COMMERCIALISATION AND SUSTAINABILITY OF WATER RESOURCE SIMULATION MODELS

Report to the

Water Research Commission

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EXECUTIVE SUMMARY

The original objectives of the project were to:

- Investigate the opportunity for the commercialisation of software models developed in WRC funded projects
- Analyse the professional water environment within and outside South Africa to better understand the user needs and the market for such models.
- Propose recommendations for the development of a strategy for achieving the commercialisation of models.

The project was designed to operate over three phases. The first phase consisted of consulting stakeholders about their current use of models and their attitudes to commercialisation of models and software through a questionnaire (Appendix B) distributed as widely as possible. This led to a summary document which formed the basis for more focused discussions about the main issues (phase 2). The third final phase consisted of the formulation of a draft report which was further discussed and amended at a final workshop.

Appendix A summarises the results of the questionnaire survey and while there were some notable gaps in the response, many of the major issues emerged from the replies. It is apparent that the South African community of model users have not committed substantial financial resources to the application of modelling software and appear to be somewhat reluctant to do so in the future. Most users appear to believe that there are models available to match their requirements and they are technically sound. However, there is a measure of dissatisfaction with the level of support and the software packaging of the models. The models in most widespread use are those which have been partially developed and are currently supported by the Department of Water Affairs and Forestry (DWAF). This is somewhat inevitable when it is considered that DWAF are the major clients for the outputs of many models.

The project identified a number of critical issues and fatal flaws. The best that can be expected in terms of commercialisation is that future income generated through licenses, training fees and ad hoc development charges to users will be sufficient to allow the model/software developers to continue to support the product without further funding support from the WRC. However, it should also be noted that the past experience of some groups has suggested that post development income is not sufficient to support further development. A model and user accreditation system, if designed and operated correctly, has the potential to promote the development of model software in a user-friendly way. There is a need for greater cooperation and coordination in the development of South African water resource models and software, as well as a need for guidelines related to the correct approaches to software design (database design, data access routines and interfaces for example).

DWAF are in the process of establishing a model and model user accreditation system which is designed to assist WMIs (such as CMAs) with the choice of model to accept for providing input into water management decision making processes. Section 4 of this report provides the details of the DWAF proposals and offers some additional comments, in terms of advantages and disadvantages of a model accreditation system.

Section 5 suggests a generic process of project development that is considered appropriate for WRC projects, which have part of their focus on model software development. The process of project proposal should begin with a problem statement and draft project specifications, and continue through the definition of the scope and estimation of the costs. From the point of view of optimising the potential for commercialisation and sustainability it is important that the following issues are addressed in the project proposal:

- Competition with existing models.
- The extent to which the proposal will add value to an existing model.
- Software design and the extent to which specialist IT input is to be used.
- Income generating possibilities at the end of the project.
- Proposed training courses and the development of training material.
- Proposed product support approaches.
- Proposals with respect to application for accreditation.

It was noted during the project that DWAF, through the IWRP Users Forum, have already established a potentially useful approach to disseminating information on models and generating discussion about various modelling approaches and software design. In the past this forum has focussed to a large extent on the suite of water resource models partially developed and supported by DWAF (WRSM2000, WRPM, WRYM and WSAM). However, there seems to be no reason why the forum should not be expanded to cover a wider range of models and model developers. This type of forum has the potential to ensure that new users and potential model developers are much more aware of what models are already available, their strengths and limitations. One of the objectives of such improved awareness would be a reduction in the degree of duplication of effort and fostering a greater level of cooperation.

The recommendations made in the report about the approach to preparing proposals related to model and software development are also relevant to the project evaluation procedures used by the WRC. It is recommended that the same principles can be applied and that proposals can be evaluated on how well the various sustainability criteria are addressed within the proposal.

With specific regard to training and capacity building in the field of model application, there is an identified need to broaden the pool of model users. This needs to be taken into account in the design of any accreditation system that includes users as well as models. The supply of model users through training should ideally be such that market forces will balance demand and supply. This should happen while ensuring that a broad base of knowledgeable model users becomes available to the different WMIs who will require their services for their water resource management needs. An adequate supply of model users is also needed to protect the water sector against the danger of being too dependent on a selected or limited group of model experts.

One of the key conclusions of this report is the need for greater cooperation in all areas of model and software development. This includes:

- Cooperation between the WRC and DWAF in the way in which they support model and software developments.
- Cooperation between scientists or engineers and software specialists to ensure that developed model products will satisfy user demands in terms of user friendliness.
- Cooperation between developers and users in terms of training material on-going support of the software.
- Cooperation between various model and software developers to ensure optimum use of resources and that existing products are improved and expanded, rather than having new and competing models being developed.

ACKNOWLEDGEMENTS

The Project Team are grateful to all those who participated in this study and contributed to the ideas and concepts that are represented in this report. This includes the many model users and developers who took the time and made the effort to respond to the initial questionnaire. It also includes those who participated in the special session dedicated to the discussion of this project at the 11th South African National Hydrology Symposium, held in Port Elizabeth during September 2003, as well as the focus group meetings that were held in Pietermaritzburg during November 2003 and Pretoria during October 2003 and March 2004.

We are grateful to the School of Bioresources and Environmental Hydrology of the University of Natal, Pietermaritzburg and specifically Prof. Jeff Smithers for assisting with the organisation of the KwaZulu-Natal focus group meeting.

The March 2004 focus group meeting was organised to discuss a draft of the final report and Ms F Makhobu, Mr C Schultz, Mr M Watson, Ms T Zokufa and the WRC Project Manager, Mr Renias Dube are thanked for their valuable comments.

1. INTRODUCTION

The South African water research community has attained international recognition through the quality of the outputs that it has produced over the years. In the sanctions era when South Africa did not have access to overseas software, institutions embarked on the development of their own simulation software models. In addition, software models that were developed for the water sector were often tailored to the specific conditions of South Africa. These models were mainly intended for in-house or in-country use and were not developed for commercial purposes. Over the past years, beyond the sanction era, the Water Research Commission of South Africa has continued to fund projects which have produced a number of models. A number of current projects in the Key Strategic Area 1 (KSA1) have "development or refinement of a model" as one of the main research deliverables.

The opportunity of commercialisation of research outputs, including such models has increasingly received attention worldwide. Greater sustainability could be achieved if this commercialisation can yield a good return, which could be reinvested in further development and support of the models. This has been to some extent the case for institutions in developed countries such as the Danish Hydraulics Institute (the MIKE suite of models including MIKE 11, MIKE Basins and MIKE SHE) in Denmark, Delft Hydraulics in the Netherlands, as well as HR Wallingford the Centre for Ecology and Hydrology (CEH) in the United Kingdom. There are other examples internationally where the models have been developed under state funding and are offered to the scientific community at minimal cost (for example, HSPF and ArcHydro from the USGS and EPA in the United States). There are also many situations where scientific software has been used to establish commercial companies that retail models and software, as well as the support (examples include Scientific Software Group who sell a range of products and Haestad Methods who provide software for the design and analysis of water distribution systems and market academic books and manuals).

In the Water Research Commission funded projects, commercialisation is therefore one aspect that is increasingly attracting more attention in project proposals as the organisation seeks to gain better returns on the research funds. In the case of projects that result in the development of models and software, the perceived need to commercialise the models is even greater.

Nowadays, with the recent advances in computer technology, the user friendliness of a model is easy to achieve through interactive interfaces. Other aspects that should be addressed to increase the marketability of a model (beyond the existence of market itself) include the production of technical reference manuals and software user manuals, as well as professional support to users.

This project was intended to cover all of the above through a consultative process in order to propose a strategy for achieving successful commercialisation of models developed with funding from the Water Research Commission of South Africa. It is emphasised that the objective of commercialisation is to ensure that the models and associated software developed using WRC funds are sustainable without the need for continued funding from the WRC.

The original purpose of this project was to:

- Investigate the opportunity for the commercialisation of software models developed in WRC funded projects
- Analyse the professional water environment within and outside South Africa to better understand the user needs and the market for such models.

- Propose recommendations for the development of a strategy for achieving the commercialisation of models.

1.1 Structure of the project

The project was designed to operate over three phases:

The first phase was the compilation and distribution of a questionnaire (Appendix A) to assess the attitudes of the broad community of model users and developers to the prospects for commercialising models developed under WRC funding. The outcome of this phase was a expected to be a paper summarising the analysis of the questionnaire returns (Appendix B).

The results of the questionnaire were used as a basis for more focused discussions on the major issues associated with model commercialisation. At this point in the project it became apparent that the focus should not be on commercialising models in the strict sense of the word, but rather on those critical issues that affect the sustainable development and use of models without the need for continual funding inputs from the WRC. Some discussions were held during the Port Elizabeth SANCIAHS symposium in September 2003, while smaller group discussions were held later. The outcome of this phase of the project was a draft report integrating the viewpoints of the participants in the focus group discussions and offering some recommendations to the WRC. The draft final report was then discussed in detail at a final workshop held in Pretoria during March 2004 to refine some of the issues, finalise the content of the report and the recommendations to the WRC.

