KROMME/SEEKOEI CATCHMENTS RESERVE DETERMINATION STUDY – TECHNICAL COMPONENT

KROMME/SEEKOEI MAIN REPORT: FINAL

February 2007

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KROMME/SEEKOEI CATCHMENTS RESERVE DETERMINATION STUDY – TECHNICAL COMPONENT
MAIN REPORT: FINAL

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EXECUTIVE SUMMARY

This report is a summary of the main objectives, outcomes and results of the Kromme / Seekoei Reserve Determination Study. The approach followed for the rivers and estuaries are outlined. Although a comprehensive EWR assessment was required for the study area, the level at which the study could be undertaken was limited by available data. The Kromme River study was conducted at an *intermediate* level of assessment, while the additional Diep River study (conducted in 2005) was conducted at a *rapid (III)* level. The Kromme Estuary assessment was conducted at a *comprehensive* level of assessment. The Seekoei studies were both conducted at a *rapid* level of assessment.

A socio-economic assessment was added as a Variation Order to the Reserve study, and socio-economic as well as ecological consequences of various flow scenarios were investigated.

A short groundwater study was conducted, i.e. to develop a *Scope of Work* for a Groundwater Reserve Study. A Groundwater Reserve Study was initiated as a separate contract between the Chief Directorate: Resource Directed Measures and the Institute for Groundwater Studies of the University of the Free State – the Executive Summary of the ensuing report is shown as an appendix to this document.

Training and capacity building was not conducted as a separate task to the study, but was incorporated into existing tasks as training components. The summary shown in this document covers the aims of capacity building and training, mentor-trainee teams and brief conclusions and recommendations for future training. Information-sharing took place with regional DWAF offices by circulating progress reports and extending invitations to attend meetings and workshops.

Public participation was not conducted as part of the study, with public awareness and information sharing limited to the distribution of short information documents at the beginning and end of the study.

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TERMINOLOGY AND ACRONYMS

ASPT	Average Score Per Taxon
BAS	Best Attainable State
BBM	Building Block Methodology
BFI	Base Flow Index
BHNR	Basic Human Needs Reserve
CD: RDM	Chief Directorate: Resource Directed Measures
DLF	Drought Low Flow
DO	Dissolved Oxygen
DRIFT	Downstream Response to Imposed Flow Transformation
DRM	Desktop Reserve Model
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EC DWAF	Eastern Cape Department of Water Affairs and Forestry
EHI	Estuarine Health Index
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FD	Fast and Deep
F-SR	Flow-Stressor Response
FRAI	Fish Response Assessment Index
FS	Fast and Shallow
GAI	Geomorphological Response Assessment Index
GDP	Gross Domestic Product
GSM	Gravel Stones Mud
HFSR	Habitat Flow Stressor Response
HSI	Habitat Suitability Index
IERM	Intermediate Ecological Reserve Methodology
IFR	Instream Flow Requirement
IGS	Institute for Groundwater Studies
IRAI	Invertebrate Response Assessment Index
LSU	Large Stock Units
MAR	Mean Annual Runoff
MCDA	Multi Criteria Decision Analysis
MLF	Maintenance Low Flow
MV	Marginal Vegetation
MVIC	Marginal Vegetation in Current
MVOC	Marginal Vegetation out of Current
NGDB	National Groundwater Database
NMMM	Nelson Mandela Metropolitan Municipality
RHP	River Health Programme
RQOs	Resource Quality Objectives
RQS	Resource Quality Services
RU	Resource Unit
SASS5	South African Scoring System version 5
SD	Slow and Deep
SI	Socio-cultural Importance
SIC	Stones in Current
SOOC	Stones out of Current
SS	Slow and Shallow

TPC	Threshold of Potential Concern
VEGRAI	Riparian Vegetation Response Assessment Index
VMAR	Virgin Mean Annual Runoff
VIC	Vegetation in Current
VOOC	Vegetation out of Current
WMS	Water Management System
WP	Wetted Perimeter
WQ	Water Quality
WQSU	Water Quality Sub-Unit
WQU	Water Quality Unit
WTW	Water Treatment Works
WRYM	Water Resource Yield Model
WRSM90	Water Resources Simulation Model 1990

1 INTRODUCTION AND BACKGROUND

1.1 Background

The National Water Act (NWA, Act No. 36 of 1998, Section 3) requires that the Reserve be determined for rivers and estuaries, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. It is therefore imperative that the Reserve be determined and requirements met before other economic activities can be satisfied. As the Department of Water Affairs and Forestry (the DWAF) is the custodian of the nation's water resources, it is the DWAF's responsibility to ensure the adequate protection and effective management of these resources. The Chief Directorate: Resources Directed Measures (CD: RDM) is the department within DWAF tasked with the responsibility of ensuring that Reserve or Ecological Water Requirements (EWR) assessments take place before licensing can proceed.

The CD: RDM identified the Kromme/Seekoei River catchments as requiring a comprehensive Reserve assessment before compulsory licensing can proceed, due to the apparent highly stressed nature of the catchments, over-utilisation of water resources and water quality problems in the Kromme, Seekoei and Swart rivers. Once Reserve requirements are available, a planning study can be undertaken to determine the availability of additional water for new developments. Other concerns include over-abstraction of well-fields by coastal towns in summer, and the impact of many illegal farm dams in the area.

1.2 Objectives

The study objectives were to use the Reserve Determination methodology to determine a range of Ecological Water Requirements and Operational Scenarios for the Kromme/Seekoei River system, and to examine the consequences of each of these scenarios on the system's ecology and the socio-economics of the area.

Detailed determinations of the requirements of the Ecological Reserve were therefore required in order to confirm current perceptions of water availability and the water quality state in the study area and aid future water resources planning and management. The Reserve study therefore provides information that will aid decision-making in the catchment area, particularly regarding what can be achieved within present constraints.

Although a comprehensive EWR assessment was required for the study area, the level at which a study can be undertaken is determined by the data available for use. The Kromme River study was conducted at an ***intermediate*** level of assessment, while the additional Diep River study (conducted in 2005) was conducted at a ***rapid (III)*** level. The Kromme Estuary assessment was conducted at a ***comprehensive*** level of assessment. The Seekoei studies were both conducted at a ***rapid*** level of assessment.

1.3 Study tasks

The main tasks undertaken in the study, and where the results are located in the document, are shown below:

Table 1-1 The main tasks undertaken for the study

Task	Chapter
Inception, Planning and Process	2
Delineation of Study Area	3
Groundwater Terms of Reference	4
Hydrology and System Analysis	5
Ecoclassification	6 + 7
Ecological Water Requirements	8
Development of Operational Scenarios	9
Ecological Consequences	10 + 11
Socio-economics	12
Ecospecs and Monitoring	14 + 15
Capacity Building and Training	16

Additional components that were incorporated into the study in 2005 are as follows:

- **Basic Human Needs Reserve:** This task was conducted to provide additional social information to the study. Results are shown in Chapter 12.
- **Goods and Services:** The implication of various operational flow scenarios on the goods and services functions of the Kromme/Seekoei system was assessed. A social profile of the area contributed to this report. Results are shown in Chapter 12.
- **Economics:** A formal market economic study was necessary to determine the economic implications of the operational scenarios. Results are shown in Chapter 12.
- **Groundwater Reserve:** A groundwater Reserve study was initiated in 2005/2006 by the Institute for Groundwater Studies. Although this study was conducted as a separate contract, the study results are shown in Appendix A.

1.4 Assumptions and limitations

- **Hydraulics:** Confidence in high flow assessments was low as no high flows for hydraulic calibration purposes were experienced during the course of the study.
- **Hydrology:** The hydrology data used in this study was based on the best available hydrological data. Observed hydrology was extremely limited due to a lack of gauges in the catchments. Present use data requires verification (numerous alleged illegal farms dams are present in the system).
- **Water quality:** Water quality data were very limited for the rivers and estuaries in the study area, with no or little Reference Condition data available for most sites.
- **Estuary data:** Due to the construction of the dams pre-dating estuarine research on the system, limited data exists for any state other than the marine-dominated state.
- **Classification System:** There was no formal classification system as required by the National Water Act for integrating the results of the ecological and socio-economic consequences to decide on the Management Class. (The preparation of this document and presentation of results are in the absence of a Classification System).
- **Groundwater study:** Note that no attempt has been made to ascertain links between ground and surface water. The groundwater Reserve study (Appendix A) was initiated as a separate contract with the CD: RDM – results are therefore presented for information only.

- **Stakeholder participation:** Stakeholder involvement in this study has been at the level of building awareness only. A Background Information Document (June 2004) and Findings Information Document (June 2006) were distributed to stakeholders.

1.5 Project team

The lead consultant for the study was Coastal and Environmental Services, with the project leader being Dr Patsy Scherman, the financial manager Dr Angus Paterson, and the project administrator Ms Marina van Zyl.

The Reserve study encompassed a team of approximately 30 specialists and included the following organizations:

- Coastal & Environmental Services
- IWR Source-to-Sea
- Water for Africa
- Ninham Shand (Pty) Ltd
- Institute for Water Research (Rhodes University)
- Geography Department, Rhodes University
- Umgeni Water
- Nelson Mandela Metropolitan University (previously University of Port Elizabeth)
- Freshwater Research Unit, University of Cape Town
- Council for Scientific and Industrial Research
- Laughing Waters
- Anton Bok & Associates
- Streamflow Solutions
- Integrated Environmental Assessments
- University of Stellenbosch
- South African Institute for Aquatic Biodiversity
- IWR Catchment Consultants
- Anchor Consulting
- SA Geoconsultants, Eastern Cape Division
- Perisseuo Consulting
- Conningarth Economists

The team was supported by input from the DWAF. In particular, the following persons and divisions have been instrumental in providing guidance and support.

- Chief Directorate Resource Directed Measures (CD: RDM)
- Eastern Cape Regional Office, particularly Mr Flip de Wet
- Resource Quality Services: Dr Neels Kleynhans and Ms Christa Thirion
- Dr Suzan Oelofse: reviewer of the Water Quality Report

The project was managed by Mr Erik van der Berg of Ninham Shand, Cape Town, and various members of Common Ground Consulting.

2 PROJECT PROCESS

2.1 Overview and objectives

A project plan, based on a well-designed process, was required to ensure successful completion of the project on brief, on time and within budget. The process was designed during the initial stages of the study, and was incorporated into a project plan. It was required that the project plan follows the RDM processes which was described in DWAF 1999 and refined in DWAF (2003). During the study period minimal deviation from the accepted plan was required.

The aims, objectives and proposed outcomes of the study were the following:

- To recommend Ecological Categories (ECs) for each relevant section of river and estuary.
- To identify alternative ECs.
- To determine Ecological Water Requirement (EWR) scenarios for each of these ECs.
- To determine the impact of EWR scenarios on the allocatable yield and, based on the impacts, devise additional scenarios to optimise the allocatable yield.
- To determine the ecological consequences of each of these scenarios.
- To provide the DWAF with all information relevant to the ECs and other issues, to enable the DWAF to recommend a scenario that will become the Reserve, and summarise all the technical information and provide to the DWAF.
- To provide the ecological specifications (EcoSpecs), as input to the Resource Quality Objectives (RQO), associated with the EC.
- To design a monitoring programme to ensure compliance to the EcoSpecs.
- Training of selected students and specialist trainees in specific tasks relating to Reserve determinations.

The Reserve process is a scenario-based approach. The technical team therefore generated a series of likely scenarios that was determined by an interactive series of discussions between key specialists of the technical and management teams. This approach enabled the DWAF to make management decisions using scenarios based on a number of alternatives with anticipated consequences.

2.2 Approach

2.2.1 Project plan

The generic 8-step Ecological Reserve procedure (as taken from the DWAF (2003)) is illustrated in Figure 2-1.

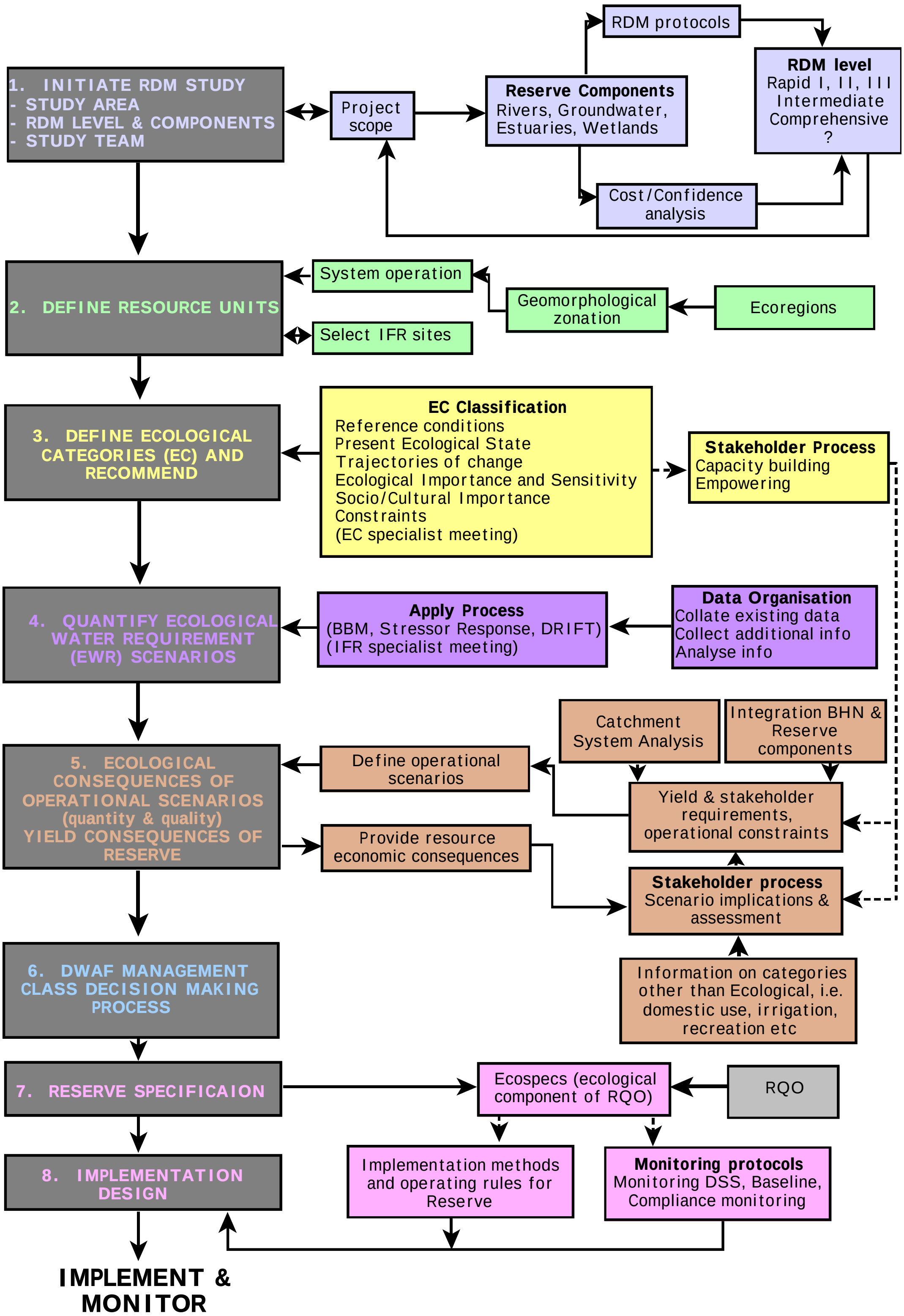

Figure 2-1 The RDM 8-step process

The RDM process is summarised as it was modified for application in the Kromme/Seekoei Reserve study.

The project plan steps were implemented in the form of a range of tasks summarised as follows:

TASK 1 Determining Resource Units
TASK 2 River Ecological Categories
TASK 3 Ecological Water Requirement (EWR) Scenarios for Rivers
TASK 4 Development of Operational Scenarios
TASK 5 EWR: Estuaries
TASK 6 Ecospecs and Monitoring

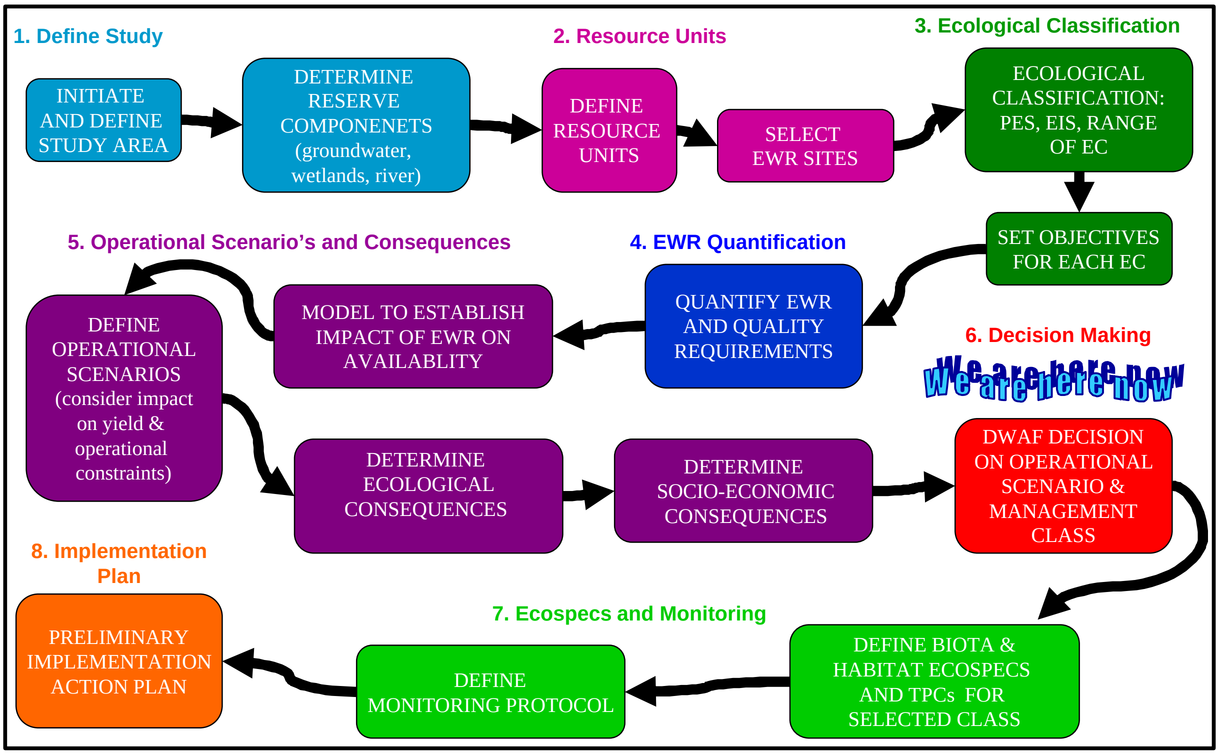

Figure 2-2 Implementation of project plan by means of a range of tasks

2.3 Linking of rivers and estuaries

The study addressed the Kromme and Seekoei estuaries and the Kromme (and Diep tributary), Seekoei and Swart rivers. Within the project plan and the generic steps, linkages between rivers and estuary had to be defined, as the estuarine flow requirements process assessess Ecological Water Requirement scenarios determined for the rivers.

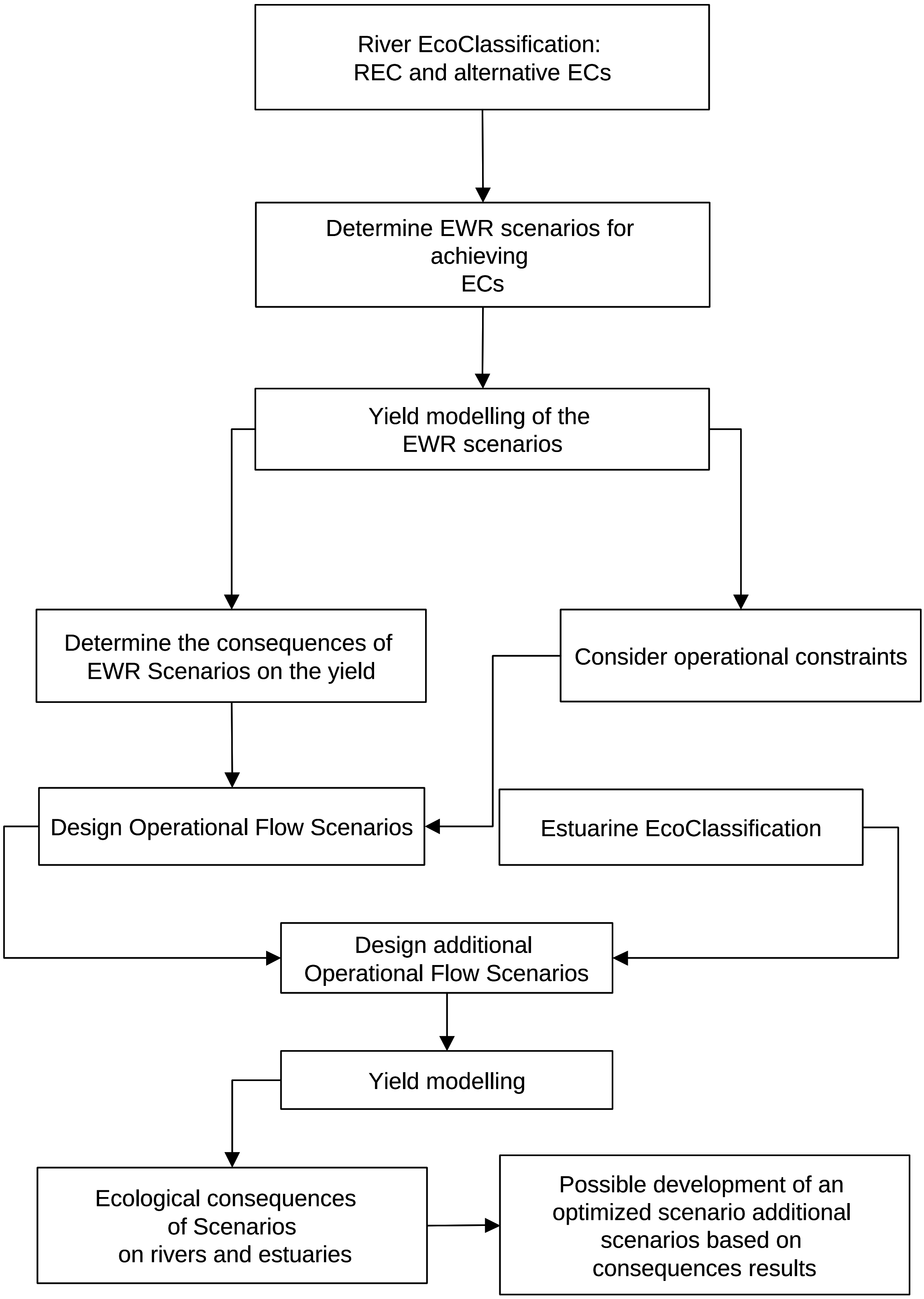

Figure 2-3 Links between rivers and estuaries within the project plan

The operational constraints of the dams, as well as the close proximity of Impofu Dam to the Kromme Estuary, has required an adjustment to the normal approach for an estuary study which would evaluate the EWR scenarios of the rivers as inflows to the estuaries. In this case the EWR river flows would mostly be contained in the dam and the inflows to the estuary could either be a river scenario designed for the short bit of river downstream of the dam, or an operational scenario specifically designed and based on estuarine requirements. Due to difficulties associated with the estuary study, it was therefore proposed that six scenarios be evaluated during the yield scenario stage, of which a number of scenarios would be estuary-driven.

2.4 Level of the study

Although a comprehensive EWR assessment was required for the study area, the level at which a study could be undertaken was determined by the data available for use. The Kromme River study was conducted at an ***intermediate*** level of assessment, while the additional Diep River study (conducted in 2005) was conducted at a ***rapid (III)*** level. A comprehensive study could not be undertaken for the Kromme system largely due to limitations in daily hydrological data and a poor water quality record. The Kromme Estuary assessment was conducted at a ***comprehensive*** level of assessment.

The Seekoei studies were both conducted at a ***rapid*** level of assessment as no gauging weirs were found in the Seekoei system, limited hydrological data existed and no systems model had been set up for this river.

2.5 Key milestones and deliverables

As part of the project plan, milestones and deliverables were identified and listed below in task sequence.

Table 2-1 Key milestones and deliverables

Task	Milestone / Deliverable	Proposed Date	Deviations
3.3	Inception Report (draft)	22/08/03	
3.3	Inception Report (final)		November 2003
3.5	Inception Report presentation meeting	15/09/03	
3.5	Client acceptance of Inception Report	26/09/03	04/03/04
3.6	Team Briefs and Appointments	29/09/03	Completed 17/2/04
4.7	EWR site selection survey	November 2003	
	Benchmarking of EWR sites (DWAF Geomatics)	November 2003	March 2004
4.8	Resource Unit Report (draft)	09/01/04	06/02/04
5.1.3	Biophysical data collection and analysis	November 2003	
	Detailed fish and invertebrate survey	February 2004	29/03/04 - 01/04/04
	Additional fish and invertebrate survey		Not undertaken
5.3	Field survey: socio-cultural importance	10-14 August 2004	
6.1.1	Hydraulic calibration and modelling	January, April, June 2004	March and August 2004
6.1.5	Specialist EWR: Rivers meeting	01/10/04	20-24/09/04
6.1.6	EWR: Rivers Report (draft)	05/11/04	28/1/05
7.1	Operational Scenarios Liaison Meetings (2)	16/11+ 07/12/04	16/11/04 only
7.4	Specialist River Ecological Consequences meeting	22/04/05	9-10 March 2005: **CANCELLED**
7.5	Systems Hydrology Report (draft)	03/06/05	September 2005
7.6	River Ecological Consequences Report (draft)	03/06/05	Short report to form part of the Main Report
7.7	Water Quality Report (draft)	03/06/05	November 2005
7.8	Preparation and submission of Briefing Document to DWAF	May 2005	March + April 2006
8	Estuary field survey	February + May 2004	
8.4	Specialist EWR Estuary meeting	25/02/05	23–25/02/05
8.5	EWR: Estuary Report (draft)	08/04/05	November 2005
9.1	River specialist meeting: Ecospecs and Monitoring	01/07/05	February 2006
9.2	Estuary specialist meeting: Ecospecs and Monitoring	01/07/05	Not required
9.3	Ecospecs and Monitoring Report (draft)	08/07/05	End May 2006
10	Groundwater Report (draft)	28/11/03	31/01/04

Task	Milestone / Deliverable	Proposed Date	Deviations
11	Main Report (draft)	19/08/05	End June 2006
VO1	Additional Scope	28/02/05	Tasks to be incorporated in VO3
VO2	Impofu Dam water quality sampling Diep River survey + workshop	December 04, January + February 05 9+10/03/05	December 04 + January 05
VO3	Proposed socio-economic study	June – November 2005	Oct 05 – end March 2006
VO3	Socio-economic study: final report		June 2006
	Associated Groundwater Reserve Study: draft report		June 2006

3 DELINEATION OF THE STUDY AREA

Note: This chapter is a summary of CES (2005), EWR Rivers Report No. RDM/ K90/ 01/CON/0405.

3.1 Overview and objectives

The Kromme and Seekoei/Swart rivers Reserve study involved quantification of the Ecological Water Requirements to meet particular objectives for the river systems, under a series of scenarios that would be defined during the course of the study. From the Reserve determination study, information would be made available in a manner that would allow the DWAF to make informed recommendations and decisions for the way forward towards compulsory licensing.

To conduct the Reserve determination study, it was necessary to delineate the study area into water Resource Units (RUs) which were significantly different from each other, in order to warrant their own specification of the Ecological Reserve. Within some of the RUs, specific study sites were selected called EWR sites.

The purpose of the delineation was to:

- Describe the study area
- Describe the process followed to define the RUs
- Provide the quantity and quality RUs (termed Water Quality Sub Units (WQSUs))
- Describe the process followed to select EWR sites within the RUs

3.2 Study area

The Kromme and Seekoei River catchments are situated in the Eastern Cape to the west of Jeffreys Bay in catchment area K90, in the Fish to Tsitsikamma Water Management Area (WMA 15). The Kromme/Seekoei area consists of 7 quaternary catchments (K90A – G), and is situated across two Ecoregions. The Kromme River is located in a narrow valley between the Suuranys and Tsitsikamma mountains, is approximately 95 km long and drains a catchment area of 1 125 km^2. The Geelhoutboom River is a significant tributary which flows into the Kromme River approximately 9 km upstream of the mouth. Other medium-sized tributaries include the Dwars River, the Witels, the Diep River and the Leeubos River. The Seekoei River flows to the east and flows to the sea across a fertile coastal plain, is approximately 35 km long and drains a catchment area of 502 km^2. The main tributary of the Seekoei is the Swart River, which joins it approximately 1 km upstream of the mouth (Bickerton and Pierce, 1988).

