DEPARTMENT: WATER AFFAIRS AND FORESTRY
DIRECTORATE: RESOURCE DIRECTED MEASURES

OLIFANTS/DORING CATCHMENT ECOLOGICAL WATER REQUIREMENTS STUDY –

INCEPTION REPORT
FINAL REPORT
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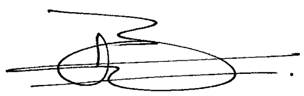

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1 INTRODUCTION

1.1 BACKGROUND

The National Water Act (Act No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for, and authority over, water resource management for the benefit of the public without seriously affecting the functioning of the natural environment. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the Reserve.

The Directorate: Resource Directed Measures (D:RDM) is tasked with the responsibility of ensuring that the Reserve requirements, which have priority over other uses in terms of the Act, are determined before license applications are to be processed, particularly in stressed catchments. The Olifants/Doring River Catchment is deemed to be one such catchment and a comprehensive determination of the Reserve is therefore needed.

This report outlines the approach, methods, tasks, schedule and budget for assessing the Ecological Water Requirements the Olifants/Doring River Catchment. The technical component of this study was awarded to Southern Waters Ecological Research and Consulting, and the project management component was awarded to Ninham Shand.

The study is being conducted under the auspices of the Resource Directed Measures (RDM) Directorate of the Department of Water Affairs and Forestry (DWAF). The results of the study are intended to support water allocations planning, in accordance with the requirements of the National Water Act (No. 36 of 1998).

1.2 OBJECTIVES

The Terms of Reference for this study are detailed in the Scope of Services presented in the Request for Proposals (RFP) for the Olifants/Doring Reserve Determination, dated 28.11.2002, and subsequently updated during negotiations. Essentially, the study has the following (revised) objectives:

Ecological Water Requirements[1]*:	To recommend a comprehensive Ecological Water Requirement (EWR), for water quality and quantity, for various reaches of the Olifants and Doring Rivers, one or two key tributaries, and the Olifants River estuary.
Wetlands:	None – removed from the study during negotiations.
Groundwater:	To review the importance of groundwater to current and potential users in the catchment,

[1] For consistency the terms used in this report follow the terminology recommended at a Pretoria meeting held in April 2003 (see Louw 2003), and those used in the RFP or proposal.

	and to prepare a Terms of Reference for an appropriate level Groundwater EWR study.[2]
Capacity Building:	To develop capacity in team members, and in particular persons from previously disadvantaged communities, and to train them in aspects of Ecological Reserve determinations.

1.3 OVERVIEW OF MAJOR ISSUES

1.3.1 Methodologies

Both the riverine and the estuarine Reserve determinations will use the RDM recommended methodologies as outlined in DWAF (1999).

For the river, the DRIFT (Downstream Response to Imposed Flow Transformations) Methodology will be used. This is in line with the recommendation that a scenario-generation database be compiled to assist in the evaluation of operational flow scenarios for the Olifants and Doring Rivers (see 1.3.2).

1.3.2 Scenario based approach

Both the riverine and the estuarine Reserve determinations will adopt a scenario-based approach. However, in both cases the number of scenarios generated and/or considered has been limited to four, excluding the naturalised and present day scenarios.

Ecological conditions for additional scenarios for the river can be produced after the EWR, if DRIFT used; as recommended, as this will allow consideration of multiple scenarios. These need only be checked with the specialists to ensure they are in agreement with the results for any particular scenario. This is not the case for the estuary, where specialists need to consider the implications of each additional different scenario, and where only one specialist meeting is planned. For this reason it is essential that the four likely 'realistic ' operational scenarios that will be presented to the estuarine team have been developed through consensus opinion with DWAF. It is also essential that these include at least two scenarios for which the river conditions (at the 'driving'[3] EWR river sites) have been determined.

1.3.3 Resource Quality Objectives and the Management Class

The Reserve Consultant is responsible for recommending an Ecological Category (EC; previously the Ecological Reserve Category) for the Ecological Reserve, and for providing Ecospecs (and other relevant information as detailed in the Inception Report) for the recommended EC. These Ecospecs would become the Resource Quality Objectives (RQOs) for the overall Management Class (MC) if the recommended EC forms part of that MC. If not some manipulation of the Ecospecs will be required.

[2] At the request of Mr Johan Wentzel, RDM Directorate, DWAF, a proposal for accomplishing this was developed in consultation with the other Teams undertaking Reserve assessments.

[3] I.e., the site that will have the greatest influence on the flow in the river system as a whole.

RQOs are defined objectives for flow, quality, biota and habitat in order to achieve a specific river state defined as the EC. A MC consists of various categories, which are not necessarily mutually inclusive, i.e., Ecological Category, Basic Human Needs Category, Domestic Use Category and Irrigation Category. The Ecological category forms only one of the components of the MC. When a recommendation regarding the MC is made by DWAF, the consequences of supplying the Reserve and the various users must be considered. In areas where socio-economic considerations outweigh other considerations, the EC may be modified to a lower category. This would be a decision taken for political or economic reasons. As the RQOs are defined for the EC associated with the MC, the MC must be the first of the three to be determined. In this way the associated EC will then be known, and the RQOs can be defined.

Similarly, as the design of the monitoring programme also requires knowledge of the condition in which the systems is to be maintained, the Monitoring Protocol in this study will be provided for the recommended EC.

1.3.4 River

The riverine quantity reserve determination will be undertaken at a comprehensive level, with the exception that no socio-economic components will be addressed in this study, and no public participation activities are planned.

The budget makes provision for six (6) EWR sites, located throughout the Olifants/Doring catchment, but with the emphasis on the main Olifants and Doring Rivers. The intention is that, where appropriate, data obtained at these sites will be used to calibrate the Desktop model for extrapolation of the results to other river reaches in of the catchment.

The number of scenarios generated and/or considered has been limited to four, excluding the naturalised and present day scenarios.

1.3.5 Estuary

The Terms of Reference called for a comprehensive reserve determination process for the estuarine environment. However, the size and complexity of the Olifants Estuary is such that the generic requirements recommended for a Comprehensive Ecological Reserve determination may not be met, e.g., historical data on invertebrates. Fieldwork for some of the components was also reduced during negotiations, and thus the level of confidence in the assessment may be lower than comprehensive. Furthermore, no socio-economic components will be addressed in this study.

The number of scenarios generated and/or considered has been limited to four, excluding the naturalised and present day scenarios.

The reduction of the overall budget in the negotiations phase resulted in a five percent (5%) cut in the estuary relative to that in the original proposal. In order to accommodate this reduction, the following main changes were made to the estuarine study relative to the plan of action given in the proposal:

- the initial literature review (in this report) was reduced in extent, as it was felt there would be a more comprehensive literature review for each of the ecosystem components later on in the study;
- the number of workshops was reduced from two to one, which means that the scenarios for consideration by the estuarine team must be complete before the estuarine EWR workshop is held (this is addressed further in Section 9 – Project Scheduling).
- the number of field trips for data collection in the fish and invertebrate components were reduced from four per annum to two per annum.

Of these, the most significant changes are the reduction in field trips for the fish and invertebrate components. In both cases, the specialists involved have stated that their confidence would increase were they allowed to undertake the number of field trips originally proposed (see Section 3.5).

1.3.6 Groundwater

The groundwater component of this study comprises the writing of a 'Terms of Reference' for a groundwater reserve determination in the Olifants/Doring Catchment. It will include a desktop overview of the relevant information, an outline of problem areas and clarification given on what needs to be done with respect to a groundwater Reserve determination for the catchment.

1.3.7 Study area

The study area is the Olifants/Doring River system (Figure 1.1), which is located some 250 km north-west of Cape Town, and has an estimated catchment area of 46 000 to 49 000 km^2. It comprises six major rivers, *viz*. the Groot River, the Tra-Tra River, the Tankwa River, the Doring River, the Sout River and the Olifants River, and their tributaries. Of these, the most important from a water resource perspective are the already heavily developed Olifants River, and the relatively undeveloped Doring River.

1.3.8 Riverine EWR sites

The results of the resource delineation tasks notwithstanding and as discussed in negotiations, we suggest that the EWR sites should be sought on the following river reaches:

- Olifants River between the Olifants River Gorge and Citrusdal.
- Olifants River between the Clanwilliam Dam and the confluence with the Doring River.
- Doring River between the confluence with the Tankwa River and confluence with the Bos River.
- Doring River between the confluence with the Brandewyn River and the confluence with the Olifants River.
- Two key tributaries.

The selection of sites for water quantity may not be the same as the selection of sites for water quality as the former are usually chosen in relation to major tributary junctions, abstraction points etc, while the latter are usually chosen in relation to towns, discharges from factories etc. This may mean that the choice and number of EWR sites may not be the same for water quality and water quantity.

We have budgeted for six EWR sites, but the zoning of the river and the choice and number of sites is clearly subject to discussion.

1.4 TERMINOLOGY

The terminology used in Reserve determinations was discussed at a workshop held in Pretoria in April 2003 (i.e. after submission of the proposal for this study). The most important changes in terminology are summarised as follows:

- ***Ecological Water Requirements (EWR)*** replaces the term Instream Flow Requirements (EWR) for various reasons, including international acceptance of the former term.
- ***Ecological Categories.*** A distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
- ***Reserve*** refers to the modified EWR, where operational limitations, and stakeholder consultation are taken into account.
- ***Ecological Water Requirement Scenarios*** (EWRS) replaces the term Reserve Scenarios. EWRS is the term to use at all stages through the Reserve process until such time a decision has been made about the Reserve.
- ***Operational Scenarios*** refers to scenarios devised on the basis of issues other than ecological, i.e. availability of water, operational constraints in the system, other demands etc.
- ***Ecological Category*** (EC) replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC). The reasons for these changes are explained in the workshop proceedings (DWAF 2002).

We have incorporated the recommendations from this workshop into this report. These terms will be used for the duration project, and unless otherwise agreed by the Client and the PSP, there will be no further changes in terminology during the course of the project.

1.5 DELIVERABLES

The following reports are the deliverables in this study:

Project Report 1: Inception Report
Project Report 2: Delineation Report
Project Report 3: Groundwater TOR
Project Report 4: Riverine RDM Report, incorporating:
- Specialist's 'Starter' Documentation.

Project Report 5: Estuarine RDM Report, incorporating:
- Reference conditions and Present Ecological Status Assessments;
- Specialist's 'Starter' Documentation.

Project Report 6: Scenario Report
Project Report 7: Monitoring Appendix

Project Report 8: Main Summary Report.

Plus:
Eight (8) Progress Reports
Minutes of PMC Meetings
Scenario-creation database for the study sites (in electronic format).

1.6 SUMMARY OF SCOPE OF SERVICES

The process to be adopted for the Olifants/Doring Comprehensive Reserve Determination is designed to provide the required level of scenario-based information necessary to make strategic recommendations with regard to water availability in the Olifants/Doring Catchment.

To do this, Southern Waters has assembled a team comprised of:

- specialists with detailed knowledge of environmental flow processes, led by Dr. C. Brown and Dr. J. King;
- aquatic ecologists involved in river studies (led by Dr. C. Brown);
- aquatic ecologists involved in estuarine studies (led by Ms. S. Taljaard);
- both a geomorphologist and a sedimentologist (Dr. E. Dollar and Prof. A. Rooseboom respectively).
- water quality specialists (led by Dr. W. Harding).
- hydrologists (led by Mr. G. Howard).
- a hydraulics engineer (Dr. A. Birkhead).
- a groundwater specialist (Mr J. Conrad).

The following institutions will provide support:

- Southern Waters Ecological Research and Consulting.
- University of Cape Town.
- University of Stellenbosch.
- University of Port Elizabeth.
- CSIR, Environmentek.
- GEOSS.
- Ninham Shand.
- Freshwater Consulting Group.

Specific objectives and outcomes are:

- Recommend ECs for each relevant section of the river and the estuary.
- Identify other ECs and provide the ecological consequences of each.
- Determine the Ecological Reserve Scenarios for each of these states (River quantity and quality, and estuary).
- Summarise all technical information and provide to DWAF.
- Provide the Ecospecs associated with the recommended EC.
- Design a monitoring programme to monitor compliance with the Ecospecs.
- Develop capacity in team members, and to train them in aspects of Ecological Reserve determinations.

The details for achieving these are provided in Sections 2 (Management) and 3 (Technical Approach).

2 MANAGEMENT

2.1 TASK 1: PROJECT MANAGEMENT

Project Administration will be organised into three tiers. These are:

- Overall Project Management
- Task Management
- Review and quality control

As part of the plan the overall project management team will devise a series of specific Terms of Reference (TOR). These TOR will detail budget, scope of work, deadlines and expected deliverables. The TOR will be discussed with the Management PSP prior to finalisation.

Each team leader will develop a detailed programme of work for their team. The programme of work will indicate the task that each specialist will be expected to undertake, their budget, scope of work, deadlines and expected deliverables. Task leaders will be required to submit quarterly progress reports on the 20th of the third month in each quarter. Budget has been allowed for all task leaders in this regard. Pro-forma progress reports (see Appendix A) will be issued to all team leaders and will-ask respondents to detail:

- Activities undertaken as per their schedule.
- Expenditure (time and disbursements).
- Time remaining to complete task.
- Problems anticipated and anticipated changes to brief/scope of work.

Payment of invoices will be conditional on satisfactory progress on required tasks.

A consolidated progress report will be sent to the client in the first week of each of April, July, October and January. This will consist of:

- A Gantt chart detailing progress per task against programme.
    - Expenditure against budget (See Appendix B for examples).
    - Progress against expenditure (See Appendix B for examples).
    - Individual team progress reports.
    - Summary of progress, potential problems and possible changes to the scope of work.

Expenditure against budget and progress against expenditure will be presented in a spreadsheet format and in a simplified bar graph (Appendix B). Allowance has been made in the budget for all of these activities.

Possible changes to scope of work will be identified as early as possible. This should be affected via the project-reporting matrix and will be brought to the Management PSP's attention through one, or more, of the following:

- progress reports;
- normal communication channels (telephone, ad hoc- meetings, fax, e-mail);
- management meetings.

Quarterly meetings with the Management PSP and Client will be preceded by an update telephone call to Task Leaders, who will report on progress.

Technical and other reports will be forwarded to the Management PSP against Milestone dates identified on the Gantt chart. Reports will be reviewed by the Management PSP and the Client and amended according. The budget allows for one revision post the client review. The final Technical Reports will be reviewed by the Management PSP, Client and nominated internal Review Specialist.

The sub- tasks that will facilitate this management are detailed below.

SUBTASK 1.1: PROJECT ADMINISTRATION (INTERNAL)

Objective
This task allows for monitoring of progress, writing of monthly progress reports that will accompany invoicing and general project management. It also includes interaction between river, water quality, estuary, and groundwater activities.

Method
Internal liaison through e-mail, phone or at meetings with task leaders and specialists.

Responsible Consultants
Southern Waters (Brown and Pemberton) and CSIR (Taljaard and van Niekerk).

Deliverables
Incorporated into progress reporting.

Information required
Feedback from team leaders.

Responsibility of RC
Sound administrative base and reporting process.

SUBTASK 1.2: PROJECT ADMINISTRATION (EXTERNAL)

Objective

This allows for liaison and *ad hoc* meetings with Ninham Shand.

Method

The liaison and *ad hoc* meetings would be over and above the regularly scheduled progress meetings and integration meetings.

Responsible Consultants
Brown and Pemberton.

Deliverables

Incorporated into progress reporting, ongoing communication with Ninham Shand.

Information required

None.

Responsibility of Southern Waters:

Sound administrative base and reporting process so as to update the Ninham Shand on an *ad hoc* basis.

SUBTASK 1.3: PMC MEETINGS

Objectives

Fifteen meetings have been allowed for, *viz.* a meeting c. every second month. It is, however, is likely that meeting will be held more often near Milestones, e.g., inception, scenario development.

Method

Task 1.3.1 Progress reports

Formal progress reports will be submitted as per the prescribed format (see Section 5.1).

Task 1.3.2 Meetings

The consultant would, in most cases, send two representatives to the meeting. These would be C. Brown and C. Pemberton.

Task 1.3.3 Minutes

The minutes of the meeting would be recorded by Southern Waters and distributed by them.

Responsible Consultants

Brown and Pemberton.

Deliverables

Quarterly progress reports.

In formation required

Standardised format of progress report as required by the Client/Ninham Shand.

Responsibility of Southern Waters

Attendance at progress meetings and production of the minutes of these meetings.

SUBTASK 1.4: FINANCIAL ADMINISTRATION

Objective

The financial administration of the project.

Method

Task 1.4.1 Monthly invoicing
Invoices will be submitted on a monthly basis. Invoices will outline expenditure per sub-consultant and per task and by disbursement per task (see Appendix C for pro-forma invoice).

Task 1.4.2 Budget management
A quarterly report of the budget would be submitted with the progress report, and will include a summary of budget used against TORs for specialists. This would be represented in both balance sheet as well as graphic format.

Task 1.4.3 Cashflow projections
Cashflow projections will be allied to the budget management process and will be set against expenditure, expected expenditure and the budget.

Task 1.4.4 Variations
Any variations between budget and actual expenditure will be noted and will be analysed in terms of impact on overall budget.

Responsible Consultants
Brown and Townsend.

Deliverables

Production of invoices and appropriate financial reporting for progress report.

Responsibility of Southern Waters:

Ensure the required high standard of financial accountability and that the VAT-invoice format is according to criteria laid down by the SARS (Appendix C).

SUBTASK 1.5: GIS AND WEBSITES

See Section 7.

3 INITIAL LITERATURE REVIEWS

3.1 INTRODUCTION

The purpose of this section is to provide a general outline of the components that will be addressed in the Reserve determination. In order to do this, the specialists on the **river** team were requested to provide literature reviews for their relevant components.

The specialists were requested to focus on the following key points:

- Identify and evaluate relevant studies and reports;
- Provide a confidence level in the results of the studies (high/medium/low);
- State reasons for this confidence level;
- Assess the information gaps and needs for their component of the study;
- Identify for the needs, and who in the study team would supply the necessary information.

Short reviews of the **estuarine** components are also provided but these are only synopses of existing information, in line with the changes outlined in Section 1.3.5. Detailed reviews of the estuarine components are to be undertaken in Sub-Task 7.1.

Section 3.5 summarises the major issues identified in the river reviews, and addresses them in the light of the planned activities for the Reserve determination. The main issues raised in discussion with the estuarine team are also outlined in Section 3.5.

3.2 PREVIOUS RIVER STUDIES

The Olifants/Doring River Systems have been the focus of several studies over the past decade (DWAF 1993; DWAF 1998; DWAF 2000, Provincial Government Western Cape: Department of Agriculture 2001) to assess potential of the rivers for water resource developments, most of these studies have to a greater or lesser extent also considered the impacts on the freshwater environment of proposed developments. The most recent and significant of these are discussed briefly below.

King and Tharme (1994) conducted an extensive evaluation of the instream flow incremental methodology (IFIM) for assessing flow requirements, which used the Olifants River as the test river. Instream flow recommendations were made for the Olifants River upstream of the Clanwilliam Dam in 1993/94 using IFIM (Tharme 1993, King and Tharme 1994), which were to be considered during the planning phase of the proposed Rosendal Dam. The option for a dam at Rosendal was however not pursued and no IFR was ever implemented. The Department of Water Affairs and Forestry also commissioned a rapid determination of the Ecological Reserve at one site on the lower Doring River (upstream of the confluence at de Brug) and two sites on the lower Olifants River (d/s of Clanwilliam dam and upstream of Lutzville) in 2000. The Ecological Management Class for the Doring site was determined as Class A, with the Ecological Reserve set at 36% of the virgin MAR. The Olifants sites were determined as Class B and C respectively, with the Ecological Reserve for each site set at 34% and 16% of the MAR respectively.

Phase 1 of the Olifants/Doring Basin study was commissioned in April 1997 by the Department of Water Affairs and Forestry, following a request for approval of a major irrigation scheme to be supplied from a dam at Aspoort, on the Doring River (DWAF 1998). The study identified a number of alternative development possibilities but did not arrive at a firm recommendation regarding the various schemes. Southern Waters Ecological Research and Consulting cc undertook the assessment of the impacts of the proposed water developments on the freshwater environment (King and Brown 1997; Dallas 1997; Brown and Day 1997).

In 2001, the Western Cape Provincial Government: Department of Agriculture initiated an investigation of the feasibility of irrigation development supplied from a dam in the lower reaches of the Doring River at Melkboom. The Western Cape Olifants/Doring River Irrigation Study (WODRIS), which was conducted by ARCUS GIBB assessed various scenarios that would provide water for agricultural development in the lower reaches of the Olifants catchment, including abstraction and artificial recharge of aquifers. Southern Waters was appointed to address the relative impacts of the options assessed on the freshwater environment, and in particular on the indigenous fish populations. The significance of the predicted impacts of the proposed water resource developments was stated as being extremely high, even with mitigation (Provincial Government Western Cape: Department of Agriculture 2001).

3.3 OLIFANTS/DORING RIVERS

The Olifants River rises in the Skurweberg and Witzenberg Mountains surrounding the Agter Witzenberg. It flows northwards through the Groot Winterhoek Mountain Catchment area to drain the western slopes of the Cedarberg and the eastern slopes of the Olifants River Mountains as it flows through the Citrusdal-Clanwilliam Valley. The Olifants is a permanent river whose flow varies considerably: in winter the flow is very strong, whereas in summer abstraction reduces the river to a trickle between large pools. The Doring River confluence is twenty kilometres downstream of the Bulshoek Dam. The numerous farm dams, together with the Clanwilliam and Bulshoek Dams and extensive agriculture in the Clanwilliam and Agter Witzenberg Valleys, have considerable negative impact on the remaining riparian vegetation.

The Olifants River mainly drains sandstones and quartzites of the Table Mountain Group, and Bokkeveld Group shales in its upper reaches and Tertiary to Quaternary sands, together with some Nama Group outcrops (SACS 1980). The geological features in the catchment have considerable influence on the vegetation in the Olifants River.

The Doring River drains the eastern slopes of the Cedarberg, the Swartruggens and the western Roggeveld Mountains. The Doring is a semi-permanent river whose flow varies considerably: in winter the flow is very strong, whereas in summer the river is reduced to a chain of pools. A variable flow regime is known to be causal to the development of diversity in riparian vegetation (Boucher 2002). This river contributes a very large proportion of the silt carried down to the Olifants River (Morant 1984). Silt deposits support different vegetation to that found on bedrock substrates and aquatic vegetation is more developed in clear water than in turbid water (Boucher 2001).

The Doring River in the western and extreme southern portion of its catchment area drains sandstones and quartzites of the Table Mountain Group, Bokkeveld Group shales and Witteberg Group quartzites and shales. All of these three stratigraphic units are components of the Cape Supergroup. The eastern parts of the catchment consist of Karoo Supergroup rocks: the easily-eroded Dwyka Formation tillites and the Ecca Group shales and sandstones (SACS 1980). The geological features in the catchment have considerable influence on the vegetation in the Doring River.

HYDROLOGY

The hydrology developed for the Olifants/Doring River Basin Study (DWAF 1998) will serve as basis for the hydrological analysis. This study involved an update of previous hydrology for the Olifants and Doring River catchments and the simulation of flow sequences at various proposed dam sites along the Olifants (upstream of gauge E2H003), Groot and Doring Rivers (upstream of gauge E2H002). Furthermore, WR90 was used to extend the hydrology from the confluence of the Olifants and Doring Rivers to the estuary.

SEDIMENTOLOGY

The main aspects with regards to the required sedimentation studies relate to:

(i) Sediment yields from the catchments and potential changes in sediment loads due to the construction of dams.

(ii) The shapes of river channels, together with the composition of bed and bank materials and potential changes which will be brought about by the construction of dams.

The most important documents that are of relevance are:

The Sediment Yield Map of Southern Africa (Rooseboom *et al*. 1992) and the sedimentation report that is being prepared by Arcus Gibb, with inputs by Rooseboom, as part of the Western Cape Olifants/Doring River Irrigation Study for the Department of Agriculture.

As there is little data available regarding sediment yields which have been measured within the catchment as a whole, there is a great deal of uncertainty regarding sediment yields and loads across the catchments. The emphasis in the ARCUS GIBB report has been on maximum foreseeable reservoir sedimentation rates and separate assessments will be necessary with regards to the most likely loads and yields which are more relevant in environmental terms.

The channel shape as well as the characteristics of bed and bank materials varies greatly along the Olifants and Doring Rivers. Sampling sites as well as sampling procedures will therefore have to be selected with care.

WATER QUALITY

The water quality aspects of the Olifants and Doring Rivers have been reviewed in *inter alia*, Brown and Day (1999), Dallas (1999) and PGWC (2003).

There are no water chemistry gauging stations on the Olifants River, although water quality has occasionally been assessed for water from the irrigation canal fed from Bulshoek Weir. In the 1970s, a survey was conducted on the mineralization of Western Cape rivers (Fourie 1976), including the Olifants River between Bulshoek Weir and Lutzville. This study concluded that return flows from irrigation, were mineralised due to the prevailing salinity of the soil. Van Rensburg (1966) and Coetzer (1982) both took instantaneous measurements of various chemical constituents and physical attributes at several sites throughout the river system. Results of both of these studies reflected similar trends in water quality as discussed below. Historical changes in water quality cannot be estimated because of the unreliability and relative scarcity of data from these studies (King and Tharme 1993).

King and Tharme (1993) measured temperature and several water chemistry constituents along the length of the Olifants River in an attempt to establish water quality zones that could be used in the IFIM process. They divided the Olifants River into six water quality zones (WQ Zone) on the basis of analysis of the data collected in summer.

- **WQ Zone A** (Equivalent to geomorphological Headwater plateau). The plateau region at the source has a distinctive water quality profile, different to that expected in an unimpacted fynbos river. The differences are possibly due to the combined influence of agriculture (fruit and vegetable crops) and alternating shales and sandstones of the Table Mountain and Bokkeveld Series. The intensity of anthropogenic influence at the source is unusual for western Cape rivers.

- **WQ Zone B** (Equivalent to geomorphological Headwall River (gorge) + Mountain River + upper Foothill River). As the river flows into the Olifants River Gorge it enters an area which is relatively inaccessible and which is largely undisturbed. The quality of the water improves and the concentrations of dissolved solids and nutrients tend to decrease as a result of the absence of anthropogenic influences and the presence of many tributaries that flow over Table Mountain Sandstone (TMS). As with other western Cape rivers that run over such strata, the water is characteristically acidic and low in nutrients and total dissolved solids.

- **WQ Zone C** (Equivalent to geomorphological Foothill River). A separate zone was identified between the upstream extent of the agricultural development near Citrusdal, and Clanwilliam Dam. The intense agricultural activity and severe reductions in flow during the summer months have led to a significant deterioration in water quality, and in particular to elevated concentrations of dissolved solids and nutrients, in this section of the river.

- **WQ Zone D** (Equivalent to geomorphological Foothill River). The area from below Clanwilliam Dam to the confluence of the Doring River formed a single reach. Bulshoek Weir did not seem to markedly affect water-quality conditions downstream (King and Tharme 1993).

- **WQ Zone E** (Equivalent to geomorphological Lowland River). The section below the confluence of the Doring River to Klawer was identified as a single water-quality zone. Water from the Doring River has a significantly higher salinity than the Olifants River, as a result of the geological formations, which it drains in its upper catchment (Fourie 1976), together with a high concentration of total suspended solids.

- **WQ Zone F** (Equivalent to geomorphological Lowland River). Below Klawer, most water quality variables increased considerably in concentration or value from the previous WQ Zone, thereby allowing identification of a separate zone.

DWAF routinely monitors two sites on the Doring River, namely at Elands Drift (Aspoort, E2H002Q01) and at Melkboom (E2H003Q01). The DWAF data for Aspoort and Melkboom span a period of 29 years from 1973 to 2001. The data are discontinuous in that sampling was either curtailed or not feasible due to the absence of dry season flows. Near continuous data exist for various periods between 1985 and 2001. The water quality of the Doring River downstream of De Mond on the Groot River comprises a blend of two sources, namely the perennial, freshwater Groot River, and the seasonal, inter-annually variable and geologically-saline upper Doring River. Downstream of De Mond seasonal tributaries from the western catchment (e.g., the Tra-Tra and Biedouw Rivers) contribute additional freshwater flows, while those from the east (e.g. the Tankwa, Bos and Koebee Rivers, as well as the Brandewyn River) evidence a distinctly saline character. In addition to the contrasting water qualities and flow durations, rainfall in the catchment of the Groot and the Tra-Tra Rivers draining the Cedarberg Mountains occurs largely during winter, while rainfall for the upper Doring River and the eastern tributaries occurs during the summer, or exhibits a bi-modal pattern. Rainfall from the eastern catchments draining to the Doring River system also evidence inter-annual hydrological variability. As has been noted by the ODRS and other studies, the available water quality data for the Doring River do not support disaggregation of the contributions, either by concentration or load, from the various tributaries, nor are they supported by hydrological data other than for the two monitored sites. This presents a major limitation for blending analyses and water quality modelling. For example, should an impoundment be constructed at Aspoort, there is no means of accurately predicting the change in water quality at any point downstream thereof or, indeed, the resultant blended character of the impounded water. Similarly, the ability to predict dry season water quality in an impoundment at Melkboom, especially during very wet summer seasons in the eastern catchments, is likewise constrained. Furthermore, relationships describing the seasonal relationships of water quality and the riverine biota for the Doring River have not been developed. In a fashion similar to that prevailing in estuaries, seasonally-saline riverine environments can develop longitudinal salinity gradients that support unique biotic communities. Disruption of these characteristics can result in severe ecosystem degradation.