2. SUMMARY OF THE QUESTIONNAIRE RESULTS

The questionnaire (Appendix A) was the first part of the process designed to assess the use of water related models, what models are being developed, users attitudes toward commercialisation and the prospects for future commercial software development. A paper summarising the results of the questionnaire survey was delivered by Jean Boroto at the 11th South African National Hydrology Symposium, held in Port Elizabeth during September 2003. The full version of this paper is reproduced in Appendix B, while the following general conclusions were highlighted:

- The majority of current model users have received access to the models for free.
- Very little is spent by the model user community on maintenance payments.
- The user base is quite small and most models have a small number of users, few WRC funded models apparently having more than 10 users.
- Most users appear to be satisfied with existing software, but fewer with the available support.
- Most SA developed models are still undergoing some form of development and it seems to take more than 3 years for most models to be developed.
- The survey indicated that most models have been developed by WRC funding, but that does not necessarily mean that they are the ones in widest use (note that WRSM, WRYM and WRPM were identified as the most used models).
- Traditionally most WRC funded models have been made available free of charge (or for a nominal fee).
- Consultants are the largest group (80%) of end users, with Government (35%) and Research (40%) groups contributing most of the rest.
- About half the respondents indicated that there are enough products to meet their requirements.
- A large proportion favoured SA products, while a little less than a half considered overseas software more competitive.

- While products are considered technically satisfactory, they are not considered satisfactory from the point of view of 'user friendliness' as well as
- support, both in respect of support to users of the products, as well as continued upgrading and improvements.
- 49% of respondents favour marketing the products at minimal cost and generate income for future developments through training and support charges. 36% considered that the WRC should assume responsibility for technology transfer.
- A slight majority considered that specialist software companies should not be used.
- The favoured price range for software was R1000 to R5000, although it is accepted that this question was difficult unless you know what the software is intended for.

From the point of view of potential for commercialisation, the important results from the questionnaire survey were that the models in most widespread use are those that are currently supported and are being further developed by DWAF (WRSM200, WRPM, WRYM, etc.) and there appears to be some resistance to high initial purchase costs, while users appear to be willing to pay for training and maintenance for well designed and user-friendly software. It is quite possible that the attitude to overseas software is a result of three factors; the low value of the SA Rand that has existed over the last few years (making software priced in foreign currency quite expensive), the relative success of locally developed products in a small market and the pre-1990s political isolation of the country.

3. CRITICAL ISSUES AND POTENTIAL FATAL FLAWS

The main emphasis of the Focus Group discussions was to develop guidelines for model software project development (the details of which are in the next section). However, during the discussions it emerged that there are a number of critical issues that all potential role players (model and software developers, model users, funders of model application projects, etc.) should be made more fully aware of.

The original terms of reference for this project refers to commercialising model software, while it has become clear that the market is relatively small and the options for generating income fairly limited. This leads to two major points that many of the participants in the project believed should be strongly emphasised:

- The WRC should not have an expectation that software developed under their funding will generate a future income stream that will offset, or repay, the costs of the development.
- The best that can be expected is that future income generated through licenses, training fees and ad hoc development charges to users will be sufficient to allow the model/software developers to continue to support the product without further funding support from the WRC. However, it should also be noted that the past experience of some groups has suggested that post development income is not sufficient to support further development. ***This is exactly the problem that this project was designed to address and yet it has been difficult to arrive at a definitive solution.***

Part of the problem with relatively sophisticated models is that potential users tend to be slow to adopt them and continue to make use of simpler and less appropriate methods. This makes it difficult for a new model to penetrate the market and to begin generating income for either future development, or the costs of supporting the software. While the whole issue of model accreditation covers much more than this specific problem, some form of 'official' recommendation for approved models may go a long way to addressing this problem. The main concept is to initiate a system which strongly encourages (note that the word 'forces' is

not used) users to apply the models that have been developed for a specific purpose and have been demonstrated to work. The implications are that the recommended models:

- Should be well designed and packaged;
- Should be well supported by training courses and user manuals;
- Should not be prohibitively expensive relative to the scope of work that they are designed for.
- Should be supported continuously throughout its useful life, both as regards user support, as well as continued upgrading and improvements.

It is important to recognise that there are high costs associated with developing sound and reliable software, as well as developing the user manual and training material necessary for effective dissemination to others. It is essential that false expectations of a fully developed and ready-for-deployment software package are not created in favour of keeping the total project budget to a minimum to be competitive; this would be a false economy.

Many of the project participants strongly emphasised the need for greater cooperation and coordination in the development of South African water resource models and software. It was recognised that several groups have spent unnecessary resources developing components, such as database design and data access routines, spatial data interfaces, graphical displays, etc., which are common to a wide range of models and may have already been developed by another group. Sharing such resources may mean the loss of a degree of independence in the development process, but can substantially reduce development costs and effort. The additional advantage is that users are confronted with fewer software package 'styles', which should make it easier for them to become familiar with a range of models and therefore encourage them to adopt new developments.

DWAF, through their IWRP users forum (see www.dwaf.gov.za/IWRP/SystemAnalysis/ and www.userssupport.co.za), have already started a process that addresses some of these issues and it is important that as many users and developers as possible participate so that the process develops even further. The users forum has the potential advantage of being able to inform potential developers of new models about what is already available and could provide them with a platform for presenting and testing new ideas. This report strongly recommends that the IWRP users forum initiative be developed further and WRC projects involved in model and software development make use of this forum to assess the market for new models and promote new developments.

Recommendation for action:
To cooperate with DWAF in the coordination of the development of models and associated support such as database design, data access routines and interfaces for greater cooperation to reduce development costs, optimize the number of new models and avoid duplication of efforts.

4. MODEL ACCREDITATION

One of the most controversial issues that was discussed was the concept of model accreditation and whether there should be any central control over which models should be used in different circumstances. Some project participants viewed this as a threat to the independence of various development groups and considered that it could stifle all future

developments. Others expressed similar concerns, but also identified some positive outcomes given that the centralised control structures were established in the correct way.

4.1. Issues associated with a model accreditation system

The following points were made about the structure of an accreditation body:

- A system of accreditation needs to apply to users as well as models. There is little point in accrediting a complex model for use and then allowing the model to be applied, un- supervised by an inexperienced or untrained user.
- The decisions on which models to accredit need to be taken by a group that consists of representatives of developers (including the funders of developments), users (those concerned with applying the models) and the end clients (those funding the applications and receiving the results).
- It will be necessary to ensure that no vested interests are allowed to influence the decisions about which models to accredit.
- Accreditation of a particular model may be qualified and refer to specific purposes of application. For example a simple model may be appropriate for a rapid estimate, where a high confidence answer is not necessarily required.
- There is an assumption that an accredited model will have to be 'user-ready', which implies that the whole package (model, software, training systems, manuals and/or on-line help and support) has reached a satisfactory level of development.
- An accreditation database needs to be established and maintained so that all role players can have access to information on current models and users that have been accredited.
- There needs to be a system of ongoing accreditation of new software versions of models.
- It is important that new users have access to fully accredited and experienced users so that they can eventually become accredited as well. The whole issue of training and capacity building for new users needs to be addressed in further detail.
- While accreditation should not be viewed as a system to 'protect' existing models, the system will have to have 'teeth' and be enforceable to be effective.
- A clearly defined system of applying for accreditation needs to be established and it should not be an endless process.
- There is no reason why several models with the same purpose cannot be accredited. An example might be the Pitman Model. It is possible that the model may be included in several other modelling packages, but there seems to be no reason why all such packages could not be accredited. This is slightly different to DWAF Head Office recommending Regional Offices or CMAs to use only a single model for a specific purpose to ensure consistency.

Some of the noted advantages of an accreditation system were:

- It could prevent the development of one-off, simple modelling approaches by consultants unwilling to invest time in learning to use recommended models and therefore encourage the more widespread use of models that the country has invested resources in. This may contribute (through training fees) to the sustainability of a core of good models.
- Encourages users to ensure that they are adequately trained in the application of models.
- Encourages developers to make their models and software 'user-ready'.
- Protects model users from possible legal action related to the use of an inappropriate model. However, it would not protect users from inappropriate use of an accredited model.
- Creates confidence within the client community in models and their results.

Some of the noted disadvantages of an accreditation system were:

- The costs of administering and managing such a system are likely to be high.
- There are a number of practicalities that are likely to make an accreditation system difficult to manage.
- It could be viewed as a system designed to entrench the use of existing models and/or users and limit the scope for new developments or discourage new users.

There seems to be little doubt that a well designed accreditation system would offer far more advantages than disadvantages, however, such as system could be difficult to establish and involve quite substantial efforts to maintain. The main criticism of establishing such a system, that it could restrict future model development and entrench the use of existing models, while being a valid concern, can be negated if the system is carefully designed to be flexible.