The study area was selected as follows (Figure 3-1):

- The Kromme River from below the Palmiet Wetlands to the estuary, including the estuary.
- The Geelhoutboom River, tributary of the Kromme River.
- The Seekoei River, including the estuary.
- The Swart River, tributary of the Seekoei River.
- The Diep River was added as a Variation Order to the study.

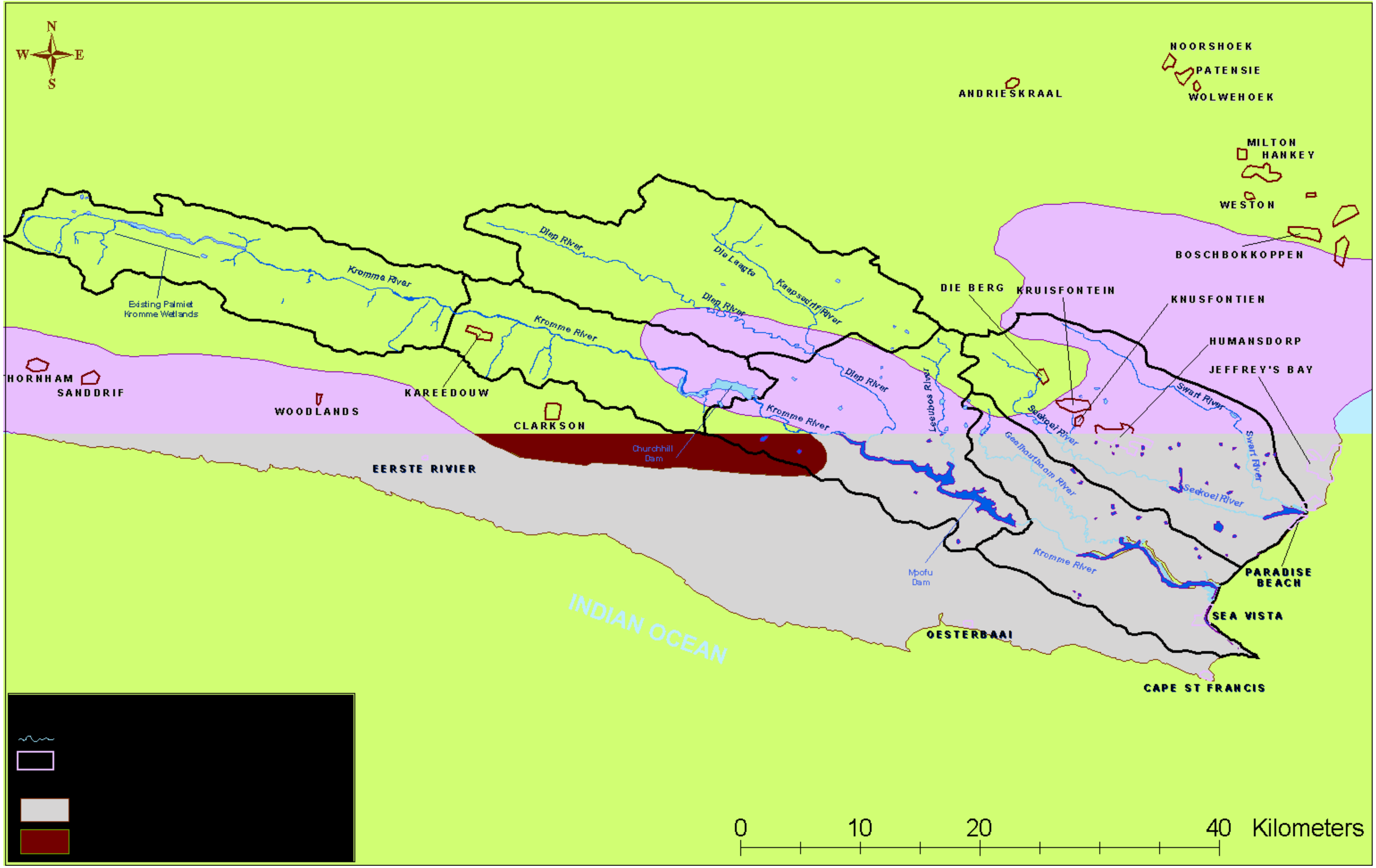

Figure 3-1 Study area

3.3 Approach

The breakdown of a catchment into RUs for the purpose of determining the Ecological Reserve for rivers was done primarily on a biophysical basis, according to the occurrence of different ecological regions (ecoregions) within the catchment. Since the endpoint of this Reserve determination was an ecological one, the concept was to delineate the catchment into units which were relatively homogenous on an ecological basis. This would ensure that the Ecological Reserve was set in appropriate terms. Delineations could then be further resolved into smaller RUs which were suited to management requirements.

The process for determining RUs considers the results of various delineations. Overlaying all the data did not necessarily result in a logical and clear delineation, and expert judgement, a consultative process and local knowledge is required to determine the RUs. The practicalities (in terms of budget and time) of dealing with numerous reaches within one study; was also considered to determine a logical and practical suite of RUs.

The following were considered during the Kromme study:

- Ecoregions – Level 2
- Geomorphological classification
- Water quality
- Operation of the system
- Hydrology
- Habitat integrity
- Local knowledge and expert judgement

3.4 Results

3.4.1 Ecoregions

The ecoregion typing approach developed in the USA (Omernik, 1987), was applied and tested at a preliminary level in South Africa. Ecoregional classification or typing would allow the grouping of rivers according to similarities based on a top-down approach. The purpose of this approach was to simplify and contextualise assessments and statements on Ecological Water Requirements. One of the advantages of such a system was the extrapolation of information from data rich rivers to data poor rivers within the same hierarchical typing context.

The Kromme catchment falls into two, Level 1 Ecoregions:

- 19 Cape Folded Mountains and
- 20 Southern Coastal Belt

The Level 2 Ecoregions are 19.02 and 20.02.

3.4.2 Geomorphological stream classification

The physical structure of a river ecosystem is determined by the geomorphological processes which shape the channel. These processes determine the material from which the channel is formed, the shape of the channel and the stability of the bed and banks. The channel geomorphology in turn determines the substrate conditions for the stream fauna and flora, and the hydraulic conditions for any given flow discharge. Geomorphology therefore provides an appropriate basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems.

Rowntree and Wadeson (1999) have developed a hierarchical classification system which 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 geomorphological zones are indicated on the longitudinal profiles (Figure 3-2) and on figure (Figures 3-3, 3-4 and 3-5)

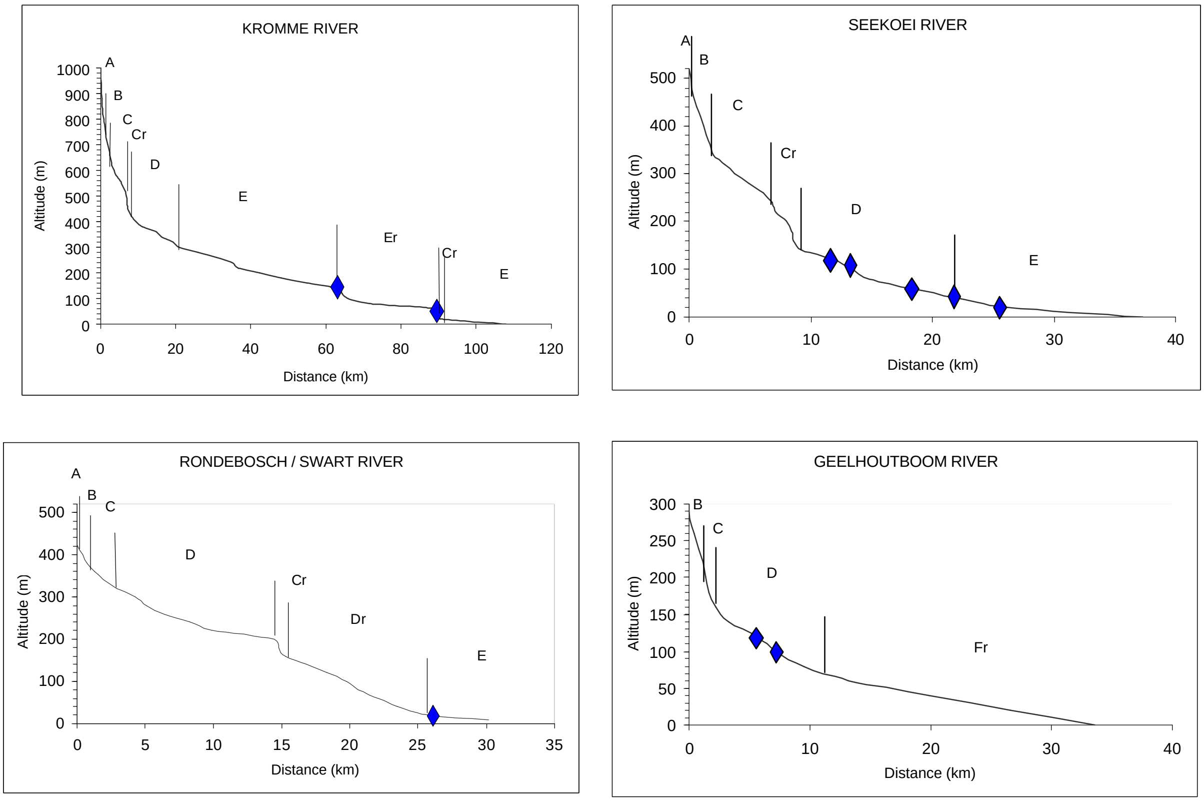

Figure 3-2 Longitudinal profiles

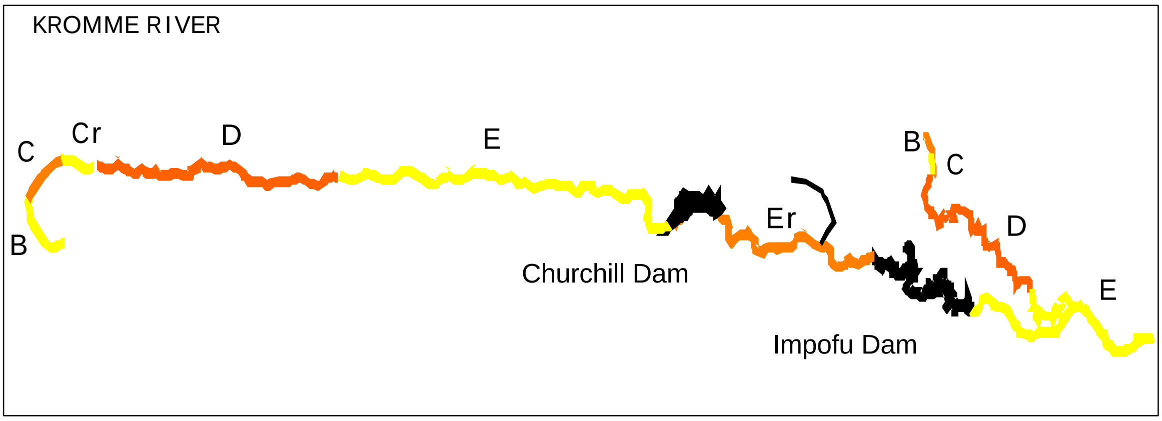

Figure 3-3 Kromme River geomorphological zones

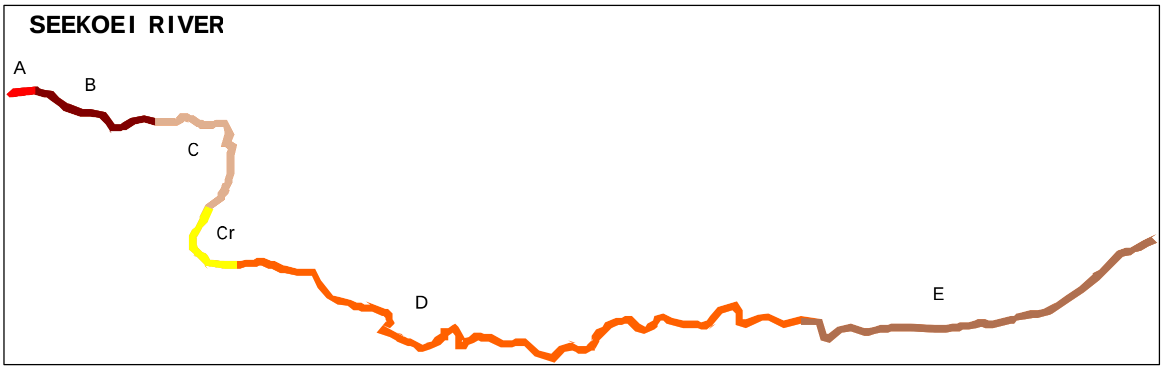

Figure 3-4 Seekoei River geomorphological zones

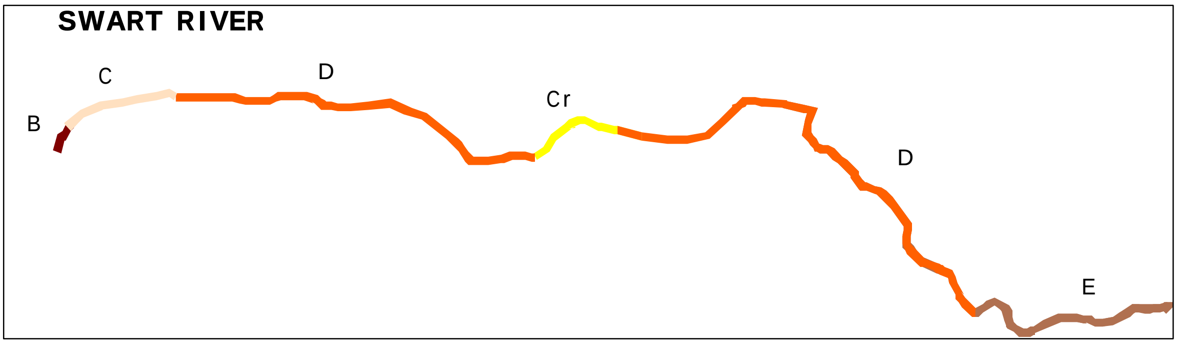

Figure 3-5 Seekoei River geomorphological zones

3.4.3 Water Quality Sub-Units (WQSUs)

The aim of deriving WQSUs is to divide stretches of river into homogenous sections in terms of water quality.

The selection of WQSUs was influenced by activities in the catchment, the availability of water quality data, and the length of the data series. The following information was accessed to assist in delineating WQSUs:

- A map of the catchment showing the location and names of the DWAF monitoring stations and their proximity to EWR sites, towns, dams, major tributaries and quaternary catchment boundaries
- Location of EWR sites within the WQSU.
- A list of the DWAF monitoring stations in the study area and the availability of water quality data from these stations.
- Background information on water quality conditions in the study area and activities that may impact on water quality, i.e. point and non-point sources of pollution.
- Level 2 Ecoregion boundaries.
- Information gained during site surveys, including biomonitoring and chlorophyll-a data.
- Information on the "system operational rules" (e.g. dam management) of the catchment, and potential effects of these on water quality.

WQSUs of the Kromme / Seekoei system are described in Table 3-1.

Table 3-1 Water quality sub-units and descriptive information for the Kromme / Seekoei Reserve study area

RU	WQSU	Description and map no.	Monitoring points	Land-use activities
KROMME RIVER				
A	1	From below Palmiet wetlands to below Melkhoutboskraal, just above Kareedouw town (Maps: 3324CC Witelsbos and 3324CD Kareedouw)	This stretch contains three WQ sites assessed in Oct '03, but two sites (Kammiesbos and Melkhoutboskraal) are monitored by EC DWAF. EC DWAF has a small database for the Melkhoutboskraal site.	This is mostly a wetland area fed by small streams. There is extensive farming in the area, e.g. Hendrikskraal (vegetables), Kammiesbos (cattle, pigs, goats etc.), Skaapdrift (sheep).
	2	Kareedouw town to below the charcoal factory on the outskirts of the town (Map: 3324CD Kareedouw)	This stretch contains three WQ sites assessed in Oct '03, but two sites (Assegaaibos Station, and below the charcoal factory (i.e. just above Goedgenoeg farm)) are monitored by EC DWAF. EC DWAF has a small database for the Assegaaibos Station site.	Impacts in this area are six oxidation ponds related to the towns wastewater treatment facility, Woodline (factory producing creosote poles), a Nestlé factory in town, run-off from town and the low-cost housing areas of Uitkyk and Kagiso Heights, and the small-scale charcoal factory below Kareedouw.
	3	From below the charcoal factory to the inlet of Churchill Dam (Map: 3324CD Kareedouw)	This stretch contains one WQ site assessed in Oct '03 at De Wilgen, but two other sites (Willowvale and Lemoenfontein) were checked for accessibility. EC DWAF continued monitoring one site at De Wilgen.	No significant tributaries are located in this stretch. Land-use is primarily agriculture and grazing. The river is encroached with Palmiet.
B	4	Wall of Churchill Dam to the inlet of Impofu Dam (Map: 3424BA Kruisfontein)	The stretch contains one WQ site assessed in Oct '03 at Diepriviermond Farm. EC DWAF continued monitoring this site. DWAF-WMS sites K9R001, K9H001, K9H002.	This area is mostly inaccessible (Krommeriviers Poort) until Diepriviermond Farm (a large dairy farm in the area).
C	5	Wall of Impofu Dam to just above the estuary (Map: 3424BA Kruisfontein)	The stretch contains one WQ site assessed in Oct '03. EC DWAF continued monitoring this site. DWAF-WMS sites K9R002, K9H003, K9H004, K9H006.	Primary land-use is dairy farming. The river is wider and deeper in this section, with no habitat for fish or invertebrate monitoring.
KROMME RIVER TRIBUTARIES				
	6	Dieprivier (Map: 3424BA Kruisfontein): This river was identified by Graham Devey of the Nelson Mandela Metropole laboratories as "good quality" and may act as a refugia area. As the river flows into Impofu Dam it has no impact on the Kromme River, but	One WQ site was assessed in Oct '03 in the lower section of the river. Data were accessed from NMMM as they routinely monitor this system, and have a database for this river.	Primary land-use is cattle farming.

RU	WQSU	Description and map no.	Monitoring points	Land-use activities
		may be a useful reference site.		
E	7	Geelhoutboom (Map: 3424BA Kruisfontein): The Geelhoutboom is a very small stream that flows only at times of good rains. There was some water in the channel at the time of the field survey, i.e. 22 October 2002, as it had rained a few days previously.	One WQ site was assessed in Oct '03. The site is downstream of the dam at Ebenezer, as an upstream site could not be found. EC DWAF continued monitoring this site.	Primary land-use is dairy farming. Below the road bridge there is a large illegal dam, which farmers are not allowed to use for abstraction (Meyer, pers. comm.).
SEEKOEI RIVER				
F	8	Upper section of the river to above Kruisfontein and Humansdorp (i.e. Orange Grove farm) (Map: 3424BA Kruisfontein)	One WQ site in this stretch was assessed in Oct '03. EC DWAF has a small database for this site. DWAF-WMS site K9H007.	This section of the river is mostly in game-farming area, and is above towns and townships. Some dairy farming is present along the lower section around Orange Grove Farm.
	9	Middle section of the river from the Kruisfontein discharge stream on Orange Grove Farm, to Geelhout Dam. This lower stretch of the Seekoei River was split by Geelhout Dam as inputs from Kruisfontein and Humansdorp would be trapped in the dam, resulting in water quality changes downstream of the dam (Map: 3424BA Kruisfontein and 3424BB Humansdorp).	One WQ site in this stretch was assessed in Oct '03, but it is above the Kruisfontein stream input, so will not be monitored in future. WQSU 9 and 10 were combined, as there is no suitable site in WQSU 9.	Primary land-use is dairy farming and urban areas (i.e. Humansdorp and Kruisfontein). Area is highly dammed.
	10	Below Geelhout Dam to above the estuary (Map: 3424BB Humansdorp)	There are two water quality sites assessed in Oct '03 in this stretch, i.e. on Soutvlei farm and around Lombardini. The Lombardini site is more accessible from the road, although very encroached by papyrus, and this one site was monitored by EC DWAF on a monthly basis.	This area has extensive dairy farms and some game farming, and is highly dammed. Due to the dams in the area and inconsistent rain, it is assumed that samples may not be taken at times, as there will not be water in the channel.

SWART RIVER				
H	11	This river is considered one sub-unit. There is very little water in the stream, with most of the small tributaries coming into the river being dammed.	Two water quality sites on this small river were assessed in Oct '03. One site is on the upper section of the stream under the road bridge on the R102, upstream of Swart River Dam and Jubilee Estates, and consists of a small stream and wetland (access difficult). The other site is downstream below Jubilee Estates and is a very small stream encroached by papyrus. This site is probably dry for much of the year, but is more accessible and this one site was monitored by EC DWAF when possible.	This area has extensive dairy farms, and is highly dammed. Due to the dams in the area and inconsistent rain, it is assumed that samples may not be taken at times, as there will not be water in the channel.

3.4.4 Index of Habitat Integrity (IHI)

The ecological integrity of a river is defined as its ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that is comparable to the characteristics of natural ecosystems of a specific region (Kleynhans, 1996). This definition is based on the concept of biological integrity. Essentially, the habitat integrity of a river will provide the template for a certain level of biotic integrity to be realised. In this sense the assessment of the habitat integrity of a river can be seen as a precursor of the assessment of biotic integrity. It follows that habitat integrity and biotic integrity together constitute ecological integrity.

Primary information on the integrity of the Kromme River system was collected by means of a helicopter survey of the system conducted during January 2003 by CD: RDM. The rivers were divided into 5 km segments from the top to the bottom of the predefined study areas. Land cover maps were also used to identify land uses.

Results are shown as figures in this chapter.

- **Kromme River – instream habitat integrity:** The instream habitat integrity of the Kromme River is a B category at the source. Thereafter it dropped to a category C for most of its length up to the Churchill Dam. The operations of the Churchill and Impofu dams had a significant modifying effect on the downstream flow regime, bringing this down further to a D category and almost as far as an E just before the estuary.
- **Kromme River – riparian zone assessment:** The riparian zone habitat integrity ranged from a category B just below its source to an E category upstream of the estuary. It dropped very rapidly due to the infestation of alien vegetation. A C category was attained in two gorge areas where alien vegetation had had a minor impact.
- **Geelhoutboom River - instream habitat integrity:** The instream habitat integrity generally remained in a C category from its source to its entry into the estuary.
- **Geelhoutboom River - riparian zone assessment:** The habitat integrity ranged from a D just downstream of its source to a B just before its entry into the estuary. The D category was largely due to the downstream impact of the dams on flow regime, the impact of inundation by the dams and the removal of vegetation in the upper reaches.
- **Seekoei River - instream habitat integrity**: The habitat integrity category of the river dropped continuously from a category B just below its source to a category E just before it flows into the estuary. This reflected the general poor management of the river.
- **Seekoei River – riparian zone assessment:** The riparian habitat integrity showed a similar trend to that of the instream component. This was largely due to the infestation of the riparian zone by exotic/alien vegetation, bank erosion from the removal of alien vegetation, impact of weirs and dams, and the general utilisation and neglect of the riparian zone.
- **Swart River - instream habitat integrity:** The integrity of this river varied from a B category just below its source to an E category just before it enters the Seekoei Estuary.
- **Swart River - riparian zone assessment:** The riparian habitat integrity varied from a C category to an E category just before the estuary. The river was generally infested by alien species, mainly Black Wattle, Gums and Poplar.

3.4.5 System operation

Two of the five major storage dams which supply the urban water demand of the NMMM are located on the Kromme River, *viz*. the Churchill and Impofu Dams. Although the main function of the Churchill/Impofu system is to supply water to the NMMM, there are some local demands on the system which include direct abstractions and releases for downstream riparian users from Impofu Dam. The environmental requirement of 2 Mm^3/a that is prescribed for the Kromme Estuary is not released from Impofu Dam. Some of the water that is released for the riparian users downstream of Impofu Dam may reach the estuary, but these releases will probably decrease in future, as one of the main downstream riparian users (Mr Gutsche) is currently constructing a pipeline to abstract water directly from Impofu Dam. No specific releases for downstream riparian users are currently made from Churchill Dam. However, the backwash water from the Water Treatment Works (WTW) located downstream of the dam is released into the river.

The town of Humansdorp, which is located in the Seekoei River subcatchment, draws water from boreholes and the Churchill supply pipeline and has little effect on the surface runoff in the catchment. However, a small scale irrigation scheme at Kruisfontein, to the north of Humansdorp, is planned for developing farmers, which will have some impact on the availability of water for downstream users. The feasibility study for this possible future scheme would however only commence following the Reserve determination.

3.4.6 Resource Units

The final Resource Units were the following:

Resource Unit A: Segment 4 - 11 (Kromme River above Churchill Dam) (Figure 3-6)

- RU A consists of one Ecoregion Level I with a break at Churchill Dam.
- RU A consists of two geomorphology zones which could be used to motivate for an additional RU.
- Instream habitat integrity are homogenous from the start of segment 4 to Churchill Dam.

The dam consisted of one operational zone consisting of run-of-river use.

The study area started below the wetlands, i.e. the start of the RU was Segment 4. Considering that this river was being assessed at an Intermediate Level.

Resource Unit B: Segment 14 - 15 (Between Churchill and Impofu dams) (Figure 3-6)

- RU B consists of one Ecoregion Level I.
- RU B consists of one geomorphology zone.
- Habitat integrity for both riparian and instream are homogenous.
- The dam consists of one operational zone linked to the management of both dams.

RU B therefore formed a logical unit between the two dams, i.e. the Churchill Dam wall and the upstream inundation point of Impofu Dam.

Resource Unit C: Segment 18 (Below Impofu Dam) (Figure 3-6)

- RU C consistsof one Ecoregion Level I.
- RU C consists of one geomorphology zone.
- Habitat integrity for both riparian and instream is homogenous.
- This section forms one operational zone.

RU C is very short and would normally not be treated as a separate unit as the estuary RUs could well have included the whole zone from the dam wall to the sea. RU C was therefore selected as a separate RU and stretched from the Impofu Dam wall to the bedrock dyke which indicated the start of the estuary zone.

Resource Unit D: Kromme Estuary (Figure 3-6)

Resource Unit E: Segment 1 to 4 (at estuary) (Geelhoutboom River) (Figure 3-6)

- RU E consists of one Ecoregion Level I.

- RU E consists of largely one geomorphology zone.
- Habitat integrity for both riparian and instream is largely homogenous.

Due to the short length of the river, RU E forms one logical RU from the source of the river, to the upstream end of the estuary. Most of the criteria used for delineation also supported the motivation for one RU.

Resource Unit F: Segment 1 to 3 (Seekoei River) (Figure 3-7)

- The Seekoei River falls largely in one Level I Ecoregion with only a small section of the upstream RU within another ecoregion.
- The upstream section of the river falls within various small geomorphological zones. The larger section of the river falls within two zones with the bottom section coinciding with segments 4 and 5.
- Habitat integrity for both riparian and instream was in a B category upstream, moving to a category C and then to a D. Outside of segment 3 it falls within an E category.
- Operationally the system is heavily utilised. Downstream of the town of Humansdorp instream farm dams are very common and there are hardly any sections of river left which are not impacted by inundation.

Due to the short length of this river, it would logically fall within one RU. The extent of development downstream of Humansdorp (segments 4 and 5) resulted in this section of the river not functioning as a river anymore. Ecological classification would probably identify this river as being in an E category. No suitable EWR site could be found in this RU and the estuary (RU G) requirements did adequately address this RU. Also, physical intervention was necessary to improve the present category of an E. The estuary (RU G) requirement dictated the operation of this section.

Resource Unit G: Seekoei Estuary (Figure 3-7)

Resource Unit H: Segment 1 to 3 (Swart River) (Figure 3-8)

- The Swart River fell in one Level I Ecoregion.
- The upstream section of the river fell within various small geomorphological zones. The larger section of the river fell within one zone.
- Habitat integrity for both riparian and instream was in a reasonable condition and then decreased.
- Operationally the system was heavily utilised with numerous farm dams.

Due to the short length of this river, it logically fell within one RU. RU I is shown on Figure 3-8 to indicate the length of RU H.

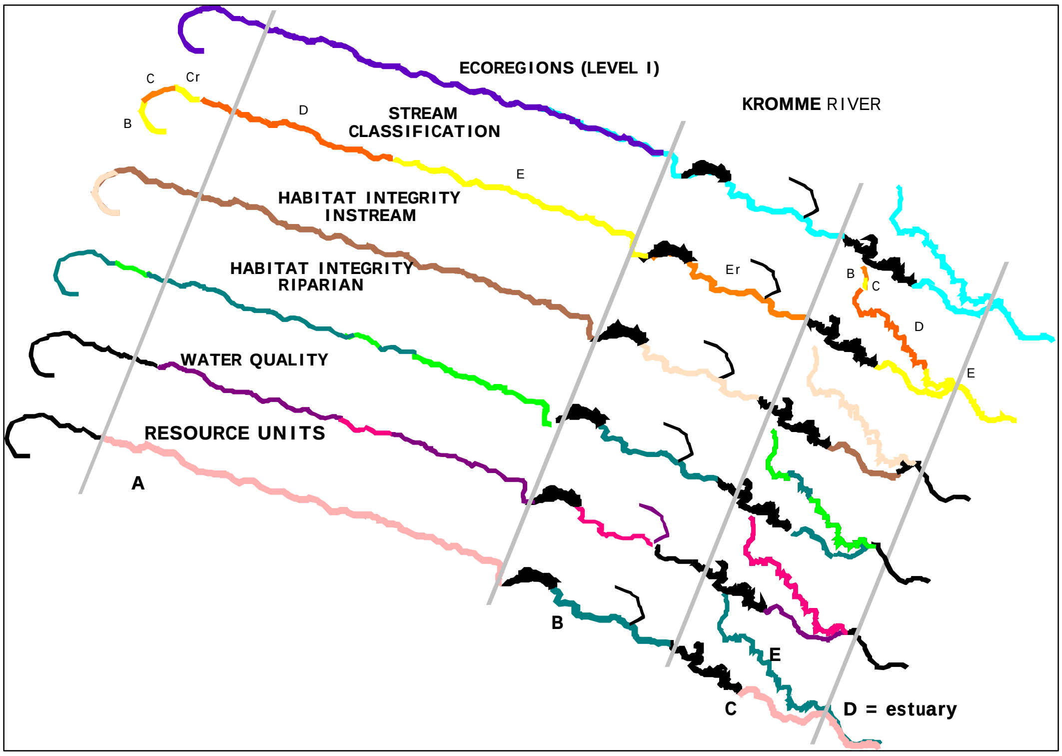

Figure 3-6 Resource Units A-E **(NOTE: The colours in these figures only reflect a change in category and do not refer to a category)**

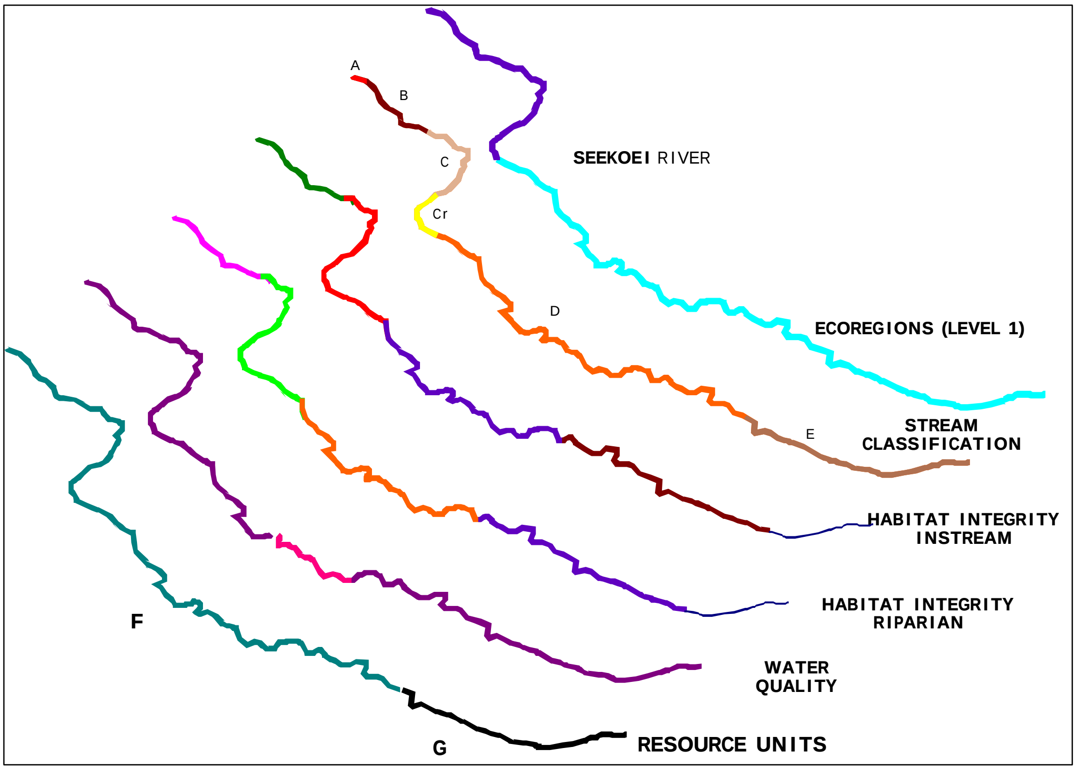

Figure 3-7 Resource Units F-G **(NOTE: The colours in these figures only reflect a change in category and do not refer to a category)**

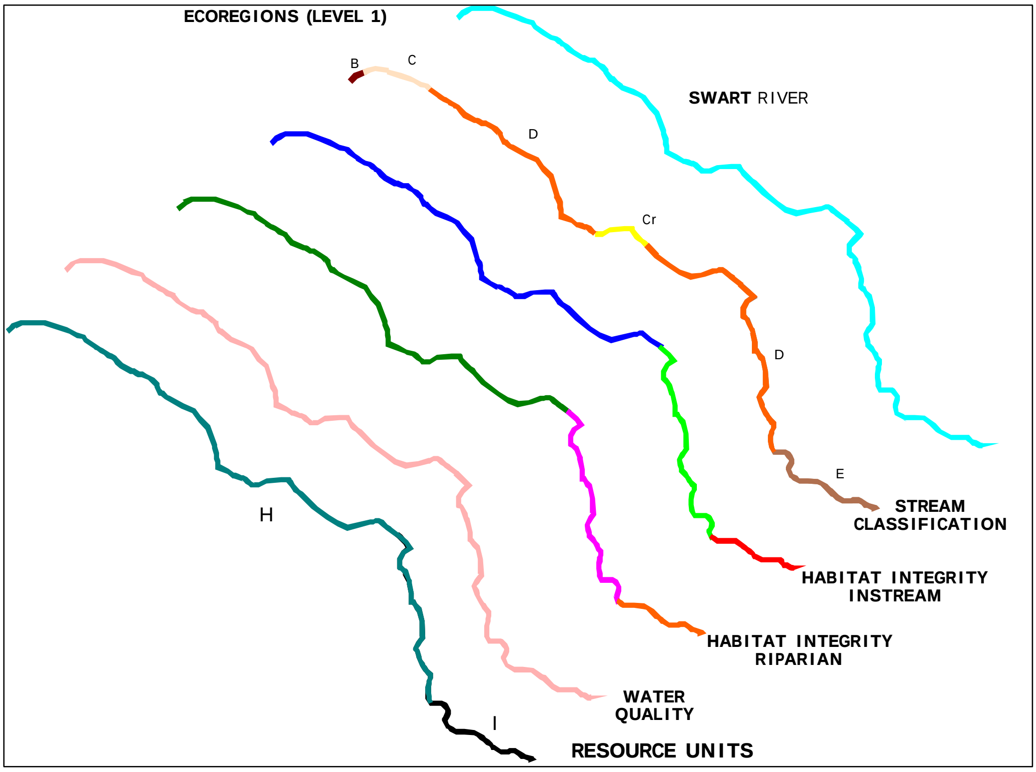

Figure 3-8 Resource Unit H **(NOTE: The colours in these figures only reflect a change in category and do not refer to a category)**

3.5 EWR sites

EWRs were set at specific points in the river. These points are called EWR sites and are critical sites within a reach of river. These EWR sites must meet certain criteria and a sequential process to determine the EWRs is required. The criteria are listed below:

- The locality of gauging weirs with good quality hydrological data.
- The locality of the proposed developments.
- The locality and characteristics of tributaries.
- The habitat integrity/conservation status of the different river reaches.
- The reaches where social communities depend on a healthy river ecosystem.
- The suitability of the sites for follow-up monitoring.
- **The habitat diversity for aquatic organisms; marginal and riparian vegetation.**
- **The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially for low flows.**
- **Accessibility of the sites.**
- **An area or site that could be critical for ecosystem functioning. This is often a riffle; which will stop flowing during periods of low or no flow. Cessation of flow constitutes a break in the functioning of the river. Those that are biota dependant on this habitat and/or on continuity of flow will be adversely affected. Pools are not considered as critical since they are still able to function as refuge habitats during periods of no flow.**
- **The locality of geomorphological reaches and representative reaches within the geomorphological reaches.**

The criteria in bold above are the most important and are therefore the overriding criteria.

Six EWR sites were selected, as shown on the study area map (Figure 3-1) and RUs and EWR sites are listed in Table 3-2.

Table 3-2 EWR sites and their location in the Kromme/Seekoei study area

EWR Site	River	Latitude	Longitude	Quaternary	RU
EWR1	Kromme	E 24º 15.680	S 33º 55.905	K90A	A
EWR2	Kromme	E 24º 29.865	S 34º 00.822	K90D	B
EWR3	Kromme	E 24º 43.6	S 34º 06.3	K90E	C
EWR4	Geelhoutboom	E 24º 44.723	S 34º 05.411	K90E	E
EWR5	Seekoei	S 33º 59.968	E 24º 42.113	K90F	F
EWR6	Swart	S 34º 00.05	E 24º 50.83	K90F	H
EWR7	Diep	S 34° 01.322	E 24° 35.557	K90D	

3.5.1 EWR site 1: Melkhoutboskraal (Kromme River)

One EWR site (Figure 3-9) was required in RU A. On the basis of the video and the photos and experience of the water quality team, three potential sites were identified. One of these sites seemed more suitable than the other two potential sites. This site was visited first, and the ground-truthing confirmed the suitability of the site, which was selected.

After the visit to this potential EWR site it was selected. The site is situated upstream of Kareedouw in segment 7 and in RU A. The site consists of a long cobble riffle with upstream and downstream pools and rapids. The riparian vegetation consists mostly of alien species such as Black Wattle.

One cross-section was located across the main riffle and another through the downstream pool.

Figure 3-9 EWR site 1

3.5.2 EWR site 2: Krommeriviers Poort (Kromme River)

This site (Figure 3-10) had to be situated in the gorge between Churchill and Impofu dams. No suitable site was identified from the video. One area with potential access was however identified and the river was visited at this point. The river is characterised in this section as consisting of large Palmiet floodplains, overgrown in places. Two possible sites where the river was contained within a distinct channel were visited. The downstream option was hydraulically more problematic than the upstream option and from all perspectives, apart from geomorphology; the upstream site was deemed to be more useful and therefore selected. The site consists of a cobble rapid with upstream and downstream pools. The site is situated immediately upstream of a low water crossing. A road impacts severely on the right bank. The left bank is overgrown with Black Wattle. Further from the river an old Palmiet floodplain exists which only has water during very high floods.

One cross-section was located through the riffle section and an upstream pool section will be selected during a later site visit.

Figure 3-10 EWR site 2

3.5.3 EWR site 3: Dyke (Kromme River)

Initially no site would have been situated in RU C. However during the site visit the following was discussed:

The overall objective of selected a site in this RU was questioned, i.e. what will the Ecological Water Requirements (EWR) in this RU achieve. The RU consists of a very small section of river which is not inundated by the downstream dam. Goods and services that can be provided in this section are limited and it is suspected that the Ecological Importance and Sensitivity (EIS) would be low. This RU and associated EWR site were selected as it was suspected that they would provide important information regarding the operation of Impofu Dam, and acknowledging that the section of river downstream of Impofu Dam and upstream of the estuary is short. Specialists indicated that this section of river, even though short, plays a vital role for fish species and macro-invertebrates that move between the marine, estuarine and freshwater systems. As no movement is possible beyond the Impofu Dam, this increases the importance of the limited section of freshwater downstream of Impofu Dam. Acknowledging this fact, the river downstream of Impofu Dam was investigated for a potential EWR site. No suitable (from a hydraulics viewpoint) EWR site could however be found.

Qualitative guidelines to the requirements of EWR site 3 can also be provided. To provide quantitative information for this short section of river, the following approach was recommended:
An EWR site has been selected downstream of Impofu Dam (EWR site 3) at which the PES, EIS and EC will be determined. Flows will be established at EWR site 2 and will be transposed to EWR site 3 for the relevant categories.

The EWR 3 site (Figure 3-11) consisted of the riffle pool section immediately upstream of the dyke that separates the estuary and the river.

Figure 3-11 EWR site 3

3.5.4 EWR site 4: Geelhoutboom River

One site had to be selected within the Geelhoutboom River, preferably some distance downstream in the system. The video was not useful as the closed canopy characteristics of the river prevented a view of the river. A site and photo taken by the water quality team was investigated and a suitable site was found about 200 m downstream. The site consists of a small riffle and an upstream and downstream pool. The riparian vegetation is in exceptional condition and forms a near to natural closed canopy.

Figure 3-12 EWR site 4

3.5.5 EWR site 5: Seekoei River

Initially a site was searched for in the downstream areas of this river, however, a site could only be found upstream of Humansdorp. From Humansdorp to the estuary, this river is extensively utilised and excessively dammed. This section of river is highly likely to be in an E category and setting objectives and a Reserve for such a river becomes problematic as the downstream river in effect has been inundated by a series of dams. The estuarine objectives must cater for the downstream section of river.

Figure 3-13 EWR site 5

3.5.6 EWR site 6: Swart River

The Swart River is also extensively dammed; in the lower reaches. In the upper reaches it has the characteristics of a wetland/sponge area. No suitable site could be found during the initial site visit.

During a second site visit an EWR site was selected in the upper reaches of the Swart River. This site is situated upstream of the first impoundment found in this river on the farm owned by Mr Sakkie Steynberg. There was a flow of 6 l/s and a cross section was established. This site is not ideal from a EWR perspective as it is way upstream in the catchment i.e. above most of the development and operational structures. As this site is located upstream of impacts on the system and historical knowledge of the system is lacking, this site represents a best estimate of the natural state or reference condition. Comparative assessments between this site and downstream sites will therefore provide some indication of changes to the system.

Figure 3-14 EWR site 6

3.6 Estuary zonation

The Resource Directed Measures for Estuaries (DWAF, 2001) stipulates that estuaries be defined on a geographical basis according to the following categories:

Downstream boundary – The estuary mouth.
Upstream boundary – The extent of tidal influence i.e. the point up to were tidal variation in water levels can still be detected or the extent of saline intrusion which ever is furthest upstream.
Lateral boundaries – The 5 m above Mean Sea Level along each bank.

Kromme Estuary

The Kromme Estuary (Figure 13-15) is a permanently open warm temperate marine dominated system. Two systems feed into the estuary *via* the Kromme and Geelhoutboom rivers.

Downstream boundary:	34°08’35” S 24°50’40” E
Upstream boundary:	*Kromme River* 34°06’40” S 24°43’20” E[1]
	Geelhoutboom River 34°06’40” S 24°45’10” E
Lateral boundary:	The 5 m above MSL contour along each bank.

[1] Not seen on map.

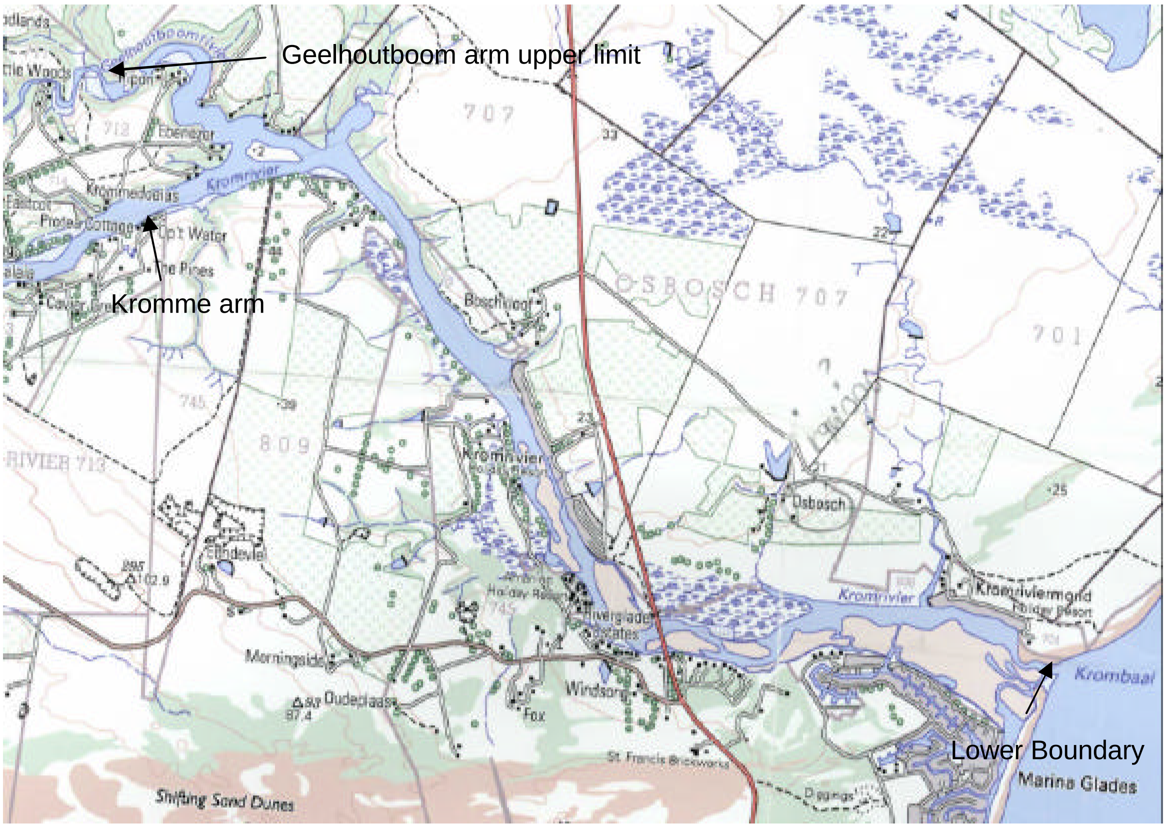

Figure 3-15   Study area – Kromme Estuary

Seekoei Estuary

The Seekoei Estuary (Figure 13-16) is a temporarily open closed temperate estuary. Two systems feed into the estuary viz. the Seekoei River and the Swart River.

Downstream boundary:	34°05'05" S 24°54'50" E
Upstream boundary:	*Swart River* 34°04'48" S 24°52'45" E
	Seekoei River 34°05'15" S 24°52'00" E
Lateral boundary:	The 5 m above MSL contour along each bank.

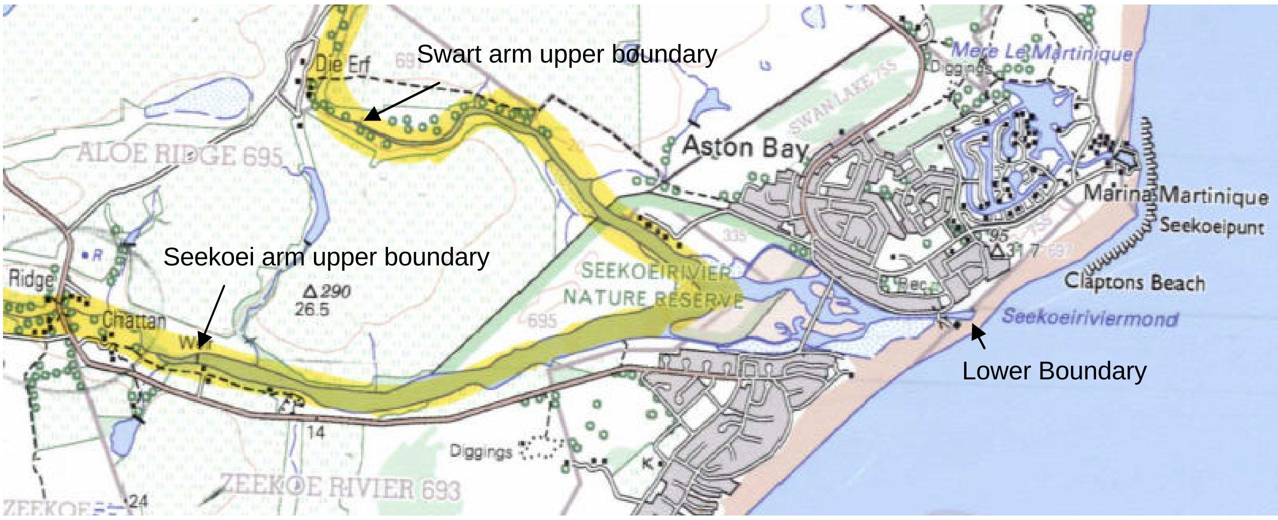

Figure 3-16   Study area – Seekoei Estuary

4 GROUNDWATER

Note: This chapter is a summary of CES (2006), Groundwater Report No. RDM/ K90/ 02/CON/0305.

The groundwater component of the Kromme/Seekoei study consisted of a *Scope of Work* for a Groundwater Reserve Determination, completed in January 2005, and a *Groundwater Reserve Study* conducted in 2006 as an associated study. Chapter 4 therefore presents the results of the 2005 study, with the main results of the Reserve study shown in Appendix A. Note that no attempt was made to link the groundwater and surface water results as the Groundwater Reserve was conducted after the completion of the river and estuary studies. This study was a separate contract directly between the Institute for Groundwater Studies (IGS) at the University of the Free State, and CD: RDM.

4.1 Overview and objectives

Reasons for conducting the 2004/2005 study included the following:

- The needs of the Kruisfontein resource-poor farmers for an allocation of additional irrigation in the Seekoei River catchment.
- There is concern about over-abstraction from well fields by coastal towns in summer (a potential cause of seawater intrusion).
- The impact of the many illegal dams, particularly in the Seekoei River.
- Population growth and the resultant increase in water requirements
- Preservation of the wetlands.
- The impact of alien vegetation in the entire K90 catchment.
- The Reserve determination forms part of a Resource Directed Methodology (RDM) designed to implement the National Water Act (NWA, Act No 36 of 1998).

To achieve the objective of the study, it was necessary to assess the current groundwater situation within the study area, review the importance of groundwater use and indicate stressed groundwater areas.

4.2 Approach

The following approach was followed in the study:

- A review of available and relevant literature and data sets. Borehole data from the National Groundwater Database (NGDB) were accessed; there are 195 boreholes within the study area, only 12 of which have time series water level data.
- The geology, hydrogeology and hydrochemistry of the area were summarised.
- The quaternary catchments were classified in terms of their importance and degree of stress.
- Field surveys were undertaken to collect additional data.

4.3 Results

The result of the study led to the following recommendations regarding groundwater Reserve determinations for the Kromme and Seekoei rivers:

- Determination of the Groundwater Reserve, quantity and quality, to be undertaken at a high level of detail.
- Determination of preliminary Groundwater Management Classes.
- Specification of preliminary Resource Quality Objectives (RQOs).
- Design of a monitoring programme.

Some aspects that need to be taken into account in the comprehensive Groundwater Reserve determination are the following:

- The impact of farming activities on groundwater.
- The occurrence of localised over-exploitation due to the dependence of surrounding towns and rural areas on underground sources for a large proportion of their water supply.
- The prominence of alien vegetation in the entire K90 catchment. The majority of this vegetation occurring along the banks of rivers is Black Wattle, known to consume groundwater.
- The corrosive nature of groundwater with a low pH in the Table Mountain Group aquifers.
- The strong interdependence between ground-and surface water in the higher rainfall coastal area. Increased abstraction of groundwater in these areas is likely to have a direct impact on the base flow in surface streams, and may induce the intrusion of sea water where wells or boreholes are located near the coast.
- Unacceptable water quality impacts in the Kromme River caused by stone mining operations.
- Contamination due to spillages from industries in Kareedouw.
- High organic loads due to inadequate pre-treatment at the dairy farm and abattoir in Humansdorp.
- Potential groundwater contamination by waste sites and wastewater treatment works.
- The requirement of catchment K90A is for 20% of the annual groundwater recharge. It is therefore assumed that groundwater may be a significant contributor to the flow regime in this segment of the river, and will require specific attention in the comprehensive Reserve determinations.
- The upstream catchments have higher groundwater requirements for the Ecological Reserve than the downstream catchments.
- There are indications from surface water investigations that the groundwater contribution to the Ecological Reserve may be higher than those contributions already estimated.
- The influence of groundwater abstraction on springs, wetlands and seepage zones occurring in the study area must be taken into account, as it forms an important part of the hydrogeology in the study area.
- Groundwater losses to the marine environment.

4.4 Conclusion

In conclusion, a number of challenges exist for the project team that would be contracted to undertake the comprehensive Groundwater Reserve. These challenges include the following:

- Critical gaps in the available geohydrological information.
- The necessity for a comprehensive hydrocensus to be undertaken.
- Stressed aquifer zones need to be identified.
- An accurate groundwater balance needs to be calculated.
- The sustainable utilisation of groundwater must be determined.
- Aquifer protection measures need to be established.
- The monitoring network must be updated.
- Groundwater dependent ecosystems need to be identified, including those associated with wetlands and springs.

A phased approach reflecting the life cycle of the project is recommended:

- Phase 1: Study initiation and design.
- Phase 2: Study implementation.
- Phase 3: Study termination.

5 HYDROLOGY

Note: This chapter is a summary of CES (2005), Hydrology Report No. RDM/ K90/ 01/CON/0805 and an additional internal report written in August 2006, Irrigation demands in the Seekoei/Swart catchment, by Anton Sparks of Ninham Shand, the modeller for the study.

5.1 Overview and objectives

This Chapter summarises the hydrology and systems analysis tasks undertaken in support of the Kromme / Seekoei Catchments Reserve Determination Study. The study was particularly important due to the Kromme catchment being such a strategic component of the water supply to the Nelson Mandela Metropolitan Municipality (NMMM).

Most of the information presented was obtained from the Algoa Water Resources System Analysis Study (DWAF, 1994a-f), Surface Water Resources of South Africa 1990 (WRSM90) (Midgley *et al.*, 1994) and relevant reports from the Tsitsikamma to Coega Internal Strategic Perspective (DWAF, 2003). More recent data was also obtained from the DWAF Directorate of Hydrology in Pretoria, the regional DWAF office in Cradock and the NMMM, and a report discussing the annual operation of the system in 2004. Seekoei / Swart River demands were based on a report prepared by Kleynhans and Associates (DWAF, 1999) and accessed from the regional (Cradock) DWAF office in October 2003. Updated information on the capacity of farm dams in the catchment was also assessed (see Section 5.2.1).

The hydrology of the Kromme River upstream of Impofu Dam was investigated in detail as part of the Algoa Water Resources System Analysis (AWRSA) Study (DWAF, 1994a-e). The Pitman Model was used to define a rainfall – runoff relationship for the catchments upstream of the flow gauging stations K9R001 (Churchill Dam) and K9R002 (Impofu Dam). This entailed calibrating the Pitman Model to generate monthly flow sequences matching the observed flow sequences at these sites.

Relevant hydrological data for the Kromme River is presented in Table 5-1, and hydrology adopted for the Seekoei / Swart system is shown in Table 5-2. The total volume of farm dams for the Seekoei / Swart system was assumed to be 7.2 Mm^3, based on the Kleynhans report (see Section 5.2.1 for more information).

Table 5-1 Hydrological data available for the Kromme River

Catchment i=incremental c=cumulative	Location	Area	MAP	Natural patched runoff	Afforestation	Irrigation	Farm Dam Caps	Present day incremental	Checking Natural inflows	Nat runoff	Nat runoff / rainfall
		km^2	mm	Mm^3/a	km^2	km^2	Mm^3	Mm^3/a		mm	%
K90A (i) (1)	US Churchill	213	740	33.6	0	2.1(1)	0.39(2)	29.5	30.4(2)	158	22%
K90B (i) (1)	US Churchill	150	740	23.7	2.2(1)	1.4(1)	0.00		K90A+B=57.3(1)	158	22%
K90C (i) (1)	US Impofu	267	596	8.4	0	1.9(1)	2.55(1)	15.8	16.9(1) vs 30.7(2)	31	5%
K90D (i) (1)	US Impofu	215	693	10.3	1.2(1)	1.5(1)				48	7%
K90E (i) (2)	DS Impofu inc Geelhoutboom	176	676	11.9	0	1.5(6)	0.90(5)	10.9	12(2)	67	10%
Cumulative at Kromme Estuary		**1021**	**699**	**87.8**				**34.0(3)**		**86**	**13%**

(1) Algoa Water Resources System Analysis (DWAF, 1994).
(2) WRSM90.
(3) Spills and releases from Impofu Dam assuming a demand with a 1 in 50 year risk of failure is applied to the system.
(4) This represents the naturalized MAR of the incremental catchment as simulated for the period 1927 to 2000. However, this is based on a very short calibration period of 1983 to 1991, which coincided with a severe drought. WRSM90 reports a larger incremental MAR for the area upstream of Impofu Dam of 30.7 Mm^3/a.
(5) Farm dam capacities of 0.9Mm^3 in K90E are based on a volume for the Geelhoutboom River of 0.77Mm^3 (Sinclair and Associates) plus the 0.13 Mm^3 for the Grasmere Dams (WRSM90 Volume V: Appendix 5.1.1).
(6) Irrigation areas in K90E are the sum of an area of 135ha for the Geelhoutboom River (Sinclair and Associates) plus an estimate of 15ha for the 0.13Mm^3 Grasmere Dams.

Table 5-2 Summary of hydrology adopted for the Seekoei / Swart catchments

Description	Quaternary K90F
Sub-catchment Area (km^2)	250
Sub-catchment MAP (mm)	699
Afforested Area (1991) (km^2)	0.0
Irrigation Area (1991) (km^2)	10.8
Irrigation water use (Mm^3/a)	8.3
Farm dam capacities (1991)	7.24 (1)
Alien vegetation water use	0.2
Naturalised MAR (Mm^3/a)	18.8
Present day MAR (Mm^3/a)	Not available

(1) Based on report by Kleynhans and Associates

Figure 5-1 illustrates the main inflows and feasible demands on the Kromme River System assuming that 36 Mm^3/a is supplied to the Nelson Mandela Metropolitan Municipality (NMMM) / coastal towns and that releases of 11 Mm^3/a are made to the estuary. The inflows to the Churchill Dam (54 Mm^3/a) are greater than those to the Impofu Dam (16 million m^3 plus 30 Mm^3/a spills from Churchill) so more water (Mm^3/a) can be supplied from the Churchill Dam to the NMMM than from the Impofu Dam (14 Mm^3/a) to reduce pumping costs. In addition to the releases from Impofu Dam, the estuary also receives an additional 19 Mm^3 in spills from Impofu Dam plus about 11 Mm^3/a from the portion of the Kromme River downstream of the Impofu Dam and from the Geelhoutboom River and other tributaries. An agricultural demand of about 2 Mm^3/a is supplied from Impofu Dam.

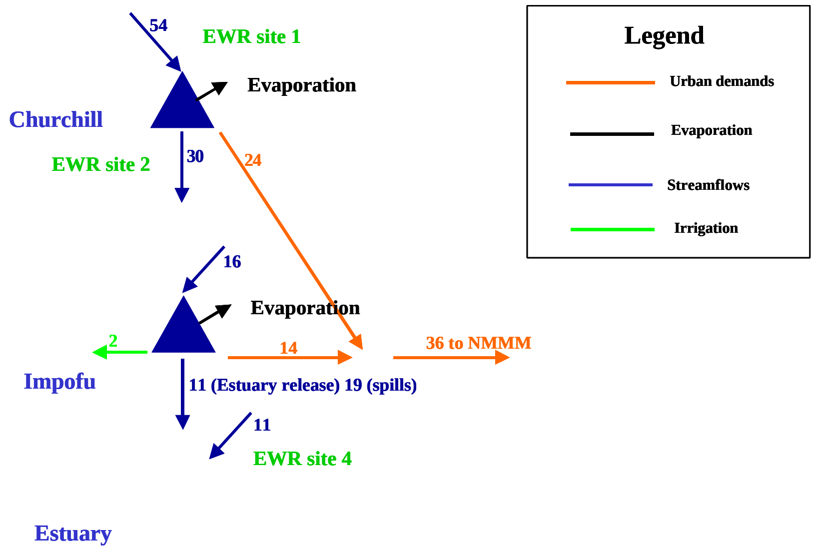

Figure 5-1 Main inflows and demands of the Kromme River System (Mm^3/a)

5.2 Approach

The Hydrology task used earlier Pitman calibrations to generate natural and present day flow sequences at specified riverine sites in the Kromme (Algoa Water Resources Systems Analysis (1994) calibration) and the Seekoei / Swart (WRSM90 calibration) rivers. For this Reserve determination study the Pitman parameters determined during the AWRSA study were used to generate long-term stream flow sequences for the period from 1927 to 2000.

The approach adopted for the Seekoei / Swart River system is shown below as updated data on the capacity of farm dams became available during the study. The potential impact of a smaller dam capacity (i.e. 5.3 Mm^3 vs 7.24 Mm^3) on irrigation demands and water availability to the Seekoei Estuary, was assessed by Mr Sparks.

Once flow scenarios had been developed by the modeller, ecologists used these flow sequences to determine the EWR that would be necessary to maintain the river in different ecological states, corresponding to different ecological categories.

The Systems Analysis task therefore determined the water available for the ecology and urban and agricultural consumers for scenarios in which the following were varied:

- EWR flows supplied at selected sites.
- Infrastructure (lumped farm dam size and irrigation abstraction).
- Urban / agricultural development levels.

A large number of scenarios were analysed using the WRYM to provide inflow sequences for assessment by the estuarine specialists. These specialists determined the impact of these scenarios on the ecological integrity of the estuary. These scenarios were grouped as follows:

- Natural conditions
- Present Day
- Future developments
- Alternative estuarine releases (indicating additional scenarios identified at; and after the scenarios workshop)

Results are detailed in Chapter 9 of this report.

5.2.1 Seekoei / Swart irrigation demands

At present about half of the natural stream-flow of the Seekoei / Swart system is intercepted by the farm dams located upstream of the estuary. Many of the inflow scenarios generated for the Seekoei / Swart estuary hypothetically assumed that ecological releases could be made from the farm dams and that the upstream development (i.e. farm dams and irrigated areas) was reduced significantly.

When modelling the Seekoei / Swart catchments in the Kromme / Seekoei Reserve Determination Study the total volume of the farm dams in the catchment was assumed to be 7.24 Mm^3. This volume was determined as part of the hydrology for the system by Ninham Shand (Dr Verno Jonker), using a report prepared by Kleynhans and Associates that was supplied by the regional office in about October 2003. The volume of dams classified for livestock and irrigation that were supplied from streamflows (as opposed to boreholes and springs) were respectively 4.01 and 3.22 Mm^3. The Kleynhans report was also used to determine the annual irrigation demand of 8.63 Mm^3/a.

Subsequent to the completion of the hydrology the co-ordinates of the environmental site on the Swart River (EWR site 6), were corrected and additional queries were received concerning the farm dams on the Geelhoutboom River. Unfortunately, no GIS coverage of the farm dams (upstream of EWR site 6 and on the Geelhoutboom system) was available and it was difficult to determine both the area upstream of the dam sites and also whether water was pumped into the dams from the river channel. During the assessment it became apparent that flows at EWR site 6 were relatively unimpacted by farm dams. As a result, it was decided that no modelling would be used to determine the present day flows at EWR site 6. Instead, the Seekoei / Swart system was modelled in a simpler manner to determine the flow at the estuary.

Towards the end of the above process additional information was received on the farm dams containing a survey by the Geomatics Section of DWAF, who physically measured the capacity of farm dams and compared their volumes with those from the Kleynhans report, which may have relied on estimates from the farmers concerned.

5.3 Results

The results of the hydrological study indicated that the Kromme/Seekoei system may require augmentation in the near future to meet the growing urban demand, even if the environmental releases are not increased.

It must also be noted that there is uncertainty concerning the dam volumes in the Seekoei / Swart catchment. Due to the discrepancies in data between the Kleynhans report and the verification survey conducted by the Geomatics division of DWAF, Mr Sparks reassessed the availability of flows to the Seekoei Estuary. The result of the assessment is that if the capacity were to be reduced by about 1.8 Mm^3 (i.e. 5.3 Mm^3 (Geomatics verification) vs 7.24 Mm^3 (Kleynhans report)), then the flows at the estuary would increase by approximately 0.6 Mm^3/a and the supply to irrigation would reduce by about 0.4 Mm^3/a. Considering the estuary requirement of 12 Mm^3/a to meet the REC, the increased availability of flows is not expected to make a large difference to the present state.

6 ECOCLASSIFICATION: RIVERS

Note: This chapter is a summary of CES (2005), EWR Rivers Report No. RDM/ K90/ 01/CON/0405, and CES (2005), Water Quality Report No. RDM/ K90/ 01/CON/1305.

6.1 Overview and objectives

EcoClassification refers to the categorisation of the Present Ecological State (PES) of various biophysical attributes compared to the natural (or near natural), reference condition. The EcoClassification process supports a scenario-based approach where a range of ecological end-points (Ecological Categories) are considered. This provides the information needed to derive desirable but attainable future ecological objectives for the river and estuary. EcoClassification must not be confused with the Classification System as indicated in the National Water Act. The latter considers a range of different issues in integrated water resources management, one of which is ecological.

6.2 Approach

6.2.1 EcoClassification

The Ecological Reserve process comprised eight steps (Table 6-1) (Louw and Hughes, 2002); which are summarised as follows:

- Determining the PES, deriving the REC and alternative ECs.
- Setting flow scenarios for various ECs.
- Determining ecological consequences for each flow scenario.
- Selecting a flow scenario and associated category to represent the Ecological Reserve.
- Designing a monitoring programme and implementing the Ecological Reserve and monitoring programme.

The EcoClassification process is an integral part of the Ecological Reserve process or, for that matter, any Environmental Flow Requirement method. Flows and quality could not be recommended without information regarding the resulting state, i.e. the Ecological Category. The Ecological Categories that were determined as part of the Ecoclassification process formed an essential part of most of the Reserve steps. These steps are described in Table 6-1, together with the role of EcoClassification in each step.

Table 6-1 EcoClassification input into the Ecological Reserve steps

	Reserve process	**Ecoclassification input**
1.	Initiate RDM study (study area, RDM level & components, study team)	Not applicable
2.	Define Resource Units	Not applicable
3.	Define Ecological Categories and recommend one (REC)	Bulk of EcoClassification process: Determination of reference conditions, PES, EIS, REC and alternative ECs
4.	Quantify Ecological Reserve Scenarios (flow scenarios)	Setting of flow scenarios for relevant ECs
5.	Identify ecological consequences of flow scenarios (Ecological Reserve and operational flow scenarios)	Interpretation of consequences in terms of impact on ECs
6.	DWAF Management Class decision making process	Selection of a Management Class and associated EC
7.	Reserve specification	Determination of Ecospecs for specific ECs.

	Reserve process	Ecoclassification input
8.	Implementation design	Design of a monitoring programme to monitor achievement of the EC associated with the Management Class
9.	Implement and Monitor	Evaluation in terms of EC.

The approach used to determine the EcoClassification is documented in Kleynhans *et al.* (2005). The approach consists broadly of the following steps:

- Define the Present Ecological State (PES) for each component in terms of categories A to F (Table 6-2).
- Integrate the component PES into an overall state called the Ecostatus.
- Determine the Ecological Importance and Sensitivity (EIS) and Socio-cultural Importance (SI).
- Based on the above, as well as considering the PES, derive the Recommended EC (REC).
- Based on the REC, derive the realistic alternative ECs, to be addressed during scenario development.

Table 6-2 Generic ecological categories for EcoStatus components (modified from Kleynhans, 1996; and Kleynhans, 1999).

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

Categories A-F forms a continuum as illustrated in Figure 6-1.

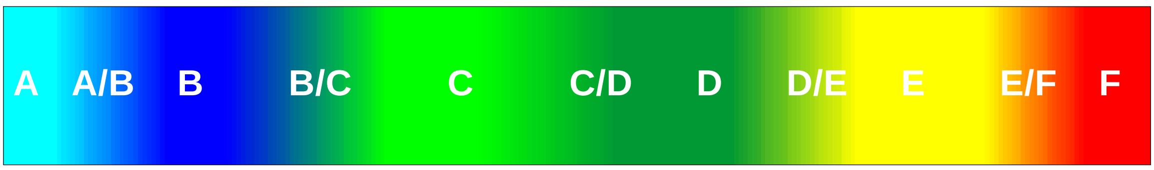

Figure 6-1 Illustration of the distribution of Ecological Categories on a continuum

6.2.2 Suite of EcoStatus Models within EcoClassification

Determination of the integrated state of rivers (EcoStatus) distinguishes between physical drivers, which encompass physico-chemical attributes, geomorphology and hydrology, and the biological responses that include fish, macro-invertebrates and riparian vegetation. The physical drivers and biological responses were referred to as components.

The following models were developed to assess the state of each component.

HAI	Hydrology Driver Response Assessment Index.
PAI	Physico Chemical Response Assessment Index
GAI	Geomorphological Driver Assessment Index
FRAI	Fish Response Assessment Index
MIRAI	Macro Invertebrate Response Assessment Index
VEGRAI	Riparian Vegetation Response Assessment Index

The Ecological Category for each of the components were assessed and then integrated into an EcoStatus using an EcoStatus model. Within the Ecological Reserve process, the flow and quality requirements were set by the individual specialists for the specific objectives defined by the component Ecological Categories. For example, if the objectives were to maintain the present conditions, which could consist of fish in a B PES, aquatic invertebrates in a C PES and a present EcoStatus of a B/C PES, the flows would be set to maintain Fish in a B status and aquatic invertebrates in a C status - which would result in an EcoStatus of a B/C. This meant that the objectives of the EcoStatus consisted of the individual objectives of each of the component categories.

6.2.3 Water quality

Due to the paucity of water quality data and inadequate monitoring of the Kormme/Seekoei catchments, an agreement was reached with EC DWAF for the collection of *monthly* samples at a number of monitoring points throughout the catchments of the study area. In many areas this was the only data available for a present state assessment. The amount of data available from the WMS database, particularly historical data describing Reference Condition, required that adjacent catchments within the same ecoregion be considered as proxy sites. The sites considered were L8H005Q01 in the Kouga River (Ecoregion Level I: Cape Folded Mountains) and K8H005Q01 in the Tsitsikamma River (Ecoregion Level I: Southern Coastal Belt).

Methods used for conducting the present state assessment were based on a methods manual produced for DWAF (2002) and discussions held at a workshop in Grahamstown in July 2003 regarding water quality Reserve methods. These methods are published in Palmer *et al*. (2004) and can also be found on the Ninham Shand web-site:
(*http://projects.shands.co.za/Hydro/hydro/WQReserve/main.htm*).

The various steps followed in the water quality PES assessment were as follows:

- Data collation: this step included the collection of relevant literature, DWAF monitoring data, site-specific water quality data biomonitoring data.
- Recalibration of benchmarks: this step allows the specialist to recalibrate benchmarks for the various variables in relation to the reference conditions, if the variables assessed do not correspond to the benchmark table categories provided in the methods manual.
- Data manipulation: once data had been selected to represent RC and PES per WQSU, data manipulation was undertaken. This step included the generation of graphs and summary statistics, and the generation of PES categories.

6.3 Results

6.3.1 Water quality

Table 6-3 is a summary of the PES for water quality per WQSU. Specific input per EWR site is shown in the text below.

Table 6-3 PES for water quality shown per WQSU

WQSU	EWR site	Overall REC	PES: water quality	Confidence in water quality PES assessment
WQSU 1:	EWR 1 - Melkhoutboskraal	C	B/C	Low
WQSU 2			C	Low
WQSU 3			B/C	Low
WQSU 4	EWR 2 – Krommeriviers Poort	D	B/C	Moderate
WQSU 5	EWR 3 – Dyke on Kromme River	D	C	Moderate
WQSU 6	EWR 7 – Diep River	C/D	B/C	Low
WQSU 7	EWR 4 – Geelhoutboom River	C/D	C/D	Low
WQSU 8	EWR 5 – Seekoei River	C	B/C	Very low
WQSU 9 + 10			B/C	Low
WQSU 11	EWR 6 – Swart River (upper section of the river)	B	A/B	Very low
WQSU 12	Lower section of the Swart River		B/C	Low

6.3.2 Ecostatus, REC and EIS

A summary is provided below per site and shown graphically on Figure 6-2. Confidence in the assessments are also shown in Tables 6-4 and 6-5.

Kromme River upstream of Churchill Dam (EWR 1)
The Kromme River upstream of the dams (Churchill and Impofu) is in a C state with most of the problems centered on the presence of alien vegetation, alien fish and upstream land-use. Potential water quality issues at EWR 1 were therefore nutrient elevation, particularly periphyton, temperature fluctuations as the river is wide and shallow with no overhanging vegetation, and increased phosphate loads during high flows due to wash-off. However, this is the best section of the Kromme River and should not be allowed to degrade further. The EIS is moderate and the SI is low. The REC is set to maintain the PES.

Diep River (EWR 7)
Issues in the Diep River catchment were focused around the presence of alien vegetation, alien fish and upstream land-use, with the PEC being a C/D category. Elevated nutrient levels (i.e. increased phosphate concentrations) were reflected in increased periphyton chlorophyll-*a* concentrations. The EIS is moderate, and the REC is set to maintain the PES.

Kromme River between Churchill and Impofu dams (EWR 2)
The section downstream of Churchill Dam are affected by decreased flows and an abnormal flow regime, as well as the presence of alien vegetation and fish. Potential water quality issues at EWR 2 were therefore temperature and oxygen impacts due to the site being downstream of Churchill Dam, and increased periphyton levels with decreased flow, which may also have resulted in increased turbidity levels. The EIS is moderate and the SI is low. The REC is set to maintain the PES of a D category.

Kromme River downstream of Impofu Dam (EWR 3)
The same impacts were present downstream of Impofu Dam, although exacerbated by abstractions from the pool downstream of the dam. This section of river, although short, is critical

for river function as it formed the only freshwater link between the marine, estuarine and freshwater environments. During most of the year, no link is possible due to lack of releases and abstractions downstream of Impofu Dam. Although there were no data available for dissolved oxygen and water temperature downstream of the dam, water quality impacts were expected, particularly if bottom releases were made from Impofu Dam. Despite the probable extensive use of fertilizers in this stretch of the river, nutrient levels were ameliorated in the dam. The EIS is high and the SI is low. The REC is set to improve the PES of a D/E to a D category.

Geelhoutboom River (EWR 4)

There is a lack of information on the functioning (hydrology and responses) of the Geelhoutboom River, particularly the seasonality of the system and therefore associated biological responses. Only a trickle of flow was seen during the site visits. Potential water quality issues at EWR 4 were therefore increased periphyton and nutrient levels with decreased flow and elevated toxics with low flows. However, the riparian vegetation is in a very good state consisting of large numbers of Yellowwood trees. The EIS is moderate and the SI is low. The REC is set to maintain the PES of a C/D.

Seekoei and Swart rivers

The PES categories for both EWR 5 (Seekoei River) and 6 (Swart River) were representative of the upstream sections of the respective rivers only. In both cases the downstream sections have been severely modified and in some cases, there is no river left as the farm dams formed a continuum. The EIS for these systems is moderate and the SI is low. Potential water quality issues at EWR 5 is nutrient status, with increased periphyton and nutrient levels with decreased flow – periphyton levels were exacerbated by cattle moving through the stream channel, although increased flow would increase phosphate loads due to wash-off. Temperature and oxygen variations were also expected at low flows. Fluctuations in nutrient status were also expected at EWR 6, with additional potential impacts being increased turbidity levels due to disturbances related to pipeline construction and maintenance (temporary impact), and water abstraction which may have impacted on flows and have a consequent impact on nutrient levels, turbidity, dissolved oxygen and temperature. The REC is set to maintain the PES of a C category for the Seekoei and B category for the Swart River.

6.3.3 Confidence

EcoClassification

The confidence in the EcoClassification is summarised as follows, and is shown on Tables 6-4 and 6-5.

0 (no confidence)	1 (low confidence)
2 (low to medium confidence)	3 (medium confidence)
4 (medium to high confidence)	5 (high confidence)

Table 6-4 Confidence – Availability of data

EWR site	Hydrology	Geomorphology	Water quality	Vegetation	Aquatic invertebrates	Fish	OVERALL
1	1	3	1	2	3	3	2 – 3: Low to medium confidence
2	1	2	1	2	2	3	2: Low confidence
4	1	2	1	1	1	1	1: Low confidence
5	1	2	1	2	2	3	2: Low confidence
6	1	4	0.5	2	2	3	2: Low confidence

Table 6-5 Confidence – Ecoclassification

EWR site	Hydrology	Geomorphology	Water quality	Vegetation	Aquatic invertebrates	Fish	OVERALL
1	2	4	1	4	3	2	2 – 3: Low to medium confidence. Note that the drivers, especially hydrology, will carry a higher weight than the responses.
2	2	3	1	3	2	2	2 – 3: Low to medium confidence. The geomorphology weighting increases the overall evaluation, as the drivers carry a higher weight than the biological responses.
4	2	3	1	3	1	1	1 – 2: Low confidence.
5	2	4	1	3	2	2	2 – 3: Low to medium confidence. The confidence is higher than the average due to the higher weight that would be allocated to geomorphology.
6	3	4	0.5	4	3	2	3 – 4: Medium to high confidence. The low water quality confidence does not carry as much weight, as water quality problems can be derived through fish and invertebrate responses.

Water quality

The confidence in the present state classification was verified using the power statistic, G-Power, where possible.

Although the Kromme/Seekoei Ecological Reserve study was to be conducted at a Comprehensive level, the results of an assessment can have differing levels of confidence depending on the quality and extent of the available data (better data provide higher confidence results), the ability to collect additional data and/or to undertake field or laboratory studies, and/or the availability of appropriate modelling tools. The water quality assessment conducted for this study is of low confidence as most of the analytical data used for the assessment was collected during the study on a monthly basis. Little data existed before the study was initiated, and the DWAF in the Eastern Cape was not conducting regular and effective water quality monitoring in the Kromme/Seekoei catchment area. Ongoing monthly monitoring was initiated during this study at a number of sites throughout the Kromme, Seekoei and Swart catchments.

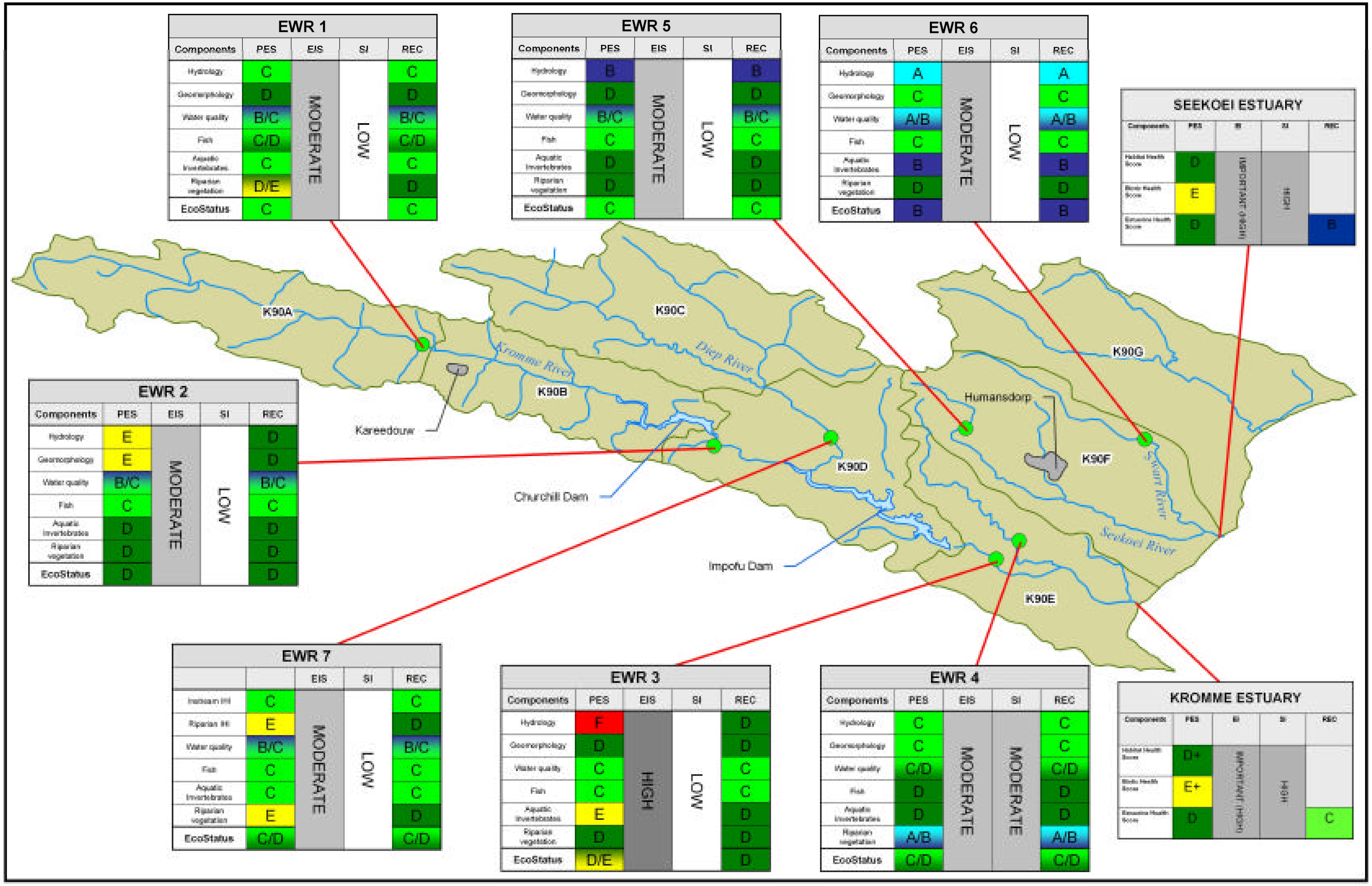

Figure 6-2 Map of the Kromme/Seekoei study area showing the PES, EIS and REC per EWR site and estuary

6.4 Conclusions

From Table 6-3 it is clear that the data availability is poor. This did effect the confidence evaluation of the EcoClassification results, as EcoClassification is based and derived on available data. The lack of data and resulting lack of understanding of the system is centred around the reduced confidence in the hydrology and the lack of understanding as to whether the system is perennial or seasonal, and if it had been modelled as being much wetter than it would normally be. Reference conditions for biota is dependent on this understanding, and this factor, combined with the lack of historical data and the minimal present day surveys undertaken, resulted in a lack of confidence in reference conditions and therefore a lack of confidence in the degree of change under present conditions. The dearth of water quality data further compounded the general uncertainty.

EWR 1 and 4 had the lowest confidence evaluation due to the uncertainty around the perenniality of the system. The confidence increases for EWR 5 and 6 as the perennial sites are far upstream in the system and perennial under present conditions.

No additional work would improve the hydrological modelling due to the lack of gauges in the system and the dearth of historical hydrological data. It is therefore more important to implement a monitoring programme targeted towards water quality, fish and aquatic invertebrates to ensure that the presence/absence of biota is clearly understood. For example, in this case it is not so important to know with accuracy whether fish is in a C or a D state, as long as the species present is known so that the flow requirements for those species could be checked or refined if necessary.

7 ECOCLASSIFICATION: ESTUARIES

Note: This chapter is a summary of CES (2005), EWR Estuaries Kromme Report No. RDM/ K90/ 04/CON/0605 and Seekoei Report No. RDM/ K90/ 04/CON/0705.

7.1 Overview and objectives

This chapter outlines the findings of a comprehensive determination of the Ecological Reserve for the Kromme Estuary and a rapid determination of the Seekoei Estuary. In particular, it provides an outline and discussion of the following key components of the study:

- PES
- RC
- The ecological importance of the Kromme and Seekoei Estuaries (Note this is estuary-specific and is not equivalent to EIS).
- REC

7.2 Approach

The standard RDM methodology for the selected studies was followed. The following sequential steps were taken to assess the Ecological Category for each estuary.

7.2.1 Initiation of the study

At the initiation of the RDM study, it was important to establish the level at which the study needed to be conducted (e.g. Rapid, Intermediate or Comprehensive). The Ecological Reserve Determination study on the Kromme Estuary was conducted at a Comprehensive level while the Seekoei was undertaken at a Rapid level.

7.2.2 Determination of the Ecological Reserve

This step involved defining a REC for each of the estuaries. In order to establish the present state of the estuaries, the following components were evaluated and described for both systems:

Abiotic (or driving) components
- Physical dynamics (including hydrodynamics and sediment dynamics)
- Water quality

Biotic (or response) components
- Estuarine flora (microalgae and macrophytes)
- Estuarine fauna (invertebrates, fish and birds)

The present state and RC of each estuary were used to assess the Estuarine Health Index (EHI) of the estuaries. The EHI is a measure of the health of a resource, based on a comparison between the RC and the PES. The EHI score is made up of two key components: the habitat health score and the biotic health score. The habitat health score considers hydrology, hydrodynamics, water quality, and physical habitat. The biotic health score considers microalgae, macrophytes, invertebrates, fish and birds.

Once the reference state, PES and EHI status had been established, the ecological importance of the Kromme and Seekoei estuaries was assessed. Ecological importance is an expression of the importance of an estuary to the maintenance of its ecological diversity and functioning on local and wider scales. Finally, the PES and ecological importance score were used to derive a Recommended Ecological Category for each of the systems.

7.3 Results: Seekoei Estuary

7.3.1 PES

The individual EHI scores, which were allocated to the PES of the Seekoei Estuary; are presented in Table 7-1. The EHI score of 42 translated into a PES of a D (Table 7-2). This indicated that the system was *largely modified*. It should be noted that the PES was at the threshold between a category D and E with a category E being described as *highly modified*. The plight of the fauna and flora is clearly demonstrated by the fact that the habitat health score is well within an E category. This is validated by the fact that the ecosystem has collapsed on a number of occasions in the last 20 years.

Table 7-1 Present State EHI scores

Variable	Weight	Score	Weighted score
Hydrology	25	58	14
Hydrodynamics and mouth condition	25	40	10
Water quality	25	40	10
Physical habitat alteration	25	61	15
Habitat Health Score			**50**
Microalgae	20	35	7
Macrophytes	20	35	7
Invertebrates	20	30	6
Fish	20	35	7
Birds	20	40	8
Biotic Health Score			**35**
Estuarine Health Score			**42**

Table 7-2 EHI Score

EHI Score	Present Ecological State	General description
91 – 100	A	Unmodified, natural
76 – 90	B	Largely natural with few modifications
61 – 75	C	Moderately modified
41 – 60	**D**	**Largely modified**
21 – 40	E	Highly degraded
0 – 20	F	Extremely degraded

7.3.2 Importance score

The estuarine importance scores allocated to the Seekoei Estuary resulted in an overall importance score of 71 (Table 7-3) which translated into the estuary being ranked as *Important* (Table 7-4).

Table 7-3 Estuarine Importance score

Criterion	Score	Weight	Weighted score
Estuary Size	90	15	14
Zonal Rarity Type	10	10	1
Habitat Diversity	80	25	20
Biodiversity Importance	85	25	21
Functional Importance	60	25	15
Estuarine Importance Score			**71**

Table 7-4 Estuary Importance classification

Importance Score	Description
81 – 100	Highly important
61 – 80	**Important**
0 – 60	Of low to average importance

The relationship between the EHI Score; PES and EC for estuaries are provided in Table 7-5.

Table 7-5 EHI score, PES and EC for estuaries

EHI Score	PES	Description	REC
91 – 100	A	Unmodified, natural	A
76 – 90	B	Largely natural with few modifications	B
61 – 75	C	Moderately modified	C
41 – 60	D	Largely modified	D
21 – 40	E	Highly degraded	-
0 – 20	F	Extremely degraded	-

Note: Should the Present Ecological State category of an estuary be either an E or F, recommendations must be made as to how the status can be elevated to at least achieve a Category D (as indicated above).

7.3.3 REC

Once the PES and the importance of the Seekoei Estuary had been established, the REC was derived according to the rules outlined in Table 7-6.

The Seekoei Estuary is a Provincial Nature Reserve. According to the guidelines for assigning the REC, the estuary should be in a Category A or the Best Attainable State (BAS).

At the specialist workshop (held on 25 February 2005 in Port Elizabeth), it was concluded that the changes that are largely contributing to the present state of the estuary are numerous farm dam developments in the catchment, the causeway running through the estuary, an increase in suspended solids in the inflowing water and artificial mouth manipulation. At this stage, it is unlikely that these changes could be reversed sufficiently to attain a Category A. Therefore the workshop decided that it should be recommended that the Seekoei Estuary be improved into the highest achievable REC, which is a Category B.

Table 7-6 REC allocation rules

Current/desired protection status and estuary importance	REC	Policy basis	Corresponding Management Class
Protected area	A or BAS	Protected and desired protected areas should be restored to and maintained in the best possible state of health.	Natural
Desired Protected Area (based on complementarity)	A or BAS		
Highly important	PES + 1, min B, or BAS	Highly important estuaries should be in an A or B category.	Good
Important	PES + 1, min C, or BAS	Important estuaries should be in an A, B or C category.	Fair
Of low to average importance	PES, min D	The remaining estuaries can be allowed to remain in a D category.	Fair

7.4 Results: Kromme Estuary

7.4.1 PES

The individual EHI scores which were allocated to the PES of the Kromme Estuary are presented in Table 7-7. The EHI score of 49 translated into a PES of a D (*largely modified* - Table 7-8). It should however be noted that the habitat health score is in a category E which is *highly degraded*.

Table 7-7 Present State EHI scores

Variable	Weight	Score	Weighted score
Hydrology	25	33.7	8
Hydrodynamics and mouth condition	25	100	25
Water quality	25	33.2	8
Physical habitat alteration	25	70	18
Habitat health score			**59**
Microalgae	20	17	3
Macrophytes	20	50	10
Invertebrates	20	20	4
Fish	20	40	8
Birds	20	70	14
Biotic Health Score			**39**
Estuarine Health score			49

Table 7-8 EHI Score

EHI score	Present Ecological State	General description
91 – 100	A	Unmodified, natural
76 – 90	B	Largely natural with few modifications
61 – 75	C	Moderately modified
41 – 60	**D**	**Largely modified**
21 – 40	E	Highly degraded
0 – 20	F	Extremely degraded

7.4.2 Importance score

The estuarine importance scores allocated to the Kromme Estuary resulted in an overall importance score of 66 (Table 7-9); which translates into the estuary being ranked as *Important* (Table 7-10).

Table 7-9 Estuarine Importance score

Criterion	Score	Weight	Weighted score
Estuary Size	100	15	15
Zonal Rarity Type	90	10	9
Habitat Diversity	20	25	5
Biodiversity Importance	87.5	25	22
Functional Importance	60	25	15
Estuarine Importance Score			**66**

Table 7-10 Estuary Importance classification

Importance Score	Description
81 – 100	Highly important
61 – 80	**Important**
0 – 60	Of low to average importance

The relationship between the EHI Score, PES and EC for estuaries are provided in Table 7-11.

Table 7-11 EHI score, PES and EC for estuaries

EHI Score	PES	Description	REC
91 – 100	A	Unmodified, natural	A
76 – 90	B	Largely natural with few modifications	B
61 – 75	C	Moderately modified	C
41 – 60	D	Largely modified	D
21 – 40	E	Highly degraded	-
0 – 20	F	Extremely degraded	-

Note: Should the Present Ecological State category of an estuary be either an E or F, recommendations must be made as to how the status can be elevated to at least achieve a Category D (as indicated above).

7.5 REC

Once the PES and the importance of the Kromme Estuary had been established, the REC was derived according to the rules outlined in Table 7-6.

The Kromme Estuary has been targeted as a Desired Protected Area. According to the guidelines for assigning a recommended REC, the estuary should be classified as a Category A or the Best Attainable State (BAS).

At the specialist workshop (held on 23 and 24 February 2005 in Port Elizabeth) it was concluded that the changes that are currently largely contributing to the present state of the estuary are related to large dam developments in the catchment (e.g. Impofu Dam). At this stage, it is unlikely that these interferences could be reversed even to get it into a Category B.

In this light the workshop decided that it should be recommended that the Kromme Estuary be improved into the minimum REC for an *Important* estuary, which is a Category C.

8 ECOLOGICAL WATER REQUIREMENTS: RIVERS

Note: This chapter is a summary of CES (2005), EWR Rivers Report No. RDM/ K90/ 01/CON/0405.

8.1 Overview and objectives

EWR refers to the flow patterns (magnitude, timing and duration) and water quality and other conditions needed to maintain a riverine ecosystem in a particular condition or state. Data analysis focuses on the relationships between discharge and habitat availability and key ecosystem processes. This process did not consider whether these flows could be supplied or managed, and impacts on users were not considered.

The objectives of this task were to recommend the magnitude, duration and timing of specific flows and flow patterns that are considered to be the most important for maintaining the abiotic (e.g. geomorphology) and biotic components (plants and animals) of each Resource Unit in a particular condition, or Ecological Category (EC).

The EWR is used in the yield model as the basis for creating and testing various flow scenarios.

8.2 Approach

8.2.1 Low flows

Recommendations for low flows were determined for each EWR site using the Habitat Flow Stressor Response (HFSR) method described by IWR Source-to-Sea (2004).

A site-specific index of zero (no stress or optimum habitat) to 10 (maximum stress or no habitat) was designed for fish and aquatic invertebrates. The approach for the instream biota was to scale the habitats (type and abundance) according to a flow-depth scale (zero to 10). The biotic response and associated stress level for these habitat conditions were then calculated.

The following tools were used to determine the stress indices:

- Hydraulics.
- Photos and videos of various flow conditions.
- Habitat modelling.
- Geomorphological information.
- Fish survey results and historical information.
- Aquatic invertebrate survey results and historical information.

Once the stress indices (for low flows) had been identified for each component, the stress figures were tabled and the unidentified flow stresses were interpolated. At any one flow, the component with the highest stress point represented the integrated or system stress curve.

The determined integrated stress index was used to identify required stress levels at specific durations for the wet and dry month or season. Drought flows were usually set at 95 to 100% assurance/duration/time equalled or exceeded. The equivalent stress assurance would be 5 to 0%. Based on the characteristics of the hydrological regime, maintenance flow assurance was determined and provided by the hydrologist.

The points plotted for the components representing the lowest stress at any time guided the shape of the recommended low flow. The points were connected to form a curve which represented a band of flow /stress requirements. The hydrologist then investigated which Desktop Reserve Model-generated curve most closely represented the recommended curve and adjusted the hydrology to approximate the hand-drawn curve.

8.2.2 High flows

A method adjusted from the standard Building Block Methodology (BBM; King and Louw, 1998) and Downstream Response to Imposed Flow Transformation (DRIFT; Brown and King, 2001) approach was followed to set high flows. The method involved the classification of floods, followed by an assessment of their ecological function. Motivated recommendations regarding timing and frequencies were provided for the recommended EC and alternative categories.

The stepwise approach to determining the high flows is as follows:

- Each specialist identified the range of high flows that would undertake similar functions. Class I high flows were the smallest events (the freshes / freshettes), and from Class II events the floods increased in size. The larger the classes, the larger the size of the events. The largest flood class would represent flows with a return period of 1:2 or more.
- Specialists provided their flood classes as the instantaneous peak which was required. The hydrologist converted this to a daily average as this was the requirement for the data to be captured into the Desktop Reserve Model.
- Specialists documented the functions and described the critical hydraulic parameters associated with each class of flood per component. The hydrologist checked the validity of these floods against naturalised daily hydrology, or in the absence of this, against any observed hydrological data or monthly volumes (the latter is used only as a last resort).
- Where possible, the hydrologist provided the number of events, which would occur under natural flow conditions for each of the flood classes. If daily hydrology was not available, an upstream reach of similar area was used to provide some indication.
- The specialists then identified which of that number of events should have occurred for each of the Reserve scenarios (ECs).

8.2.3 Final results

The low flows and high flows were incorporated into an integrated flow regime. The final output, i.e. the IFR rules (presented as duration tables), was provided from the Desktop Reserve Model. The IFR assurance rules and IFR tables (the tab tables) were presented per EWR site.

8.3 Results

EWR assessments were not undertaken for EWR 3 as it was not possible to undertake a hydraulic assessment at this site. The importance of this site was highlighted as it was the only stretch (3km) of freshwater to link with the marine and estuarine environments. Flow requirements for this stretch of river should have consisted of at least two flood releases followed by at least 10 days of continuous base flow. The magnitude of the floods could not be determined as no hydraulic rating at this site was possible. The magnitude was however not important as this flood had to serve as a trigger for fish migration.

The results of the other EWR sites are summarised in the following table (Table 8-1) and in Figure 8-1 as a percentage of the virgin mean annual runoff. It should be noted that these percentages had to be used with caution due to the uncertainty around the naturalised hydrology. The hydrology for the study was based on simulated hydrology with low confidence. Pitman calibrations were used to generate natural and present day flow sequences at specified riverine sites in the Kromme (AWRSA (1994) calibration) and the Seekoei / Swart (WRSM90 calibration) rivers.

Table 8-1 The summarised results for the EWR sites

EWR site	REC	Maintenance low flows (%)	Drought low flows (%)	High flows (%)	Long term mean of VMAR (%)
EWR 1	C	13.76	1.93	15.94	29.7
EWR 2	D	3.13	0.57	10.95	14.08
EWR 4	C/D	5.76	1.02	11.38	17.14
EWR 5	C	12.17	2.07	11.25	23.43
EWR 6	B	12.32	3.28	11.95	24.27

8.4 Conclusions

None of the results indicated any significantly different results from those expected as a percentage of the virgin MAR. The high maintenance flows required at EWR sites 5 and 6 were high when compared to the other sites, probably due to these sites being situated closer to the the sources of the rivers, i.e. in the upper half of the quaternary catchment. It has long been suspected that the smaller rivers usually situated on steep gradients or high in the system require a larger percentage of base flows than the larger downstream rivers. This could have been due to the fact that a small decrease in flow can have a major impact on habitat in a small river, compared with a less noticeable impact in a larger river.

Confidences for low and high flow assessments are shown in Tables 8-2 and 8-3 respectively.
The confidence in the EWR is summarised as follows:

0 (no confidence)
1 (low confidence)
2 (low to medium confidence)
3 (medium confidence)
4 (medium to high confidence)
5 (high confidence)

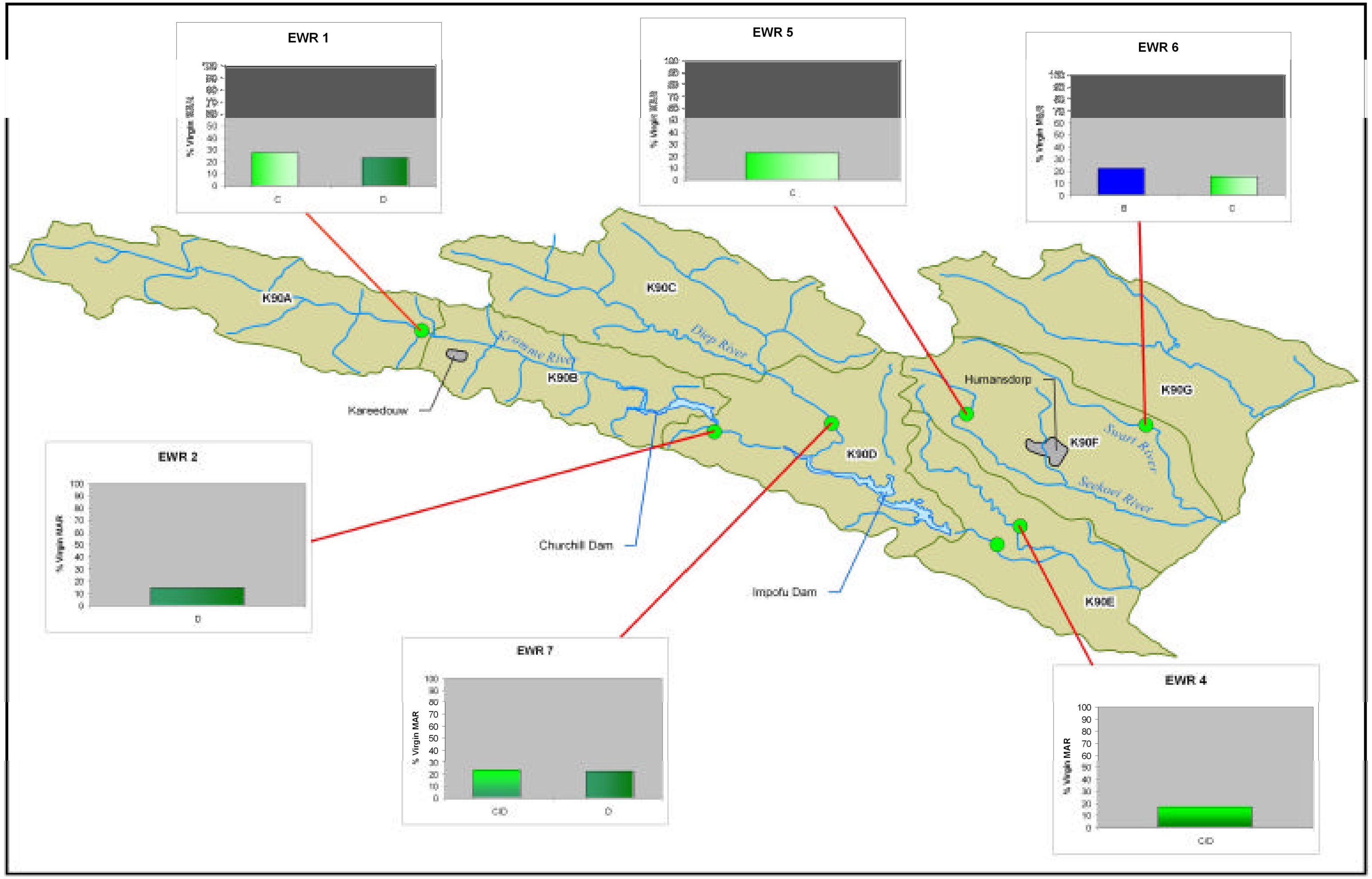

Figure 8-1 EWR for the Kromme/Seekoei study area, expressed as a percentage of the natural or virgin MAR (VMAR)

Table 8-2 Confidence - Low flows

EWR site	Hydraulics	Geomorphology	Vegetation	Aquatic invertebrates	Fish	OVERALL
1	4	0	2	2	4	3: Medium confidence. Hydraulics carries the largest weight of all the components.
2	4	0	4	3	4	3 - 4: Medium confidence to high. Hydraulics is evaluated as high. Aquatic Invertebrates however are the primary motivator for the flows and the low confidence modifies the hydraulic confidence to an overall of 3.
4	2	0	0	2	3	2 - 3: Low to medium confidence. Both fish and aquatic invertebrates are primary motivators for flow and evaluation is therefore between 3 and 4; probably being closer to 4.
5	3	0	0	3.5	3.5	3: Medium confidence. The higher invertebrate confidence is discounted as the fish is the primary motivator and therefore carries a higher weight.
6	3	0	0	4	3	3 – 4: Medium to high confidence. Invertebrate confidence is primary and the evaluation is therefore probably slightly higher than 3, but would be more towards 3 than 4.

The evaluation ranges from medium to medium - high. This was mostly due to the reasonable hydraulic confidence as most hydraulic calibrations were obtained during low flow conditions.

Table 8-3 Confidence – High flows

EWR site	Hydraulics	Geomorphology	Vegetation	Aquatic invertebrates	Fish	OVERALL
1	2	3	4	3	4	2: Low confidence. Lack of confidence in hydraulics overrides the higher confidence in fish and aquatic invertebrates.
2	3	2	2	3	4	2 - 3: Low to medium confidence. The higher confidences in components other than hydraulics are linked to the confidence in the water levels/velocity etc required. As the hydraulics are of low confidence and the conversion from hydraulic parameters is low, the hydraulic confidence overrides the other higher confidences.
4	3	2	2	3	3	2: Low confidence. Both geomorphology and vegetation have been evaluated as low and are therefore more important high flow components. The higher biota confidences are therefore modified by the lower hydraulics and driver confidence.
5	2	2	2	3	3	2: Low confidence. Geomorphology, vegetation and hydraulics have a low evaluation. Linked to the low hydraulics motivation, the higher biota evaluation is ignored.
6	1	2	3	4	3	2 - 3: Low to medium confidence. The low hydraulic confidence overrides all the other confidences that are linked to water levels etc. and not to flow.

Four of the five high flow EWR site evaluations were of low confidence. This was purely based on the lack of high flows experienced during the data collection phase and the resulting low confidence in converting water levels to flow.

Low flows: No additional data collection was required apart from a Reserve monitoring programme.

High flows: Any additional work outside of a Reserve monitoring programme would be centred around obtaining additional hydraulic calibrations during high flow conditions. High flows could then be modified accordingly and new flow results could be generated. Further work regarding the biophysical components could be undertaken as part of a Reserve monitoring programme.

9 DEVELOPMENT OF OPERATIONAL SCENARIOS

Note: This chapter is an extract from CES (2005), Hydrology Report No. RDM/ K90/ 01/CON/0805.

9.1 Overview and objectives

Operational flow scenarios were designed based on impacts of the EWR scenarios on yield and users, as well as considering operational constraints such as sizes of dam outlets. As more water than is required is currently available at the EWR river sites, i.e. the required EWR is presently available in the system, the focus of developing operational scenarios was meeting the needs of the Kromme and Seekoei estuaries.

Operational flow scenarios were developed for both estuarine systems. Both estuaries presented certain challenges in the development of flow scenarios, compared to the normal approach of evaluating a range of river scenarios entering the estuary from one point. In terms of the Kromme Estuary the challenges were related to a large dam (Impofu Dam) being located at the head of the estuary, which attenuates almost all flow into the estuary, and a second input of freshwater via the Geelhoutboom river which enters the estuary just below the head of the system. With respect to the Seekoei Estuary, this estuary has two sets of rivers which run into the head of the estuary namely the Swart and Seekoei rivers.

The key objective was therefore to establish a range of flow scenarios for the two systems which took the above peculiarities into consideration and would also provide a range of ECs that, in conjunction with other considerations such as economics, goods and services etc. would enable the authorities in the selection of an appropriate Reserve.

9.2 Approach

9.2.1 Seekoei Estuary

As discussed, the Seekoei estuary has two rivers that enter the system; namely the Seekoei and Swart rivers. The traditional approach of evaluating various river scenarios which will result in a range of estuary categories was adopted. In this case, however, the river inflows to the estuary were not based on determined EWRs as both EWR sites are situated far upstream in the catchment. The lower rivers consist mostly of dams and the EWRs set at the upstream site would not be applicable. An artificial EWR was therefore created using the Desktop Reserve Model. The simulation of inflows into the Seekoei/Swart River estuary are described below and shown graphically in Figure 9-1:

A. Firstly the natural inflow from quaternary catchment K90F.nat was simulated from rainfall records using the Pitman model.

B. Then the releases to maintain the river in various categories were deducted from this natural flow to determine the stream flow retained in the dummy reservoir.

C. The dummy reservoir represents the total storage in the Seekoei/ Swart catchments and the demands acting on the reservoir are the total demands supplied from surface water (excluding groundwater) in the catchment. The Ressim programme was used to determine the volume actually supplied to irrigation and the spills to the estuary.

D. Thereafter the spill from the dummy reservoir (Step C) was added to the ecological releases (Step B) to determine the inflow to the estuary.

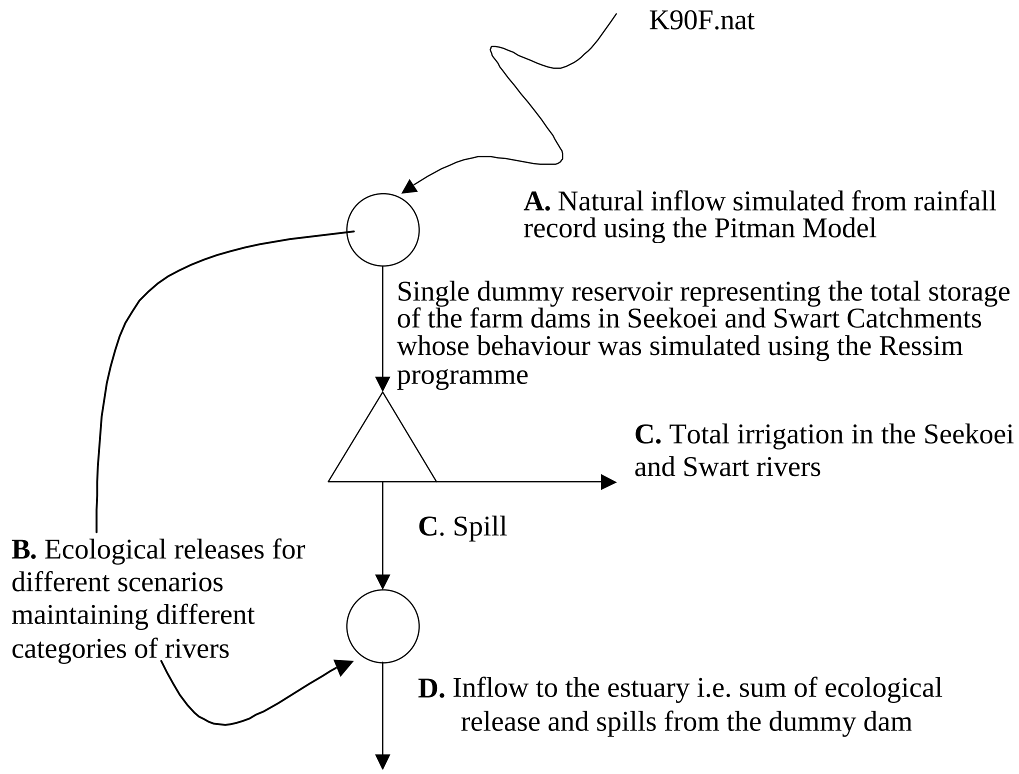

Figure 9-1 Modelling the inflow to the estuary for the Seekoei / Swart system

9.2.2 Kromme Estuary

As Impofu Dam is situated immediately upstream of the Kromme Estuary; the normal process of evaluating different river flow scenarios as inflow to the estuary was not applicable. Through the development of a 3D salinity model of the system, a number of dam release scenarios were developed which would result in a range of different abiotic states within the estuary. Various estuary scenarios were therefore developed to establish what measures could be undertaken to improve or maintain the health of the system. Flows from the Geelhoutboom tributary of the Kromme River were included in the generation of the various scenarios.

9.3 Results

9.3.1 Seekoei Estuary

The suite of scenarios evaluated for the Seekoei Estuary were the following (Table 9-1):

Table 9-1 Suite of scenarios evaluated for the Reserve study of the Seekoei Estuary

Name	Seekoei Estuary	Volume (Mm^3/a)
Reference	Reference	20
Present	Present Flows	11.5
Scenario 1	High volume river inflow and 15 Mm^3/a to estuary	17
Scenario 2	Moderate volume river inflow	12
Scenario 3	Low volume river inflow	11
Scenario 4	High volume river inflow and 13 Mm^3/a to estuary	15

9.3.2 Kromme Estuary

The suite of scenarios evaluated for the Kromme Estuary can be described as follows (Table 9-2):

Table 9-2 Suite of scenarios evaluated for the Reserve study of the Kromme Estuary

Scenario	River	
	Kromme	**Geelhoutboom**
Reference	Natural Flows	Natural Flows
Present	0.4 x 10^{6} m^3	Present inflows + 0.95 Mm^3/a abstraction
Scenario 1	5 x 10^{6} m^3 released in Nov	Present inflows + 0.95 Mm^3/a abstraction
Scenario 2	10 x 10^{6} m^3 released in Oct and Jan	Change in monthly flow distribution from present with 0.95 Mm^3/a abstraction
Scenario 3	0.4 x 10^{6} m^3 (Present inflows)	Change in monthly flow distribution from present without 0.95 Mm^3/a abstraction
Scenario 4	5 x 10^{6} m^3 released in Nov	Change in monthly flow distribution from present without 0.95 Mm^3/a abstraction
Scenario 5	7.5 x 10^{6} m^3 released in Oct and Nov	Change in monthly flow distribution from present with 0.95 Mm^3/a abstraction
Scenario 6	16 x 10^{6} m^3 released mainly in Oct – Jan, with low winter baseflows	Present inflows
Scenario 7	16 x 10^{6} m^3 released mainly in Oct – Jan	Present inflows

All scenarios were designed so that the system has the capacity to release the required flows and no scenarios that require engineering intervention were considered.

10 ECOLOGICAL CONSEQUENCES: RIVERS

Note: This chapter is a summary of CES (2005), EWR Rivers Report No. RDM/ K90/ 01/CON/0405.

10.1 Overview and objectives

The aim of this component of the study was to describe the ecological and water quality consequences of various operational scenarios. These operational scenarios are designed based on impacts of the EWR scenarios on yield and users, as well as considering operational constraints such as sizes of dam outlets.

10.2 Approach

The ecological consequences of the operational scenarios are determined by evaluating the impacts on Ecological Category.

10.3 Results

The EWR were tested using the yield model to determine whether there would be any impacts on users of the system. It was found that more water than the required EWR was presently available in the system.

Operational constraints of Churchill Dam outlets affecting EWR 2 were the only issue. However, as flows were only set to maintain the present condition, there were no specific releases required for EWR site 2.

Two additional flow scenarios for future developments in the Geelhoutboom system were evaluated. These additional scenarios were devised to represent increased storage (i.e. development of an upstream dam) and abstraction upstream from EWR site 4. The scenarios were as follows:

GHB Sc 2: Upstream dam spilling and no EWR release required.
GHB Sc 3: Upstream dam operated to release EWR.

The impact of GHB Sc 2 in the dry season will be unacceptable due to a no-flow situation occurring for 98% of the time in all Januaries and 62% of the time in all Augusts. This would result in a drop in EC to below the present C/D EcoStatus and probably below a D EcoStatus.

The EWR would be met under GHB Sc 3 and would be an improvement on present conditions during the dry season as fewer periods of no flow will occur. This scenario was therefore similar to that requested and should maintain the C/D EcoStatus. It was however considered unlikely that a dam with the capacity to release EWR will be built in this area.

10.4 Conclusions

Of the three scenarios evaluated, only GHB Sc 2 would not meet the REC due to a prolonged no-flow situation.

11 ECOLOGICAL CONSEQUENCES: ESTUARIES

Note: This chapter is a summary of CES (2005), EWR Estuaries Kromme Report No. RDM/ K90/ 04/CON/0605 and Seekoei Report No. RDM/ K90/ 04/CON/0705.

11.1 Overview and objectives

This chapter outlines and discusses the ecological consequences of the operational scenarios for both estuaries.

11.2 Approach

To determine the EC of the estuary for each scenario, the anticipated changes in abiotic characteristics were assessed in terms of their biological implications, using the same Estuarine Health Index used to derive the Present Ecological State (PES). Results from these evaluations were then used to select the 'recommended ecological scenario' for each system, defined as the run-off scenario (or a slight modification thereof) that represented the largest reduction in river inflow that would still protect the aquatic ecosystem of the estuary and maintain it in the Recommended Ecological Category.

The runoff scenarios evaluated for the Kromme and Seekoei estuaries were discussed in Chapter 9, see Tables 9-1 and 9-2. All scenarios were designed so that the system has the capacity to release the required flows and no scenarios that require engineering intervention were considered.

11.3 Results

11.3.1 Seekoei Estuary

The individual EHI scores, as well as the corresponding REC for the different scenarios for the Seekoei Estuary, are shown on Table 11-1.

Table 11-1 EHI scores for the four scenarios evaluated for the Seekoei Estuary

Variable	Weight	Present	Runoff Scenario			
			1	2	3	4
Hydrology	25	58	81	60	58	71
Hydrodynamics/mouth condition	25	40	85	45	20	80
Water quality	25	40	63	51	43	61
Physical habitat alteration	25	61	76	68	61	74
Habitat Health Score	**50**	**50**	**76**	**56**	**46**	**71**
Microalgae	20	35	70	40	25	65
Macrophytes	20	35	70	40	30	65
Invertebrates	20	30	75	50	35	75
Fish	20	35	80	40	35	70
Birds	20	40	80	55	40	70
Biotic Health Score	**50**	**35**	**75**	**45**	**33**	**69**
Estuarine Health Index Score		**42**	**76**	**51**	**39**	**70**
Ecological Category (EC)		**D-**	**B**	**D**	**E**	**C**

11.3.2 Kromme Estuary

The individual EHI scores, as well as the corresponding REC for the different scenarios for the Kromme Estuary are shown on Table 11-2.

Table 11-2 EHI scores for the seven scenarios evaluated for the Kromme Estuary

Variable	Weight	Present	Runoff scenario					
			1	2	3	4	5	6
Hydrology	25	33.7	38	42	35	44	38	51
Hydrodynamics/mouth condition	25	100	100	100	100	100	100	100
Water quality	25	33.2	41	47	35	42	47	62
Physical habitat alteration	25	70	70	70	70	70	70	70
Habitat Health Score	**50**	**59**	**62**	**65**	**60**	**64**	**64**	**71**
Microalgae	20	17	17	17	17	17	17	17
Macrophytes	20	50	52	56	51	54	55	65
Invertebrates	20	20	20	20	20	20	20	57
Fish	20	40	50	55	45	60	65	85
Birds	20	70	75	80	72	77	78	80
Biotic Health Score	**50**	**39**	**43**	**46**	**41**	**46**	**47**	**61**
Estuarine Health Index Score		**49**	**53**	**55**	**50**	**55**	**55**	**66**
Ecological Category (EC)		**D**	**D**	**D**	**D**	**D**	**D**	**C**

11.4 Conclusions

11.4.1 Seekoei Estuary

The Seekoei Estuary is a Provincial Nature Reserve. According to the guidelines for assigning a REC, the estuary therefore needs to be in a Category A or the Best Attainable State (BAS). However, due to the fact that the changes are contributing to the present state of the estuary (Category D) are seen as partially irreversible it was decided that it should be recommended that the Seekoei Estuary be improved into the highest achievable EC, which is a Category B.

Four scenarios (Table 11-3) were evaluated Scenarios 1 and 4 resulted in a significant improvement in the biotic health state of the system (Scenario 1: E to a B; Scenario 4: E to a C). Scenario 2 resulted in an overall change from a Low D to a D category, but most importantly it changed the biotic health from an E to D category. Scenario 3 resulted in a decrease in EC to an E category (*highly degraded*).

Table 11-3 Ecological consequences of Seekoei Estuary scenarios

Variable	Present	Seekoei Estuary Scenario			
		1	2	3	4
Habitat Health Score	D	B-	D+	D-	B-
Biotic Health Score	E+	B-	D-	E+	C+
Ecological Category (EC)	D-	B-	D	E+	B-

Urgent management intervention is required for the Seekoei Estuary as the biotic health score indicates a highly degraded system. The REC of a B can be achieved through a combination of flow and non-flow related management interventions, as anthropogenic influences (other than flow) have had a significant influence on the estuary's health. An evaluation was therefore made of the combination of flows associated with a REC of a C combined with the reversal of the non-flow related influences. Scenarios 1 and 4 will achieve this in combination with addressing the non flow-related influences.

Scenario 4 (Figure 11-1) was selected as the recommended Ecological Flow Requirement (Scenario) for the Seekoei Estuary, with flow distributions as summarised on Table 11-4.

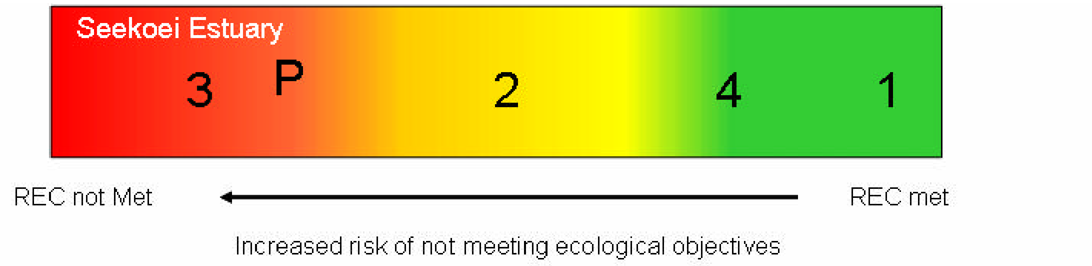

Figure 11-1 Ecological consequences for various operational scenarios in the Seekoei Estuary

Table 11-4 Summary of the flow distribution in m^3/s for the recommended Ecological Water Requirement (Scenario) for the Seekoei Estuary

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99%ile	20.15	9.37	3.83	1.03	2.03	10.26	5.38	15.07	14.87	9.71	19.96	24.55
90%ile	4.69	3.40	0.40	0.22	0.19	0.27	0.90	1.44	2.18	2.25	3.34	6.93
80%ile	2.63	1.71	0.28	0.22	0.19	0.22	0.36	1.08	1.09	1.43	2.18	3.46
70%ile	1.40	1.08	0.27	0.21	0.18	0.21	0.35	0.87	0.62	0.86	1.68	2.24
60%ile	0.97	0.62	0.25	0.20	0.16	0.19	0.32	0.74	0.51	0.62	1.24	1.81
50%ile	0.67	0.56	0.23	0.17	0.15	0.18	0.29	0.54	0.40	0.46	0.61	1.44
40%ile	0.52	0.44	0.18	0.14	0.12	0.14	0.24	0.43	0.32	0.35	0.39	1.10
30%ile	0.33	0.31	0.13	0.10	0.09	0.10	0.17	0.33	0.23	0.23	0.29	0.76
20%ile	0.18	0.19	0.07	0.07	0.05	0.07	0.11	0.18	0.14	0.15	0.20	0.46
10%ile	0.10	0.11	0.05	0.04	0.04	0.04	0.06	0.11	0.08	0.08	0.09	0.25
1%ile	0.07	0.08	0.04	0.03	0.02	0.03	0.04	0.08	0.06	0.06	0.07	0.18

11.4.2 Kromme Estuary

The Kromme Estuary has been targeted as a Desired Protected Area (DWAF, 2004a). According to the guidelines for assigning a recommended REC, the estuary needs to be in a Category A or the Best Attainable State (BAS). However, due to the fact that the changes that are currently largely contributing to the present state of the estuary (Category D) are related to large dam developments in the catchment (e.g. Impofu Dam), and that it is unlikely that these interferences could be reversed even to get it into a Category B, it was decided to at least recommend that the Kromme Estuary be improved into the minimum REC for an *Important* estuary, which is a Category C.

The scenarios evaluated indicated that of the seven scenarios evaluated, five of them resulted in the system remaining in a D category (Table 11-5). The biological responses (biotic health score) improved from an E to a D for all scenarios, however, the system did not easily move into a C category in terms of biotic health. Scenarios 6 and 7 were the only scenarios that would result in a C Ecological Category.

Table 11-5 Ecological consequences of Kromme Estuary scenarios

Variable	Present	Kromme Estuary Scenario						
		1	2	3	4	5	6	7
Habitat Health Score	D+	C-	C-	C-	C-	C-	C-	C-
Biotic Health Score	E+	D-	D-	D-	D-	D-	C-	D+
Ecological Category (EC)	D	D+	D+	D	D+	D+	C-	C-

Scenario 6 (Figure 11-2) was selected as the recommended Ecological Flow Requirement (Scenario) for the Kromme Estuary, with flow distributions (mean monthly flows in m^3/s) as summarised in Table 11-6.

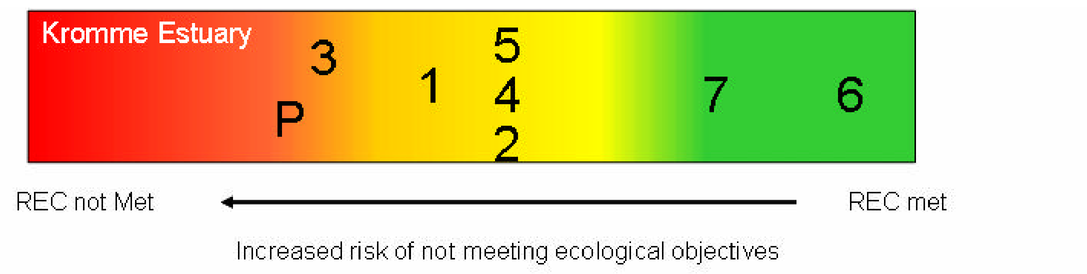

Figure 11-2 Graphical representation of ecological consequences for various operational scenarios in the Kromme Estuary

Table 11-6 Summary of the flow distribution in m^3/s for the recommended Ecological Water Requirement (Scenario) for the Kromme Estuary

Kromme: Summary of flow distributions (16 x 10^6 m^3 release mainly Oct to Jan)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99%ile	14.86	26.47	5.53	5.79	3.49	3.90	4.91	29.21	15.89	19.20	25.78	31.75
90%ile	5.62	2.14	1.11	0.80	0.54	0.60	0.69	2.93	3.13	2.63	6.26	12.01
80%ile	2.81	1.42	0.91	0.72	0.37	0.38	0.40	0.63	0.60	0.79	1.54	3.60
70%ile	2.26	1.36	0.86	0.69	0.30	0.33	0.35	0.36	0.47	0.56	0.84	0.97
60%ile	2.08	1.25	0.81	0.68	0.29	0.26	0.30	0.31	0.33	0.42	0.52	0.79
50%ile	2.02	1.19	0.81	0.66	0.26	0.25	0.27	0.27	0.31	0.36	0.42	0.66
40%ile	1.97	1.16	0.79	0.65	0.24	0.25	0.25	0.25	0.28	0.33	0.37	0.57
30%ile	1.93	1.13	0.77	0.63	0.24	0.23	0.24	0.24	0.26	0.28	0.32	0.52
20%ile	1.85	1.09	0.75	0.47	0.24	0.22	0.22	0.22	0.24	0.25	0.29	0.49
10%ile	0.40	0.42	0.33	0.27	0.23	0.08	0.08	0.08	0.12	0.17	0.25	0.34
1%ile	0.06	0.30	0.26	0.24	0.22	0.02	0.03	0.02	0.03	0.04	0.08	0.12

Green hatched months represent flows where the surface salinities would still be representative of State 2, red hatched months represent flows less than 0.2 m^s/s when hypersaline conditions can potentially develop. Green blocks represent flows between 1 and 8 m^3/s, and white blocks are >8 m^3/s.

Geelhoutboom: Summary of flow distributions (Present State)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99%ile	1.05	1.21	0.34	0.43	0.29	0.32	0.28	1.17	0.90	1.18	1.72	2.09
90%ile	0.37	0.36	0.05	0.00	0.05	0.07	0.08	0.18	0.21	0.18	0.41	0.57
80%ile	0.24	0.11	0.01	0.00	0.00	0.01	0.04	0.07	0.10	0.11	0.17	0.22
70%ile	0.13	0.06	0.00	0.00	0.00	0.00	0.01	0.03	0.06	0.07	0.13	0.16
60%ile	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.08	0.09
50%ile	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.05	0.06
40%ile	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03
30%ile	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02
20%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Pink blocks resprent flows <0.8 m^3/s, green blocks represent flows between 0.08 and 1 m^3/s, and white block are flows exceeding 1 m^3/s.

12 SOCIO-ECONOMICS

Note: This chapter is a summary of CES (2006), Socio-Economics Report No. RDM/ K90/ 05/CON/ 1205.

12.1 Overview and objectives

This Reserve comprises an Ecological Reserve, which is the quantity, quality and reliability of freshwater flows needed to sustain ecosystem functioning, and a Basic Human Needs Reserve, to safeguard water supplies for direct use by people.

The Basic Human Needs Reserve is determined on the basis of the number of people dependent on a catchment's water resources. The Ecological Reserve is not a fixed quantity, however. While provision is made in the NWA to ensure that all water resources are maintained at or above a minimum level of health (Category D), the decision as to what level of health the aquatic ecosystems are maintained in is negotiable, which means that the specifications of the Ecological Reserve can vary considerably. The desired state of health of the aquatic ecosystems will depend on the value of those ecosystems and how much the value is affected by a change in ecosystem health, as well as the benefits that could be obtained from the use of the water resources in other productive activities. Thus there is essentially a trade-off between the allocation of water to the environment versus water users.

The aim of the socio-economic study was to describe the social and economic implications of alternative scenarios of water allocation, in order to facilitate the decision-making process required for classification and management of the water resource. The key objectives of the task were as follows:

- Describe the socio-economic characteristics of the catchments.
- Describe the social and economic value of the aquatic ecosystem goods and services that are influenced by instream flow and water quality.
- Describe the social and economic value of water that is currently abstracted from the system.
- Estimate the change in these values under different scenarios of water allocation.

12.2 Approach

12.2.1 Socio–economic profile

Existing information was used to develop a socio-economic profile of the affected communities. A household survey was conducted to gather inputs directly from people living in the catchments and to verify information from the census data. The focus of the survey was on the poorer communities found in the catchments as the richer farming community and the mostly rich resident and visitor communities of St Francis Bay and Paradise Beach had previously been surveyed. The poorer communities surveyed included Kruisfontein, Kwa-Nomzamo informal settlements and Die Berg (all situated close to the town of Humansdorp), Kareedouw and associated townships of Mountain View, Kagiso Heights and Nuwwe rus, and St Francis Bay townships of Sea Vista and Zwelitsha.

An interview schedule was developed, with a range of questions dealing with demographics and water-use related questions. Thirty interviews were conducted with household members between 27 February and 3 March 2006. Particular effort was made to include woman, youth and the aged in the survey as these groupings are often excluded in consultation processes. The households were randomly selected, representative of the size of the towns and the possible impacts that communities could have on the associated rivers. Additional data were collected by means of focus group meetings and one-on-one interviews with key informants.

12.2.2 Calculation of the Basic Human Needs Reserve

At present there is no official methodology for a Basic Human Needs Reserve (BHNR) assessment. Cues as to the manner in which the BHNR should be calculated were derived from the definition as set out in the Act that states that "the Basic Human Needs Reserve provides for the essential needs of individuals served by the water resource in question and includes water for drinking, for food preparation and for personal hygiene". Whereas the quality component of the BHNR is defined through reference to what is considered to be a "potable standard", the quantity that makes up the BHNR has no absolute definition. It should be noted that there is no "official" BHNR figure. As such the convention of using the RDP targets of 25 litres per person per day, 50 litres per person per day and 60 litres per person per day were used.

12.2.3 Values generated by aquatic ecosystems and implications of different flow scenarios

This study approach concentrated on two ecosystem values: the direct use values associated with the estuaries as recreational amenities, and the indirect use values associated with the nursery function of the estuaries.

Recreational value was estimated in terms of the following:

- The portion of the investment in property made by residents that is attributable to each estuary.
- The expenditure in the area made by non-residents visiting each estuary.

The methods used were a combination of hedonic pricing, travel cost method, conjoint valuation and contingent valuation. The approach was designed to be able to predict the change in value under the different scenarios. Data were collected by means of a survey of estate agents, residents and visitors at the two estuaries.

The nursery function of estuaries has been roughly estimated and valued for all estuaries in the country. The contribution of the Kromme and Seekoei estuaries was estimated, and the change in this contribution resulting from the different scenarios was estimated on the basis of expert assessment.

12.2.4 Economic value of water use and implications of different flow scenarios

In order to value water use in the catchment under various water availability scenarios, the Kromme/Seekoei River catchment area was sub-divided into four economic sub-areas which are.

- The area above Churchill Dam in the Kromme River. The sectoral water uses were dependent on run-of-river abstractions and will not be affected by any changes in the available water.
- The area downstream of Churchill Dam but upstream of Impofu Dam. This sectoral water uses for this sub-area are dependent on the available water in Churchill Dam.
- The area downstream of Impofu Dam up to the estuary. This sectoral water uses for this sub-area are dependent on the available water in Impofu Dam.
- The Seekoei River catchment as a separate sub-area of the sectoral water use in the catchment.

Furthermore the Kromme/Seekoei River catchment transfers water to the Nelson Mandela Metropolitan area for use in commercial, institutional, industrial and domestic sectors. The economic value of this transfer was also determined separately as the available water would most likely change with managed releases for various flow scenarios that were determined for the estuary.

12.2.5 Valuation of out of stream water usage

Conceptual framework of the Water Impact Model

In order to conduct a valuation of the social and economic impact of the flow scenarios determined by ecological specialists on the water using sectors as identified in the preceding sections, a Water Impact Model was developed. The underlying principal of this model is the fact that water is a scarce resource. As such, the allocation of water between competing users (i.e. agriculture, domestic households, industry, and the ecosystem) needs to be structured in such a way that positive socio-economic impacts are maximized.

The primary objective of the Water Impact Model was twofold. In the first instance, the model was structured in such a manner that it provides a detailed description of the current water usage (consumptive and non-consumptive) situation in the catchment area, i.e. the volumes of water used by various water users by abstraction from the river system, and the economic and socio-economic impacts resulting from this particular usage pattern. In the second instance, the model makes it possible to undertake a scenario analysis of the water usage situation where the amount of water used by each water user is altered from its current state. Once again, given each new water usage scenario, it was possible to determine the economic and socio-economic impacts emanating from this change in water usage. Thus, the model generated the consequences of multiple scenarios where the available water to the water using sectors changed with each ecological flow regime considered in each scenario.

The Water Impact Model determines the different impacts that the current and new situations will have on the economy. By subtracting the impact of these situations from the base scenario (i.e. no EWR), the marginal differences in economic and socio-economic impacts were calculated for each ecological water requirements scenario. This made it possible to ascertain the nature and magnitude of the impact that changes in water use patterns will have on the community around the catchments, as well as on the broader economy.

Economic valuation at sub- catchment level

A separate dynamic Water Impact Model was developed for each of the identified four sub-catchments. These separate models only feature the water users that are relevant for each sub-catchment, i.e. in the case of the Seekoei, which was considered as a sub-system, only irrigated pasture was included in the Agricultural Water Impact Model since that is the only irrigation activity taking place.

In addition, the sub-catchment models were also structured in such a way that each water user sector is dealt with individually so that the economic and socio-economic impacts emanating from re-allocations of water between and within user sectors can be calculated separately. In doing so, the impact of changes in water use patterns can be uniquely measured for each water user sector, and comparative analyses between various user sectors can be performed in terms of the economic impacts emanating from each water re-allocation change.

Economic variables used

The criteria of the economic impacts of water re-allocations between users were measured in terms of the following macroeconomic variables:

- Impacts on profit (i.e. the impact on surpluses generated by each water user).
- Economic growth (i.e. the impact on Gross Domestic Product [GDP]).
- Job creation (i.e. the impact on labour requirements).
- Impact on capital formation.
- Income distribution (i.e. the impact on low-income, poor households and the total income households).

After determining the magnitude of change for each water user individually, the model ranks water users in accordance with their contribution to these economic variables per m^3 of water used in the production process. In doing so, the allocation of water rights in this catchment can be re-visited, and adjustments can be made according to the magnitude of each entity's contributions towards the economy.

12.3 Results

12.3.1 Socio-economic profile

The study area is characterised by extremes of wealth and poverty, with wealthy people inhabiting coastal nodes such as St Francis Bay and Paradise Beach, and growing informal settiments as a result of an influx of people from the Transkei since 1994. More than 60% of the population of about 22 500 people is estimated to be living in poverty (<R38 400/annum). Agriculture is the main employer, providing 27% of jobs.

There are no communal lands in the study area, and there is little, if any, dependence on riparian systems for water or natural resources. All households have access to municipal water. Cultural use of riparian systems is limited to initiation ceremonies and baptism on the Seekoei and the upper Kromme (near Kareedouw). Some households fish for home consumption on a small scale.

12.3.2 Basic Human Needs Reserve

Based on population projections and a planning horizon of 2020, the BHNR was calculated as being up to 0.31, 0.61 or 0.74 Mm^3 per annum, on the basis of 25, 50 or 60 litres per person per day. However, since no-one in the catchment is directly dependent on the river systems for water supply for subsistence purposes, a BHNR is not considered necessary in the Kromme/Seekoei catchments.

12.3.3 Description of the operational flow scenarios

A total of seven and four operational flow scenarios were considered for the Kromme (Table 9-1) and Seekoei (Table 9-2) subsystems, respectively – see Chapter 9 for detailed information. These scenarios impact on both water supply to users and on ecosystem health and characteristics. In both cases, the scenarios largely impact on the estuaries, and not the rivers, due to the location of the dams. Thus the changes in ecosystem characteristics are only considered for the two estuaries. The following are derived from the reports of the Kromme/Seekoei RDM study – see Tables 12-1 and 12-2 for the Kromme and Seekoei estuaries respectively.

Table 12-1 Water flow scenarios used for the Kromme River and the expected changes in estuary health (relatively to the natural condition) and water yield (Mm^3)

Scenario	Flow volume (Mm^3/a)	% natural flow	Estuary health category (% of natural)	Water supply (historical firm yield, Mm^3/a)	% present day system supplied
Present	35	36%	D (49%)	44	100%
1	38	39%	D (53%)	39	89%
2	43	44%	D (55%)	34	77%
3	35	36%	D (50%)	42	95%
4	38	39%	D (55%)	39	89%
5	41	42%	D (55%)	37	84%
6	50	52%	C (66%)	37	84%
7	50	52%	C	39.4	90%

Table 12-2 Water flow scenarios used for the Seekoei River and the expected changes in estuary health (relatively to the natural condition) and water yield (Mm^3)

Scenario	Flow volume (Mm^3/a)	% natural flow	Estuary health category (% of natural)	Water supply (to irrigation, Mm^3/a)	% present day irrigation supplied
Present	11.36	56.0%	D (42%)	7.5	100%
1	16.65	82.1%	B (76%)	2.5	33%
2	11.97	59.1%	D (51%)	6.5	86%
3	11.10	54.8%	E (39%)	7.1	95%
4	14.71	72.6%	C (70%)	4.5	60%

12.3.4 Values generated by aquatic ecosystems and implications of different flow scenarios

Based on a review of aquatic ecosystem goods, services and attributes and different types of value, the recreational and tourism values and the nursery value of the estuaries in terms of their contribution to marine fisheries were identified as the most important values to concentrate on in this study. These were selected because of their importance as well as the fact that they were considered likely to be affected by the flow scenarios.

At the Kromme estuary, there are a total of 4584 erven and 2555 properties in the Cape St Francis to Kromme River area, of which 45% are occupied by permanent residents. It is estimated that visitors spend a total of 1.1 million visitor days in the area per year. Respondents claimed that the estuary accounts for 17% of the attractiveness of the area. The extensive use of the estuary is evident by the fact that there are an average or 1.5 boats per household (half are motorised).

Distance to the estuary is a significant factor determining property prices in the area. Based on the property price premium associated with river-front property, the overall property value contributed by the estuary is conservatively estimated as R578 million. This translates to about R17.7 million in terms of direct value added to national income in the real estate sector. In addition, recreational use of the estuary accounts for about R25 million of the annual expenditure in the area.

People's enjoyment of the estuary is significantly affected by the area of saltmarsh, abundance of angling fish and abundance of birds, but is not affected by eelgrass abundance. Based on a conjoint model of how utility changes in response to these variables, and how use of the estuary changes with utility, it was estimated that the scenarios under consideration would lead to an increase in the recreational value of the area of about 5% for all scenarios, with the response to all scenarios being very similar.

There are a total of 2300 erven and 770 properties in the vicinity of the Seekoei estuary, of which about 60% are occupied by permanent residents. Visitors spend an estimated 240 000 visitor days per year. The estuary makes up about 11% of the attractiveness of the area. There is relatively little use of the estuary, and only 1 in 10 households have a boat on average. House prices are significantly correlated with size and proximity to the beach, but proximity to the estuary was not a significant factor. Recreational use of the estuary results in expenditure of about R3 million per annum. People's enjoyment of the estuary is significantly affected by the abundance of angling fish and birds. Based on a conjoint model of use and utility changes in response to these variables, it was shown that the recreational value of the estuary could increase by up to 55% under the different scenarios. It is important to note that the Seekoei scenarios led to a much wider range in estuarine condition than did the Kromme scenarios, which made little difference to estuary condition.

Both the Kromme and Seekoei estuaries act as nursery areas for marine fish that breed in estuaries. This production then contributes to the inshore marine fisheries of the south Cape coast. Based on the proportion of estuary dependent fish in these fisheries and the contribution of these estuaries to the total estuarine nursery area, the nursery value of the Kromme and Seekoei estuaries is estimated to be in the region of R10.8 million and R5.2 million per annum, respectively. For the Kromme, this value would only change significantly under scenario 6, with an increase of 13%. For the Seekoei, the value increases significantly under scenario 1 (29%) and 4 (14%).

12.3.5 Economic value of water use and implications of different flow scenarios

The catchment can be divided into three areas in terms of water use. In the Kromme River catchment, the main water user sectors are commercial forestry (55 ha, mostly in the upper catchment), irrigated agriculture (807 ha; vegetables, deciduous fruit and lucerne) and livestock farming (13 412 LSUs[2]). In the Seekoei catchment there are 184 ha under commercial forestry, 367 ha under irrigation, and livestock (7169 LSUs).

Total use of water from the Kromme catchment amounts to 32.5 Mm^3/a, including the almost 8 Mm^3 lost to alien invasive plants. The bulk of water is (18.9 Mm^3 on average) is for urban use in the Nelson Mandela Metropolitan Municipality. Water use from the Seekoei catchment amounts to 4.5 Mm^3/a.

Table 12-3 Summary of water use within the two catchments

Mm^3/a	Reduction in runoff due to alien vegetation	Reduction in runoff due to afforestation	Water use by irrigated field areas	Total urban water use (Domestic)	Total rural water use (Livestock and Domestic)	Total
Kromme	7.75	0.07	5.52	18.81	0.35	32.5
Seekoei	0.87	0.14	1.97	1.34	0.2	4.52

The economic value of water use at present and under the different scenarios was estimated using a Water Impact Model. This entailed determining the volume of water allocated to each user type in each subcatchment and stipulating a level of assurance of supply for each user. Data required for the model include the agricultural areas, and the water use, production, labour inputs and capital requirements per ha and water production elasticity, and similar types of data for domestic, industrial and environmental use of water. Under different water allocation scenarios, water is allocated proportionally to current use, and the change in output of each activity is calculated on the basis of the above data. For each type of activity, a set of multipliers is then applied to estimate how a change in economic activity in one sector impacts on overall levels of economic activity in the economy. These multipliers are applied to estimate total value added, employment and capital formation, and the impact on low income households. The multipliers were obtained from a Social Accounting Matrix developed for the Eastern Cape (2002), which is considered adequately relevant to this area.

Under present use, water user sectors in the Kromme-Seekoei catchment contribute R271 million to GDP (mainly from the industrial sector), while industrial users in the NMMU generate some R5 billion. Of this some R94 million and R1.9 billion is translated into income to low-income households in the two areas, respectively.

[2] Large Stock Units

Four of the scenarios were economically evaluated for the Kromme (Scenarios 4, 5, 6 and 7 (Sc 7: qualitative assessment only)), and three for the Seekoei (Scenarios 1, 2 and 3). In both cases, all of the scenarios lead to a loss of income, employment and capital formation from water user sectors because of various amounts of water being reallocated from users back to the environment. In the case of the Kromme, contribution to GDP is estimated to fall by R202 million to R1279 million, with concomitant losses of 2700 to 17 400 jobs. The Seekoei scenarios result in GDP losses of R1.9 million to R19.8 million and 46 to 121 job losses.

12.4 Conclusions

12.4.1 Kromme River system

The different scenarios impact mainly on the economic activity in the Nelson Mandela Metropolitan Municipality, because of the reduced availability of water for transfer. The economic impact relating to a change in the availability of water for use is directly inversely proportional to the amount of water required for the Ecological Reserve.

The opposite relationship holds for economic impacts of use of the aquatic ecosystems, but the effect is not quite as linear, because of the complexity of ecosystem characteristics and the way in which they determine value.

In the case of the Kromme, the losses incurred under all of the scenarios are orders of magnitude greater than the economic gains accrued due to improvement in estuary condition (Table 12-4). The change in value added due to water use ranges from a loss of R200 million (scenario 4) to a loss of R1280 million (Scenario 6), whereas the change in value from ecosystem use ranges from zero to a gain of under R1 million in Scenario 6. It is important to note that the latter does not fully value the utility gains, in that consumers' surplus and non-use values have not been estimated.

Table 12-4 Comparison of changes in value due to water and ecosystem use and overall value under different flow scenarios for the Kromme system. Values are estimates of change in GDP (R millions).

		Scenario						
Type of value		**1**	**2**	**3**	**4**	**5**	**6**	**7**
Water use					-202	-538	-1279	-942
	Real estate	0.85	0.89	0.87	0.89	0.89	0.90	
	Tourism	1.20	1.25	1.23	1.25	1.25	1.28	
	Nursery value	-	-	-	-	-	1.02	
Total ecosystem value		2.05	2.14	2.09	2.14	2.14	3.20	-
	Overall change				**- 199.86**	**- 535.86**	**-1,275.80**	

Impacts on employment are correlated with the economic impacts of water use as described above. Most of these impacts would be felt in the NMMU. It is not anticipated that there would be much impact on households in the catchment, either from the changes in water use values or ecosystem use values.

12.4.2 Seekoei River system

The scenarios analysed for the Seekoei River system were far more varied compared with those analysed for the Kromme system. The scenarios impact mainly on the irrigation use of the water, with Scenario 1 resulting in a 72% loss of GDP from this catchment. As for the Kromme, the values generated from ecosystem use follow the opposite trend to those generated from water use. The change in value added due to water use ranges from a loss of R1.9 million (Scenario 2) to a loss of R19.8 million (Scenario 1), whereas the change in value from ecosystem use ranges from a gain of R0.4 million (Scenario 3) to a gain of R3.14 million (scenario 1). Again, it is important to note that the latter does not fully value the utility gains, in that consumers' surplus and non-use values have not been estimated. Taken together, Scenario 2 has the lowest net cost (Table 12-5).

Table 12-5 Comparison of changes in value due to water and ecosystem use and overall value under different flow scenarios for the Seekoei. Values are estimates of change in GDP (R millions)

Type of value		**1**	**2**	**3**	**4**
Water use		-19.80	-1.92	-2.83	
	Real estate	-	-	-	-
	Tourism	3.14	1.26	0.40	2.23
	Nursery value	1.17	-	-	0.57
Total ecosystem value		4.31	1.26	0.40	2.80
	Overall change	**- 15.49**	**- 0.66**	**- 2.43**	

Impacts on employment are correlated with the economic impacts of water use described above. Most of these impacts would be felt locally, with losses of 46 to 121 jobs. This would be ameliorated to some extent by gains due to increased value of the estuary, but this gain has not been quantified and is expected to be relatively small.

It should be stressed that ecosystem values estimated here are only partial, and this is particularly important to consider where values are reasonably close in the case of the Seekoei. They do not include non-use values, such as option and existence value associated with the estuaries. In particular, and pertaining to option value, the estimates are based on current use of and investment in these two areas, whereas only a small proportion of the present erven are actually developed.

13 RECOMMENDED RESERVE

13.1 Overview and objectives

Various operational flow scenarios have been generated and the ecological and socio-economic consequences of each scenario determined. The next step in the process is therefore to select one of the scenarios as the recommended Reserve. The outstanding tasks, i.e. the identification of the final Ecospecs and the monitoring programme will be undertaken for the recommended Reserve.

13.2 Approach

The decision-making process would form part of the Classification Process. In the absence of the Classification Process, a scenario-based approach to decision-making was applied during the Kromme/Seekoei Reserve study. The results of specialist studies and the rationale for the recommendation was documented in a results summary document, submitted and presented to the DWAF senior management in April 2006.

13.3 Results

13.3.1 Rivers

As the REC is being met at present without any impact on other users, the REC and associated Ecological Reserve was recommended.

13.3.2 Estuaries

Kromme Estuary

Scenario 6 and 7 (see Chapter 9 for scenario descriptions) will achieve the REC for the estuary. These scenarios are however the worst in terms of impacts on economics, although all scenarios are similar in terms of impacts on fisheries and recreational activities (goods and services) of the system. A compromise scenario would therefore be Scenario 4. Scenario 4 still results in an improvement of the ecological state of the system, while the economic implications under Scenario 4 are much more acceptable than that under scenarios 6 and 7. The results of the study are shown as Figure 13-1. The numbers shown on the diagram indicate the scenarios assessed, with green to red showing a decline in state.

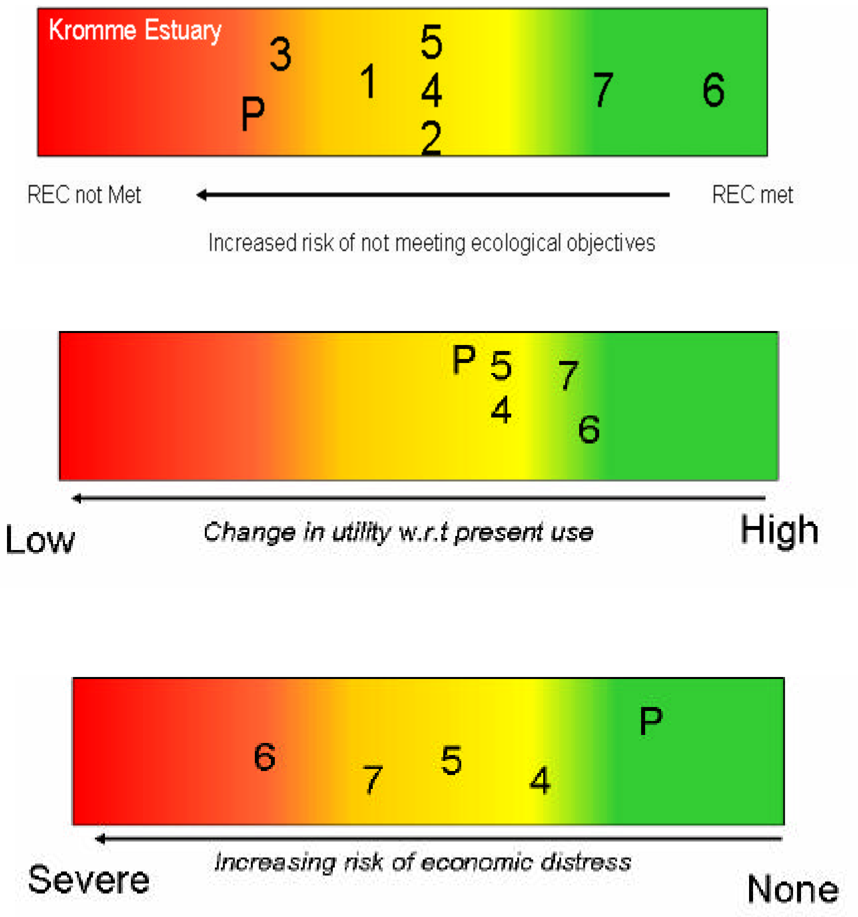

Figure 13-1 Comparison of consequences of various scenarios across study components (ecological, selected goods and services, economics) for the Kromme Estuary

Seekoei Estuary

The REC of a B can be achieved through a combination of flow and non-flow related management interventions, under scenarios 1 and 4. However, an economic evaluation of Scenario 1 showed high economic implications, with a similar outcome anticipated for Scenario 4 as a similar quantity of water would be required by the estuary. Scenario 2 therefore presents the best compromise, with an improvement in the biotic health state of the estuary, while the economic implications under Scenario 2 are more acceptable than that under scenarios 1 and 4. The results of the study are shown as Figure 13-2.

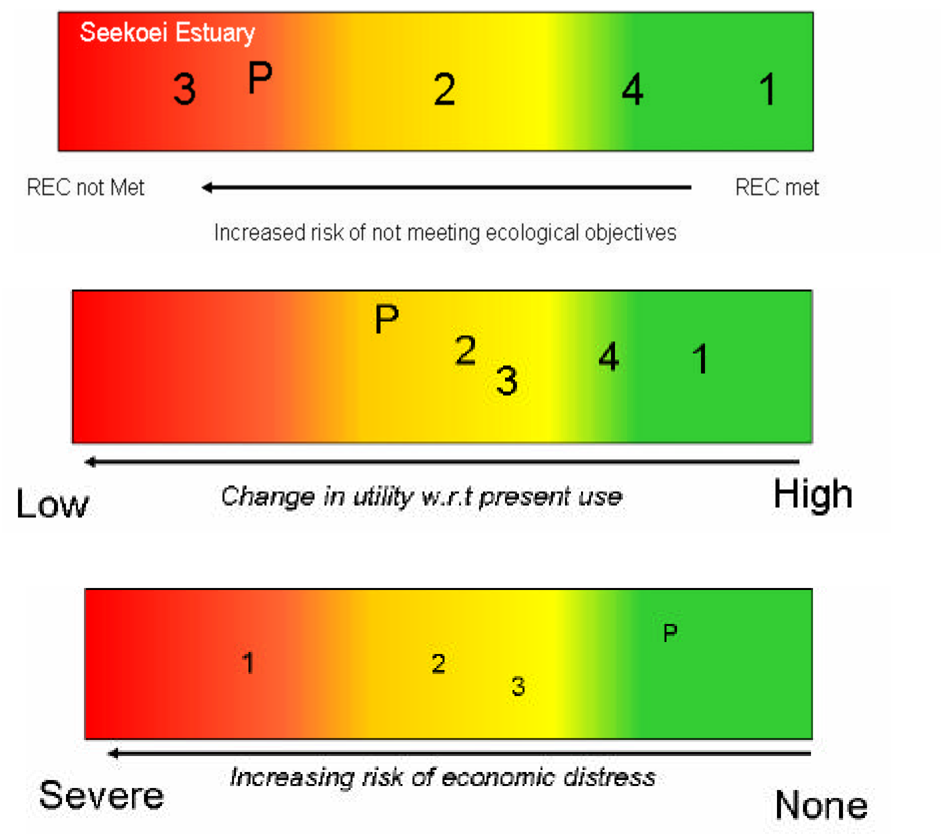

Figure 13-2 Comparison of consequences of various scenarios across study components (ecological, selected goods and services, economics) for the Seekoei Estuary

13.4 Conclusions

Kromme Estuary: It was recommended that **Scenario 4** be accepted for this system as it represents a compromise between the lowest acceptable economic implications and some improvement in the ecological state of the estuary.

Seekoei Estuary: It was recommended that **Scenario 2** be accepted for this system. This scenario will have the least impact on the economic activity, with some improvement of the PES of the estuary.

Kromme and Seekoei rivers: As flow is available to maintain the REC without impacting on any users, it is recommended that the EWRs for the REC be accepted as the Ecological Reserve

The recommendation made to DWAF in April 2006 was accepted as outlined in Section 13.4 of this document.

14 ECOSPECS AND MONITORING: RIVERS

Note: This chapter is a summary of CES (2006), Monitoring Report: Rivers No. RDM/ K90/ 00/CON/1005.

14.1 Overview and background

This task included the determination of Ecological Specifications, or EcoSpecs, and Thresholds of Potential Concern (TPC). This information was collated for the future Ecological Reserve Monitoring of the study area and formed part of step 7 of the RDM procedure.

This chapter summarises the documentation of the EcoSpecs and TPCs as well as the surveys required to establish a baseline. The specific aims of this task were as follows:

- **Baseline monitoring requirements** - To identify biological survey requirements to establish a baseline against which to monitor.
- **EcoSpecs** - To set EcoSpecs for each monitoring site, and for one set of Ecological Categories (ECs).
- **Threshold of Potential Concern (TPC)** - To set TPCs for each monitoring site.

14.1.1 Study area

The EWR sites within the Resource Units had been selected as monitoring sites. An additional monitoring site in the Seekoei River was however required upstream of the EWR site. Most of the biological monitoring for the Seekoei would be focussed on this new monitoring site.

14.2 Approach

In terms of Ecological Reserve Monitoring, "monitoring" is defined as the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective (taken from Kleynhans *et al*., 2005 and based on Elzinga *et al*., 1998).

The purpose of Ecological Reserve Monitoring is to:

- Determine whether the ecological objectives (in terms of Ecological Categories and EcoSpecs) were being met.
- To identify the possible cause of the problem.
- To determine the required actions according to a Monitoring Decision Support System to be followed if the ecological objectives were not being met.

The biota, specifically instream, would be the indicators used during monitoring to detect problems. The instream biota usually responded rapidly to any significant driver changes.

EcoSpecs are derived from RQOs as per the RDM and are clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that define the Ecological Category and serve as an input to RQO. EcoSpecs refer explicitly and only to ecological information whereas RQOs include economic and social objectives.

TPCs are upper and lower levels along a continuum of change in selected environmental indicators. When this level is reached (or when modelling predicts it will be reached), it prompts an assessment of the causes of the extent of the change. The assessment provides the basis for deciding whether management action is needed or recalibrates the TPC. TPCs provide management with strategic goals or endpoints within which to manage the system.

14.3 Results

14.3.1 Baseline information requirements

Available information collated historically and during this study was evaluated to determine whether this was suitable for the baseline requirements against which any changes identified during Ecological Reserve Monitoring had to be measured. A rating system was developed to evaluate the existing information. Evaluations from moderate to high would indicate that no additional work is required.

The overall baseline information requirements is summarised in the table below (Table 14-1).

Table 14-1 Summary of baseline surveys

Component	Conclusion
Geomorphology	
EWR 1	One survey to collect data explicitly in terms of the GAI (Level 4).
EWR 2	Assessment method was undertaken using old method and then data was used to populate the new GAI. This will reduce overall confidence. A once off field visit to each site to collect data explicitly in terms of the GAI would be an advantage.
EWR 4	One survey to collect data explicitly in terms of the GAI would be an advantage.
EWR 5	An analysis of the reach that includes the new fish monitoring site must be undertaken to determine the most relevant place for GAI assessment.
EWR 6	Baseline data required.
Water quality	
EWR 1	Analysis of DWAF data that has been collected since the initial study.
EWR 2	No further baseline required.
EWR 4	Analysis of the additional DWAF information that has been collected.
EWR 5	Undertake surveys to establish a baseline at the new site. Continue existing DWAF monitoring at Bergplaas.
EWR 6	Baseline data required.
Riparian vegetation	
EWR 1	Convert information to VEGRAI level 4.
EWR 2	Need to do survey using VEGRAI level 4.
EWR 4	VEGRAI data to be converted to VEGRAI level 4.
EWR 5	Convert info to VEGRAI level 4. Also establish VEGRAI at the new EWR site.
EWR 6	Data needs to be converted to VEGRAI level 4.
Fish	
EWR 1	Require additional fish site and survey (RHP Level 3) to confirm the absence of indigenous fish.
EWR 2	No further baseline is required.
EWR 3	No further baseline data needed, unless there is a significant change in environmental conditions.
EWR 4	Base line surveys according to requirements in Appendix A must be undertaken to establish whether any fish species occur in the river.
EWR 5	Baseline surveys at new fish site (1 km upstream above old weir) according to requirements (Appendix A).

Component	Conclusion
EWR 6	Baseline surveys are required to establish presence of indigenous species at two fish sites.
Aquatic Invertebrates	
EWR 1	One additional survey required in a different season than those for the Reserve study.
EWR 2	No additional surveys required, as the RU is isolated between the two dams.
EWR 4	Proper baseline to be established during flowing conditions.
EWR 5	Additional invertebrate site to be established at the new fish site.
EWR 6	One additional survey required in a different season than those for the Reserve study.

14.3.2 Summary of primary EcoSpecs

The primary EcoSpecs are related to the Ecological Categories for each site and the EcoStatus. These are shown in Table 14-2 below.

Table 14-2 Primary EcoSpecs

EWR site	Geomorphology	Physico Chemical	Fish	Invertebrates	Riparian Vegegetation	**EcoStatus**
1	D	B/C	C/D	C	D	**C**
2	D	B/C	C	D	D	**D**
3	D	C	C	D	D	**D**
4	C	C/D	D	D	A/B	**C/D**
5	D	B/C	C	D	D	**C**
6	B	A/B	C	B	D	**B**

The quantified EcoSpecs and TPCs for geomorphology, physico-chemical, fish, invertebrates and riparian vegetation were provided in the Monitoring Report: Rivers RDM/ K90/ 00/CON/1005. The methods used are described in Appendix A of this monitoring report.

14.4 Conclusions

Recommendations regarding monitoring are summarised below:

- Baseline monitoring should be initiated as soon as possible. If this does not happen, the biophysical information that are at this stage suitable for monitoring, becomes historical information and all the biophysical surveys required for baseline must be undertaken.
- Three of the six sites were undertaken at a Rapid III level, following a Rapid III survey level. Additional surveys will therefore be required to refine the Reserves and EcoSpecs.
- During the Kromme River study, the process to determine the EcoStatus and EcoSpecs were being developed. Some changes in the EcoStatus model will require the EcoStatus to be updated after the baseline monitoring has been completed. This should be done in conjunction with the updating of the EcoSpecs and TPCs.

The results of the study must be used to determine an implementation strategy. Once the operation is agreed on, a rainfall model (Hughes pers comm.) must be calibrated for the catchment to determine natural triggers for operation.

15 ECOSPECS AND MONITORING: ESTUARIES

Note: This chapter is a summary of CES (2006), Monitoring Report: Estuaries No. RDM/ K90/ 00/CON/0905.

15.1 Overview and objectives

Currently the *Resource directed measures for protection of water resource: Methodology for the Determination of the Ecological Water Requirements for Estuaries, Version 2* (DWAF, 2004a) does not provide any guidance on the determination of ecological specifications for estuaries. Therefore, the approach that was applied and approved by DWAF as part of the Thukela study was followed (DWAF, 2004b).

15.2 Approach

15.2.1 Ecological specifications

Ecological specifications are clear and measurable specifications of ecological attributes (in the case of estuaries, hydrodynamics, sediment dynamics, water quality, and different biotic components) that define a specific Reserve category which was decided upon by the authorities utilizing environmental, social and economic criteria. It must be noted that the Scenarios selected for monitoring are not the REC's as these were found to be to onerous in terms of their impacts on the social and economic environment. The monitoring programme has therefore been designed for the EC below (the applicable flow scenario is shown in brackets).

Kromme Estuary – D (Scenario 4)
Seekoei Estuary – D (Scenario 2)

Thresholds of potential concern (TPC) are defined as measurable end points related to specific abiotic or biotic indicators that if reached prompts management action. In essence, thresholds of potential concern should be defined such that they provide early warning signals of potential non compliance to ecological specifications. In essence this concept implies that the indicators (or monitoring activities) selected as part of a long term monitoring programme need to include biotic and abiotic components that are particularly sensitive to ecological changes associated with changes in river inflow into the system.

15.2.2 Baseline information

The studies that are carried out for an Ecological Reserve determination study at Comprehensive level may be considered as the baseline data against which the long-term monitoring is carried out. The status of baseline data currently available for different abiotic and biotic components in the Kromme and Seekoei estuaries, after completion of the current ecological Reserve determination studies was established by comparing the currently available information against the data requirements as specified for an Ecological Reserve determination on a comprehensive level (DWAF, 2004a). All additional work items identified were given a priority rating using the following scale (Table 15-1).

Table 15-1 Aadditional work items identified were given a priority rating using the following scale

HIGH	High priority, considered as a minimum list of indicators sufficient to monitor the effectiveness of the Reserve.
MEDIUM	Medium priority, will improve the confidence of the auditing process and should be added to the process if funding is available.
LOW	Low priority, will add to the overall confidence of the auditing process, but not considered to be a critical indicator in the case of the Kromme Estuary.

15.2.3 Long-term monitoring requirements

The purpose of long-term monitoring programmes, in this context, is to assess (or audit) whether the Ecological Specifications (defined as part of the Ecological Reserve determination process) are being complied with after implementation of the Reserve. In addition, these programmes can also be used to improve and refine the Ecological Reserve measures (including the Resource Quality Objectives), in the longer-term through an iterative process (Taljaard *et al*., 2003).

Although baseline studies and long-term monitoring programmes have different purposes, it is extremely important that long-term monitoring programmes follow on from similarly structured baseline studies. In essence, the monitoring activities selected for the long-term monitoring programme should be derived from the monitoring activities conducted as part of the baseline studies, but implemented on less intensive spatial and/or temporal scales (Taljaard *et al*., 2003).

Abiotic and biotic indicators considered relevant for a long-term monitoring programme were identified for both the Kromme and Seekoei Estuaries.

15.3 Results

15.3.1 Ecological specifications and TPCs

In both the Kromme and Seekoei estuaries the ecological specification for the following components were established for the following:

- Hydrodynamics
- Sediment
- Water quality
- Macroalgae
- Microalgae
- Invertebrates
- Fish
- Birds

The specifications clearly outlined the thresholds of potential concerns (TPCs) for the management of the estuaries. These TPCs will enable the monitoring team to evaluate the health and functioning of the estuaries according to the ecological specifications targeted for:

Kromme Estuary - D category estuary arising from the implementation of the operational flow Scenario 4.
Seekoei Estuary - D category estuary arising from the implementation of the operational flow Scenario 2.

15.3.2 Baseline data requirements

The Kromme Estuary Reserve was undertaken at a comprehensive level and thus, other than limitations identified at the outset of the study (Inception Report RDM/ K90/ 00/CON/0105), there should not have been a major difference between the data required for a comprehensive determination and the data available at the completion of the Reserve study. The gap analysis identified a few areas were additional work is required. These are:

- The majority of data is orientated around the common marine state in the system. Data associated with high flow is very limited. This was a limitation identifies at the outset of the project as the marine state has predominated in the system since the construction of the dams.
- The simulated runoff data provided was of low confidence.
- Historical data has been aggregated in many occasions which do not allow it to be analysed at a high level of resolution.
- There are a limited set of historical photos.

The overriding data gap identified for the Kromme Estuary was the lack of data (flow records and biological response) around high flows entering the system.

For the Seekoei Estuary the Reserve was undertaken at a Rapid level and thus there are significant data gaps in all components of the Reserve. Significant baseline work is still required before the available data would equate to that required for a comprehensive Reserve.

15.3.3 Long-term monitoring plan

A long-term monitoring plan was developed for both systems which outlined the following key parameters, as listed below for each Reserve component component (hydrodynamics, water quality, sediment, macroalgae, microalgae, invertebrates, fish and birds):

- The ecological component being measured.
- The related TPC.
- The temporal scale. This involved outlining when and where the samples should be undertaken.
- The spatial scale. This involved the position and number of stations required.
- The human resources required to undertake the work. This was further broken down onto the resource type (scientist versus technician) and in what activity the resources should be deployed (sampling, analysis, reporting).

15.4 Conclusion

For both the Kromme and Seekoei estuaries the following key Reserve activities were accomplished:

- Ecological specifications and TPCs were set.
- A gap analysis between available data and that required for a comprehensive Reserve was established.
- A long-term monitoring plan was designed and the human resources were quantified.

16 CAPACITY BUILDING AND TRAINING

16.1 Introduction

The capacity building and training activities associated with the Kromme / Seekoei Reserve study are reported in this document. Training was not conducted as a separate task of the study, but was incorporated into existing tasks as training components. The summary shown here covers the aim of capacity building and training, mentor-trainee teams and brief conclusions and recommendations for future training.

16.2 Overview and objectives

The main aim of the capacity building and training process is to ensure that each trainee has acquired the following information and skills:

- A theoretical understanding of the Reserve concept and process.
- An understanding of the concepts related to each trainee's specific discipline.
- The ability to utilize the tools or software required by their discipline within the Reserve process, or understand the use of these tools, e.g. time-series analysis, water quality modeling or field techniques.
- The ability to interpret information related to their discipline, particularly within the broader scope of the Reserve process.
- The ability to work in a team of specialists from different disciplines, but with a common goal.

The capacity building and training process will be evaluated according to the aims of training, as outlined in the Inception Report. The Inception Report required that training be reported on every six months, and a short training report be produced at the end of the study. Information-sharing was to take place with regional DWAF offices by circulating progress reports and extending invitations to attend meetings and workshops. Capacity building of regional staff was to be on the basis of information sharing and not intensive training courses.

16.3 Mentor and trainee teams

The following mentor – trainee teams were identified for the study:

- General river methods: Ms Louw (mentor) + Ms Koekemoer (trainee). Ms Koekemoer arranged and participated in the river site selection visit of November 2003 and the biological survey and hydraulic calibration of March 2004. Ms Koekemoer attended the Specialist EWR: Rivers meeting in September 2004, and undertook all organisation and preparation of specialist data before the meeting. She assisted in the preparation and compilation of the Resource Unit, EWR: Rivers, Monitoring and Main reports, and edited the Diep River Rapid Report. Ms Koekemoer has played a significant role in the budget management and financial administration of the water quantity tasks of the project.

- Invertebrates: Dr Uys (mentor) + Ms Maseti (trainee). Ms Maseti successfully participated in the biological surveys of March 2004, where she assisted Dr Uys with macroinvertebrate surveys.

- Systems model: Mr Jonker / Sparks (mentor) + Mr Kamish (trainee). Mr Kamish assisted Mr Jonker with obtaining hydrological information for the study area, but had limited training on the project as he was replaced by Mr Makhabane when he became unavailable to the study. Mr Makhabane has received the following training as part of the modeling team:
    - Understanding the penalties used in the Water Resources Yield Model.
    - Preparing a generic configuration.

- Modifying the generic configuration for different scenarios (e.g. switching on dams / changing EWR requirements).
- Extracting output and preparing plots for reports. Assistance with the Hydrology and System Analysis Report.

- Hydrology: Prof Hughes (mentor) + Ms Bukhosini (trainee). Ms Mbhele from the CD: RDM (trainee study manager) was also included in hydrological training. Ms Bukhosini and Ms Mbhele both participated in a training session in Grahamstown to prepare data for the Specialist EWR: Rivers meeting in September 2004. Ms Bukhosini participated at the specialist meeting.

- Water quality: Dr Scherman (mentor) + Ms Maseti (trainee). Ms Maseti participated in the water quality survey of October 2003, as well as the selection of Water Quality Sub-Units for input to the Resource Unit Report.

  Ms Gola replaced Ms Maseti in May 2004 when Ms Maseti took up a post at Rand Water. Ms Gola assisted in the data analysis and preparation for the Specialist EWR: Rivers meeting in September 2004. She also participated in the meeting, as well as attending the introductory training session held before the specialist sessions. Ms Gola also assisted with the preparation of the Water Quality Report. Ms Kaleni of DWAF: Port Elizabeth joined the team for workshops and meetings.

- Geomorphology: Prof Rowntree (geomorphology) - Ms L du Preez (trainee). Ms du Preez participated in the site selection survey of November 2003 and assisted in the collection of geomorphological data on site. She also participated in the Specialist EWR: Rivers meeting and assisted with the preparation of the geomorphological component of the EWR: Rivers Report. Ms du Preez participated in the developmental Ecospecs workshop held in November 2005.

- Estuaries: trainees include Adonis, Rajkaran, Ngesi, Beck, Snow, Deyzel and Thwala
  - Estuaries trainees (Adonis, Rajkaran, Ngesi and Beck) participated in the field survey of February 2004
  - Ms Beck has assisted Professor Basson with data analysis and the preparation of the sediment specialist report. Ms Beck has also submitted her PhD and is a good prospect for further involvement with Reserve studies.
  - Mr Snow assisted Prof Janine Adams in the compilation of the Microalgae report and conducted the Impofu Dam water quality sampling. Mr Snow also shows good promise in terms of future expertise.
  - Mr HP Deyzel and Ms M Thwala assisted Prof Wooldridge in the compilation of the invertebrate report.

16.4 Training / involvement of regional DWAF staff

A number of training opportunities were presented to the regional DWAF staff – all considered follow-up training to the FETWater courses run in the Eastern Cape in January 2004.

16.4.1 Field surveys

River: Eight staff members from the Cradock office attended the river field survey of March / April 2004, where they were primarily exposed to fish sampling procedures and general process.

Estuary: An estuary trip took place at the end of November 2004, which assisted the RDM officers and Project Management members involved in the project to gain a better understanding of the functioning of estuaries.

16.4.2 Workshops

A training workshop, facilitated by Prof J O'Keeffe (previously of the Institute for Water Research, Rhodes University), was held in conjunction with the *Specialist EWR: Rivers meeting in September 2004*, as well as before the *Specialist EWR: Estuaries meeting in February 2005*. Training sessions were held before specialist sessions, so as to assist trainees in developing an understanding of the specialist components of the workshop. Trainees also attended specific specialist sessions as observers. The river training workshop was overseen by Ms Stassen, with the assistance of the project team. Feedback from trainees is shown in Appendix B. Fifteen trainees, from the DWAF Cradock, Port Elizabeth and King Williams Town offices, as well as RDM staff, attended the river workshop. Eight trainees also participated in all or part of the Estuaries workshop.

16.4.3 Participation as part of the Project Management Team (PMT)

The participation of DWAF regional staff as part of the PMT has been extremely valuable, and their continued support of the project was appreciated. Ms Pumsa Kaleni (DWAF PE) provided water quality support, while Mr Flip de Wet (DWAF Cradock) was instrumental in data gathering and catchment-specific input to the study.

16.5 Conclusions and recommendations

All available opportunities were used to train both identified trainees and DWAF personnel. However, a number of recommendations can be made regarding future training for Reserve studies. Most of these points have been taken from the Training and Capacity Building Report of the Thukela study (DWAF, 2004c) as the points remain valid for this study.

- Budgets should be allocated for training, either as a sum of money to be allocated to training or as a percentage of the overall Reserve budget. A training budget allowed for successful training in the Thukela Reserve study, but a similar process has not been followed for the Reserve studies initiated in 2003.
- Trainees and the client must have realistic expectations of the training process. The expectations must therefore meet the budget and skills level of the trainees.
- A combined rivers and estuaries training session should be conducted at the outset of the study, so as to allow trainees time to understand the process they will be conducting.
- A "wrap-up" session should be held for trainees and mentors to provide a useful overview of the study. This workshop would serve the purpose of placing the separate components of the Reserve study in context, and give the river and estuaries trainees an opportunity to interact and gain an overview of each discipline within the study.
- All river trainees should attend an EWR site visit, including the hydrology trainee. The water quality trainee may chose to rather accompany the water quality team on the survey of the study area.
- All trainees should be involved from the beginning of the study, so as to be exposed to all the preparatory work before workshops and field surveys are initiated.
- The training programme must address the long pauses between workshops, meetings and field surveys, which leads to fragmentation of the training process. Mentors must be encouraged to remain in close contact with their trainees during these times, and update them regarding progress.
- The training programme should be structured – possibly with general feedback on the progress of the study through one allocated person.
- If Reserve training is to be successful, follow-up training e.g. inclusion in subsequent Reserve studies, should be offered to trainees. It must be understood by the trainee that training in the Reserve process will require commitment and hard work, particularly as mentors carry additional demands of meeting deadlines and fulfilling the tasks required of them. Trainees working on subsequent studies should be carefully selected, particularly in

terms of specialist field and time they will be able to commit to the project, while still fulfilling their other work commitments. Additional exposure and training is critical to expanding the specialist skills base in South Africa.

- More time and budget must be allocated to practice and proper learning. Due to deadline constraints and the pressures of a workshop environment, there is not enough time for trainees to practice on associated case studies so as to develop their skills. It is possible that this type of training should be conducted outside of a specific Reserve study, but should be seen as a development tool for trainees specifically wanting to train as Reserve specialists.
- Trainees must be carefully selected. If a trainee is not selected for a particular discipline on the basis of some previous or associated exposure to the subject, it cannot be expected that they develop as independent Reserve specialists. These trainees often feel abandoned by the process, partly because they do not have the specific background in the field. There is a vast amount of background knowledge and experience that is required to be a successful specialist, and this cannot be taught in workshops and field surveys. This is perceived to be an important shortcoming, primarily due to the lack of trainees available to specialists. One recommendation is that CD: RDM develop a database of available trainees for Reserve studies, and include their level of competence and experience.
- It should be acknowledged by DWAF that changes do take place in mentor and trainee careers over a 3 year study, and that this contributes to the fragmentation of the training process. It is unfortunately difficult to avoid this fragmentation, as seen during the Kromme/Seekoei study.
- Trainees must be encouraged to be proactive in their inclusion in future studies. A suggestion is that trainees (either individually or as a group) approach the CD: RDM with requests to be included in future Reserve studies.
- It must be acknowledged that there are three levels of training. (1) General training so as to understand and interpret Reserve results meaningfully. (2) Specialist training, so that the trainee is proficient and has some experience in their particular field. (3) Application and further development of this specialist training and knowledge to the Reserve process.

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APPENDIX A

Groundwater Reserve Study

Dr I. Dennis, IGS, University of the Free State

The document below is the Executive Summary of the independent document submitted to CD: RDM by Dr Dennis.

GROUNDWATER

The Kromme (K90 A to E) and Seekoei (K90F) River Catchments are located in the Eastern Cape to the west of Jeffreys Bay. The catchments are located in the Fish to Tsitsikamme Water Management Area (WMA 15). The main towns within the study area are Kareedouw, Humansdorp and St Francis Bay.

The primary objective of the study is to determine a comprehensive Groundwater Reserve for the study area, taking into account issues rained in the ISP (DWAF, 2003):

- Most of the sub-area is already water stressed.
- Over-abstraction from wellfields by coastal towns during peak use in holiday seasons may lead to desalination of wellfields through seawater intrusion, and could render them permanently damaged and unfit for urban use.
- It is important that sufficient groundwater continues to feed the Kromme and Seekoei/Swart rivers at all times to meet the requirements of the ecological component of the Reserve.
- Wetlands in the Kromme and Seekoei Catchments are highly rated and should be protected.
- The requirement for a regional solid waste site, which has been in planning for many years, is urgent.
- There is a major alien infestation problem in the sub-area.

Due to the budget and time constraints the assessment discussed in this document falls more into the category of intermediate determination and as a result the confidence levels attached to the results determination should be medium.

Land use in the Kromme/Seekoei study area is predominantly grazing for livestock, with intensive cultivation of irrigated land along the main rivers as well as significant rain-fed farming. Farming of sheep, goats and cattle takes place in the area, and there are also significant game populations. The area is not rich in minerals and mining operations consist mainly of quarrying for building materials. Alien vegetation is a problem within the study area, in particular there is a major Black Wattle infestation.

The climate of the study area is strongly influenced by its location relative to the coast and topography. Most of the inland are has a typical dry Karoo climate. Maximum temperatures are experienced in January and minimum temperatures usually in July. Rainfall generally occurs throughout the year in the coastal region and in spring/autumn in the inland areas. The peak rainfall months are December and January. The average precipitation is 596 – 774mm.

There are two major veld types namely: thicket (dune and valley thicket) and fynbos (south west coast Renoster, grassy and mountain fynbos).

The study area is characterized by fractured rock aquifers, with localized primary aquifer systems in place. There are three major aquifer systems within the study area. These three aquifer types are named after the geological Groups (units) that they are comprised of namely: the Table Mountain Group, the Bokkeveld Group and the Algoa Integranular Aquifer.

The groundwater level is on average approximately 15 mbgl, with a maximum of 92 mbgl and a minimum of 0 mbgl.

Water quality in general is good in the study areas, ranging from excellent in the crystalline rocks of the TMG, to moderate in the Bokkeveld Group and poor at some sites ion the Algoa Integranular aquifers. From the data sets evaluated, it is evident that very little groundwater contamination is occurring in the study area, with rare exceptions close to pollution sources, e.g. waste sites and informal settlements. Elevated salinity levels in the groundwater are thus a function of the natural geochemistry, or proximity to the coast, rather than contamination.

The TMG water is considered to be corrosive and treatment with lime is often required before entering into reticulation systems. Bio-fouling caused by iron-bacteria is another problem associated with these conditions.

The groundwater quality in the Bokkeveld group is highly variable and depends on the sandstone/shale content. The water is sodium-chloride-rich. However, the electrical conductivity ranges from above 100 mS/m to about 400 mS/m. This is attributed to the high sodium and chloride levels and often exceeds drinking water standards. From the historical data as well as reports (Smith, 2005 and Septhon, 1994), the iron concentrations in the Bokkeveld Group are reported to be higher than those found in the TMG Formations. However, this is not reflected in the analysis of the samples.

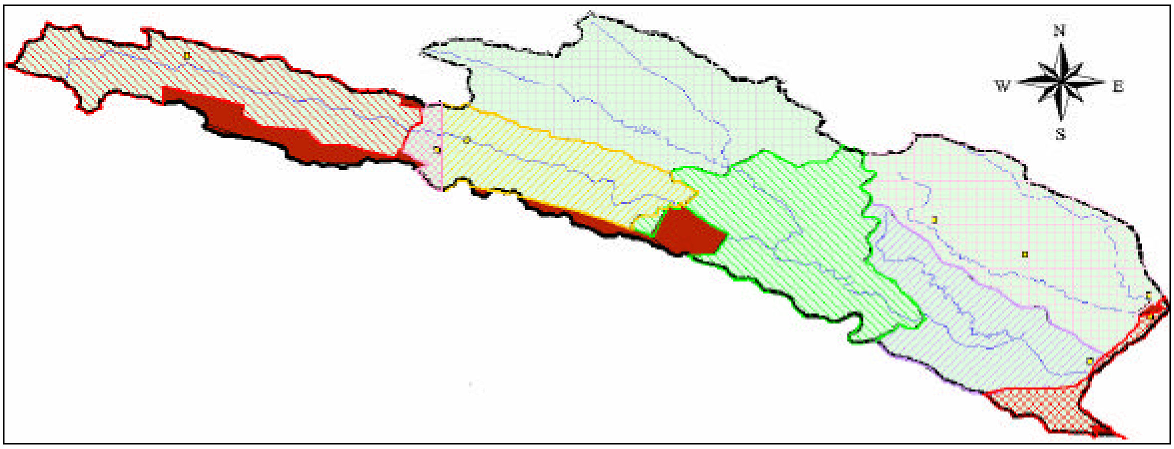
Aeolian sands are present along the coast to the west and east of Cape St Francis. Municipal supply boreholes for St Francis Bay (and Cape St Francis) are located on these aquifers and samples were taken from selected boreholes. Electrical conductivity ranges between 100 mS/m and 200 mS/m. Elevated levels of iron (2.5 mg/l to 7.1 mg/l) were measured in boreholes, although the pH of the water is neutral to slightly basic. This is attributed to mixing the primary aquifer water with that of the TMG or Bokkeveld Aquifer water. Although most of these boreholes exceed the drinking water standards for certain parameters, no contamination from specific contamination sources is evident from the current results. Elevated salinity can be attributed to rainfall recharge from evaporated sweater and the shell content of the sand aquifer. The proximity of the boreholes to settlements and development, however, increases the vulnerability of the aquifer system to contamination.

A number of samples were taken from surface water resources and springs throughout the catchment. These results were used to compare the groundwater quality with the surface water quality. Generally the water quality of the surface water resources and springs are excellent (EC < 70 mS/m), except within the estuary close to the coast. The water is of similar nature (sodium-choride type) as of that found in the TMG Aquifer, with the only difference that higher alkalinity and associated pH values are measured. From these results it seems that the contribution of groundwater from the TMG Aquifer to the river systems is important.

The following groundwater dependant ecosystems have been identified within the study area:

- Springs and seeps
- Riparian systems
- Wetlands
- Estuarine and coastal systems

The groundwater resource units for the study area are shown below.



The groundwater resource units are therefore as follows:

- Groundwater resource unit 1: Quaternary Catchment K90A. The wetlands have been restored and Black Wattles in the area eradicated. Localised farming occurs along the Kromme River.
- Groundwater resource unit 2: Upper section of Quaternary Catchment K90B up to Kareedouw. The wetlands have been restored and Black Wattles in the area eradicated. Localised farming occurs along the Kromme River.
- Groundwater resource unit 3: Quaternary Catchment K90B from Kareedouw to the Churchill Dam. The riparian zone is infested with alien vegetation. Farming occurs along the riparian zone and there is riparian zone degradation.
- Groundwater resource unit 4: Quaternary Catchment K90C. No detailed information is available here.
- Groundwater resource unit 5: Quaternary Catchment K90D. The dams have impacted the flow regime. In places the riparian zone is critically infested and modified by Black Wattle. These alien species have out-competed the natural riparian species, leaving little diversity.
- Groundwater resource unit 6: Quaternary Catchment K90E, excluding the integranular coastal aquifer system. In this catchment the Geelhoutboom River joins the Kromme River. The dams have impacted the flow regime of the Kromme River. There is also inundation and removal of vegetation in the upper reaches due to the dams. In places the riparian zone is infested and modified by Black Wattle, which has out-competed the natural riparian species – leaving little diversity. There is no documentation of Black Wattle along the Geelhoutboom River. Intense farming occurs along the riparian zone of both rivers.
- Groundwater resource unit 7: Quaternary Catchment K90F. This catchment contains both the Seekoei and Swart rivers. The riparian zone of the Seekoei River is infested by exotic/alien vegetation. There is also bank erosion from the removal of alien vegetation, impact of weirs and dams, and the general utilization and neglect of the riparian zone. The Swart River riparian zone is generally infested by alien species, mainly Black Wattle, Gums and Poplar.
- Groundwater resource unit 8: Integranular aquifer along the coast, including the coastal dunes and associated wetlands and estuaries.

Two tertiary areas (red circles on map) have been delineated based on the importance of the area when considering the ecology and basic human needs. The groundwater importance in the vicinity of Kareedouw (TRU1) and St Francis Bay and coastline in the vicinity of St Francis Bay (TRU2) is high due to its ecological importance because of wetlands along the Kromme River and in the dunes in the vicinity of St Francis Bay. In addition, the wetlands associated with the Kromme estuary also increase the groundwater importance, this in addition to the dependence on groundwater for basic water supply in these areas.

The present status categories are listed in the table below, together with the groundwater resource categorization.

Resource Unit	Present Status Category	Resource Category
RU1	B	Natural
RU2	B	Natural
RU3	C	Fair
RU4	B/C	Good
RU5	C/D	Fair
RU6	C/D	Fair
RU7	C/D	Fair
RU8	C	Good

The groundwater component of the Reserve is the part of the groundwater resource that sustains basic human needs and aquatic ecosystems. To be able to quantify the groundwater component of the Reserve, we need to be able to estimate the volume of groundwater needed to satisfy basic human needs (BHN) and groundwater discharged to surface water bodies. Groundwater can only be allocated to users and potential users once the volume of groundwater that contributes to sustaining the Reserve has been quantified and RQOs have been met.

The groundwater Reserve is usually expressed as a percentage of the recharge within the resource unit. The Reserve results are shown in the table below.

Resource Unit	Recharge (Mm^3/a)	BHN (Mm^3/a)	Baseflow (Mm^3/a)	Reserve (% of recharge)
1	6.58	0.00	3.58	54.44
2	0.57	0.00	0.10	17.82
3	3.37	0.02	0.60	18.44
4	7.70	0.00	0.30	3.93
5	5.88	0.00	0.52	8.90
6	4.58	0.00	2.25	49.14
7	7.23	0.28	2.16	33.71
8	3.91	0.02	0.31	8.45

The purpose of the Resource Quality Objectives is to establish clear goals relating to the quality of the relevant water resource. The RQOs for the study area are listed below.

Resource Unit	RQOs
1&2	Natural groundwater levels must be maintained 1400 m from the Kromme River to ensure the wetlands/baseflow along the river are not impacted by abstraction. No sources of contamination may occur within a 2000 m distance from these wetlands and the river. There are few BHN boreholes in the study area. These boreholes must be protected with a radius of influence of 1500 m.
3	Natural groundwater levels must be maintained 1100 m from the Kromme River to ensure the baseflow along the river is not impacted by abstraction. No sources of contamination may occur within a 1.5 km distance from these wetlands and the river. There are BHN boreholes in the study area. These boreholes must be protected with a radius of influence 1500 m.
4	Natural groundwater levels must be maintained 900 m from the rivers to ensure that the baseflow along the river is not impacted by abstraction. No sources of contamination may occur within a 1500 m distance from these wetlands and the river. If there are BHN boreholes in the study area these boreholes must be protected with a radius of influence 1500 m.
5	Natural groundwater levels must be maintained 500 m from the rivers to ensure that the baseflow along the river is not impacted by abstraction. No sources of contamination may occur within a 1500 m distance from these wetlands and the river. If there are BHN boreholes in the study area these boreholes must be protected with a radius of influence 1500 m.
6	Natural groundwater levels must be maintained 1500 m from the rivers to ensure that the wetlands/baseflow along the river and the groundwater contribution to the Kromme estuary are not impacted by abstraction. No sources of contamination may occur within a 1500 m distance from these wetlands and the river. If there are BHN boreholes in the study area these boreholes must be protected with a radius of influence 1500 m.
7	Natural groundwater levels must be maintained 800 m from the rivers to ensure that the wetlands/baseflow along the river and the groundwater contribution to the Kromme estuary are not impacted by abstraction. No sources of contamination may occur within a 1500 m distance from these wetlands and the river. If there are BHN boreholes in the study area these boreholes must be protected with a radius of influence of 1500 m.
8	Natural groundwater levels must be maintained 1500 m from the rivers to ensure the wetlands/baseflow along the river and the groundwater contribution to the Kromme estuary are not impacted by abstraction. No sources of contamination may occur

Resource Unit	RQOs
	within a 1000 m distance from these wetlands, estuaries, the rivers and the sea. If there are BHN boreholes in the study area these boreholes must be protected with a radius of influence of 500 m.

Only cold water springs have been observed in the study area. Springs supply both Humansdorp and Kareedouw with water. A 3000 m distance must be maintained from these springs (for abstraction and contamination). Low yield springs (< 2 l/s) should have a 500 m protection distance. There are wetlands within the study area other than those associated with rivers and the estuaries. These wetlands need to be protected with a 500 m protection distance.

Most of the protected areas in the study area are up gradient of any activities and are naturally protected. However, where this is not the case (such as RU5) there must be a 1000 m protected zone surrounding the area where no abstraction and contamination can occur.

No additional RQOs are set for the two tertiary units (TRU1 and TRU2). However, if is recommended that these units be monitored bi-monthly.

The total amount of groundwater recharge and the Reserve requirements per resource unit has been calculated. The amount of allocatable groundwater can now be calculated. The potential groundwater allocation per resource unit is documented below.

Resource Unit	Area (km^2)	Allocatable Groundwater (Mm^3/a)
1	177.84	3.42
2	20.10	0.29
3	118.00	2.57
4	269.40	3.20
5	213.18	5.36
6	168.30	0.93
7	265.80	0.59
8	40.20	3.58

From the study, a number of brief recommendations are listed below:

- The RQOs should be enforced within the study area. The wetlands (particularly those is K90A), the springs (particularly those used to supply basic human needs and the basic human need boreholes) should be monitored to ensure the RQOs are enforced.
- It is suggested that the isolated mismanagement of groundwater at some of the local municipalities be corrected and that structured monitoring of municipal boreholes be enforced; this includes a detailed monitoring plan for the two tertiary resource units.
- There is very little water quality time series data for the study area. These data must be collected to determine if there is change in water quality with time due to anthropogenic impacts.
- The role of groundwater within the study area is not fully understood by many of the managers and users of this resource. The awareness of groundwater and associated impacts must be improved.

APPENDIX B

Specialist EWR Rivers Meeting: September 2004

Dr P. Scherman, Coastal & Environmental Services

SPECIALIST EWR RIVERS MEETING (21 – 22 SEPTEMBER 2004)

Training Programme

Time	Programme	Venue
Tuesday, 21 September 2004		
09:00	Purpose of training and relationship to other training courses (Rheta)	Marine Hotel
09:15	FETWATER, training programme and trainee expectations during next 2 days (Dana Grobler, Jay)	Marine Hotel
09:30	This specialist meeting and the Reserve process (8 steps) (Jay)	Marine Hotel
10:00	TEA	Marine Hotel
10:10	Determination of EWR - flow and quality - general principles Step 1: Initiate study (Jay) Study area RDM level and components Study team Step 2: Define resource units (Jay, Patsy) Water Quantity Geomorphological zonation Riparian Vegetation Habitat Integrity Water Quality (Patsy) Step 3: Define ecological categories and recommend Reference conditions, including data preparation (Patsy and Thoki) Present Ecological State (Eco-status) (Neels) Water Quality (Patsy) Ecoclassification, including Ecological Importance & Sensitivity (Neels) Social importance (Jay)	Marine Hotel
13:00	LUNCH	5th Ave Beach Lodge
EWR1: ECOCLASSIFICATION		
13:45	Trainees observation: Component PES, Ecostatus PES, Issues, EIS, SI, Recommended EC, Alternative ECs	Marine Hotel, Oyster Catcher Conference Room
15:00	TEA	5th Ave Beach Lodge
15:10	Discussion of Ecoclassification (Jay) Step 4: Quantify ecological water requirement scenarios Flow stressor response method for low flows Modified DRIFT method for high flows	5th Ave Beach Lodge
17:00	CLOSURE	
WEDNESDAY, 22 SEPTEMBER 2004		
EWR 1: IFR DETERMINATION		
08:00	Trainees observation: Determination of EWR low flows and high flows	Marine Hotel, Oyster Catcher Conference Room
10:30	TEA	5th Ave Beach Lodge
10:40	Discussion of flow determination methods and results (Jay) Step 5: Ecological consequences of operational scenarios Yield consequences of Reserve (Denis Hughes) Water Quality (Flow concentration modelling) (Patsy) Integration of water quantity and quality	5th Ave Beach Lodge
13:00	LUNCH	5th Ave Beach Lodge
13:45	General Discussion of assessment methods (steps 1 to 4) (Jay) Discussion of implementation issues Assessment of training and expectations.	5th Ave Beach Lodge
15:00	TEA	5th Ave Beach Lodge
16:00	CLOSURE	

Expectations of Trainees

- Implementation of Reserve determination results.
- Validity of the results in terms of time and geographical scales.
- Water quality requirements when dealing with natural saline rivers.
- Signing off (approval) of Reserve determination results.
- Recommendations/conditions of Reserve determination studies.

Specific questions/issues raised and discussed during the training session

Reserve requirements to be provided as flows (m^3/s) and not as volumes and the time step should be daily. This can be done for intermediate and comprehensive study results, but not for desktop and raid Reserve determination studies.

It is important that stakeholders are involved during Reserve determination studies to create awareness. The RDM process should also be brought closer to the management of the resources.

Regional Officials should be more involved with the choice of resource units and Ecological Water Requirement (EWR) sites to ensure the sites coincide with their management units. They can also assist during Reserve determination studies with the collection of data, e.g. water level readings, etc.

The results of Reserve determinations should assist the Regional Officials with the setting of 'standards' for sewage treatment works.

Organic parameters are not specified in the water quality Reserve determination results. This is however important for the Regional Offices for the management of the resource.

Regional Officials should be consulted prior to the finalization of the water quality variables to be included in the analysis and the final Reserve determination results.

The approach/method to determine the basic human needs need to be revised.

The use of forums to discuss specific implementation issues regarding Reserve determination results.

Summary of Trainee comments

It is useful to link the training to a specific ongoing Reserve determination study (e.g. Seekoei/Kromme study) and should be done during other Reserve determination studies.

The training presentations and study reports should be provided to all the trainees for future reference. More technical tasks of the sections should be included during training session.

Future training should also include officials involved in other technical fields to provide a better understanding in the Regional Offices (e.g. officials involved with the River Health programme).

More detail should be provided prior and during the observation sessions (sessions when the trainees attend the specialist workshop). Explanations on how the various scores are derived should be provided by the specialist to ensure a better understanding of the process.

The challenge is to make a complex issue (Reserve) simple without losing the message.

Training is needed on the practical implementation of the Reserve determination results, especially when effect should be given where the Reserve requirements are almost equal to the flow in the river.

The focus during implementation of the Reserve determination results should also include:

- Monitoring requirements;
- Public demands regarding information requirements and protection levels;
- How the Reserve impacts on decisions regarding water use licenses; and
- Conditions regarding the protection of the water resources.

Models are needed when the Reserve requirements are taken into account during the licensing process to calculate the volumes available for the various users.

The RDM process should cater for the variability of the various water resources as well as addressing the implementation of the results on a daily basis against the availability of results in monthly and/or seasonal averages.

More time and resources should be devoted to fully understand the need for the RDM process.

An approach is needed when dealing with the Basic Human Needs and natural saline rivers on how to address and implement.

Field visits are required as part of the training to get a better understanding of the integrated nature of Reserve determination studies and other aspects beyond the Regional Official's specific expertise.

The need for public education/awareness concerning Reserve determination studies and specifically the implementation of the results should be addressed.

Interactions between DWAF officials and technical specialists were very helpful to create a better understanding of the interpretation of the results.

The validity of Reserve determination results should be discussed in more detail during training, especially if the resource changes due to e.g. a flood event. How should this be addressed when the Reserve is implemented?

More time should be provided for the training session to discuss specific issues regarding Reserve requirements and implementation. A case study where a 'simulated' Reserve determination is done can be very helpful.

Classification system is needed urgently to link the Reserve to the economic and social needs in the catchment.

Good training session!

List of trainees/trainers

Name	Organisation	Contact no
Jacques van der Merwe	DWAF, WRM, Cradock	048 8813005
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Philip de Wet	DWAF, WRM, Cradock	048 8813005
Pieter Retief	DWAF, WQM, PE	041 5864884
Andrew Lucas	DWAF, WQM, EL	043 7223805
Johan Venter	DWAF, WRM, Cradock	048 8813005
Martin Labuschagne	DWAF, WRM, Cradock	048 8813005
Pumza Lubelwana	DWAF, WQM, KWT	072 3474 762
Retha Stassen	DWAF, RDM, Pta	012 3367843
Jay O'Keeffe	IWR, Rhodes University	046 6222428
Wiesaal Salaam + Budu Manaka	Common Ground	021 7013360
Dan Mtati	DWAF, Forestry Development, KWT	083 6334 307
Phumza Kaleni	DWAF, WQM, PE	041 5864884
Pearl Gola	IWR, Rhodes University	046 6038532
Patsy Scherman	CES, Grahamstown	082 5036 070
James Kettledas	DWAF, WRM, Cradock	048 8813005
Eben Bosman	DWAF, WRM, Cradock	048 8813005
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Dana Grobler	DWAF, RDM, Pta	082 4183 289
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