



**DEPARTMENT OF WATER AFFAIRS AND FORESTRY
CHIEF DIRECTORATE: SCIENTIFIC SERVICES**

**FINAL DRAFT
INITIAL INVESTIGATION REPORT
MONITORING AND ASSESSMENT INFORMATION SYSTEMS
MAIS Phase 3**

For discussion and comment
October 2001

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1 Introduction

This document is an output of the Initial Investigation of Phase 3 of MAIS. It describes the

- results of analysing information needs for water resources management and
- proposals for MAIS functions as the development team sees it in the “To Be” scenario.

The purpose of the document is to facilitate discussion among stakeholders to clarify and refine the proposals. The overall aim is to develop a common vision for and understanding of MAIS with respect to:

- its purpose,
- its functions and general structure, and
- the requirements for its sound governance.

The stated purpose of MAIS is to address requirements of the National Water Act (Act 36 of 1998) (NWA), specifically

- Section 137 - requires the development of monitoring systems,
- Section 138 - requires establishment of mechanisms and procedures to co-ordinate the monitoring of water resources, and
- Section 139 - requires development of national information systems regarding water resources.

The goal of the information and monitoring systems is to deliver water related information, which is effectively used in decision making by water management institutions as established by the NWA.

The MAIS strategy was approved by DWAF’s Water Resources Management Committee in April 2000 and further elaborated on in the inception report for the current Phase 3 project. This strategy has been developed under the guiding principles that MAIS should:

- be focused on cost-effective delivery of the information required to execute DWAF’s water resources management functions,
 - provide its users with “a single version of the truth,” for example, the geographic location of a monitoring site, the observed data for the site, *etc.*, and
 - minimise duplication of effort and infrastructure for acquiring, storing and managing data
- promote the development and enforcement of a consistent IT platform,
- ensure knowledgeable clients, and
- encourage strong corporate governance of monitoring and assessment.

Governance is considered a critical element is MAIS because the nature of integrated assessment of water resources will require substantial coordination within separate groups at DWAF and between DWAF and a large number of external organisations. Governance issues cover a wide variety of topics, from enforcement of the use of naming conventions and IT platforms, through intergovernmental liaison, funding, and staffing.

The major objective of the MAIS strategy is to enhance the flow of information - from measurement activities, through analysis and incorporation of diverse data types into integrated assessments – to ensure effective use in water resources decision making. The major components of this analysis were the assessment of information required for water resources decision making and the proposal of a MAIS structure to achieve enhanced information flow.

2 Functional Model for MAIS

An important perspective we used in describing MAIS during interviews and presentations was the functional model displayed in **Figure 1**. Most people we interacted with found it a useful model. The rows in the graphic represent the generic components of the information system, namely, Data Acquisition, Data Storage and Management, and the Information Products that result from Information Generation and Dissemination. The row at the bottom, labelled Complex Knowledge Products, are the documents, reports, decisions, recommendations, *etc* that are used in conducting the business of water resources management. Complex knowledge products use output from the information system as input into their assessment and decision-making processes.

2.1 Information Products vs Complex Knowledge Products as a MAIS Boundary

A MAIS boundary lies between what is designated in Figure 1 as “Information Products” and “Complex Knowledge Products.” Information Products are outputs from MAIS created by compiling measured results or processing existing data; Complex Knowledge Products are created by the information users themselves using the outputs they obtain from MAIS, together with other information and expertise. The Complex Knowledge Products represent the output – either final or intermediate - of business processes of water resources management. They require an understanding of the wider consequences and implications of decisions made during the course of the analysis.

It is important to define the concepts of Information Products and Complex Knowledge Products as clearly as possible, since the boundary depends on them. Although clear criteria that separate the two types of products may not exist, we describe the concepts more fully in the following paragraphs.

Complex Knowledge Products can only be generated through experienced practitioners in a particular domain of water resources management adding their tacit knowledge (insight / understanding / experience) to the information they obtain from different sources to reach a conclusion, recommendation, or decision. Although the processes they apply may be standardised, the specific conclusions, recommendations and / or decisions they reach are usually case specific. Examples of typical Complex Knowledge Products are:

- ♦ A catchment management plan,
- ♦ Evaluation (including recommendations for license conditions) of a water use license application,
- ♦ Assessment of a dam safety application,
- ♦ Assessment of whether or not a user complies with the conditions stipulated in a water use license,
- ♦ Establishing Resource Directed Measures, including the management class of a water resource, the ecological and basic human needs reserves, and Resource Quality Objectives (RQOs), and
- ♦ Assessment of the current status of a water resource compared to its RQOs for surface and ground water.

In contrast, **Information Products** result from processing data using standard tools and applications. The repeated production of a particular information product does NOT require tacit knowledge of the water resources management domain in which the information is to be applied. Typical examples of Information Products are:

