNPRRP researchers are recognised to have exerted a direct or indirect influence and we cannot necessarily attribute sole responsibility to the KNPRRP. Nevertheless, we suggest that the following examples can be considered to represent successes in this arena:

- Water quality guidelines: here, KNPRRP researchers contributed significantly to the development of the first edition of water quality guidelines for aquatic ecosystems which was drawn up by the Department of Water Affairs and Forestry (DWAF, 1997). This influence included important conceptual insights into the structure and functioning of aquatic ecosystems in general.

- Assessment of river health: KNPRRP researchers have again provided significant contributions to the conceptualisation of assessment procedures and their practical application.

- Biomonitoring: Biomonitoring techniques, especially the early versions of the South African Scoring System (SASS), owe much to the preliminary work conducted within the KNP. Subsequent enhancements of this technique have also been influenced by work within the KNP and have contributed to resource protection policies.

- Ecotoxicology: Practical experience gained through applications of ecotoxicological assessment techniques within the KNP have contributed to the refinement of techniques and the incorporation of these principles in resource protection policies.

- In-stream flow requirements: Several individuals within the KNPRRP or associated with the KNPRRP have contributed important insights and procedural changes to widely used techniques to estimate the in-stream flow requirements of aquatic ecosystems. These now form key components of the new water policy and are incorporated in legislation.

- Water Law review: Again, certain individuals have been pivotal in the establishment of the concept of the ecological reserve and in the development of policy around integrated water resource management. Both of these components now form key aspects of the new National Water Act.

In contrast to these successes, several individuals interviewed felt, and the Review Panel concurs, that the KNPRRP could have been even more influential had they fully engaged the water law review process as a programme. It is recognised, however, that many of the research projects being carried out within the KNPRRP at the time were at a level of detail which may not have been appropriate for application in the development of national policy and legislation. We also recognise that several of the individual KNPRRP researchers did take this opportunity to contribute to the development of policy outside core programme activities.

5 CONCLUSIONS AND RECOMMENDATIONS ARISING FROM THE EVALUATION

The Review Panel has carefully considered the lessons learnt arising from this review and has the following recommendations:

5.1 Programme management

The Programme management approach developed in the Kruger National Park Rivers Research Programme (KNPRRP) provides a good model for the management of multi-disciplinary scientific projects and programmes and should be promoted and adopted elsewhere. Lessons learnt during the KNPRRP shows that careful consideration should be given to the mix of experience and skills in Programme teams. Effective dissemination of research outputs requires expertise in communication, education, resource management and implementation of corrective action policies. Mechanisms also need to be put in place for continuous self-evaluation and progress tracking against agreed criteria to gauge efficiency and effectiveness. The Review Panel recognises that well-developed skills in scientific programme management are limited in South Africa and capacity building in this area is a priority need.

5.2 Communications and stakeholder involvement

Lessons learnt in the KNPRRP demonstrate the need for a properly structured and targeted communications strategy early in the Programme planning stage. This should include the planning of consensus-building and consultation processes to engage wider stakeholder groups. This takes time and requires adequate budget provision. The lessons learnt in the KNPRRP provide very useful experience that could provide a valuable input into the preparation for the future CMAs.

5.3 Technology transfer and diffusion

The products from the KNPRRP have not yet been effectively transferred to the full range of potential end-users. This will require the implementation of a targeted knowledge management and transfer strategy that takes account of the needs of different end-users including the research community, resource managers and catchment stakeholders. Users should be consulted about their specific needs first so that tools and information can be produced in a way that is meaningful to them. This may well require different kinds of products for different end-users. Partnerships with the private sector should be explored for wider scale application of products.

5.4 Corrective action and capacity building

Experience suggests that reliance on inter-institutional links is not always successful. A range of methods should be pursued. More effort should be placed in actively seeking enthusiastic

and energetic individuals to serve as 'champions' to make links with and stimulate interest in institutions and communities. This should involve user groups in previously disadvantaged communities to make best use of valuable indigenous knowledge as well as technical knowledge.