Based on the available water quality information, the condition of the Doring River at both Aspoort and Melkboom may be regarded as unimpaired. The water quality, a blend of fresh and naturally-saline sources, is characterized by neutral to sub-alkaline pH, fresh to slightly-saline conductivities, and negligible to low (oligotrophic) levels of nitrogen and phosphorus. Based on the characterizations provided by other studies, varying levels of inorganic turbidity occur in the river as a consequence of silt loads borne by the rivers draining the Karoo catchments. Overall, the prevailing conditions generate a unique and unimpacted gradient of water quality conditions down the length of the Doring River.

RIPARIAN VEGETATION

Olifants River: General flora and conservation worthiness

The Olifants River, above the confluence with the Doring River, extends through most of the mountainous parts of the North-West Phytogeographic Centre of the Cape Floristic Region (Goldblatt & Manning, 2000), on the Cape Supergroup sediments. The lower Olifants River forms the southern border of the Knersvlakte Endemic Centre of the Succulent Karoo Floristic Region (Van Wyk & Smith, 2001).
The riparian flora of the Olifants River has not been assessed over its whole extent to date. Local studies do record species present, for example, Boucher (1997a) briefly listed some dominant species found in the proposed Rosendal and Visgat Dam sites in the Agter Witsenberg and in the Keerom-Bodrif and Grootfontein Dam sites at the head of the Citrusdal-Clanwilliam Valley. He described the vegetation associated with the dams and listed known threatened plants.

A means to assess the botanical value of an area as a whole is by means of the ratio of area to endemic species, which indicates the number of square kilometres, which on average would contain one endemic species. In southern Africa the ratio is 1 endemic to every 161 km^2. In the Cape Floral Kingdom it is 1:15 km^2 (Hall & Veldhuis 1985). Rare and endangered plants can also be rated similarly. The Western Mountain Region of the Cape Floristic Kingdom, which includes the Koue Bokkeveld, Cedarberg and Olifants River mountains, in 1984 had a ratio of listed rare and endangered species to area of 1: 42 km^2 (Boucher 1991). The number of listed rare species in the Flora of southern Africa has increased from 2 373 in 1984 to 3435 in 1995 (Hilton-Taylor (1996). Development contributed substantially toward this increase in rare species.

Olifants River: vegetation

No formal phytosociological vegetation studies have been undertaken along the Olifants River.

The *Acacia karroo – Cynodon dactylon* Riparian Woodland community described from the Doring River valley extends downstream along the Olifants River in patches where higher salinities occur, such as in the vicinity of the junctions with the Hol and Sout Rivers (Boucher 1997; Provincial Government Western Cape: Department of Agriculture 2003).

Bands (1985) described and mapped the broad-scale structural vegetation units of the Groot Winterhoek area but did not include a detailed assessment of the riparian vegetation. Taylor (1988) undertook a detailed phytosociological vegetation survey of the Cedarberg Nature Reserve but it did not extend it onto the Olifants River proper although it did include tributaries in the reserve that drain into the Olifants and Doring River.

Doring River: General flora and conservation worthiness

The Doring River is located on the border between the North-West Phytogeographic Centre of the Cape Floristic Region (Goldblatt and Manning, 2000), on Cape Supergroup sediments, and the Hantam-Roggeveld Endemic Centre of the Succulent Karoo Floristic Region (Van Wyk and Smith, 2001), on the Karoo Supergroup rocks. The relationships between geology and vegetation are illustrated in the latest vegetation map of South Africa that is currently in press (Vegmap project undertaken by the National Botanical Institute for the Dept of Environmental Affairs and Tourism).

The Succulent Karoo Region is considered to be one of the earth's "hotspots" (geographical areas which contain the world's greatest plant and animal diversity). It contains some 5 000 plant species of which 40% are endemic. This region is the world's only entirely arid hotspot (Van Wyk and Smith, 2001).

The Cape Floristic Kingdom, one of six world floral kingdoms, is internationally renowned for its special rich flora containing an estimated 9 000 species of vascular plants of which almost 69% are endemic (restricted to the region). This makes it one of the richest regions in the world in terms of botanical diversity. It is characterized by five endemic families and by the conspicuous presence of, amongst others, species belonging to the families Aizoaceae, Ericaceae, Fabaceae, Iridaceae, Orchidaceae, Proteaceae, Restionaceae, Rutaceae and Scrophulariaceae (Goldblatt and Manning, 2000).

Proposals put forward to register the Cederberg as a biosphere reserve with UNESCO under their MAB programme (Dennis Moss Partnership 2001). This proposal is in the process of being enlarged, under the guidance of the Cape Nature Conservation Board and the SKEP programme, to include the Cederberg area within a mega-biosphere reserve that will stretch from the coast at the Olifants River estuary, through the southern section of Namaqualand, to include the proposed Gifberg-Cederberg complex Biosphere Reserve and stretch at least to the Tanqua Karoo National Park. The Doring River drainage basin forms an integral part of this plan as it separates and drains the Gifberg and Cederberg Mountain complexes, that are both known to be particularly rich in endemic species, as well as draining most of the Tanqua Karoo.

Doring River: vegetation

The following three major riparian plant communities, recognised on the basis of the presence or absence of defining species following Braun-Blanquet phytosociological principles, have been described along the lower Doring River (PGWC 2003).

Acacia karroo – Cynodon dactylon Riparian Woodland

This community is described in the riparian zone on a fine silty-sand substrate over bedrock or between boulders and cobbles along the Doring River Valley extending from Doringbos downstream to the confluence with the Olifants River. The main characterising species are: *Acacia karroo, Cynodon dactylon, Cyperus textilis* and the invasive shrub, *Nerium oleander.* This community extends upstream at least to the start of the Tankwa Karoo and downstream in patches along the Olifants River where higher salinities occur such as in the vicinity of the junctions with the Hol and Sout Rivers (Boucher 1997; Provincial Government Western Cape: Department of Agriculture 2003). It is seriously invaded by thicket-forming *Prosopis glandulosa* short trees along this latter section.

Ruschia brevibracteata - Diospyros ramulosa Doring River Slopes Tall Shrubland

This community is found in shallow clay between rocks on the slopes along the Lower Doring River valley. The main characterising species of this community are: *Ruschia brevibracteata, Diospyros ramulosa, Pentaschistis tomentella* and *Tetragonia arbuscula.* This community occupies the sides of the lower Doring River valley (Provincial Government Western Cape: Department of Agriculture 2003).

Fynbos Mountain Foothill Zone communities

This vegetation is briefly described by Boucher (1997a, b) from the Leeu (Groot) and Matjies Rivers near Aspoort along the Doring River. Dominant fynbos river species found here include *Freylinia lanceolata, Ischyrolepis subverticillata, Metrosideros angustifolia, Morelola serrata* and *Prionium serratum.*

Detailed information about longitudinal variation and lateral zonation patterns along the Doring River are virtually non-existent. Understanding these patterns is essential to determine the flow requirements of the vegetation.

MACROINVERTEBRATES

The Olifants / Doring River system comprises reaches that are vastly different in character. Whilst the fish fauna is highlighted because of its endemicity and threatened status, the river also provides a hydraulically diverse environment for many of the endemic species of macroinvertebrates typical of the Western Cape. An understanding of the flow needs of macroinvertebrate fauna is an important component of identifying the potential consequences of any possible modified flow regime. In anticipation of data collection for this purpose, the specialists involved in the RDM processes are required to identify the most important information gaps and data requirements that will allow the Reserve to be determined with a reasonable level of confidence.

Relevant studies and reports

The invertebrate fauna of the Olifants River has been the subject of four biological surveys. Comparatively fewer and less detailed investigations of the macroinvertebrates of the Doring River are available. The following studies have been briefly examined in order to identify information requirements for this Reserve Determination study:

Coetzer (1982):

- Family level assessment of macroinvertebrates on the Olifants (eight sites) and Doring Rivers (three main stem sites, three tributary sites) in wet and dry conditions, and including some water chemistry data;
- The study was largely descriptive, sampling only stones-in-current at each site; sampling protocol was not clear; specimen identifications are not considered to be overly reliable. The fact that these data were not incorporated into subsequent studies (e.g. as comparison) demonstrates a low confidence in the results.

Fouts (1990):

- An assessment of the instream flow requirements of invertebrates at a single site on the Olifants River, including habitat suitability indices for “key species”;
- The study was superseded by King and Tharme (1994).

King and Tharme (1994):

- An extensive detailed evaluation of the instream flow incremental methodology (IFIM) for assessing flow requirements, which used the Olifants River as the test river;
- Seasonal data collected at 10 sites and 2 tributary sites, identified to Family level. Summer data was processed to a moderate-resolution species level (i.e., some taxa at higher orders);
- The study covered biological zonation, detailed habitat descriptions and habitat suitability indices for three species;
- The confidence in the data is high, given the detailed documenting and quantitative nature of sampling methods and verification of species identifications;
- The report produced, however, only lists summer data. Whilst other seasonal data were reportedly collected, they are not readily available in the published literature and permission may need to be sought from the authors for use of the wider data set (or clarification of its status);
- The survey also only included rocky and sand substrata, and ignored the fauna of marginal or instream vegetation.

Dallas (1997):

- Situation assessment of the Olifants River, based on existing data;
- Presented biological zonation and SASS-level data, derived from the summer data set of King and Tharme (1994);
- High level of confidence in the data used for the assessment, although the application of SASS to the collected data (quantitative benthic samples) makes the SASS results not compatible with results using the normal SASS protocol.

Brown and Day (1997):

- Situation assessment of the Doring River, based on two surveys undertaken immediately after flooding and post the flood season;
- This study presented the first fairly detailed information on species assemblages in major biotopes for six primary sites (sampled during flooding conditions) and SASS level data (not separated into biotopes) for 17 secondary sites (not all corresponding to primary site locations) taken approximately one month after flood recession.

Day *et al.* (1999):

- Biomonitoring survey of the Olifants / Doring system, covering 16 sites in October 1998;
- This study presented Family-level macroinvertebrate data per biotope, coupled with *in-situ* chemical measurements
- Whilst the data were used only to present the standard biomonitoring assessments, the data sets would provide useful information on community composition;
- The reliability of the data is considered to be high (validated SASS practitioners; repeatable protocols).

General evaluation of past studies

Most of the data available represent only winter or spring conditions, with some summer data in the case of the Olifants River. No species-level data exist describing the seasonal variation in invertebrate assemblages, linked to the full array of available biotopes along the length of either of these rivers or their major tributaries. Chemical and physical data are also available only for site (not biotope) conditions – which particularly in a highly seasonal or intermittent system is a shortcoming in describing the habitats available to support the biota.

In addition, whilst habitat suitability measures provide very useful, quantified information on the flow (and substratum) requirements of individual species, this essentially needs to be tied to fairly complicated modelling approaches to setting a reserve for it to be fully utilised. Such an approach is precluded from the present standard methods for environmental flow evaluations.

Information needs and information required from other specialists

(i) *Seasonal distribution of invertebrate fauna, at species level (invertebrate specialist)*: baseline data on patterns of distribution and abundance need to be described for all sites. It is considered that abundances can be measured semi-quantitatively, using the SASS sampling protocol, particularly if tied to mapped (measured) biotope areas. Where historical data exist, inter-annual variations in assemblage structure can be evaluated, and potentially linked to variation in the flow regime.

(ii) *Distribution of physical habitat for invertebrates (hydraulics specialist; sedimentologist; geomorphologist)*: baseline data on the seasonally-changing availability and relative importance of hydraulic conditions. Two approaches to providing this information need have been used in other studies – flow-type and substratum mapping ("biotope mapping") as well as more quantitative measurement of hydraulic conditions within a reach. Both are considered necessary, because the link between subjectively defined "biotopes", ranges in various hydraulic measurements (e.g. depth; velocity; near bed shear velocity; stream power), and invertebrate assemblage structure is not well defined. The scale at which biotopes are differentiated should also be the scale at which invertebrate data are collected.

Marginal and instream vegetation provides one of the most important biotopes for invertebrates, often associated with unique species. The relationship between flow and these need to be described (e.g. extent of inundation, loss of connectivity from the flow channel etc.) and should be part of the mapping exercise.

Biotope / hydraulic conditions need to be tied to river flow, in two respects.

Firstly, the extent of different biotopes and / or the range of hydraulic conditions represented within each biotope should be linked both with discharge and the invertebrate assemblage (e.g. at what discharge does a riffle become drowned; or, at what discharge does the range in hydraulic conditions in a run, and in faunal assemblage associated with a run, change significantly). This could be used to define thresholds of discharge at which change is likely to be substantial. This information need is unlikely to be provided by single or even two field collection visits. However, some attempt at biotope mapping / measurement of hydraulics for selected sites at multiple discharges should be considered.

Secondly, the hydrological requirements for the maintenance of biotope diversity will be an important consideration for the ecological flow requirements of invertebrates. Rates of bedload transport, associated with flood size and sequence should be considered.

(iii) *Water chemistry and food availability for invertebrates (water quality specialist, possibly with invertebrate specialist; freshwater phycologist)*: flow-related data on water chemistry (per biotope) and in the quantities of both benthic algae and organic detritus are needed, as these are important drivers of invertebrate assemblages.
In particular, the summer sequences of changing conditions related to hydrological changes (from flow to pool formation to late summer drought) are important in non-perennial parts of the system. Likewise, the alteration in the food base associated with the onset of flow and / or flooding should be described, linked to invertebrate assemblage change.

Some of this information can be gleaned from existing ecological studies, but it is anticipated that seasonal field studies will be needed to augment these data. In relation to descriptions of the availability of algae and organic detritus, no studies viewed to date provide this information. Data collection could be undertaken by the invertebrate specialist, but it is anticipated that additional specialist input by a phycologist will be needed.

Inter-annual variability in flow conditions in the Olifants-Doring system should inform all these analyses, and the setting of environmental flow requirements.

FISH

The Olifants and Doring Rivers support ten endemic fish species, eight of which are endemic to these systems. There are three cyprinid redfin minnow (*Barbus* and *Psuedobarbus* spp.), two rock catfish (Austroglanididae), and three large cyprinid species (*Barbus* and *Labeo* spp.). The three redfin minnow and two catfish species are restricted to the headwaters of tributaries, whereas the three larger cyprinids occur throughout the mainstem and tributaries of both systems. In addition to the endemic species, there are two other indigenous species with wider South African distributions, a small cyprinid *Barbus anoplus*, which occurs in the northern tributaries of the Doring River, and the Cape Kurper *Sandelia capensis,* which is endemic to the Western Cape, but may have been introduced into the Olifants River (Hamman *et al*. 1984). In the 1930's bass (*Micropterus* spp.) were introduced for angling, and the bluegill sunfish *Lepomis macrochirus* was introduced as fodder for the bass. These species are widely distributed through the catchment and pose a significant threat to the native species. Abstraction, particularly in the Olifants River, is believed to have contributed to the decline in numbers and range of the three large cyprinids, i.e.

Clanwilliam yellowfish *Labeobarbus capensis* (VU A1ce), the sawfin *Barbus serra* (EN B1 +2abde, C1) and Clanwilliam sandfish *Labeo seeberi* (CR A1ace).

Relevant studies and reports

The endemic fish populations of the Olifants and Doring Rivers have been the subject of a number of reports on their conservation status and distribution (e.g. Gaigher 1973; Impson 1999; Abrahams and Pretorius 2000). Comparatively fewer studies have examined their ecological requirements and life history parameters, e.g. van Rensburg (1966) examined the reproduction; Gore *et al*. (1991) the habitat, Cambray *et al*. (1997) and King *et al.* (1998) the spawning requirements of the Clanwilliam yellowfish. These studies are evaluated in Table 3.1. Recent surveys have clarified the distribution of the Clanwilliam yellowfish, sawfin and sandfish (Paxton *et al*. 2002), however, no life history and very little ecological information is available for the latter two species. Similarly, there is no detailed ecological information on the three redfin minnow and two catfish species.

Research needs

The most critical information requirements for target species are outlined in the following sections, as well as being listed in Table 3.1.

Baseline ecological and environmental information

- Fish distribution: baseline data on existing and historical patterns of distribution and abundance of both exotic and indigenous fish species and size-classes compiled from historical distribution records and monitoring surveys. Spatial and temporal variability, i.e. zonal, intra- and inter-annual variations in assemblage structure and distribution need to be described for all sites.
- Habitat distribution: catchment-wide analysis of the distribution of critical habitat (spawning, feeding, nursery) identified as critical by the flow-related ecological profile (see below) of selected species and compiled from a desktop reach analysis, followed by ground-truthing at selected sites.

This information will be compiled from specialist reports, existing studies, historical records and site visits during the course of the Reserve Determination.

Table 3.1. Studies relevant to the ecological flow requirements of the endemic fish of the Olifants and Doring Rivers.

Author	***Subjects***	**Confidence**	**Reason for Confidence Level**	**Research needs**
Van Rensburg (1966)	▪ Reproduction *L. capensis* and *B. serra* – monthly classification of gonad stage (peak October – December).	high	▪ Results based on the weight and stage of 123 *L. capensis* and 410 *B. serra* gonads.	▪ Information on batch fecundity and spawning frequency (i.e. batch or total spawners).
	▪ Diet composition *B. capensis*, *B. serra* and *L. seeberi*.	high	▪ Diet composition based on stomach content analysis of 50 *L. capensis*, 48 *B. serra* and *L. seeberi*.	▪ Information on seasonal and ontogenetic variability in diet composition.
	▪ Age-length relationships.	medium	▪ Age was determined on the basis of scale annuli, which is prone to error. No calibration using otolith annuli or tetracycline (OTC) marking. No growth models were fitted to the data.	▪ Calibration of age-length relationships using otoliths and tetracycline marking. ▪ Fitting of growth models to age-length data. ▪ Independent analyses for adult tributary mainstem populations and larval fish.
Gore *et al*. (1991)	▪ Application of the Instream Flow Incremental Methodology (IFIM) to Olifants River tributaries. ▪ Considered habitat availability for Clanwilliam yellowfish *L. capensis* and sawfin *B. serra* in the Olifants River.	medium	▪ Habitat Suitability Index (SI) curves were constructed from data obtained from tributary reaches only – no information on habitat use in mainstem. ▪ Did not include description of egg and larval habitat. ▪ Problems and limitations of Habitat Suitability Curves (see Gore and Nestler 1988) – these techniques are not considered useful unless they have been linked to population dynamics and combine suitability measures for different seasonal and ontogenetic changes in habitat requirements.	▪ Information on habitat requirements of all life history stages – particularly larvae and juvenile. ▪ Integration of above information with effects of inter-annual hydrological variability on fish recruitment. ▪ Instream habitat conditions required for fish passage over spawning season linked to fish swimming capacity. ▪ Role of hydrology and hydraulics in mediating competitive and predator-prey interactions of local and introduced species.

King and Tharme (1994)	▪ Creation of habitat Suitability Index (SI) curves for sawfin *B. serra* (juveniles), Clanwilliam rock catfish *Austroglanis gilli* (juveniles and adults), Clanwilliam redfin minnow *Barbus callidus* (juveniles and adults), smallmouth bass *Micropterus dolomieu* (juveniles).	medium	▪ Habitat Suitability Index (SI) curves were constructed from data obtained from tributary reaches only – no information on habitat use in mainstem. ▪ Did not include description of egg and larval habitat. ▪ Problems and limitations of Habitat Suitability Curves (see Gore and Nestler 1988) – these techniques are not considered useful unless they have been linked to population dynamics and combine suitability measures for different seasonal and ontogenetic changes in habitat requirements.	▪ Information on habitat requirements of all life history stages – particularly larvae and juvenile. ▪ Integration of above information with effects of inter-annual hydrological variability on fish recruitment. ▪ Instream habitat conditions required for fish passage over spawning season linked to fish swimming capacity. ▪ Analysis of habitat use at mesohabitat and catchment wide scales. ▪ Role of hydrology and hydraulics in mediating competitive and predator-prey interactions of local and introduced species.
Cambray *et al*. (1997) and King *et al.* (1998)	▪ Effects of experimental dam floods and temperature on spawning of *L. capensis*. ▪ *L. capensis* identified as multiple, possibly repeat spawners. ▪ Experimental releases possibly increased spawning activities. ▪ *L. capensis* may require temperatures of 19 ºC and stable or rising to spawn.	medium	▪ Could not control for thermal regime. ▪ Behaviour of fish on spawning beds was not consistent with experimental releases.	▪ Studies controlling for photoperiod, thermal and flow regime. ▪ Effects of freshets on primary and secondary productivity (i.e. food availability) in nursery areas over the spawning season, larval nursery areas and larval drift. ▪ Information on effects of hydrological variability on fish recruitment. ▪ Understanding of hydrological/ temperature/photoperiod stimuli for migration/spawning. ▪ Analysis of habitat use at mesohabitat and catchment wide scales.

Flow-related ecological profile:

I. Functional habitat units: identification and description of critical functional habitat units, for spawning, larval rearing and overwintering.
II. Hydrology and fish production: relationship between inter-annual hydrological variability and fish recruitment.
III. Thermal and temperature cues: thermal or hydrological cues required to trigger gonad development, spawning migrations, spawning aggregations and spawning events.
IV. Fish movement: function, timing and extent of fish movement and the hydrological cues and hydraulic conditions required for fish passage and migration. Function, timing and extent of active or passive dispersal of larvae and juveniles.
V. Non-native species: the role of flow in mediating the competitive and predator-prey relationships between native and non-native species, potential for range extensions following flow modification.
VI. Habitat: habitat requirements of egg and larval life history stages, particularly relationship between availability of spawning and nursery habitat and fish production.

Due to time and manpower constraints, except for (vi) above, it is unlikely that the information requirements listed in 3.2 be will met within the scope of the current EFA. This information will need to be extrapolated from studies of similar species conducted elsewhere in the world. Studies are underway to test the swimming ability and examine catchment-wide habitat use by the three large cyprinids, but is unlikely that this information will be available before the conclusion of the Reserve Determination.

Information required from other specialists

Hydrology

- Hydrological analysis: historical analysis of hydrological conditions in the catchment and hydrological modelling.
- For assessing ecological implications of the hydrological regimes of the Olifants and Doring Rivers: description of hydrological variability (timing, magnitude, duration, frequency, rate of change and index of variability for flow categories) compared for each season in the Olifants and Doring Rivers.
- For assessing importance of late winter/early summer flows for fish spawning: report on the inter-annual timing, magnitude, frequency, rate of change and variability in, peak late winter/early summer flows (freshets) over the historical record.

Hydraulics

- For assessing importance of flows for connectivity between river reaches and ‘windows of opportunity’ for fish passage and for assessing availability suitable hydraulic conditions for fish spawning: depth and velocity distributions in each morphological unit represented at each EF site, (1) following first winter flows and reconnection of Doring River pools

(June/July), (2) spring/early summer (October/September), (3) late summer (January/February).

- For assessing and describing backwater and slackwater larval nursery areas: quantification of aerial extent and duration of inundation of littoral areas over spawning and larval rearing season (October – February).
- For assessing hydraulic conditions at spawning site: modelling hydraulic conditions at known spawning sites. Produce velocity and depth frequency distributions for different discharges.

Water quality

- For correlating fish migration and spawning behaviour with thermal regime: continuous monitoring of temperature over one year (by means of temperature loggers) to determine the thermal regime at selected sites on the mainstems and tributaries of both the Olifants and Doring River.
- For assessing the importance of oxygen to larval fish in backwater/slackwater areas: spatial and temporal variability of oxygen concentrations at the reach scale, particularly in backwater and slackwater areas over the spawning season (i.e. October to December).
- Spatial and temporal variation in turbidity of river reaches.

Sedimentology

- For assessing changes in habitat resulting from flow modification: likely impact of flow modification on the deposition, entrainment and transport of different substrate particles sizes (e.g. sand, cobble, boulder), with particular reference to sedimentation in riffles with a comparison between the Olifants and Doring Rivers.
- For assessing effects of silt on egg hatching and larval survival: suspended sediment dynamics of the Olifants and Doring Rivers.

Geomorphology

- For identifying associations of characteristic functional habitat units (e.g. spawning, feeding, nursery) with catchment-scale variation: desktop reach analysis, i.e. catchment-wide classification of river into zones, segments and reaches based on climate, hillslope gradient and geology, followed by ground-truthing at selected sites.
- For linking fish production in river reaches with availability of mesohabitat features (~100 m): classification, aerial extent and proportional representation of morphological units (i.e. pools, riffles, rapids, slackwater/backwater) at each site.
- For linking fish production in river reaches with availability of microhabitat features (1-10 m) and for identifying critical spawning habitat: size frequency distribution of substrate particles within each major morphological unit (see above), with a quantification of the degree of embeddedness.
- For assessing changes in habitat resulting from flow modification: likely impact of flow modification on channel morphology.

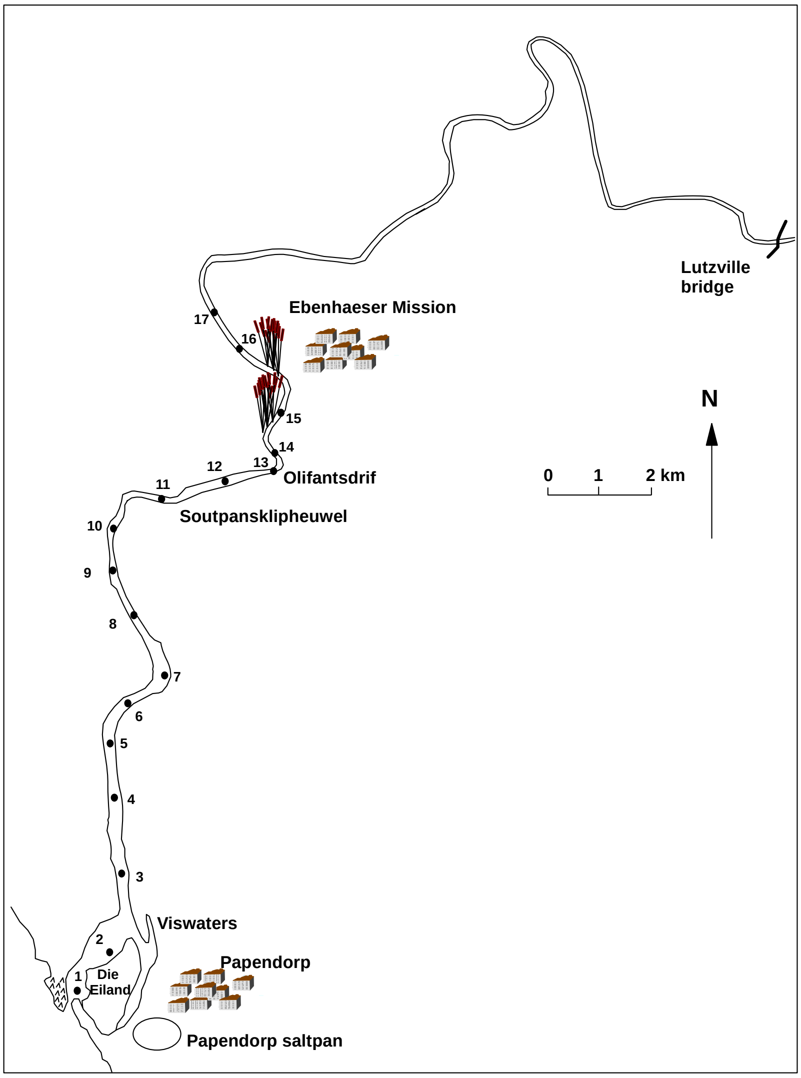
Vegetation

- For assessing the effect of marginal vegetation on critical instream habitats: encroachment of vegetation into instream habitat, particularly riffle areas.
- For assessing the availability of food for adult omnivorous fish: description and quantification of primary productivity, i.e. biomass, phytoplankton and periphyton succession. Comment on the significance of flows for primary productivity.

Invertebrates

- For assessing availability of invertebrates as food for adults and juveniles: succession of benthic invertebrate fauna in pools, riffles, vegetation and backwaters.
- For assessing availability of invertebrates as food for larval and post-larval life stages: succession of zooplankton in backwaters, slackwaters and pools over the summer period, with comments on the significance of flows for secondary productivity.

3.4 OLIFANTS ESTUARY



The Olifants Estuary is approximately 250 km north-west of Cape Town. It is, with the Great Berg Estuary, one of the two major estuaries on the west coast of South Africa.

The estuary itself is still largely in a pristine state, but, based on the simulated run-off data provided for this project, it is estimated that the mean annual run-off has been reduced by 34% per cent, from 1042 x 106 m^3/a under natural conditions to 691 106 m^3/a at present. The run-off from the catchment area shows strong seasonal variations with high flows and major floods during the winter months and low flows during the summer months. The baseflow during the summer months is strongly influenced by return flow from irrigation water along the river.

The estuary mouth is permanently open and bounded by a stable sand spit on the southern side and a rocky bluff “Die Punt” on the northern side (Morant 1984). A rocky spillway, the “Hartebees Kanaal” bisects Die Punt. Until recently this channel was blocked by rubble from the diamond works on the northern side of the mouth, but since then has been blasted clear at the request of the local fishers (Sowman *et al*. 1997). The upper regions of the estuary are regarded as being stable, whereas the lower region is relatively dynamic with estuarine channels changing their course during floods (Morant 1984). The estuary splits into three arms approximately 2 km from the sea. The northern and central arms encircle Die Eiland, the latter only carrying water during floods. The southern arm ends blindly at the Papendorp saltpan and remains dry throughout most of the year. Water depths in the upper estuary range from 1-3 m whereas in the lower 2 km from 0.5-7 m along the southern and northern bank respectively. The estuary has a strong tidal influence with a tidal difference of 1 m being recorded at the Lutzville causeway 36 km upstream. Saline water has been recorded at the Lutzville causeway but the tidal prism seldom extends further than Ebenhaeser situated 15 km upstream (Morant 1984).

Considerable tidal variation has been recorded at the low water bridge at Lutzville 36 km upstream of the mouth and during low flow periods intrusion of saline water from the sea has been measured a few km upstream of Olifantsdrif, approximately 13.5 km from the mouth.

Agricultural developments have taken place along the Olifants River between the Bulshoek Dam and Olifantsdrif. Water for irrigation is being transported from the Bulshoek Dam along the valley through irrigation canals. Saltworks are found near the mouth of the estuary.

In 1997 a preliminary investigation on the effect of future changes in runoff on the Olifants Estuary (DWAF 1997; Adams and Bate 1997; Bickerton and Wooldridge 1997; Huizinga and Van Niekerk 1997; Lamberth and Whitfield 1997; Taljaard 1997; Turpie 1997).

TOPOGRAPHY

Some topographical data on the Olifants Estuary were collected as part of a monitoring programme of estuaries undertaken by the CSIR for the Department of Environment Affairs and Tourism (CSIR 1995).

These data show that the estuary is up to 545 meters wide near the mouth and gradually becomes narrower further upstream with a width of 19 meters just below the low water bridge at Lutzville. The depths are mostly between 2 and 3 meters below mean sea level (MSL). A maximum depth of 6.6 meters below MSL is observed at 18.5 km from the mouth.

SEDIMENTATION AND EROSION

In the literature (Morant 1984) a sediment discharge rate of 6.5 x 10^6 m^3a^{-1} is mentioned, which is considered relatively high and which reflects soil erosion caused by agricultural activity in the catchment area.

WATER LEVEL VARIATIONS

Water level variations were measured in 1994 by visual observations from gauging poles at five positions in the estuary, as part of a CSIR research project. Data were collected during a neap tide on 22 January 1994 and a springtide on 28 January 1994 (Huizinga and Van Niekerk 1997).

The results show the existence of strong vertical tidal variations along the whole estuary and, for example, a water level variation of almost one meter at springtide below the low water bridge at Lutzville.

MOUTH CONDITION

The mouth of the Olifants Estuary is permanently open and because of the length of the estuary and the still relatively high run-off of the system, it is considered highly unlikely that the mouth will close under present day conditions. Huizinga and Van Niekerk (1997) summarises the occurrence of wave conditions at the mouth from different directions. This information was obtained from observations from ships offshore of the mouth of the Olifants River. These data show that southerly to south westerly wave conditions are prevailing in this area.

SALINITY AND TEMPERATURE PROFILES

Longitudinal profiles of salinity and temperature distributions in the estuary were collected in February and April 1990 as part of a research project of the CSIR (CSIR 1990). Salinity and temperature profiles were also collected during June 1999 at the end of a low flow period (CSIR 1999).

Within the estuary the thermohaline regime is strongly seasonal. In winter after heavy rainfall, the estuary can become fresh (salinity of 2,8 ppt) throughout. Conversely, in summer, when there is little river flow, seawater can penetrate as far as Ebenhaeser on occasions (Morant 1984; CSIR 1999). The upstream extent of saline intrusion, like in any estuary, is a function of tidal conditions, river inflow and the length of time any particular set of conditions has persisted (CSIR 1990).

WATER QUALITY

Published data on water quality in the Olifants Estuary date back to the 1976 and 1980, when preliminary chemical studies on a number of Cape estuaries, including the Olifants Estuary (Eagle and Bartlett 1984 and Morant 1984) were undertaken. Thereafter limited observations were also made in January/February 1994 by Harrison *et al.* (1994). Parameters include transparency, dissolved oxygen and inorganic nutrients.

ESTUARINE VEGETATION

In a botanical importance rating of 33 Cape estuaries (Coetzee *et al.* 1997) the Olifants Estuary achieved the highest score. The Olifants estuary also had the highest score in the estuarine health index (EHI) survey of the west coast (Harrison *et al*. 1994) and has been ranked amongst the top 10 estuaries important for waterbird conservation in South Africa.

The Olifants Estuary is important botanically as it has large areas of intertidal and supratidal salt marsh in the lower reaches that are in good condition.

Other macrophytes in the estuary include the submerged macrophytes *Zostera capensis* and *Potamogeton pectinatus* and emergent macrophytes *Phragmites australis* and *Scirpus littoralis*.

No studies have been conducted on microalgae in the estuary. Phytoplankton probably makes a significant contribution to primary production, particularly during the summer months when water retention is longer and nutrient concentrations are high.

INVERTEBRATES

Sources of available information on the benthic invertebrate fauna of the Olifants Estuary are Brown (1969); Day (1981) and Morant (1984). Some of the descriptions in Brown (1969) are common to the summaries by subsequent authors.

The fauna of the Olifants Estuary is very similar to, though richer than, that of the Berg Estuary to the south (Brown 1969). Some 45 species of aquatic invertebrates have been recorded from the Olifants Estuary. This list is not exhaustive since very little detailed work has been undertaken since the original survey by Prof. J. H. Day of the University of Cape Town in 1949 (Morant 1984).

FISH

A total of 30 fish species from 21 families have been recorded from the Olifants Estuary (Lamberth, unpublished; Day 1981, Morant 1984; Harrison *et al*. 1994). Six of these are entirely dependent on estuaries to complete their life cycle. These are *Gilchristella aestuaria* and *Psammogobius knysnaensis*, which breed only in estuaries and *Lichia amia*, *Mugil cephalus*, *Myxus capensis* and *Lithognathus lithognathus*, which are dependent on estuaries as nursery areas. A further 12 species, e.g. *Pomatomus saltatrix* and *Syngnathus acus,* are at least partially dependent on estuaries. In all, 60 % of the fish species recorded from the Olifants can be regarded as either partially or completely dependent on estuaries for their survival. Eight of the remaining species were marine species, e.g., *Sardinops sagax* and *Argyrosomus inodorus,* which occur in, but are not dependent on, estuaries. Four are euryhaline freshwater species whose penetration into estuaries is determined by salinity tolerance, e.g., *Barbus serra* and *Oreochromis mossambicus*.

BIRDS

Full counts of the Olifants River estuary were carried out in 1980 (Ryan *et al.* 1988; Underhill and Cooper 1984), and prior to that, there was a count of the shorebirds (Charadrii) only, in 1976. All of these counts were carried out during mid summer, when the numbers of migrants are high. No full counts were made of the estuary during winter prior to 1996, although a cursory survey, listing species, was carried out in August 1983 (Morant 1984). The largest source of bird data is in the form of Coordinated Waterbird Counts (CWAC), which were initiated in January 1996. One summer and one winter count have taken place each year since 1996.

3.5 COMMENTS ON ISSUES IDENTIFIED IN RELATION TO THIS STUDY

The preceding Sections (3.3 and 3.4) have identified several actions and/or information gaps of relevance to the comprehensive Reserve determination for the Olifants/Doring River. This section addresses each of these, and discusses them in the light of the planned activities in this study. Activities that will form part of the study have also been included in the Technical Approach outlines in Section 4.

It is important to emphasis that, while any Reserve determination should endeavour to provide information at the highest level of confidence possible, such studies must *per force* operate within defined time and financial constraints. In the case of ecological studies, such as Reserve determinations, time constraints dictate not only the number of data collection trips that can be accomplished and the number of samples that can be collected (i.e., replicate data collections) but also, *inter alia*, the potential for collecting long-term data sets and the information required to develop an understanding of the response of an aquatic ecosystem to changes in its flow regime. If such information is not already available at the start of a Reserve study, it will not be used in the study.

Often the best that can be achieved in studies with a one- or two-year data collection period is a 'snap-shot' of the conditions in the ecosystems at the time of the study. Repeat samples during that period may provide greater confidence that the conditions at the time are accurately recorded and represented, but will provide no indication of conditions at another time under different climatic conditions (dry years versus wet year), nor will they assist in describing the ecosystem after a major event, such as the 2000 floods in Mpumalanga. Similarly, it is not possible to answer the multitude of basic ecological questions that arise in a Reserve study, during the study itself. Thus, although information collected during a Reserve study can (and should) be used to augment baseline ecological research, it cannot replace it. The time lines (and budget) simply do not support this.

In Reserve studies, specialists are expected to draw on previous research and existing data pertaining to their discipline and, based their own understanding of their field of study, arrive at an 'expert judgment' on the likely consequences for their component of the ecosystem of change in the flow regime to that ecosystem. These expert judgments are often predictions of what will happen under conditions never before experienced by an ecosystem. While specialist's confidence in their predictions may increase slightly with additional data collection during a Reserve determination, there are several other considerations that must be taken into account when evaluating the amount of data collection during the study, *viz*.:

- it is likely that specialists' confidence in their predictions would increase far more (than with additional sampling during a Reserve study) if there are data describing historic conditions, or monitoring data describing change in the system or similar systems;
- it is likely that specialists' confidence in their predictions would increase far more if the relationships between flow and the sub-components making up 'their' component of the ecosystem have been well-studied and are known;
- specialists' confidence will be higher when they are predicting consequences of flow change not too different from that which they have witnessed themselves;
- specialists' confidence will be extremely low, if they do not have faith in the hydraulic and hydrological information on which they are required to base their predictions. Thus, effort must be directed at this component of the study.

Finally, uncertainty is a reality. No matter how many data, or how deep the understanding of an ecosystem, it is impossible to accurately predict its every response to changing flow conditions.

ISSUES OF RELEVANCE TO THE RIVER QUANTITY RESERVE DETERMINATION

The issues highlighted in the initial literature review for the river are discussed below.

Sedimentology

Prof. Rooseboom notes a dearth of data on sediment yields and loads across the catchments, and separate studies are necessary with regards to the most likely loads and yields, which are more relevant in environmental terms. While their lack will reduce the confidence of the predictions made in the study, such data cannot be collected as part of a Reserve determination.

Vegetation

Dr Boucher reports that detailed information about the longitudinal variation and lateral zonation patterns along the Olifants and Doring Rivers are virtually non-existent, and that these patterns must be understood in order to determine the flow requirements of the vegetation. This study includes provision for delineation of the lateral vegetation zones at the EWR sites. To a certain extent, information on longitudinal variation will be obtained from comparison between the EWR sites.

Dr Boucher also states that no phytosociological vegetation studies have been undertaken for the Olifants River. While there will be some (limited) opportunity to collect phytosociological data during the Reserve determination, detailed phytosociological vegetation studies are outside the scope of this study.

Macroinvertebrates

Ms Ractliffe highlights the lack of species level data on the seasonal distribution of invertebrate fauna in the study rivers, and the fact that no historical data of this nature exist. Provision has been made in the study for the collection of invertebrates samples in different seasons and under different hydraulic conditions. The first set of samples will be collected by Ms Ractliffe, thereafter, Mr Pemberton will (under Ms Ractliffe's direction) collect additional samples for Ms Ractliffe, however, it is likely that the majority of these samples will only be identified to the level of family.

Ms Ractliffe also raises the need for distribution and availability of physical habitat for invertebrates needs to be assessed – see ***Habitat Mapping*** above for a discussion of this aspect.

Finally, Ms Ractliffe highlights the need for flow-related data on water chemistry (per biotope), and data on the quantities of both benthic algae and organic detritus. The collection of such data is outside the scope of a normal Reserve determination, however, water quality samples will be collected from the EWR sites under different conditions. The usefulness, and possible expansion of this exercise will be discussed at the Planning Meeting.

Fish

There is no doubt that the indigenous fish communities of the Olifants/Doring River catchment will be a focus for the setting of a Reserve for the rivers. Mr Paxton identifies the following issues as of importance for the fish component of the study:

- baseline data on the distribution and abundance of both indigenous and exotic fish species;
- information on the distribution of critical habitat for indigenous fish species through out the catchment;
- an understanding of the habitat requirements of egg and larval life history stages.

He also outlines some of the efforts that have been made in recent years to fill these information gaps. It is acknowledged that, while the information base for fish in the Olifants/Doring River is far from complete, there is far more information available than before on which to base a Reserve assessment. In recognition of both the importance of the fish, and the relative lack of understanding of their flow-related ecology, provision has been made in this study to increase the expert input through the inclusion of two fish specialists, Mr Paxton and Dr Bok, both of whom have considerable experience of the Olifants/Doring River. However, the considerable information gaps that still exist will reduce the confidence of the final Reserve determination. Addressing these gaps is outside the scope of this study, but the importance of implementing a comprehensive monitoring programme, for all components of the riverine ecosystem, is underscored by the fish component.

Habitat mapping

No hydraulic modeling or habitat mapping has been incorporated into our programme as this is not possible within the available budget. Habitat modeling would add considerable value to the confidence of the study, and we would be happy to incorporate this aspect should additional funds be available. Habitat mapping of the EWR sites at three different discharges could be achieved for *c*. R60 000.00.

In the absence of habitat maps, changes in habitat availability will be recorded using fixed-point and close up photographs taken at different discharges, in addition to the hydraulic information for the selected cross-sections.

ISSUES OF RELEVANCE TO THE RIVER QUALITY RESERVE DETERMINATION

Water quality

Dr Harding noted that the available water quality data for the Doring River (nor indeed for the Olifants River) do not support aggregation of the contributions, either by concentration or load, from the various tributaries, nor are they supported by hydrological data other than for Aspoort and Melkboom. Such information should be generated by a long-term sampling programme, and cannot be produced in this study. Nonetheless, water quality data will be collected during the various sampling trips planned for this study, and used to improve the understanding of the system to the extent that is possible. Obviously climatic conditions, during the study will, to a certain extent, dictate both the potential for collecting information and value of the information collected. For instance, only if there are rains in the Great Karoo, and the Tankwa River flows into the Doring River, can water quality sample be collected from the Tankwa River.

The lack of certainty with respect to the water quality of (especially) the Doring River will also affect the confidence of the river quantity reserve determination.

ISSUES OF RELEVANCE TO THE ESTUARY RESERVE DETERMINATION

The main issues for the estuary are discussed below.

Estuarine invertebrates

No historical data exist on the estuarine invertebrates. While this will be addressed to some extent by sampling during the Reserve determination, the lack of historical data will reduce the confidence of this component of the Reserve determination. Prof. Wooldridge has suggested that the two field trips now proposed may not even provide a 'medium level' of confidence, and that the re-inclusion of the full suite of field trips originally proposed would ensure a 'medium level' of confidence. At this stage it is not know how the level of confidence in the invertebrate component will affect the confidence of the overall estuarine Reserve.

Fish

Mr Lamberth reported to the team that his confidence would increase if he were allowed to undertake the number of field trips originally proposed.

4 TECHNICAL APPROACH

4.1 TASK 1: MANAGEMENT

See Section 2.

4.2 TASK 2: STUDY IMPLEMENTATION AND DESIGN

SUBTASK 2.1: INITIAL LITERATURE REVIEW

See Section 3.

SUBTASK 2.2: PROJECT PLAN AND INCEPTION REPORT

Objective

- To finalize the project plan and to prepare an Inception report.

Method

The method utilised will be a series of meetings and interactive discussions. The inception report will be based on the Tugela template provided by Ninham Shand, and on the proposal submitted by Southern Waters and accepted by the D:RDM (DWAF) for this study.

Responsible Consultants

Overall and river water quantity:	C. Brown and C. Pemberton
River water quality:	W. Harding
Estuary:	S Taljaard and L van Niekerk
Groundwater	J. Conrad.

Information required

- Content of original proposal.
- Outcomes of negotiations.
- Resolution of riverine EWR methodology.
- Outcome (minutes) of meetings with the DWAF regarding scope of work.

Responsibility of RC

Prepare relevant components as input to Inception Report.

Deliverables and Timing

October 2003.

SUBTASK 2.3: TEAM BRIEFS AND APPOINTMENTS

Objective

- To prepare specialist TORs.
- To appoint specialists for the duration of the study.
- To negotiate and sign relevant contracts with sub-consultants.

Method

Each specialist/sub-consultant will be given a clear TOR and budget. They will be expected to meet their TOR within the budget provided.

Responsible Consultants

Brown, Pemberton and Taljaard (for the estuarine specialists).

Information required

Approved scope of work, and resolution of methodology to be used for the determination of the river EWR.

Responsibility of RC

Prepare relevant documents and distribute for signature. Negotiate with sub-consultants if there are any discrepancies/uncertainties.

Deliverables and Timing

November 2003.

4.3 TASK 3: GROUNDWATER

SUBTASK 3.1: PREPARATION OF GROUNDWATER TORS

Objective

The Department of Water Affairs and Forestry have requested a "Terms of Reference" be drawn up for the Olifants/Doring Catchments for a groundwater reserve determination, which in turn must be woven into the integrated reserve calculations for the catchments. The groundwater "Terms of Reference" must take the following steps into account:

1. *Determine geohydrological and management units*. The determination of resource units is the first step of the generic procedure for classification and determination of the reserve. It is therefore the foundation for all further calculations. The objective of this step is to define the location and geographical boundaries of groundwater dependent ecosystems. Communities depend on groundwater must also be identified.
2. *Determine reference conditions for these units*. Reference conditions describe the natural pristine or 'unimpacted' conditions of a geohydrological region. They present a baseline from which the

current conditions can be calculated. Factors such as groundwater volumes and quality need to be taken into account while considering physical parameters/structure of the aquifer.

3. *Determine the current status of these units*. Determining the current status of a geohydrological region entails an assessment of the resource usage, the quality of the resource, land uses and socio-economic conditions. An assessment of the current status of a resource is necessary to determine the degree of modification and hence the current degree of risk of irreversible damage.
4. *Establish a future management class for these units*. This step entails the selection of an appropriate management class for the protection and management of the resource.
5. *Quantify the basic human needs and ecological reserves*.
6. *Set resource quality objectives*. The objective of this step is to set objectives for the maintenance of the groundwater level and piezometric head, rates of change in level or piezometric head, and water quality which will satisfy the requirements for maintaining the integrity of the aquifer as a water resource and meeting the needs of groundwater dependent ecosystems.
7. *Design a monitoring plan*. Monitoring will effectively help understand resource systems. Monitoring may be carried out with a view to detecting, predicting and preventing abnormal behaviour of groundwater systems of interest and as such forms an important component of resource management.

Method

Before setting up the terms of reference for the study areas all existing information concerning groundwater in these catchments will be reviewed. Basic water balance calculations and water quality assessments will be conducted to identify important and impacted (i.e. stressed) areas.

Depending on the importance, sensitivity and condition of the resource, various levels of determinations will be suggested. These are summarised in the following table:

Level of determination	Method used to determine ecological and BHN component	*Frequency of estimates
Low confidence	Analytical	Annually
Medium confidence	Analytical/Numerical/Base flow separation	Bi-annually (or percentiles wise)
High confidence/ comprehensive	Numerical + Base flow separation	Monthly (or percentiles)

***Frequency of estimates refers to how accurately the reserve and borehole allocations need to be estimated.**

If groundwater is not important for basic human needs and the ecology in a certain region then a low to medium confidence assessment can be conducted. The reserve determination can be averaged and only calculated on a yearly basis. However, if the region is stressed/sensitive and there are many dependents on groundwater, it might be necessary to do an in depth comprehensive investigation.

Emphasis will be placed on achievable resource quality objectives, which in term will aid in the successful management of the system. In addition the correct classification of the resource will play a vital role in ensuring the long-term sustainability (quantity and quality) of the resource.

Integration of groundwater within the total resource quantification and management scheme is another aspect of which the importance will be highlighted.

Responsible Consultant

Conrad.

Information required

- All relevant literature from DWAF – Directorate: Geohydrology, as well as all relevant and recent consultancy reports.
- All available and relevant groundwater maps are to be obtained for the WMA, at an optimal scale of 1:500 000.
- Time series data for water levels and EC will have to be obtained from the DWAF national groundwater database to assess degree of modification and importance.
- All relevant data from the national groundwater-monitoring network will have to be obtained.
- The amount of groundwater contribution to surface water flows and systems will have to be calculated/obtained.
- The latest rainfall and evaporation point and regional climatic data will have to be obtained for the past five years.
- Surface-water data in the form of time-series flow volumes are required for the WMA. River classification data and IFR site assessment data will also be required.
- Groundwater abstraction data for municipal and agricultural supply will be required.

Responsibility of RC

The work will only entail a desktop and superficial overview of the study areas. The groundwater review will only outline problem areas and clarify what needs to be done and to what level of detail within the Olifants/Doring Water Management Area.

Deliverables and Timing

Term of Reference for a Groundwater Reserve Determination.

19th December 2003.

4.4 TASK 4: DELINEATE STUDY AREA, RESOURCE UNITS AND EWR SITES

SUBTASK 4.1: ESTUARY: CLASSIFICATION

Objective

For the purposes of the preliminary determination of the Ecological Reserve in estuaries, the geographical boundaries of an estuary are defined as follows:

- Downstream boundary: Estuary mouth
- Upstream boundary: Extent of tidal influence, i.e. the point where tidal variation in water levels can still be detected
- Lateral boundaries: 5 m contour above MSL along each bank.

Method

The boundaries should be mapped using aerial photograph or orthophoto maps.

Responsible Consultants

Taljaard/van Niekerk (CSIR).

In formation required

Aerial photographs or orthophotos (recent aerials and orthophotos available from DWAF – Bellville).

Responsibility of RC

- Obtain necessary maps and photographs
- Provide boundaries on map.

Deliverables and timing

Map with estuary boundaries illustrated for inclusion in the Delineation Report (see Sub-Task 4.7).

Date: February 2004

SUBTASK 4.2: RIVER: CLASSIFICATION

Objective

The geomorphological processes that shape the channel determine the physical structure of a river system. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems.

Method

The hierarchical classification system of Rowntree and Wadeson (1999) is based on a combination of desktop and field approaches and aims to provide a scale-based framework linking the various components of the river system, ranging from the catchment to the instream habitat. The classification system comprises six levels: the catchment, the segment, the zone, (desktop analysis) the reach, the morphological unit, the hydraulic biotope (desktop and field work required). The classification for proposed here is a desktop study, and will be done to the level of the zone.

Responsible Consultant

Dollar.

Deliverables and timing

Chapter in the Delineation Report (see Sub-Task 4.7)
Map with reaches illustrated.

In formation required

- All prior analysis undertaken (if any).
- 1:50 000 maps of the area.

Responsibility of RC

The RC will be responsible for

- obtaining the necessary maps;
- writing a chapter in the Delineation Report in the required format;
- using the information generated during previous studies and updating it;
- providing the results on a map.

The budget for this task excludes an ecoregional typing analysis, which is not critical to this study.

SUBTASK 4.3: RIVER: HABITAT INTEGRITY

Objectives

- To provide a detailed assessment of the habitat integrity for the instream and riparian components of the rivers within the selected study area on a 5 km basis.
- To provide input in the PES component of Task 5.
- To provide an aerial video for use in various specialist studies.

Method

Habitat integrity assessments of the Doring River and the section of the Olifants River upstream of the confluence with the Doring River were completed in 1997 by Dr C.J. Kleynhans (DWAF). In this assessment Dr Kleynhans, accompanied by Drs Brown and Boucher from the study team assessed the river longitudinally by means of a continuous aerial video taken at low level from a helicopter.

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Additional aerial surveys are not planned for this study, and Dr Kleynhans has been requested to make his assessment and the video footage available to the team.

Existing reports and data will be used to extend the habitat integrity assessment along the Olifants River from the confluence with the Doring River to the tidal influence, and to provide habitat integrity assessments for key tributaries where EWR sites are situated. Similarly, old reports and anecdotal evidence will be used to provide information regarding the trajectory of change in river state.

The river sections to be addressed will be:

- Olifants River from the Olifants River gorge to the river mouth.
- Doring River from the confluence with the Groot River, to the confluence with the Olifants River.
- Koebee River from the boundary of the Oorlogskloof Nature Reserve to the Doring River confluence.
- Tra-tra River from Wuppertal to the Doring River confluence.
- Groot River from the boundary of the Koebokkeveld agriculture to the Doring River confluence.
- Heks River from Citrusdal / Koebokkeveld Road to the Olifants River confluence.
- Jan Dissels River.

Responsible Consultant

Brown and Pemberton.

Deliverables and timing

Chapter in the Delineation Report (Sub-task 4.7).

Information required

- 1:50 000 and 1:250 000 topographical maps.
- Previous videos and maps showing 5 km segments used.
- Relevant GIS coverages.

Responsibility of RC

The RC is responsible for

- obtaining the necessary maps and videos (new and previous);
- reviewing and updating the habitat integrity assessments for the selected rivers;
- providing a summary of recent changes in habitat integrity, if apparent;
- producing a specialist appendix for the Delineation Report with a map illustrating the results.

The RC budget does not include

- obtaining video footage or GPS tracklog;
- adjustments of past results to the present Kleynhans methodology.

SUBTASK 4.4: RIVER: MAP QUANTITY REACHES

Objective

- To divide the river into Reserve units, six of which will comprise the agreed reaches for which Reserve recommendations will be made and EWRs determined.

Method

The results of the stream flow classification, the habitat integrity and locality of tributaries and structures such as dams will be used to delineate the resource units. The units will be discussed with the specialists at the EWR Planning Meeting to ensure that the zonation agrees with their knowledge of the system. Agreements reached during negotiations necessitate limiting the number of Reserve units actually assessed to six (6).

Responsible Consultant

Brown and Pemberton.

Deliverables and Timing

Chapter and map in the report Delineation Report (Sub-task 4.7).

Information required

- 1:50 000 and 1:250 000 topographical maps.

Responsibility of RC

The RC is responsible for
- obtaining the necessary maps and information from previous studies;
- providing a chapter in the Delineation Report (Sub-task 4.7).

SUBTASK 4.5: RIVER: EWR SITE SELECTION

Objective

- To select EWR sites at specific points at the river.

Method

The site selection process as documented in the BBM manual will be followed. This will consist of
- determining the reaches in which the EWR sites must be selected;
- identifying possible sites from the aerial video, where available;
- field confirmation and final selection of sites;
- documenting the process, disadvantages and advantages of each site.

The budget is based on six (6) sites, with agreed focus areas being:

- Olifants River between the Olifants River Gorge and Citrusdal.
- Olifants River between the Clanwilliam Dam and the confluence with the Doring River.
- Doring River between the confluence with the Tankwa River and confluence with the Bos River.
- Doring River between the confluence with the Brandewyn River and the confluence with the Olifants River.
- Two key tributaries, namely the Groot and Rondegat Rivers.

Criteria for site selection are:

- proximity to a DWAF gauging station with an accurate daily flow record;
- accessibility;
- degree of disturbance. Sites should be as undisturbed as possible, so that clues on required flow regimes can still be gleaned from the natural distribution patterns of aquatic plants and animals;
- suitability for accurate hydraulic modelling of the full range of flows, but particularly of low flows;
- presence of critical habitats (those necessary for completion of life cycles) for riverine biotas, or flow-sensitive habitats such as riffles.

Existing sites with available information will be used where possible.

Responsible Consultants

Brown, Pemberton, Dollar, Paxton, Ractliffe, Birkhead and Boucher.

Deliverable and timing

December 2003.

Information required

- Delineation results.
- River team's knowledge and experience of working in the catchment.
- Relevant GIS coverages.
- Key areas of concerns from DWAF's perspective.
- Key areas of concern from Department of Agricultures perspective.
- Key areas of concern from Cape Nature Conservation's perspective.

Responsibility of RC

The RC is responsible for:

- obtaining all the necessary information on the EWR sites;
- coordinating and organizing the EWR site visits;
- selecting the most suitable EWR sites according to the site selection criteria and within constraints such as access.

The RC budget does not include:

- more than 6 sites to be selected.

SUBTASK 4.6: RIVER: DETERMINE QUALITY REACHES

Objective

- To determine river units homogenous in terms of water quality (water quality units).

Method

Ecological categories will be set for the identified water quality units. The availability of water quality data, the length of the data series, and landuse activities in the catchment will influence the initial selection of water quality units. This process will also identify gaps in the data, and help prioritise where additional data should be collected. The final number of water quality units will be also be selected in terms of cost-effectiveness and practicality.

Reserve Consultant

Harding

Deliverables and Timing

- Desktop estimate of selected water quality reaches.
- An assessment of the availability of water quality data and the potential data requirements.
- Completion of water quality section in report (Sub-task 4.7) describing methods and motivation for the selection of water quality reaches. A map illustrating the relevant water quality reaches will be included.

Information Required

- DWAF water quality data and co-ordinates of water quality monitoring points.
- Information regarding landuse practises and sources of pollution in the catchment.
- Relevant maps.

Responsibility of RC

The RC is responsible for the

- Obtaining of all relevant maps and information (DWAF monitoring points and data, landuse activities etc.)
- Writing of the water quality section for the report (Subtask 4.7).

SUBTASK 4.7: REPORT COLLATION AND EDITING

Objective

- To document Sub-tasks *4.1-4.6* in the Delineation Report.

Method

A contents page will be provided to the Management PSP prior to compiling the report. The report format will be that agreed between the Client and the Consultant. Draft reports will be provided to the client in .pdf format (Acrobat) for comments. Reports will be finalised after one round of comments have been received and one unbound hard copy will be provided to the client as well as a CD with the report in the original software as well as converted to .pdf format. Only comments of a technical nature (as opposed to reporting style comments) will be incorporated. The RC will check all reports for consistency and the correct use of the English language.

Responsible Consultants

Brown and Pemberton.

Deliverables and Timing

Delineation Report.
First draft report in March 2004.

Responsibility of RC

The RC is responsible for:

- compiling the report in the required format;
- providing draft copies for comments;
- incorporating one round of comments;
- providing the required number of copies of the report (see section 12.13).

The RC budget does not include:

- more than one round of comments to be incorporated;
- the additional costs that will be required if comments are not received within one month or an agreed on date from the draft report being received by the client.

4.5 TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE RIVER STATES

SUBTASK 5.1: EWR PLANNING MEETING

Objective

- To plan the quantity component of the river studies.

Method

A one-day meeting will be held on the 24th November 2003, and will be linked to the EWR site selection and initial data collection.

Responsible Consultants

Brown, Pemberton, King, Birkhead, Howard, Ractliffe, Boucher, Dollar, Paxton, Harding, Rooseboom, Kamish, Sparks and Kereko.

Deliverables and Timing

- Minutes (December 2003).

Information required

- Delineation of the study area.
- Gauge positions.
- Previous EWR site information.

Responsibility of RC

The RC is responsible for:

- coordinating the meeting;
- facilitating the meeting;
- producing minutes of the meeting.

SUBTASK 5.2: REFERENCE CONDITIONS, PRESENT ECOLOGICAL STATE AND ECOLOGICAL IMPORTANCE

Objective: Reference conditions

- To determine and describe the reference conditions of the study rivers, i.e., the natural condition prior to anthropogenic change.

Method: Reference conditions

Historical information and data, and/or data from similar minimally impacted sites, are used together with expert judgement to describe the reference conditions for water quality, geomorphology, riparian and instream vegetation, macroinvertebrates and fish.

Owing to data limitations, and/or the absence of category A reaches, the reference condition may not describe the pristine condition of the river, but a best estimate of a minimally impaired baseline state.

Objective: *Present Ecological State (PES):*

- To determine and describe the PES of the study rivers.

Method: PES

The PES of the river will be expressed separately for each component of the river ecosystem, namely, habitat integrity, fish, riparian vegetation, aquatic invertebrates, fluvial geomorphology, hydrology and water quality. Each component will be assigned a classification level (A-F), where categories A-D are judged to be ecologically sustainable, and categories E and F indicate a current state that is ecologically unsustainable. Motivations for each classification level will be supplied. The direct impacts on the river are listed separately into flow-related and non-flow related activities. The sources of the changes are provided. For example, sedimentation can be seen as the cause of habitat change, with over-grazing (agriculture) being the non-flow related source. The Trajectory of Change describes the direction of change in condition for each of the biophysical components under consideration, *viz*. positive (improving), negative (degrading) or stable. This information is used to assess whether the PES is stable, or whether it is changing.

The methods to be followed for the various components are as follows:

- Habitat integrity: Discussed under Sub-task 4.3.
- Hydrology: The approach to be used will be based on the monthly time series data generated for natural and present day conditions.
- Geomorphology: The Geomorphological Index, as used in the River Health Programme, will be used to score geomorphological condition.
- Aquatic invertebrates: The SASS index will be used to attach a PES Category to the aquatic invertebrates.
- Riparian vegetation: All past survey data together with professional opinion will be used to place the riparian vegetation into PES Categories.
- Fish: An assessment of community structure based on past survey data together with professional opinion will be used to place the fish for each reach into a PES category. The FAII will not be used, as it is better suited for rivers with a relatively high diversity of species, which is not the case in the Olifants/Doring system.

Ecostatus: The integration of the different PES values into an overall PES state will take place at the start of the specialist meeting (Sub-task 5.9). This will establish the ecostatus for each reach adhering to the above guidelines. This integration is very much a qualitative approach and not an easily defined process. However, Dr Neels Kleynhans and Ms Delana Louw are currently investigating a structured way of determining Ecostatus. Should the methods and recommendations from this Ecostatus Project be available prior to the specialist workshop, and depending on budgetary constraints, they will be adopted for the determination of the overall Ecostatus.

For now, the following guidelines will be followed:

- examine the driving processes (flow, water quality, geomorphology). If one of these is in a lower category than the biota then examine the causes, source and trajectories of change;
- if the biota are likely to follow the critical driving process, then the ecostatus category will usually be set in the same category as the driver;
- if the biotic categories are in the same as or lower categories than the drivers then examine the causes, source and trajectories. The confidence in the assessment of each component and the ecostatus category will usually be set in the same category as the critical biotic component.

Ecological importance and sensitivity: The ecological importance of a river is an expression of its contribution towards the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (DWAF RDM report, 1999 - Volume 3). Determination of the EIS of the system will take place at the start of the specialist meeting (Sub-task 5.9). The DWAF Ecological Importance and Sensitivity model will be run in order to attach an importance evaluation for each river reach.

SUBTASK 5.3: ATTAINABLE AND RECOMMENDED EC FOR THE RIVER

Objective

- To determine a recommended and an attainable Ecological Category for the selected EWR reaches.

Method

Determination of the EC will take place at the start of the Specialist EWR Meeting (Sub-task 5.9), where consensus will be sought between the specialists on:

- the overall PES for each EWR reach;
- the sources of degradation;
- how effective remedial actions might be in reducing their effect on PES;
- the difficulty of achieving an improved PES.

The EIS model will be used to assist in determining the recommended EC. The following guidelines (among others) are used:

- o If the EIS is High or Very High, the ecological specialists will recommend a flow regime that will allow an improvement of the PES if the PES is lower than a class B.
- o If the PES is Low or Moderate, the ecological specialists will recommend a flow regime that will maintain the PES. Unless PES is lower than a Class D, in which case it will be require improvement regardless of the EIS.

Reserve Consultant

Brown, Pemberton, Harding, Dollar, Boucher, Paxton, Bok and Ractliffe.

Deliverables and Timing

Chapter for the Riverine RDM Report.

November 2004.

In formation required

- Information generated during all previous sub-tasks.
- Information regarding the present operation of the system.
- Input during the specialist meeting on the difficulties of addressing the causes and origins.

Responsibility of RC

- Undertaking the activities listed above.

The RC budget does not include:
- analysis of the difficulties inherent in addressing the causes of the PES.
- the provision of quantitative and qualitative information on the present operation of the system. This will be gleamed from the current Internal Strategic Perspective process.
- *force majeure*.

SUBTASK 5.4: CROSS-SECTIONAL SURVEY AND HYDRAULIC CALIBRATION

Objective

- To provide information on the topography of the EWR sites using cross-sectional surveys.
- To procure field data at EWR sites to enable cross-sections to be rated (relationship between discharge and stage).
- To achieve the highest possible confidence in the hydraulic characterisations by undertaking data collection at a range of flows, from lowflows through to high flow periods.

Method

One field trip will be undertaken during which:
- the cross-sectional profiles will be surveyed;
- the stage levels and longitudinal river bed and water surface gradients relative to a local datum will be measured.

Detailed surveying of one to three cross-sections at each EWR site. Stage-height records will be collected at four different times (and four different discharges) during the study. Collection of data for a wide range of flows will depend on the flows in the river during the data collection period, and cannot be guaranteed.

The product of the hydraulics work comprises a series of relationships between flow rate and, amongst others, flow depth, flow velocity, wetted perimeter and shear stress. These relationships are determined for cross-sections or transects that are surveyed at the EWR sites. In order to satisfactorily characterise the hydraulic relationships for an EWR study, extensive use is made of field data, with discharge and stage being recorded at each of the cross-sections for a range of flows observed over the hydrological season. The hydraulic modeling component of the study involves using the measured cross-sectional and flow data to develop rating relationships (discharge against flow depth) and the biologically useful parameters (wetted perimeter and flow velocity) for the entire range of flows of interest.

The hydraulic complexity of the EWR sites and positioning of cross-sections through important and critical habitats have a profound influence on the ways in which hydraulic data are collected and analysed. Proportions of observed and modeled data required for the development of reliable hydraulic relationships useful for the EWR process are highly site-dependent. As a general rule:

> *the more hydraulically complex the site, the greater the reliance on observed data for reliable results from the hydraulic analysis. Although hydraulic considerations cannot be expected to enjoy pre- eminence in the EWR site selection process, it is essential that the selected sites are hydraulically tractable within the limits of available resources.*

The HER presentation software will be prepared to provide the hydraulics data at the specialist meeting in a cost-effective way.

Responsible Consultants

- Birkhead, Pemberton and surveyor.

Deliverables and Timing

- Cross-sectional survey complete by the end of January 2004.
- Rating data for cross-sections at EWR sites, with the database of hydraulic and photographic information updated following each of the four scheduled field trips.
- Hydraulic relationships complete by September 2004.

Information required

- Rating tables for selected DWAF gauging stations along the river systems.

Responsibility of RC

The RC is responsible for:

- ensuring four field trips are undertaken to collect the data required for the hydraulic cross-sections;
- establishing benchmarks along each of the cross-sections;
- updating the survey information database following each field trip;
- updating the hydraulic database following each field trip.

The RC budget does not include:

- additional unscheduled data collection field trips;
- the re-surveys and hydraulic data collection required if (i) previously established fixed stations (bench marks) cannot be located; and (ii) fixed stations positioned during this course of this study are removed by flooding or vandalism;
- GPS positioning of stations relative to the LO system is not included within the budget;
- *force majeure*.

SUBTASK 5.5: PREPARATION OF HYDROLOGICAL DATA

Objective

- To provide reliable daily and monthly hydrological data representing present-day and naturalised conditions for each of the six EWR sites selected in Sub-task 4.5.
- To present these data in the required format to facilitate understanding and manipulation by the river specialists at the EWR meeting (Sub-Task 5.9).

Method

For the purpose of this technical proposal, it has been assumed that the existing hydrology is sufficient and no provision has been made in the budget for the existing hydrology to be updated or revised. Furthermore, cognizance should be taken of the fact that the existing hydrology does not simulate alien vegetation water use explicitly.

Standard hydrology:

- Assessment of all available information on natural, historical and present day flow patterns (making use of observed data, previous model results, patterns of water use, control and abstraction).
- Selection of appropriate modeling tools for simulating daily flows where necessary and possible.
- Generation of daily flow time series for natural and present day conditions where necessary and possible (given time constraints).
- Summarise the data availability, methods and results and compile the starter document for hydrology.
- Ensure that all the data are in a suitable format for displaying and carrying out further analyses during the EWR workshops and that suitable software is available.

An underlying philosophy of our approach is that most river scientists take as their starting point in understanding any river, its nature and condition at the time of their studies. Their predictions of flow-related change describe how the river will change from present, although they may use as background any information on past characteristics of it and similar rivers. Therefore, in the Olifants/Doring study the present-day and naturalized flow regimes will be considered for the EWR sites (particularly in the Olifants River), and analysed to illustrate (to the extent possible) how and when changes in flow have occurred in the past.

The naturalise and present-day daily flow data will be analysed to characterise present flows and presented to the specialists to facilitate the component-specific assessments of flow related changes in the catchment. .

Additionally, the discharges at which relevant channel features are inundated or exposed will be identified.

Responsible Consultants

Kamish, Howard and Brown.

Deliverables and Timing

- Representative time series of natural and present day daily AND monthly flows for all identified EWR sites.
- Analysis of the natural and present-day time series.
- Short report outlining procedures used, and problems (if any) encountered for inclusion in the Riverine RDM Report.

March/April 2004.

Information required

- rating tables for DWAF gauging stations along the river systems.
- Data for DWAF gauging weirs along the river systems.

Responsibility of RC

The RC is responsible for

- the quality of the hydrological data produced;
- corrections required later as a result of incorrect data being used.

The RC is not responsible for:

- updating the existing hydrology for the system.

SUBTASK 5.6: SPECIALIST DATA COLLECTION (RIVER QUANTITY DETERMINATIONS), EXCLUDING HYDROLOGY AND HYDRAULICS

Objective

The goal for each specialist is to be in a position to predict how a specified set of flow reductions (or additions) would change their component of the ecosystem. The changes are quantified to the extent possible at the Specialist EWR meeting (Sub-task 5.9).

Methods

Geomorphology: Site-specific information will be collected at each site. This will enable the assessment of flows in order to maintain the necessary geomorphological processes. This information is collected during the EWR site selection visit.

Riparian vegetation: Site-specific information will be collected at each site. This will enable the assessment of flows required to sustain riparian vegetation. Indicator trees will be identified and their positions surveyed onto cross-sections. Profiles illustrated with the relevant trees will be provided.

Aquatic invertebrates: Site-specific information will be collected at each site, which will enable the assessment of flows required for the aquatic macroinvertebrates.

Fish: Data collected in 2002-2003 at certain EWR sites will be used in conjunction with site-specific information for the remaining sites, which will be collected during the EWR sampling trips.

Photopoint monitoring: The objective is to provide a visual record of different known flows. Fixed-point photography will be used to characterise the riverine habitat provided by the flows in the rivers during each of the scheduled hydraulic field trips.

Responsible Consultants

Pemberton, Dollar, Boucher, Ractliffe and Paxton. Plus various assistants.

Deliverables and Timing

See Sub-task 5.8.

Information required

- All previous collected relevant information.

Responsibility of RC

The RC is responsible for

- Collecting the required data according to the recommendations described in the BBM manual.

The RC budget does not include

- additional surveys beyond what is specified in the Inception Report.

SUBTASK 5.7: SPECIALIST DATA COLLECTION (RIVER QUALITY DETERMINATIONS), EXCLUDING HYDROLOGY AND HYDRAULICS

Objective

The goal is to be in a position to predict how a specified set of flow reductions (or additions) would change water quality in the riverine ecosystem.

Methods

As per DWAF (1999). Mainly based on existing data.

Responsible Consultants

Harding.

Deliverables and Timing

See Sub-task 5.8.

Information required

- All previous collected relevant information.
- DWAF water quality records.

Responsibility of RC

The RC is responsible for

- Collating and interpreting the required data.

The RC budget does not include

- additional data collection.

SUBTASK 5.8: SPECIALIST REPORTS AND APPENDICES

Objective

- To document the data collection and analysis procedures used, and the results obtained, in each specialist study, including hydrology and hydraulics. The raw data collected in Sub-tasks 5.4, 5.5 and 5.6 will be incorporated in these documents.
- To produce relevant lists (Generic Lists) of each of the aspects of their specialty for which they will motivate flows and describe the consequences of flow change in Sub-Task 5.9. These lists should include any known information pertaining the relationship between the items listed and flow.

Method

<u>Hydrology</u>: see Sub-Task 5.5.

<u>Hydraulics</u>: see Sub-task 5.4.

<u>Fluvial geomorphology and sedimentology</u>: Site-specific information will be analysed and a specialist appendix provided. The methods as described in the BBM manual will be used.

<u>Riparian vegetation</u>: Site-specific information obtained during Sub-task 5.2 will be analysed and a specialist appendix provided on the flow requirements of the riparian vegetation. A figure illustrating key species will also be provided. The methods as described in the BBM manual will be used.

<u>Aquatic invertebrates</u>: Site-specific information obtained during Sub-task 5.2 will be analysed and a specialist appendix provided. The methods as described in the BBM manual will be used.

<u>Fish:</u> Site-specific information obtained during Sub-task 5.2, as well as previously collected data will be analysed and a specialist appendix provided. The methods as described in the BBM manual will be used.

<u>Water quality</u>: Water quality information produced during Tasks 5 and 6 will be used together with hydrological data at the EWR workshops.

Responsible Consultants

Brown, Pemberton, Howard, Kamish, Birkhead, Dollar, Rooseboom, Harding, Boucher, Paxton and Ractliffe.

Deliverables and timing

- Water quality preparation to be completed before attending the EWR workshops.
- Specialist appendixes.

September 2004.

Information required

- All available information on the historical and present day patterns of water abstraction and control within the Olifants/Doring basin;
- Observed flow data from DWAF Hydrology;
- Time series of monthly flows for natural and present day conditions, as generated by the Systems Model Consultants
- Median monthly concentrations for RC and PES for each water quality reach information generated during Task 5.
- Mean monthly flows (RC and PES) for each EWR site from the project hydrologist for the water quality preparation.
- Information collected during Task 5 and Sub-tasks 8.1-8.4.

Responsibility of RC

Each specialist is responsible for:

- obtaining the relevant data required for their component of the river system;
- determining the most appropriate methods for analysis, simulation or presentation of the data;
- preparing comprehensive Generic lists – except hydraulician.
- preparing their starter document;
- providing the software for flow analysis at the workshops;
- preparing HER software to present the hydraulics at the specialist meeting;
- accessing all information required in terms of water quality;

The RC budget does not include

- collecting or checking information on the water use, control and abstractions within the Olifants/Doring catchment.

SUBTASK 5.9: SPECIALIST EWR MEETING

Objective

- To integrate the information gathered in Sub-tasks 5.1 to 5.8 to provide the modified flow regime that will maintain the river in a certain state.

Method

The PSP accepts that the D:RDM office requires that the initial determination of the Reserve for the recommended EC is done according to the **DRIFT**

Methodology. DRIFT is explained in detail in King *et al*. (2003), and summarised in Appendix D.

Once the Reserve has been determined for the recommended EC, the Reserve requirements for one EC higher and one lower than the recommended EC will also be generated. Both of these will be for a percentage of the natural Mean Annual Runoff (MAR) at the various study sites, with a temporal distribution that is deemed to be optimal for the riverine ecosystem.

In order to accommodate the expected requirement for review of scenarios with a sub-optimal temporal distribution of flows, a scenario-creation database, is populated at the EWR workshop.

The database is essentially a data-management tool, allowing data and knowledge to be used to their best advantage in a structured process. The central rationale is that different parts of the flow regime elicit different responses from the river ecosystem. Thus, removal of one part of the flow regime will affect the ecosystem differently than removal of another part.

Thus:

- it is possible to identify and isolate these different parts of the flow regime within a long-term hydrological data set of daily flows;
- it is possible to describe in isolation the probable biophysical consequences of partial or whole removal of any one of these parts;
- the parts of the flow regime and their linked consequences can be re-combined in various ways, to describe the river condition of any flow regime of interest (the biophysical part of the scenario).

The biophysical specialists typically involved in the EWR assessment are: hydrologist, hydraulic modeller, water chemist, fluvial geomorphologist, sedimentologist, botanist (riparian), ichthyologist and macroinvertebrate zoologist. The hydrologist and hydraulic modeller will provide information on the river that the other specialists use to develop recommended flow regime and their predictions of change. Task 5 summarises the main activities in achieving this, and the culmination in the assessment of EWR scenarios for alternative river states.

Each biophysical specialist chooses her/his own component-specific methods to derive the kinds of flow-related links described above. PHABSIM, for instance, could be used to establish links between wetted usable area and discharge for selected fish species. Plant and animal ecologists could use multivariate-analysis packages to establish flow-species relationships and be able to use strong inference in their predictions of likely change.

In the Olifants/Doring study, the goal for each specialist is to be in a position to predict how flow reductions (or additions) would change their component of the ecosystem. The changes are quantified to the extent possible at the Specialist EWR meeting (Sub-task 5.9). Obviously, the greater the investment in river studies to achieve predictive capacity, the higher the confidence in the predictions.

Reserve Consultants

- Brown, Pemberton, Birkhead, Boucher, Dollar, Paxton, Harding, Howard, Ractliffe, Bok and King.

Actions

- Coordinate the specialist meetings.
- Design a programme for the specialist meetings.
- Undertake all the logistical arrangements for the specialist meetings.
- Facilitate the specialist meetings.
- Participate in the specialist meetings.

Deliverables and timing

- One specialist meeting (end of 2004).

In formation required

Information contained in the starter document for the specialist meeting.
Information generated during the EC specialist meeting.

Responsibility of RC

The RC is responsible for

- coordinating and facilitating the specialist meetings;
- undertaking the logistical arrangements for the RC team;
- supplying flow scenarios for various river states as specified at the specialist meeting.

The RC budget does not include

- providing more than four (4) flow scenarios per site, however, using DRIFT additional scenarios can be provided on request.

SUBTASK 5.10: REPORT COLLATION AND EDITING

Objective

To document the approach followed at the specialist meeting, summarise the specialist appendices and provide the results generated at the specialist meetings.

Method

Reporting procedures as provided in Subtask 4.7 will be followed. Summaries of information such as water quality that is documented in separate reports will not be repeated as specialist appendices to this report.

Reserve Consultant

Brown and Pemberton

Deliverables and timing

Riverine RDM Report, incorporating:

- o Specialist's 'Starter' Documentation;
- o Raw hydrological data (in electronic format);
- o Scenario-creation database (in electronic format).

March 2005.

Responsibility of RC

The RC is responsible for:

- coordinating and editing specialist's inputs to the Riverine RDM Report;
- compiling the reports;
- printing and distributing the reports;
- coordinating the completion of corrections.

4.6 TASK 6: WATER QUALITY QUANTIFICATION

SUBTASK 6.1: QUANTIFICATION OF QUALITY RESERVE LINKED TO DIFFERENT ECS

Objective

Use the ECs as decided during Subtask 5.3.

Method

Set the quality reserve per water quality variable and water quality unit, using the RDM methodology (DWAF, 1999) and toxicity tables generated during Subtask 5.4.

Reserve Consultant

- Harding, Morrison and replacement for February.

Actions

- A desk-top study using information already generated and RDM documents (DWAF 1999).

Deliverables and Timing

- Water quality reserve determinations for the water quality reaches:

December 2004.

In formation required

- PES information produced during Sub-task 5.2.
- ECs produced per water quality reach during Sub-task 5.3.
- Toxicity tables generated for salinity during Sub-task 5.4.

Responsibility of RC

The RC is responsible for

- producing a reserve assessment for water quality for each defined water quality reach in the Olifants/Doring catchment.

SUBTASK 6.2 REPORT COLLATION AND EDITING

Objective

The information available from Sub-tasks 4.6, 5.2, 5.3, 5.4 and 6.1 will be collated to produce a water quality report on PES, trajectories of change in terms of water quality, ERC and quantifying the quality reserve per water quality unit. A report will be produced that incorporates all the previous information generated for water quality from the abovementioned Sub-tasks.

Method

Reporting procedures as provided in Task 4.7 will be followed.

Reserve Consultant

Harding and Morrison

Deliverables and Timing

- Water Quality (River) Reserve Report.

December 2004.

Responsibility of RC

- Writing the Water Quality (River) Reserve Report;
- As per Sub-Task 4.7.

4.7 TASK 7: ESTUARY ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE ESTUARY STATES

SUBTASK 7.1: DATA COLLECTION

Objective

The estuarine field data collection programme is required to collect the data that are necessary to conduct a preliminary ecological Reserve determination on a Comprehensive level as described in the methods for estuaries. Field data collections will be undertaken in the first quarter and last quarter of 2004.

Method

As prescribed by *DWAF (1999): Resource Directed Measures for Protection of Water Resources; Volume 5: Estuarine Component (Version 1.0)* and subsequent revisions of such documentation currently in preparation (B Weston, DWAF, pers. comm.).

The field surveys will cover hydrodynamics, sediment dynamics, water chemistry (water quality), microalgae, macrophytes, invertebrates, fish and birds. The proposed field data collection programme has been designed based on the data requirements specified in the methods for the determination of a preliminary Ecological Reserve for estuaries on a comprehensive level. Due to budgetary constraints, the complete estuarine field data set, as recommended for a comprehensive ecological reserve determination, cannot be collected as part of this project. It, therefore, should be noted that the confidence might be lower than required for a comprehensive determination for some of the components. This will however only be determined once data collection has taken place.

Responsible consultants

Van Niekerk, Huizinga, Taljaard, Basson, Theron, Bate, Adams, Wooldridge, Lamberth and Turpie.

Actions

1 Collect all previous relevant information.
2 Undertake required field-sampling programmes. A summary of the field studies to be undertaken is provided below:

Sediment dynamics: One detailed field survey will be conducted to do a grading analysis of bed sediment samples. A hydrodynamic model with sediment transport modules will be used to analyze the long-term equilibrium of the estuary under natural, present (with dam development) and possible future runoff and catchment development conditions (February 2004).

The hydrodynamic model will be calibrated on the recorded water level, river flow and tidal data. Sediment input from the river could be based on a suspended sediment rating curve if data are available, or the sediment transport capacity of the river could be calibrated against the catchment sediment yield to obtain a time series of sediment load. A hydrodynamic model with sediment transport modules will be used to analyse the long-term equilibrium of the estuary under natural, present (with dam development) and possible future runoff and catchment development conditions.

Hydrodynamics. For proper calibration and verification of the numerical model, longitudinal salinity profiles will be collected on two occasions, representative of summer and winter flow conditions (February/March 2004 and July/August 2004). Profiles will be collected on high tide and low tides.

Water quality. During the summer (February/March 2004) and winter (July/August 2004) water quality data will be collected along the estuary (high tide) for:

- System variables (salinity, temperature, turbidity, SS, DO and pH)
- Dissolved nutrients distribution (nitrite, nitrate, ammonia, phosphate and silicate)

Field data on toxic substances (e.g. trace metals) in sediments will not be included as part of this study as the estuary is not located in close proximity of industrial zones. It is also assumed that the water quality of river inflow will be provided by the river component. Seawater quality for the area will be derived from available literature.

Microalgae. One detailed field survey will be conducted in summer (low flow period) on phytoplankton and microbenthic algae. As the microalgae need water quality input, this survey will be conducted simultaneously with the summer water quality survey (February/March 2004). A limited winter survey will be included to coincide with the winter water quality survey (February/March 2004).

Macrophytes. One detailed survey to be conducted in summer where the macrophyte plant communities in the estuary will be identified and mapped. Three permanent transects in the lower, middle and upper region needs to be repeated (February/March 2004).

I*nvertebrates*. Two field surveys, one in summer and one in winter, will be conducted. Grain size and organic content in sediments will be included as part of the invertebrate component (February/March 2004 and July/August 2004).

Fish. Two field trips will be conducted one in autumn or spring and summer. Fish will be sampled with seine and gill-nets from the mouth to Lutzville ± 36 km upstream. The field data will be augmented by that found in the published and unpublished literature (February/March 2004 and July/August 2004).

Birds. In view of the bi-annual Coordinated Water Bird Counts (CWAC), data available from the Avian Demography Unit at UCT, two 2-day field surveys, one in spring and one in autumn, will be required to collect essential information (February/March 2004 and July/August 2004).

3 Analyse and interpret data (September - November 2004)

4 Document results in Specialist Reports - Specialist Reports will be prepared for each of the components listed above. This report will include an assessment of field data in relation to changes in river runoff (December 2004).

Information Required

- All previous relevant information on the Olifants Estuary.
- A range of simulated runoff scenarios (e.g. derived from the Ecological Reserves allocated to different EC's on the lowest EWR site) provided to the estuarine consultant by DWAF or hydrological consultant. These scenarios need to include the Reference Condition, the Present State and a range across the Mean Annual Runoff (MAR) spectrum. ***The***

budget allows for a <u>maximum</u> of 4 runoff scenarios in addition to the Reference Condition and Present State scenarios.

- River inflow data collected at the low water bridge at Lutzville, as well as all available water level recorder data collected at the estuary mouth to be provided by DWAF.
- Water quality river inflow (i.e., as represented by the lowest recorded site on the Olifants River) for the Reference Condition and Present State to be supplied by the water quality specialist on the river component.

Responsibility of RC

Undertake field studies as specified.
Analyze and interpret data.
Prepare Specialist Report.

Deliverables and timing

Completed field studies (February/March 2004 and July/August 2004).

Specialist Reports (December 2004).

SUBTASK 7.2: ESTUARY CLASSIFICATION AND SCENARIO EVALUATION SPECIALIST MEETING AND MONITORING PROGRAMME DESIGN

Objective

To determine the following Resource Directed Measures for the Olifants Estuary that will feed into the larger RDM process:

- Present Status Category
- Ecological Importance
- Ecological Categories associated with a series of run-off scenarios
- Recommended Ecological Category
- Recommended Ecological Flow Requirement Scenario
- Ecological Specifications (ES) for the recommended Ecological Category
- Monitoring Programme to refine confidence of Ecological Reserve and to test for compliance to ES after implementation of the Reserve (auditing).

Method

A 4-day workshop, convened after completion of the fieldwork and specialist reports to determine the above-mentioned resource directed measures for the Olifants Estuary, based on the methods for the determination of the preliminary Ecological Reserve for estuaries.

Responsible consultants

Coordination of workshop:	Ms S Taljaard (CSIR)
RDM report on Estuarine Component:	Ms S Taljaard (CSIR)
Hydrodynamics:	Ms L van Niekerk (CSIR) and Mr P

	Huizinga (Private)
Water quality:	Ms S Taljaard (CSIR)
Sediment dynamics:	Prof G Basson (US) and Mr A Theron (CSIR)
Microalgae:	Prof G Bate
Macrophytes:	Dr J Adams
Invertebrates:	Prof T Wooldridge
Fish:	Mr S Lamberth (Private)
Birds:	Dr J Turpie (Southern Waters).

Actions

Complete RDM templates for abiotic and biotic components, staggering the completion in the following order: Abiotic components, microalgae and macrophytes, invertebrates, fish and birds. Final templates (i.e. fish) to be completed one week before specialist workshop (March – April 2005)

Conduct specialist workshop (May 2005). The methods to be used to meet objectives are summarised below:

The method for estuaries uses simulated runoff scenarios, where scenarios are typically simulated over a 50-70 year period and are presented as average monthly flows that represent inflows at the head of the estuary. For the definition of the recommended Ecological Category simulated runoff scenarios for the *present state* and the *reference condition* are used.

<u>Present Ecological Status</u>

Firstly, the Present State of an estuary is defined as a quantitative description of the present abiotic (hydrodynamics, sediment dynamics and water quality) and biotic (microalgae, macrophytes, invertebrates, fish and birds) characteristics and functioning of the system.

Thereafter the Reference Condition for the estuary is defined. For the purposes of the preliminary determination of the Ecological Reserve, the reference condition of an estuary refers to the ecological status that it would have had:

- when receiving 100% of the natural MAR
- before any human development in the catchment or within the estuary
- before any mouth manipulation practices (e.g. artificial breaching).

Typically, the reference conditions in an estuary refer to its ecological status 80 to 100 years ago.

The present state and reference condition of an estuary are then used to determine the Present Ecological Status (PES). The PES is a measure of the health of a resource, based on a comparison between the reference condition and the present state. An Estuarine Health Index (EHI) is used to determine the PES for estuaries.

Estuarine Importance

Also included in this step is an assessment of the Estuarine Importance (ecological) of an estuary. Estuarine importance is an expression of the importance of an estuary to the maintenance of ecological diversity and functioning on local and wider scales. Variables were discussed in a workshop setting, regarding their suitability for inclusion in an Estuarine Importance Index. The importance scores have been derived for most South African estuaries as part of a project entitled: *Classification and prioritisation of South African estuaries on the basis of health and conservation status for determination of the estuarine water reserve* (Turpie *et al*. 2002). The only importance score that needs to be derived by the estuarine ecological reserve team (at the specialist workshop) is the functionality score (e.g. link with freshwater and marine environment).

Recommended Ecological Category

The Present Ecological Status and estuarine importance score are used to come to a recommended Ecological Category for an estuary, according to pre-defined guidelines as stipulated in the methods.

Ecological Categories for Range on Simulated Runoff Scenarios

To determine the Ecological Category of the estuary associated with each of the flow scenarios, the runoff simulations together with an understanding of the present state are used to determine changes in abiotic states within an estuary for each of the scenarios. Changes in abiotic characteristics are then assessed in terms of the biological implications, using the same estuarine health index that was used to derive the Present Ecological Status.

Recommended Ecological Water Requirement Scenario

Results from these above evaluations are then used to select the 'recommended Ecological Water Requirement scenario', defined as the run-off scenario, or a slight modification thereof, that represents the highest reduction in river inflow that will still protect the aquatic ecosystem of the estuary and keep it in the recommended Ecological Category.

Ecological Specifications for the recommended Ecological Category

Ecological Specifications are clear and measurable specifications of ecological attributes that define a specific ecological reserve category. Although procedures for setting Ecological Specifications for estuaries have not been formulated, it is envisaged that the concept of 'Thresholds of Potential Concern' will be used. Thresholds of potential concern are defined as measurable end points related to specific abiotic or biotic indicators that if reached (or when modeling predicts that such points will be reached) prompts management action. In essence, thresholds of potential concern endpoints should be defined such that they provide early warning signals of potential non-compliance to Ecological Specifications (i.e. not the point of 'no return'). This concept implies that the indicators (or monitoring activities) selected as part of long-term monitoring programme need to include biotic and abiotic components that are particularly sensitive to ecological changes associated with changes in river inflow. Ecological Specification needs to be determined for:

- Water quantity (in this instance the recommended Ecological Flow requirement scenario)
- Water quality
- Habitat (i.e. abiotic characteristics within the estuary)
- Biota.

Resource Monitoring Programme

The purpose of the resource monitoring programmes is to assess (or audit) whether the Ecological Specifications are being complied with after implementation of the Reserve. In addition, these programmes can also be used to improve the confidence and refine the Ecological Reserve measures (including the Ecological Specifications), in the longer-term through an iterative process.

A report on resource monitoring procedures for application in the Ecological Reserve determination and implementation process in estuaries (including refinements to baseline data requirements) have been completed as part of a Water Research Commission project, but still needs to be reviewed by the wider estuarine community before inclusion into the official methods (Taljaard *et al.*, in press). This report will be used as reference framework for the design of a resource-monitoring programme for the Olifants Estuary as part of this project.

Information Required

Data and information contained in Specialist Reports and templates.

Responsibility of Estuarine Consultant

- Coordinate template preparation process
- Coordinate specialist workshop (including logistics)
- Facilitate specialist workshop
- Conduct workshop
- Prepare RDM report on Estuarine component.

The RC will be responsible for providing the ecological consequences for the estuary for a maximum of 4 runoff scenarios in addition to the Reference Condition and Present State scenarios. These will all be evaluated at the specialist workshop in May 2005. Thus it is imperative that the scenarios to be evaluated have been decided on and prepared for presentation at the workshop. No additional estuarine scenario workshops have been budgeted for.

Deliverable

Estuarine RDM Report (Task 7.3).

SUBTASK 7.3: REPORT COLLATION AND EDITING

Objective

- To document the complete process undertaken in Sub-tasks 7.1 and 7.2 in a RDM report on Estuarine Component with the individual specialists reports as appendices.

Method

A contents page will be provided to the Management PSP prior to compiling the report. The report format will be that agreed between the Client and the Consultant. Draft reports will be provided to the client in .pdf format (Acrobat) for comments. Reports will be finalised after one round of comments have been received and one unbound hard copy will be provided to the client as well as a CD with the report in the original software as well as converted to .pdf format. Only comments of a technical nature (as opposed to reporting style comments) will be incorporated. The RC will check all reports for consistency and the correct use of the English language.

Responsible Consultant

Taljaard and van Niekerk.

Deliverables and Timing

Estuarine RDM Report

July 2005.

Responsibility of RC

The RC is responsible for:

- compiling the report in the required format;
- providing draft copies for comments;
- incorporating one round of comments;
- providing one unbound hardcopies and 1 .doc and 1 .pdf copy of the final report.

The RC budget does not include:

- more than one round of comments to be incorporated;
- the additional costs that will be required if comments are not received within one month or an agreed on date from the draft report being received by the client.

4.8 EWRS: SCENARIOS AND OPERATIONAL ASPECTS

SUBTASK 8.1: SCENARIO GENERATION

Objective

- To simulate the effects of different development scenarios on flows entering the estuary to provide realistic scenarios for consideration by the estuarine team, and to ensure that at least one of the scenarios assessed by the estuarine team should be an output from the sites likely to drive the river Reserves

Method

The system analysis component of the study will utilize the existing Water Resources Yield Model (WRYM) configuration (Olifants/Doring River Basin Study, DWAF 1998), which may have to be updated in order to accommodate proposed water resource development scenarios.

In line with the current methodology for determining environmental flow requirements at estuaries, the WRYM will be used to simulate the effects of different development scenarios on flows entering the estuary to provide realistic scenarios for consideration by the estuarine team.

In order to link the estuarine and river Reserve determinations some preliminary system analysis will be required. This is in line with recent recommendations that at least one of the scenarios assessed by the estuarine team should be an output from the sites likely to drive the river Reserves. This will facilitate integration of the Reserves for different ecosystem components.

The effects of the selected operating rules and development scenarios on water quality will not be determined as part of this study. Nor will the effect on historical firm yield be determined.

Responsible Consultant

Sparks.

Deliverables and Timing

- present day and naturalized flow sequences for the estuary;
- realistic flow scenarios for consideration by the estuarine team;
- at least one scenario representing the output from the sites likely to drive the river Reserve;
- system analysis chapter for the Scenario Report.

March 2005.

Responsibility of RC

The RC is responsible for:

- provide present day and naturalized flow sequences for the estuary;
- provide realistic flow scenarios for consideration by the estuarine team;
- include at least one scenario representing the output from the sites likely to drive the river Reserve.
- write-up the system analysis chapter for the Scenario Report.

The RC budget does not include:

- determination of the effects of the selected operating rules and development scenarios on water quality;
- determination of the effects of reserve scenarios on historical firm yield of the system.

SUBTASK 8.2: ECOLOGICAL CONSEQUENCES OF SCENARIOS

The ecological consequences of any development scenarios other than those determined at the EWR workshop will be evaluated using the scenario-creation database, and distributed to the specialist's for comment.

NOTE: Ecological consequences of the scenarios for the estuary will be assessed in Subtask 7.2. No additional estuarine scenario workshops have been budgeted for. Thus it is imperative that the scenarios to be evaluated have been decided on and prepared for presentation at the estuarine specialists workshop (see Task 7.2).

SUBTASK 8.3: REPORT COLLATION AND EDITING

Objective

- To document the approach followed for scenario generation, summarise, and provide any additional ecological consequences required for the river and a summary of results generated at the estuarine specialist meetings.

Method

Reporting procedures as provided in Subtask 4.7 will be followed. Summaries of information, such as water quality, that are documented in separate reports will not be repeated as specialist appendices to this report.

Reserve Consultants

Sparks, Brown and Pemberton.

Deliverables and timing

Scenario Report, incorporating:

- o Preliminary Systems analysis;
- o Hydrological data (in electronic format);
- o Ecological consequences for additional scenarios, where required;
- o Summary of ecological consequences for the estuary of the scenarios assessed at the estuarine workshop (see Sub-tasks 7.2 and 8.1).

November 2005.

Responsibility of RC

The RC is responsible for:

- coordinating and editing specialist's inputs to the Scenario Report;
- compiling the report;
- printing and distributing the report;

- coordinating the completion of corrections.

4.9 TASK 9: ECOSPECS AND MONITORING PROTOCOLS

SUBTASK 9.1: RDM FORMAT RESERVE DOCUMENTATION

Objective

- To compile the standard DWAF briefing document for the riverine, estuarine and water quality reserves.

Method

Reporting procedures as provided in Subtask 4.7 will be followed.

Reserve Consultants

Harding, van Niekerk and Pemberton.

Deliverables and timing

- RDM Format Reserve documentation.

September 2005.

Responsibility of RC

- See Sub-task 4.7.

SUBTASK 9.2: CONVERT RECOMMENDED EC OBJECTIVES, FLOW AND QUALITY RESULTS INTO ECOSPECS

Objective

To define Ecospecs for **quality, biota and habitat** linked to the flow regime for the **recommended** EC to enable measurable guidelines to be provided to measure compliance through monitoring.

Method

During the EWR specialist meeting, the specialists compile detailed a 'Generic list' plus a set of consequences of flow change for items on their generic list. These descriptions and attendant data will be used as a starting point for setting of the Ecospecs. Ecospecs will be set based on available information, and in most cases will only be defined qualitatively.

Reserve Consultants

Taljaard, van Niekerk, Brown, Pemberton, Harding, Boucher, Dollar, Paxton, Ractliffe, Howard, Ractliffe and Bok.

Deliverables and timing

- See Sub-task 9.4.

Responsibility of RC

The RC is responsible for:

- Translating the objectives and consequences for the recommended EC into Ecospecs.
- Checking the resultant Ecospecs with the relevant specialists.
- Producing the report (see Sub-task 4.7).

The RC is not responsible for:

- Producing Ecospecs for all other scenarios.

SUBTASK 9.3: DESIGN A MONITORING PROTOCOL TO MEASURE COMPLIANCE TO THE RQOS

Objective

- To design a Monitoring Protocol to measure compliance of the Ecospecs.

Method

The RCs will liase with the relevant specialists to design a Monitoring Protocol to measure compliance of the Ecospecs.

Reserve Consultants

Harding, Taljaard, van Niekerk, Brown and Pemberton. Plus relevant specialists.

Deliverables and timing

- See Sub-task 9.4.

Responsibility of RC

The RC is responsible for:

- Designing the Monitoring Protocol in liaison with the relevant specialists.
- Producing the Appendix (see Sub-task 4.7).

The RC is not responsible for:

- Designing Monitoring Protocols for all other scenarios.
- Costing the implementation of the Monitoring Protocol.
- Implementing the Monitoring Protocol.

SUBTASK 9.4: REPORT COLLATION AND EDITING

Objective

- To produce two appendices for the Main Report, reporting on Sub-tasks 9.2 and 9.3.

Method

Reporting procedures as provided in Subtask 4.7 will be followed.

Reserve Consultants

Harding, Taljaard, van Niekerk, Brown and Pemberton. Plus relevant specialists.

Deliverables and timing

- See Sub-task 9.2.

September 2005.

Responsibility of RC

- See Sub-task 9.2.

4.10 TASK 10: MAIN SUMMARY REPORT

Objective

- To write a summary report, comprised of summary chapters and/or appendices for each deliverable of the study.

Method

Reporting procedures as provided in Subtask 4.7 will be followed.

Reserve Consultants

Brown and Pemberton.

Deliverables and timing

- Main Summary Report

December 2005.

Responsibility of RC

- See Sub-task 4.7.

5 STUDY TEAM

5.1 STUDY TEAM CHANGES SINCE PROPOSAL

There have been some changes to the proposed consultant team:

- Ms Ewart-Smith is no longer available and so her duties will be taken over by Ms Geordie Ractliffe (*curriculum vitae* in Appendix E).
- Mr Rodney February has resigned from Southern Waters to follow his interests in development. He will thus not be available as the Deputy Task Leader for Water Quality. Dr Harding will seek a replacement, and report back to the team once he had appointed somebody.
- The field assistant for the riverine vegetation study has been identified. He is Mr J. Kereko, a PhD student at the University of Stellenbosch.
- The field assistants for the riverine fish study have been identified. They are: Mr Londloza Nzima and Mr Bjorn Fortuin.
- Dr M. Sowman has been left out of the team following negotiations, and an agreement not to include socio-economic considerations.
- People have been identified to fill three of the four previously unallocated positions for field assistants in the estuarine study. They are M. Vosloo, M. Thwala and S. Deysel.

5.2 MEMBERS OF THE STUDY TEAM

The members of the team and their positions on the team are provided in Table 5.1.

Table 5.1 Members of the team and their positions on the team.

Person	**Organisation**	**Reserve Component**	**Position on Team**
RIVER - QUANTITY			
C. Brown	Southern Waters	River Quantity	Project Leader and River TL
C. Pemberton	Southern Waters	River Quantity	Deputy PL and Deputy RTL
A. Birkhead	Streamflow Solutions	River Quantity	Hydraulics engineer
Surveyor	Not yet sourced	River Quantity	Technician
G. Howard	Ninham Shand	River Quantity	Hydrologist
W. Kamish	Ninham Shand	River Quantity	Hydrologist
E. Dollar	CSIR	River Quantity	Geomorphologist
A. Rooseboom	Univ. of Stellenbosch	River Quantity	Sedimentologist
C. Boucher	Univ. of Stellenbosch	River Quantity	Botanist
J. Kereko	Univ. of Stellenbosch	River Quantity	Filed Assistant: Botany data collection
G. Ractliffe	Freshwater CG	River Quantity	Invertebrates
B. Paxton	Univ. of Cape Town	River Quantity	Fish specialist
A. Bok	A. Bok and Assoc.	River Quantity	Supervisor: Fish specialist
L. Nzima	Living Landscapes Project	River Quantity	Field Assistants - Fish data collection
B. Fortuin	Living Landscapes Project	River Quantity	Field Assistants - Fish data collection
J. King	Southern Waters	River Quantity	Supervisor: Quality control
A. Sparks	Ninham Shand	River Quantity	System Analyst
A. Joubert	Univ. of Cape Town	River Quantity	Data base set-up
RIVER - QUALITY			
W. Harding	Southern Waters	River Quality	WQ and Wetland Task Leader
I. Morrison	Private	River Quality	WQ modelling

Person	Organisation	Reserve Component	Position on Team
R. February[4]	Southern Waters	River Quality	Deputy WQ and Wetland TL
ESTUARY			
S. Taljaard	CSIR	Estuary	Estuarine Task Leader (ETL)
L. van Niekerk	CSIR	Estuary	Deputy ETL
P. Huizinga	CSIR	Estuary	Supervisor: Quality control
G. Basson	Univ. of Stellenbosch	Estuary	Sedimentologist
J. Beck	Univ. of Stellenbosch	Estuary	Junior Sedimentologist
G. Bate	UPE	Estuary	Est. Microalgal specialist
J. Adams	UPE	Estuary	Est. Macrophyte specialist
T. Wooldridge	UPE	Estuary	Estuarine invert. ecologist
S. Lamberth	Private	Estuary	Estuarine fish ecologist
K. Hutchings	Univ. of Cape Town	Estuary	Junior Fish ecologist
J. Turpie	Southern Waters	Estuary	Ornithologist/Resource eco.
A. Theron	CSIR	Estuary	Field and laboratory assistants
A. Adonis	CSIR	Estuary	Field and laboratory assistants
P. Smailes	UPE	Estuary	Research assistants
T. Bornman	UPE	Estuary	Research assistants
A. Rajkaran	UPE	Estuary	Research assistants
M. Thwala	UPE	Estuary	Research assistants
S. Deysel	UPE	Estuary	Research assistants
M. Vosloo	UPE	Estuary	Research assistants
Student 3[5]	UPE	Estuary	Research assistants
N. Popose	Univ. of Cape Town	Estuary	Research assistants
GROUNDWATER			
J. Conrad	Geoss	Groundwater	Groundwater Task Leader
SPATIAL DATA			
G. Harding	Electric Egg	All	Website and database admin.
Z. Munch	Geoss	GIS	GIS Task Leader
J. Conrad	Geoss	GIS	GIS
R. Robyntjies	Geoss	GIS	GIS
LOGISTICS AND FINANCIAL CONTROL			
R. Townsend	Southern Waters	River Quantity	Logistics and financial control

[4] Replacement being sought – see note in Section 5.1.
[5] Will be chosen from UPE 2004 intake.

6 CAPACITY BUILDING PROGRAMME

6.1 APPROACH

Capacity building forms an integral part of the project, and opportunities for building capacity have been incorporated at all levels of seniority. These are outlined below.

6.2 CAPACITY BUILDING APPOINTMENTS

QUANTITY DETERMINATIONS - RIVER

River Team Leader: Mr Charles Pemberton will work in close liaison with Dr Brown, and in so doing will gain experience in Overall Project Coordination and River Quantity Reserve Determinations. Southern Waters has used this process successfully in the past to train two River Quantity Reserve Determination facilitators, who now operate independently of the company. Ms Liz Frazer will also be assisting with packing and catering for the field trips.

Botanical laboratory and field assistant: Mr J. Kereko, a PhD student at the University of Stellenbosch, will assist Dr Charlie Boucher with the riverine botanical surveys and data analysis.

Fish specialist: Mr Bruce Paxton will be teamed with Dr Anton Bok. Mr Paxton has gained experience in fish studies over the last two years through running Southern Waters' fish surveys for DWAF and DAD, and is currently reading for his MSc on the fish of the Olifants and Doring Rivers, at UCT. He has however not acted as a fish specialists in an EWR determination before and, in recognition of the importance of fish in the system, Dr Bok will assist Mr Paxton, through advice and assistance in data gathering; review of the fish starter document, and assistance in the data interpretation at the EWR workshop.

Fish field assistants: Mr Londloza Nzima and Mr Bjorn Fortuin will assist Mr Paxton and Dr Bok with their field data collection. Both are from the Clanwilliam District by the Living Landscapes Project team in Clanwilliam. Mr Nzima and Mr Fortuin are also involved in an ongoing joint UCT-Southern Waters project on the indigenous fish of the Olifants/Doring River.

QUALITY DETERMINATIONS - RIVER

Water Quality assistant: Mr Rodney February will not be available but Dr Harding will appoint somebody else to work in close association liaison with him and in doing so gain some experience in accessing and collating water quality data for Reserve determinations. Dr Harding's intention is to seek a HDI appointee.

QUANTITY AND QUALITY DETERMINATIONS - ESTUARY

The main focus of the capacity building component will be on the development of estuarine fieldwork skills such as:

- site selection,
- scientific sampling techniques,
- boating skills, and
- species identification in the field.
- observational skills needed identified the relationship between river inflows and abundance/species composition.

The fact that some of the specialists would be replaced by field assistance/students on some of the site visits would also empower the students in terms of developing their abilities and learning to trust their own skills.

After completion of the field excises students/assistants would also be involved in the data analysis and will be encouraged to develop their report writing skills.

The following students have been identified:

- S. Deysel
- M. Vosloo
- M. Thwala[6]

The other student assistant will be chosen from the 2004 Student Intake at the University of Port Elizabeth. Dr Adam's intention is to seek a HDI appointee.

The bird field assistant has also been identified, he is Mr Nqubane Popose.

The fish specialist involved in the RDM study is also involved in setting up a Local Catch Monitoring Programme (for Marine and Coastal Management, DEAT) on the Olifants Estuary. He intends to use the opportunity to employ local fisher from the Ebenaezer Community in the field data collecting exercise. It is envisage that 6-8 local HDI fishers would be involved in the sampling process.

Empowerment of HDI's

The skills developed during the fieldwork part of the work programme assist the HDI students to conduct future field research, as part of either their own studies or as part of RDM studies. Comprehensive training to conduct these types of investigations usually takes a number of years.

Local HDI community at Ebenaezer would be involved in the estuarine fish sampling and be taught about the estuarine system dynamics, e.g. how do fish recruitment work in an estuary? Members of the local community will be taught the importance of fish catch monitoring and what role they can play in resource management. This in turn would empower the local fisherman in terms of local decision-making and sustainable utilization of their primary food source.

It is envisaged that 6-8 local HDI fishers will be involved in the fish sampling process.

[6] Conditional on to her returning to University of Port Elizabeth next year (2004)

GIS

GIS assistant: Ms Robyntjies will receive ongoing, on the job training in GIS data capture and processing from Ms Munch and Mr Conrad.

6.3 INVOLVEMENT OF HISTORICALLY DISADVANTAGED INDIVIDUALS

Our team includes 23 historically disadvantaged professionals (out of 42 team members) at all levels of seniority (Table 6.1), and 10 out of 14 field assistants (excluding fishers from Ebenaezer) are HDI.

Table 6.1 Historically disadvantaged individuals on the team.

Name	Position on team	Designation
Dr J. Adams	Macrophyte Specialist	White female
Mr A. Adonis	Technical Assistant	Coloured male
Ms Julia Beck	Trainee sedimentologist	White female
Dr C. Brown	Team Leader and River Task Leader	White female
Mr R. February[7]	Deputy WQ and Wetland Task Leader	Coloured male
Mr B. Fortuin	Fish data collection assistant	Coloured male
Ms E. Frazer	Field and laboratory assistant	Coloured female
Mr W. Kamish	Hydrologist	Coloured male
Mr J. Kereko	Trainee vegetation specialist	Black male
Dr J. King	Quality control	White female
Ms A. Joubert	Database	White female
Mr L. Nzima	Fish data collection assistant	Black male
Ms Z. Munch	GIS Data capture and analysis	White female
Mr N. Popose	Estuarine bird field assistant	Black male
Ms G. Ractliffe	Macroinvertebrate specialist	White female
Ms A. Rajkaran	Trainee macrophyte specialist	Coloured female
Ms R. Robyntjies	GIS Data capture and analysis	Coloured female
Ms S. Taljaard	Estuarine Task Leader	White female
Ms P. Smailes	Trainee microalgal specialist	White female
Ms R. Townsend	Logistics and financial control	White female
Dr J. Turpie	Estuarine ornithologist and resource economist	White female
Ms M. Thwala	Specialist Laboratory Assistant	Black female
Ms L. van Niekerk	Deputy Estuarine Task Leader and hydrodynamics.	White female

[7] Replacement being sought – see note in Section 5.1.

7 DATA STORAGE AND PRESENTATION

7.1 DATA STORAGE

Ensuring that the data collected and analyses generated during the study are properly collated, audited and stored is a central focus of this proposal. The Deputy Task Leaders have all been allocated time for data management, including:

- the creation of project specific GIS data base
- raw data storage
- a scenario-creation database for the river.

The GIS support team will provide assistance to all team members with capturing, analysing and producing GIS data.

7.2 GIS

All information that can be portrayed effectively and efficiently on GIS will be done so. The data will be prepared in accordance with DWAF's latest specifications for electronic spatial data.

Drawings will be produced according to Client specifications.

8 DELIVERABLES AND LINEAR RESPONSIBILITIES

8.1 MILESTONE LIST

Milestone		**Due Date**
Project Report 1:	Inception Report	October 2003
Project Report 2:	Delineation Report	March 2004
Project Report 3:	Groundwater TOR	19th December 2003
Project Report 4:	Riverine RDM Report, incorporating: Specialist's 'Starter' Documentation.	March 2005
Project Report 5:	Estuarine RDM Report, incorporating: Reference conditions and Present Ecological Status Assessments and Specialist's 'Starter' Documentation.	July 2005
Project Report 6:	Scenario Report	May 2005
Project Report 7:	Monitoring Appendix	October 2005
Project Report 8:	Main Summary Report.	December 2005
Scenario-creation database for the rivers (in electronic format).		December 2005
In addition to the milestones, eight progress reports will be produced		
Progress Report 1		January 2003
Progress Report 2		April 2004
Progress Report 3		July 2004
Progress Report 4		October 2004
Progress Report 5		January 2005
Progress Report 6		April 2005
Progress Report 7		July 2005
Progress Report 8		October 2005

8.2 LINEAR RESPONSIBILITY AND STAFFING

Project administration will occur at three levels, as detailed below:

L1. OVERALL PROJECT LEADERSHIP, INCLUDING ADMINISTRATIVE, OVERALL TECHNICAL AND FINANCIAL CONTROL

Dr Cate Brown is the Project Leader and will take responsibility for overall project leadership. She will be assisted by:

Administrative and Technical: Mr C. Pemberton
Financial: Ms R. Townsend.

L2. Task Leadership

Task leaders will each take responsibility for administrative and technical control for each of the following study components:

River:	Dr C. Brown/Mr C. Pemberton.
Estuary:	Ms S. Taljaard/Ms L. van Niekerk.
Water Quality	Dr W. Harding.
Groundwater	Mr J. Conrad.
GIS	Ms Z. Munch.

L3. Specialist Activities

Individual specialist will take responsibility for execution of their tasks according to the TOR issued to them by the Task Leaders. The specialists involved in each of the study components are listed in Table 5.1.

The linear responsibility organogram is provided in Figure 8.1.

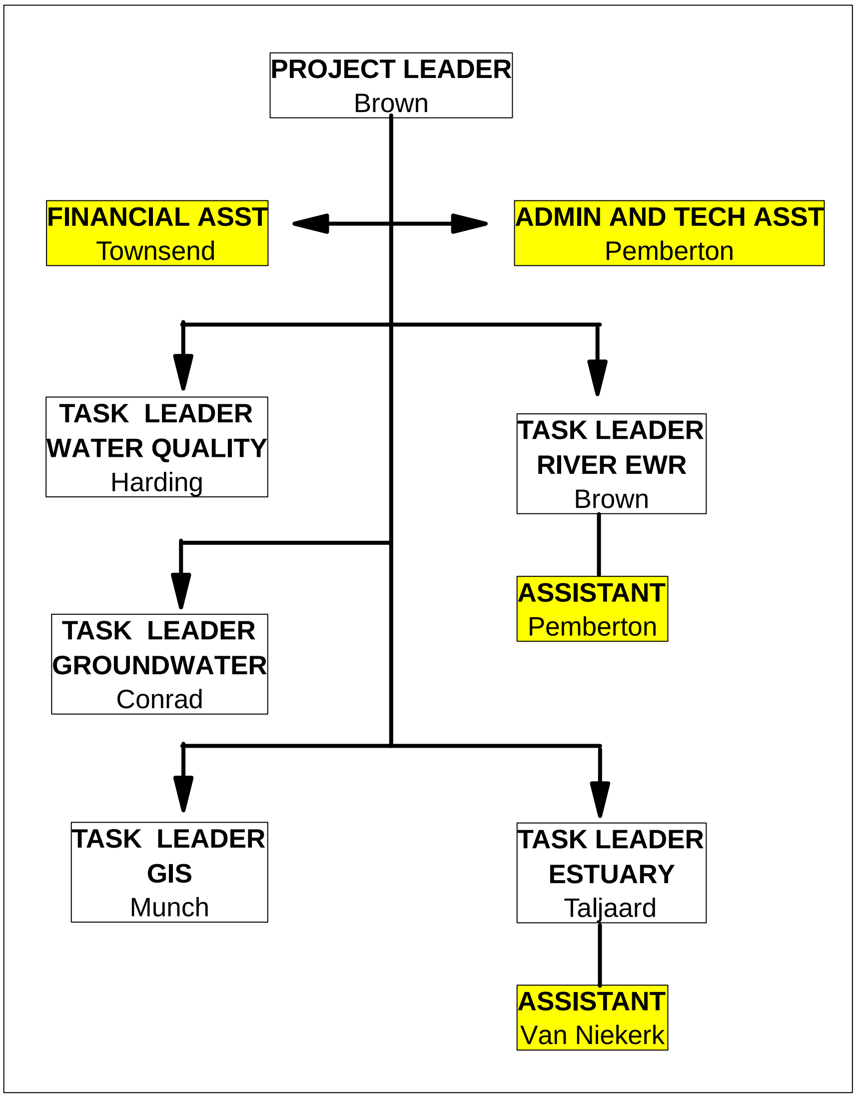

Figure 8.1 Linear responsibility organogram.

9 PROJECT SCHEDULING

9.1 SUB-TASKS ON THE CRITICAL PATH

The sub-tasks on the critical path for this project are shown in chronological order below. Delay in one or more of the deliverables from these sub-tasks will result in an overall delay in the project.

Sub-task 2.2: Project plan and inception report
Sub-task 4.2: River: classification
Sub-task 5.1: EWR planning meeting
Sub-task 4.5: River: EWR site selection
Sub-task 4.6: River: Determine quality reaches
Sub-task 5.4: Cross-sectional survey and hydraulic calibration
Sub-task 5.5: Preparation of Hydrological Data
Sub-task 5.6: Specialist Data Collection (River Quantity Determinations), excluding Hydrology and Hydraulics
Sub-task 5.7: Specialist Data Collection (River Quality Determinations), excluding Hydrology and Hydraulics
Sub-task 5.8: Specialist Reports and appendices
Sub-task 5.9: Specialist EWR meeting
Sub-task 6.1: Quantification of quality Reserve linked to different ECs
Sub-task 7.1: Data collection
Sub-task 8.1: Scenario generation
Sub-task 8.2: Ecological consequences of scenarios
Sub-task 7.2: Estuary classification and scenario evaluation specialist meeting and Monitoring Programme.

Note 1: Sub-task 4.5: EWR site selection will take place immediately AFTER Sub-task 5.1: EWR Planning Meeting as this will reduce the number of air trips required to have the required personnel present at those two activities.

Note 2: Sub-task 8.1: Scenario generation should <u>precede</u> Sub-task 7.2: Estuary classification and scenario evaluation specialist meeting and Monitoring Programme.

The links between the sub-tasks and the critical path are indicated in the Gantt chart in Figure 9.1.

Figure 9.1 Gannt chart

TASK AND SUBTASKS	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
TASK 1: PROJECT MANAGEMENT																														
Subtask 1.1: Project administration (internal)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Subtask 1.2: Project administration (external)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Subtask 1.3: PMC Meetings				■			■			■			■			■			■			■			■			■		■
Subtask 1.4: Financial administration	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Subtask 1.4: GIS and Website	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TASK 2: STUDY IMPLEMENTATION AND DESIGN																														
Subtask 2.1: Literature review	■	■	■																											
Subtask 2.2: Project plan and inception report	▒	▒	▒	▒																										
Subtask 2.3: Team briefs					■																									
TASK 3: GROUNDWATER																														
Subtask 3.1: Preparation of Groundwater TORs				■	■	■																								
TASK 4: STUDY AREA, RUs AND EWR SITES																														
Subtask 4.1: Estuary: classification								■																						
Subtask 4.2: River: classification				▒	▒	▒																								
Subtask 4.3: River: Habitat integrity				■	■	■																								
Subtask 4.4: River: Map quantity reaches				■	■	■																								
Subtask 4.5: River: EWR site selection					▒	▒																								
Subtask 4.6: River: Determine quality reaches					▒	■	■																							
Subtask 4.7: Report collation and editing									■																					
TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE RIVER STATES																														
Subtask 5.1: EWR planning meeting					▒	▒																								
Subtask 5.2: Reference conditions, PES and EIS													■	■	■		■													

TASK AND SUBTASKS	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Subtask 5.3: EC for the River																														
Subtask 5.4: Cross-sectional survey and hydraulics																														
Subtask 5.5: Preparation of Hydrological Data																														
Subtask 5.6: Specialist Data Collection - quantity																														
Subtask 5.7: Specialist Data Collection - quality																														
Subtask 5.8: Specialist Reports and appendices																														
Subtask 5.9: Specialist EWR meeting																														
Subtask 5.10: Report collation and editing																														
TASK 6: WATER QUALITY QUANTIFICATION																														
Subtask 6.1: Reserve linked to different ECs																														
Subtask 6.2 Reporting																														
TASK 7: ESTUARY ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE ESTUARY STATES																														
Subtask 7.1: Data collection																														
Subtask 7.2: Estuary Reserve and Monitoring Programme																														
Subtask 7.3: Report collation and editing																														
TASK 8: EWRS: SCENARIOS AND OPERATIONAL ASPECTS																														
Subtask 8.1: Scenario generation																														
Subtask 8.2: Ecological consequences of scenarios																														
Subtask 8.3: Report collation and editing																														
TASK 9: ECOSPECS AND MONITORING PROTOCOLS																														
Subtask 9.1: RDM Format Reserve documentation																														
Subtask 9.2: Ecospecs																														
Subtask 9.3: Design a monitoring protocol																														
Subtask 9.4: Report collation and editing																														

TASK AND SUBTASKS	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
TASK 10: MAIN SUMMARY REPORT																														
Main summary report																														■
MILESTONES:																														
Project Report 1: Inception Report				■																										
Project Report 2: Delineation Report									■																					
Project Report 3: Groundwater TOR										■																				
Project Report 4: Riverine RDM Report																					■									
Project Report 5: Estuarine RDM Report																									■					
Project Report 6: Scenario Report																							■							
Project Report 7: Monitoring Appendix																												■		
Project Report 8: Main Summary Report.																														■
DRIFT database for the rivers (in electronic format).																														■
PROGRESS REPORTS																														
Progress Report 1							■																							
Progress Report 2										■																				
Progress Report 3													■																	
Progress Report 4																■														
Progress Report 5																			■											
Progress Report 6																						■								
Progress Report 7																									■					
Progress Report 8																												■		

Timing of activity	■	■	■	■	■

TASK AND SUBTASKS	2003						2004												2005											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Timing of activity on the critical path																														

10 RESOURCES AND BUDGET

Estimated personnel time per Task is highlighted in Table 10.1. All personnel approached have indicated that they are available for the times and tasks allocated to them, except where otherwise illustrated. The total time allocated to the project is estimated at *c.* 1050 working days, and the project has a duration of 30 months (July 2003 - December 2005).

There have been some adjustments to the preliminary cost estimates budget presented in the proposal and post-negotiations. These do not affect the overall price.

A full budget is provided below in the following formats:

- Estimated personnel time per Task (Table 10.1).
- Estimated disbursements per Task (Table 10.2).
- A summary with totals per Task (Table 10.3).
- Cash flow by quarter (Table 10.4 and Figure 10.1).

Table 10.1 Estimated personnel time and budget per Task.

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 1: MANAGEMENT							
SUB-TASKS 1.1 AND 1.2: PROJECT MANAGEMENT (INTERNAL AND EXTERNAL)							
1.1 & 1.2	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	100	R 410.00	*R 41,000.00*
1.1 & 1.2	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	320	R 175.00	R 56,000.00
1.1 & 1.2	W. Harding	Southern Waters	Partner	WQ Task Leader	16	R 410.00	R 6,560.00
1.1 & 1.2	J. Conrad	Geoss	Director	Groundwater Task Leader	4	R 300.00	R 1,200.00
1.1 & 1.2	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	80	R 385.00	*R 30,800.00*
1.1 & 1.2	L. van Niekerk	CSIR	Consultant	Deputy ETL	12	R 240.00	*R 2,880.00*
1.1 & 1.2	Sub-total for professional fees:						R 138,440.00
SUB-TASK 1.3: PMC MEETINGS							
1.3	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	32	R 410.00	*R 13,120.00*
1.3	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	32	R 175.00	R 5,600.00
1.3	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	16	R 385.00	R 6,160.00
1.3	Sub-total for professional fees:						R 24,880.00
SUB-TASK 1.4: FINANCIAL							
1.4	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	80	R 410.00	*R 32,800.00*
1.4	R. Townsend	Southern Waters	Administrator	Financial control and logistics	160	R 180.00	R 28,800.00
1.4	Sub-total for professional fees:						R 61,600.00
SUB-TASK 1.5: DATA MANAGEMENT, GIS AND WEBSITE							
1.5	J. Conrad	Geoss	Director	Groundwater Task Leader	70	R 300.00	*R 21,000.00*
1.5	Z. Munch	Geoss	Researcher	Groundwater and GIS	200	R 250.00	R 50,000.00
1.5	R. Robyntjies	Geoss	Researcher	Groundwater and GIS	210	R 100.00	R 21,000.00
1.5	W. Harding	Southern Waters	Partner	WQ Task Leader	12	R 410.00	R 4,920.00

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
1.5	A. Joubert	Univ. of Cape Town	Researcher	DRIFT data base set-up	8	R 275.00	R 2,200.00
1.5	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	40	R 175.00	R 7,000.00
1.5	L. van Niekerk	CSIR	Consultant	Deputy ETL	16	R 240.00	R 3,840.00
1.5	G. Harding	Electric Egg	Student	Website and database admin.	40	R 140.00	R 5,600.00
1.5	Sub-total for professional fees:						R 115,560.00
						SUB TOTAL FOR TASK 1 - PERSONNEL	**R 340,480.00**
			TASK 2: STUDY IMPLEMENTATION AND DESIGN				
SUB-TASKS 2.1: INITIAL LITERATURE REVIEW							
2.1	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	4	R 410.00	*R 1,640.00*
2.1	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	10	R 175.00	*R 1,750.00*
2.1	A. Rooseboom	Univ. of Stellenbosch	Consultant	Sedimentologist	4	R 480.00	*R 1,920.00*
2.1	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	4	R 345.00	*R 1,380.00*
2.1	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	4	R 175.00	*R 700.00*
2.1	W. Harding	Southern Waters	Partner	WQ Task Leader	4	R 410.00	*R 1,640.00*
2.1	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	2	R 385.00	*R 770.00*
2.1	L. van Niekerk	CSIR	Consultant	Deputy ETL	2	R 240.00	*R 480.00*
2.1	Sub-total for professional fees:						R 10,280.00
SUB-TASK 2.2: PROJECT PLAN AND INCEPTION REPORT							
2.2	G. Howard	Ninham Shand	Consultant	DRIFT Hydrologist	4	R 400.25	*R 1,601.00*
2.2	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	78	R 410.00	*R 31,980.00*
2.2	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	48	R 175.00	*R 8,400.00*
2.2	J. Conrad	Geoss	Director	Groundwater Task Leader	4	R 300.00	*R 1,200.00*
2.2	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	16	R 385.00	*R 6,160.00*
2.2	Sub-total for professional fees:						*R 49,341.00*
						SUB TOTAL FOR TASK 2 - PERSONNEL	**R 59,621.00**

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 3: GROUNDWATER							
SUB-TASK 3.1: PREPARATION OF GROUNDWATER TERMS OF REFERENCE							
	J. Conrad	Geoss	Director	Groundwater Task Leader	100	R 300.00	*R 30,000.00*
	Sub-total for professional fees:						R 30,000.00
						SUB TOTAL FOR TASK 3 - PERSONNEL	**R 30,000.00**
TASK 4: DELINEATE STUDY AREA, RESOURCE UNITS AND EWR SITES							
SUB-TASK 4.1: ESTUARY CLASSIFICATION							
4.1	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	6	R 385.00	*R 2,310.00*
4.1	L. van Niekerk	CSIR	Consultant	Deputy ETL	6	R 240.00	*R 1,440.00*
4.1	Sub-total for professional fees:						R 3,750.00
SUB-TASK 4.2: RIVER CLASSIFICATION							
4.2	E. Dollar	CSIR	Consultant	Geomorphologist	24	R 325.00	*R 7,800.00*
4.2	Sub-total for professional fees:						R 7,800.00
SUB-TASK 4.3: RIVER HABITAT INTEGRITY							
4.3	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	16	R 410.00	*R 6,560.00*
4.3	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	24	R 175.00	*R 4,200.00*
4.3	Sub-total for professional fees:						R 10,760.00
SUB-TASK 4.4: RIVER MAP QUANTITY REACHES							
4.4	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	8	R 410.00	*R 3,280.00*
4.4	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	*R 2,800.00*
4.4	Sub-total for professional fees:						R 6,080.00
SUB-TASK 4.5: EWR SITE SELECTION							
4.5	E. Dollar	CSIR	Consultant	Geomorphologist	28	R 325.00	R 9,100.00
4.5	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	24	R 175.00	R 4,200.00
4.5	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	24	R 410.00	*R 9,840.00*

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
4.5	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	24	R 175.00	R 4,200.00
4.5	J. King	Southern Waters	Partner	Supervisor: Quality control	24	R 410.00	R 9,840.00
4.5	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	24	R 250.00	*R 6,000.00*
4.5	A. Birkhead	Streamflow Solutions	Director	Hydraulics engineer	28	R 310.00	R 8,680.00
4.5	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	24	R 345.00	R 8,280.00
4.5	J. Kereko	Univ. of Stellenbosch	Field assistant	Botany assistant	24	R 35.00	R 840.00
4.5	E. Frazer	Southern Waters	Assistant	General assistant and logistics	24	R 50.00	R 1,200.00
4.5	Sub-total for professional fees:						R 62,180.00
SUB-TASK 4.6: RIVER DETERMINE QUALITY REACHES							
4.6	W. Harding	Southern Waters	Partner	WQ Task Leader	16	R 410.00	R 6,560.00
4.6	RF. Replacement	Southern Waters	Researcher	WQ Assistant	16	R 200.00	R 3,200.00
4.6	Sub-total for professional fees:						R 9,760.00
SUB-TASK 4.7: REPORT COLLATION AND EDITING							
4.7	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	8	R 410.00	R 3,280.00
4.7	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	R 2,800.00
4.7	Sub-total for professional fees:						R 6,080.00
						SUB TOTAL FOR TASK 4 - PERSONNEL	**R 106,410.00**
TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE RIVER STATES							
SUB-TASK 5.1: EWR PLANNING MEETING							
5.1	E. Dollar	CSIR	Consultant	Geomorphologist	5	R 325.00	*R 1,625.00*
5.1	W. Kamish	Ninham Shand	Consultant	Hydrologist	5	R 235.61	*R 1,178.05*
5.1	A. Sparks	Ninham Shand	Consultant	System Analyst	5	R 399.46	*R 1,997.30*
5.1	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	5	R 175.00	*R 875.00*
5.1	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	5	R 410.00	*R 2,050.00*
5.1	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	5	R 175.00	*R 875.00*

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Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
5.1	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	5	R 250.00	*R 1,250.00*
5.1	J. King	Southern Waters	Partner	Supervisor: Quality control	5	R 410.00	*R 2,050.00*
5.1	W. Harding	Southern Waters	Partner	WQ Task Leader	5	R 410.00	*R 2,050.00*
5.1	A. Birkhead	Streamflow Solutions	Director	Hydraulics engineer	5	R 310.00	*R 1,550.00*
5.1	A. Rooseboom	Univ. of Stellenbosch	Consultant	Sedimentologist	5	R 480.00	*R 2,400.00*
5.1	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	5	R 345.00	*R 1,725.00*
5.1	J. Kereko	Univ. of Stellenbosch	Field assistant	Botany assistant	5	R 35.00	*R 175.00*
5.1	Sub-total for professional fees:						R 19,800.35
SUB-TASKS 5.2 and 5.3: REFERENCE CONDITIONS, PRESENT ECOLOGICAL STATUS AND ECOLOGICAL IMPORTANCE - and ATTAINABLE AND RECOMMENDED ECOLOGICAL CATEGORY FOR THE RIVER							
5.2 & 5.3	E. Dollar	CSIR	Consultant	Geomorphologist	6	R 325.00	*R 1,950.00*
5.2 & 5.3	G. Howard	Ninham Shand	Consultant	DRIFT Hydrologist	4	R 400.25	*R 1,601.00*
5.2 & 5.3	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	6	R 175.00	*R 1,050.00*
5.2 & 5.3	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	6	R 410.00	*R 2,460.00*
5.2 & 5.3	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	6	R 175.00	*R 1,050.00*
5.2 & 5.3	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	6	R 250.00	*R 1,500.00*
5.2 & 5.3	W. Harding	Southern Waters	Partner	WQ Task Leader	6	R 410.00	*R 2,460.00*
5.2 & 5.3	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	6	R 345.00	*R 2,070.00*
5.2 & 5.3	Sub-total for professional fees:						R 14,141.00
SUB-TASK 5.4: CROSS-SECTIONAL SURVEY AND HYDRAULIC CALIBRATION							
5.4	A. Birkhead	Streamflow Solutions	Director	Hydraulics engineer	240	R 310.00	*R 74,400.00*
5.4	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	120	R 175.00	*R 21,000.00*
5.4	Surveyor	Not yet sourced	Field surveyor	Technician	120	R 200.00	*R 24,000.00*
5.4	Sub-total for professional fees:						R 119,400.00
SUB-TASK 5.5: PREPARATION OF HYDROLOGICAL DATA							

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
5.5	G. Howard	Ninham Shand	Consultant	DRIFT Hydrologist	100	R 400.25	*R 40,025.00*
5.5	W. Kamish	Ninham Shand	Consultant	Hydrologist	160	R 235.61	*R 37,697.60*
5.5	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	56	R 410.00	*R 22,960.00*
5.5	Sub-total for professional fees:						R 100,682.60
SUB-TASK 5.6: SPECIALIST DATA COLLECTION (RIVER QUANTITY) EXCLUDING HYDROLOGY AND HYDRAULICS							
5.6	A. Bok	A. Bok and Assoc.	Director	Supervisor: Fish specialist	40	R 300.00	*R 12,000.00*
5.6	E. Dollar	CSIR	Consultant	Geomorphologist	40	R 325.00	*R 13,000.00*
5.6	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	40	R 175.00	*R 7,000.00*
5.6	L. Nzima	Clanwilliam LifeStyle P	Field assistant	Fish assistant	80	R 25.00	*R 2,000.00*
5.6	B. Fortuin	Clanwilliam LifeStyle P	Field assistant	Fish assistant	80	R 25.00	*R 2,000.00*
5.6	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	10	R 410.00	*R 4,100.00*
5.6	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	40	R 175.00	*R 7,000.00*
5.6	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	60	R 250.00	*R 15,000.00*
5.6	R. Townsend	Southern Waters	Administrator	Financial control and logistics	40	R 180.00	*R 7,200.00*
5.6	A. Rooseboom	Univ. of Stellenbosch	Consultant	Sedimentologist	40	R 480.00	*R 19,200.00*
5.6	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	60	R 345.00	*R 20,700.00*
5.6	J. Kereko	Univ. of Stellenbosch	Field assistant	Botany assistant	80	R 35.00	*R 2,800.00*
5.6	E. Frazer	Southern Waters	Assistant	General assistant and logistics	80	R 50.00	*R 4,000.00*
5.6	Sub-total for professional fees:						R 116,000.00
SUB-TASK 5.7: SPECIALIST DATA COLLECTION (RIVER QUALITY) EXCLUDING HYDROLOGY AND HYDRAULICS							
5.7	W. Harding	Southern Waters	Partner	WQ Task Leader	24	R 410.00	*R 9,840.00*
5.7	RF. Replacement	Southern Waters	Researcher	WQ Assistant	32	R 200.00	*R 6,400.00*
5.7	Sub-total for professional fees:						R 16,240.00
SUB-TASK 5.8: SPECIALISTS REPORTS AND APPENDICES (EXCL. HYDROLOGY AND HYDRAULICS)							
5.8	A. Bok	A. Bok and Assoc.	Director	Supervisor: Fish specialist	4	R 300.00	*R 1,200.00*

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
5.8	E. Dollar	CSIR	Consultant	Geomorphologist	40	R 325.00	*R 13,000.00*
5.8	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	40	R 175.00	*R 7,000.00*
5.8	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	32	R 410.00	*R 13,120.00*
5.8	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	40	R 175.00	*R 7,000.00*
5.8	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	40	R 250.00	*R 10,000.00*
5.8	J. King	Southern Waters	Partner	Supervisor: Quality control	16	R 410.00	*R 6,560.00*
5.8	W. Harding	Covered under Sub-task 6.2					*n/a*
5.8	A. Rooseboom	Univ. of Stellenbosch	Consultant	Sedimentologist	24	R 480.00	*R 11,520.00*
5.8	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	40	R 345.00	*R 13,800.00*
5.8	Sub-total for professional fees:						R 83,200.00
SUB-TASK 5.9: SPECIALIST EWR MEETING							
5.9	A. Bok	A. Bok and Assoc.	Director	Supervisor: Fish specialist	52	R 300.00	*R 15,600.00*
5.9	E. Dollar	CSIR	Consultant	Geomorphologist	52	R 325.00	*R 16,900.00*
5.9	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	48	R 175.00	*R 8,400.00*
5.9	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	48	R 410.00	*R 19,680.00*
5.9	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	48	R 175.00	*R 8,400.00*
5.9	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	48	R 250.00	*R 12,000.00*
5.9	J. King	Southern Waters	Partner	Supervisor: Quality control	48	R 410.00	*R 19,680.00*
5.9	RF. Replacement	Southern Waters	Researcher	WQ Assistant	24	R 200.00	*R 4,800.00*
5.9	W. Harding	Southern Waters	Partner	WQ Task Leader	48	R 410.00	*R 19,680.00*
5.9	A. Birkhead	Streamflow Solutions	Director	Hydraulics engineer	52	R 310.00	*R 16,120.00*
5.9	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	48	R 345.00	*R 16,560.00*
5.9	J. Kereko	Univ. of Stellenbosch	Field assistant	Botany assistant	48	R 35.00	*R 1,680.00*
5.9	E. Frazer	Southern Waters	Assistant	General assistant and logistics	48	R 50.00	*R 2,400.00*
5.9	Sub-total for professional fees:						R 159,500.00

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
SUB-TASK 5.10: REPORT COLLATION AND EDITING							
5.10	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	40	R 410.00	*R 16,400.00*
5.10	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	60	R 175.00	*R 10,500.00*
5.10	Sub-total for professional fees:						R 26,900.00
						SUB TOTAL FOR TASK 5 - PERSONNEL	**R 655,863.95**
TASK 6: WATER QUALITY QUANTIFICATION							
SUB-TASK 6.1: QUANTIFICATION OF QUALITY RESERVE LINKED TO DIFFERENT ECOLOGICAL CATEGORIES							
6.1	W. Harding	Southern Waters	Partner	WQ Task Leader	40	R 410.00	*R 16,400.00*
6.1	I. Morrison	Private	WQ modeller	WQ modelling	44	R 300.00	*R 13,200.00*
6.1	RF. Replacement	Southern Waters	Researcher	WQ Assistant	24	R 200.00	*R 4,800.00*
6.1	Sub-total for professional fees:						R 34,400.00
SUB-TASK 6.2: REPORT COLLATION AND EDITING							
6.2	W. Harding	Southern Waters	Partner	WQ Task Leader	8	R 410.00	*R 3,280.00*
6.2	Sub-total for professional fees:						R 3,280.00
						SUB TOTAL FOR TASK 6 - PERSONNEL	**R 37,680.00**
TASK 7: ESTUARY ECOLOGICAL CONDITIONS AND EWR SCENARIOS FOR ALTERNATIVE ESTUARY STATES							
SUB-TASK 7.1: DATA COLLECTION							
7.1	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	126	R 385.00	*R 48,510.00*
7.1	L. van Niekerk	CSIR	Consultant	Deputy ETL	288	R 240.00	*R 69,120.00*
7.1	P. Huizinga	CSIR	Consultant	Supervisor: Quality control	48	R 440.00	*R 21,120.00*
7.1	A. Theron	CSIR	Consultant	Field and laboratory assistants	35	R 385.00	*R 13,475.00*
7.1	A. Adonis	CSIR	Consultant	Field and laboratory assistants	48	R 121.00	*R 5,808.00*
7.1	G. Bate	UPE	Head of Department	Est. Microalgal specialist	80	R 250.00	*R 20,000.00*
7.1	J. Adams	UPE	Researcher	Est. Macrophyte specialist	70	R 286.00	*R 20,020.00*
7.1	M. Thwala	UPE	Student	Research assistant	480	R 37.50	*R 18,000.00*

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
7.1	T. Wooldridge	UPE	Researcher	Estuarine invert. ecologist	96	R 340.00	*R 32,640.00*
7.1	M. Vosloo	UPE	Student	Research assistant	128	R 25.00	*R 3,200.00*
7.1	S. Deysel	UPE	Student	Research assistant	128	R 25.00	*R 3,200.00*
7.1	Inverts Student 3	UPE	Student	Research assistant	62	R 25.00	*R 1,550.00*
7.1	S. Lamberth	Private	Consultant	Estuarine fish ecologist	112	R 275.00	*R 30,800.00*
7.1	J. Turpie	Southern Waters	Consultant	Ornithologist/Resource eco.	88	R 400.00	*R 35,200.00*
7.1	N. Popose	Univ. of Cape Town	Field assistant	Bird assistant	40	R 35.00	*R 1,400.00*
7.1	G. Basson	Univ. of Stellenbosch	Head of Department	Sedimentologist	100	R 480.00	*R 48,000.00*
7.1	J. Beck	Univ. of Stellenbosch	Researcher	Junior Sedimentologist	140	R 80.00	*R 11,200.00*
7.1	P. Smailes	UPE	Student	Research assistant	24	R 165.00	*R 3,960.00*
7.1	T. Bornman	UPE	Student	Research assistant	56	R 200.00	*R 11,200.00*
7.1	A. Rajkaran	UPE	Student	Research assistant	56	R 25.00	*R 1,400.00*
7.1	K. Hutchings	Univ. of Cape Town	Researcher	Junior Fish ecologist	64	R 75.00	*R 4,800.00*
7.1	Sub-total for professional fees:						R 404,603.00
SUB-TASK 7.2: ESTUARY CLASSIFICATION AND SCENARIO EVALUATION SPECIALIST MEETING AND MONITORING PROGRAMME DESIGN							
7.2	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	72	R 385.00	*R 27,720.00*
7.2	L. van Niekerk	CSIR	Consultant	Deputy ETL	40	R 240.00	*R 9,600.00*
7.2	P. Huizinga	CSIR	Consultant	Supervisor: Quality control	40	R 440.00	*R 17,600.00*
7.2	G. Bate	UPE	Head of Department	Est. Microalgal specialist	40	R 250.00	*R 10,000.00*
7.2	J. Adams	UPE	Researcher	Est. Macrophyte specialist	40	R 286.00	*R 11,440.00*
7.2	T. Wooldridge	UPE	Researcher	Estuarine invert. ecologist	40	R 340.00	*R 13,600.00*
7.2	S. Lamberth	Private	Consultant	Estuarine fish ecologist	40	R 275.00	*R 11,000.00*
7.2	J. Turpie	Southern Waters	Consultant	Ornithologist/Resource eco.	40	R 400.00	*R 16,000.00*
7.2	G. Basson	Univ. of Stellenbosch	Head of Department	Sedimentologist	40	R 480.00	*R 19,200.00*
7.2	Sub-total for professional fees:						R 136,160.00

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
SUB-TASK 7.3: REPORT COLLATION AND EDITING							
7.3	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	40	R 385.00	*R 15,400.00*
7.3	L. van Niekerk	CSIR	Consultant	Deputy ETL	20	R 240.00	*R 4,800.00*
7.3	Sub-total for professional fees:						R 20,200.00
						SUB TOTAL FOR TASK 7 - PERSONNEL	**R 560,963.00**
TASK 8: SCENARIOS AND OPERATIONAL ASPECTS							
SUB-TASK 8.1: SCENARIO GENERATION							
8.1	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	24	R 410.00	*R 9,840.00*
8.1	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	*R 2,800.00*
8.1	A. Sparks	Ninham Shand	Consultant	System Analyst	184	R 399.46	*R 73,500.64*
8.1	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	8	R 385.00	*R 3,080.00*
8.1	G. Howard	Ninham Shand	Consultant	DRIFT Hydrologist	8	R 400.25	*R 3,202.00*
8.1	Sub-total for professional fees:						R 92,422.64
SUB-TASK 8.2: ECOLOGICAL CONSEQUENCES OF SCENARIOS							
8.2	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	24	R 410.00	*R 9,840.00*
8.2	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	32	R 175.00	*R 5,600.00*
8.2	E. Dollar	CSIR	Consultant	Geomorphologist	8	R 325.00	*R 2,600.00*
8.2	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	8	R 175.00	*R 1,400.00*
8.2	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	8	R 250.00	*R 2,000.00*
8.2	W. Harding	Southern Waters	Partner	WQ Task Leader	4	R 410.00	*R 1,640.00*
8.2	A. Rooseboom	Univ. of Stellenbosch	Consultant	Sedimentologist	8	R 480.00	*R 3,840.00*
8.2	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	8	R 345.00	*R 2,760.00*
8.2	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	8	R 385.00	*R 3,080.00*
8.2	Sub-total for professional fees:						R 32,760.00
SUB-TASKS 8.3: REPORT COLLATION AND EDITING							

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
8.3	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	16	R 410.00	*R 6,560.00*
8.3	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	40	R 175.00	*R 7,000.00*
8.3	Sub-total for professional fees:						R 13,560.00
						SUB TOTAL FOR TASK 8 - PERSONNEL	**R 138,742.64**
	TASK 9: ECOSPECS AND MONITORING PROTOCOLS						
SUB-TASK 9.1: RDM FORMAT RESERVE DOCUMENTATION							
9.1	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	*R 2,800.00*
9.1	L. van Niekerk	CSIR	Consultant	Deputy ETL	8	R 240.00	*R 1,920.00*
9.1	W. Harding	Southern Waters	Partner	WQ Task Leader	8	R 410.00	*R 3,280.00*
9.1	Sub-total for professional fees:						R 8,000.00
SUB-TASK 9.2: ECOSPECS OF RECOMMENDED ECOLOGICAL CATEGORY							
9.2	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	16	R 410.00	*R 6,560.00*
9.2	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	30	R 175.00	*R 5,250.00*
9.2	E. Dollar	CSIR	Consultant	Geomorphologist	6	R 325.00	*R 1,950.00*
9.2	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	6	R 250.00	*R 1,500.00*
9.2	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	6	R 175.00	*R 1,050.00*
9.2	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	6	R 345.00	*R 2,070.00*
9.2	W. Harding	Southern Waters	Partner	WQ Task Leader	4	R 410.00	*R 1,640.00*
9.2	Estuarine component will be undertaken in Task 7.						
9.2	Sub-total for professional fees:						R 20,020.00
SUB-TASK 9.3: DESIGN A MONITORING PROTOCOL TO MEASURE COMPLIANCE WITH RQOS							
9.3	E. Dollar	CSIR	Consultant	Geomorphologist	8	R 325.00	*R 2,600.00*
9.3	B. Paxton	Univ. of Cape Town	Researcher	Fish specialist	8	R 175.00	*R 1,400.00*
9.3	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	24	R 410.00	*R 9,840.00*
9.3	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	*R 2,800.00*

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
9.3	G. Ractliffe	Freshwater CG	Consultant	Invertebrates	8	R 250.00	*R 2,000.00*
9.3	A. Birkhead	Streamflow Solutions	Director	Hydraulics engineer	8	R 310.00	*R 2,480.00*
9.3	C. Boucher	Univ. of Stellenbosch	Lecturer	Botanist	8	R 345.00	*R 2,760.00*
9.3	W. Harding	Southern Waters	Partner	WQ Task Leader	8	R 410.00	*R 3,280.00*
9.3	Sub-total for professional fees:						R 27,160.00
SUB-TASK 9.4: REPORT COLLATION AND EDITING							
9.4	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	10	R 410.00	*R 4,100.00*
9.4	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	16	R 175.00	*R 2,800.00*
9.4	Sub-total for professional fees:						R 6,900.00
						SUB TOTAL FOR TASK 9 - PERSONNEL	**R 62,080.00**
TASK 10: MAIN REPORT							
SUB-TASK 10.1: REPORT COLLATION AND EDITING							
10.1	C. Brown	Southern Waters	Managing Partner	Project Leader and River TL	40	R 410.00	*R 16,400.00*
10.1	C. Pemberton	Southern Waters	Junior consultant	Deputy PL and Deputy RTL	60	R 175.00	*R 10,500.00*
10.1	J. King	Southern Waters	Partner	Supervisor: Quality control	12	R 410.00	*R 4,920.00*
10.1	S. Taljaard	CSIR	Consultant	Estuarine Task Leader (ETL)	8	R 385.00	*R 3,080.00*
10.1	Sub-total for professional fees:						R 34,900.00
						SUB TOTAL FOR TASK 10 - PERSONNEL	**R 34,900.00**

Table 10.2 Disbursements per Task.

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 1: MANAGEMENT							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	1690	R 2.50	R 4,225.00
	Printing	Progress reports		per page	350	R 0.50	R 175.00
	Miscellaneous	CD disks		each	4	R 10.00	R 40.00
		Stationary		lump sum	1	R 5,000.00	R 5,000.00
		Telecommunications		per month	30	R 300.00	R 9,000.00
	TOTAL DISBURSEMENTS TASK 1						**R 18,440.00**
TASK 2: STUDY IMPLEMENTATION AND DESIGN							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	500	R 2.50	R 1,250.00
	Meetings	Venue Room Hire		per day	2	R 500.00	R 1,000.00
		Lunches and teas		per person per day	30	R 100.00	R 3,000.00
	Printing			per page	800	R 0.50	R 400.00
	Miscellaneous	CD disks		per disk	15	R 10.00	R 150.00
		CWAC data		lump sum	1	R 10,000.00	R 10,000.00
	TOTAL DISBURSEMENTS TASK 2						**R 15,800.00**
TASK 3: GROUNDWATER							

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	100	R 2.50	R 250.00
	Printing			per page	60	R 0.50	R 30.00
	Miscellaneous	CD disks		per disk	1	R 10.00	R 10.00
	TOTAL DISBURSEMENTS TASK 3						**R 290.00**
TASK 4: DELINEATION OF STUDY AREA, RESOURCE UNITS AND EWR SITES							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
		Mileage (river)		per kilometre	5000	R 2.60	R 13,000.00
		Air tickets (river)			2	R 3,000.00	R 6,000.00
		Car Hire (river)			2	R 1,000.00	R 2,000.00
	Accommodation	River		per night	80	R 350.00	R 28,000.00
	S&T	All		per day	80	R 125.00	R 10,000.00
	Meetings	Venue Room Hire		per day	2	R 500.00	R 1,000.00
		Lunches and teas		per person per day	30	R 100.00	R 3,000.00
	Printing		averaged to account for B&W and colour	per page	200	R 0.60	R 120.00
	Photocopy			per page	300	R 0.40	R 120.00
	Miscellaneous	CD disks	Backups		3	R 10.00	R 30.00
	TOTAL DISBURSEMENTS TASK 4						**R 63,270.00**

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE RIVER STATES							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
		Mileage (river)		per kilometre	24500	R 2.60	R 63,700.00
		Car Hire (river)			6	R 1,000.00	R 6,000.00
	Accommodation	River	averaged to account for different rates, incl. of meeting room hire for workshops	per night	140	R 350.00	R 49,000.00
	S&T	All		per day	140	R 125.00	R 17,500.00
	Analyses	Water quality (river)		per sampling trip	3	R 6,000.00	R 18,000.00
		Sediments		per sample - estimated	200	R 20.00	R 4,000.00
	Equipment hire	Total station		per day	20	R 300.00	R 6,000.00
		Electroshocker		per day	7	R 100.00	R 700.00
		Boat 1 (River croc)		per day	45	R 100.00	R 4,500.00
	Printing		averaged to account for B&W and colour	per page	1000	R 0.60	R 600.00
	Photocopy			per page	1000	R 0.40	R 400.00
	Miscellaneous	CD disks	Backups		15	R 10.00	R 150.00
		Photography			150	R 10.00	R 1,500.00
		Plant identification	NBI	per species - estimated	100	R 30.00	R 3,000.00
		Sundry supplies		at cost	50	R 50.00	R 2,500.00
	TOTAL DISBURSEMENTS TASK 5						**R 177,550.00**

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 6: WATER QUALITY QUANTIFICATION							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	1000	R 2.50	R 2,500.00
	Accomm			Covered in Task 5.			
	Printing			per page	60	R 0.50	R 30.00
	Analyses					Covered under Task 5	n/a
	Miscellaneous	CD disks		per disk	1	R 10.00	R 10.00
	TOTAL DISBURSEMENTS TASK 6						**R 2,540.00**
TASK 7: ESTUARY ECOLOGICAL CONDITIONS AND EWR SCENARIOS FOR ALTERNATIVE ESTUARY STATES							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage (estuary)		per kilometre	18000	R 2.50	R 45,000.00
		Air tickets (estuary)			3	R 3,000.00	R 9,000.00
	Accommodation	Estuary		per night	134	R 350.00	R 46,882.50
	S&T	Estuary		per day	134	R 125.00	R 16,750.00
	Analyses	Water quality (estuary)		per sampling trip	1.9	R 20,000.00	R 38,000.00
	Equipment hire	System analysis Computer		per day	30	R 75.00	R 2,250.00
		MIKE 11 Programme		per day	0.95	R 8,000.00	R 7,600.00
		Instrument hire (est.)		per day	4.75	R 200.00	R 950.00
		Boat 2 (Estuary row)		per day	21	R 150.00	R 3,150.00

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
		Boat 3 (Estuary engine)		per day	14	R 500.00	R 7,000.00
	Printing		averaged to account for B&W and colour	per page	1000	R 0.60	R 600.00
	Photocopy			per page	1000	R 0.40	R 400.00
	Miscellaneous	CD disks	Backups		5	R 10.00	R 50.00
		Photography			150	R 10.00	R 1,500.00
	TOTAL DISBURSEMENTS TASK 7						**R 179,132.50**
TASK 8: SCENARIOS AND OPERATIONAL ASPECTS							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	100	R 2.50	R 250.00
	Printing	Summary reports		per page	250	R 0.50	R 125.00
	Miscellaneous	CD disks	Backups	each	5	R 10.00	R 50.00
	TOTAL DISBURSEMENTS TASK 8						**R 425.00**
TASK 9: ECOSPECS AND MONITORING PROTOCOLS							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Travel	Mileage		per kilometre	100	R 2.50	R 250.00
	Printing	Summary reports		per page	250	R 0.50	R 125.00
	Miscellaneous	CD disks	Backups	each	5	R 10.00	R 50.00
	TOTAL DISBURSEMENTS TASK 9						**R 425.00**

Task no.	Team member	Company name	Position in company	Study position	Time (hrs)	Hourly rate	Total costs
TASK 10: MAIN REPORT							
	Disbursements:						
	Item	**Sub-item**			**No.**	**Unit cost**	**Cost**
	Printing	Summary reports		per page	2000	R 0.50	R 1,000.00
	Photocopy			per page	2000	R 0.40	R 800.00
	Miscellaneous	CD disks	Backups	each	5	R 10.00	R 50.00
	TOTAL DISBURSEMENTS TASK 10						**R 1,850.00**

Table 10.3 A summary with totals per Task.

TASK 1: MANAGEMENT	
Personnel	R 340,480.00
Disbursements	R 18,440.00
TASK TOTAL	**R 358,920.00**
TASK 2: STUDY IMPLEMENTATION AND DESIGN	
Personnel	R 59,621.00
Disbursements	R 15,800.00
TASK TOTAL	**R 75,421.00**
TASK 3: GROUNDWATER	
Personnel	R 30,000.00
Disbursements	R 290.00
TASK TOTAL	**R 30 290.00**
TASK 4: DELINEATION OF STUDY AREA, RESOURCE UNITS AND EWR SITES	
Personnel	R 106,410.00
Disbursements	R 62,270.00
TASK TOTAL	**R 168,680.00**
TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS	
Personnel	R 655,865.95
Disbursements	R 177,550.00
TASK TOTAL	**R 833,415.95**
TASK 6: WATER QUALITY QUANTIFICATION	
Personnel	R 37,680.00
Disbursements	R 290.00
TASK TOTAL	**R 37,970.00**
TASK 7: ESTUARY ECOLOGICAL CONDITIONS AND EWR SCENARIOS	
Personnel	R 560,963.00
Disbursements	R 179,132.50
TASK TOTAL	**R 740,095.50**
TASK 8: SCENARIOS AND OPERATIONAL ASPECTS	
Personnel	R 138,742.64
Disbursements	R 425.00
TASK TOTAL	**R 139,167.64**
TASK 9: ECOSPECS AND MONITORING PROTOCOLS	
Personnel	R 62,080.00
Disbursements	R 425.00
TASK TOTAL	**R 62,505.00**
TASK 10: MAIN REPORT	
Personnel	R 34,900.00
Disbursements	R 1,850.00
TASK TOTAL	**R 36,750.00**

TOTAL, excl. VAT and escalation	**R 2,486,893.09**
TOTAL, incl. VAT	**R 2,835,058.12**

Table 10.4 Cash flow by quarter per task, excluding VAT and escalation.

TASKS	**2003**		**2004**				**2005**			
	3	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
TASK 1: PROJECT MANAGEMENT										
	R 34,470.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00	R 36,050.00
TASK 2: STUDY IMPLEMENTATION AND DESIGN										
	R 37,000.00	R 37,000.00	R 1,421.00							
TASK 3: GROUNDWATER										
		R 30,290.00								
TASK 4: STUDY AREA, RUs AND EWR SITES										
		R 84,080.00	R 84,080.00							
TASK 5: RIVER ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE RIVER STATES										
		R 140,358.00	R 146,202.60	R 120,558.00	R 138,978.00	R 218,478.00	R 56,108.00	R 14,471.35		
TASK 6: WATER QUALITY QUANTIFICATION										
						R 37,970.00				
TASK 7: ESTUARY ECOLOGICAL CONDITION AND EWR SCENARIOS FOR ALTERNATIVE ESTUARY STATES										
	R 20,000.00	R 234,867.66		R 234,867.66		R 234,867.66	R 15,406.50			
TASK 8: EWRS: SCENARIOS AND OPERATIONAL ASPECTS										
							R 142,447.64			
TASK 9: ECOSPECS AND MONITORING PROTOCOLS										
									R 62,505.00	
TASK 10: MAIN SUMMARY REPORT										
										R 35,930.00
TOTAL	R 91,470.00	R 562,645.66	R 267,753.60	R 391,475.66	R 175,028.00	R 527,365.66	R 250,012.14	R 50,521.35	R 98,555.00	R 71,980.00

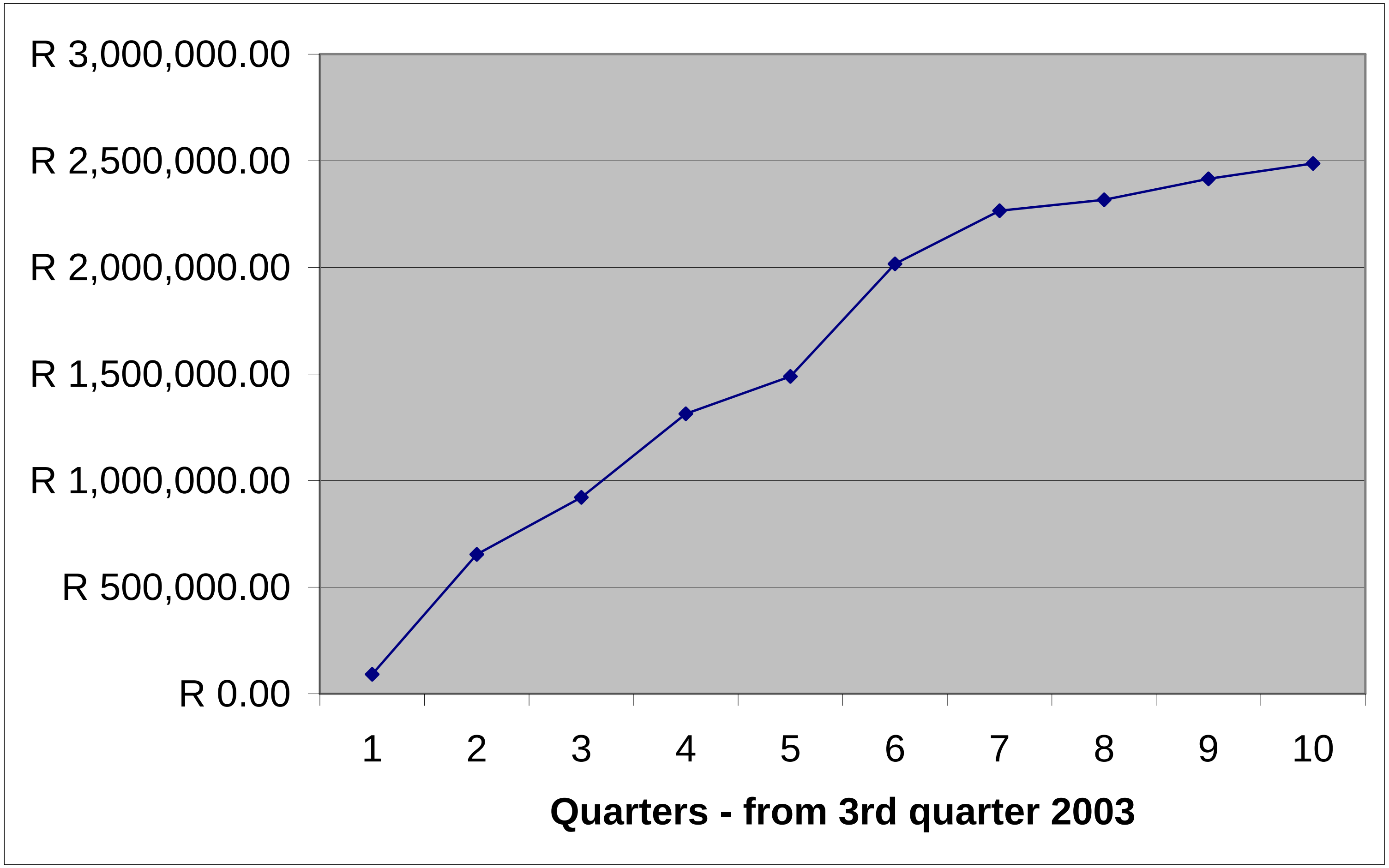
R 3,000,000.00
R 2,500,000.00
R 2,000,000.00
R 1,500,000.00
R 1,000,000.00
R 500,000.00
R 0.00
1
2
3
4
5
6
7
8
9
10
Quarters - from 3rd quarter 2003

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Figure 10.1 Cash flow by quarter, excluding VAT and escalation.

11 PROJECT MONITORING AND CONTROL SYSTEM

In order to facilitate more exact project monitoring and control, the Stages and Tasks provided in the proposal have been further divided into Tasks and Sub-tasks (Sections 2, 3 and 4), and some have been reallocated, e.g., GIS into Task 1 – Management. The budget allocations, Gantt chart and other project control mechanisms have also been reworked according to Sub-tasks.

The Gantt chart detailing progress per Sub-task against programme (Section 9), the Cash Flow Projections (Section 10), and the Expenditure Against Budget (Appendix B) and Progress against Expenditure (Appendix B) worksheets together provide the basis for project monitoring and control. These will be submitted to the Management PSP for review as part of the quarterly progress reporting.

These monitoring measures will be augmented with the following control measures:

1. Clear and concise briefs to each Task Leader, detailing their programme of work, budget and schedule of deliverables. These are to be sent to specialists once the Inception Report has been accepted, and will require that team members sign agreement to complete the work in the time and budget allocated.
2. Sub-consultant performance management.
    a. Team members not adhering to the agreed schedules will be queried as to the reasons for performance failure and assisted where possible to meet their agreed terms.
    b. Payment will only be made on evidence of the relevant tasks having been undertaken.
    c. At least 10% of each team member's budget for each Sub-Task will be withheld until that task has been completed to the satisfaction of the Task Leaders, Project Leader and Management PSP.
    d. 5% of each team member's budget will be permanently withheld for report contributions that are not formatted according to the required format for this project (Appendix F). This money will be used to pay someone else to format their contribution.
    e. Team members will be replaced if necessary.

12 ASSUMPTIONS AND LIMITATIONS

The following section details the assumptions and limitations of this study in alphabetical order. Unless otherwise agreed by the Client and the PSP, the methods described in this report will be adhered to for the duration of the project. Should any requested changes to the procedures affect the study plan significantly, a revision of the budget may be needed.

12.1 AVAILABILITY OF TEAM MEMBERS

We have assumed that all Team members will be available at the times indicated in the schedule, but it is inevitable that the proposed schedule will need to be modified to accommodate clashes with other activities (see Schedule).

12.2 BIOLOGICAL SAMPLING

The budget makes provision for limited biological sampling. It is acknowledged that additional biological sampling would add confidence to the results, however, it is not possible at this stage to determine how much additional sampling would result in a significant benefit to the study – this is only possible once the planned sampling has been undertaken.

12.3 CONTINGENCY

The budgets for the specialists have been slightly reworked to provide some in-house contingencies but there are no formal contingencies included in the budget.

12.4 ESCALATION

Escalation is included in the budget. However, delays in project start up may increase escalation costs over an above those provided for in the budget (see Schedule).

12.5 EWR SITES

The budget includes provision for six (6) EWR sites, with the added proviso that at least five of these will be situated on the mainstems of the Olifants or Doring Rivers. This means that sites will have to be carefully selected to obtain the best distribution from both a scientific and water resource management perspective.

12.6 EXTERNAL REVIEW

The budget does not make provision for external review. Limited internal review is however included in the budget.

12.7 HABITAT INTEGRITY

The budget excludes an aerial survey. Habitat integrity will be assessed on the basis of existing information.

12.8 HYDRUALICS

No hydraulic modeling has been incorporated into our programme as this is not possible within the available budget. Habitat modeling would add considerable value to the confidence of the study, and we would be happy to incorporate this aspect should additional funds be available.

We have budgeted for four field visits to measure river hydraulics and take fixed-point photographs (the initial site selection visit plus three). There is no budget to replace reference pegs should these be vandalised or swept away by floods and the budget excludes the costs of geo-referencing EWR profiles.

12.9 OBSERVERS

The budget excludes the costs for observers or members of the Client, Project Management Consultants, or other Interested and Affected Parties who may attend site visits or meetings. These will be billed separately.

12.10 PROJECT MANAGEMENT MEETINGS

The budget makes provision for x PMC meetings, all in Cape Town. Our budget has assumed that these meetings have no cost to the project other than time and reimbursable to the team.

12.11 SCHEDULE

The proposal assumed a starting date of mid February 2003, but the project was not awarded until July 2003. In addition, uncertainty about when the project would commence meant that advance planning with the teams was not possible, hence project planning began in August 2003.

Delays in starting the project may cause problems with the timing of later activities, and this may require re-scheduling that could affect the budget in terms of escalated costs.

We have assumed that the PMT and External Reviewer(s) will respond with comments and feedback on all reports within one (1) month of submission, and that reports will be finalised following one (1) iteration of editing.

12.12 SOCIAL ASSESSMENT

There is no budget for social resource utilisation only, except for limited consideration of the social importance of the estuary.

12.13 REPORTING

We have budgeted for the printing, binding and distribution costs of two (2) draft and two (2) final copies, as well as one (1) CD containing a .doc and .pdf file of the following reports (page estimates):

- Inception Report (120 pages)
- Main Summary Report (100 pages, 5 colour)
- Groundwater TOR (30 pages, 1 colour)

- Delineation Report (100 pages, 10 colour)
- Starter Document (200 pages, 15 colour)
- River Reserve Report (350 pages, 8 colour)
- Estuarine Reserve Report (350 pages, 8 colour)
- Scenario Report (80 pages, 7 colour)
- Monitoring Appendix (80 pages, 2 colour)
- Progress Reports (170 pages, 0 colour)
- Minutes (135 pages, 0 colour).

Copies and binding of reports will be charged according to DWAF rates.

12.14 RESERVE TEAM MEETINGS

The budget makes provision for the following team meetings only:

River

Planning meeting:	5-hour meeting in Cape Town.
Site selection:	3-day site visit attended by key specialists.
Initial data collection:	5-day site visit attended by river specialists.
EWR Workshop:	5-day workshop.
Scenario meeting:	1-day meeting (or consultation) attended by ecologists and water quality specialist.

Estuary

Initial data collection:	5-day site visit attended by river specialists.
EWR Workshop:	5-day workshop.

12.15 WATER QUALITY SAMPLING

The extreme inter-annual and seasonal variability that prevails in the Doring River study area, coupled with the logistical constraints (costs, distance, isolation of sites, etc), significantly reduce the likelihood of undertaking an effective event-driven programme of monitoring within the duration of the project (maximum of two hydrological year-windows, and possibly only a portion of the second). The project may span two atypical years. This constraint is obviously also applicable to the collection of biotic information.

12.16 WETLANDS RESERVE

The budget excludes Reserve determinations for wetlands and seeps.

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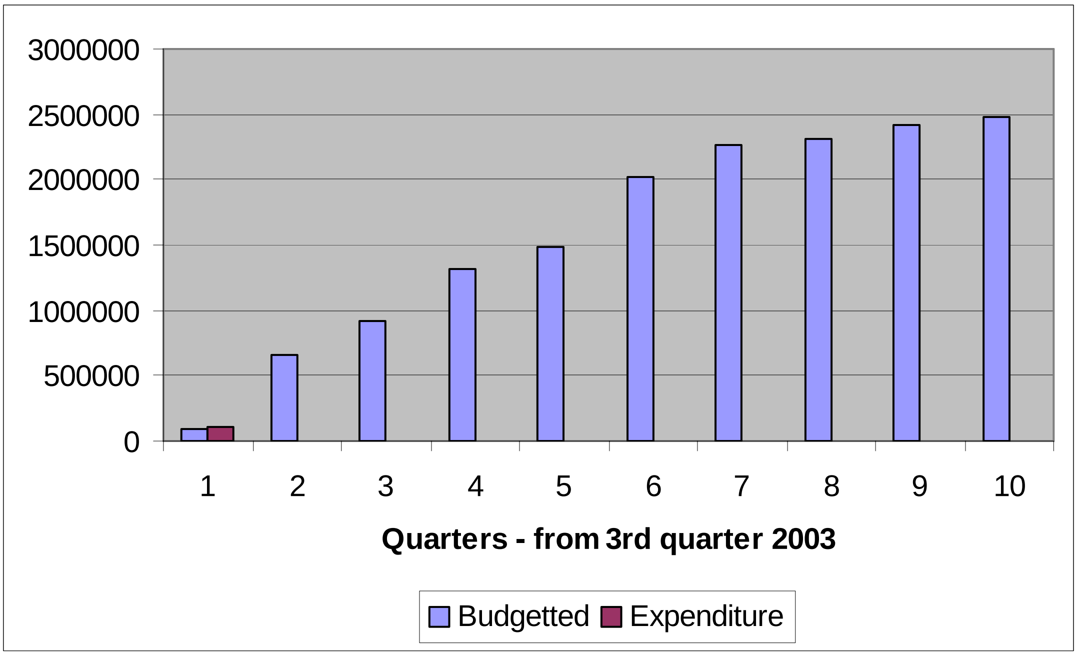
APPENDIX A PROGRESS REPORT TEMPLATE

Name of consultant:
Dates of reporting period:
Task number and description:
Summary of progress and percentage of work completed to date:
Percentage of work completed prior to this reporting period:
Budget spent to date (please provide a breakdown of expenses):
Budget remaining for completion of task:
Original deadline for task completion:
Information requirements for next phase of task:
Problems anticipated and changes to the scope of work:
Anticipated deadline for task completion:

Signature:______________________________ Date:___________________

APPENDIX B BUDGET TEMPLATES

TEMPLATE: EXPENDITURE AGAINST BUDGET



TEMPLATE: PROGRESS AGAINST EXPENDITURE

To be developed.