4.2. Alignment with DWAF's processes

In order to assist Water Management Institutions to comply with the new requirements of the National Water Act, DWAF developed two sister documents with specific focus on water resources modelling:

- Gu*idelines For Water Resources Modelling Procedures To Support Water Management Institutions (DWAF, 2003)* in order to assist Water Management Institutions (WMIs), such as Catchment Management Agencies (CMAs), in the choice of models to use in performing their water resource management functions.
- Guide *for the Advisory Committee for Water Resources Modelling* (DWAF, 2003) with a model accreditation system through an Advisory Committee to be established in terms of Section 99(1) of the National Water Act, Act 36 of 1998.

The latter document has the following provisions with regard to an accreditation system:

1) The establishment of an Advisory Committee whose purpose and function would be to:
   I. Coordinate, guide and control the use of models and their related procedures in the water resources management domain.
   II. Provide expert guidance to WMIs, such as DWAF and CMAs, regarding issues in the domain of water resources modelling.
   III. Coordinate and guide the accreditation of modellers in the water resources domain.
   IV. Coordinate the ongoing implementation and improvement of the *Guidelines For Water Resources Modelling Procedures To Support Water Management Institutions.*
   V. Coordinate the introduction of candidate models or modelling support tools hitherto not applied in water resources studies in South Africa.
   VI. Review on behalf of any WMIs or sectoral representatives the degree of compliance of water resources studies, in which disputes have developed, with the aforementioned *Guidelines*.
   VII. Disseminate relevant information on water resources modelling to WMIs and the water resources decision support community in South Africa.
   VIII. Monitor capacity-building needs in the water resources and related modelling fields and to initiate appropriate actions to ensure continued development of the related skills base.
   IX. Identify new model development and model customising needs.
   X. Promote standardisation of data formats among all water resources-related monitoring agencies.

2) It is proposed that the Committee should comprise eight (8) members with the following representation:
   - DWAF (1 member)

- CMAs (1 member)
- WRC (1 member)
- Professional Service Providers (2 members from different specialisations)
- Researchers/Academics (2 members from different specialisations)
- Water user sectors (1 member)

Eligibility requirements for individuals in the consulting and research fields are that they should either be recognised specialists in one or more aspects of water resources modelling, or be widely experienced in water resources analysis studies. For the DWAF, CMA and water user representatives the eligibility requirements are that they should be directly involved in technical or scientific aspects of water resources management.

The Committee shall be established by DWAF under the auspices of DWAF's Water Resources Functional Management Committee (WRFMC), according to the prescriptions of Section 99 of the NWA.

3) The following protocol of conventions may be used as a screen to assess whether or not a new model being introduced in South Africa would be regarded as eligible for use in decision support to CMAs:

Convention 1:
The model must be satisfactorily verified, following the procedures in the *Guidelines for Modelling,* in at least two different bio-geo-climatic regions of South Africa.

Convention 2:
The model must be shown to provide more accurate and/or more credible outputs than comparable existing models already on the list of currently established models, using identical input data and comparing outputs on an equal footing.

Convention 3:
The model must offer simulation of processes, state variables or quality constituents not available in models already on the list of currently established models.

Convention 4:
The model must offer superior inter-operability with other required models and support tools compared with currently established models.

Convention 5:
The model must offer a superior graphical user interface, GIS linkages and other communication advantages over currently established models.

Recommendation for WRC action:
To seek alignment with DWAF guidelines for modelling procedures and accreditation system in order to achieve consistency in the accreditation of models.

5. GUIDELINES FOR MODEL SOFTWARE PROJECT DEVELOPMENT

Figure 1 illustrates the generic process of project development that is considered appropriate for WRC projects, which have part of their focus on model software development. The process of project proposal should begin with a problem statement and draft project specifications, and continue through the definition of the scope and estimation of the costs. The main part of the project is represented by the model development and testing loop, while the implementation component refers to the distribution and technology transfer actions. The blue shaded components of the diagram are those which are of more direct relevance to the development of guidelines for ensuring the sustainability of the products of such WRC funded projects. Consequently these were the components that the groups discussions were focused on.

It is recognised that projects of this type usually include the development of the scientific basis for the model. The assumption is made that the purpose of developing a model software package is so that the developed technology (a model, data analysis procedure, database access procedure, etc.) can be made as accessible as possible to a wide range of potential users for a sustained period of time. The focus of this specific study is on the critical issues that will ensure sustainability and not on the specific technical aspects of any model development proposal. It is further assumed that the WRC would be very reluctant to finance the development of software that will be used solely by the project team. ***This document is not really relevant to projects that do not include a component of software development and that are restricted to the development of the model science.***

5.1 Draft specifications of the model to develop

This component represents the preliminary phase of developing a proposal to the WRC and is designed to ensure that a prospective proposer considers the basic points before considering the development of a detailed proposal:

- What is the model intended for?
- What will be the scientific basis for the model (it is important that the WRC does not fund well packaged, but badly researched models)?
- Why is the model required? Are there other models of a similar type (i.e. addressing the same kind of problems) that are not adequate? Are there no models of a similar type?
- What is the potential market for the model and the software that will be associated with it?
- What procedures will be used to ensure quality control of the model results?
- Are the model information requirements accessible and affordable?
- What is the likely time-scale of the models use, i.e. is it addressing an immediate issue or is it expected to be of use in the long-term?
- How will the model and software be linked to existing related models and databases (to what extent is the new model going to ‘add value’ to previous developments)?
- Are the resources for successful software design available to the model developer?
- How will the model be packaged and distributed and does the development team have the necessary resources?
- Is support going to be provided in the forms of a user manual and/or a technical manual and any other form of user support?

All of these points are raised in further detail during the discussions of the following components, but it is important to ensure that the above points are considered at the very beginning of any project conceptualisation.

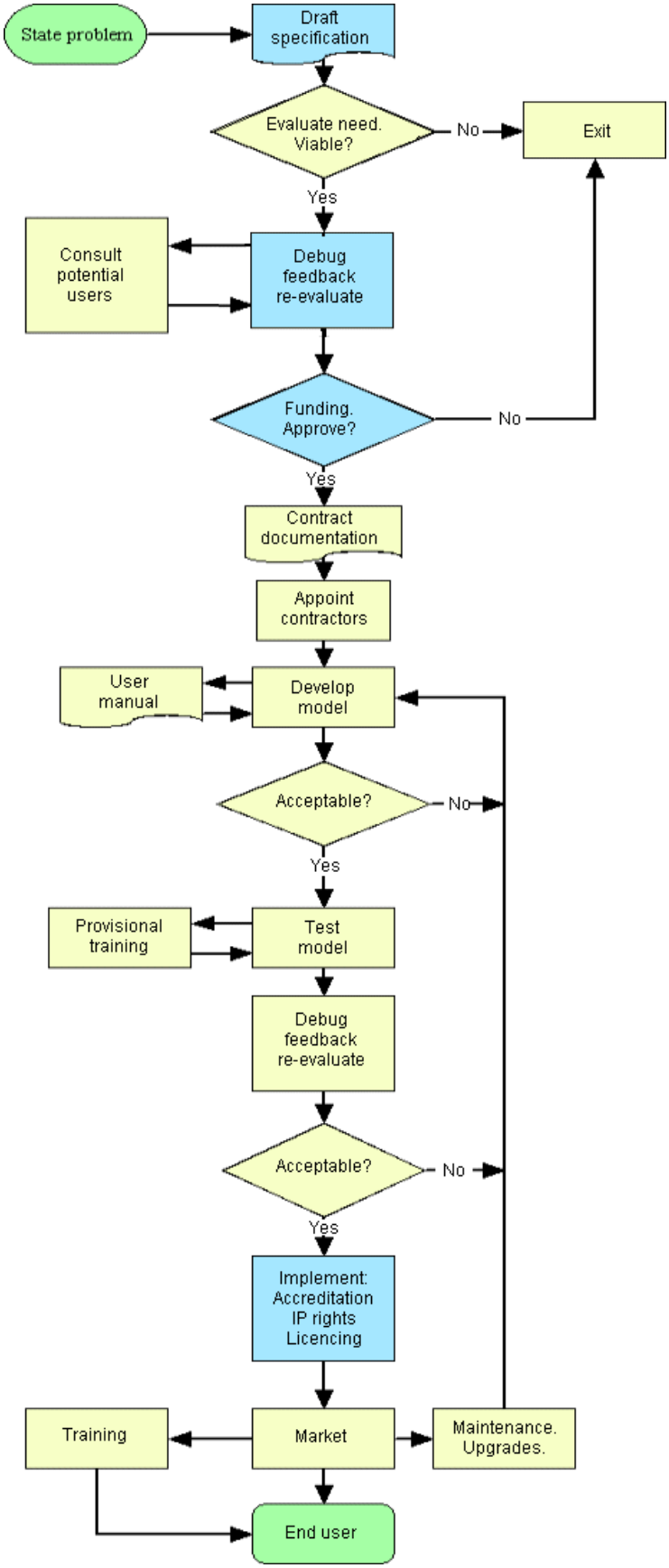

Figure 1

Generic flow diagram of the development process of a WRC project focused on model and software development.

