THUKELA WATER PROJECT DECISION SUPPORT PHASE

RESERVE DETERMINATION MODULE
BRIEFING DOCUMENT

March 2004

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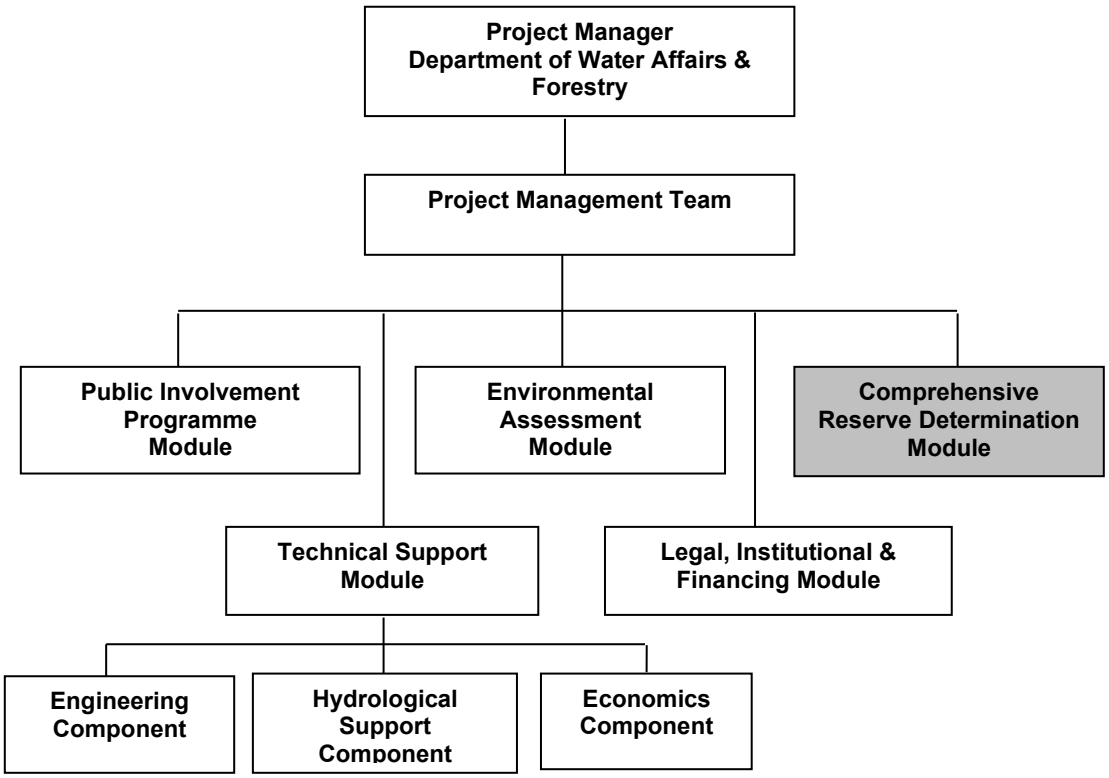
STRUCTURE OF DECISION SUPPORT PHASE



DEPARTMENT OF WATER AFFAIRS & FORESTRY
NATIONAL WATER RESOURCE PLANNING

THUKELA WATER PROJECT DECISION SUPPORT PHASE
RESULTS AND RECOMMENDATIONS OF THE THUKELA RESERVE

IWR SOURCE-TO-SEA **MARCH 2004**

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SYNOPSIS

The primary objective of the Thukela Reserve Study was to provide consequences of different flow scenarios, on ecology (including water quality), Ecological Goods and Services, market economy and Thukela Bank (marine systems). Stakeholder input was sought. This was to assist with decision-making regarding the preliminary Reserve and a preliminary Management Class. The final output of the study will be flow, quality, biota and habitat Ecospecs for the selected scenario as well as the design of a monitoring programme.

The full spectrum of investigations included the Basic Human Needs requirements, a scoping groundwater study, Ecological Water Requirements assessments, Ecological Goods and Services surveys, Market Economics studies, Stakeholder input and impact study on fish and prawn catch in the marine environment (Thukela Bank).

The study has addressed a sequential serious of events to achieve the objectives by answering the following questions:

- What are the Basic Human Needs Requirements?
- What is the range of Ecological states that needs to be considered?
- What are the flow and quality requirements to achieve these Ecological states?
- Is the water available without impacting on the existing yield and therefore users of the system? If not, can adjustments be made to the flow scenarios that could minimise this impact?
- What are the ecological, yield, market economy and Goods and Services consequences of each of all the scenarios under investigation?
- What are the stakeholder opinions and desires regarding this range of scenarios?

A scenario that is regarded as a best fit, i.e. Scenario 9 has been developed and its implications examined in detail. The Ecological and Goods and Services consequences are minimal (only one area of the river will not achieve the ecological objectives, but the present state will be maintained). The impact on the market economics is minimal and only apparent in the Little- and Sundays Rivers. The impact on the yield follows the economic trend but there is also a minor impact on the Tugela Vaal transfer in 2015. (about 5% in the worst case). The recommendation is therefore that Scenario 9 be accepted as the preliminary Reserve and its associated categories.

Scenario 9 is now presented to DWAF for consideration as the Preliminary Reserve for signing-off. The Professional Service Provider will then proceed to develop Ecospecs and a monitoring program to verify and refine the Reserve for the approved scenario.

EXECUTIVE SUMMARY

BACKGROUND

The Thukela Reserve Study was initiated in the year 2001 with a view to supporting the then imminent implementation of the Thukela Water Project (TWP). The TWP was at that stage the most likely option to be constructed to augment water supplies to the Vaal River System by 2011. It was later found that water requirement projections in the Vaal River System were not being realised as previously expected and work on preparing the TWP for implementation was slowed down accordingly. Despite this change, the Department of Water Affairs and Forestry (DWAF) decided to complete the Ecological Reserve Determination in the Thukela River Catchment.

OBJECTIVES

This briefing document provides executive management level information about the Thukela Reserve Study and its findings. The findings emphasise the impacts that the selected flow regime scenarios are expected to have on the broader environment in the Thukela River Basin. A recommendation is made regarding, what is believed to be, the most acceptable Ecological Reserve flow regime. It is intended that the level of detail provided in this document will enable DWAF Management to respond to this recommendation and provide approval for the study team to complete the study.

The major objectives of the Thukela Reserve Study were to:

- Generate a set of Ecological Reserve flow scenarios and test these scenarios.
- Determine the impact of the scenarios on the available yield.
- Determine the impact of the scenarios on the aquatic ecology.
- Determine the economic impact of selected scenarios. This included an evaluation of the impact on the Thukela Marine Bank.
- Determine the impact of selected scenarios on the goods and services delivered by the riverine system.

STUDY APPROACH

The study commenced during March 2001 and will continue until December 2003. The project is within the brief (as amended from time to time), on budget and on time.

The Reserve Determination study is comprised of a number of interrelated studies and modules.

Basic Human Needs Reserve (BHNR)

The BHNR component used demographic information to derive recommendations. Central to this process was the estimation of the population living within a 5km buffer, which were regarded as being primarily dependent on run of river for their water supplies. It was recommended that an amount of 60 litres per capita per day constitute the BHNR. This is close to that which was estimated to be abstracted from groundwater for those not proximate to the river, and was deemed sufficient to allow for all basic needs as defined in the National Water Act (NWA). This volume would also allow some water for uses such as minor subsistence irrigation of vegetables and other crops. A volume of 16.55 million cubic metres per annum is currently required from the river for the BHNR. This increases to just under 20 million cubic metres per annum in the year 2015, which is still a fraction of the total Mean Annual Runoff of the river of around 3800 million cubic metres per annum.

Ecological Reserve

The determination of the ecological component of the Thukela Reserve Study was a sequential process, consistent with the Resource Directed Measures (RDM) protocols (see Figure on page iv for a process diagram). The initial task was the delineation of the study area (Thukela and its major tributaries) into Resource Units (RUs) and the estuary. The RUs were then examined by specialists who determined a reference condition for each unit and the estuary, as well as the Present Ecological State (PES). The specialists suggested Ecological Categories (EC) (termed Ecological Reserve Category during the course of the study) for each of the RUs. Once the PES and EC were determined the Thukela Reserve Determination team set about developing flow scenarios at specific sites on the river called Instream Flow Requirement (IFR) sites. Please see Figure on page v for the location of these sites in the Thukela River Basin.

Scenarios are alternative possible flow regimes which will result in different river states (Ecological Categories) at any IFR site. It was deemed important to consider the full range of implications of these scenarios on the broader social and ecological environment. An optimised scenario which would have minimal impact on water users and the ecology, was devised. Each of these scenarios was tested to determine their effect on water quality and the overall resulting state of the river and estuary.

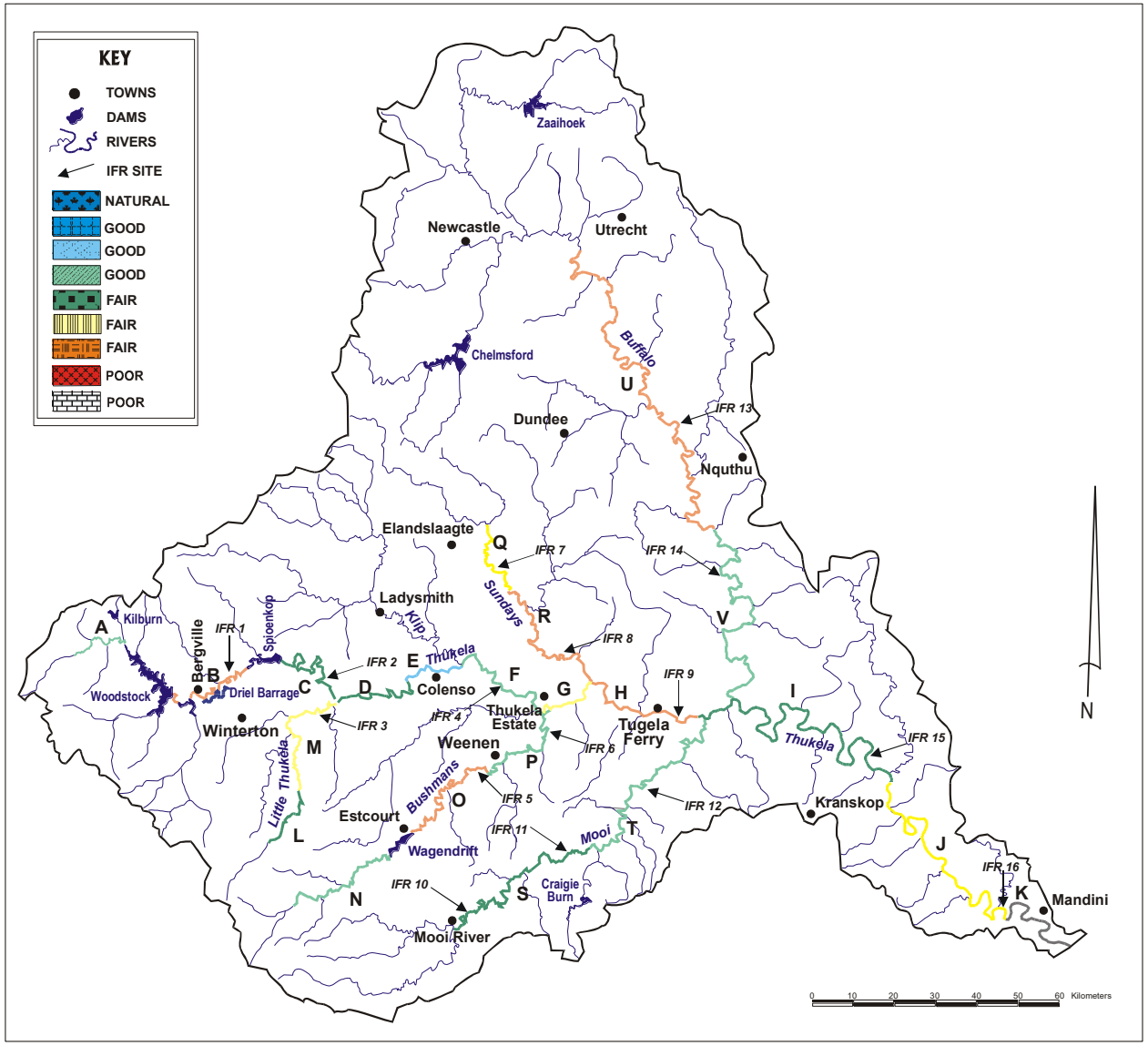
In summary, the process included the following steps and results:

- The Water Resources Yield Model (WRYM) was run using three IFR scenarios to achieve:
  - the initially suggested EC (Scenario 2),
  - an EC higher than that suggested (Scenario 1), and
  - one that would result in an EC lower than that suggested by the specialists (Scenario 3).
- The results of the modelling indicated that the three scenarios would result in a range of impacts on the yield of the water resource and would have impacts on the water users in the Thukela River Catchment.
- A review and optimisation of the IFR scenario assumptions and the practical operation of river system was undertaken, and Scenarios 4, 5 and 6 were devised.

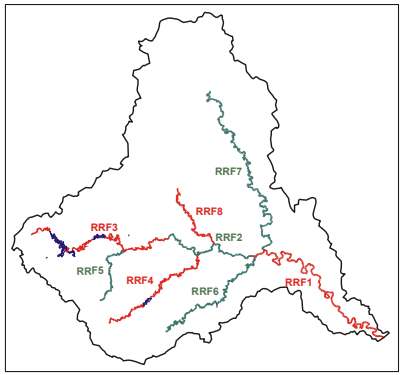
Diagram illustrating the sequential nature of the process followed for the Thukela Reserve Study

Study area

MAP OF THE STUDY AREA



Study area map



- The WRYM model was again run using the new scenarios.
- An evaluation of the ecological and yield impacts indicated that Scenario 5 had minimal ecological impacts and Scenario 6 had minimal impacts on the yield. The specialists optimised the proposed ecological water requirement flow regime (especially flood requirements), and another iteration was entered into, which resulted in the formulation of a ninth scenario.
- Scenarios 7 and 8 were described as baselines (i.e. current and future conditions with absolutely no IFRs supplied), against which all the other scenarios could be compared.
- Scenario 9 was then evaluated in detail. This scenario used Scenario 6 input for areas where there were no ecological problems, and Scenario 5 where the EC was not being met when Scenario 6 was applied. The flooding regime was also checked and optimised.

Modelling Results

Yield modelling results indicated that water users in the Bushmans and Buffalo River catchments are the only ones that will not be impacted under all the Ecological Reserve scenarios from 2 to 9. Under Scenario 2, there would be curtailments in water supplies to water users, even some severe reductions in the level of assurance of supply, in all of the remaining sub-catchments in the Thukela River System. Scenario 6 has a slightly diminished impact on water availability, but is still not free of unacceptable impacts on water users in certain areas. Scenario 9 proved to have a relatively small impact on the Tugela-Vaal transfer, with slightly larger impacts on the users in the Little Thukela and Sundays River systems. Both rivers are uncontrolled and present water use is more than the sustainable water resource availability.

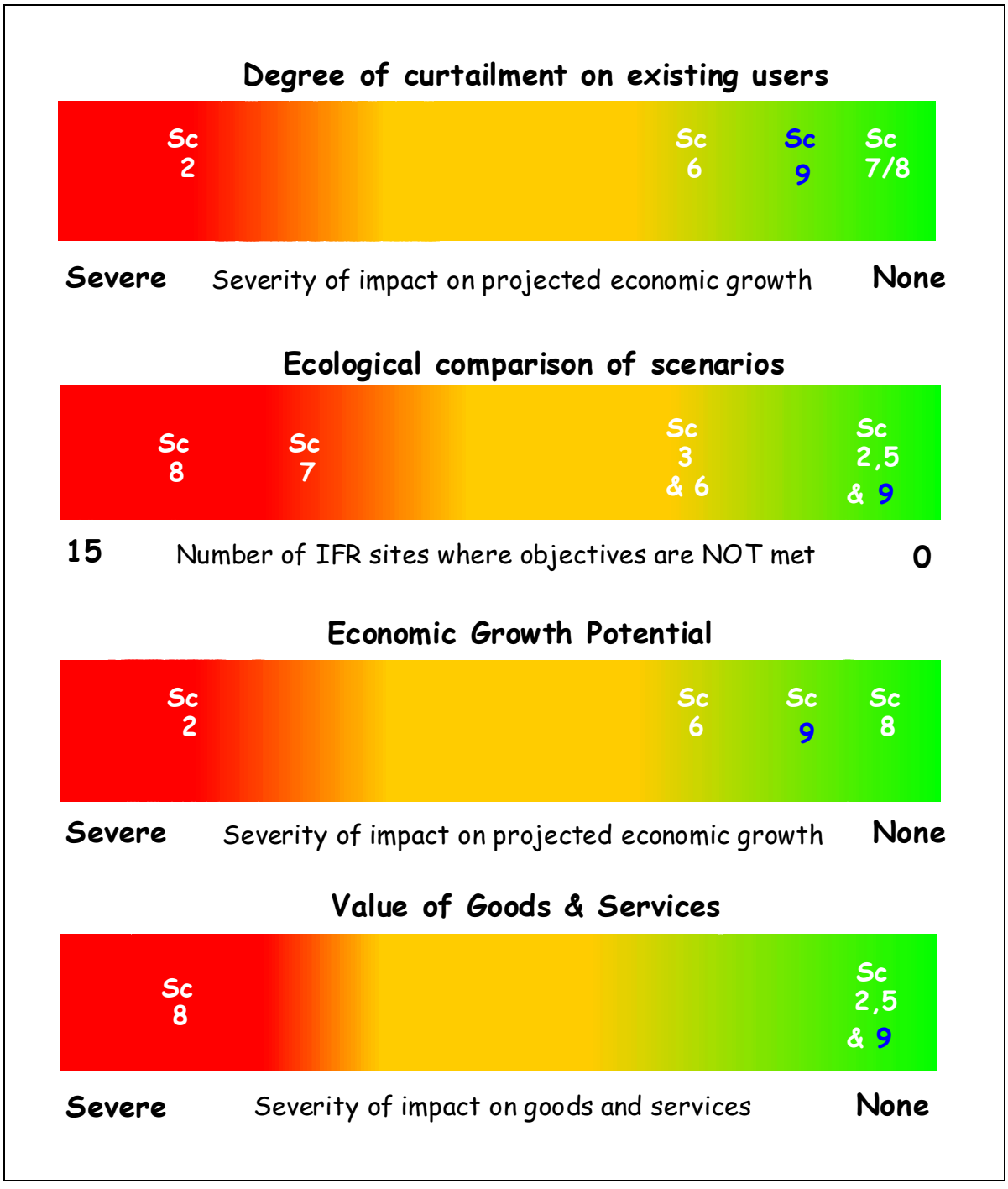
Context of Impacts on Water Users

In order to provide a broader suite of contextual information and to aid the decision- making process, a set of studies aimed at determining the economic impacts of the scenarios was undertaken. This had three major components:

- Goods and Services: A set of Goods and Services at a subsistence level are provided by the riverine system to local inhabitants. Economists and ecologists examined the critical goods and services provided by the river and examined the direction of change (either positive or negative) associated with scenarios and estimated the magnitude of the change in benefits and costs that may be experienced within the Thukela catchment under the relevant scenario.
- A second more ‘traditional’ market economic study attached values to the various sectors of the regional economy and looked at the impact of each of the scenarios on each of these sectors within each sub-catchment.
- The economic impact of different flow scenarios on the Thukela Marine Bank was examined by evaluating the link between flow and reported commercial catches of prawns and key fish species. The impact of a number of the scenarios on the value of the catches was estimated.