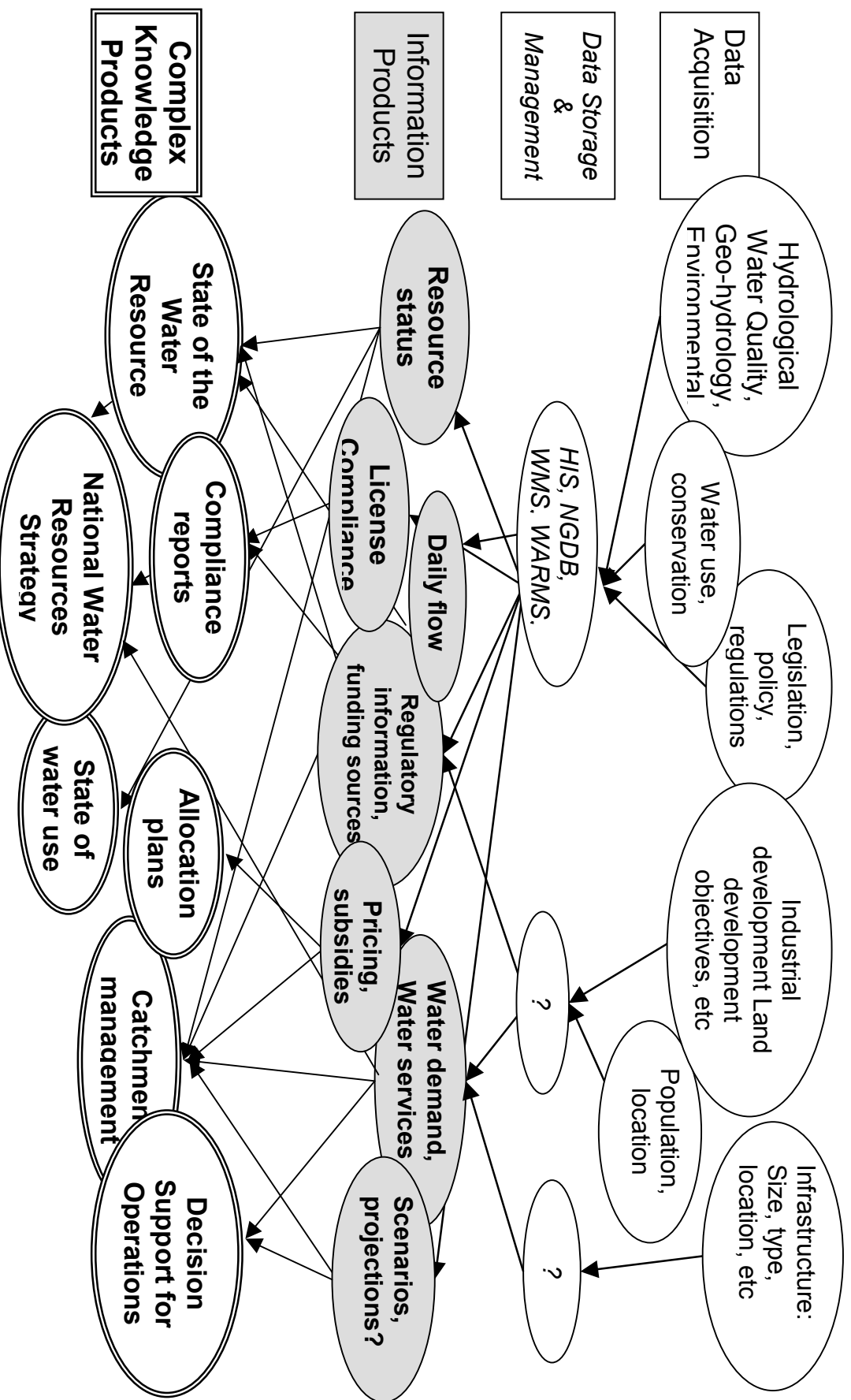


Figure 1. Functional Model of MAIS with illustrative examples

- ♦ A time series of measured flow, salinity, rainfall, *etc.* at a given point, plus important statistics such as the median, trend, frequency distribution *etc*
- ♦ Graphical representation of the spatial variation in hydrological components.
- ♦ A map showing the distribution of vegetation, soil types, land use, *etc.* of an area.

Some Information Products require extensive knowledge to create the product, however, once it is created, it can serve as a static representation of the knowledge and form an important input into a number of decision-making processes. Land cover maps are one example of these Information Products.

As described above, an important criterion in distinguishing information and knowledge products is the need for increasing amounts of tacit domain knowledge to produce the more complex outputs. As the tacit knowledge required for a given product becomes codified, (for example in the form of standard methods for patching flow records) such products previously considered Complex Knowledge Products can be treated as Information Products because they now require little additional tacit domain knowledge for their repeated production. The inclusion of meta-data with stored data can sometimes reduce the need for specialist input to an analysis, however, it is unlikely to have a major impact on the category of a specific product.

In other information systems, expert systems have been used in an attempt to codify analysis, but have not met with large-scale success. Knowledge management is a more recent attempt to address the need for general applications of decision support in the absence of specialised experience. Those approaches may form part of the overall process to supply information products, but will not be a central focus of MAIS.

Because the distinction between Information Products and Complex Knowledge Products is fuzzy and will remain so, it is pointless to attempt an accurate definition as the basis for establishing the information system boundaries. Instead, we propose that the boundary is established through negotiation between MAIS owners and the relevant information users and that these boundaries are re-negotiated from time to time as information needs and capabilities change. The negotiation process will form an important component of information flow. It will effectively provide the criteria by which information flow is judged to be adequate and information is identified as appropriate.

2.2 Relationship between Complex Knowledge Products and Information Products

In analysing the development of a number of Complex Knowledge Products, it is clear that a series of processes occurs, often using the output of a previous processing step as input to the next process. This creates a series of Information Products ⇒ intermediate Information Products ⇒ Complex Knowledge Products. Complex Knowledge Products often serve as input to other Complex Knowledge Products.

MAIS and the CKP owner would negotiate an Information Product to meet certain of the information needs that correspond directly to water resource related information and/or are listed for a number of CKPs. It is clear that, in many cases, the same Information Product could satisfy more than one information need because several CKP's had very similar information needs. In other words the following picture which relates CKPs to information needs and Information Products emerged:

CKP 1 ⇒	Information need 1.1	Information Product 1.1
	Information need 1.2	<u>Information Product x</u>
	⋮	
CKP 2 ⇒	Information need 1. <i>n</i>	Information Product 1. <i>n</i>
	Information need 2.1	<u>Information Product x</u>
	Information need 2.2	Information Product 2.2
CKP 3 ⇒	⋮	
	Information need 2. <i>n</i>	Information Product 2. <i>n</i>
	Information need 3.1	Information Product 3.1
	Information need 3.2	Information Product 3.2
	⋮	
	Information need 3. <i>n</i>	<u>Information Product x</u>

Information Product x is an example of a single Information Product that meets three needs, namely information needs 1.2, 2.1, and 3.*n* associated with CKPs 1, 2 & 3.

2.3 Information types as a MAIS boundary

One of the services that MAIS intends to provide is to facilitate the exchange of data between DWAF and other organisations. It would foster existing liaison channels or create additional ones to help ensure access to the primary data required for Information Products. It would also negotiate when necessary for owners of data to perform specified analyses in cases where the analytical expertise resides in the organisation that collected the data or with other external specialists. The information acquired in that manner would be that identified as required in negotiated Information Products that will be used by a number of clients. It would be an integral part of the Integrated Monitoring Programme that produces the Information Product. An example of this service might be to negotiate with the Department of Agriculture to obtain spatial data on soil types and slopes that has been analysed in terms of erosion potential.

There is a limit to the data and information that MAIS will acquire in this manner. There may be cases where a specific type or instance of information will be required for an analysis for use in a single Complex Knowledge Product. For cases where information needed is restricted to a single use, the owner of the CKP would negotiate with the external supplier to obtain the information. MAIS could function as a resource in identifying the location of the information and the results could be stored on the corporate information system. MAIS would not be responsible for acquiring, maintaining, or updating the information.

Another special case of information management is the use of data on a real-time scale to perform operations on infrastructure. Examples are operation of irrigation schemes, dam releases, response to pollution incidents, and similar activities. Because the data acquisition activities are so closely associated with the management activities, control of the entire process should be as close as possible to the information use. While the data collected for those activities may later be processed and stored in the information system, the data acquisition and primary information products may not form part of a MAIS Integrated Monitoring Programme.

2.4 MAIS Interface with Other Information Systems

MAIS does not claim to be the umbrella information system for DWAF, rather, it forms a part of DWAF's portfolio of information systems. Its primary purpose is to provide water resource related Information Products to information users. It is recognised that MAIS will need to interface with the other information systems to exchange data or information. The existence of MAIS together with other information systems requires that boundaries, in terms of responsibilities, of the separate information systems be

specified. Issues related to facilitation of the interaction among information systems will be addressed in the MAIS design. MAIS will assume as an important objective the support for strong corporate governance and encourage the enforcement of standards across information systems.

3 Analysis of Information Needs for DWAF Water Resource Management Functions

The investigation of information needs relied primarily on:

- ♦ The insights the development team gained from interviewing;
 - information users, representing most of DWAF's main water resources management functions, and
 - information providers, mainly from within the Scientific Services Chief Directorate, but also others.
- ♦ The Preliminary Functional Analysis that was completed as part of the Strategic Transformation and Restructuring Project. The version we used was dated April 2001.