5.5 Evaluation process

The Review Panel believes that this evaluation process for the KNPRRP has been valuable and could be applied in a similar way to other research programmes. The consultation with a wide range of stakeholders has provided good insight, particularly in relation to the delivery of benefits from the Programme and the different expectations of end-users. We would recommend that future evaluations of this sort are carried out periodically and well before the end of the Programme so that recommendations can be taken up during the lifetime of the Programme rather than just conducting a retrospective 'lessons learnt' exercise.

5.6 Future potential

The KNPRRP has produced management strategies and information products that have the potential for uptake beyond the immediate confines of the Kruger National Park. In particular, the SAM approach, which has been applied effectively within the Kruger National Park, could be adopted more widely in planning research programmes and to support a wide range of environmental management needs. We believe that it could be very helpful in the catchment management planning processes that are now being developed in preparation for the CMAs. This approach needs to be more actively marketed in order to convince future users of its benefits.

The potential benefits of the ICIS system have yet to be fully realised. Concerted effort needs to be put into completing this tool and into customising it at different levels according to the needs of different end-users. Consideration should be given to partnerships with the private sector to bring in technical and marketing expertise in the development of practical software products. Sabie catchment stakeholders are the obvious target audience, but consideration should be given to how the generic components of the system could be applied more widely in other catchments. Without further funding and management there is a risk that this transfer process will not take place and the potential benefits of the system will not be realised. This requires immediate attention.

ACKNOWLEDGEMENTS

The Review Panel could not have completed this review of Phases II and III of the KNPRRP without the active and enthusiastic participation and support of several individuals and organisations in South Africa. Particular thanks are owed to Mr P Odendaal, Chief Executive Officer of the Water Research Commission, and Dr G Von Gruenewald, Vice-President of the National Research Foundation (NRF), for enabling the Review Panel to interact with a wide range of individuals, comprising both members of the KNPRRP and representatives of external stakeholder groups.

Sincere thanks are due to all the individuals and organisations, both participants in the KNPRRP and representatives of external stakeholder groupings, who gave willingly of their time to travel long distances and be interviewed by the Panel. These individuals provided the Review Panel with a series of unique insights into the overall direction and performance of the KNPRRP, as well as the scope and scale of its potential contributions to water resource management in South Africa.

The Review Panel's short stay in the Kruger National Park enabled the panel to interact directly with members of the research team as well as with external Stakeholders, and to visit key project sites and portions of the Sabie River catchment. We are very grateful to Mrs J Deacon and Mrs S Coetzer who provided excellent catering during our visit.

Sincere thanks are also due to the NRF who provided the secretariat and office facilities that enabled the Review Panel to achieve its goals. In this context, a special word of thanks is due to Mrs Lesley Di Santolo of the NRF, who arranged and co-ordinated all our interviews with the many individuals and organisations that were consulted during the review process. The Review Panel would not have been able to complete its brief without her very capable help and assistance.

Appendix 1: Kruger National Park Rivers Research Programme

Terms of Reference for Review Panel

PREAMBLE

The Kruger National Park Rivers Research Programme (KNPRRP) was envisioned at a workshop convened by the Department of Water Affairs in March 1987. It was initiated in 1989 jointly by the government departments of Water Affairs and Environment Affairs, the National Parks Board, the Water Research Commission (WRC), the Foundation for Research Development and various other institutions. The first phase was reviewed in 1993. This was followed by a second (1994 - 1996) and the current third phase (1997 - 1999).

As the name implies, the programme is concerned with rivers that flow through the Kruger National Park, and more particularly, the water requirements (quantity and quality) of these river systems in South Africa and further afield.

ASSIGNMENT TITLE

Evaluation of the KNPRRP Phase II onwards 1994 – 1999.

ASSIGNMENT PRINCIPALS

The Executive Director of the WRC
The President of the National Research Foundation (NRF)

ASSESSMENT COORDINATOR

The NRF Evaluation Centre, PO Box 2600, Pretoria, 0001

SUMMARY OF SERVICE

The assignment

The Review Panel is requested to conduct a formative assessment of the KNPRRP, with particular emphasis on Phases II and III, according to the dimensions outlined in 4.2 and to submit a report on their findings to the assignment principals.