APPENDIX C INVOICE TEMPLATE

Invoice:

VAT No: 4110148774

TAX INVOICE

Attention:	Mr H.H. Pienaar	Invoice No.	
Resource Directed Measures		Our Reference:	236CB/rst
Department of Water Affairs and Forestry		Your Reference:	2002-376
Private Bag X313		Page	1 of 3
Pretoria 0001		Date:	23/09/2003

PROJECT: OLIFANTS DORING RESERVE DETERMINATION STUDY

Description	Total claimed to date	Previously claimed	Now claimed
PROFESSIONAL FEES PER TASK	R	R	R
As per attached schedules			
Task number and description			
Total Professional Fees			
DISBURSEMENTS			
As per attached schedules			
1 Travel costs			
2 Printing costs			
3 Other recoverables			
Total Disbursements			
Sub-Total	0.00	0.00	0.00
Add VAT	0.00	0.00	0.00
TOTAL R	0.00	0.00	0.00
			Now Due

Invoice payable on presentation.

Standard Bank

Rondebosch - 02500911

A/c no: 270688145

Schedule of professional fees per task:

PROJECT: OLIFANTS DORING RESERVE DETERMINATION STUDY

Our reference: Your reference:

Invoice no. Page 2 of 3

1 SCHEDULE OF PROFESSIONAL FEES PER TASK:

Task No.	Team member	Hours worked	Approved Rate R/h	Total cost/ member R	Total cost/task carried over to invoice R
				R	0

Schedule of disbursements:

PROJECT: OLIFANTS DORING RESERVE DETERMINATION STUDY

Our reference: Your reference:

Invoice no. Page 3 of 3

2 SCHEDULE OF DISBURSEMENTS

2.1 Travel

Team member	Date travelled	Purpose of trip	Distance travelled km	Vehicle classification and engine size	Approved rate c/km	Cost/trip R
					R	0

2.1 Typing and Printing Costs:

Typing (reports only):
Photocopies:
Binding of reports:
Printing of plans:

Total cost carried over to invoice at DWAF rates R

2.2 Other Recoverable Costs: At cost

Date	Item Description	Invoice No*	Cost / Item
	Total cost carried over to invoice	R	0

* Invoices attached

APPENDIX D SUMMARY OF THE DRIFT METHODOLOGY

SUMMARY OF THE DRIFT METHODOLOGY

Cate Brown and Jackie King

Southern Waters Ecological Research and Consulting cc
50 Campground Road
Rondebosch, Cape Town
South Africa

IMPORTANT NOTICE

This report was compiled under contract to The WorldFish Centre as part of a research contract falling within the ambit of the CGIAR Comprehensive Assessment Programme.

Southern Waters would like to thank The WorldFish Centre for permission to make the report available to other users.

INTRODUCTION

DRIFT (Downstream Response to Imposed Flow Transformations) is an interactive, holistic (Tharme, 1996) approach to advising on environmental flows for rivers. It was developed from earlier holistic methodologies such as the Building Block Methodology (BBM) (King & Louw, 1998), through several applications in southern Africa (e.g. King *et al.* 1999; Brown *et al.* 2000; Brown & King 2002). It is described in detail in King *et al.* (2002) and Brown & Joubert (in prep.).

The central rationale of DRIFT is that different categories of flow (wet and dry season low flows; small, medium and large floods) maintain different parts of the river ecosystem. Thus, manipulation of one or more of these categories of flow will affect the ecosystem differently than manipulation of some other combination (Brown & King 1999; King *et al.* 2002). Furthermore:

- these categories of flow can be identified and isolated from the historical hydrological record;
- the probable biophysical consequences of manipulation of a single flow category can be described;
- once these consequences have been described for all flow categories, flows can be re-combined in various ways and the overall impact on river condition of each new flow regime derived;
- the change in river condition can be indicated as a change in River Management Class;
- the implications of the change in river condition for common-property users of the river's resources can be described.

The main features of the DRIFT process are:

- taking the present-day flow regime as a starting point, ecosystem changes linked to a range of flow manipulations are predicted;
- a database of these predictions is compiled, which is queried to produce biophysical scenarios of the ecosystem changes linked to any contemplated flow manipulation;
- the biophysical scenarios are taken further to describe social impacts for common-property subsistence users of the river (the Population at Risk or PAR).

OUTLINE OF DRIFT

DRIFT Modules

DRIFT consists of four modules (biophysical, subsistence use, biophysical and social scenario development and social compensation economics (King *et al*. 2002). In the first, or biophysical module, the river ecosystem is described and predictive capacity developed on how it would change with flow changes. In the second, or subsistence module, links are described between riparian people who are common-property subsistence users of river resources, the resources they use, and their health. The objective is to develop predictive capacity of how river changes would impact their lives. In the third module, scenarios are built of potential future flows and of the predicted impacts of these on the river and the riparian people. The fourth, or compensation-economics, module lists compensation and mitigation costs (King *et al*. 2002). Although all four modules have been applied (e.g. King *et al*. 1999; Sabet *et al*. 2002), the first and third modules can be applied alone (e.g. King *et al*. 1999; Brown *et al.* 2000; Brown & Louw 2002) and are the most developed.

Imparting structure to the DRIFT process

DRIFT has several characteristics that impart structure to specialist deliberations on the consequences of flow changes (King *et al*. 2002):

Environmental Flow Sites
Data collection and subsequent deliberations are centred on river sites, each of which is representative of a river reach.

Daily hydrology
The present-day long-term daily flow data for each site are separated into ten flow categories (Table 1) and specialists predict the consequences of up to four levels of change from present condition in each flow category for different components of the river ecosystem.

Multi-disciplinary team
The specialists routinely included are in the following disciplines: sedimentology/fluvial geomorphology, water quality, plants, aquatic invertebrates and fish (Table 1). Depending on the river under study additional components, such as mammals, birds and herpetofauna, can be added. The specialists build up a picture of predicted change to any presented flow manipulation, starting with channel changes, then water quality and temperature, then vegetation, invertebrates and fish. Other disciplines included where relevant are inserted into this sequence as appropriate.

Table 1. Flow categories that are reduced, or increased, in magnitude or number, to produce described consequences, and the five ecosystem components for which consequences are routinely predicted (King *et al.* 2002)

<table>
<tr><th>FLOW CATEGORIES</th><th>Consequences described for:</th><th>Ecosystem component</th></tr>
<tr><td>1. Dry-season low flow (range of low flows)</td><td rowspan="2">4 levels of increase or decrease</td><td rowspan="10">1. Fluvial geomorphology
2. Water quality
3. Plants
4. Aquatic invertebrates
5. Fish

The hydraulics of the river channel are also computed.</td></tr>
<tr><td>2. Wet-season low flow (range of low flows)</td></tr>
<tr><td>3. Intra-annual floods: Class 1</td><td rowspan="4">4 changes in the number per annum</td></tr>
<tr><td>4. Intra-annual floods: Class 2</td></tr>
<tr><td>5. Intra-annual floods: Class 3</td></tr>
<tr><td>6. Intra-annual floods: Class 4</td></tr>
<tr><td>7. 1:2 year flood</td><td rowspan="4">Presence or absence</td></tr>
<tr><td>8. 1:5 year flood</td></tr>
<tr><td>9. 1:10 year flood</td></tr>
<tr><td>10. 1:20 year flood</td></tr>
</table>

Generic lists
When recording the consequences of each considered flow change, the specialists consider any number of sub-components that may be relevant to their ecosystem components. These are contained in Generic Lists for each component (Section 2.2.1).

Severity ratings
Each consequence is accompanied by a Severity Rating (Table 2), which indicates (1) if the sub-component is expected to *increase* or *decrease* in abundance, magnitude or size; and (2) the *severity* of that increase/decrease, on a scale of 0 (no measurable change) to 5 (very large change). The scale accommodates some uncertainty, as each rating encompasses a range in percentage gain or loss. Greater uncertainty can be expressed through providing a range of severity ratings (i.e. a range of ranges) for any one predicted change (after King *et al.* 2002).

Integrity ratings

To assist with the eventual placement of flow scenarios within a classification of overall river condition, the Severity Ratings are taken further to indicate whether the change would be a shift toward or away from the natural condition. The Severity Ratings hold their original numerical value of between 0 and 5, but are given an additional negative or positive sign, to transform them from *Severity Ratings* (of changes in abundance or extent) to *Integrity Ratings* (of shift to/away from naturalness), where:

- *toward natural* is represented by a positive Integrity Rating;
- *away from natural* is represented by a negative Integrity Rating.

Table 2. Severity Ratings for each prediction of flow-related change (King *et al.* 2002)

Severity rating	**Severity of change**	**EQUIVALENT LOSS** (abundance/concentration)	**Equivalent gain** (abundance/concentration)
0	None	no change	No change
1	Negligible	80-100% retained	1-25% gain
2	Low	60-79% retained	26-67% gain
3	Moderate	40-59% retained	68-250% gain
4	Severe	20-39% retained	251-500% gain
5	Critically severe	0-19% retained; includes local extinction	501% gain to ∞: up to pest proportions

GENERIC LISTS

For each considered flow change at each study site, the affect on each selected item on the Generic List is described. Each specialist's list may consist of any number of items, but usually four to less than twenty (Table 3). For each flow reduction at each study site, the affect on each item on each list is described. The list items may include anything that increases or decreases in abundance or size, such as species or habitats, and are chosen based on their known susceptibility to flow changes, their role as key species or features, or their relevance to subsistence users. In the Lesotho study (King *et al.* 2000), about 130 items were included in the various lists and, with all eight study sites and flow-change levels considered, more than 20,000 consequences were recorded. These were entered into a custom-built database.

Table 3 Examples of entries in generic lists for an environmental flow study for the Lesotho Highlands Water Project (King *et al.* 2000)

Discipline	**Generic list entry**	**Description of the links to flow (upper entry) and social relevance (lower entry)**
Geomorphology	Deposition of colloidal material	Minimum velocity for maintenance of movement of colloidal material in main channel = 0.05 m s^{-1}.
		Muddy areas are linked to loss of cobble habitat, increased algal growth, bogging of livestock, and gastric illnesses.
Water quality	Nutrient levels	Nutrient levels in pools increase under low flow conditions. Water in pools flushed by > Class II floods.
		High nutrients encourage algal growth, which is linked to increased incidence of diarrhoea in people and livestock, and loss of cobble habitat.
Vegetation	*Chenopodium album*	Found mostly in the wetbank vegetation zone, the width of which is reduced by a reduction in the volume and variability of lowflows and in the number of Class I floods. Abundance is affected by narrowing the zone.

		Important source of firewood. Also used as a medicine.
Fish	Maluti Minnow	Inhabits quiet, shallow waters in rocky reaches with high water quality
		IUCN Red Data Book rare species. Restricted to the Highlands of Lesotho. Threatened with extinction.
Invertebrates	*Simulium nigritarse*	Filter feeder in slow, eutrophic water.
		Blood-sucking pest of poultry.

THE DRIFT BIOPHYSICAL DATABASE

Data contained in the database

The output of the DRIFT specialist sessions is a matrix of consequences, completed by the specialists, for a range of possible reductions (or additions) in the ten flow categories (Table 1). These data are entered into the DRIFT database (
Figure 1), together with information on the data sources used.

In summary, each entry within the database consists of (Table 4):

- a site name
- a flow reduction from (or addition to) the present-day status of one of the low or high flow categories (e.g. presently an average of four Class 2 floods per annum: reduce to two per annum);
- the consequences of this for a range of ecosystem components (e.g. plants) and their sub-components (e.g. algae), expressed as:
    - the direction of predicted change (increase or decrease in abundance);
    - the extent of change (Severity Rating);
    - the expected impact on river condition, relative to natural (Integrity Rating);
    - descriptions of the ecological and social significance of the predicted change;
- the volume of water required to deliver this flow, expressed as $m^3 \times 10^6$ per annum for each of the ten flow classes, per season and per annum.

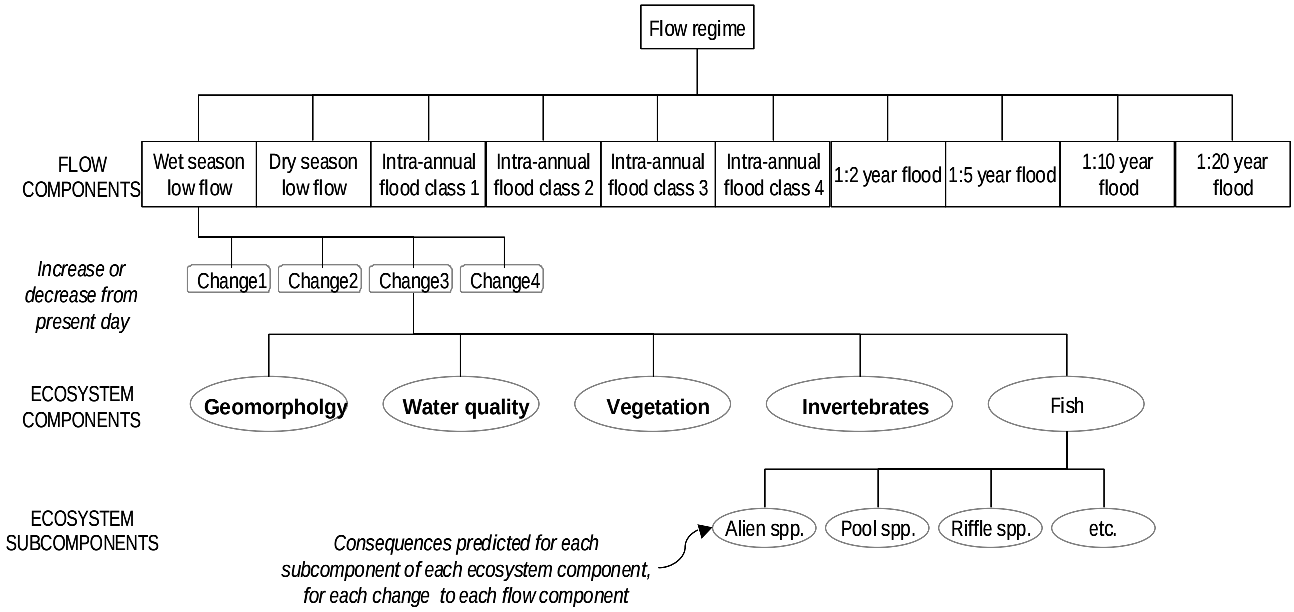


Figure 1. Framework for consequences of reductions (or additions) in low or high flows for ecosystem sub-components.

Table 4. Example of a consequence entry in the database for one ecosystem sub-component

Type of information	Information
Site	2
Flow reduction level	Reduction level 4 of dry-season low flows
Component	Invertebrates
Sub-component	*Simulium nigritarse*
Direction of change in abundance	Increase
Severity Rating	5: critically severe
Integrity Rating	–5: away from natural
Ecological significance	Filter feeder in slow, eutrophic water
Social significance	Blood-sucking pest of poultry
Volume of water	12 m^3 x 10^6 per annum

Structure of the database

The DRIFT database comprises six Excel worksheets that can loosely be divided into two groups: data storage, and scenario creation and evaluation (Figure 2; Brown & Joubert in prep.). In the second group, integer linear programming (Winston 1994) is used to recombine a selected change level for each flow category into a modified flow regime and describe its consequences, using the software DRIFTSOLVER and DRIFT CATEGORY.

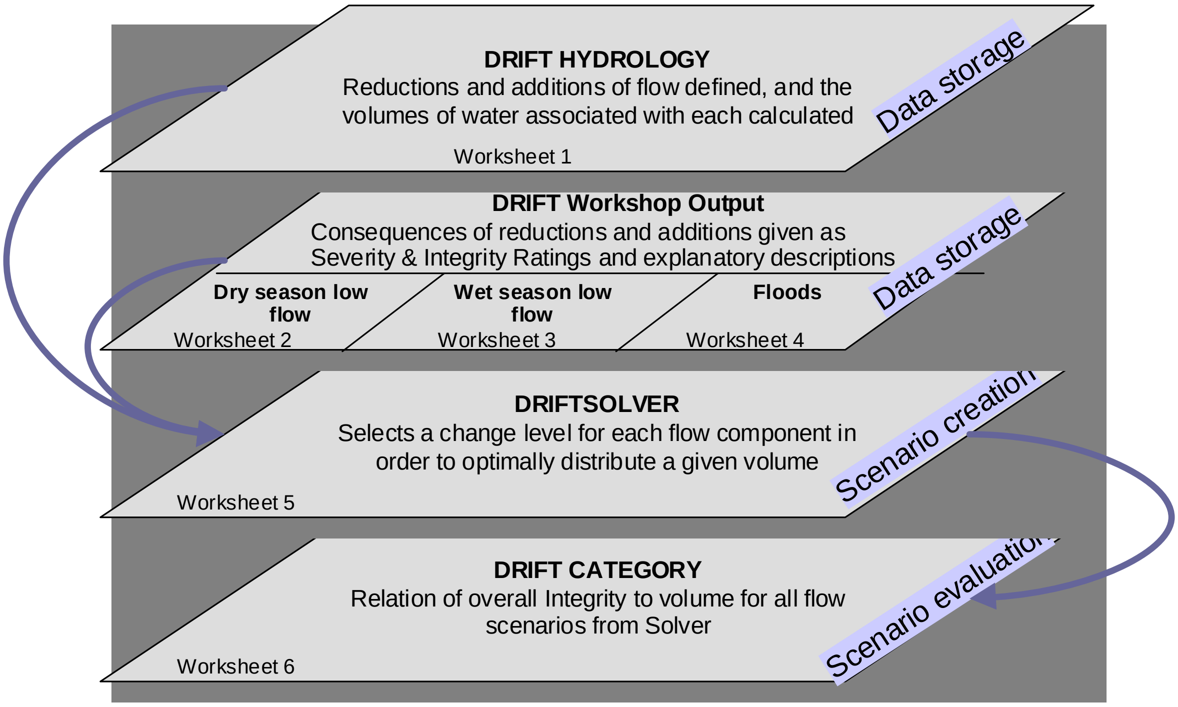


Figure 2. The Excel worksheets within the DRIFT database (from Brown & Joubert in prep.).

In DRIFTSOLVER, the integer linear program optimises the distribution of a given total volume of water among different change levels of flow categories in a way that results in the lowest aggregate impact on the riverine ecosystem according to the Integrity Ratings. It does this by summing the Integrity Ratings of all the sub-components, taking into account all the negative or positive signs, to produce combinations of high and low flows that return the highest possible Overall Integrity Score for that volume.

DRIFT CATEGORY provides a summary of many scenarios, showing the relationship between overall river condition and volume of water remaining in the river. The shape of the plot is specific for the river site under its present flow and management conditions, and is based on the "least-damaging" mix of high and low flows. The plot can be used to examine the relationship between volume of water and ecosystem integrity, and identify features such as inflection points where a small change in flow is linked to a large change in integrity status. Although DRIFTSOLVER automatically searches for the optimal distribution of low and high flows for any volume of water, DRIFT CATEGORY can be used to indicate the implications for river condition of non-optimal distributions of flows, such as may happen where large floods (e.g. > Class 2 floods) cannot be released through an upstream dam.

The DRIFT CATEGORY plots are intended for use in decision-making. The level of detail they provide is sufficient to inform the broad-level tradeoffs considered by decision makers when balancing potentially conflicting uses such as environmental protection versus agricultural development. The summary plots are, however, backed by the detailed consequence data provided by the specialists.

Detailed biophysical descriptions

Compilation of the detailed description of change for any flow scenario is not yet automated. When a flow scenario, with its descriptions, is compiled (whether manually or automated), this requires interpretation by one or more experienced river scientists as a quality-control measure. Examples from a detailed description are given in Table 5.

LINKS TO THE SUBSISTENCE AND ECONOMIC MODULES (not in Olifants/Doring Reserve determination)

The predicted changes in river condition could affect the lives and livelihoods of common-property subsistence users of the river (the PAR). Thus, the biophysical scenarios created by DRIFTSOLVER are used as the template for developing social scenarios and their economic implications. For each scenario, site and resource, the impacts are ranked as none, low, moderate and severe, using expert opinion and considering the following issues (Sabet *et al*. 1999):

- the level of predicted change of a resource;
- importance of the resource for the livelihoods of the affected populations;
- number of households harvesting the resource;
- frequency of usage of the resource;
- availability of alternative resources.

The categories of social impact are broadly defined as follows:

None: No appreciable change expected.

Low: The resource is not important or, if important, its quantity is predicted to change by less than 20%.

Moderate: The resource is important, and its quantity is predicted to change by 20-50%.

Severe: The resource is considered essential for the livelihoods of the PAR; **and** it is used by >20% of the PAR households; **and** the predicted biophysical change is > 50%.

The predicted impacts on health of each of the scenarios takes into consideration:

- the wide range of factors influencing health in the PAR, some of which will have no links to the river;
- the extent of river use by members the PAR;
- the predicted biophysical changes that could influence people's health.

Table 5 provides an example of the considerations that were used to create the link between biophysical changes in the river and a listed PAR health concern. The column 'Ecological link' lists some parts of the ecosystem that could change with a flow change, and an explanation of how this could affect people and their livestock. The weighting indicates the importance of this to the health issue under discussion. The 'Onset' entry indicates the time span over which the impacts described in column 1 may become apparent. The likelihood of the ecological conditions described in column 2 developing is given in the biophysical scenarios developed in DRIFTSOLVER.

Table 5 Examples of health-related ways a river ecosystem could change, and the relevance of this for diarrhoeal and eye and skin diseases among the PAR (Sabet *et al.* 1999). Columns 1 and 2 should be considered together. Explanation in text.

Ecological link	Weighting	Onset (years)
Colloids An increase in colloidal material allows diarrhoeal, disease-causing organisms such as *Giardia* to remain in the river for longer, thus increasing the chances of people becoming infected either through contact (skin and eye infections) or consumption (diarrhoeal disease).	High	2-10
<u>Total Dissolved Solids</u> Drinking turbid water with high TSS levels does not necessarily have direct health effects, but such effects can occur when infectious disease agents adsorb onto the particulate matter.	High	2-10
<u>Algal blooms</u> High summer flows flush algae from the river, but low winter flows allow the plants to accumulate in quiet areas. Loss of flushing flows will increase the risk of algal blooms, with resulting adverse health effects through swallowing algae-contaminated water	High	1-2
<u>Black flies</u> Increases in the numbers of blackflies can result in an increase in the level of irritation caused by their bites. Blackflies can also carry disease from faeces to food or utensils used by humans (faecal – oral route).	Low	1-2

VERIFICATION OF RESULTS ACHIEVED USING DRIFT

To date, DRIFT has been used in a predictive capacity, and insufficient time has passed for the accuracy of its predictions to be verified through monitoring. However, monitoring programmes aimed at verification of DRIFT biophysical and social predictions have been approved for the rivers downstream of Lesotho Highlands Water Project Phase 1 structures (LHDA 2003), and a programme for the verification of DRIFT biophysical results has been proposed for the Palmiet River, in the Western Cape, South Africa (Brown *et al.* 2000).

Additional support for the rationality of the results obtained using DRIFT was also forthcoming from a dual application of the BBM and DRIFT methodologies at three sites on the Breede River, Western Cape, South Africa, where the same team of scientists used the same data sets to provide environmental flow scenarios (Brown and King 2002; Brown and Louw 2002). The results obtained for the two methods were very similar in terms of:

- percentage MAR required to facilitate a desired river condition;
- temporal distribution of the annual volume of water allocated to the environmental flow.

A detailed analysis of the dual application, and the relative similarities, difference, advantages and disadvantages of the BBM and DRIFT that it illustrated is currently being compiled, and will be available mid-2003 (King & Brown in prep.).

RESEARCH NEEDS

The following aspects and concerns have been raised as possible areas of future development and research on DRIFT.

User manual:
Write a manual for DRIFT (funds granted by the South African Water Research Commission, for 2003/04).

Generic lists:
Expand and refine the drop-down lists of components, sub-components, elements and sub-elements. These lists exist in draft form for upland rivers, funded by the South African Water Research Commission. Generic lists need formulating for lowland rivers, floodplains and estuaries.

Hydrology
Explore additional hydrological parameters that express variability. Develop new hydrological parameters for generic list.

Large rivers - longitudinal interactions
Develop a process for the inclusion and consideration of biological and hydrological longitudinal interactions. Issues to include: the need of a species to migrate, the extent and route of that migration; which life stages migrate, bigger-scale processes and lateral process such as invertebrate drift.

Variability:
Build in natural variability, and natural changes in abundance. This may be possible using 'gates' in the system (e.g. and/or and if/then logical statements). Explore the possibility of using a Bayesian approach.

Weightings:
Assign weights that reflect the contributions of different sub-components to overall river condition.

Validation:
Calibrate DRIFT CATEGORY using monitoring results. There is also a need to check how synergistic affects would be dealt with in the model.

Automation:
Explore semi-automation of the detailed results, possibly through a Bayesian approach. Develop and semi-automate the social component. Incorporate subsistence use data into DRIFTSOLVER.

Floodplain rivers and fisheries:
Develop new hydrological parameters and determine appropriate time steps for floodplain rivers. For instance, there is some indication that it may not be necessary to look spatially at habitat in large rivers: multi-species approaches may be sufficient for EF concerns related to fisheries.

Anthropogenic effects:
Explore possible inclusion of feedback loops that will affect ecosystem functioning, such as:
Effects of exploitation of riverine resources;
losses that affect social groups differently;
effects of land-use on hydrological patterns.

Other models:

Explore the possibility for inclusion of conceptual models (e.g. from Australia).

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APPENDIX E CURRICULUM VITAE

Sylvia Georgiana Ractliffe (Geordie)

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Address	:	Freshwater Research Unit Tel: 021-650-4767 Zoology Department University of Cape Town, 7700 Email: geord@iafrica.com

Profession	:	Freshwater Ecologist
Experience	:	11 years
Qualifications	:	BSc (Hons)
Year of birth	:	1964
Nationality	:	South African
Specialisations	**:**	Freshwater ecosystem management, including compiling, implementation and monitoring environmental management plans. Experience in rehabilitation strategies for rivers and wetlands. Special interest in and specialist knowledge of the effects of natural and development-related impacts on river ecosystems and invertebrate assemblages, including the effects flow modification.

Languages: English, Afrikaans.

Background

Geordie Ractliffe has 11 years experience in river and wetland research and management. She has undertaken or been involved in ecological studies ranging from impact assessments of proposed dams, altered flow regimes and urban development on rivers, to assessments of instream flow requirements (IFR) for rivers, to developing and managing the implementation of Environmental Management Plans. She has particular experience in environmental management and monitoring programmes for rivers, during the construction phases of developments like road and dam construction, and in general landscape and urban river / wetland rehabilitation.
Geordie is currently researching the role of disturbance in invertebrate community structure for her PhD, and is the technical co-ordinator for the Berg River baseline monitoring programme, whose aim is to develop a conceptual model of ecosystem function against which the impacts of Skuifraam Dam can be monitored. She was also part of a team conducting a formative evaluation of the Working for Water programme nationally.

CAREER SUMMARY

Freelance consultant on freshwater ecosystems, recently trading as the Freshwater Consulting Group.	1998 to date
Director of Southern Waters Ecological Research and Consulting cc.	1995-1997
Part-time lecturer at the University of Cape Town	1995-1997
Environmental control officer (Dept. of Transport)	1991-1994

I confirm that the above CV is an accurate description of my experience and qualifications and that I am available and willing to undertake the components of the Olifants Doring Reserve determination allocated to me in this proposal.

Date:_______25.09.2003__ Signature:

APPENDIX F FORMAT FOR REPORTS

In order to ease the compilation of reports specialists are requested to adhere to the following points regarding the format of their documents. If you are unsure of any of the following instructions please contact either Cate or Charles at Southern Waters. The formatting procedures adopted in the Inception Report (of which you will all receive a copy) should be used as a template for future documents.

The following general formatting guidelines apply:

1. All reports should be written in MS Word.
2. All reports are to be written in Arial 11 point regular, with all text single-spaced and justified.
3. Tabs should be set using the correct procedure in MS Word. Please do not use repeat tabs to align your text.
4. All bullets are to be aligned at 1 cm from the left hand margin.
5. Only three levels of headings are to be used in reports, starting with Level 2. The actual format of the headings does not matter, but the headings must be correctly designated as Heading Level 2,3 or 4 in Ms Word. All other text in your reports must be designated as normal.
6. Please only use ONE line between headings.
7. Do not include headers and footers.
8. Do not insert section breaks in reports. If a different orientation is required (i.e., landscape) then please include the relevant section in a different file, and use an asterix to denote its position.
9. When compiling reference lists please adhere to the format in the Inception Report. Author names are written in capitals and dates in brackets. Please do not use hanging indents when compiling reference lists.

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