5.2 Defining the project scope and estimating costs

This component is principally about developing a proposal, while the next section provides some suggested guidelines on how the WRC would evaluate proposals. The two sections therefore need to be considered together in their joint context.

Preparation for the definition of the project scope should include consultation with potential users and a ***market survey*** to demonstrate why the model is required. It is accepted that a full market survey is probably beyond the resources of the typical project proposal team. However, this issue should not be entirely neglected and the project proposal should demonstrate that the proposal team is familiar with existing models and the extent to which their proposed model is likely to find a niche in the market. The market survey should indicate the likely size of the market, which sectors of the water industry are being targeted and the geographic scope of the market (only South Africa, Southern Africa or more widespread).

The detailed proposal should include:

- A more detailed description of the models technical components, which should include some details of the software design.
- A proposal on how to assess user requirements and incorporate them into the final product. This aspect is designed to address the needs of the market and how these needs will be more fully identified during the course of the project.
- How the model is to be packaged as software.
- Proposals on the database structure and how the model will interface with existing models or information, where appropriate.
- Proposals on the ownership of intellectual property (IP) rights, with due consideration given to existing WRC policy on such matters.
- What is the expected life-span of the developed software.
- Proposals on sustaining the model after the projects termination.
- Proposals on an initial training and testing programme.
- Proposals on software distribution and training approaches.
- Proposals on access restrictions and copy protection.
- Proposals on the development of a user and or technical manuals and/or guidelines for the use of the model and software.
- The proposal needs to structure the project deliverables in a way which is linked to project costs and WRC payments to the project team.

Detailed consideration needs to be given, within the proposal, to a number of issues and these are highlighted in the following paragraphs.

Competition with existing models: Are there existing models that the proposed model will compete with and if so what will be the advantages of the new model? This will be important with respect to any future model/software accreditation system (see later) that might be developed and applied specifically in model applications that are publicly funded.

Adding value: Are there existing modelling software packages that could be used as a 'home' for the new model to avoid the need to create new front-ends or database designs? If so what are the requirements in terms of cooperation with other groups and sharing of ownership and IP rights? The assumption is that most groups will be aware of existing models and software, however, this may not be the case. During the focus group discussions the need for improved information dissemination, now that the CCWR no longer exists, was noted. There is a need to pool resources and add value to existing products whenever appropriate, rather than always creating something that is totally new and different

to everything else. For this approach to be effective it is necessary for the WRC to encourage the community of model and software developers to work more closely together.

IT specialist input and software design: This point is related to the rather controversial issue of the extent to which IT specialists are to be consulted and/or employed on the project. There are several opinions about this, but there seems to be a favoured attitude that the use of commercial software development companies would, in general, be far too expensive. However, it also seems to be generally accepted that IT specialists have a major role to play in assisting the scientists/engineers, whose focus is on the model, to ensure that the final software product is well designed and robust. It has been suggested that a set of guidelines for WRC funded software development be formulated and that these should reflect sound IT principles. They should not be too prescriptive, but it should be recognised that deviation from such principles would have to be thoroughly justified. They could be of assistance to the scientists and engineers who develop models, but are less familiar with some of the basic principles of modern software development. This may be one way of resolving some of the differences of opinion about whether commercial software specialists should be used to design the final software packaging. The guidelines could be formulated by IT specialists, who are familiar with the needs of the water resources research and practice community, in consultation with representatives of the user community. These guidelines could address issues such as database design, appearance of menus, etc. and could be updated as changes occur in computer technology.

This report purposely makes no recommendations with respect to the computer language that should be used in software. To a large extent, the project team considered that this is not an important issue as long as the language used, and the final executable program, is compatible with modern computer operating systems. Unfortunately, such systems are changing all the time and it is not always a simple matter to keep pace with operating system developments. However, most software written for earlier versions of Windows operating systems work perfectly well under more recent Windows versions. Updating problems may occur with software written to operate directly through the internet. Direct internet access to model software (rather than using the internet to download and update software) has not been considered as part of this project.

Recommendation for action:
Develop a project to establish and document generic guidelines for water resource type modelling software. These guidelines should be developed by a team consisting principally of IT specialists familiar with water resource models, but should include a scientist or engineer who has experience of model development. It is essential that DWAF and the IWRP User's Forum are involved in this process.

Selling price or license fee: What will be the approach to establishing selling prices, license fees or royalty payments for the use of the software at the conclusion of the project? It should be noted that the questionnaire revealed that most users have a resistance to high purchase costs, but are willing to pay for training and further developments or maintenance. There are a number of possible options that should be considered:

- Minimal selling price and annual maintenance fee. This may be the best solution for some software packages, but it should be noted that resources are required to administer the license fee if the user base is quite large.

- The payment of royalties for the use of the software on a job-by-job basis will be too difficult to administer and is unlikely to be worth considering as an option.

Other income generating possibilities: While most participants did not consider that the selling price or license fees will be likely to generate a great deal of income, other income generating activities need to be considered:

- Payment for training (including the development of training material) has the potential to generate part of the income necessary to cover the costs of support personnel. The project proposal should address this issue in some detail.
- It should be recognised that the model and software developers are in an ideal position to generate income as specialist consultants in the use of their own products. This applies particularly to very specialised models that require extensive training and experience to apply efficiently and obtain the best results.

Training courses and material: There are a number of important issues related to the deployment of the software and training of future users that need to be thoroughly covered by the proposal. Some of these are related to training charges and have been covered in the previous point. However, others relate to the development of training material:

- Does the developer have access to the resources required to offer training in the product at the end of the project?
- Training can be facilitated by the production of guidelines for practical use and worked examples. The proposal needs to consider the amount of time that will be required to develop this material and whether or not that time will be included as part of the project budget or will be covered by training fees after the project conclusion.
- Some participants noted the need for some training in the use of the software during the project as a component of the testing and evaluation phase.

Recommendation for action:
The WRC are encouraged to develop some basic generic guidelines for the compilation of training material that would assist project teams in designing their specific material.

Product support: The proposal should address the issue of ongoing future support and it should be recognized that there are a number of possible (and not mutually exclusive) options. It has been noted that many users will ask the same questions and therefore a Question and Answer (Q&A), internet based bulletin board can be a very efficient method of providing base-level support. Higher-level support can be very time consuming and the proposal should indicate (if appropriate) how such support will be offered and funded. It is worth noting that DWAF has established an internet based user support system for the suite of models that fall within their control (WRSM200, WSAM, WRPM, WRYM – see www.usersupport.co.za). The main objectives of the User Support System are to:

- Obtain feedback from users
- Enable users to suggest improvements
- Provide information on upcoming workshops, training and other events
- Provide users with a facility to download new model releases and documentation.

Accreditation: If it is the intention of the developer to promote the final product in terms of any model accreditation system that exists within South Africa the methods of promotion (e.g. establish a group of test users, hold a workshop to demonstrate the products capabilities, etc.) should be addressed in the proposal. Alignment will be sought with the

process proposed by DWAF for the accreditation of models and the guidelines for modelling procedures as discussed in section 4.2.

5.3 Proposal evaluation and basis for approval of funding

Based on the comments received from the participants in the project, this report offers the WRC some guidelines for evaluating proposals that include a component of model and software development. There are clearly other evaluation issues that are common to all submitted proposals and are not related to the terms of reference of this project.

- The technical capabilities of the proposed project team with respect to the model to be developed (clearly important but not part of this study).
- The extent to which the proposed project corresponds with the aims and objectives of the WRC.
- The extent to which the model is likely to compete with existing models and the implications of this competition. It is not implied that new competing models should not be supported, only that justification for a new and revised approach needs to be adequate.
- The extent to which the proposed software developments will add value to existing products in use. It is expected that this will be an important criterion, given that the WRC would like to foster stronger cooperative development programmes.
- The extent to which the project proposal has considered the necessity of adopting sound IT design principles for the final software product and have noted any guidelines that are available.
- The extent to which the proposals for training and sustaining the model/software are considered realistic and practical.
- Whether the model is designed to address a unique or more generic problem and the strategic importance of the problem being addressed.

It was noted that, given the WRC's central role in supporting research and development, a strategically important development that has little possibility of attaining a commercial value should not be rejected in favour of the development of more commercially viable products.

5.4 Accreditation, IP rights and licensing

This component applies when the programme of initial model and software testing has been completed and the product is considered to be market ready.

If there is a system of model accreditation in place and it is intended to apply for accreditation for the model, it will be necessary to promote the model in some way. It is possible that the model may not be initially accredited and that accreditation will be delayed until more experience has been gained in the application of the model. Lack of accreditation does not mean that the development has no value and should not necessarily be considered a fatal flaw in a product (It needs to be noted that whatever model accreditation system is developed for SA should not be restrictive and should not prevent innovative new products from being developed and tested).

The WRC, in collaboration with DWAF, could maintain a website based database of the current status of models and software developed with WRC funding. The information could contain some technical details, the availability of the software, manuals, training and maintenance, reference to examples of the application of the software and other details that are relevant to a potential user.