The framework for evaluation

The programme strives to inform those who have responsibility for or interest in the management of the natural environment of river systems. It achieves this through research designed to promote a strategic management process and to provide the necessary procedures and technologies required to achieve this. The extent to which this has been achieved is considered equally important as the production of research products. The reviewers are therefore, requested to provide a broadly based assessment of strengths and weaknesses of the Programme, of lessons learned and of opportunities.

Internal performance

This component assesses the performance of the Programme relative to its objectives and its ability to adapt.

(i) Objectives

- To contribute to the conservation of the natural environment of rivers
- To promote transdisciplinary and inter-institutional communication and collaboration necessary for integrated research on river management
- To develop understanding of the ecological functioning of the natural environment of rivers necessary to develop informed and scientifically based skills and methodologies required to manage change in natural river systems
- To develop skills and methodologies required to manage change in river environment including:
  - defining the desired state and setting operational goals
  - predicting the consequences of management actions
  - evaluating the acceptability of change
  - measuring goal attainment
  - decision support systems that promote integrated river management
- To promote adoption of skills and methodologies by stakeholders including researchers and resource-use managers
- To develop an information management system
- To facilitate trade-offs between demands for water from river systems
- To develop research capacity and enhance capacity among stakeholders.

(ii) Adaptability

- Appraise the development/history and focus of the programme in terms of the original objectives and the provision made for needs and opportunities as they emerged.

External performance

This component assesses commitment and support from stakeholders in the public and private sector. Key stakeholders are:

- Department of Agriculture, Land and Environment (Northern Province)
- Department of Environmental Affairs (Mpumalanga)
- Department of Water Affairs and Forestry
- KwaZulu Natal Conservation Services
- Mpumalanga Parks Board
- National Department of Agriculture
- National Department of Environmental Affairs and Tourism
- NRF
- South African National Parks
- WRC
- Non-government Organisations (River Fora)

Management performance

This component addresses the efficiency and effectiveness of the structure, management, administration, monitoring and marketing of the Programme. The key interviewees are members of the Programme Policy Committee and Development and Management Committee, the Secretariat and the WRC.

Alignment with world trends

This component assesses the

- alignment of the programme with related and leading programmes (known to reviewers) elsewhere in the world

- performance of the programme relating to others given the local context of financial and human resources.

Lessons learned and capacity built

Make recommendations regarding the focus and scope of the programme, cost effectiveness, national and international linkages, efficient ways to reach objectives, lessons for the future, advice on strategies to be followed, etc.

THE PROCESS

The appointment of the Review Panel

The Review Panel comprising experts in the relevant fields will be appointed by the evaluation principals.

Responsibilities of the Review Panel

(i) It will be expected of the Review Panel to work through the detailed resource documents that will be submitted well in advance of the review. Resource documents will comprise, among others, a report from the Programme manager, annual reports, reports from project leaders, etc.

(ii) The Review Panel, in terms of the requirements outlined in the Terms of Reference, will have to decide on:

- the usefulness and appropriateness of the proposed programme *and modus operandi* (e.g. the selection/sample of projects within the programme to be assessed in depth etc.)
- the main line of questions to be asked during the assessment
- performance indicators (e.g. the number and quality of publications and services, number and quality of students, improvement of products and processes, etc.)

(iii) During the period of review, the review team will participate in site visits and will have the opportunity to have discussions with stakeholders, e.g. members of the policy and management committees, the Programme director and managers, team members, students, clients, etc.

(iv) Review Panel members will have to advise on appropriate ways of reporting their findings and recommendations to the respective principals and the various programme managers.

Responsibilities of the Evaluation Centre of the NRF

The Evaluation Centre will act as coordinator for all evaluation proceedings.

Deliverables

(i) Verbal feedback to the principals of the KNPRRP on completion of the *in loco* reviews.