Graphical Portrayal of Results

The following diagrams show the relative impacts of each scenario against the criteria components considered.



Public Involvement

In addition to the study criteria listed above, a robust Public Involvement Programme (PIP) supported the Thukela Reserve Determination Study. The process was designed to ensure that representatives of relevant stakeholders are adequately consulted in evaluating the various scenarios and in the selection of a Reserve for the future management of the Thukela system. There have been a series of structured and well documented interactions with the stakeholders. These have included the following:

- First round of eight River Reach Forum (RRF) meetings in eight parts of the Thukela River Basin. These were open public forums where people were thoroughly informed regarding the Reserve Determination process. This empowerment to participate in the Reserve Study also included field visits to the Thukela River.
- Second round of River Reach Forum meetings.
- First Stakeholder Reference Group (SRG) Meeting in Ladysmith. This forum was made up of elected representatives of the RRF's. Information provided at the SRG meeting was conveyed back to stakeholders via public newsletters.
- Second Stakeholder Reference Group Meeting to present preliminary results.
- Third Stakeholder Reference Group Meeting to present the recommendations contained in this document.

PIP team representatives stationed in Ladysmith and Mtunzini regularly visited key roleplayers to keep them informed of progress on the study. These team members also responded to queries raised by stakeholders during the course of the study.

CONCLUSION AND RECOMMENDATION

After consideration of the original scenarios, and bearing in mind the aim of recommending a Reserve flow regimen to DWAF, it became apparent that it was possible to develop a scenario that both optimised flow requirements for sustainability of the resource and had the least potential impact on all sectors.

Scenario 9 appears to achieve a compromise between satisfying all in-basin user meeting. most ecological objectives and causing the least negative impact on the economy of the area and on the delivery of riverine Goods and Services.

The recommendation is that Scenario 9 and the resulting Ecological Categories at each IFR site and the estuary be accepted as a Preliminary Reserve and as the basis for future planning. The evaluation of a Reserve for a water abstraction licence at any point in the Thukela River System can now be determined by extrapolating the flow regime up or downstream from an existing IFR site.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AIDS	Auto Immune Deficiency Syndrome
BBM	Building Block Methodology
BHNR	Basic Human Needs Reserve
DRIFT	Downstream Response to Imposed Flow Transformations
DWAF	Department of Water Affairs and Forestry
EA	Enumerated Area
EHI	Estuarine Health Index
ERC	Ecological Reserve Category replaced by Ecological Category
EIS	Ecological Importance and Sensitivity
EC	Ecological Reserve Category
EWR	Ecological Water Requirement
HDI	Historically Disadvantaged Individual
IFR	Instream Flow Requirement
ℓ/c/d	Litres per capita per day
MAR	Mean Annual Runoff
NWA	National Water Act
PES	Present Ecological State
RD	Reserve Determination
RDM	Resource Directed Measures
RDP	Reconstruction and Development Programme
RU	Resource Unit
SCM	Source Control Management
SI	Social-Cultural Importance
SRG	Stakeholder Reference Group
TWP	Thukela Water Project
TWPDSP	Thukela Water Project Decision Support Phase
WRYM	Water Resources Yield Model

1 THE THUKELA RESERVE STUDY: INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

The study supports the Thukela Water Project Decision Support Phase (TWPDSP). The TWPDSP was set up following the TWP Feasibility Study, in order to supply strategic information to decision makers. Studies identified as necessary to provide a greater level of confidence in the feasibility of the TWP were:

- The Thukela Reserve Study (Consultant: IWR Source-to-Sea).
- Additional Environmental Assessment of issues that emerged from the Feasibility Study (Consultant: Environmental Assessment Technologies).
- Hydrological Systems Analysis (Consultant: WRP).
- Public Involvement Programme (Consultant: ACER Africa).

These studies were supported by a dedicated project management component (Consultants: BKS and Tlou & Matji).

1.2 PURPOSE OF THIS DOCUMENT

This document provides information about the Thukela Reserve Study and its findings to support the DWAF Executive Management decision-making. Recommendations are made regarding future resource management, with emphasis on maintenance of stream flow. Only the results and implications of the key components of this study are provided in a summarised format, however the level of detail provided should enable the DWAF to respond to the recommendations. A number of technical reports as well as a main report supports this document.

1.3 STUDY AREA

The study area is shown in Figure 1.1. It includes the main Thukela River and the downstream sections of the Little Thukela, Bushmans, Sundays, Mooi and Buffalo Rivers. Specialist work was undertaken at study sites called IFR sites. Each IFR site is situated in a Resource Unit (RU), which is a section of river which is sufficiently different from other sections to warrant its own Reserve. A total of 16 IFR sites were selected as well as the estuary that was investigated as a separate unit.

1.4 LEVEL OF THIS STUDY

The study was designed to follow, as far as practically possible, a comprehensive Reserve Determination approach to provide the highest confidence possible and is the most comprehensive of all Reserve Determinations undertaken so far in South Africa. The comprehensive approach required that a stakeholder involvement programme be included. The individual components were addressed at different levels, depending on data availability and the importance of the component in the study area (see Table 1.1).

The major components and undertaken in the study are set out in Table 1.1. For each, the present project status, the level of detail, and the specialist fields in which capacity building took place, are indicated.

Additional components that were incorporated into the study were:

- A comprehensive stakeholder awareness programme.
- An economic study that included an examination of the Ecological Goods and Services provided by the Thukela system, and a formal market economic study. The Goods and Services component was considered critical in generating an

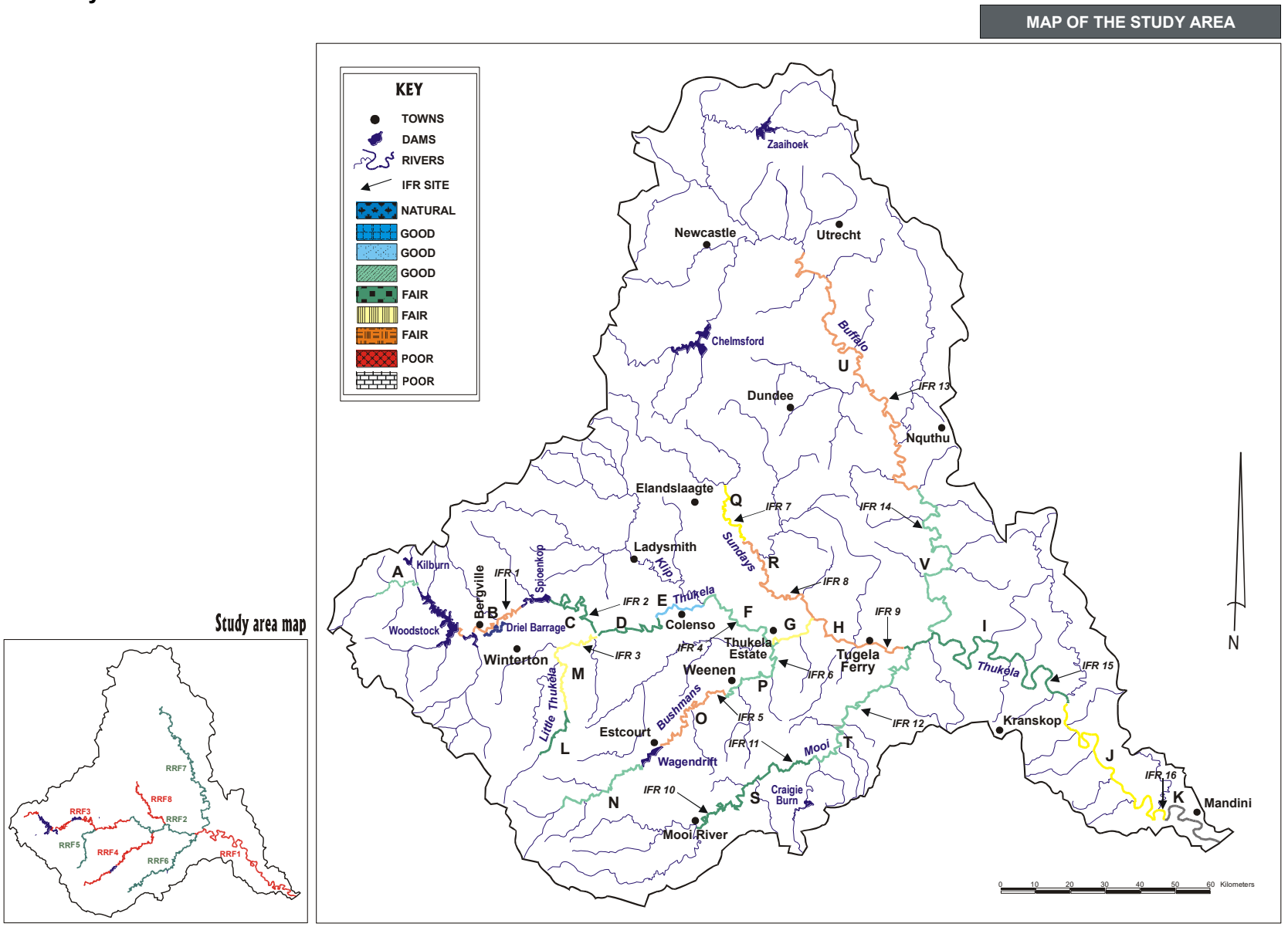
understanding of the linkage between the largely rural marginal communities and human dependence on the resource base (sustained by the health of the river).

A study of the Thukela Marine Bank was considered on the premise that there is a link between river flows and catches of prawns and certain fish species on the Bank. The assessment of ecological implications, with regard to fishery and prawn catches, due to the changes in freshwater flows was considered important.

Table 1.1 Components/Tasks addressed within the study

Study components	Level	Status (1 Aug 03)	Capacity Building
Project Management	Comprehensive	Ongoing	Yes
Basic Human Needs Reserve	Comprehensive	Final	Yes
Ecological Water Requirement scenarios (River quantity and quality)	Comprehensive	Final	Hydrology, water quality, aquatic invertebrates, geomorphology
Ecological Water Requirement scenarios (Estuary quantity and quality)	Intermediate - Comprehensive	Final	Macro-invertebrates, vegetation, estuarine dynamics, sediment transport
Groundwater assessment	Scoping	Final	-
Economic evaluation	-	Final	Yes
Goods and Services evaluation	-	Final	Yes
Thukela Marine Bank economic study	-	Final	-
Stakeholder process	Comprehensive	Final	Yes
Ecospecs and monitoring	Comprehensive	Pending	Hydrology, water quality, aquatic invertebrates, geomorphology, macro-invertebrates, vegetation, estuarine dynamics, sediment transport
Capacity building	Comprehensive	90% complete	-

Fig 1.1 Study area



1.5 STUDY OBJECTIVES

The study objective was to determination a Reserve for the system which best meets the legal, socio economic and sustainability goals/needs.

1.6 PROCESS

The following process was followed in order to address the objectives:

- The Basic Human Needs Reserve was determined.
- A set of Ecological Water Requirement (EWR) scenarios was generated to test through the application of a yield model. Each scenario represents a possible flow regime, intended to have specific outcomes linked to the Reserve. Scenarios specify how much water is required, where and when, and take cognisance of the likely water quality consequences.
- Based on the impacts of the EWR scenarios a set of flow scenarios, called Operational Scenarios, was generated and tested. These scenarios are realistic scenarios as impacts on users and constraints such as outlet sizes of dams are considered. Decision makers will select one of these scenarios as the Reserve.
- The likely impact of the Operational Scenarios on the available yield was determined.
- The likely impact of the Operational Scenarios on the aquatic ecology was determined.
- The likely economic impact of selected Operational Scenarios was determined. This included an evaluation of the impact on the Thukela Marine Bank.
- The likely impact of selected Operational Scenarios on the Goods and Services delivered by the riverine system was determined.
- The information resulting from the former steps was provided in a user-friendly format to stakeholders and included a recommendation for their consideration.

An additional requirement of the study was the application of specialist and technical capacity building throughout the project with an emphasis on Historically Disadvantaged Individuals (HDIs) (see Table 1.1 for further information).

1.7 WORK STILL REQUIRED

The following actions are required to complete the fulfilment of the study objectives:

- To brief the DWAF Executive Management on the recommended Reserve and to facilitate further decision-making.
- To determine Ecospecs (the ecological component of Resource Quality Objectives). To develop a monitoring programme to measure whether the Ecospecs are being achieved.

This process is consistent with the RDM protocols, and is illustrated in Figure 1.2. Best practice was followed, based on the most recent RDM developments. Where RDM protocols were not available for components of the study, rational processes were developed. Where RDM protocols were changed during the course of the study, a variation order was obtained and the study programme was amended to take cognisance of the new requirements.

1.8 PROGRAMME

The study was initiated during March 2001 and finalised by March 2004.

Fig 1.2 **Diagram illustrating the sequential nature of the process followed for the Thukela Reserve Study Dark Green=Ecological Classification; Brown=Stakeholder processes; Purple=EWR quantification; Blue=Operational Scenarios and consequences; Orange=where we are now; Red=DWAF decision making; Light green=defining Ecospecs and monitoring**

2 BASIC HUMAN NEEDS RESERVE

2.1 OVERVIEW

In terms of the National Water Act (NWA), the Basic Human Needs Reserve (BHNR) is one component of the Reserve. The other component is referred to as the Ecological Reserve.

2.2 METHODOLOGY

The sequential process of generating the BHNR for the Thukela Reserve Determination Study included a number of stepwise actions. Demographic data, supplied by the Directorate Water Services: DWAF, was used as a basis for analysis. The base information supplied by the DWAF was adjusted data from the 1996 census, and provided information that had been collected at an Enumerator Area (EA)[1] level. Using this data, a '"fine-grained" demographic profile of the Thukela catchment was generated.

For the purposes of this study, the EA data was disintegrated to reflect the likely direct users of the surface water resources of the Thukela. This involved demarcating a 5km buffer zone on either side of the Thukela and its major tributaries, and using this zone to estimate the number of people who would likely be reliant on the flow in the relevant river reach (the Thukela, Little Thukela (Injasuthi), Bushmans (Mchezi), Buffalo (Mzinyathi), Sundays, and Mooi Rivers).

It was assumed that people outside of this area, although they might be making use of water from the rivers via a formal urban supply or a community water supply scheme, would in the main be using springs, minor streams or groundwater. It should be noted that virtually all major urban settlements in the Thukela catchment fall within the 5km buffer.

The exercise involved firstly demarcating the EAs within the buffer zone. The percentage area of each EA within the buffer zone was then used to calculate the number of people within each EA residing within the buffer zone. For example, where 60% of the EA area fell within the buffer zone, it was assumed that 60% of the population of that EA would be within the buffer zone.

The data was further analysed to estimate the population numbers upstream and downstream of the IFR sites. These numbers give an indication of the amount of water that would need to pass certain IFR sites in order to meet the downstream needs.

1 The EA is the most fine-grained demographic information available. EAs are the building blocks of the census and EA data are often aggregated into census district information for the purposes of public consumption and broad-based planning.

2.3 RESULTS

Human Need scenarios were calculated on the basis of the currently accepted Reconstruction and Development Programme (RDP) norm of 25 ℓ per capita per day, as well as on the more liberal allowances of 60 ℓ and 100 ℓ per day[2]. In addition, the population growth was projected to 2020. Accurate projection of population growth is problematic given the uncertainty around the impact of HIV/AIDS. To err on the side of caution, a 1.5% per annum growth rate in population growth was allowed for. Current estimates are that many rural areas will have a zero or even a negative growth rate over the medium term. The Thukela catchment is predominately rural. This demographic analysis estimated a population of 2.07 million by 2020.

In addition to the coarse-grained analysis, the population in the catchment was disaggregated into four logical categories of settlement: rural villages (18.6% of the population of the catchment), scattered rural settlement (55.9%), urban (19.9%) and peri-urban (5.6%). Growth rates were applied to each of these categories, based on current, settlement-based, projections. These projections considered a fairly high growth rate of 2% for the urban and peri-urban areas over the next 20 years. A lower growth rate starting at 1.5% and declining to nil was used for the rural areas.

This is in keeping with urbanisation trends, and takes into account the expected impacts of AIDS. By the year 2020 the more fine-grained analysis predicts a population of 1.87 million, some 130,000 lower than that for the coarse-grained analysis. The total population living within the 5km buffer zone in 2001 is calculated to be 715 281, or 45.6% of the total population of the catchment.

Following this analysis, an allowance of 200 litres per capita per day (ℓ/c/d) has been allowed for urban areas. The peri-urban areas have a current allowance of 100 ℓ/c/d, growing to 200 ℓ/c/d per person per day by the year 2020. This would be consistent with a "high road" scenario, assuming electrification and growth in prosperity in these areas leading to the purchase of appliances using higher amounts of water such as washing machines. Rural villages start with 25 ℓ/c/d growing to 50 ℓ/c/d per person per day by the year 2010 and 100 ℓ/c/d by 2015. This again assumes growth in prosperity and village electrification. Scattered rural areas retain a 25 ℓ/c/d allocation for the entire period under consideration. This is based on the assumption that they will probably never have house connections and the literature shows us that the effort involved in transporting water from stand pipes or protected springs caps consumption at about 25 ℓ/c/d.

Table 2.1 presents the summarised estimates for the areas within the 5km buffer zone as already defined.

[2] The Reconstruction and Development Programme (RDP) defined 25 ℓ per person per day as an initial supply of water that should be made available to all people within South Africa. Community water supply schemes were largely designed around this target.

Table 2.1 Population figures and water demand for the 5km buffer zone (expressed in million cubic meters per annum) to 2020

Year	2001	Annual water demand	2010	Annual water demand	2020	Annual water demand
Settlement	**Population**		**Population**		**Population**	
Rural village	87364	0.80	99741	1.82	101415	3.70
Scattered rural	316989	2.89	323169	2.95	323169	2.95
Urban	249982	18.25	304727	22.25	352968	25.77
Peri-urban	60946	2.22	90208	4.94	103500	7.56
TOTAL	715281	24.16	817845	31.95	881051	39.97

Table 2.1 reflects the probable demand pattern for those people living within the buffer zone and dependent on run of river. The final total is not necessarily a BHNR as the amounts applied to some of the settlement types probably exceed those constituting a basic human need.

For those living outside the buffer zone, it is assumed that groundwater is probably of great importance. A groundwater report commissioned for this project (DWAF, 2003) estimates that current groundwater abstraction for the BHNR is in the region of 18 million cubic meters (MCM)/a. According to this estimate the population outside of the buffer zone uses approximately 57 ℓ/c/d groundwater. The groundwater report indicates that the abstraction of groundwater for rural water supply is not expected to pose a threat to the resource, as usage expressed as a percentage of the total amount available, is very low. Assuming that the 60 litres per person per day should also apply within the buffer zone, a BHNR scenario should be along the lines of that summarised in Table 2.2.

Table 2.2 60 ℓ per person per day BNHR allowance for population within 5km buffer zone (expressed in million cubic meters per annum)

Year	2001	Annual water need	2010	Annual water need	2020	Annual water need
Settlement	**Population**		**Population**		**Population**	
Rural village	87364	1.91	99741	2.18	101415	2.22
Scattered rural	316989	6.94	323169	7.08	323169	7.08
Urban	249982	5.47	304727	6.67	352968	7.73
Peri-urban	60946	2.22	90208	1.98	103500	2.27
TOTAL	715281	16.55	817845	17.91	881051	19.30

As such, for those living within the 5km buffer zone it should be assumed that 60 ℓ per capita per day constitutes the BHNR. This is probably sufficient to allow for all basic needs as defined by the NWA. It would also allow some water for uses such as minor subsistence irrigation of vegetables and other crops. This amounts to 16.55 million cubic metres per annum to be provided from the river.

2.4 SUMMARY

The total amount required for all people within the entire catchment, including those supplied by groundwater, would be 34.32 million cubic metres per annum. For the year of 2002, the 60 ℓ per person allowance for people within the 5km buffer zone would have amounted to a total of 19.30 million cubic metres, and for the entire catchment the total would have been 45.54 million cubic metres.

In incorporating the BHNR into the overall calculations for the Reserve, the hydrologists included in their hydrological model a “demand” category that allowed for domestic usage of water. The BHNR was therefore regarded as a demand within the model (which was used for the purposes of evaluating scenarios). This domestic “demand” category took consideration of current and projected demand patterns for all major settlements, as well as minor settlements with a known provision of water. Scattered settlements were not included in this calculation but the amounts actually required by these settlements are minor for most of the time and therefore have negligible impact on the water quantities required. None of the scenarios would impact upon the availability of water for this type of abstraction.

3 ECOLOGICAL CLASSIFICATION

3.1 OVERVIEW AND OBJECTIVES

The objective of the Ecological classification is to create an understanding of the present Ecological State and ecological functioning of the river and estuary and, based on this, to set realistic ecological aims/objectives. This information is necessary as a scenario approach is followed and suites of ecological aims or ecological states therefore have to be described. For each of these, a flow scenario must be described (Chapter 4).

Ecological classification must not be confused with the Classification System to determine Management Classes. It forms a component of the Classification System which considers a much wider suit of components than just Ecological.

3.2 METHODOLOGY

The sequential steps followed in Ecological Classification are shown in Table 3.1.

Table 3.1 The sequence of actions required for providing technical information on the EC. The left hand column shows the question that the action in the right hand column is answering.

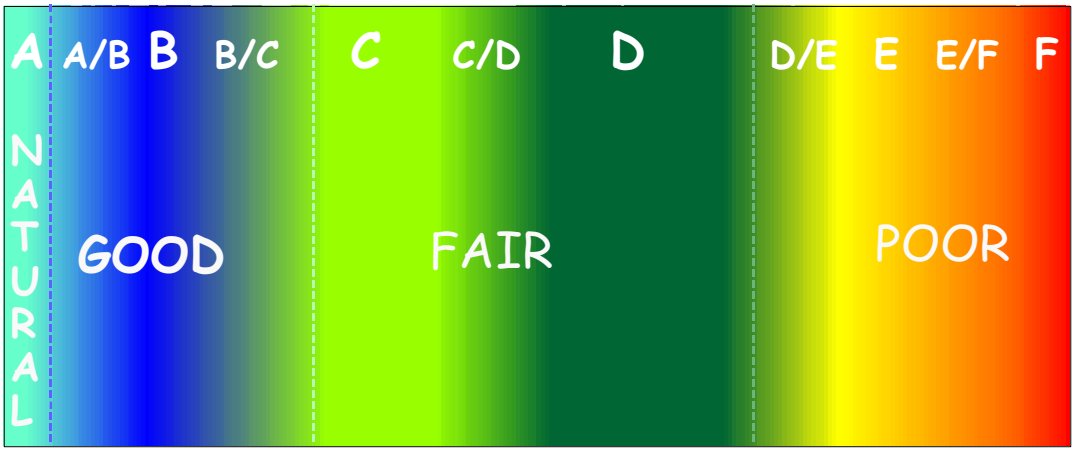
What was the river like before human impact?	1. DETERMINE REFERENCE CONDITIONS.
Compared to how the river used to look like, what does it look like now?	2. DETERMINE PES. (Category A - F).
Is the river changing, and if so, how severely? how fast?	3. DETERMINE TRAJECTORY OF CHANGE IF THE STATUS QUO IS MAINTAINED.
What is the main cause for the change?	4. DETERMINE CRITICAL CAUSE FOR THE PES and/or the TRAJECTORY OF CHANGE.
What is the source of the causes?	AND GIVE THE SOURCE OF THE CAUSE.
How ecologically and socially important is the river?	5. DETERMINE IMPORTANCE AND SENSITIVITY CATEGORIES (Low, Moderate, High, Very High) as well as Socio-Cultural Importance.
What would the ecological aims be for the river?	6. CONSIDERING THE IMPORTANCE AND THE PRESENT ECOLOGICAL STATE SHOULD THE PES BE IMPROVED (if so, by how much) OR MAINTAINED? (NOTE: Maintaining the PES could still require restoration management depending on the trajectory of change). (Category A - D).
Can the main cause realistically be addressed to achieve the ecological aims?	7. DETERMINE WHAT WOULD BE REQUIRED TO ADDRESS THE CAUSES. 8. DETERMINE HOW DIFFICULT IT WOULD BE TO ADDRESS THE SOURCE. (RESTORATION/REVERSIBILITY POTENTIAL). (Easy, reasonable, difficult, very difficult). PROVIDE REASONS.
What should the Ecological category be for the river?	9. CONSIDERING THE ECOLOGICAL AIMS, AND THE DIFFICULTY OF ACHIEVING THE AIMS, DETERMINE THE ATTAINABLE ECOLOGICAL CATEGORY FOR EACH COMPONENT.

The results of the process, i.e. the PES and EC are provided as different river categories ranging from A (near natural) to F (completely modified). These will be converted to a descriptive terminology when applied to Management Classes which are the output of the Classification System procedures (as referred to in the Act and which must still be devised).

The interface between ECs and management Classes are provided in Figure 3.1.

The so-called 'half categories', e.g. B/C, are also used in cases where there are uncertainties regarding whether the category is, for example, a B or a C. Categories represent bands or a range within a continuum, and the B/C therefore represents a condition close to the B band. An illustration of these concepts is provided in Figure 3.1.

Fig 3.1 Illustration of the distribution of Ecological Categories on a continuum and the relationship with Management Classes



The range of Ecological Categories (ECs) for which flow scenarios must be supplied are guided by the rules as shown in Table 3.2. This must be seen as guidelines to determine a *realistic* range of ECs which can be addressed within the scenario-approach.

Table 3.2 Guidelines for the range of ECs to be addressed

PES	Range of ECs
A	A
A/B	A/B, B/C
B	B, C
B/C	B, B/C, C/D
C	B, C, D
C/D	B/C, C/D, D
D	C, D
D/E, E, E/F, F	D

3.3 RESULTS OF THE ECOLOGICAL CLASSIFICATION PROCESS

The recommended (from an ecological perspective) ECs are provided spatially on maps (Figures 3.1 – 3.2) and tabulated (Table 3.4). A descriptive summary of the results follows.

3.3.1 Thukela River

Ecologically, the section of the Thukela River, which is considered closest to natural, is the most upstream section (due to minimal disturbance) and the section in the gorge upstream of the Bloukrans River confluence (due to inaccessibility). The proposed Jana Dam site is situated in this gorge.

The most ecologically modified sections in the Thukela River are those between Driel and Spioenkop Dams (due to the operation of the dams) and the downstream section around Mandini (due to water quality and sedimentation problems).

The only sections assigned a high ecological importance are the gorge section in which Jana Dam site is situated and the Buffalo River downstream of IFR 14. The aim for the gorge section is an improvement on the PES. The lower Buffalo River requires an improvement in water quality to achieve an improved EC.

The section downstream from the Klip River confluence has a higher Socio-cultural Importance (SI) than the EIS. No improvement is however warranted as the PES is a B and the recommended EC is already a B. The section of river downstream of the Bushmans River also has a high SI compared to the moderate EIS. However, an improvement of the PES will not improve the relevant socio-cultural components which are due to catchment (not flow) related problems.

3.3.2 Little Thukela River

The Little Thukela is in a moderately modified to modified state mostly due to informal and formal land-use. The EIS is moderate and no improvements in categories are required.

3.3.3 Bushmans River

The Bushmans is presently in a largely natural to moderately modified ecological state above Wagendrift Dam and in the gorge sections downstream of Wagendrift Dam. In the more accessible areas there are extensive irrigation activities which result in it being in a largely modified state. The EIS is high in the gorge section. Maintenance of the gorge will result in improvement of the downstream sections.

3.3.4 Sundays River

The Sundays River is largely modified due to informal and formal land-use and specific water quality problems. The ecological importance is moderate, with a high social importance in the lower section. This does not however warrant an improvement in the PES. Addressing the negative trajectory of change by recommending some improvements in the present management of the system will improve the social utilisation of the Goods and Services.

3.3.5 Mooi River

The section of the Mooi River included in the study area varies from largely natural in the gorge sections to largely modified areas in the downstream irrigation and rural areas. The EIS is moderate, and the Social Importance is high in the downstream areas. Maintaining the gorge section in its present state will ensure an improvement of the downstream areas.

3.3.6 Buffalo River

The Buffalo River ranges from largely modified in the upper reaches or sections (largely due to formal agriculture and water quality problems) to a largely natural in the gorge sections (mostly due to its inaccessibility). The high ecological importance in this section requires improvement in water quality to achieve an improved PES. The EC was therefore set half a category higher than the PES.

3.3.7 Estuary

The estuary PES is largely natural to moderately modified (B/C PES). The detailed breakdown of the individual components is provided in Table 3.3.

Table 3.3 Estuarine Health Score results for the Present Ecological State of the Thukela Estuary

Variable	Weight	Score	Weighted score
Hydrology	25	87	22
Hydrodynamics and mouth condition	25	80	20
Water quality	25	54	14
Physical habitat alteration	25	80	20
Habitat health score			**75**
Microalgae	20	65	13
Macrophytes	20	60	12
Invertebrates	20	60	12
Fish	20	70	14
Birds	20	70	14
Biotic health score			**65**
ESTUARINE HEALTH SCORE			**70**

The Estuarine Health Index (EHI) score of 70 allocated to the Thukela Estuary translates into a Present Ecological State of a B/C (referred to in the Estuarine Reserve Methodology as a C+).

The estuarine importance is high and the ecological aim should be to improve the estuarine state to a B category. The results of the specialist meeting indicated that non-flow (catchment) related anthropogenic activities (such as human disturbance of birds, over-fishing and removal of wetlands for agriculture) have had a significant influence on the present state of the estuary. As some of the changes caused by these activities would be difficult to reverse, it was recommended that the PES be maintained, i.e. B/C category.

3.4 CONCLUSION

In all cases apart from the following the aim and EC was set to maintain the PES.

- IFR 4: Thukela River downstream of the proposed Jana Dam (RU F).
  Due to both the high EIS and SI, the B/C PES was improved to a B EC.
- IFR 14: Lower Buffalo River (RU V)
  Due to the both the high ecological and socio-cultural evaluation, the PES of a B/C was set to improve to a B EC. In this case however, the only improvement required to achieve this was in water quality. The flow regime for both a B/C and a B EC in this case would therefore be the same.

Table 3.4 Summary of the PES, EIS, SI and EC results

Dark blue = B; dark blue to light green = B/C; light green = C; light green to dark green = C/D; dark green = D

RU	PES	EIS	SI	EC
THUKELA				
A	B/C	Moderate	Moderate	B/C
B	D	Moderate	Low	D
C	C	Moderate	Moderate	C
D	C	Moderate	Moderate	C
E	B	Moderate	High	B
F	B/C	High	High	B (B/C)
G	C/D	Moderate/High	Moderate	C/D
H	D	Moderate	Moderate	D
I	C	High	High	C (C/D)
J	C/D	Moderate	Moderate	C/D (D)
Estuary	C	High	Moderate	C

RU	PES	EIS	SI	EC
LITTLE THUKELA				
L	C	Moderate	Moderate	C (C/D)
M	C/D	Moderate	Moderate	C/D (D)

RU	PES	EIS	SI	EC
BUSHMANS				
N	B/C	Moderate	Moderate	B/C
O	D	Moderate	Moderate	D
P	B/C	High	Moderate	B/C

RU	PES	EIS	SI	EC
SUNDAYS				
Q	C/D	High	High	C/D
R	D	Moderate	High	D

RU	PES	EIS	SI	EC
MOOI				
S	C	Moderate	Moderate	C
T	B/C	Moderate	High	B/C

RU	PES	EIS	SI	EC
BUFFALO				
U	D	Moderate	Moderate	D (D/E)
V	B/C	High	High	B (B/C)

Fig 3.2 Upper Thukela ecological classification results

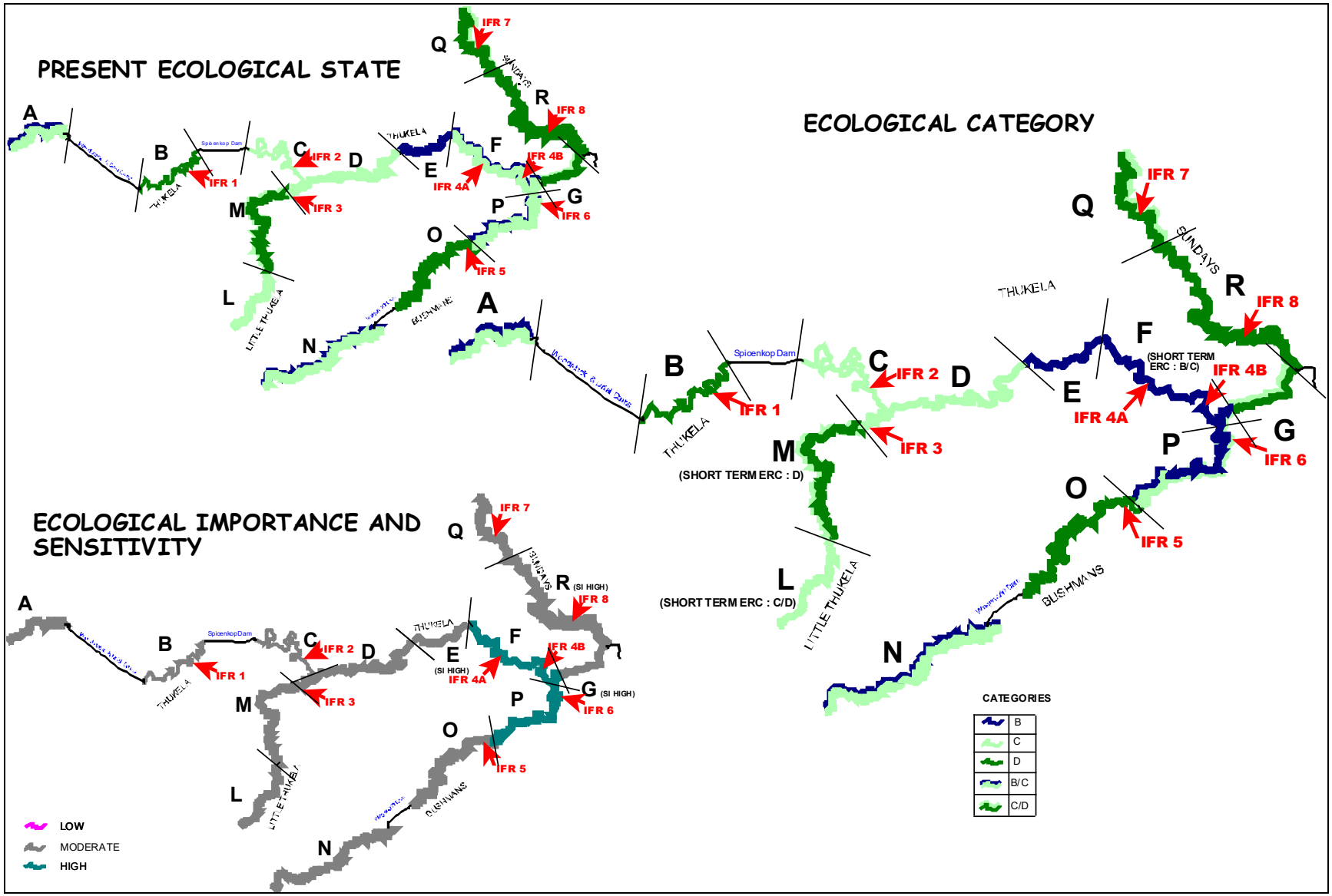
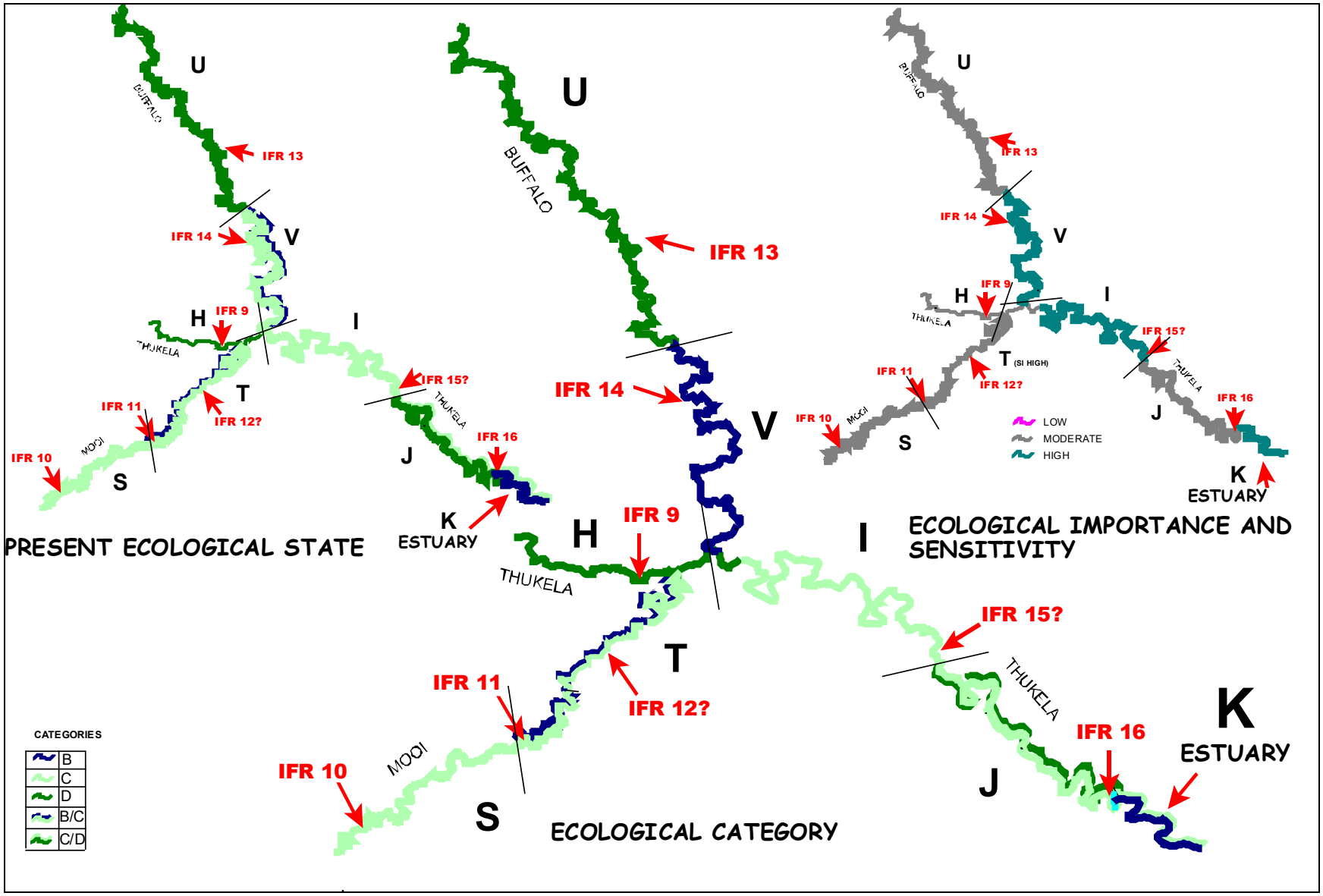


Fig 3.3 Lower Thukela ecological classification results



4 ECOLOGICAL WATER REQUIREMENTS SCENARIOS

4.1 OVERVIEW AND OBJECTIVES

The objective of this task was to provide flow regimes (IFRs) for different sites in the rivers to achieve a specific ecological state as described in Chapter 3. This would be the flow scenarios which would result in the Ecological Categories prescribed. Quality consequences are provided for each flow regime. This flow and quality requirements are termed Ecological Water Requirements (EWR). The EWR are then determined for the estuarine assessment in terms of impact on estuarine health, i.e. the estuarine ecological state.

4.2 RIVER RESULTS

The approach followed was a combination of three published South-African environmental flow requirement methods. These are the Building Block Method (BBM), the Flow Stressor-Response method and the Downstream Response to Imposed Flow Transformations (DRIFT). The processes and the motivations for the results are provided in detail in the technical reports. These flow results are then provided to yield modellers as input to the Water Resource Yield Model (WRYM). Consequences of providing the Instream Flow Requirements scenarios can then be tested based on the outputs of the WRYM (see chapter 6, 7, 8, and 9).

NOTE: IFR 6 and 12 was not evaluated further.

- IFR 6
  This was an old IFR site and had been irreversibly changed by the farmer. Access was limited and benchmarks destroyed. Due to the general lack of indicators present at the site additional (to the previous work) would not have any purpose.
- IFR 12
  This site could only be used if the benchmarks that had been vandalized would be reinstated by DWAF. These benchmarks were reinstated by DWAF after all site work was completed and could therefore not be used. However, this site could be used in future as a monitoring site.

The results for the river linked to each IFR site are provided in Figures 4.1 – 4.2. Results are provided as percentages of the natural MAR. A confidence is also attached to the results.

Fig 4.1 IFR for the Upper Thukela

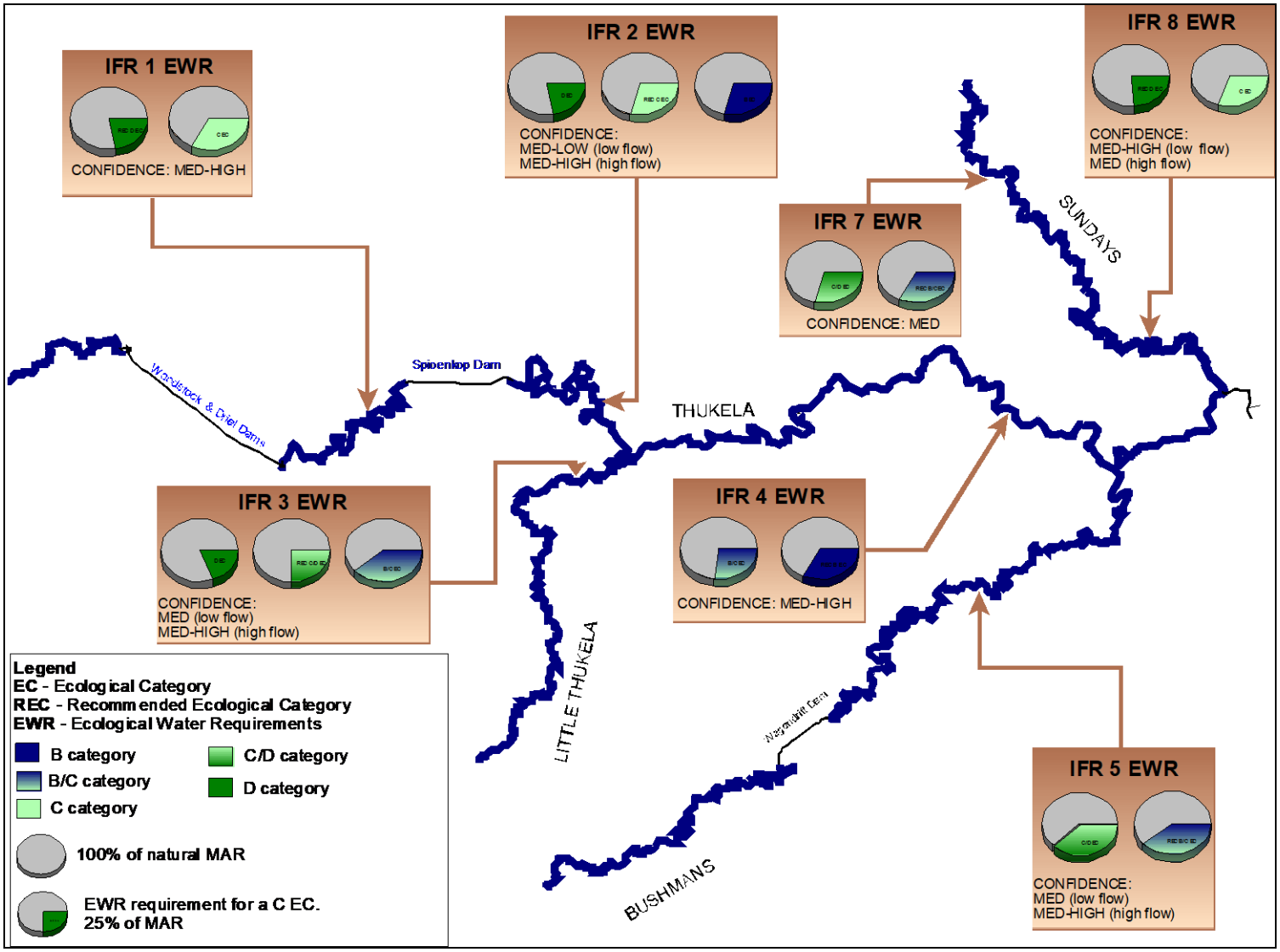
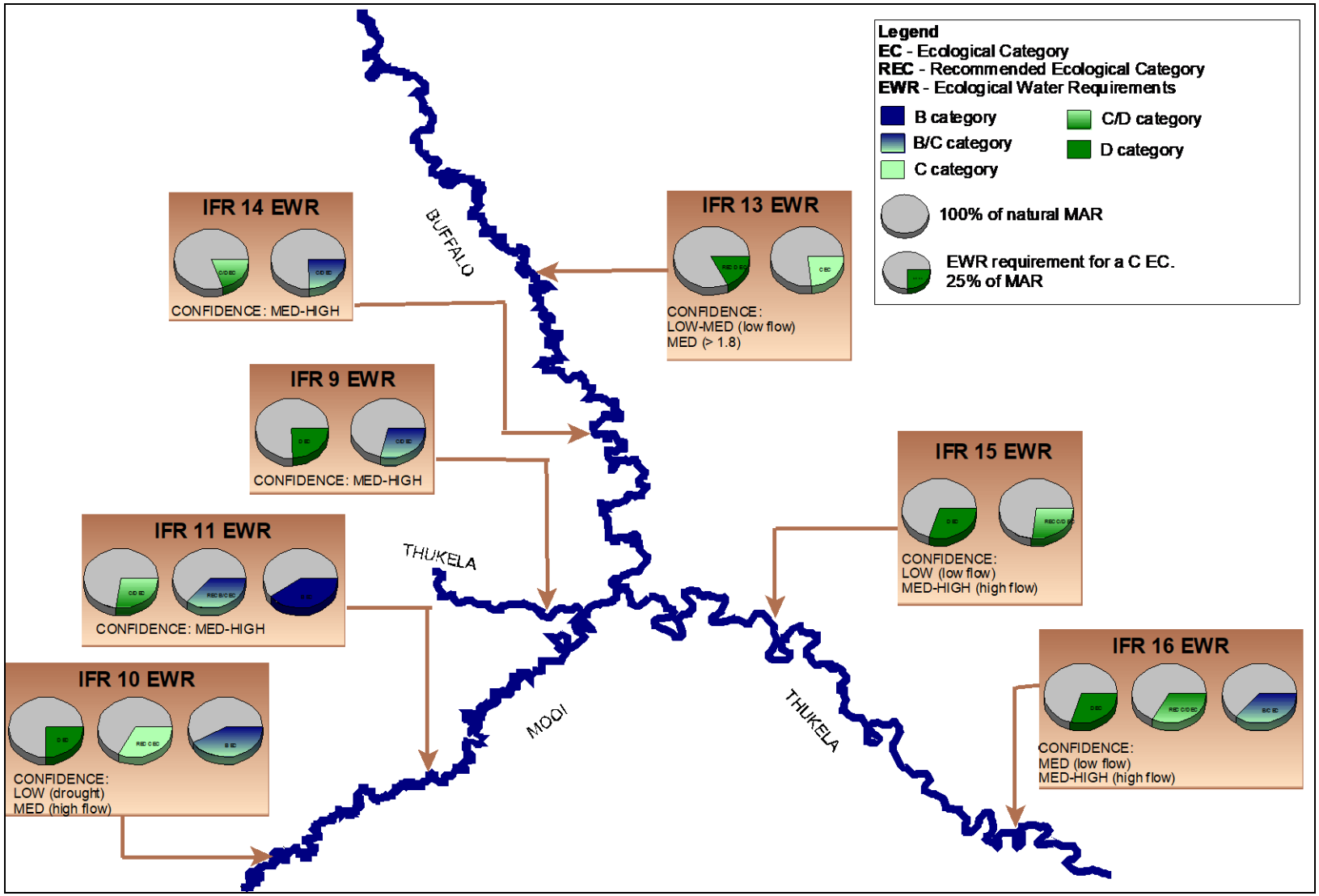


Fig 4.2 IFR for the Lower Thukela



4.3 ESTUARY RESULTS

Compared to the bottom-up approach followed for rivers, the estuarine approach follows a top-down approach. The output of the estuarine approach provides, for each EWR scenario, the ecological consequences to the estuary. The results are expressed as a resulting ecological category.

The flow scenarios provided for estuary analysis were modelled present day flows, worst-case development scenarios (which included the TWP dams) and estimated river requirements for various river ECs. Note that this estuary assessment pre-empted the task during which the EWRs were generated and the river results (as provided in 4.2) were available. Estimated river results were therefore provided for analysis. The results are provided in Table 4.1 which indicates that only the River Category A and B maintained the estuary PES of a C+ (B/C).

An estuary analysis of additional flow scenarios followed at a later stage to assess the IFR results as an output of the yield model and other Operational Scenarios. These results are provided as ecological consequences in Chapter 6.

Table 4.1 Estuary results of the scenario evaluation of various flow scenarios

COMPONENT	INITIAL SCENARIO						
	Present State	River Cat A	River Cat B	River Cat C	River Cat D	Worst Case 1	Worst Case 1
Hydrology	87	89	79	74	69	69	69
Hydrodynamics	80	100	100	95	95	20	20
Water quality	54	70	62	58	50	46	46
Physical habitat	80	68	68	68	68	68	68
HABITAT HEALTH SCORE	**75**	**82**	**77**	**74**	**70**	**51**	**51**
Microalgae	65	65	65	65	65	35	35
Macrophytes	60	62	64	67	67	60	60
Invertebrates	60	65	65	25	25	17	17
Fish	70	70	70	60	60	40	40
Birds	70	70	70	70	70	25	25
BIOTA HEALTH SCORE	**65**	**66**	**67**	**57**	**57**	**35**	**35**
EHI SCORE	**70**	**74**	**72**	**66**	**64**	**43**	**43**
CORRESPONDING EC	**C+**	**C+**	**C+**	**C-**	**C-**	**D-**	**D-**

5 DEVELOPMENT OF OPERATIONAL SCENARIOS

5.1 OVERVIEW AND OBJECTIVE

Ecological Water Requirement scenarios had now been developed by ecologists as sets of possible flows to achieve different river states (or Ecological Categories) for each IFR site (see Section 4). This process did not consider whether these flows could be supplied or managed. The impact on users was also not considered. To provide decision makers with more comprehensive information, it was considered necessary to examine each of the scenarios and their full range of implications. Thereafter, a process was followed to devise an optimised scenario that would have the least overall impact on the users and the ecology. All these Operational Scenarios were tested to determine the resulting state of the river and estuary, and the water quality consequences of each flow scenario were supplied.

5.2 METHODOLOGY

The decision-making process to determine a range of scenarios is described here:

- The Water Resources Yield Model (WRYM) was run using three different IFR scenarios: one that would achieve an EC higher than recommended (Scenario 1), one that would achieve the recommended EC (Scenario 2), and one that would result in an EC lower than recommended (Scenario 3).
- The results of the modelling process indicated that all three scenarios would result in a range of impacts on the yield and therefore on the users.
- An initial optimisation process that also took account of operational constraints was undertaken and Scenarios 4, 5 and 6 were thus devised.
- The WRYM model was run again with the new scenarios.
- An initial evaluation of the ecological and yield impacts indicated that Scenario 5 has minimal ecological impacts and Scenario 6 had minimal impacts on the yield.
- An additional scenario (Scenario 9) was devised using Scenario 6 input for areas where there were no ecological problems, and Scenario 5 where there were ecological problems (the EC not being met) when Scenario 6 was applied. The flooding regime was also checked and optimised.

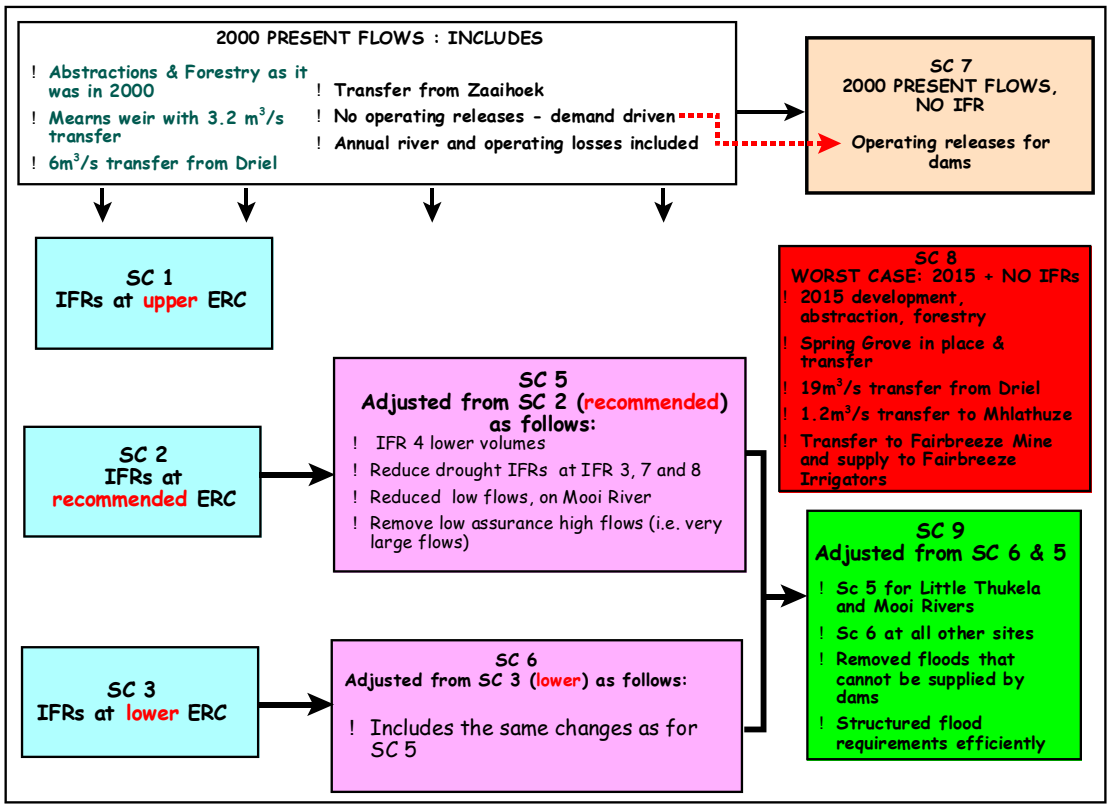
Note: Scenarios 1 and 4 were not evaluated further as they were unrealistic.

The scenarios are described in Table 5.1. The links between the scenarios are illustrated in Figure 5.1.

Table 5.1 Scenario descriptions

Scenario Number	Description
1	Current (2000) level of development in the catchment, with flows set to improve the PES to a better state than the recommended EC. This was abandoned as it was considered unrealistic.
2	Current (2000) level of development in the catchment, using the flows set for the recommended EC. These flows are generally lower than those set for Scenario 1, as they were intended to maintain the recommended EC. An interesting point is that when the flows for this scenario were modelled, the ecological conditions at a number of the IFR sites improved, i.e. the EC achieved would be better than the PES.
3	The current level of development with flows set to achieve a lower than recommended EC. Recommended flows are generally lower than for Scenarios 1 and 2.
4	Current level of development with flows set to achieve the EC at all sites apart from IFR 4. As this scenario still included floods that could not be provided, it was considered unrealistic, and was abandoned.
5	Current level of development, with flows set to achieve the EC at all sites apart from IFR 4. Floods that could not be met were removed and in some cases drought periods were increased.
6	Current level of development with flows set to achieve an EC lower than that recommended. Floods that could not be provided were removed and in some cases drought periods were increased.
7	Current level of development and flows. Flows with more efficient operating rules for the dams.
8	A 2015 level of development with no IFRs provided. The developments included are Spring Grove Dam, increased transfer from Driel Dam, Middledrift transfer and the proposed Fairbreeze transfer. This scenario is a worst case for the ecology.
9	This scenario was designed to achieve a better balance between ecological requirements and impact on water available to other users. Scenario 9 is a combination of Scenario 5 and 6, with changes in flood patterns.

Fig 5.1 Links between scenarios



6 ECOLOGICAL CONSEQUENCES OF THE OPERATIONAL SCENARIOS

6.1 OVERVIEW AND OBJECTIVES

In order for each of the operation scenarios to be assessed, it was necessary to consider their ecological consequences. The ecological evaluation is based on an assessment of the impact on the states or ECs recommended for each component. Information on the water quality assessment as a key driver is provided below, followed by the overall assessment.

6.2 WATER QUALITY CONSEQUENCES

Each of the flow scenarios where checked through simple concentration modelling to determine whether the water quality objectives would be met under these flow conditions. Where it would not meet the water quality objectives, an assessment of whether the problems can be addressed at source is provided.

The results of the water quality assessment are provided in Table 6.1 and Figure 6.1.

Table 6.1 Water quality consequences of the different flow scenarios

Y=Yes; N=No; EC=Ecological Category; SCM=Source Control Measures

IFR site	Sc2		Sc3		Sc 5		Sc6		Sc7		Sc8		Sc9	
	EC?[1]	SCM?[2]	EC?	SCM?	EC?	SCM?	EC?	SCM?	EC?	SCM?	EC?	SCM?	EC?	SCM?
THUKELA RIVER														
1	Y	N	Y	N	Y	N	Y	N	Y	N	N	Y	Y	N
2	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
4 *	Y	N	Y	N	Y	N	Y	N	Y	N	N	Y	Y	N
9	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
15 *	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
16	Y	N	Y	N	Y	N	Y	N	Y	N	N	Y	Y	N
LITTLE THUKELA RIVER														
3	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
BUSHMANS RIVER														
5 *	Y	N	Y	N	N	Y	N	Y	Y	N	Y	N	N	Y
SUNDAYS RIVER														
7#	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
8 *#	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
MOOI RIVER														
10	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
11	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
BUFFALO RIVER														
13	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
14*	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y

1 REC (Recommended Ecological Category)? : If the flow scenario is implemented, will the recommended water quality EC be met?

2 SCM (Source Control Management)?: If the EC cannot be met, is SCM required and realistic?

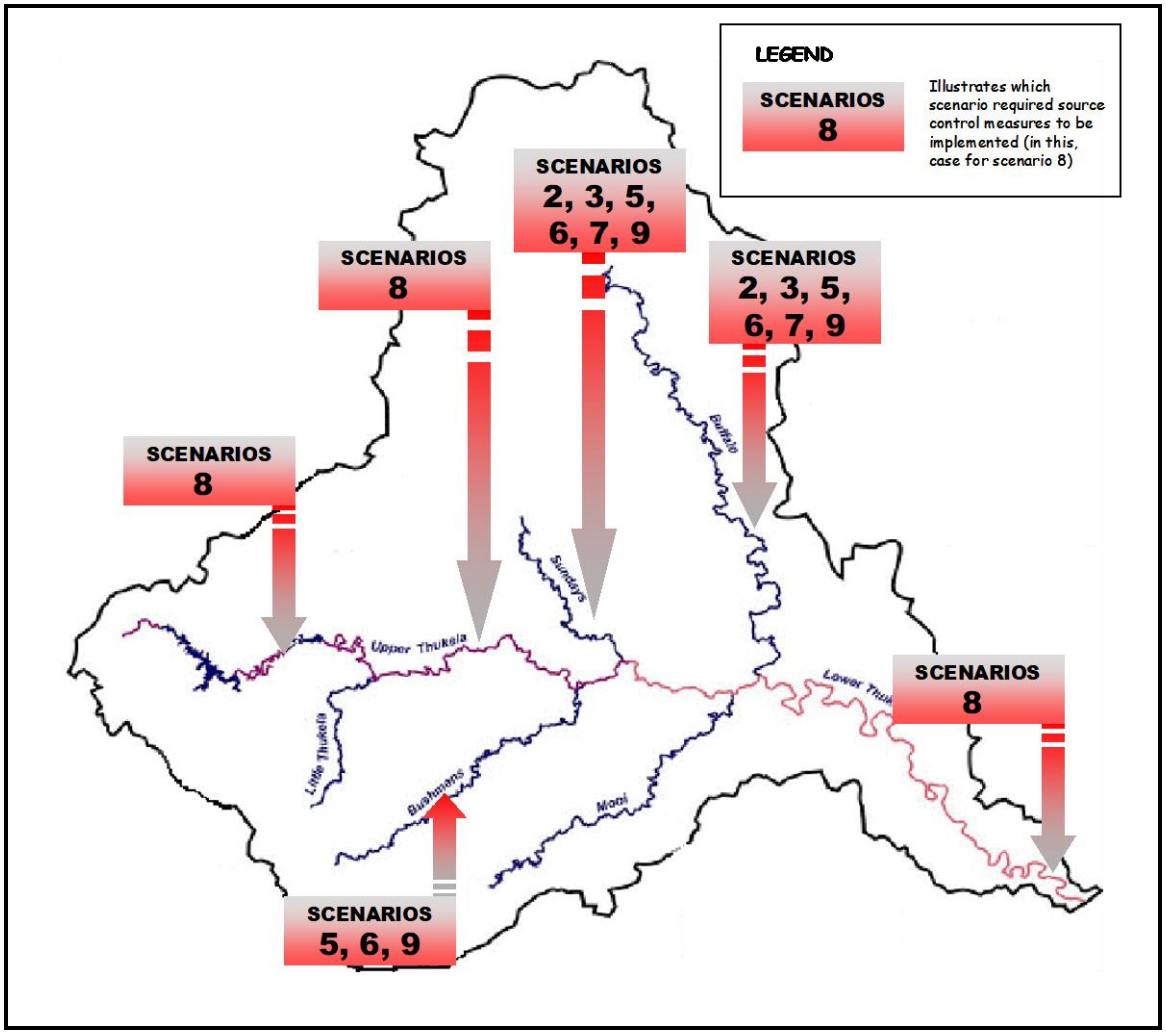
* Low confidence as no modelling was carried out and few data points for PES assessment (weekly data for two months – August and September 2001).

\# Note that the criteria for evaluating magnesium sulphate have not been verified and there is therefore low confidence with the assessment of an E/F (see the notes for IFR 7 and 8 below).

Note that:

- Table 6.1 refers to the PES and EC as determined by the revised methods of DWAF (2002) for assessing the Ecological Reserve: Water Quality. To maintain continuity with previous reports based on DWAF (1999) water quality methods, a “y” or “yes” to the EC means that the present state will be maintained.
- **Sc8, IFR 1:** Elevated phosphates, therefore agricultural practices to be managed and improved.
- **Sc8, IFR 2:** Elevated sulphates and nutrients – Klip River input to be managed.
- **Sc8, IFR 16:** Elevated phosphates and sulphates.
- **Sc5, 6 and 8, IFR 5:** Concerns include Estcourt’s sewage effluent and erosion in the area (professional judgement and catchment knowledge used, as water quality data does not reflect these concerns (e.g. no turbidity data)).
- **IFR 7:** Flow scenarios are similar to present, except during the dry season. Changes in flow would therefore not be sufficient to change the current status, but Source Control Measures (SCM) should be implemented under all scenarios due to high sulphates and phosphates. Management of acid-mine drainage from coal mines is therefore required.
- **IFR 8:** Flow scenarios are similar to present; changes in flow would therefore not be sufficient to change the current status, but SCM should be implemented under all scenarios due to high sulphates and periphyton (indicating eutrophication?). Management of acid-mine drainage from coal mines, particularly in the Wasbank catchment, is therefore required.
- **IFRs 10 and 11:** There are high periphyton levels at a site located between the IFR sites, so although conditions at the sites will be maintained under all flow scenarios, reductions in flow will exacerbate poor periphyton conditions downstream of IFR 10.
- **IFR 13:** Although all flow scenarios are similar and will maintain current conditions the PES is not acceptable and SCM is needed to address high sulphates and nutrients.
- **IFR 14:** Although all flow scenarios are similar and will maintain current conditions, the PES is not acceptable and SCM is needed to address the high sulphates and the periphyton conditions. The upper Buffalo River is of particular concern.

Fig 6.1 Areas where source control measures will be required under certain flow scenarios



6.3 ECOLOGICAL CONSEQUENCES

The results as depicted on the Figures are summarised in Table 6.2. A Traffic Light diagram comparing the ecological effects of the different scenarios is shown in Figure 6.2. The results per IFR site are summarised in Figures 6.3 – 6.4.

Table 6.2 Summary of ecological results (Note: For the purpose of this table the estuary is referred to as an IFR site, i.e. there are 14 IFR sites in the river which have been addressed, and the estuary – a total of 15 IFR sites)

Scenario	No. of IFR sites MEETING the recommended EC	No. of IFR sites NOT MEETING the recommended EC
2	14	1 (IFR 4[1])
3	11	4 (IFR 3, 4, 10 & 11)
5	14	1 (IFR 4)
6	11	4 (IFR 3, 4, 10 & 11)
7	6	9
8	2	13
9	14	1 (IFR 4)

1 None of the scenarios meet the recommended EC for IFR 4, which in this case was an improvement in the PES. However Scenarios 2, 3, 5, 6 and 9 do meet the PES.

It is clear from Table 6.2 that Scenarios 2, 5 and 9 would meet the recommended Ecological Category at most sites (although Site 4 below Spioenkop Dam is problematic as it does not meet the ecological objectives). Scenarios 3 and 6 would be problematic at IFR Sites 3 (Little Thukela), 10 and 11 (Mooi), as well as at IFR 4. Scenario 7 shows that the current situation, even with releases from the main dams, does not meet the recommended EC at 9 sites. Scenario 8 shows that the river, if not better managed, would continue to degrade at 13 sites as the system were further developed.

It should be noted that Scenarios 2 and 3 were initial attempts to see what flows meeting the EC would do in terms of the amount of water available. Scenarios 2 and 3 should be seen as one end of a continuum and, in fact, some of the floods that were included in the scenarios could not be supplied. As such, Scenarios 5, 6 and 9 were developed to give a more realistic picture of how the river could be managed.

The Traffic Light diagram in Figure 6.2 summarises Table 6.2 and shows the approximate difference between scenarios, from an ecological point of view, along a continuum of the scenarios.

Fig 6.2 Ecological comparison of scenarios. Note that red illustrates an unacceptable situation for ecology and green an acceptable condition. The numbers in the traffic diagram in the white blocks refer to scenarios. The scale refers to the number of IFR sites.

The continuum illustrates how successfully the scenarios meet the IFR objectives at the 15 IFR sites. Scenario 8 fails to meet the ecological objectives at 12 IFR sites, whereas scenarios 2, 5 and 9 fail to meet the objectives only at IFR 4. IFR 4 is one of the sites where improvement is required. It is this improvement that cannot be met, while the PES is maintained. These scenarios will therefore not degrade the river at IFR 4.

Fig 6.3 **Ecological consequences of operations scenarios at each IFR site: Upper Thukela**

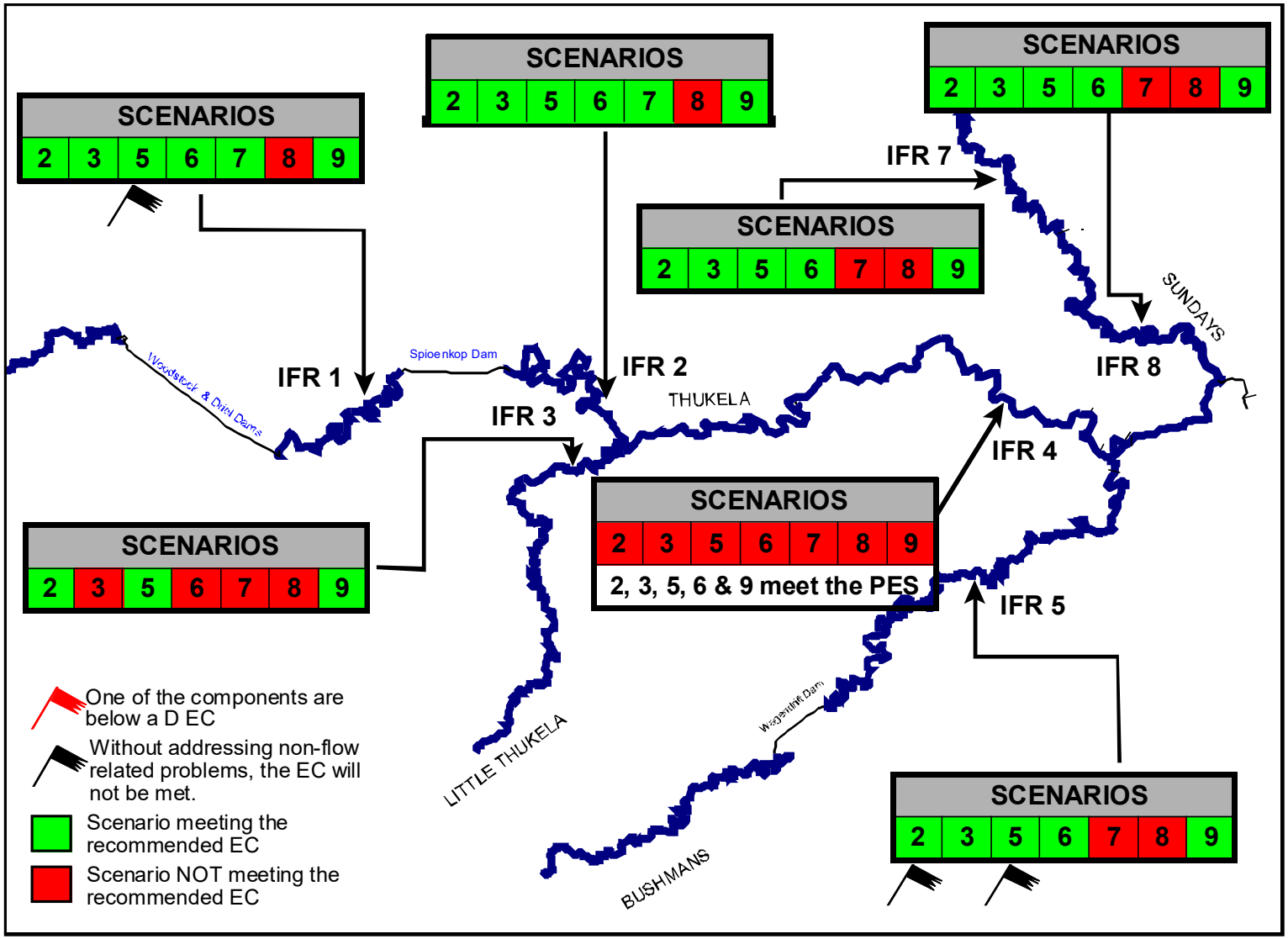
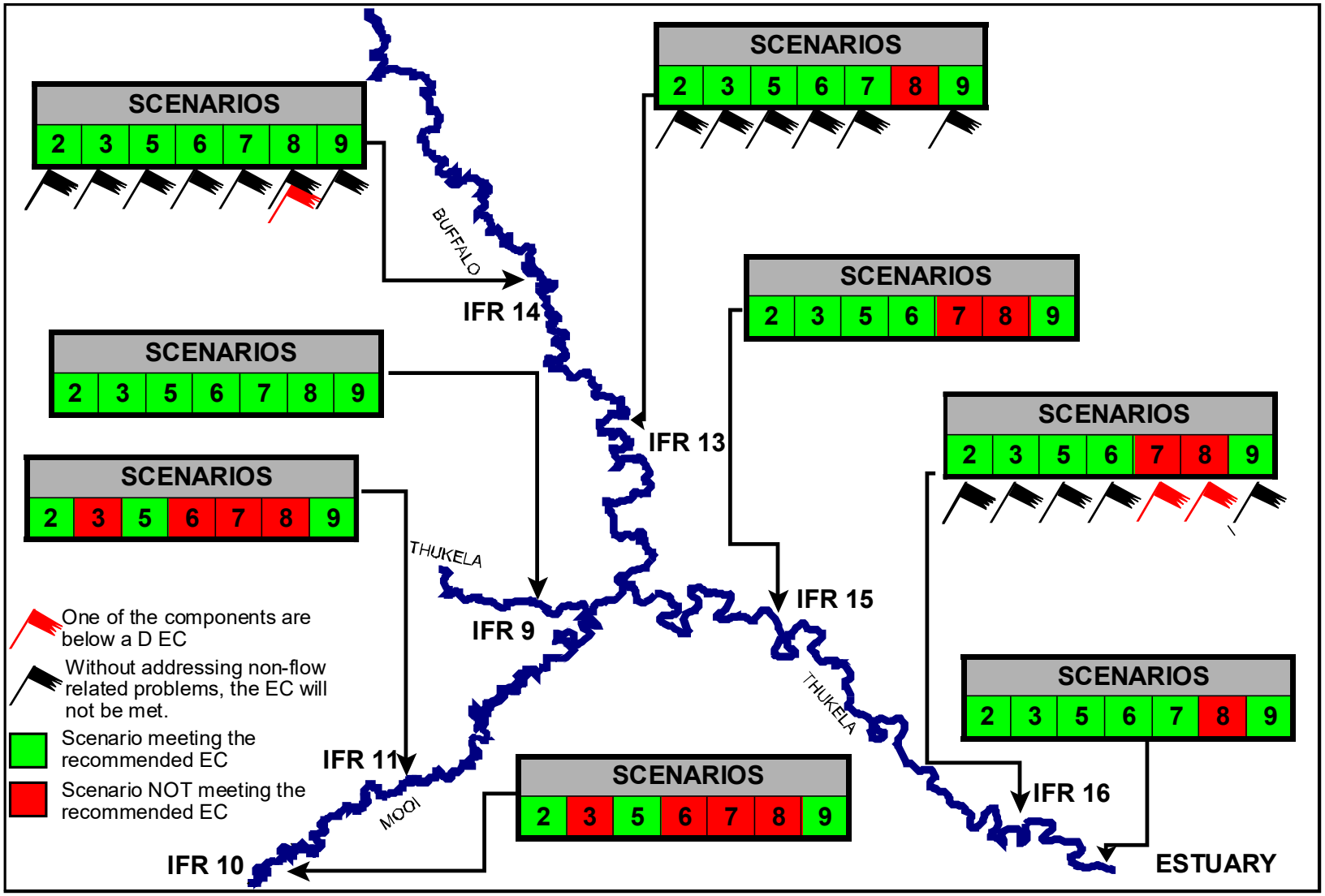


Fig 6.4 **Ecological consequences of operations scenarios at each IFR site: Lower Thukela**



7 IMPACT OF THE DIFFERENT FLOW SCENARIOS ON WATER YIELD

7.1 OVERVIEW AND OBJECTIVES

With regard to the management of the water resources of the Thukela River Catchment, it is imperative that the impact of implementing the Ecological Water Requirements on the yield or water availability within the catchment is understood. This could have an effect on the water available to existing water users (e.g. the Tugela-Vaal Transfer Scheme, irrigators, urban and industrial users).

7.2 METHODOLOGY

- As mentioned in Chapter 5, the Water Resources Yield Model (WRYM) was used to determine the flow regimes linked to the various scenarios.
- The original hydrology of the Thukela Water Project Feasibility Study (DWAF, 2000) was used as the basis for the modelling of the river system.
- The scenario assumptions set out in Figure 5.1 (Chapter 5) were adopted.
- The operating rule used for assessing the Fairbreeze Mine licence application (Mhlathuze Water, 2002) was used for modelling purposes. It should be noted that this operating rule was not developed to optimise the operation of the Thukela River System, but was used merely to illustrate that the available resources could support the system requirements for the licence application. This operating rule assumption together with the fact that IFRs were channelled separately in the WRYM (i.e. no conjunctive river flow or " piggy-backing" of IFRs with water releases in the river for other users) provides slightly more conservative water availability results (i.e. slightly less water in the system than may occur in practice). These operating assumptions are justifiable at this level of investigation. Specific operating rules per river reach can be developed when a Reserve is implemented in the future.
- In-basin water requirement volumes used in the modelling were recently verified and may be considered to be representative.

7.3 RESULTS

The WRYM results indicated that the original IFR scenario (e.g. Scenario 2) had significant impacts on the availability of water in the river system for other users.

7.3.1 Water transfer to the Vaal River

Scenario 2 reduced the volume of water available for transfer through the Tugela-Vaal Scheme by one third (250 million m^3/annum) by the year 2015.

With the various adjustments made to the Ecological Water Requirements, Scenario 9 showed that the volume available was only reduced by 35 million m^3/annum by 2015. Scenario 9 reductions are therefore extremely small in the bigger picture (i.e. transfers to Vaal from the Thukela could be in excess of 600 million m^3/annum, and the water available in the Vaal River System is many more times this volume). With this in view and the fact that the Tugela-Vaal Transfer Scheme is not usually operated on a full-time basis (i.e. during some periods there is enough water in the Vaal River System), it can be deduced that the impact of the current Ecological Water Requirements estimate on the yield available for this strategic transfer is minimal both now and by the year 2015.

7.3.2 Mooi River

Implementation of the Ecological Reserve on the Mooi River system will result in lower levels of assurance of supply to irrigators by the year 2005. The current and future transfers to the

Umgeni River System will not be affected. The construction of the Spring Grove Weir by the year 2015 will alleviate these water yield problems.

7.3.3 Little Thukela River and Sundays River

The catchment area includes a portion of the densely populated Okahlamba Tribal area and the Winterton Irrigation Scheme. Water allocations in this area already exceed the water resources available, since there is no major storage (i.e. major dams) on this section of the river. Implementation of the recommended Ecological Reserve (Scenario 9) will therefore have a serious impact on the availability of water to all users in the Little Thukela River Catchment area. Levels of supply/assurance for irrigation drop by 20 – 30% for scenario 9, and by more than 50% for Scenario 2 by 2005. Compulsory licensing may be required here in order to reduce existing water allocations, and to affect a balance between water use and the protection of the ecological integrity of this system.

The Sundays River is also not regulated by storage, but the impact of implementing the Ecological Reserve on the yield is slightly less than on the Little Thukela River.

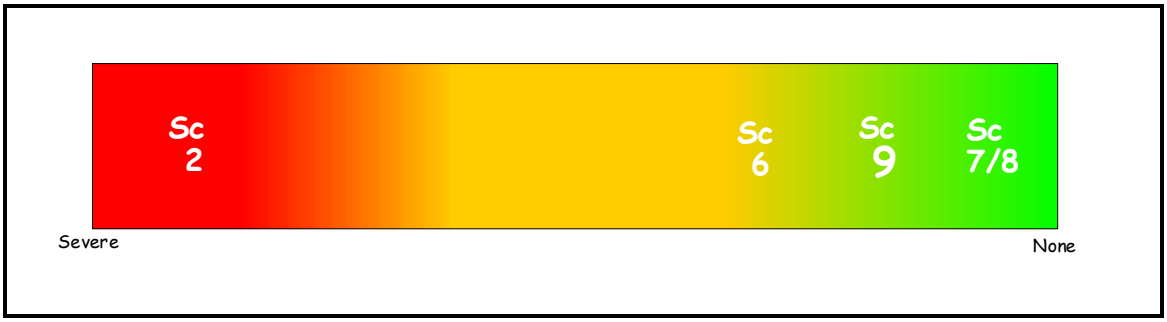
7.3.4 Lower Thukela River

The impact of the Ecological Reserve on the other users in the Thukela River Catchment would be minimal.

7.4 CONCLUSION

Modelling results have indicated that water users in the Bushmans and Buffalo River catchments are the only ones that will not be impacted on under all the Ecological Reserve scenarios from 2 to 9. Under Scenario 2, there will be some level of curtailment (or reduction in the level of supply) in all of the remaining sub-catchments in the Thukela River System. Scenario 6 has a slightly lower impact on the water resource yield availability, and Scenario 9 only has a relatively small impact on the Tugela-Vaal transfer and the Little Thukela and Sundays River systems. This is shown graphically in Figure 7.1.

Fig 7.1 Degree of curtailments on existing users



8 CONSEQUENCES OF THE OPERATIONAL SCENARIOS ON GOODS AND SERVICES

8.1 OVERVIEW AND OBJECTIVES

In addition to the ecological information that was generated during this study, it was considered important to assess the broader consequences of flow scenarios. To this end, potential economic impacts were also considered, in an effort to equip decision makers with the most comprehensive information possible. The first of these studies focussed on the ecological Goods and Services of the river, and is discussed in this section. The ecological Goods and Services of the riverine and estuarine systems provide the basis for subsistence survival for many of the marginal people in the area.

In addition to the Goods and Services assessed (see section 8.2) there are other values that, though important, are difficult to cost or quantify. These are for example the beauty of the river (aesthetic value) and the spiritual and cultural significance of the river. As none of the proposed scenarios were considered to significantly affect these aspects, they were not further considered in the calculations.

While rivers supply benefits with positive values to the Thukela community, they may also represent disservices to the community. Rivers may host water-borne diseases, and changes to these disservices can be measured by assessing the changes to the costs (rather than the benefits) that they generate for communities.

8.2 METHODOLOGY

The critical Goods and Services provided by the river, and the direction of change (positive or negative) in these due to any individual scenario, was examined. The magnitude of the change in benefits and costs provided by the Goods and Services that may be experienced within the Thukela catchment was estimated.

The Goods and Services considered were the following:

- Fish
- Reeds
- Sedges
- Waste assimilation
- Waste dilution
- Cultivated floodplains
- Cynodon lawns
- Rafting
- Canoeing
- Swimming
- Trout fishing
- Estuary fishing

The disservices considered were as follows:

- Bilharzia treatment
- Bilharzia productivity loss
- Cholera treatment
- Cholera productivity loss
- Other pathogen treatment
- Other pathogen productivity loss

The flow scenarios investigated were:

- Scenario 2 and 5 (referred to as 2/5)
- Scenario 8
- Scenario 9

The following process was followed:

- An analysis of potential economic changes per scenario was undertaken, based on a valuation of the status quo, i.e. the value of the Services currently provided by the water that currently remains within the Thukela and its tributaries.
- The biophysical specialists then identified the potential change that each key service may undergo per scenario.
- The current value of Services was then multiplied by the factors of change identified for each tributary in each scenario to provide an indication of the potential future value of the Service, and the change in value was measured.
- The numbers of people or households impacted was also noted to provide an idea of how many people or households may be impacted by the potential changes. For example, in the Upper Thukela some 4 800 households may be impacted by the change in subsistence fishing.

The assessment is illustrated in Table 8.1. Figure 8.1 shows where Goods and Services would change markedly, and under which scenarios.

8.3 RESULTS

Under Scenarios 2, 5 and 9 the main changes were that subsistence fishing (Upper Thukela and Little Thukela) would be negatively affected. Overall, these scenarios had a positive impact on the Goods and Services available. In Scenario 8, with the exception of trout fishing and estuary fishing, all the services would be either seriously impacted or partially negatively impacted.

Under scenario 2/5, all the disservices would be reduced, with a reduction of costs to user communities. In Scenario 9, the impacts would be similar to Scenario 2/5, except that there would be an increase in costs associated with bilharzia in the lower Mooi River. In Scenario 8 all the disservices would be aggravated, with serious increases in costs being borne by Thukela river communities.

Table 8.1 Summary of service benefits and costs

Thukela River: Summary of service benefits and costs								
Services and disservices	Households or individuals impacted	Status quo	Scenario 2/5		Scenario 8		Scenario 9	
		Total value (R millions)	Total value (R millions)	Total change in value (R Millions)	Total value (R millions)	Total change in value (R Millions)	Total value (R millions)	Total change in value (R Millions)
Services as benefits								
Fish*	17,000	9.00	7.60	-1.40	8.10	-0.90	7.60	-1.40
Reeds*	7,000	0.50	0.50	0.00	0.50	0.00	0.50	0.00
Sedges*	16,000	1.00	1.10	0.10	1.00	0.00	1.10	0.10
Waste assimilation*	64,000	4.40	4.50	0.10	3.60	-0.80	4.50	0.10
Waste dilution*	64,000	29.00	29.10	0.10	14.50	-14.50	29.10	0.10
Cultivated floodplains*	16,000	3.00	3.10	0.10	2.60	-0.40	3.10	0.10
Cynodon lawns*	16,000	17.00	17.40	0.40	14.00	-3.00	17.30	0.30
Rafting	3,000	1.30	1.30	0.00	1.00	-0.30	1.30	0.00
Canoeing	2,000	0.90	1.00	0.10	0.90	0.00	1.00	0.10
Trout fishing	300	4.20	4.20	0.00	4.20	0.00	4.20	0.00
Estuary fishing	5,000	1.00	1.10	0.10	1.50	0.50	1.10	0.10
Disservices as costs								
Bilharzia treatment	105,000	15.60	15.00	0.60	33.30	-17.70	15.60	0.00
Bilharzia productivity loss	105,000	12.00	11.60	0.40	25.70	-13.70	12.00	0.00
Pathogens treatments	36,000	0.80	0.70	0.10	1.00	-0.20	0.70	0.10
Pathogens productivity loss	36,000	7.20	6.50	0.70	9.40	-2.20	6.60	0.60
Cholera treatment	5,000	0.30	0.30	0.00	0.40	-0.10	0.30	0.00
Cholera productivity loss	5,000	1.40	1.30	0.10	1.80	-0.40	1.30	0.10

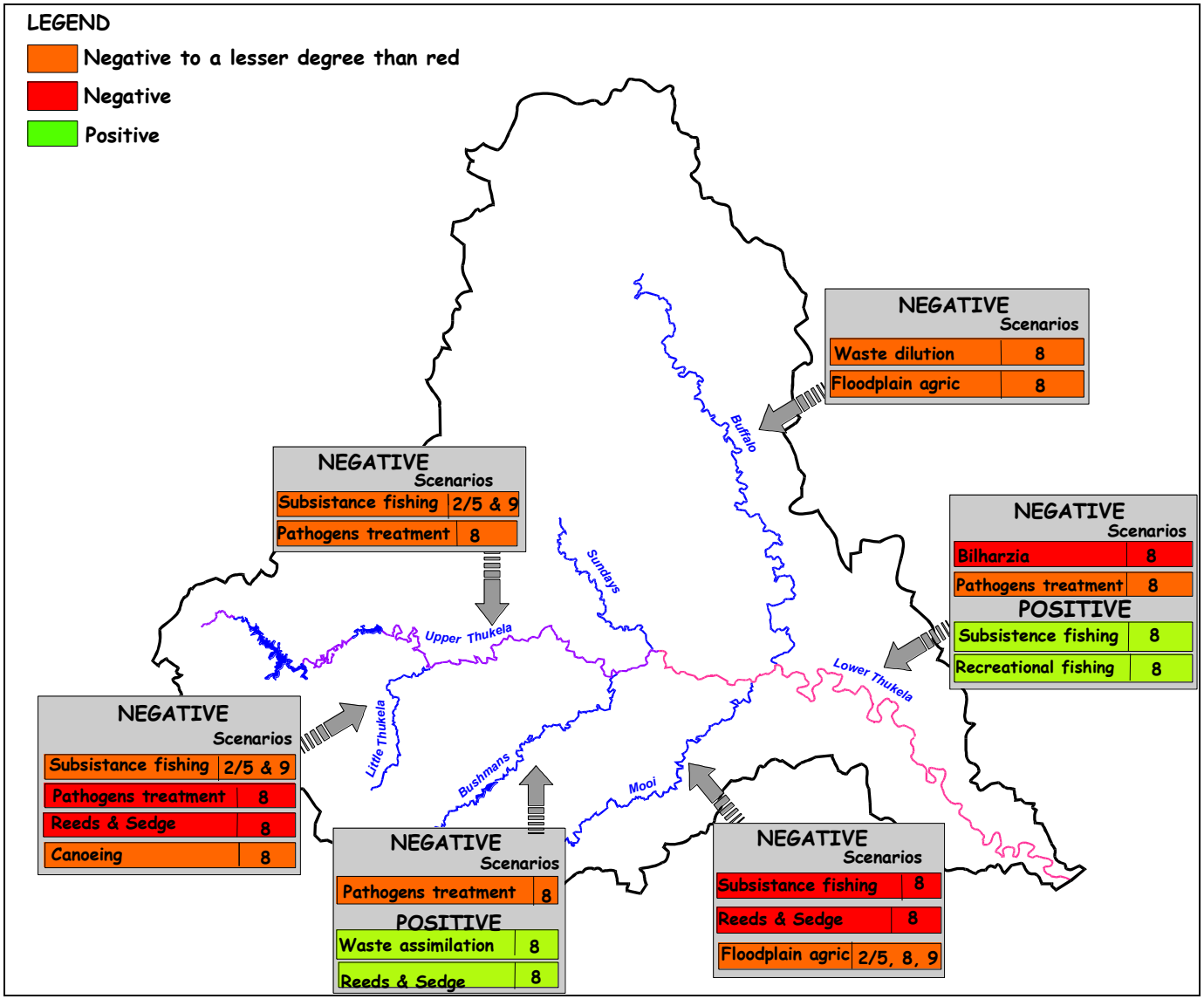
* These services benefit households while the rest (including costs) are for individuals.

Significant negative change.

8.4 CONCLUSIONS

Overall, the change in value between the status quo and Scenario 2/5 is insignificant. There is also an insignificant overall reduction in value of Scenario 9. In summary Scenario 8 has serious negative impacts on the Thukela community, despite there being an improvement in the Bushmans River and Thukela estuary. This scenario has serious implications for community well-being in the Thukela catchment. It should be borne in mind that although the values that are estimated are relatively low, in the greater scheme of things, they represent changes to communities that can least afford it and as such impacts are significant. The Goods and Services that change markedly, and the scenarios that would entail these changes are summarised in Figure 8.1 below. Of note are the changes to the bilharzia and pathogens regimes. These were deemed to have changed significantly as the amount of water under Scenario 8 was greatly reduced at certain points of the river thereby exposing some communities to greater health risks.

Fig 8.1 Goods and Services impact summary map



9 ECONOMIC CONSEQUENCES OF THE OPERATIONAL SCENARIOS

9.1 OVERVIEW AND OBJECTIVES

In addition to the Goods and Services investigations, a formal market economic study was commissioned. The market economy study valued various sectors of the regional economy. These were:

- Irrigated Agriculture
- Livestock
- Forestry
- Sugar Cane
- Mining and Heavy Industries
- Urban Requirements (incl. light industries, commerce and tourism ventures)

The objective of the study was to provide the economic consequences on each of the above sectors of each Operational Scenario.

9.2 METHODOLOGY

For purpose of investigation, the Thukela system was divided into the following sections:

- Upper Thukela (from source to confluence with the Sundays River)
- Lower Thukela (from confluence with the Sundays River to the mouth)
- Little Thukela
- Bushmans
- Sundays
- Mooi
- Buffalo

It should be noted that all minor catchments e.g. the Klip River, fall within one or other of the above sections. After the value of each of the sectors was determined for each of the river sections, the economic impacts of the following scenarios were measured:

- Baseline (Scenario 8) with development projected to the year 2015. Projected economic development was based on historic trends as well as likely growth.
- Scenario 2 with development projected to the year 2015.
- Scenario 6 with development projected to the year 2015.
- Scenario 9 with development projected to the year 2015.

9.3 RESULTS

The results are summarised per sector and per river section in the following sections. The results are also illustrated in Figures 19.1 – 9.2. Where the sector would grow from the present day to 2015, an up-arrow is shown. Where projected growth will be affected, a red down-arrow is shown. A down-arrow means that this sector will not grow at the projected rate but does not necessarily mean that existing development will be negatively affected. It should be noted that for Scenario 6 and 9, no existing development would need to be curtailed.

9.4 IRRIGATION

Scenario	Upper Thukela	Lower Thukela	Little Thukela	Bushmans	Sundays	Mooi	Buffalo
8	↑	↑	↑	↑	↑	↑	↑
2	↓	↓	↓M	↑	↓M	↑*	↑
6	↑	↑	↓M	↑	↓M	↑*	↑
9	↑	↑	↓M	↑	↓M	↑*	↑

M marginal

* If Spring Grove Dam is not built, the arrows would be pointing down and red.

Scenario 6 and 9 both have negative economic impacts on projected irrigation growth in the Little Thukela and Sundays Rivers. The potential for the irrigation sector to expand particularly in the Little Thukela and Sundays River is very limited. Although projected growth is shown to be restricted under Scenarios 2, 6 and 9, the actual value of this growth is very small (marginal).

9.5 AFFORESTATION

Scenario	Upper Thukela	Lower Thukela	Little Thukela	Bushmans	Sundays	Mooi	Buffalo
8	↑	↑	NA	↑	NA	↑	↑
2	↓	↓	NA	↑	NA	↑*	↑
6	↑	↑	NA	↑	NA	↑*	↑
9	↑	↑	NA	↑	NA	↑*	↑

* If Spring Grove Dam is not built, the arrows would be pointing down and red.

Only Scenario 2 has a negative impact on projected (marginal) afforestation growth in the main Thukela River.

9.6 MINING AND HEAVY INDUSTRY

Scenario	Upper Thukela	Lower Thukela	Little Thukela	Bushmans	Sundays	Mooi	Buffalo
8	↑	↑	NA	NA	↑	NA	↑
2	↓	↓	NA	NA	↓	NA	↑
6	↑	↑	NA	NA	↓	NA	↑
9	↑	↑	NA	NA	↓	NA	↑

* If Spring Grove Dam is not built, the arrows would be pointing down and red.

Scenarios 6 and 9 both have negative economic impacts on the projected growth in the Sundays River.

9.7 URBAN, COMMERCIAL AND LIGHT INDUSTRY

Scenario	Upper Thukela	Lower Thukela	Little Thukela	Bushmans	Sundays	Mooi	Buffalo
8	↑	↑	↑	↑	↑	↑	↑
2	↓	↓	↑	↑	↓	↑*	↑
6	↑	↑	↑	↑	↓	↑*	↑
9	↑	↑	↑	↑	↓	↑*	↑

* If Spring Grove Dam is not built, the arrows would be pointing down and red.

Scenarios 6 and 9 both have negative economic impacts on projected growth in the Sundays River only.

In terms of the livestock and sugar cane sectors, the scenarios have negligible impact on projected growth.

From an economic perspective, Scenario 2 would have the greatest negative impact and is not considered further. The negative impacts of Scenario 6 and 9 are only relevant for the Little Thukela and Sundays River (irrigation) and only on the Sundays River for the other sectors. A comparison is provided in Table 9.1. It should, however, be noted that without Spring Grove Dam in place, there is a potential negative impact on projected growth in the Mooi River under all the scenarios.

Table 9.1 Summary of negative impacts of Scenario 6 and 9 on projected economic growth

Scenario	Little Thukela	Sundays
IRRIGATION		
6	↓M	↓M
9	↓M	↓M
MINING AND HEAVY INDUSTRY; URBAN, COMMERCIAL AND LIGHT INDUSTRIAL		
6		↓
9		↓

9.8 IMPACT ON THE FISH AND PRAWN CATCH ON THE THUKELA BANK

The commercial crustacean (mostly prawn) fishery is estimated to have a total value of about R37 million per year (2003 Rands), which could range between R21 and R43 million due to the variability in catches. The impact of some of the scenarios was estimated.

Estimates indicated that there would be a R260 000 decrease per year in an unlikely, worst-case scenario[3]. These values are small and only amount to a minor change in the value of the prawn fishery. The reported changes are unlikely to affect viability of the fishery for the companies involved. It would be expected that even much larger changes could be weathered without much economic impact.

The commercial boat-based line fishery on the Thukela Banks has an estimated yearly income of R3 million (1997 Rands). It must be noted that these data are low confidence. However, it would seem that all the scenarios apart from the worst-case scenario would have a negligible impact on catch.

[3] This scenario was included to provide a lower boundary for the results. This is a possible future scenario with development at 2025 level and with the TWP dams in place. The full transfer capacity to the Vaal of about 35m^3/s was utilised and no releases (an unlikely situation) were made for the Reserve.

Fig 9.1 Impact on economic growth to 2015 – Upper Thukela

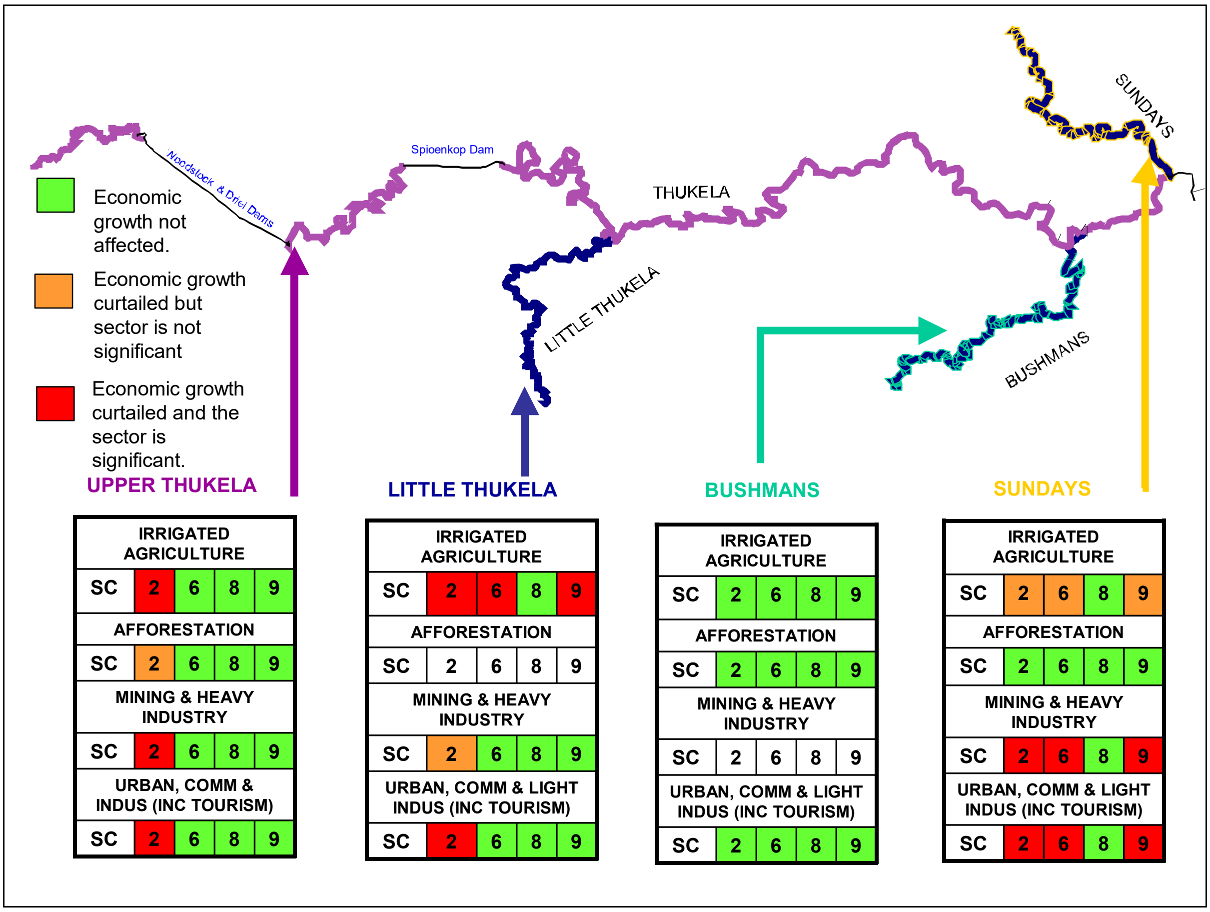
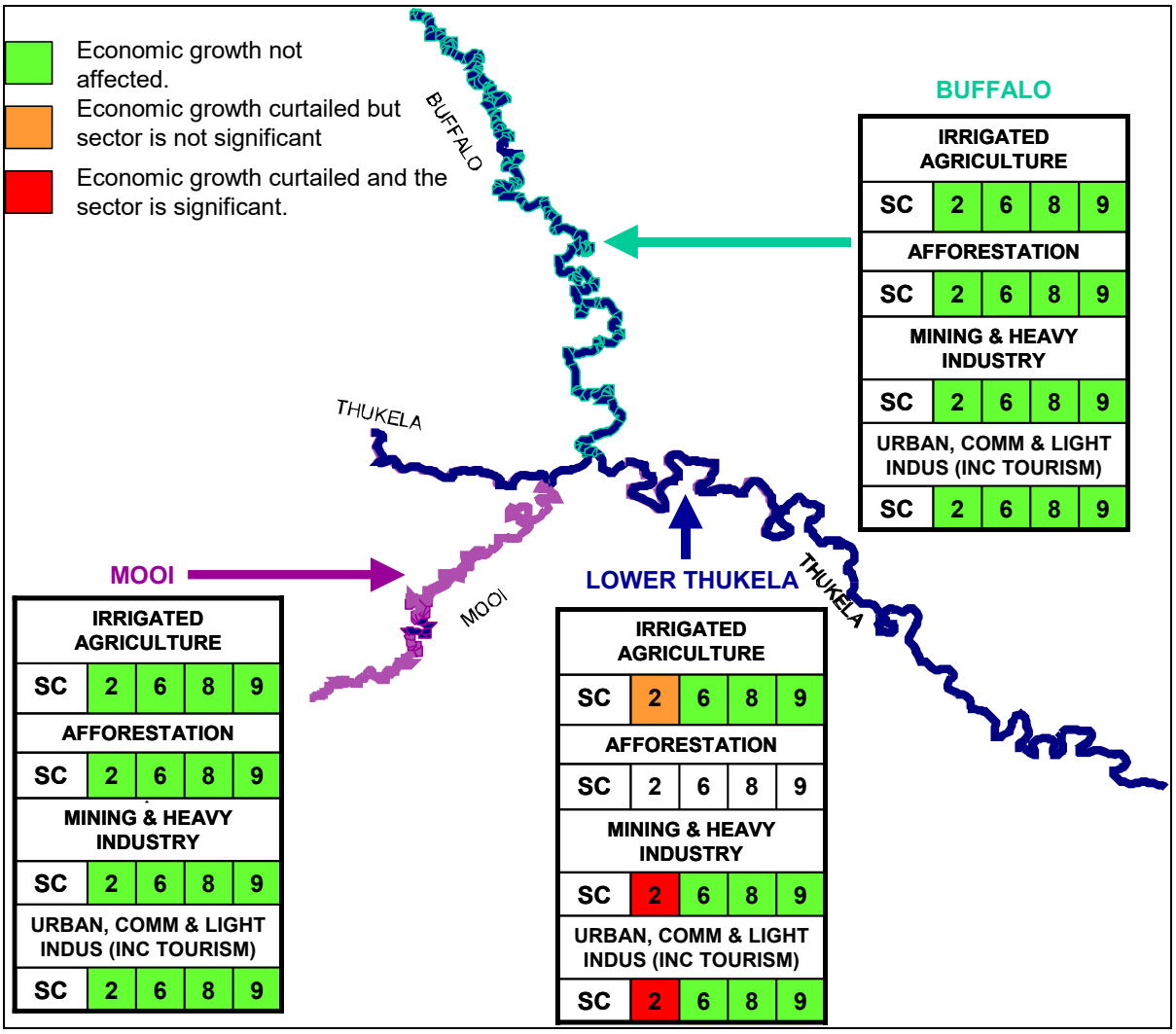


Fig 9.2 Impact on economic growth to 2015 – Lower Thukela



10 STAKEHOLDER PROCESS

10.1 OVERVIEW AND OBJECTIVES

Although not strictly part of the Reserve Determination process, it was decided that a robust Public Involvement Programme should accompany the Thukela Reserve Study. A team of consultants, under the auspices of ACER (Africa), was appointed to manage this programme. The process was built around ensuring that representatives of relevant stakeholders were informed of the process throughout the study, and given the opportunity to participate in recommending a scenario for the future management of the Thukela system. Stakeholders have also been involved so that they might act as a "reality check" for the specialists, and to supply the local knowledge that assisted the Reserve Determination team in ensuring that the way in which they have represented the Thukela system resonates with the requirements of those living in the area.

The objective of this task was to provide as comprehensive as possible information to the decision-maker which therefore included the opinions of stakeholders.

10.2 METHODOLOGY

The process followed is illustrated in Figure 10.1.

Stakeholders were requested to indicate whether they were interested in participating in the Reserve Determination study, and these stakeholders were divided into River Reach Forums. Approximately 450 stakeholders expressed an interest in the study.

In order to meet these objectives there have been a series of structured interactions with the stakeholders, including:

- A first and second round of River Reach Forum meetings.
- A first, second and third Stakeholder Reference Group Meeting.
- A series of newsletters sent out at appropriate intervals during the study to the $\pm$ 1000 people on the database (managed by ACER (Africa)).

The first round of River Reach Forum meetings were held during January 2002. The purpose of these meetings was to build the capacity of stakeholders as to what the Reserve process entailed, and to equip them with the basic concepts that they would require in order to understand the way in which the study would be undertaken. The meetings were advertised in the press and all stakeholders on the database were sent invitations. The following venues were visited during this round of River Reach Forum meetings, and attended by the indicated number of people:

Table 10.1 Venues and number of Stakeholders attending

Location	No of stakeholders attending
Mandeni	13
Thukela Ferry	12
Thukela Estates	38
Ladysmith & Loskop	59
Estcourt	27
Mooi River	15
Dundee	9
Newcastle	12
Ekuveni	16

These forum meetings were accompanied by visits to the Thukela River and tributaries. Here, the basic ecology of the river was explained and some of the techniques used by the specialists to gather data were demonstrated. Those who attended the forum meetings were provided with a workbook that explained and re-iterated much of what had been explained during the course of the meetings. Workbooks were provided in English and Zulu.

The second round of River Reach Forum meetings were held during July 2002. These meetings took up from where the first round had left off. The second round of meetings also presented the Present Ecological State (PES) descriptions for each of the Resource Units. These had been generated by the specialists but were available for stakeholder scrutiny. The recommended Ecological Category (EC) was outlined. A second set of workbooks was provided and these detailed the PES for the sections of the system proximate to the meeting locations. As such, the meetings and the workbooks focused on the localities relevant to the particular River Reach Forum. Again the workbooks were in Zulu and English. The following venues were visited during this second round of River Reach Forum meetings, and attended by the number of people indicated in the right hand column:

Table 10.2 Venues and number of Stakeholders attending

Location	No of stakeholders attending
Mandeni	7
Thukela Ferry	4
Thukela Estates	23
Ladysmith	11
Bergville	14
Estcourt	16
Loskop/Emangeni	10
Mooi River	9
Dundee	8
Newcastle	9
Ekuveni	13

At the second round of meetings, participants were asked to nominate representatives to go forward to the Stakeholder Reference Group (SRG). It was decided to establish an SRG so that information could be presented to a single body seen to be representative of the diverse interest groups in the catchment. A group of 65 stakeholders was nominated to form the SRG.

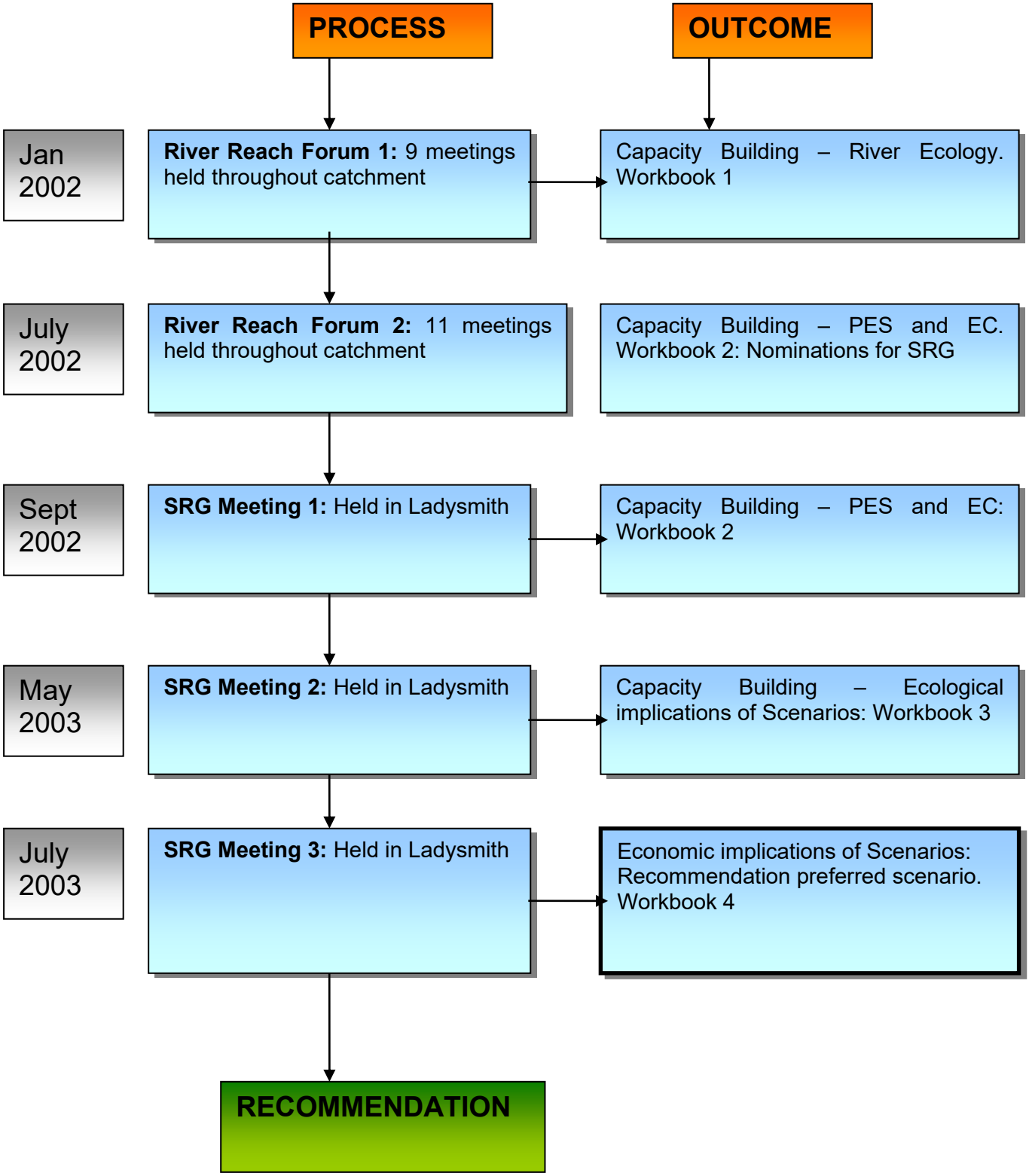
The first SRG meeting was held in September 2002 in Ladysmith. Forty-two stakeholders attended. This meeting built on what had been discussed during the second round of River

Reach Forums, but concentrated on the whole catchment. Those who attended were given an overview of the current and recommended ecological status of the system (PES and EC), and the economic conditions in the catchment. The SRG members were also made aware of the role that the SRG would play in making a recommendation (or recommendations) regarding their preferred method of river management. Updated versions of the second stakeholder workbook were presented to those who attended.

The second SRG meeting was held in May 2003 in Ladysmith. Fifty-five stakeholders attended. This meeting focused on the flow scenarios that had been generated and the ecological implications of these scenarios. A third stakeholder workbook was compiled for the purpose of this meeting.

The third SRG meeting was held in July 2003 in Ladysmith. This focused on the economic and ecological implications of the scenarios. Specialists presented an integrated picture of the scenario results and recommendations, and asked the stakeholders to make comments based on what had been presented to them. A fourth stakeholder workbook was compiled for this meeting. There was support from the stakeholders for the scenario recommendation made by the TWP team. This recommendation is set out in more detail in Chapter 12.

Fig 10.1 Stakeholder Process



11 CAPACITY BUILDING

11.1 OVERVIEW AND OBJECTIVES

A capacity building programme formed part of this study and forms a component with a dedicated budget. The objective of the capacity building was to increase the technical expertise available for Reserve related studies in the country.

11.2 METHODOLOGY

To initiate the training, a number of trainees were identified and mentors appointed. Trainees were selected largely from HDIs as persons who had relevant skills and who were interested in the Reserve Determination process. The following trainees and mentors were selected:

- **Hydrology Specialist:** Trainee Ms S Shange - Mentor Prof D Hughes.
- **Water Quality:** Trainee Ms N Valisa - Mentor Dr P Scherman.
- **Geomorphology:** Trainee Mr M Soviti - Mentor Dr R Wadeson.
- **Invertebrates:** Trainee Mr T Bokwe - Mentor Dr C Dickens.
- **Estuaries:** Trainees Mr P Gama, Mr T Buthelezi, Mr M Mzimela - Mentors Dr A Paterson, Dr J Adams.
- **IFR Process and Reserve administration:** Trainee Ms S Koekemoer – Mentors Ms D Louw, Mr G Huggins.

Trainees were exposed to skills development through a number of avenues. In the first place they attended all relevant site visits with their mentors. Secondly, they helped to prepare the specialist reports that formed part of key workshop documentation. Thirdly, they participated in the specialist workshops and gave input. Ms Shange took charge in running the hydrological component of the second specialist workshop under the mentorship of Prof. Hughes.

In addition the estuarine trainees benefited from a dedicated course that was run by mentors as preparation for the initial estuarine specialist workshop. It is anticipated that the training will be rounded off in a completion workshop that will involve a comprehensive review of the Thukela Reserve process and the way forward. All trainees as well as the project management and the relevant mentors will attend this workshop.

One of the outputs of the Thukela Reserve will be a capacity building report. This report will give an overview of the training programme and will include evaluations by the mentors of their trainees as well as an evaluation by the trainees of the mentoring programme.

12 RECOMMENDATION

After consideration of the original scenarios it became apparent that it was possible to develop a scenario that optimised flow requirements and had the least potential impact on all sectors. As such, Scenario 9 was developed. The specific impacts of scenario 9, as compared to the other relevant scenarios, are specified in Chapters 5, 6, 7 and 8.

Figure 12.1 below indicates the degree to which Scenario 9 achieves a compromise in satisfying the range of all user components.

- Yield analysis: Results indicate that water users in the Bushmans and Buffalo River catchments are the only ones that will not be impacted upon under all the Ecological Reserve scenarios from 2 to 9. Under Scenario 2 there will be some level of curtailment (or reduction in the level of supply) in all of the remaining sub-catchments in the Thukela River System. Scenario 6 has a slightly diminished impact on the water resource yield availability, with Scenario 9 having only a relatively small impact on the Tugela-Vaal transfer as well as on the Little Thukela and Sundays River systems.
- Ecology: Scenario 9 (as well as 2 and 5) meets the ecological objectives at all the IFR sites (apart from IFR 4) and the estuary. The ecological objectives at IFR 4 represent an improvement and even though these objectives are not met, the Present Ecological State will be maintained. It must be noted that in order to achieve the ecological objectives under Scenario 9, Source Control Measures will have to be implemented in the Sundays, Buffalo and Bushmans Rivers. Some catchment management activities will also be required in the Buffalo River and the Lower Thukela at IFR 16.
- Goods and Services: Overall, There is an insignificant reduction in value of scenario 9. The change in value between the status quo and scenario 2/5 is also insignificant. Scenario 8 has serious negative impacts on the Thukela community and has serious implications for well being in the Thukela catchment.
- Market Economics: Scenario 2 would, from an economic perspective, have the greatest negative impact and is not further considered. The negative impacts of Scenario 6 and 9 are only relevant for the Little Thukela and Sundays River (irrigation) and only on the Sundays River for the other sectors.

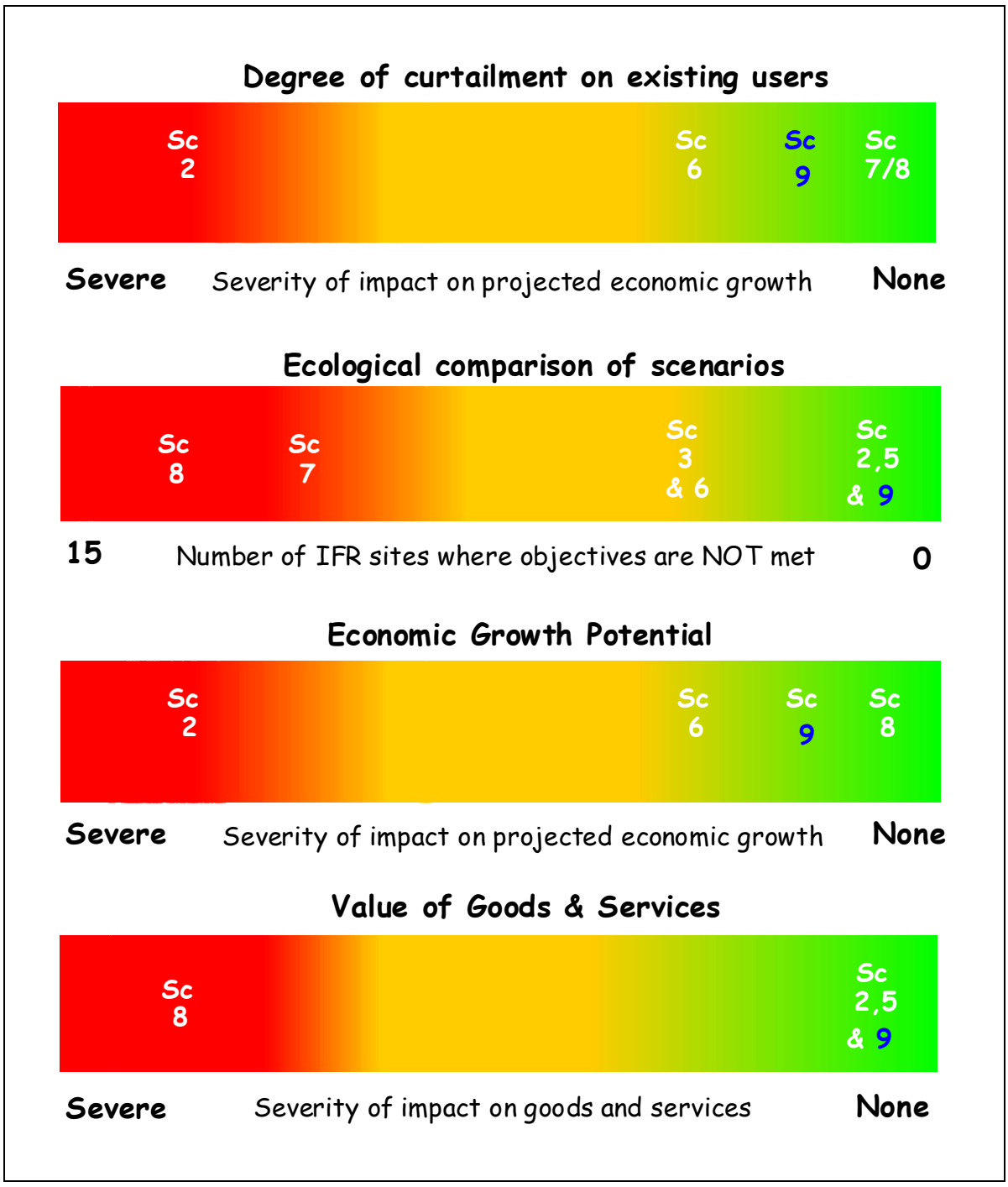
As such, Scenario 9 meets most ecological objectives and has among the least negative impact on the economy of the area and on the delivery of riverine Goods and Services.

During the last stakeholder meeting the overall results of the Thukela Reserve Determination study as well as the implications of the scenarios were presented. The general feeling form the stakeholder grouping was that there was no reason why Scenario 9 should not be favoured.

The recommendation is that Scenario 9 and the resulting Ecological Categories at each IFR site and the estuary be accepted as a Preliminary Reserve and for future planning purposes. Water quality objectives that cannot be met due to Source Directed Problems, have been identified

If this recommendation is accepted by DWAF, then the Reserve Determination study will be completed. The final task, i.e. the determination of Ecospecs and a Monitoring programme will then be completed within the context of Scenario 9.

Fig 12.1 Comparison of scenario impacts across major study components



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