The draft WRC intellectual property rights policy, when adopted, needs to be implemented. While the standard approach is to share copyright between the model development team and the WRC, it may also be necessary to acknowledge the contribution of other organisations that have had some form of input (intellectual or financial) into the software or model development process.

The procedures for licensing users need to be established.

5.5 Marketing, training and capacity building

A marketing strategy needs to be developed that takes into consideration the views expressed by the stakeholders consulted in order to tailor the marketing approach to their preferences. Some of the views are expressed in section 5.2. above under the heading '*Selling price and license fee'* and '*Other income generating possibilities*' and include:

- The willingness to pay a purchase price that is not too exorbitant
- The willingness to pay for training and an annual maintenance fee
- The possibility for model and software developers to generate income as specialist consultants in the use of their own products.

These are elements that would assist in the development of a marketing strategy, but a comprehensive assessment of the market would be required.

With specific regard to training and capacity building, the need to broaden the pool of model users will require that a pro-active approach is taken. It will target specifically the previously disadvantaged groups that were not exposed to science in general and to modelling in particular. This assumes that the education sector would have trained people in science and technology (and with exposure to a water related field) who can be ably introduced to water resources modelling.

The supply of model users through training should ideally be such that market forces will balance demand and supply. This should happen while ensuring that a broad base of knowledgeable model users becomes available to the different WMIs who will require their services for their water resource management needs. An adequate supply of model users is also needed to protect the water sector against the danger of being too dependent on a selected or limited group of model experts.

5.6 Maintenance and Upgrades

The procedures for maintaining the software (fixing errors), upgrading (adding improvements) and further development need to be established. These procedures should focus on a medium to long-term business plan which includes time and cost implications, as well as an estimate of the likely market.

It is recommend that contracts (both for the development of the software, as well as for users of the software) in future require that any upgrade/improvement to the original software be reported to the WRC and that a copy of the new software be submitted to the WRC, which the WRC can then use at its discretion.

6. CONCLUSIONS AND RECOMMENDATIONS

While the replies to the questionnaire were less representative of the modelling activity in South Africa than was initially hoped for, it did point to some of the main issues related to model development and use. The replies to the questionnaire provided a sound basis for later discussions between the project team and a wide variety of stakeholders involved in various aspects of modelling.

It is apparent that the WRC should not have an expectation of income generation from software and models developed with their funding. It has also been noted from experience that post-development income streams are not easy to generate. It is therefore essential to improve the marketing of such products, if further developments are to be financed through charges for the software, its support or training in its use. It is also essential to coordinate the development of models and associated support such as database design, data access routines and interfaces for greater cooperation so that development costs are reduced, the number of new models is optimised and to avoid duplication of efforts.

DWAF have developed guidelines for procedures to assist Catchment Management Agencies (CMAs) in the choice of models to use in performing their water resource management functions. The guidelines include a recommendation for the establishment of an advisory committee to coordinate and guide the use of models and manage a system of accreditation for models and model users. It is essential for the WRC to seek alignment with the DWAF guidelines in order to achieve consistency in the accreditation of models. The details of these procedures are provided in section 4.

The report recommends that the WRC adopt procedures similar to those presented in Section 5 and illustrated in Figure 1. One of the existing gaps in the implementation of such a process is the lack of a set of guidelines for software design. It is therefore recommended that the WRC develop a project to establish and document generic guidelines for water resource type modelling software. These guidelines should be developed by a team consisting principally of IT specialists familiar with water resource models, but should include a scientist or engineer who has experience of model development. The WRC are also encouraged to develop some basic generic guidelines for the compilation of training material that would assist project teams in designing their specific material.

If the WRC (or any other funding agency) are to continue to financially support model and software development, they should be aware that there is a already a great deal of technical competition for the supply of such products, both from South Africa as well as from foreign developers. This means that both existing products, as well as any new developments should be attractive enough to users to be competitive. While the main responsibility for ensuring that the products are competitive should lie with the developers, the role of the WRC cannot be ignored. If the products do not become competitive and find a market then it could be concluded that the WRC funds have not been used effectively.

One of the key conclusions of this report is the need for greater cooperation in all areas of model and software development. This includes the WRC, as a major funder, DWAF as one of the main end-users of the model outputs, but also involved in development, as well as the various research teams and consultants involved in the se of models. This requirement for cooperation includes the software development process, as well as the information that is required by the models if they are to generate useful results.

7. REFERENCES

DWAF, 2003.Guidelines For Water Resources Modelling Procedures To Support Water Management Institutions - Edition 1. DWAF, Directorate: National Water Resources Planning

DWAF, 2003. Guide for the Advisory Committee for water resources modelling- Edition 1. DWAF, Directorate: National Water Resources Planning

APPENDIX A Paper delivered at the 11th South African National Hydrology Symposium, September 2003, Port Elizabeth Technikon.

Commercialisation of models and modelling software developed under WRC funding.

D Hughes, J Boroto and H.C Viljoen

A1. INTRODUCTION

The South African water research community has attained international recognition through the quality of the outputs that it has produced over the years. In the sanctions era when South Africa did not have access to overseas software, institutions embarked on the development of their own simulation software models. In addition, software models that were developed for the water sector were often tailored to the specific conditions of South Africa. These models were mainly intended for in-house or in-country use and were not developed for commercial purposes. Over the past years, the Water Research Commission of South Africa has continued to fund projects which have produced a number of models. A number of current projects in the Key Strategic Area 1 (KSA1) have "development or refinement of a model" as one of the main research deliverables.

The opportunity of commercialisation of research outputs, including such models has increasingly received attention worldwide. Greater sustainability could be achieved if this commercialisation can yield a good return, which could in turn be reinvested in further development and support of the models. This has been to some extent the case for institutions in developed countries such as the Danish Hydraulics Institute in Denmark, Delft Hydraulics in Holland, and HR Wallingford in the United Kingdom. In the Water Research Commission funded projects, commercialisation is therefore one aspect that is increasingly getting more attention in the project proposals as the organisation seeks to gain better returns on the research funds. In the case of projects that result in the development of models, the need to commercialise the models is even greater.

This paper summarises the results of a preliminary survey of the broad base of model users within the country. The questionnaire was designed to provide information on the current use of models (Section B), the status of models that have been developed within South Africa (Section C) and general attitudes on model design and use (Section D). The questionnaire is provided as an appendix for more information, while the following three parts of this paper summarise the replies that were received for the three sections.

A2. SECTION B – EXISTING USE OF MODELLING SOFTWARE

The questionnaire replies referred to 49 different models and with some multiple model references a total of 85 model/organisation combinations were referred to.

A2.1 The models

Table A1 lists the models referred to by the organisations that replied, their application category and brief descriptions of their purpose (when available).

Table A1 The models referred to in Section B of the replies.

Name of Model	Model Type	Short Description
SPATSIM	1,5,11	Integrated spatial and numerical database system with links to a wide variety of models
WRYM	2	Water resources yield model
WRSM 2000	1	Surface water and reservoir simulation model
ACRU	1,7,13	Surface water, reservoir, sediment and water quality simulation model
WRPM	2	Water resources planning model
WSAM	1,2	National water resources availability and yield model
UPFlood	5	Flood modelling and design (deterministic and probabilistic)
SAPWAT	12	
Modflow	3	Ground Water model
HEC-RAS	10	Hydraulic routing and hydrodynamic model
ETO Calculator	12	
SWAT	2	
HSPF	1,7,13	Database management system with links to surface water, water quality and sediment models
SCS-SA	5	Design flood simulation model based on SCS method adapted for SA
WAS	12	
US National Weather Service River Forecast System	1	
SWB	7	
Saltman	7	
Rain	14	
EPA Net	?	
Civil Designer	1	
3pg	14	
WRSM 90	1	Surface water and reservoir simulation model (see WRSM 2000)
WISH	3	
Watercad	9	Water supply reticulation design using CAD type approach
WADISO SA 4.3	9	
VTI (Hymas - Dos)	1	Daily surface water simulation model (now in SPATSIM)
TSOFT	1	Generalised time series display and analysis program (see SPATSIM)
SWAP	12	
Stasoft	7	
Salt Balance	7	
RETC	13	
Reserve Desktop Model	11	Low confidence model to estimate the ecological reserve requirements (see SPATSIM)
Rapid GW Reserve	3	
Patching Model	1	Streamflow data patching, extension model based on flow duration curves (see SPATSIM)
Mike Basins	1,2	Surface runoff and yield model
Mike 11	10	Hydraulic routing and hydrodynamic model
ISIS	10	
IMPAQ 1.1	7	
IHACRES	1	Daily surface water simulation model

Groundwater VISTAS	3	
Geo Seepw	3	
Geo Ctrain	7	
GAMS		
FC Method	4	
Drift And Drift-Solver	11	Model for the determination of the ecological reserve based on workshop outcomes
Cropwat	12	Crop water requirement modelling
CFP	10	
Aquawin	3	

A2.2 Purchase costs

The majority of the models that were referred to were obtained for no cost (see Table A2) and therefore it can be concluded that there is very little financial investment by existing model users. As many of the models referred to are of South African origin, it may be assumed that the costs have been largely carried by the organisations that sponsored the development of the models.