(ii) A preliminary report on the outcome of the evaluation on completion of the review.

(iii) An evaluation report in accordance with the framework outlined in 4.2 within two weeks of completion of the *in loco* review.

TIME FRAME

The evaluation of the KNPRRP should take place during November 1999 and the estimated duration of the *in loco* review will be a maximum of seven working days.

BUDGET

The evaluation principals will be jointly responsible for the costs incurred for this evaluation.

Appendix 2: List of persons interviewed

Mr M.K. Angliss, Agriculture and Environment, Gyani
Dr H.C. Biggs, Programme Manager, Scientific Services, KNP
Dr L.E.O. Braack, General Manager, Conservation Development, Kruger National Park (KNP)
Prof C.M. Breen, Managing Director, KNPRRP and Subprogramme Manager, Corrective Action, Institute for Natural Resources, University of Natal (UN)
Mr G. Cowan, Deputy Director, Environmental Conservation, Department of Environmental Affairs and Tourism
Dr A.R. Deacon, Senior Scientist, KNP
Dr M.C. Dent, Subprogramme Manager, Information Management and Facilitation Subprogramme, UN
Mr F. de Wet, Grassland Monitoring, Mondi Forests, Sabie
Dr C. Dickens, Principal Scientist, Hydrobiology, Umgeni Water and South African Society for Aquatic Sciences
Mr G. Diedericks, Water Quality Monitoring, Mondi Forests, Sabie
Dr J. Engelbrecht, Head Scientist, Aquatic Section Mpumalanga Parks Board
Dr S. Freitag, Head, Resources Management, KNP
Mr P. Gardiner, Technical Water Issues, Mondi Forests, Pietermaritzburg
Dr W.P.D. Gertenbach, General Manager, Nature Conservation, KNP
Prof C.S. James, Department of Civil Engineering, UW
Dr G. Jewitt, Bio-Resources Engineering and Environmental Hydrology, UN
Mr H. Karodia, Director, Catchment Management, DWAF
Mr K.R. Legge, Chief Engineer, Social and Ecological Services, Department of Water Affairs and Forestry, (DWAF)
Mr J. Lubbe, Chairperson, Sabie River Working Group
Dr H.M. MacKay, Assistant Director, Institute for Water Quality Studies, DWAF
Mr B. Madikizela, Department of Zoology, University of the Transkei (KNPRRP Subprogramme partner, Monitoring)
Mr K. Mare, Harvesting Operation, Mondi Forests, Sabie
Mr M.J. Mathebe, Ikangala Water
Mr S. McCartney, Environmental Manager, Mondi Forests, Sabie
Dr S. Mitchell, Research Manager, WRC
Dr P.A. Nevhutalu, Director: Corrective Action, NRF
Mr A.O. Nkabinde, Highveld Water & Sanitation Association
Ms P. Nyakane, Chairperson, Bushbuckridge Water Board
Mr P.E. Odendaal, Executive Director, Water Research Commission (WRC)
Prof J.H. O'Keeffe, Subprogramme Manager, Monitoring Subprogramme, Institute for Water Research, Rhodes University (RU)
Mr R. Parris, Director, Parks, South African National Parks
Mr J.C. Pauw, Manager, Sustainable Environment, NRF
Mr C. Phiri, Research Officer, Association for Water and Rural Development

Mr L. Prinsloo, Weed Control Programme, Mondi Forests, Sabie
Mr L.A.J. Ramokolo, Eskom Hydro & Water Department, Eskom
Prof K.H. Rogers, Subprogramme Manager, Research Subprogramme, Centre for Water in the Environment, University of the Witwatersrand (UW)
Ms G. Rolando, Liaison Officer, KNPRRP, NRF
Dr D. Roux, Project Manager, Water Resource Management, ENVIRONMENTEK, CSIR
Mr W.S. Rowlston, Director, Directorate Strategic Planning, DWAF
Mr C. Ruiters, Deputy Director, Department of Environmental Affairs, Mpumalanga
Mr D. van der Merwe, Deputy Executive Director, WRC
Mr J.L.J. van der Westhuizen, Director: Directorate Water Quality Management, DWAF
Dr H.M. van Vliet, Chief Director, Scientific Services, DWAF
Mr M.A. van Wyk, General Manager, Lisbon Estates
Mr N.J. van Wyk, Chief Engineer, Project Planning, DWAF
Mr H.C. van Zyl, Vice-President, Environmental & Rehabilitation, Anglo Coal
Dr F.J. Venter, Subprogramme Manager, Integrated Rivers Management Subprogramme, Scientific Services, Kruger National Park (KNP)
Dr G. von Gruenewaldt, Vice-President, National Research Foundation (NRF)
Mr D. Weeks, Institute for Water Research, RU

Appendix 3: Schedule for the Review

Evaluation of the Kruger National Park Rivers Research Programme (KNPRRP)

Programme

18 November 1999 – 26 November 1999

Review Panel

Dr P.J. Ashton, Project Manager, Environmentek, CSIR (Convenor)

Dr H.M. MacKay, Assistant Director, Institute for Water Quality Studies, Department of Water Affairs & Forestry

Dr T.J. Ruredzo, Chief Programme Officer (Information), Commonwealth Science Council, London, UK

Dr J. Seager, Environment Agency, Bristol, UK

Accommodation in Pretoria (Dr Ruredzo, Dr Seager)

Shere View Lodge
15 Disselboom Street
Wapadrand
Pretoria

Tel: (012) 809-0096
Fax: (012) 809-0177

Tuesday, 16 November 1999

10:10 Dr T.J. Ruredzo arrives Johannesburg International Airport on SA506

Wednesday, 17 November 1999

14:10 Dr J. Seager arrives at Johannesburg International Airport on BA6206

Thursday, 18 November 1999

08:15 Depart from the National Research Foundation (NRF) to the Water Research Commission (WRC)

09:00 – 10:00 Welcoming and briefing of Review Panel

Mr P.E. Odendaal, Executive Director, WRC
Mr D. van der Merwe, Deputy Executive Director, WRC
Dr S. Mitchell, Research Manager, WRC
Dr G. von Gruenewaldt, Vice-President, NRF
Dr P.A. Nevhutalu, Director. Corrective Action, NRF
Ms G.U. Schirge, Manager. Evaluation Centre, NRF
Mrs L.C. Di Santolo, Coordinator, Evaluation Centre, NRF

Venue: Committee Room B, 3rd Floor, Watko Building

10:00 – 10:20 Staff of NRF Evaluation Centre to discuss logistics with Review Panel

Venue: Committee Room B, 3rd Floor, Watko Building

10:20 – 11:00 Review Panel to discuss *modus operandi* of review

Venue: Committee Room B, 3rd Floor, Watko Building

11:00 – 13:30 Mr P.E. Odendaal, Executive Director, WRC
Mr D. van der Merwe, Deputy Executive Director, WRC
Dr S. Mitchell, Research Manager, WRC

This session will include a working lunch

Venue: Committee Room B, 3rd Floor, Watko Building

13:30 Depart for NRF

14:00 – 15:00 Dr G. von Gruenewaldt, Vice-President, NRF
Dr P.A. Nevhutalu, Director, Corrective Action, NRF

Venue: Committee Room A119, NRF Building

15:00 – 16:00 Mr J.C. Pauw, Manager, Sustainable Environment, NRF

Venue: Committee Room A119, NRF Building

16:00 – 16:30 Ms G. Rolando, Liaison Officer, KNPRRP, NRF

Venue: Committee Room A119, NRF Building

17:00 - 19:00 Cocktail function

Venue: Atrium, NRF Building

Friday, 19 November 1999

±07:30 Depart from Pretoria to Johannesburg International Airport (Details to be confirmed)

09:30 Flight SA1201 departs from Johannesburg International Airport to Skukuza Airport

10:40 Arrival at Skukuza Airport

11:30 – 13:00 Dr L.E.O. Braack, General Manager, Conservation Development, Kruger National Park (KNP)
Dr W.P.D. Gertenbach, General Manager. Nature Conservation, KNP

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

13:00 – 13:30 Lunch

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

13:30 – 15:00 Dr H.C. Biggs, Programme Manager, Scientific Services, KNP
Dr A.R. Deacon, Senior Scientist, KNP

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

15:00 – 16:00 Dr J. Engelbrecht, Head Scientist, Aquatic Section, Mpumalanga Parks Board

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

16:00 - 16:30 Dr S. Freitag, Head, Resources Management, KNP

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

17:00 Review Panel travels to Pretoriuskop

Accommodation for Review Panel on 19 November 1999:

Pierre Joubert Guest House, Pretoriuskop
Kruger National Park

Tel: (013) 735-5128

Saturday, 20 November 1999

Interviews with participating scientists and field visits in the Kruger National Park will take place over the weekend.

The purpose of this component of the review is to:

- contextualise the research programme by way of a site visit;
- provide for formal and informal contact with team members, thereby adding depth and quality to the review.

Team participants

Prof C.M. Breen	Managing Director, KNPRRP and Subprogramme Manager, Corrective Action Institute for Natural Resources, University of Natal (UN)
Dr M.C. Dent	Subprogramme Manager, Information Management and Facilitation Subprogramme, UN
Prof J.H. O'Keeffe	Subprogramme Manager, Monitoring Subprogramme Institute for Water Research, Rhodes University (RU)
Prof K.H. Rogers	Subprogramme Manager, Research Subprogramme Centre for Water in the Environment, University of the Witwatersrand (UW)
Dr F.J. Venter	Subprogramme Manager, Integrated Rivers Management Subprogramme Scientific Services, Kruger National Park (KNP)

Subprogramme partners

Adv M. Uys	Lawyer (apologies)
Dr J. Jaganyi	Institute for Natural Resources, UN (apologies)

Senior researchers/researchers

Ms Y. Coetzee	Consultant, Skukuza (apologies)
Dr A.R. Deacon	Senior Scientist, KNP
Dr G. Jewitt	Bio-Resources Engineering & Environmental Hydrology, UN
Mr D. Weeks	Institute for Water Research, RU
Prof C.S. James	Department of Civil Engineering, UW

Past Subprogramme manager

Dr H.C. Biggs	Programme Manager, Scientific Services, KNP

06:00 Review Panel departs Pretoriuskop for Skukuza

07:00 – 08:00 Breakfast

Venue: Skukuza Restaurant

08:00 - 08:45 Introduction to the rivers of the Kruger National Park by Dr F.J. Venter

Catchment Information System by
Dr M.C. Dent

Environmental water requirements by
Prof J.H. O'Keeffe

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

08:45 Depart for Sabie together with Mr S. McCartney from Mondi Forests, Sabie

10:00 - 16:00 Catchment field trip led by

Dr F.J. Venter
Prof J.H. O'Keeffe
Mr D. Weeks

(The above field trip has been arranged by Mr McCartney, Mondi Forests. Lunch will be enjoyed *en route* and will be hosted by Mr McCartney.)

18:00 Arrival in Skukuza

Accommodation for Review Panel in Skukuza

Waterkant Guest House, Skukuza
Kruger National Park

Tel: (013) 735-5611

Sunday, 21 November 1999

07:00 – 08:00 Breakfast

Venue: Waterkant Guest House

08:00 - 12:00 Field visit to Sabie River in the Kruger National Park
Emphasis on hydrology, hydraulics, geology, geomorphology, vegetation and integrated modelling.

Leaders: Prof K.H. Rogers
Prof C.S. James
Dr G. Jewitt
Mr D. Weeks

Field visit: River management and monitoring

Leaders: Dr H.C. Biggs
Dr M.C. Dent
Prof J.H. O'Keeffe
Dr F.J. Venter

12:00 - 14:00 Lunch

14:00 - 15:30 Interviews with programme managers

Prof C.M. Breen
Dr M.C. Dent
Prof J.H. O'Keeffe
Prof K.H. Rogers
Dr F.J. Venter
Dr H.C. Biggs

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

15:30 - 17:00 Interviews with other team members

Ms Y. Coetzee (apologies)
Dr A.R. Deacon
Dr J. Jaganyi
Dr G. Jewitt
Mr D. Weeks

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

19:00 Braai

Venue: Waterkant Guest House

Monday, 22 November 1999

07:00 – 08:00 Breakfast

Venue: Waterkant Guest House

08:00 – 09:00 Mr C. Ruiters, Deputy Director, Department of Environmental Affairs, Mpumalanga

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

09:00 – 10:00 Ms P. Nyakane, Chairperson, Bushbuckridge Water Board
Mr C. Phiri, Research Officer, Association for Water and Rural Development

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

10:00 – 11:30 Sabie River Working Group:
Mr J. Lubbe, Chairperson, Sabie River Working Group
Mr P. Gardiner, Mondi Forests, Pietermaritzburg
Mr C.P. Koza, Bushbuckridge Water Board (apologies)
Mr M.A. van Wyk, General Manager, Lisbon Estates
Mr G. Marais, Environmental Manager, South African Forestry Company Limited (SAFCOL) (apologies)

Venue: Nature Conservation Board Room, Nature Conservation Building, Skukuza, Kruger National Park

11:45 Depart for Skukuza Airport

12:30 Flight SA1204 departs from Skukuza Airport to Johannesburg International Airport

13:45 Arrive at Johannesburg International Airport

15:30 – 16:30 Mr K.R. Legge, Chief Engineer, Social and Ecological Services, Department of Water Affairs and Forestry, (DWAF)
Mr W.S. Rowlston, Director, Directorate Strategic Planning, DWAF

Venue: Atrium Committee Room B, NRF Building

Tuesday, 23 November 1999

08:30 – 10:00 Review Panel: Discussion and preparation of report

Venue: Atrium Committee Room B, NRF Building

10:00 – 11:00 Mr R. Parris, Director, Parks, South African National Parks

Venue: Atrium Committee Room B, NRF Building

11:00 – 12:00 Mr M.K. Angliss, Agriculture and Environment, Gyani

Venue: Atrium Committee Room B, NRF Building

12:00 – 13:00 Mr B. Madikizela, Department of Zoology, University of the Transkei (KNPRRP Subprogramme partner: Monitoring)

Venue: Atrium Committee Room B, NRF Building

13:00 – 14:00 Lunch

Venue: Atrium, NRF Building

14:00 – 15:30 Dr D. Roux, Water Resource Management, Environmentek, CSIR

Venue: Atrium Committee Room B, NRF Building

15:30 – 16:00 Dr H.M. MacKay, IWQS, Department of Water Affairs & Forestry

Venue: Atrium Committee Room B, NRF Building

16:00 - 17:00 Review Panel: Discussion and preparation of report

Venue: Atrium Committee Room B, NRF Building

Wednesday, 24 November 1999

09:30 – 11:00 Olifants River Forum:
Mr H.C. van Zyl, Vice-President, Environmental & Rehabilitation, Anglo Coal
Mr L.A.J. Ramokolo, Eskom Hydro & Water Department, Eskom
Mr M.J. Mathebe, Ikangala Water
Mr A.O. Nkabinde, Highveld Water & Sanitation Association

Mr R. Lorimer, Lorimer Environmental Consultants (member of the Sabie Rivers Working Group) (apologies)

Venue: Atrium Committee Room B, NRF Building

11:00 - 12:00 Mr G. Cowan, Deputy Director, Environmental Conservation, Department of Environmental Affairs and Tourism

Venue: Atrium Committee Room B, NRF Building

12:00 - 13:00 Mr J.L.J. van der Westhuizen, Director, Directorate Water Quality Management, DWAF
Mr N.J. van Wyk, Chief Engineer, Project Planning, DWAF