The MAIS design began with an analysis of information needs of water resources management functions to meet the objective of ensuring an adequate flow of appropriate information. In order to help identify information needs, we applied an informal business process analysis technique to identified functions, specifying detail to the level required to be able to clearly identify information needs.

This section describes our approach and the associated terminology that was used in conducting and documenting this part of the process.

3.1 Levels of functions

Effective management of water resources requires an intricate set of interdependent functions. These functions can be viewed from a large number of perspectives, some more useful than others. In order to prevent a proliferation of separate lists of water resource management functions, we categorised the analysis in the same terminology as that used in the Functional Analysis of the Strategic Transformation and Restructuring Project, Version April 2001. Functions were broken down to five levels in order to be able to clearly identify information needs. The levels are described below.

- ♦ **Level 0 (zero): Water Resources Management**
 - **Level 1 Functions:** The six functional areas described in the analysis of the Strategic Transformation and Restructuring Project. These are:
 - 1 Policy and strategy development;
 - 2 Water use regulation;
 - 3 Physical implementation / make water available;
 - 4 Institutional support;
 - 5 Information management;
 - 6 Auditing water resource management
 - **Level 2 Functions:** Components of the Level 1 functions were listed in the analysis. For example, the Functional Area 1: Policy and strategy development contained
 - 1.1 Develop legislation, internal policy & policy about international water

- resources obligations;
 - 1.2 Develop National Water Resources Strategy;
 - 1.3 Develop catchment management strategies;
 - 1.4 Develop and maintain guidelines, methodologies and procedures for strategic functions
 - 1.5 Develop and maintain a pricing strategy;
 - 1.6 Formulate the water resource components of the Medium-Term Expenditure Framework (MTEF) on the basis of DWAF's strategic business plans.
- **Level 3 Functions:** These corresponded largely to the “primary outputs” listed for each Level 2 function. For example, 1.2 Develop National Water Resources Strategy outputs were
 - 1.2.1 Resource Directed Measures;
 - 1.2.2 Direct WRM Strategies;
 - 1.2.3 Roles for WRM Institutions (WMI);
 - 1.2.4 A coordinated process for the compilation, promulgation & regular updating of NWRS
 - 1.2.5 A coordinated process for the implementation of the restructuring of the WRM component of DWAF
 - **Level 4 Functions:** These corresponded largely to the “primary tasks” as clarified by the Procedural Activities” listed in the functional analysis and the activities identified from the interviews held with information users. For example, 1.2.2 Direct WRM Strategies contains, among others:
 - 1.2.2.1 Reconcile water resource availability & demand in & between WMAs (national assessment);
 - 1.2.2.3 Develop national quality/ instream management strategy;
 - 1.2.2.4 Conduct a feasibility study for the construction of a specific dam at an identified location...

In the interviews with information users, we disaggregated the functional areas to at least Level 4 in order to identify Complex Knowledge Products at a sufficient level of detail to clearly identify the information needed. Many Complex Knowledge Products identified were therefore associated with performing a Level 4 water resources management function. The result was that the population of CKPs and their associated information needs had a structure that mirrored that of the functional analysis. The majority of information needs identified were required as inputs to Level 4 functions that produced Level 4 CKPs as their outputs. There are CKPs associated with higher level functions, but they usually need CKPs from Level 4 functions as their input, rather than Information Products.

As an illustrative example of the identification of information needs, a Level 4 function, “Conduct a catchment situation assessment” produces as its Complex Knowledge Product a Catchment Situation Assessment Report. Examples of the information needs associated with the Assessment Report are:

- ♦ Hydrological characteristics for the area (for example, naturalised monthly flows for quaternary catchments)
- ♦ Demographics
- ♦ Social characteristics
- ♦ Economic characteristics
- ♦ Ecological characteristics
- ♦ Others

3.2 Presentation of the results of interviews

The results of the analyses of information needs performed according to the above description were documented in two ways, one as Framework 5.4 Diagrams. Framework 5.4 is the software recommended by the “Integrator” for documenting business process analyses. **Figure 2** illustrates the configuration and organisation of the display and **Figure 3** shows an example developed from an analysis of the water resources planning process. The diagrams can be viewed on the MAIS Website at www-dwaf.pwv.gov.za/iwqs/wrmais.

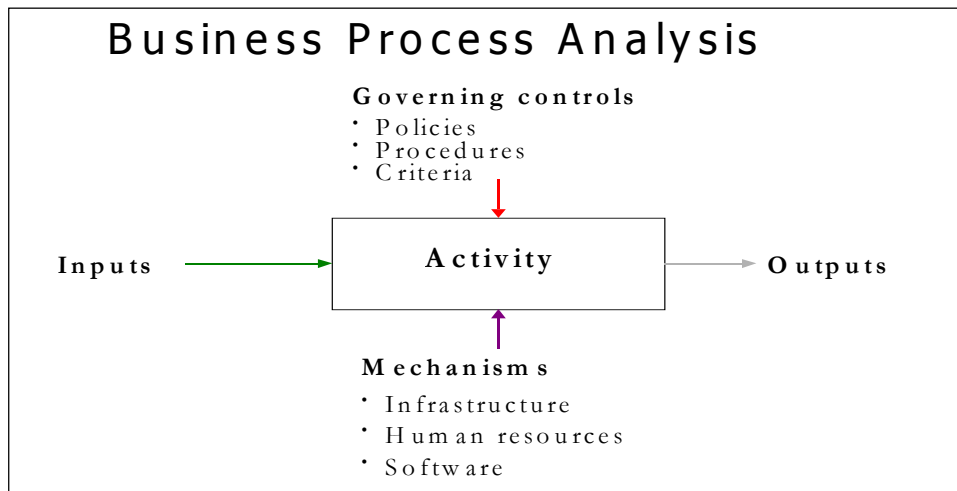
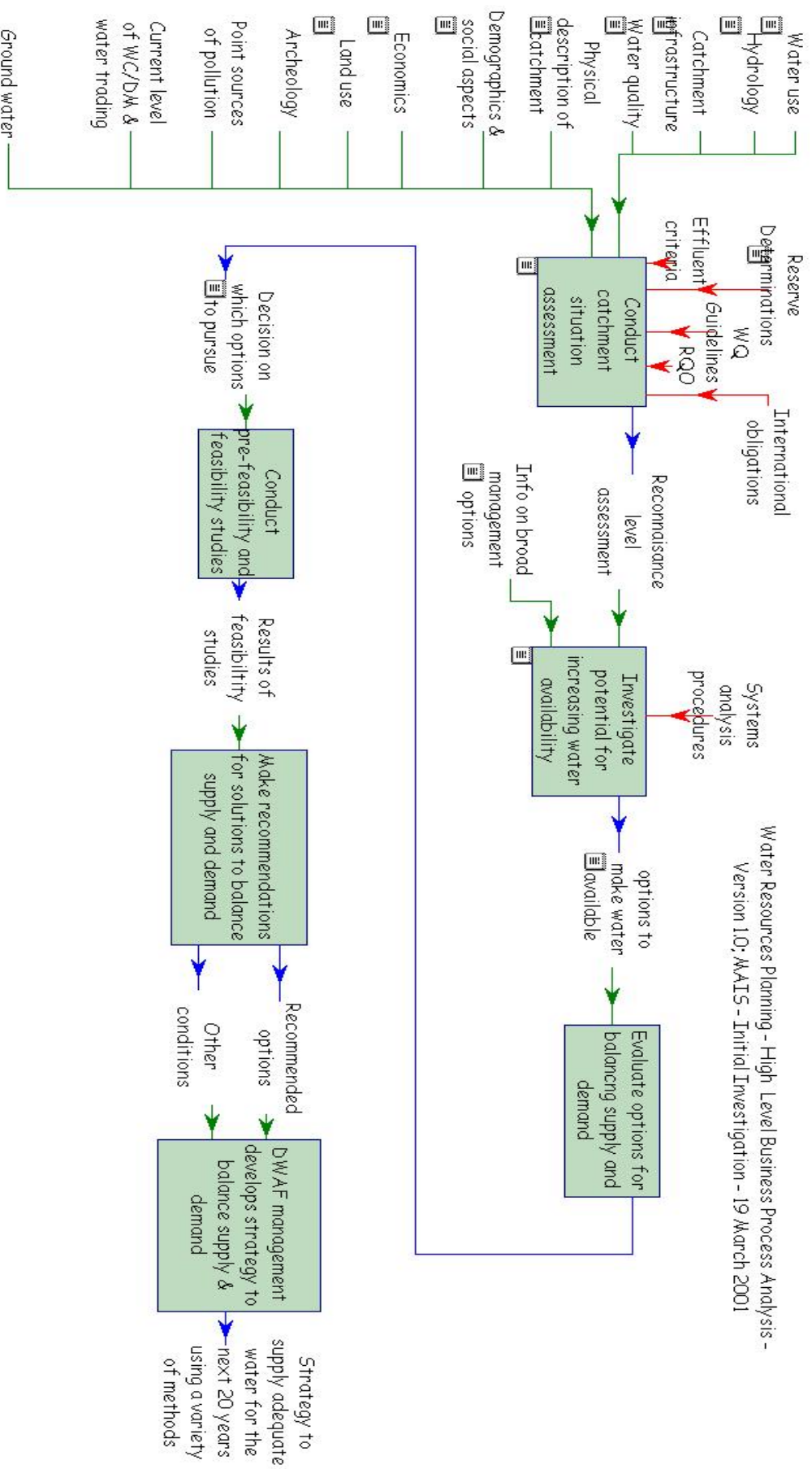


Figure 2. Format of Framework 5.4 Business Process Analysis diagrams

The second format for output of the interview information was tabulated using the same functional areas as those used by the Strategic Transformation and Restructuring Project. Complex Knowledge Products were listed for each division of the functional areas, together with information needs for the CKPs. The table was presented to the Task Team and comments received were incorporated. It is included as **Appendix 1** and can be viewed or downloaded from the MAIS Website www-dwaf.pwv.gov.za/iwqs/wrmais

A summary of the information needs for each functional area is given in **Table 1**.



Water Resources Planning - High Level Business Process Analysis -
Version 10; MAIS - Initial Investigation - 19 March 2001

Figure 3. Example of Framework 5.4 diagram for water resources planning process

Table 1. Summary of information needs for functional areas described in Strategic Transformation and Restructuring Project

1	Policy and Strategy
1.1	Describe characteristics and their dynamics
1.1.1	of the Resource, including habitats; ecosystems
1.1.2	of Resource use; including equity of access; efficiency
1.2	Predict future water use
1.3	Evaluate options to make water available
1.4	Establish Resource Directed Measures
1.5	Evaluate efficacy of implemented policies
2	Water Use Regulations
2.1	Compliance with license conditions
2.1.1	with CMA/Regions
2.2	Compliance with dam safety requirements
2.3	Information to assess impacts of proposed regulations
3	Auditing Water Resources Management
3.1	Compliance with Resource Quality Objectives
3.1.1	with CMA/Regions plus independent sampling
3.2	Other institutional auditing
3.2.1	for example, financial, social aspects
3.3	DWAF compliance with Constitutional and other statutory requirements
4	Physical implementation
4.1	Special studies
4.1.1	Impact assessments
4.1.2	Evaluate license applications
4.2	Real time operations
4.2.1	Response to flood conditions
4.2.2	Infrastructure operations
4.2.3	Investigate incidents
5	Institutional support
5.1	Provide support for information systems
6	Information Management
6.1	Information to support policy and strategy development for Information Management

In addition to the specific information needs identified, two general conditions were noted in the interviews, namely:

- ♦ Information required to perform the water management functions will be needed at different levels of detail to allow issues to be addressed at national, catchment, and site specific scales. One should be able to aggregate and disaggregate (zoom in and out) information from the largest to the smallest scale.
- ♦ Information will be collected, stored and analysed by different institutions.

4 The Current Status of DWAF Monitoring Programmes

DWAF currently has several water resources related monitoring programmes, focused primarily on data acquisition. The programmes can be broadly grouped as:

- ♦ Hydrological Monitoring (flow, dams, evaporation, rainfall)
- ♦ Geohydrological Monitoring (water levels, water quality, rainfall, abstraction)
- ♦ Water Quality Monitoring (chemical, microbiological, eutrophication, river health, radioactivity, others)
- ♦ Compliance Monitoring
- ♦ Special Surveys (for example, those conducted by Geomatics)
- ♦ Project specific monitoring activities (RDM related monitoring, special water quality investigations, license evaluations, etc.)

The programmes have been differentiated primarily on the scientific / technical discipline involved, namely, hydrology, water quality, and geohydrology and each programme has its own data acquisition, data storage and management, and information generation functions.

4.1 Organisational structure of existing monitoring programmes

Located within the Chief Directorate: Scientific Services, the Directorates of Hydrology, Geohydrology and the Institute for Water Quality Studies (IWQS) are responsible for the majority of water resource monitoring programmes. A fourth directorate, Geomatics, is responsible for spatial data and is a primary link with external data sources to obtain much of that data. A fifth directorate, Social and Ecological Services, has been created more recently and does not yet have a clear mandate for data acquisition, although their role in establishing frameworks for social impact assessments and environmental impact studies is influential in determining information needs. Each of DWAF's Regional offices also conducts monitoring programmes, primarily to determine compliance with water use license conditions. Consultants often conduct monitoring for project specific activities. Water users typically measure their own water use volumes and chemical and physical characteristics of waste discharge. DWAF monitoring programmes are used to validate the information supplied by water users.

Each monitoring programme is organised differently, but usually addresses data acquisition, data storage and management, and occasionally produces routine reports. Programme design or modification is typically initiated by programme operators responding to perceived needs for information at the time of development. For example, many of the first flow gauging sites were located at proposed reservoir inflow sites to provide information for dam design. Sites have subsequently been located for other reasons.

Staff in Regional offices are responsible for most of the operations required for measurements in the geohydrology and hydrology programmes, that is, maintaining measuring equipment, taking samples, downloading electronic files, and the initial processing of water levels, etc. Much of the chemical water quality sampling is conducted by Regional staff and analysed at the IWQS analytical laboratories in Pretoria. Other developing programmes, such as microbial, eutrophication, and radioactivity monitoring are creating their own sampling and analysis infrastructure using staff from DWAF and other organisations.

Information generation typically involves making the data accessible to potential users. There has been recent attention given to producing reports that contain analysis or

interpretation of the data, but little coordinated effort to ensure integration of a wider range of information into reports that are designed with information users.

Assessment activities have developed in units separate from the data acquisition programmes, in Chief Directorates: Scientific Services, Water Use and Conservation, Planning, and Regions. These include extensive hydrological analysis for planning purposes, evaluation of license applications, reporting of the status of surface chemical water quality, geohydrological assessment and Reserve determinations.

Each Directorate in Scientific Services with monitoring responsibility is currently developing or investigating the purchase of an information system to meet its own needs. In addition, a number of efforts are underway in Regional offices to develop information systems or software applications focussed on specific information and communication requirements identified in that context.

The directorates are responsible for functions other than data acquisition. For example, Directorate: Hydrology is responsible for response to flood conditions; IWQS conducts research studies at the request of other groups within DWAF; and Geomatics conducts engineering surveys of among others, bottom elevations of dams. Geohydrology has acquired a management function since ground water was changed from privately owned water in the previous Water Act (Act 56 of 1954) to a component of the hydrological cycle under the custodianship of the Minister of Water Affairs and Forestry in the NWA.

4.2 Concerns related to information flow

The current situation with respect to monitoring and assessment programmes has several concerns that were identified during these Phase 3 interviews and during Phase 1 investigations. The primary concerns that MAIS aims to address are:

- ♦ current monitoring and assessment programmes are perceived to be poorly aligned to the information needs of the core functions of water resource management— particularly new needs that arise from the Act;
- ♦ difficulty in accessing or integrating data and information available on disparate IT platforms;
- ♦ lack of coordination that produces duplication of infrastructure, resources and effort, particularly with respect to the data acquisition, data storage, processing and management components of these programmes;
- ♦ shortage of skills required for adequate information flow and support for capacity building, and
- ♦ widespread and often duplicated data manipulation throughout the Department to meet needs not currently addressed by the information providers.

A notable property of the current structure and operations of monitoring programmes is the lack of a set of formal procedures for the data acquisition programmes to interact with information users. There is considerable informal discussion between the two parties, but no structured way for information users to affect decisions regarding priorities for data acquisition. This is particularly relevant in the current situation where the NWA imposes additional requirements for information that are not part of an existing monitoring programme. The emphasis of the Act on the social issue of equity of access and the ecological issue of sustainable water use are obvious examples of areas where interaction between information users and data acquisition operators could lead to important decisions regarding new data collection efforts.

Examples of duplication of infrastructure, resources, and effort are:

- ♦ The WMS system being developed under the auspices of the IWQS, Directorate: Water Quality Management, and Gauteng Region, primarily for data storage and management of water quality and related data and monitoring management;
- ♦ The REGIS system being evaluated and further developed under the auspices of the Directorate: Geohydrology for use with ground water data storage and assessment;
- ♦ The HYDSYS system being investigated by the Directorate: Hydrology as a system for capturing, storing, and managing hydrological data.

Examples of duplicated data manipulation are:

- ♦ The Strategic Environmental Assessment project (DFID project) conducted under the auspices of the Directorate: Water Allocation to develop information for catchment assessments;
- ♦ Integrated Water Resources Management Project (DANCED Project) under the auspices of Directorates: Catchment Management, Water Conservation, and Geohydrology to establish ground water information systems for use in assessments by CMAs;
- ♦ Efforts by the Directorate: Strategic Planning to develop and assess information for a national scale situation assessment required for water resources planning;
- ♦ Efforts by Directorate: Water Quality Management to audit the implementation of policy at regional office / CMA level, including policies related to information systems and situation assessments;
- ♦ Situation assessments conducted under the auspices of the Directorate: Water Resources Planning to evaluate options to make water available and assess ecological and basic human needs Reserve estimates.

There was little evidence that these initiatives are pursuing a common strategy towards storage and management of water resources data. There is little evidence that common standards or a common IT platform are being considered.

None of these initiatives has yet progressed so far that significant benefits cannot be gained from a concerted effort at establishing a joint strategy. From the strategy, commonality around data storage and management standards needs to be developed and, if possible, a shared IT platform for data storage and management should evolve.

5 Proposed functions for MAIS

To give effect to the principles advocated by MAIS, a structure must be incorporated into DWAF's organisational structure. DWAF is currently in the process of strategic restructuring and transformation. In order to facilitate that process, the following section lists the provisional functions that have been identified as essential to implement the MAIS model of information flow. Although the provisional functions described below are informed by the intermediate outputs from the transformation and restructuring process, the intention is definitely not to prescribe that process' final outcome. The functions are suggested as examples to clarify the implications of the model proposed for MAIS within the Information Management functional area, and as such may be used as input, if considered relevant. The provisional functions are also intended to provide a framework outlining the requirements for governance of MAIS.

Table 2 lists the sub-functions in each of three major functions, Information Product Management, Data Storage and Management, and Data Acquisition. The primary integrative and coordination functions are grouped together into the "Information Product Management," together with the more technical Information Generation and Dissemination. These functions are presently performed to some extent in DWAF, but

are not systematically coordinated between existing directorates. The references to “integrative” and “specialised” are to the requirements for input to the function. Integrative functions are those that require input or analysis from a number of specialist areas to perform the function adequately. Specialist functions are those that require in-depth knowledge of the particular technical area in order to perform the function.

Table 2 Functions and sub-functions required for MAIS, using the proposed model

INFORMATION PRODUCT MANAGEMENT	
Management	<i>Integrative</i>
- MAIS Policy and strategy development	
- Planning	
- Supervision	
- Budgeting	
Coordination	<i>Integrative</i>
- Information source for all data acquisition efforts	
▪ internal efforts; coordinating DWAF data acquisition activities in all programmes and in all locations	
▪ external efforts; liaison with CMAs, central and Provincial government, influencing other data acquisition	
- Enforce specifications for data acquisition; “enforce” includes communication, support, training, and other facilitative actions with punitive measures forming a second tier of enforcement mechanisms	
- Enforce guidelines, procedures, standards and methods for data acquisition, data storage and management	
- Meet requirements of Access to Information Act	
- Training (for all areas)	
Client Liaison	<i>Integrative</i>
- Information dissemination to internal and external clients	
- Identification and negotiation with clients to define Information Products	
- Publications	
- User support (for all areas)	
Information Generation	
- Applications design	<i>Specialised</i>
▪ Modelling	
▪ Spatial analysis	
▪ Apply design principles and standards in software development	
- Measurement network design	<i>Specialised</i>
▪ Design	
▪ Update instrumentation	
▪ Communications systems	
- Generate integrated assessments	<i>Integrative</i>
▪ Conduct standardised assessments	
▪ Conduct special assessments	
DATA STORAGE AND MANAGEMENT	
Systems management, enhancement and quality assurance	<i>Integrative</i>
- Database administration	
- Software enhancement	
- Integration support	
Systems development	<i>Specialised</i>
- Project based{Need for development established by Policy & Strategy}	
Information systems coordination	<i>Integrative</i>
- Coordination with other systems	

<ul style="list-style-type: none"> • DWAF • CMAs • Other government departments 	
- Liaison with users (primarily through established user groups)	
DATA ACQUISITION	
Programme Implementation	<i>Specialised</i>
- Establish new data acquisition programmes	
- Instrumentation installation	
- Construction	
- Institutional coordination	
Technical Support	<i>Specialised</i>
- Data processing, for example, converting water level to discharge	
- Chemical analysis	
- Skills identification / development	
- Data capture, data entry	
Operations Management	<i>Integrative</i>
- Sampling	
- Scheduling	
- Equipment maintenance	

The overall structure is shown graphically in **Figure 4**.

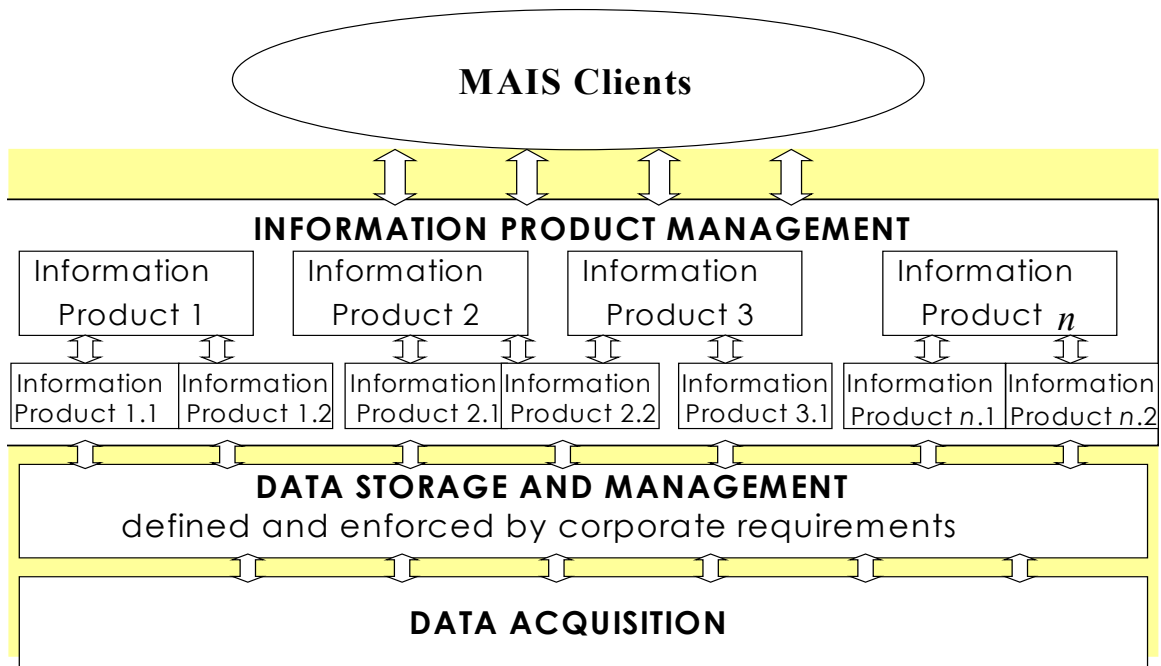


Figure 4. Graphic illustration of the organisation of proposed MAIS functions

5.1.1 Information Product Management Functions

The MAIS Information Product Management group of functions would coordinate activities within MAIS to produce the suite of Information Products in response to identified needs of clients inside and outside DWAF. Those clients include other central government departments and other tiers of government that need water

resources information, general public awareness of water resources issues, water management institutions, or specialist consultants. Client liaison with external organisations that supply relevant data is also included within this function. When an additional information need is defined, MAIS would negotiate with those responsible for the function that uses the information and agree on the relevant Information Products to be supplied. For some client needs, particularly general public awareness, MAIS would initiate Information Products that are likely to be effective, since negotiations with the general public to define the Information Products will not be possible. General management functions, such as planning and budgeting, which will be required to perform the coordination activities efficiently, are included in this group.

The Information Generation group of functions represents the major focus of MAIS. These functions use the specifications from clients and data supplied by Data Acquisition through Data Storage and Management to create the Information Products. The final Information Products would be available in the format agreed with the client and may include access to specific software applications developed for the Information Product, production of CD-ROMs for distribution to several users, Web-enabled access, or other procedures.

Design of monitoring programmes, that is, specification of measurement methods, frequency, location, *etc* to meet identified information needs is included in this group of functions. The design activities would be conducted in close collaboration with specialists in data acquisition to improve realism in the outcomes.

The final group of functions is the set needed to generate the designed reports and other products. It is anticipated that a set of standardised reports or products will be more or less continuously produced throughout the year and a parallel process will deal with specialised requirements that arise on a routine or variable interval.

5.1.2 Data Storage and Management Functions

The Data Storage and Management function would ensure the infrastructure, including hardware and standards, were in place. System management, enhancement, and quality control would be applied in a consistent manner to all data storage and management activities. Specific details would emerge from the requirements for data access, data security, applications, and networking requirements for the Information Products. The data and intermediate information products required would be stored and managed according to corporate security requirements, to ensure the integrity of the databases and to provide access to information in accordance with the Access to Information Act (Act 2 of 2000).

The requirement for new systems development would be addressed on a project basis. The need for development would be identified in response to policy and strategy issues that emerge from overall management, coordination, and client liaison concerns, which would set priorities for new development.

5.1.3 Data Acquisition Functions

Data Acquisition activities, including measurements and links with other databases, would be conducted to supply the primary data. Data specifications result from precision and reliability requirements of Information Products and are specified in service level agreements established with clients and between the Information Product Management group of functions and the Data Acquisition functions.

The Data Acquisition function would be responsible for populating the databases. An operations management function would ensure the sampling activities were

coordinated, including scheduling of sampling and supply of consumable items, such as sampling bottles, recording charts, or batteries. Routine maintenance of installed equipment would also be a function in this group.

Initial processing of data is included in the Data Acquisition Unit to ensure close coordination and quality control of the initial phase of database population. The initial processing would include such things as chemical analysis of water quality samples, conversion of water level measurements to discharge values, and logging of boreholes.

A separate set of functions has been identified for implementation of new programmes, because the activities required are substantially different from those required to operate mature programmes.

5.2 Criteria for MAIS structure

The MAIS structure should be selected to provide the following qualities:

- ♦ Maintain the focus of MAIS on satisfying information needs for water resources management;
- ♦ Provide the ability to control the range of activities necessary to produce the negotiated Information Product;
- ♦ Ensure access to adequate budgets using client input or support where possible;
- ♦ Ensure appropriate information for coordinated decision-making at national, regional, and local scales
- ♦ Facilitate the acquisition and retention of excellent technical skills for data acquisition, data storage and management, information generation, and client liaison.
- ♦ Consider the need for independence of functions; for example, the perception of biased measurements could be alleviated by creating an independent information management structure
- ♦ Consider the need for communication between functions; those areas with the strongest need to communicate should be located in the same organisational structure and other needs to communicate should be addressed in establishing reporting structures

Consider the need for accountability; the person or group assigned accountability for a specific result should have control over the inputs to create the result.

5.3 Location of the Units

Our proposals recognise that some of the water resources management functions currently performed by DWAF will, in future, be performed by water management institutions operating on at least three different geographic scales, namely:

- ♦ DWAF head office and regional offices providing policy, strategy, technical support, and auditing at the national and regional level,
- ♦ CMAs operating at the WMA and catchment scales, and
- ♦ CMA / WUA operating at the local scale.

Data Acquisition will necessarily occur at disbursed points throughout the nation, conducted by staff from DWAF and other WMLs. Management, scheduling, training, and auditing of procedures would be coordinated within the Data Acquisition functions, using DWAF staff or establishing contracts with other organisations, either consultants or WMLs. Technical support may be housed in a number of offices strategically located at a few centres.

Data Storage and Management would occur at the most logical point, depending on temporal and spatial requirements. For example, continuous water level data may be

stored at the CMA where it is measured and processed, but the daily average flow values that result from the processing may be stored or archived at a central location.

Information Product Management will require the highest level of specialist input and is likely to be constrained by available skills. Some centralisation will probably be necessary and desirable.

Appendix 1

Complex Knowledge Products required for water resources management

Complex Knowledge Products and the information needed to produce them

Complex knowledge products	Information Needed
1. Functional Area: Policy and Strategy Development	
1.1 Develop legislation, internal policy & policy about international water resources obligations	
1.2 Develop the national water resources strategy (NWRS)	
National Water Resources Strategy	Description of all water resources Delineation of significant water resources (need CASs) Types of water resource – wetland, estuary, impoundment, river, groundwater, international rivers, Catchment boundaries Description of features relevant for classification River reaches Sensitivity indicators social – demography, rural, urban, status economic- industry, agriculture, mining, other environmental indicators, International agreements Strategic water uses water use requirements water resource problems/concerns SEAs
-RQOs for each water resource for each type of objective, legal/administrative info (when set)?	-interactive map to show RQOs for each significant water resource (including Groundwater resources) metadata supporting the decisions CAS, Management classes, visioning processes Stakeholder input Reserve
-Scenarios for quantity & quality of ecological reserve at different ecological categories	Delineation of eco-regions Geo-morphological boundaries Catchment boundaries geo-morphological characteristics biological characteristics habitat characteristics hydrological & geohydrological characteristics ecological importance ecological sensitivity water quality characteristics water quality requirements reference conditions hydrological analysis; per CMA
-Quantity & quality of basic human needs reserve	-population not served to acceptable standards – quality and quantity projected availability of water suitability of quality of water for domestic use

Complex knowledge products	Information Needed
1. Functional Area: Policy and Strategy Development	
<p>-Monitoring programme designs (to help set the reserve or to audit it?) – Not sure if a monitoring programme design will constitute a CKP. Programme design serve specific requirements for management purposes. The design of a programme will serve the information needed for a management decision.</p>	<p>-database on monitoring programmes designed for specific objectives</p>
<p>-Water resource system yield, including surface and ground water -WC/DM input to WSAM</p>	<p>-system configurations {large scale} water network capacity (canal, pipelines, well fields etc) - network configurations {within systems} (matter of resolution) -rainfall data; from point measurements; areal from radar measurements; results of patching method $X_1, X_2, X_3, \dots X_n$ Map of existing and planned economic development areas (industry, mining, power generation, agric) map of irrigated areas -map of uncontrolled irrigation including farm dams -map of forested areas with indigenous forests delineated International agreements/ plans/ obligations ? discharges/return flows from point sources (re-entry into the system)</p>
<p>-Existing water use (is this CKP in a the correct functional area? Should it not be in functional area 2 (water use regulation).</p>	<p>- license conditions registered users historical users (permitted) land cover from satellite imagery/aerial photography - measured water flow to licensed users {may not be feasible}{provided by the users to fulfil licence requirements farm boundaries agricultural, forestry, mining use - existing activities per catchment</p>
<p>-Projected water demand</p>	<p>-existing water use for specified areas/prevaling conditions -proposed industrial/economic (agric/mining) development and quantity & quality requirements planned for next n years -projected change in population in 10 year increments international requirements (Mozambique)</p>

Complex knowledge products	Information Needed
1. Functional Area: Policy and Strategy Development	
<p>-National status of surface water quality / fitness for use ito domestic, agricultural, industrial and recreational use, aquatic environment</p> <p>-National status of ground water quality / fitness for use ito domestic, agricultural, industrial use, aquatic environment</p>	<p>database of water quality measurements</p> <p>location of monitoring sites / boreholes</p> <p>demography</p> <p>list of water quality guidelines</p> <p>list of water quality objectives</p> <p>list of RQO's</p> <p>catchment boundaries</p> <p>aquifer boundaries</p> <p>boundaries of main towns and settlements</p> <p>list of registered water users</p> <p>impacts / hot spots of non compliance with licence requirements</p> <p>geology</p> <p>land use/cover</p> <p>disease vectors</p> <p>per quaternary catchment</p> <p>per WMA</p> <p>trends, spatial variations</p> <p>user requirements</p> <p>water quality issues/concerns/problems</p> <p>constituents of concern – primary sources</p>
<p>instream integrity assessment</p>	<p>map of instream integrity standards</p> <p>-per quaternary catchment</p> <p>-per WMA</p> <p>Delineation of eco-regions</p> <p>Geo-morphological boundaries</p> <p>Catchment boundaries</p> <p>geo-morphological characteristics</p> <p>biological characteristics</p> <p>habitat characteristics</p> <p>hydrological characteristics</p> <p>ecological importance</p> <p>ecological sensitivity</p> <p>water quality requirements</p> <p>reference conditions</p> <p>hydrological & geohydrological analysis</p> <p>River Health</p>

Complex knowledge products	Information Needed
1. Functional Area: Policy and Strategy Development	
-input to SEAs	-database of biodiversity measurements -catchment yield -per WMA Delineation of eco-regions Catchment boundaries geo-morphological characteristics biological characteristics habitat characteristics hydrological characteristics ecological importance ecological sensitivity water quality requirements reference conditions; others? Social issues Economic development Stakeholder requirements Projected growth/development
-Options for water augmentation	hydrological characteristics water quality characteristics registered users water demand (quality and quantity) water conservation
Zoning plans for dams	Location of dams Land use characteristics of area surrounding inundated area Projected water demands EIAs
assessment of water availability assessment of water demand assessment of water quality assessment of status of aquatic ecosystem strategy to deal with water resource management issues results of reports on audits of water resources management	-output from yield model -national scale situation assessment -same as "projected water demand" above -same as "National water quality / instream integrity assessment" above ecological reserve human needs reserve -Information needed for public participation process
1.3 Develop catchment management strategies (CMSs)	
Catchment situation assessment – scale & focus related to specific issue being assessed	Same information as listed for NWRS, with finer resolution
Selected RQOs Water use allocation plans Assessment of water quality issues and feasible options Situation analysis Guidelines for risk-based decision making Technical Framework document for CMS – will identify information needs	Other national and regional plans (co-operative governance) Inventory of stakeholders (relationships/roles) Inventory of institutions Projected future status of water resource in catchment

Complex knowledge products	Information Needed
1. Functional Area: Policy and Strategy Development	
<i>1.4 Develop and maintain guidelines, methodologies and procedures for strategic functions</i>	
<i>1.5 Develop and maintain a pricing strategy</i>	
<i>1.6 Formulate the water resource components of the Medium-Term Expenditure Framework (MTEF) on the basis of DWAF's strategic business plan</i>	
<i>1.7 Plan for DWAF's and other WMIs public safety responsibilities in terms of water resources</i>	
<i>1.8 Develop or support other statutes, strategies, plans and WRM-related bodies</i>	

Complex knowledge products	Information needed
2. Functional Area: Water Use Regulation	
2.1 Registration of water users	
Registration procedure – not sure if this classifies as a CKP : is the CKP not WARMS?	applications received from potential water user amount of water requested location of water source property where water will be used ?? catchment assessments – demands, stresses, requirements
Register of authorisations	authorised water use relevant meta-data
2.2 Authorise water use	
assessment of potential impact of water use assessment of mitigation options waste discharge standards Assessment in terms of CEIMP requirements	details of water use – for waste discharge, volume rate, concentrations; composition receiving water characteristics RQOs potential impact on RQO technological limitations for treatment, recycling, etc social impacts of refusing license EMPRs, EIAs Co-operative governance Visioning processes for catchment Stakeholder inputs Other user requirements BPEOs
NWRS; CMS	Allocation Plan Identification of areas where compulsory licences are required Water use; Yield Geohydrological Assessment economic and social analysis of proposed regulations
report on impact of proposed SFRA	proposed SFRA location area type of trees slope of land to be planted water resource characteristics how long to maturity status of land proposed to be planted downstream impacts user requirements

Complex knowledge products	Information needed
2. Functional Area: Water Use Regulation	
2.3 Collect water use charges	
2.4 Enforce compliance with water use authorisation conditions	
<ul style="list-style-type: none"> -Annual reports to compare authorisation with actual conditions -Technical advice on hazardous waste sites (CKP: Management of hazardous waste) 	<ul style="list-style-type: none"> monitoring programme designed for water use monitoring monitoring programme implemented for water use monitoring appropriate technology for measurements criteria that will be used to compare actual & authorised {to determine precision required for measurements] authorisation conditions actual condition
<ul style="list-style-type: none"> -Compliance reports 	<ul style="list-style-type: none"> all information on comparisons between authorisations and actual conditions – to be consolidated into a report or series of reports for specific areas
<ul style="list-style-type: none"> -Directive to prevent &/or remedy effects of pollution 	<ul style="list-style-type: none"> information on violation incidents appropriate options to be applied to cases Record of correspondence / paper trail
2.5 Regulate dam safety	
<ul style="list-style-type: none"> -Safety risk of dams -Classification of dams 	<ul style="list-style-type: none"> Inspection reports

Complex knowledge products	Information needed
3. Functional area: Physical Implementation / Make Water Available	
3.1 Water resource infrastructure development	
3.2 Water resource system operation and maintenance	
3.3 Water conservation (WC) and demand management (DM)	
-Guidelines for cleaner technology -Plumbing standards – is this a CKP? Available /assimilative capacities of water resources	location of bulk infrastructure water use unaccounted for water effluent discharges – cleaner technology, efficient treatment procedures, process designs – availability to accept discharges
3.4 Flood and drought management activities	
-Flood potential in relation to infrastructure -Strategic flow information for flood management for national and international rivers Available /assimilative capacities of water resources	real time data on rainfall flow quantities options for flood management hydrological & geohydrological analysis water availability over time water use over time – availability to accept discharges
3.5 Emergency response interventions	
Degree of intervention	location of areas at risk for potable water contamination - extent of problems - monitoring data - co-operative governance location of incidents of impacts on potable water and water health characteristics nature of incidents options for response
Potential Impact on resource	location of toxic/hazardous pollution incidents – extent nature of incident options for response; who & what reference conditions (rehabilitation/clean up standards)
3.6 Rehabilitation of water resources	
-Rehabilitation plans	existing resource characteristics reference conditions (rehabilitation standards) options for rehabilitation rehabilitation designs

Complex knowledge products	Information needed
4. Functional area: Institutional Support	
4.1 Establish statutory Water Management Institutions	
4.2 Delegate or assign powers, duties and functions to Water Management Institutions	
4.3 Facilitate establishment of non-statutory participatory bodies	
4.4 Build WRM-related capacity in both statutory and non-statutory Water Management Institutions	
	water resource-related skills required water resource-related training available capacity building aids/material availability (brochures, posters, booklets) specifically designed capacity building programmes around integrated water resource management – role of institutions
4.5 Coordinate activities of Water Management Institutions	
	water resource operation strategies
4.6 Intervene to support and re-direct WMIs	
	information on impacts of exercise of powers or duties information on options that are effective in mitigating impacts of the exercise of powers or duties

Complex knowledge products	Information needed
5. Functional area: Information Management	
5.1 Information System Design	
5.2 Data acquisition	
5.3 Data & information storage and management	
5.4 Information generation and dissemination	
5.5 Support for complex knowledge products	
-Annual resource status reports	existing conditions for all water resources desired conditions for all water resources – catchment specific
5.6 Information Management Research	

Complex knowledge products	Information needed
6. Functional area: Auditing Water Resources Management	
6.1 Audit strategies and their outcomes	
<ul style="list-style-type: none"> -Comparison of key outputs & performance indicators for NWRS; RDM; WRM strategies: Institutional development strategy with actual performance -DWAF response to Economic & social rights protocol -Report on DWAF's compliance with Access to Information Act -Report on DWAF's compliance with CEIMP requirements 	<ul style="list-style-type: none"> measures of strategies on performance indicators measures for key outputs - likely to include a long list of institutional aspects, plus things like number of people served, water restrictions imposed, water quality issues, and bio-physical characteristics (for RDM) among others -Location of individuals affected by toxic waste (one example of info in Econ. & Social Rights audit)
6.2 Audit water use regulation	
<ul style="list-style-type: none"> Audit report on compliance with license conditions Meeting RQOs Resource Quality 	<ul style="list-style-type: none"> license conditions actual conditions
6.3 Audit water management institutions	
<ul style="list-style-type: none"> Resource Quality Monitoring Management Report Plans to eradicate poverty Plans to redress previous inequities Water use? Waste Discharge charges? Water Pricing? Water Allocations? IWRM? Stakeholder needs? 	<ul style="list-style-type: none"> Registered monitoring programmes Monitoring sites Samples received Results received Compliance with quality controls Compliance with monitoring requirements Financial status of monitoring HR Capacity to undertake monitoring Resources to undertake monitoring
6.4 Audit physical WRM-related interventions	