Table A2 Percentage of all model/organisation combinations referred to (85) subdivided by purchase price categories.

Cost	Free	<500	500-1000	1000-5000	5000-20000	>20000
Percentage	67	5	7	11	5	5

A2.3 Maintenance costs

The majority of the replies either failed to fill in the maintenance cost question or specified no maintenance cost. While this could be because maintenance is not provided (or where provided, not used), it is also clear that very few financial resources are expended on software maintenance. The total annual maintenance costs for all 85 model/organisation combinations is R56 000.

A2.4 Number of users

The estimated total number of individual users is 163 and Table A3 illustrates the extent to which individual models are in use. It is clear that many models out of the total of 49 referred to in the replies are used by a small number of individuals, while very few models are in more widespread use. The models falling into the top three categories (i.e. more than 10 users) are WRSM, WRYM, WRPM, ACRU, SPATSIM and MODFLOW. This may be a reflection of the type of organisations that replied and their interest in this survey. However, this is considered by the review team to be a reasonable reflection of the relative extent of model use within South Africa, even if the actual number of users is greater. WSAM, UPFLOOD and SAPWAT all reflected a total of 7 users, which also confirms some of the perceptions of the review team.

Table A3 Percentage of models (total = 49) falling into 5 categories based on the number of users.

No of users	1-4	5-9	10-14	15-19	20-30
Percentage	82	6	8	2	2

A2.5 Frequency of use

66% of the 85 model/organisation combinations reported infrequent use, 20% moderately frequent use and 14% frequent use.

A2.6 Satisfaction with software and support

Many replies failed to identify their satisfaction with the level of support and in most cases the assumption was made that they did not receive support or had not called upon any support services and the reply was assumed to be 'No Support'. This has biased the results for this component of the survey and the figures given in the third row of Table A4 may not be an adequate reflection of the support offered by the model developers or custodians. It is apparent that there is a high level of satisfaction with the software available to South African organizations, but that there is a need to address levels of support.

Table A4 Percentage of the 85 model/organisation combinations reporting different levels of satisfaction with the software and support.

Satisfaction	Excellent	Good	Fair	Poor	No Support
Software	31	48	19	2	N/A
Support	22	22	25	6	25

A2.7 General observations

There were some notable gaps in the replies, with some relatively large organisations that are known to make extensive use of models (and develop their own) not submitting returns. However, an understanding of their level and type of model use suggests that the general conclusions from this section would not have been affected. The main impact would have been to increase the degree of model use and add a few more models to the list. It is difficult to estimate what the effect would have been on the level of satisfaction though.

In general terms it is apparent that the existing level of model use is relatively small and mainly lies with a limited number of organisations and individuals. This may have a significant impact on the potential to commercialise models and software.

A3. SECTION C – SUMMARY OF INFORMATION ON MODEL DEVELOPMENT

Section C of the questionnaire deals with model development. The responses are first described per grouping before the main conclusions are drawn in relation with the objective of the study.

A3.1 Profile of respondents

13 respondents are involved in model development,
Their profile is as follows:

- 7 research institutions (54%)
- 5 consultancy firms (38%)
- 1 directorate within a government department.

A3.2 Type of models

20 models were reported on, covering by priority ranking the fields shown in Table A5.

Table A5 Models under different fields

Field	Number of models	Comment
Agriculture water management	7	5 models are from 2 departments within one university and 2 models from one consultant.
Flood modelling and design	5	3 models are from one research institution
System yield modelling	3	One specific model is about groundwater yield while the others are about surface water
Surface water modelling	2	
Water quality modelling	2	
Groundwater modelling	1	
Environmental flows modelling	1	

Note: one specific model covers two fields (flood modelling and design and surface water modelling), hence the total number of models above is 21 because of this double counting.

A3.3 Model development

Under this section, the model development time, the status of the development (if the model is finalised or not) and the nature of the development (on the technical content or the packaging).

A3.3.1 Development time

Table A6 Development time of models

Duration	Number of models	%
>5 years	9	45
3 to 5 years	6	30
1 to 3 years	4	20
1 year	1	5

Only one model was developed within a year, the developer recognises however that it needs to be upgraded. It appears that most models take more than 5 years to complete. This is stated considering that most models are still under development.

A3.3.2 Status of development

15 of the 20 models (or 75%) are still under development. The next section describes the nature of the development.

A3.3.3 Nature of development

The technical content of 12 models is still being developed and similarly, the packaging of 12 models is also being developed. Of the above, development of both the technical content and the packaging is taking place for 9 models.

A3.4 Funding

The following points summarise the funding situation for the development of the models with respect to the source of funding.

- 16 of the 20 models (or 80%) are funded by the Water Research Commission.
- 8 of the 16 models funded by the WRC (or 50%) have funding from their own organisations or from another source. The questionnaire did not ask for a distribution (%) of the funding.
- Of the 20 models, 6 (or 30%) have funding from other sources (other than the WRC's or their own), including DWAF.
- None of the models has a joint funding by the WRC and DWAF.

A3.5 Model availability

Table A7 summarises the responses on the availability of the models under development.

Table A7 Availability of models

	Number of models
Code freely available	8
Model freely available	7
Model free by arrangement	9
Model free after training	7

Most models, especially those funded by the WRC or public money from elsewhere (such as the USA) are available for free or for a nominal fee (of between R500 and R1200). The bulk of the costs are in the training on the use of the model and can vary from R2400 to thousands of Rands (in this case, it is not only the training but further applications or adaptations of a model for which the code is freely available).

A3.6 Training and support

The responses indicate that in most cases, the training and support is generally available (Table A8) from the model developer's perspective. One specific model developer noted that after sales support could however be time consuming.

Table A8 Availability of support and training

Type of support	**Number of models**
Technical Manual available	11
Model Software Manual available	14
Training available	15
After sales support	13

A3.7 Users profile

It appears that the majority of models are used by a limited number of organizations (Table A9). Two specific models (not included above, hence the total is 17) seem to be used by the developer's organisation alone, but most likely on behalf of his clients. Of the 4 models used by more than 15 organisations, 3 have funding from the WRC, although one is originally from the USA.

Table A9 Use of developed models

Number organisation using model	Number of models used	Comment
1 to 2	8	
2 to 5	4	
5 to 10	2	
10 to 15	0	
>15	4	3 have funding from the WRC

Table A10 The distribution of users by organisation type

Organisation type	Number of models	Comment
Government	7	
Consultants	16	
Researchers	8	
Other	1	The 'other' users for this model are Agriculture Extension Officers who could be seen as part of government.

A3.8 Conclusions

With regard to the support of the Water Research Commission in model developments, the following conclusions are drawn from the above responses:

- 75% (3 out of 4) of the models that have a wide user range (>15 organisations) are funded by the WRC. This is however limited to a few models only since the vast majority has lesser users (11 models are used by less than 5 organisations).
- 80% of the models are funded by the WRC
- Models are mostly freely available or at a nominal fee, but training is provided a cost.
- Support is available from the developers.
- Models are likely to be 'living' models since for most of them, their technical content and/or their packaging are under development.
- It is of worth to note that while the majority of respondents were from research institutions, the majority of users are consultants (see section 7 above). This suggests that they might be prepared to carry the costs associated with the use of a model if there are clear benefits for them.
- The conclusions were drawn from the sample of respondents. It is likely that more responses could have yielded different conclusions, but this is not sure either.

A4. SECTION D - GENERAL ATTITUDE AND PERCEPTIONS ABOUT COMMERCIALIZATION OF MODEL SOFTWARE.

A4.1 Profile of respondents

37 useful questionnaires were received and analysed for Section D, the profiles being as given in Table A11.

Table A11 Distribution of replies by sector.

Government	Consulting	Research	Other
8	15	11	6
20%	37.5%	27,5%	15%

A number of institutions described themselves with two characteristics, for example Government+Research, University+Research (3), Consulting+Research (2), and CSIR+ Research. The "Other" category includes a Water utility, University (3), Technikon, Electricity Suppliers (Eskom), CSIR and Water Board (Amatola Water).

In some instances the respondents indicated clearly that their answers to questions were based on a personal opinion, and that it does not necessarily represent the official viewpoint (if in fact such a viewpoint is available) of the organisation concerned.

Individual general comments on the completion of Section D are:

"*My organization, DWAF, is big and with diverse modelling needs. My views in this response are therefore only limited to my Sub-directorate of Systems Operation of the Directorate of Water Resources Planning Systems*".

"I am unable to fill in the entire questionnaire, as I have not yet begun to use the models/techniques developed for ecological flow determinations".

A4.2 There are sufficient products to meet requirements

Answers are as follows:

Yes	No	Yes & No
17	16	2
49%	46%	6%

For a number of questions respondents either did not indicate a clear preference, or chose both "Yes & No", stating that the answer is conditional, depending on the type of product intended. On this question about half of the respondents are of the opinion that sufficient products are available to meet their requirements.