Venue: Atrium Committee Room B, NRF Building

13:00 - 14:00 Working lunch with Dr C. Dickens, Principal Scientist: Hydrobiology, Umgeni Water and South African Society for Aquatic Sciences

Venue: Atrium, NRF Building

14:15 Depart NRF for Department of Water Affairs and Forestry, Schoeman Street, Pretoria

15:00 – 16:00 Dr H.M. van Vliet, Chief Director, Scientific Services, DWAF

Venue: 423 Patterson Building, Schoeman Street, Pretoria

16:15 – 17:15 Mr H. Karodia, Director, Catchment Management, DWAF

Venue: 918 Residensie Building, Schoeman Street, Pretoria

Thursday, 25 November 1999

08:30 – 17:00 Review Panel: Preparation of report

Venue: Atrium Committee Room B, NRF Building

Friday, 26 November 1999

08:30 – 13:00 Review Panel: Finalise draft report. Preparation of overheads for presentation of report if necessary.

Venue: Committee Room C239, NRF Building

13:00 – 14:00 Lunch

Venue: Bateleur Dining Room, NRF Building

Dr P.J. Ashton
Dr H. MacKay
Dr T.J. Ruredzo
Dr J. Seager
Dr G. von Gruenewaldt
Dr P.A. Nevhutalu
Ms G.U. Schirge

14:00 – 16:00 Feedback of Review Panel's findings

WRC and NRF Executive
Members of WRC and NRF Management
Members of the Policy Committee

Venue: Board Room, NRF Building

16:00 – 16:30 Debriefing Session

Venue: Board Room, NRF Building

Flight: Dr J. Seager departs from Johannesburg International Airport on KL594 for Amsterdam at 20:00.

Dr T.J. Ruredzo (details still to be confirmed)

Appendix 4: List of documents consulted by the Review Panel

1. Terms of Reference for the review.
2. Bound compilation of a series of documents including:
3. KNPRRP Phase II (1994 – 1996) Final Contract Report
4. Phase II Programme Approach
5. The Phase III Programme.
6. KNPRRP Phase II: Programme description.
7. The KNPRRP Phase III (1997 – 1999) Final Report; Draft for consideration by the Policy Committee.
8. Several volumes of *River News* between May 1995 and July 1999.
9. Distribution list of *River News*.
10. KNPRRP Minutes of the 18th, 19th and 20th meetings of the Policy Committee.
11. Mondi Forests – general information booklet.
12. Breen, C., first draft of Concept Note. Knowledge management for river environment sustainability: testing a model on the Sabie River.
13. Rogers, K., Roux, D and Biggs, H. The value of visions and art of visionaries. *In Press. Conservation Ecology.*
14. Rogers, K., Roux, D. and Biggs, H. Challenges for catchment management agencies, lessons from bureaucracies, business and resource management. Submitted to *Water SA.*
15. The website of the KNPRRP at http://www.ccwr.ac.za/KNPRRP/.
16. Land-use and Wetland/Riparian Habitat Working Group. 1999. Wetland/riparian habitats: practical field procedure for identification and delineation.
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Appendix 5: List of abbreviations and acronyms used in this report

ACRU	Agricultural Catchments Research Unit Modelling Systems
BLINKS	Biotic-abiotic Links Project (The linking of abiotic and biotic predication capabilities)
CMAs	Catchment Management Agencies
DSOH	Desired State Objectives Hierarchy
DWAF	Department of Water Affairs and Forestry
FRD	Foundation for Research Development
HBUs	Historically Black Universities
HSPF	Hydrological Simulation Programme Fortran
ICIS	Integrated Catchment Information System
KNPRRP	Kruger National Park Rivers Research Programme
KNR	Kruger National Park
NGOs	Non-Government Organisations
NRF	National Research Foundation
PDMC	Programme Development and Management Committee
SAM	Strategic Adaptive Management
SANP	South African National Parks
SASS	South African Scoring System
SWOT	Strengths, Weaknesses, Opportunities and Threats
TPC	Threshold of Potential Concern
WRC	Water Research Commission