A4.3 Preference for South African developments

Answers are as follows:

Yes	No	Yes & No
28	5	-
85%	15%	

There is a clear consensus that South African developed products are indeed preferred by the majority (85%) of respondents.

A4.4 This organization finds overseas software more competitive

Answers are as follows:

Yes	No	Yes & No
13	15	6
38%	44%	18%

Again the split between “yes” and “no” are about equal, with a larger number of “Yes & No” conditional statements.

A4.5 Level of satisfaction with available products

Table A12 Satisfaction with available models

The available products are satisfactory:	Yes	No	Yes & No
From a technical point of view.	27	6	4
From a ‘user friendly’ software point of view.	17	13	4
From the point of view of training availability.	14	13	7
From the point of view of support.	14	15	5

Whereas the majority (82%) of respondents find the available products satisfactory from a technical point of view, only slightly more than half (57%) find the products satisfactory from a “user friendly” point of view (Table A12). As far as product support is concerned, again about half of the respondents do not consider support satisfactory. Of those opting for a “yes & no” conditional response, one respondent stated: “*None of the above can have a single answer*.”

A4.6 Most appropriate method of ensuring WRC developments are made available

Preferences are as follows, with a number of respondents opting for more than one option:

Table A13 Preferences for future development

WRC assumes the responsibility for technology transfer.	17	36%
Market the product commercially to generate income for future developments and support.	4	8%
Market the model at minimal cost, but generate income through training and support charges.	23	49%
Market the expertise in the use of the model, but restrict access to the model.	3	6%

There is a clear preference for the third option, with the first option getting only slightly less support. Four respondents indicated a preference for both options 1 and 3. The second and fourth options received very little support.

"Other" possibilities requested resulted in the following proposals:

"*I don't know the answer to this question. The adaptation of a model is not only based on its technical attributes but also on easy of use and availability. Cost restricts availability. Easy of use speeds up applications. I also feel that the technical complexity (too many parameters) being built into models is limiting our ability to use them on a regular basis*." (ESKOM)

"*The WRC should leave the commercialization of models to the private sector. Where there are merits they should assist researcher/developers by financing developments up to a point where these models are ready to commercialize. The WRC should see this as an investment in knowledge and in increasing the efficiency of water resources use. In the long-run these models could in some cases contribute to water savings which in turn will, from a welfare point of view, put money back into the taxpayers pocket even if the commercialization of the model was left to the private sector*."

"*Including government organizations should provide financial support to ensure that the models/s are available for users especially SA users, together with the necessary national databases*." (CSIR Environmentek – Pietermaritzburg)."

"*The need for a model must be properly evaluated before it is developed. If the need for the model exists, the rest will be a logical outflow from there. The WRC cannot take responsibility for the technical support – the developer must do that*." (Dept of Water Affairs and Forestry).

A4.7 Should specialist software companies be used to develop the products?

Yes	No
14	16
47%	53%

Again, there is no conclusive preference here, with slightly more than half the respondents being of the opinion that specialist software companies should not be used to develop the product once the model design is finalised. One respondent, who did not vote on this question, commented: "*Yes for WRC, No for DWAF*".

PD Naidoo & Associates commented as follows: "*I found the question on whether or not to use specialist software companies in the development of the models very odd. I feel that it is essential to use qualified software people to build software products. Imagine a community of architects wrestling with the problem of making their buildings more commercially viable. Imagine them posing the question: 'Should we use properly qualified civil engineers to build our buildings?' The question would be absurd because the role of a civil engineer in a civil engineering project is beyond question.*"

A4.8 How much would your organisation be prepared to pay for a software package meeting all your needs?

Table A14 Preferred price range of models

Price range	<R500	R500-1000	R1000-5000	R5000-20000	>R20000
"yes" replies	5	3	13	7	7
	14%	9%	37%	20%	20%

Those opting for the lower price categories included all the universities and a technikon. Some respondents opted for more than one category, indicating that the price depends entirely on the complexity of the model and that they are willing to pay more for a model that does more. There is a clear indication of a preference for the middle of the above range, i.e. in the region of R1000 – R5000.

This question solicited the following comments:

"This is a loaded question – the answer depends on how much work can be generated using the model and/or how necessary the model is to the work being done. We would not have an issue with >R20000 if answer to above was 'lots' and/or 'very'. Having said that – we get a lot of assistance from cheap/free models that are user-pseudofriendly, have no manuals and little technical support – provided someone can show us how to drive them in the first place."

"*This answer depends entirely on how often it has the potential to be used, i.e. if used once a year on a loc budget project then <R500; however, if on a big project dependant on that software package, and used only once, then R20 000 is quite okay.*"

A4.9 Any other Comments

The invitation for "Any other comments" resulted in the following statements by individuals:

"*The cheaper the cost of the program material for the user, the better. It must not restrict development though. We do not physically use all these programs listed above on a daily basis. Future upgrades and improvement is a must*".

"*I am not sure you can separate hydrological models from GIS (spatial systems) any longer?*" (Eskom).

"*Learning how to write a computer program is a simple matter for most people. The critical point for me is that being able to program does not make a person a commercially competitive software developer. In the same way that knowing how to type does not make a person a commercially viable author. Being able to draw does not make one an architect*".

"Much of the water modelling software that I have seen looks like books that can only be used by the author. These books are unusable by the rest of the community despite the fact that they contain all the correct information. The point that I am trying to make is that the thing that is needed does not come from the author's knowledge base, it comes from the science of commercial publishing. "Speaking as a software professional working in the field of water modelling systems I feel we should be asking the question: "How do we draw on the science of software development to make our software systems more commercially viable?" As a community, we need to find a way to tap into the lessons learnt by the computer science community. "This questionnaire is, for me, a vivid example of how the water modelling community has undermined its own efforts by ignoring the science of software development. Despite the fact that this questionnaire deals mainly with the commercialisation of software, it lacks critical questions pertaining to the issues that the software community know have an affect on commercial penetration of software products."

"*If the development of a model is funded by the WRC, I believe the source code should be made available to all in South Africa, who may use some of the algorithms in other applications. I find that when models are developed, the developers hold onto the source code for dear life as a means of ensuring a competitive edge, and ensuring that future developments can only be done by themselves. To me the challenge is integrated water resources modelling, which will require a number of models to potentially interact with one another, or for a model to include a number of routines (algorithms) from different sources. I think this needs to be looked at, and is one of the reasons that models stagnate in South Africa. However, having said this, I do see the danger of having numerous hybrid models floating around*."

"*A model development aligned with the National Water Act (1998) is essential and beneficial*". (GEOSS)

"*My organization Optimal Agricultural Business Systems CC (OABS) is a small organization (4 people) but we offer very specialized micro and macro economic modeling services not to be found (or difficult to found) in South Africa. There is probably not more than three Agricultural Economists in South Africa that use the methodologies on a day to day basis. We are more than willing to make our contribution to make these methodologies more accessible*."

The comments below are from a group-discussion with members of the Freshwater Research Unit (UCT):

"It is difficult to fill in this questionnaire in that models are not often used at FRU, and when they are this is often for research purposes (and therefore usually once-off). "
"It is important that adequate support and training is available for WRC-funded models. It is therefore a good idea to commercialise models to raise funds for this as long as the cost of the model (and support and training) doesn't then become too expensive (especially for Universities)."

"In the case above a distinction should be made between models that are sold for use in consulting (and therefore to generate income) and models used for research purposes. South African buyers should pay less for a model than SADC buyers. Overseas buyers should pay considerably more."

"It wasn't clear from the questionnaire if only modeling software is being considered or databases as well. It is also important that databases (e.g. the "Biobase" a biological and chemical database developed by Dallas, Day et. Al.) be curated and updated."

"If a model is commercialised, royalties should be paid to WRC which will pay for the original project in which the model was developed (and for future development of the model through WRC-funded projects)."

"Some models (e.g. DRIFT) are based on EXCEL. This makes it difficult to protect the software so it can't be copied."

"*The original developers of the models must be made responsible to market the software. Future funding from the WRC can be used as a stick/carrot approach. The training component of the software should cover their expenses and would at the same time increase the advertisement and product knowledge to potential users.*" (Dept of Water Affairs & Forestry)

"*My experience with water-related models is limited to Spatsim, a model for blackfly control, and the River Health Database (all WRC funded). I found Spatsim powerful and useful, but the structure of the programme as it interfaces with the user is not intuitive, which makes it difficult to learn and remember. The help menu, for example, is not always where one would expect to find it. It may be useful to have a second professional programmer make it more user friendly.*

The blackfly control programme was developed by Americo Bonkewitz. The code was written in Spanish, and he is likely to be the only person able to modify it. It was never applied because there was only one target user (Dept Agriculture) and they were simply not interested. In retrospect this was a waste of money, and highlights that models should only be developed where there is sufficient user interest.

The Rivers Health Database, although not a model as such, is software that was developed with WRC funding, and has huge potential advantages for many users. I have tried to load various versions onto my computer and it always causes havoc. I have not been able to use it, and I refuse to load any further versions on my computer until others start using it without complaining. I get the impression that it aims to achieve too much and is unnecessarily complicated. Again, the need for professional programmers, who understand the user needs, is essential to make it work." (AfriDev)

"*Software developed for / by the WRC needs to be properly promoted and training courses set up. It is not good enough to simply develop the software then think everyone will use it.*" (Parsons & Associates).

"*We also need models that look at issues of climate change impacts on water resources. The user-friendliness of the systems analysis models, especially regarding source codes, needs to be improved. Not all models have user-support systems in place, we suggest that WRC takes a leading role in making sure that these systems are put in place. Training courses should focus more on practical problems and the modeling issues like model set-up should be addressed in detail. We support the idea that WRC assumes responsibility for technology and skills transfer and in so doing there would be a dedicated focus on training and support issues.*" (Umgeni Water)

"*Models have to be developed. This costs money. The Clients pay for the models we use either directly or indirectly (DWAF etc). Commercial distribution of models and upgrades could result in reluctance to upgrade. Clients could specify version to be used and pay upgrade cost as disbursement.*" (Knight Piésold Consulting)

"*Models should be able to do "What if" scenarios regarding water quality. For example impacts with specific license conditions, etc to have a legal standing Water Quality Planning, foresight, scenario planning.*" (RQS - previously IWQS)

A4.10 Conclusions

- There clearly is a need for products to be made available to meet South African requirements, since only half of the respondents are satisfied that this is indeed the case.
- There is a clear preference (85%) for products to be developed in South Africa in an effort to produce products that meet domestic demands.
- Half of the respondents are of the opinion that overseas products are more competitive that domestic models. This refers primarily to price competitiveness, but may include quality factors as well.
- The great majority (82%) of respondents are satisfied from a technical point of view with the available models, but only slightly more than half find them user friendly. User friendliness, the availability of training, and ongoing support is clearly a need, with half of the respondents not satisfied with the present levels of these aspects.
- Two approaches stand out as the preferred ways of making WRC funded models and software developments available, these being:
  - The WRC itself should assume responsibility for technology transfer; and
  - There is a clear preference to market models at minimal cost, and to generate income through training and support charges.
- There is little support to market the product commercially to generate income for future developments and support, and also little support to market the expertise in the use of the model, but to restrict access to the model.
- Only half of the respondents are of the opinion that specialist software companies should be used to develop a product once the model design has been finalised, although some respondents regard this as a necessity.
- Regarding the price users are willing to pay for models, there is a clear preference for the price range R1k – R5k; however, users are willing to pay upwards of R20k if the quality of the model warrants it.
- Higher educational institutions (HEI's) have a preference for lower cost models (<R1k), which raises the possibility of making models available at a special price (or even free) for educational purposes (provided it is not used for consultancy work or commercial gain).
- Model development should be:
  - aligned with the National Water Act (1998), and
  - take into consideration that hydrological models cannot be separated from GIS (spatial systems).

APPENDIX B – The Questionnaire

SECTION A - General

The details can be filled in for a complete organisation, while in some cases it may be more convenient to submit returns for individual sections, divisions or regional offices. The choice is up to the organisation as long as the source of the reply is made clear.

Organisation				
Business (Mark with an x)	Government	Consulting	Research	Other (Indicate)
Contact Name				
Contact Phone		Contact Fax		
Contact E-Mail				

Existing user of model software	Yes / No
Involved in the development of models and model software	Yes / No

If the answers to both these questions is No then skip the rest of this section and ignore sections B and C

No of technical/scientific/engineering staff involved in the use of model software:

1-2	2-5	5-10	10-15	>15

Main fields of model software use (Mark with an X the boxes to the right of each number for ALL areas of involvement):

Surface water modelling	1		Sewage reticulation design	8	
System yield modelling	2		Water supply reticulation design	9	
Groundwater modelling	3		Hydraulics/hydrodynamics modelling	10	
Ground water abstraction design	4		Environmental flows modelling	11	
Flood modelling and design	5		Agricultural water management	12	
Urban stormwater design	6		Morphological/sediment transport	13	
Water quality modelling	7		Other (specify)	14	

SECTION B – Existing use of modelling software.

Please complete one entry for each model or modelling software package being used by your organisation (copy a blank entry if not enough are provided in the document). *When finished move down to Section C if your organisation is involved in model development.*

Section B (ENTRY 1)

Name of model or modelling package	
Developer / Obtained from	

Main field of model software: Please refer to number in section A above; (i.e. Surface water modelling is 1, System yield modelling is 2, Groundwater modelling is 3, etc.). **Mark with an X as appropriate**.

1	2	3	4	5	6	7	8	9	10	11	12	13	14

Costs:

Price range	Free	<R500	R500-1000	R1000-5000	R5000-20000	>R20000
Purchase costs						
Maintenance/user support per year						

Use:

No of users in your organisation	1-2		2-5		5-10		10-15		>15	
Frequency of use	Infrequent (less than once a month)		Moderately frequent (weekly)		Frequent (once a day)					

Model upgrades:

How many times (approximately) has the model been upgraded in the last 10 years	1	2	3	4
Last year of upgrade (e.g. 1999)				
Are you using the latest version?	YES		NO (which version are you using)?	

Satisfaction with Software and Support: **Mark with an X as appropriate**.

Level of satisfaction	Excellent	Good	Fair	Poor	No support	Comment
Software						
Support						

Nature of support provided by developers:

	Yes	No	Comment
Email			
Telephone			
Website			
Training course			

Model use and code protection:

	Yes	No	Comment
Is the model source code provided?			
Is the model use protected with a dongle?			

SECTION C – Information on model development.

Please complete the sections below if your organisation is or has been involved in the development of models and/or associated software. Please complete one entry for each model or modelling software package being developed by your organisation (copy a blank entry if not enough are provided in the document). *When finished move down to Section D.*

Section C (ENTRY 1)

Name of model or modeling package

Main field of model software: Please refer to number in section A above; (i.e. Surface water modelling is 1, System yield modelling is 2, Groundwater modelling is 3, etc.). **Mark with an X as appropriate**.

1	2	3	4	5	6	7	8	9	10	11	12	13	14

Brief description of model type or purpose:

Development details:
Approximate Development time <1 yr 1 – 3 yrs 3 – 5 yrs > 5 yrs

Is the development of the model?	Yes	No	Comment (if any)
Finalised			
Continuing			

If ***continuing***, are the upgrades related to technical content and/or packaging (user friendliness)

	Yes	No	Comment (if any)
Technical content			
Packaging			

Development funded by (Tick more than one box if necessary)

WRC		
NRF		
Own Organisation		
Specific Client		
Other (specify)		

Current availability:

Source code available (Y or N)		
Model freely available		
Model free by arrangement		
Model free after training		
At a cost of		

Comments on availability:

Section C (ENTRY 1 – Continued)

Training and support: ***Delete the answers that do not apply***

Model technical manual available	Y/N	Hardcopy / Online
Software manual available	Y/N	Hardcopy / Online
Training available	Y/N	By arrangement / Regular courses
After sales support	Y/N	Free / At Cost / Limited / By Arrangement / Routine

Number of other organisations using this product:

1-2 ☐ 2-5 ☐ 5-10 ☐ 10-15 ☐ >15 ☐

Type of other organisation using this product: **Mark with an X**

Business	Government	Consulting	Research	Other (Indicate)

SECTION D – General attitude and perceptions about commercialisation of model software.

Please indicate which of the responses best reflects your organisation's attitudes towards models and software.

There are sufficient products available to meet your requirements.	Yes / No
This organisation prefers to use South African developed products when available.	Yes / No
This organisation finds overseas software more competitive.	Yes / No

The available products are satisfactory:

From a technical point of view.	Yes / No
From a 'user friendly' software point of view.	Yes / No
From the point of view of training availability.	Yes / No
From the point of view of support.	Yes / No

What do you consider is the most appropriate method of ensuring that WRC funded model and software developments are made available to other users in a sustainable way (tick the most appropriate answer or offer a further suggestion)?

WRC assumes the responsibility for technology transfer.	
Market the product commercially to generate income for future developments and support.	
Market the model at minimal cost, but generate income through training and support charges.	
Market the expertise in the use of the model, but restrict access to the model.	
Other:	

Do you think that specialist software companies should be used to develop the product once the model design is finalised? Yes / No

How much would your organisation be prepared to pay for a software package meeting all your needs on technical content, user manuals, technical support and user friendliness?

Price range	<R500	R500-1000	R1000-5000	R5000-20000	>R20000
Mark with an X					

Are there members of your organisation who believe that they have more comments and opinions to contribute and would like to be considered for participation in one or more of the following focus groups (fill in the table below)?

Focus group	**Nominated person**	**E-mail Address**
Surface Hydrology		
Groundwater hydrology		
Water Resources Planning		
Water Quality		
Hydraulics/Hydrodynamics		

Agriculture water use		
Commercial Software		

Any other comments: