DEVELOPMENT OF THE WATER RESOURCE CLASSIFICATION SYSTEM (WRCS)

Overview and 7-step classification procedure - February 2007







1st Edition

Chief Directorate
Resource Directed Measures

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THE DEVELOPMENT OF THE WATER RESOURCE CLASSIFICATION SYSTEM (WRCS)

First Edition: February 2007
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Overview and 7 – Step Classification Procedure

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Technical Guidelines for
DEVELOPMENT OF THE WATER RESOURCE CLASSIFICATION SYSTEM (WRCS)

First Edition

Department: Water Affairs and Forestry

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Preface

The Water Resource Classification System (WRCS) was established in response to the South African National Water Act of 1998. The WRCS is a set of guidelines and procedures that, when applied to a specific catchment, will ultimately assist in the process of maintaining a balance between protecting our national water resources and using them to meet economic and social goals. The procedures are to be applied as part of a consultative 'Classification Process', the final outcome of which is a decision about the set of desired characteristics for each of the water resources in a given catchment.

The Classification Process sets a 'Class', which defines objectives for every significant water resource—watercourse, surface water, estuary, or aquifer. There are three classes, ranging from the minimally used to the heavily used. These objectives describe the desired condition of these resources and the extent to which they can be utilised.

The Classification Process is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use. A key component of classification is therefore the ongoing process of evaluating options with stakeholders in which the economic, social and ecological trade-offs will be clarified and decided upon.

Volumes 1 to 5 of these reports build on an earlier version of the classification system and meet the terms of reference as set out in the inception report (DWAF, 2005). The development of the new system was completed in twelve months using the Olifants/Doring catchment as a 'proof of concept' catchment. The Olifants/Doring system was chosen for two reasons: 1) a recent Reserve determination study had provided much of the required information. 2) Most of the WRCS project team had been involved in the determination study.

It was initially planned that once the draft WRCS had been developed, it would be tested, refined and possibly streamlined using two other, more complex catchments (such as Thukela and Incomati). This turned out not to be possible. The description of the classification procedure has therefore been left as generic as possible so that future applications of the WRCS can build on and improve the procedures and guidelines presented in these volumes.

The classification system regulations will be developed from these volumes.

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ACRONYMS

ASGISA	Accelerated and Shared Growth-South Africa
BHN	Basic Human Needs
CBA	Cost-Benefit Analysis
CD: IWRP	Chief Directorate: Integrated Water Resource Planning
CD: RDM	Chief Directorate: Resource Directed Measures
CMA	Catchment Management Agency
CMP	Catchment Management Plan
CMS	Catchment Management Strategy
CSIR	Council for Scientific and Industrial Research
DG	Director-General
DRIFT	Downstream Response to Imposed Flow Transformations
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EGSAs	Ecosystem Goods, Services and Attributes
EISC	Ecological Importance and Sensitivity Category
ELU	Existing Lawful Use
EMC	Ecological Management Class
ESBC	Ecologically Sustainable Base Configuration (scenario)
EWRs	Ecological Water Requirements
FHSR	Flow Habitat Stressor Response
GDP	Gross Domestic Product
GGP	Gross Geographic Product
GW	Groundwater
HI	Habitat Integrity
I&AP	Interested and Affected Parties
IMS	Information Management System
IUAs	Integrated Units of Analysis
IWA	International Water Agreement
IWRM	Integrated Water Resources Management
MC	Management Class
MCDA	Multi-Criteria Decision-Analysis
NDSD	National Department of Social Development
NEMA	National Environmental Management Act
nMAR	Naturalised Mean Annual Runoff
NRE	Natural Resource and Environment
NWA	National Water Act
NWRS	National Water Resource Strategy
PES	Present Ecological Status
PSP	Professional Service Provider
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RWQO	Resource Water Quality Objective
SAM	Social Accounting Matrix
SAWQG	South African Water Quality Guidelines
SDC	Source Directed Controls
SW	Surface Water
TDS	Total Dissolved Salts
TEV	Total Economic Value
WMA	Water Management Area
WR90	Water Resource 1990

WRCS	Water Resource Classification System

1 INTRODUCTION

1.1 The Water Resource Classification System (WRCS)[1]

The WRCS is required by the National Water Act (NWA) (No. 36 of 1998), and consists of a set of guidelines and procedures for determining the different classes of water resources (Chapter 3, Part 1, Section 12). Desired characteristics of the resource are represented by a Management Class (MC) which outlines the attributes required of different water resources by the resource custodian (Department: Water Affairs and Forestry (DWAF)) and by society.

The WRCS will be used in a consultative process (i.e. the Classification Process) to classify the water resources within a geographic region in order to facilitate finding a balance between protection and use of the water resources. The actual process of *applying* the WRCS procedures described in this volume to a catchment is called the Classification Process i.e. establishing the MC. The economic, social and ecological implications of choosing a MC need to be established and communicated to all Interested and Affected Parties (I&AP) during the Classification Process.

The outcome of the Classification Process will be the setting of the MC, Reserve and Resource Quality Objectives (RQOs) by the Minister or delegated authority for every significant water resource (watercourse, surface water, estuary, or aquifer) under consideration. This will be binding on all authorities or institutions when exercising any power, or performing any duty under the NWA. This MC, which will range from Minimally to Heavily used (Table 1.1), essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised. In other words, the MC of a resource sets the boundaries for the volume, distribution and quality of the Reserve and RQOs, and therefore informs the determination of the allocatable portion of a water resource for use. This has considerable economic, social and ecological implications.

Table 1.1 Proposed water resource classes

Class I: Minimally used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
Class II: Moderately used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
Class III: Heavily used
The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

1.2 Prescribing the WRCS

Section 12 of the NWA provides that the Minister of Water Affairs must prescribe a system for classifying water resources. This requires gazetting the WRCS. The gazetted WRCS will provide a definition of the classes that are to be used (Table 1.1), and the procedures to be followed to recommend a class (see Figure 5-2). In addition to the gazetted WRCS, supporting documentation will be developed to be followed to recommend a class (Figure 1-1). This documentation will be sanctioned by DWAF, but will not be gazetted. This report forms part of the supporting documentation.

As soon as reasonably practicable after the Minister has prescribed a system for classifying water resources the Minister must, subject to Section 13(4), by notice in the (Government) *Gazette*, determine for all or part of every significant water resource –

[1] This section has been adapted from DWAF (2006a).

(a) a class in accordance with the prescribed classification system; and
(b) resource quality objectives based on the class determined in terms of paragraph (*a*)

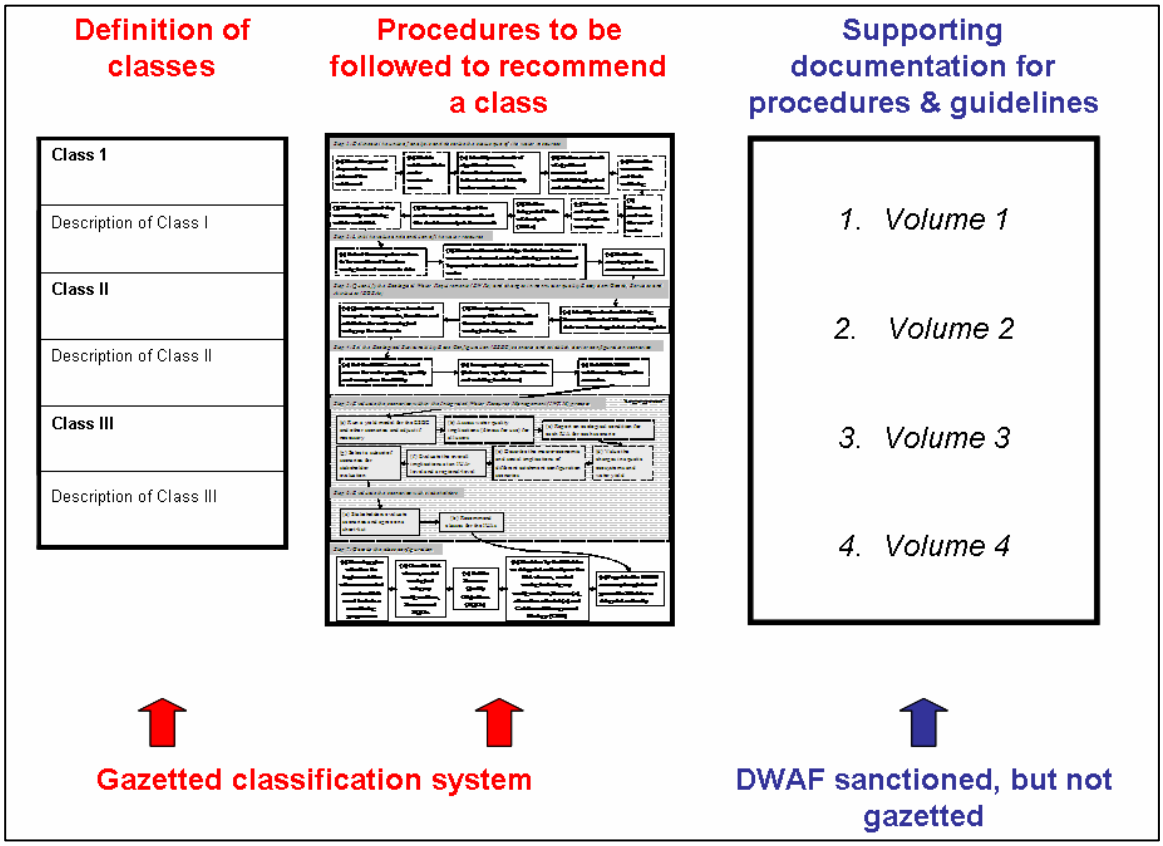

Figure 1-1 Information provided for the gazetted WRCS and the 'supporting documentation'

1.3 The WRCS within the broader DWAF Integrated Water Resource Management (IWRM) environment[2]

As mentioned previously, the purpose of the WRCS is to facilitate finding a balance between resource protection and resource development and utilisation. A complex institutional environment surrounds this process, both in terms of the systems and procedures of Integrated Water Resource Management (IWRM), and the division of roles and responsibilities between DWAF and the Catchment Management Agencies (CMAs).

The WRCS is therefore, necessarily, an integral component of the IWRM environment. Accordingly, the Classification Process does not occur in isolation, but is fundamentally linked to other processes in the integrated planning of water resource protection, development and utilisation, and in the management and control of water use (Figure 1-2). In particular, the Classification Process and the Catchment Management Strategy (CMS) are iterative, and the proposed MC has significant implications for the allocation schedule (Figure 1-2). A key component of IWRM is therefore an iterative process of evaluating scenarios with stakeholders where the economic, social and ecological trade-offs will be made, and out of which will emerge

[2] Adapted from DWAF (2006b)

the allocation schedule, installed modelling system, MC, Reserve, RQOs and the CMS (Figure 1-2). This process is referred to as the 'Larger Process', or the Compulsory Licensing Process.

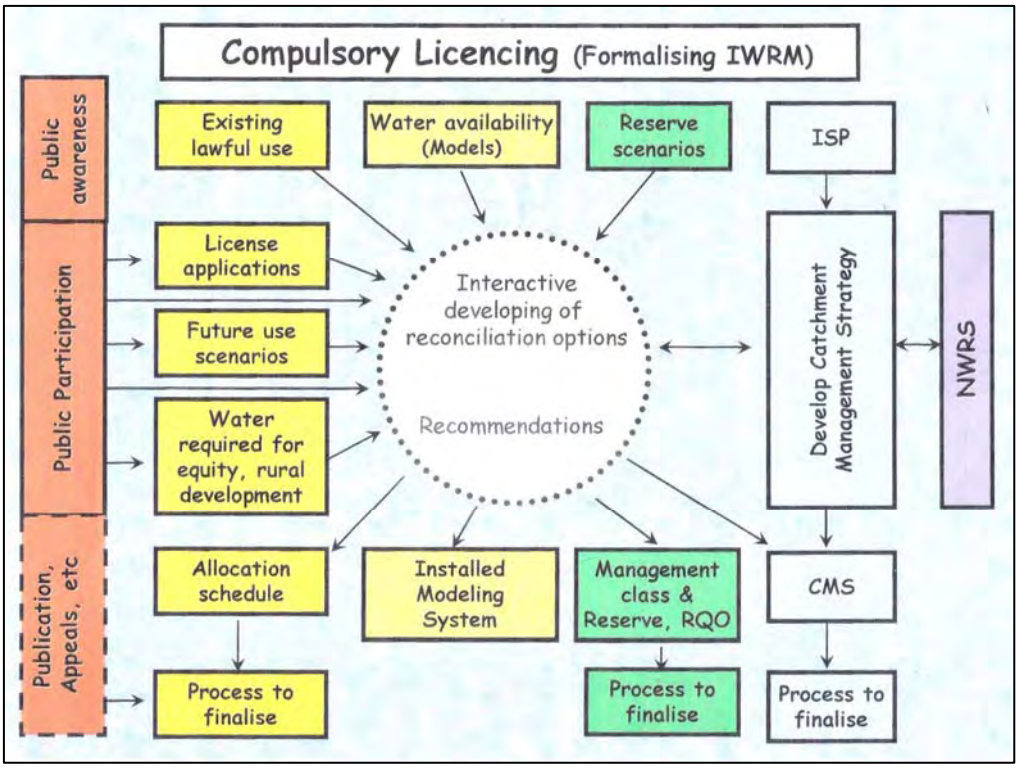

Figure 1-2 The determination of the MC, Reserve and RQOs forms part of the overall compulsory licensing process within DWAF

Given the complex and interrelated nature of the IWRM process, careful consideration of the linkages between the WRCS and the 'Larger Process' is required. As a result, the institutional arrangements to support such linkages are an important element of the WRCS described in this volume.

Institutionally, the IWRM environment is complicated by the institutional change process within DWAF involving the decentralisation of roles and responsibilities and the establishment of CMAs. Once decentralisation is complete, the institutional and management arrangements to support the WRCS and the Classification Process will follow the division of roles and responsibilities between DWAF and the CMAs. DWAF retains custodianship of the resource and of the broad strategic objectives of IWRM (including the WRCS and Classification Process) through oversight and regulation of the resource and its management, and through support to the CMAs. The CMAs are fundamentally responsible for management of the resource. Accordingly, the CMAs develop recommendations on the class, which are assessed and reviewed by DWAF for ultimate consideration and gazetting by the Minister. Before decentralisation is complete, DWAF both acts as custodian of the resource and as manager of the resource, and this includes developing recommendations on the class.

Beyond the IWRM environment, the WRCS has bearing on a range of broader processes, given the wider socio-economic, political and ecological implications of the class. Accordingly, cooperation with all three spheres of Government, participation of stakeholders and engagement with civil society is required to ensure appropriateness and acceptability of the WRCS and, ultimately, of the proposed class. This implies that the WRCS process is founded on consensus-seeking, participation and cooperative governance to ensure socio-economic balance and sustainability in addition to the technical elements of ecological sustainability. The institutional

arrangements and, importantly, the capacity for implementation of the WRCS must take cognisance of this socio-economic imperative.

Accordingly, the key institutional issues in terms of the evolving WRCS should focus on:

- creating an enabling environment, both in terms of the enabling legislation and the institutional environment, to ensure integration with associated systems and processes in IWRM;
- clarifying the roles and responsibilities of different groups and institutions in the Classification Process, considering the process of institutional change; and
- developing appropriate institutional arrangements and the requisite capacity for implementation, particularly in the CMAs, to enable cooperative governance, participation and stakeholder consultation, and to support the technical processes of the WRCS.

Further discussion on the institutional arrangements for the WRCS can be found in DWAF (2006b).

1.4 The legal basis for the WRCS

The principle of *sustainable development* is made explicit in the South African Constitution.[3] The Bill of Rights enshrines each citizen's right to an environment that is not harmful to human health, as well as the right to reasonable legislative and other means to protect the environment. The protection of water resources was initially effected through the Water Law Principles (DWAF, 1996a)[4] and later the DWAF (1997) National Water Policy.[5] The NWA gave effect to these principles and policies. An important feature of the NWA is that the twin themes of sustainability and equity[6] are echoed throughout the Act, thereby representing one of the first attempts in the world to 'legislate for sustainability' at a national-level.[7] In addition to the NWA, the sustainable management of water resources must be carried out in a manner consistent with national environmental policy and within the framework of the National Environmental Management Act (No. 107 of 1998) (NEMA).

The context of the WRCS relates to the fundamental purpose of the NWA (as outlined in Chapter 1), which *inter alia*, indicates that water resources management must:

- meet the water needs for current and future generations;
- promote the efficient, sustainable and beneficial use of water in the public interest; and
- protect aquatic and associated ecosystems and their biological integrity.

The protection of water resources is fundamentally related to their use, development, conservation, management and control. Chapter 3 of the NWA lays down the measures that together are intended to ensure the 'comprehensive protection of all water resources.' These measures will be developed progressively within the contexts of the National Water Resource Strategy (NWRS; DWAF, 2004) and CMS (provided for in Chapter 2 of the NWA).

[3] www.policy.org.za/govdocs/constitution/saconst.html

[4] Principle 13 makes provision for '… the apportionment, management and use of those (water) resources (to be) carried out using the criteria of public interest, sustainability, equity and efficiency of use.'

[5] This policy interprets the Water Law Principles and establishes the notion of a Reserve. The purpose of the Reservc is to identify the degree of change or impact that is considered acceptable, and is unlikely to damage a water resource beyond repair. Water resources are to be grouped into classes representing different levels of protection. The Water Law Principles also enshrine the notion that resources should not become irreversibly degraded.

[6] Equity refers to equity of access to the water resources, and equity of access to the benefits from the use of water resources.

[7] This means that experience gleaned from elsewhere cannot be applied directly to South Africa because, in effect, South African is at the forefront of these types of legal and policy developments.

Part 1 of Chapter 3 of the NWA provides the initial basis for the protection process: the development of a system to classify the Nation's water resources. The purpose of the WRCS is therefore to help facilitate consistent, transparent and stream-lined decision-making. The key Sections pertaining to the WRCS system are 12 to 18. These deal with:

12 Prescription of (the) classification system.
13 Determination of (the) class of water resources and (the) RQOs.
14 Preliminary determination of (the) class or (the) RQOs.
15 Giving effect to (the) determination of (the) class of water resource and RQOs.
16 Determination of (the) Reserve.
17 Preliminary determinations of (the) Reserve.
18 Giving effect to (the) Reserve.

The system provides guidelines and procedures for determining different classes of resources. The Minister must prescribe, as soon as is reasonably practicable a system for classifying water resources that may (2)

(a) establish guidelines and procedures for determining different classes of water resources;
(b) in respect of each class of water resource –
    (i) establish procedures for determining the Reserve;
    (ii) establish procedures which are designed to satisfy the water quality requirements of water users as far as is reasonably possible, without significantly altering the natural water quality characteristics of the resource;
    (iii) set out water uses for instream or land-based activities that must be regulated or prohibited in order to protect the water resources; and
(c) provide for such other matters relating to the protection, use, development, conservation, management and control of water resources, as the Minister considers necessary.

Part 2 of Chapter 3 requires utilising the WRCS established in Part 1 to determine the class and RQOs for all or part of water resources considered significant. The purpose of RQOs is to establish clear goals relating to the quality of the relevant water resources. In determining RQOs, a balance must be sought between the need to protect and sustain water resources on the one hand and the need to develop and use them on the other. Importantly, provision is made for preliminary determinations of the class and of water resources before the formal classification system is established. Once the class of a water resource and the RQOs have been determined, they are binding on all authorities and institutions when performing any duty or exercising power under the NWA.

Section 13 deals with determining the class of the water resources and RQOs.

(1) The Minister having prescribed a system for classifying water resources, must as soon after as is reasonably practicable, subject to subsection (4), by notice in the *Gazette,* determine for all or part of every significant resource -
    (a) a class in accordance with the prescribed classification system; and
    (b) RQOs based on the class determined in terms of paragraph (a).
(2) A notice in terms of subsection (1) must state the geographical area in respect of which RQOs will apply, the requirements for achieving the objectives, and the dates from which the objectives will apply.
(3) The objectives determined in terms of subsection (1) may relate to:
    (a) the Reserve;
    (b) the instream flow;

(c) the water level;
(d) the presence and concentration of particular substances in the water;
(e) the characteristics and quality of the water resource and the instream and riparian habitat;
(f) the characteristics and distribution of aquatic biota;
(g) the regulation or prohibition of instream or land-based activities which may affect the quantity of water in or quality of the water resources; and
(h) any other characteristic of the water resource in question.

(4) The Minister needs to publish in respect of each water resource a notice in the *Gazette* setting out the details of the above (paraphrased).

Section 14 deals with the preliminary determination of the class and RQOs, and reflects what is currently being done (in the absence of a prescribed WRCS). Section 15 deals with giving effect to the determination of class and RQOs for the water resource.

Part 3 deals with the Reserve, the Basic Human Needs (BHN) Reserve and the ecological Reserve. The Reserve refers to both the quality and quantity of the water in the resource, and will vary according to the class of the resource. The Minister is required to determine the Reserve for all or part of any significant water resource.[8]

In addition to the aforementioned legislation, the following additional provisions of the Act are of significance to the WRCS:

1. All water management institutions must give effect to the class when exercising powers or performing any duty in terms of the Act [**s15**].

2. The classification system is the platform for the Resource Directed Measures to ensure resource protection and effective management, including the Reserve [**s16(2)a**] and RQOs [**s13(1)b**].

3. The NWRS must give effect to the class in terms of the Reserve [**s6(1)(b)i**] and water quality objectives [**s6(1)i**]. CMSs must take account of (and give effect to) the class of the water resources in the Water Management Area (WMA) [**29(a)**], particularly in terms of the water allocation plan.

4. Any water use licences or general authorisations issued or allowed under the Act must take account of the class [**s27(g)**]. Regulations on water use may differentiate between different classes of water use [**s26(2)a**]. An existing water user who has applied for a licence may be restricted without compensation to provide for the Reserve [**s22(7)(b)i**].

5. The pricing strategy for water use charges may differentiate between classes [**s56(4)(b)vi**], and the Minister must consider the class in setting the pricing strategy [**s56(6)a**].[9]

[8] It is important to note that considerable investment has been made into developing methods to determine the quantity and quality of water necessary to maintain ecosystem functioning. Less attention has been paid to developing the underlying considerations for determining the appropriate balance between protection and utilisation of the resources – a largely social, economic and politically-driven process.

[9] The WRCS and Classification Process need not take responsibility for determining these aspects, but should link closely with the processes put in place to do so.

In order to implement the Act, DWAF makes use of seven types of strategies/regulatory activities:

1. CMSs.

2. NWRS.

3. Allocation plans.

4. Resource Directed Measures (RDM) – defining the desired level of protection for a water resource, and on that basis, setting the Reserve as well as clear numerical or narrative goals of the resource (the RQOs). These measures focus on the quality of the resource itself.[10]

5. Source Directed Controls (SDCs) – controlling impacts on the water resource through the use of regulatory measures such as registration, permits, directives and prosecution, and economic incentives such as levies and fees, in order to ensure that RQOs are met. These measures contribute to defining the limits and constraints that should be imposed on the use of water resources to achieve the desired level of protection.

6. Managing demands on water resources to keep utilisation within the limits for protection; including water conservation and demand management.

7. Monitoring the status of the country's water resources to ensure the RQOs are being met, and to enable the modification of programmes for resource management and impact control as and when necessary.

In future, the WRCS and the Classification Process will be closely linked to the management of catchments by CMAs for each WMA (DWAF, 2004). The management plans developed by these CMAs will play a critical role in managing the demand and supply of water resources through incorporation of SDCs such as licensing and incentive measures, and through demand management and monitoring. It is envisaged that the CMAs will use a strategic adaptive management approach in ensuring that the RQOs defined in the Classification Process are met.

[10] At present ecological Reserve assessments produce a recommended EcoStatus Category (EC), and this is taken to be the preliminary Ecological Management Class (EMC) of the resource. The Director-General (DG) is the delegated authority who considers the recommendations about the preliminary class and considers the socio-economic implications when making a decision on the MC. The current policy is that an EMC cannot be set at a lower class than the EC under conditions of partial information gleaned from short-term studies.

2 GUIDING PRINCIPLES

2.1 Guiding principles that will inform the scope and intent of the WRCS

Given the aforementioned context, it is prudent to define an acceptable set of principles, based on sound scientific knowledge, and informed by the spirit and letter of the South African Constitution to guide the WRCS and Classification Process. This will help make the process open, transparent and reasonably predictable, and will also reduce the level of potential contestation. The following principles were identified for the evolving WRCS during Phase 1 of the project (DWAF, 2005):

2.1.1 Principle 1: Balance and trade-off for optimal use

The chosen MC should balance protection of the resource with its utilisation in line with societal norms and values. Utilisation of the resource provides economic and social benefits; it also has the potential, however, to compromise ecosystem integrity, which has economic and social costs. This balance will require trade-offs. The WRCS should therefore broadly outline the implications of different MCs to facilitate informed decision-making.

2.1.2 Principle 2: Sustainability

The principal reason for the protection of water resources is to maintain ecosystem integrity at a level that ensures the continued delivery of desired Ecosystem Goods, Services and Attributes (EGSAs)[11] for use (NWA [Chapter 1, Interpretation and fundamental principles]). The WRCS therefore needs to provide a framework to help facilitate the sustainable and equitable use of water resources. It is also recognised that there is a sustainability baseline that if crossed, could result in the non-delivery of the EGSAs necessary for economic growth, poverty alleviation and the redress of historical inequality. As there is a degree of uncertainty as to the exact position of this baseline, and as the risks of exceeding the limits of sustainability are considerable, a cautious approach should be adopted.

2.1.3 Principle 3: National interest and consistency

A MC of a water resource may produce solutions that are acceptable at a local-level, but are sub-optimal when considered at a national-level. Catchment-level decisions therefore need to be evaluated against national-level interests (and where appropriate, international-level constraints e.g. international obligations). The WRCS should also outline a clear intention with respect to the characteristics of different MCs and provide for consistency in this regard.

2.1.4 Principle 4: Transparency

Stakeholders should be consulted both in the development of the WRCS and in the process of classifying the Nation's water resources. The approach should be legitimate and transparent, and ensure that the evaluation method used for determining trade-offs is fair. As the MC has considerable economic, social and ecological implications, stakeholders will need to be informed in a meaningful way of the potential impacts on and risks (and benefits) of the WRCS to them. Further, stakeholders will need to be informed about the level of uncertainty that accompanies many of the economic, social and ecological predictions inherent in the Classification (and 'Larger') Process.

2.1.5 Principle 5: Implementability

The WRCS needs to be used, at reasonable cost, by trained DWAF/CMA staff at an operational level. The institutional and transactional costs associated with making a decision on the MC should

[11] For a full explanation of EGSAs see Volume 3 (Turpie *et al*., 2007)

be as low as possible. The WRCS should also be sufficiently robust to make a decision in the light of imperfect knowledge. The final outcome of the Classification Process should take into consideration the impacts of existing entitlements to use water (for both abstraction and disposal) as well as regional- and national-development objectives.

2.1.6 Principle 6: Interdependency of the hydrological cycle

All components of a water resource are linked. As such, the WRCS needs to account for the interlinkages between all resources dependent on water; watercourse, surface water, estuary or aquifer.

2.1.7 Principle 7: Legally defensible and scientifically robust

The WRCS should be legally defensible and scientifically robust. It should be based on sound socio-economic and ecological principles in line with IWRM goals. The WRCS and Classification Process should be legally defensible, apply due diligence in the decision-making process, and prevent legal liability accruing to DWAF or the stakeholders. It should also be consistent with South Africa's international obligations and other environmental legislation both at a national- and an international-level. The guidelines should indicate the best available tools and data sets to be used in the Classification Process. These will need to be regularly updated to account for developments in science and technology.

2.1.8 Principle 8: Management scales

The scale at which the WRCS is applied should be appropriate to the problem at hand. The end result of the Classification Process will be the recommendation of a MC for a resource. The implications of this need to be understood, implemented and checked at multiple scales.

2.1.9 Principle 9: Auditable and enforceable

The WRCS needs to be auditable and enforceable to ensure that it is operationalised. Thus, the regulator will need to ensure that a transparent, permanent record of the procedures, information and logic used for classifying a particular resource is created and maintained. The outcomes of the WRCS also need to be monitored and enforced.

2.1.10 Principle 10: Lowest level of contestation and the highest level of legitimacy

Given the strategic importance of the WRCS, the principle of lowest level of contestation and highest level of legitimacy should be applied. This requires consultation with, and the highest level of buy-in from, internal (DWAF) and external strategic stakeholders and interested and affected parties (I&APs).

2.1.11 Principle 11: Utilisation of existing tools, data and information

The WRCS will use existing tools, data and information wherever possible. Where applicable, existing tools, data and information will be modified or extended to meet the requirements of the WRCS. Unless there is an urgent need to do so, no new tools, data or information will be developed or collected.

3 INTEGRATING ECONOMIC, SOCIAL AND ECOLOGICAL GOALS IN THE MANAGEMENT CLASS

The NWA calls for the efficient, equitable and sustainable use of the nation's water resources. These three goals (economic, social and ecological), are embodied in DWAF's official motto, '*ensuring some, for all, for ever, together*'. The economic goal of efficiency relates to maximising economic returns from water resources, or achieving the maximum net benefit. The social goal of equity seeks to allocate and distribute the costs and benefits of utilising the resource fairly, while the ecological goal of sustainability seeks to promote the use of resources in a way that meets the needs of current generations, but does not compromise the economic opportunities and social wellbeing of future generations. These goals are also consistent with government's Accelerated and Shared Growth-South Africa (ASGISA)[12] strategy that takes the position that without interventions targeted at reducing South Africa's historical inequalities, growth is unsustainable. In the context of IWRM, this involves allocating water for historic redress as a legal imperative, and contributing to eliminating the second economy.

However, these economic, social and ecological goals are potentially conflicting, and are not easy to solve simultaneously. It is clear that trade-offs[13] will need to be made in the Classification and 'Larger' Process (and reflected in the MC and the allocation schedule respectively) that will require a suitable, integrated, analytical decision-making system. For example, if the resource is not protected, most water resources will be allocated to consumptive use. On the other hand, overprotection incurs opportunity costs in the form of lost economic production and reduced societal wellbeing. An optimal balance is therefore required that maximises societal welfare and effectively deals with the core issues of redressing historical inequality and reducing poverty. This balance requires trading-off the value of water as a direct input to economic production and, for example, the costs associated with the use of the resource to dissipate waste, the socio-economic costs of environmental damages, and the potential health risks and cost that overuse, stream flow reduction activities and dry land agriculture may have on other users. These costs (negative externalities) and benefits (goods and services that a functioning resource contributes to economic production e.g. fish, reeds, water purification and flood attenuation), however, are seldom accounted for in conventional economic analyses. It is proposed that these costs and benefits and trade-offs need to be considered both in the Classification and 'Larger' Process.

[12] www.info.gov.za/issues/asgisa/.
[13] The trade-offs, however, are also influenced by the characteristics of the resources themselves and by scale.

4 BACKGROUND TO THE ENVISAGED CLASSIFICATION PROCESS

The WRCS should be designed to deliver on the outcome of the Classification Process – information for the Minister or delegated authority to set the MC and RQOs of a resource. As mentioned earlier, the Classification Process, which is nested within (and informs and influences) the 'Larger Process', will require a wide range of complex trade-offs to be assessed and evaluated at a number of scales. These trade-offs will include those between use and protection (which may or may not be conflicting), between downstream impacts and upstream uses and *vice versa*, between possible use of resources within a catchment and between catchments, and between possible resource use between different parts of the country. Decisions on these trade-offs will have different implications for different stakeholders at local-, regional- and national-levels, and will thus be inherently complex and contestable. It is proposed, however, that the primary scale for the Classification Process be the river basin scale (catchment) which provides a practical, understandable spatial unit within which socio-economic and ecological trade-offs can be made.

Catchment-level decisions may, however, be sub-optimal when placed in the context of broader national-interest, so catchment-level decisions may need to be evaluated against national- and regional-level constraints and/or opportunities. It is therefore proposed that the Classification Process focus initially on finding a balance between protection and use at a catchment-scale, through within-catchment trade-offs, but that the final decision-making process around a MC find an appropriate balance between national-, regional- and catchment-scale socio-economic implications of a MC and biodiversity, and between national-, regional- and catchment-scale biodiversity and sustainability considerations of a MC. The WRCS should therefore take cognisance of national- and regional-level considerations (and possible trade-offs) at multiple scales.

5 OUTLINE OF THE ENVISAGED CLASSIFICATION PROCEDURE

A 7-step procedure to recommending the MC of a resource (the outcome of the Classification Process) is proposed (Figure 5-1). The seven steps, which may be embedded in other DWAF processes, are as follows:

Step 1: Delineate the units of analysis and describe the status quo of the water resources:-

a. Describe the present-day socio-economic status of the catchment;
b. Divide the catchment into socio-economic zones;
c. Identify a network of significant resources, describe the water resource infrastructure and identify the water user allocations;
d. Define a network of significant resources and establish the biophysical and allocation nodes.
e. Describe communities and their wellbeing;
f. Describe and value the use of water;
g. Describe and value the use of aquatic ecosystems;
h. Define the Integrated Units of Analysis (IUA);
i. Develop and/or adjust the socio-economic framework and the decision-analysis framework; and
j. Describe the present-day community wellbeing within each Integrated Unit of Analysis.

Step 2: Link the value and condition of the water resource:-

a. Select the ecosystem values to be considered based on ecological and economic data;
b. Describe the relationships that determine how economic value and social wellbeing are influenced by the ecosystem characteristics and the sectoral use of water; and
c. Define the scoring system for evaluating scenarios.

Step 3: Quantify the Ecological Water Requirements and changes in non-water quality Ecosystem Goods, Services and Attributes:-

a. Identify the nodes to which Resource Directed Measures data can be extrapolated and make the extrapolation;
b. Develop rule curves, summary tables and modified time series for all nodes for all ecological categories; and
c. Quantify the changes in relevant ecosystem components, functions and attributes for each ecological category for each node.

Step 4: Determine an Ecologically Sustainable Base Configuration scenario and establish the starter configuration scenarios:-

a. Determine an Ecologically Sustainable Base Configuration (ESBC) scenario that meets feasibility criteria for water quantity, water quality and ecological needs;
b. Incorporate the planning scenarios (future use, equity considerations and existing lawful use); and
c. Establish the Resource Directed Measures configuration scenarios.

Step 5: Evaluate scenarios within the Integrated Water Resource Management (IWRM) process:-

Steps 5 and 6 form part of the ‘Larger Process’ where the economic, social and ecological trade-offs will be made. Trade-offs will also need to be made between Existing Lawful Use (ELU) and equity considerations. Emerging from this ‘Larger Process’ will be the recommended MC, Reserve and RQOs, CMS, allocation schedule, modelling system and the monitoring, auditing and

compliance strategy. A number of key questions will need to be addressed in this 'Larger Process'. These include:

- at what level will the trade-offs be negotiated?
- in what institutional setting will they be negotiated?
- what types of scenarios will inform the process of negotiation?; and
- since the recommended MC, Reserve, RQOs, CMS and allocation schedule will impact on specific groups of people in different ways, what processes will guide decisions about who benefits and who pays the social and economic cost?

These key questions should be framed (and assessed) in the context of equity, efficiency and sustainability as required by the NWA, and by the core objectives of the present government which are, amongst others, to halve poverty and unemployment by 2014, to reduce the regulatory burden on small and medium businesses, and to eliminate the second economy[14]. Step 5 should therefore contribute to meeting government's objective of '…reduce(ing) inequality and virtually eliminating poverty'.[15] To address these objectives and to fit within the larger DWAF institutional context, Classification Procedure Step 5 needs to include the following sub-steps:

a. Run a yield model for the Ecologically Sustainable Base Configuration scenario and other scenarios and adjust the scenarios if necessary;
b. Assess the water quality implications (fitness for use) for all users;
c. Report on the IUA-scale ecological condition and aggregate impacts for each preliminary scenario;
d. Value the changes in aquatic ecosystems and water yield;
e. Describe the macro-economic and social implications of different catchment configuration scenarios;
f. Evaluate the overall implications at an Integrated Unit of Analysis-level and a regional-level; and
g. Select a subset of scenarios for stakeholder evaluation.

Step 6: Evaluate the scenarios with stakeholders:-

a. Stakeholders evaluate scenarios and agree on a short-list; and
b. Recommend classes for the Integrated Units of Analysis.

Step 7: Gazette the class configuration:-

a. Populate the Integrated Water Resource Management summary template and present to the Minister or his/her delegated authority;
b. Decision by the Minister or his/her delegated authority on the Integrated Unit of Analysis classes, nested ecological category configurations, Reserve(s), allocation schedule(s) and the Catchment Management Strategy;
c. Set the resource quality objectives;
d. Gazette Integrated Unit of Analysis classes, nested ecological category configurations, Reserve(s) and resource quality objectives; and
e. Develop a plan of action for implementation of the recommended scenario which must include a monitoring programme.

The following sections describe each of the classification procedure steps in greater detail. The relationships and flow of information between all the sub-steps and procedures are shown graphically in Figure 5-2.

[14] www.info.gov.za/issues/asgisa/.
[15] www.info.gov.za/issues/asgisa/.

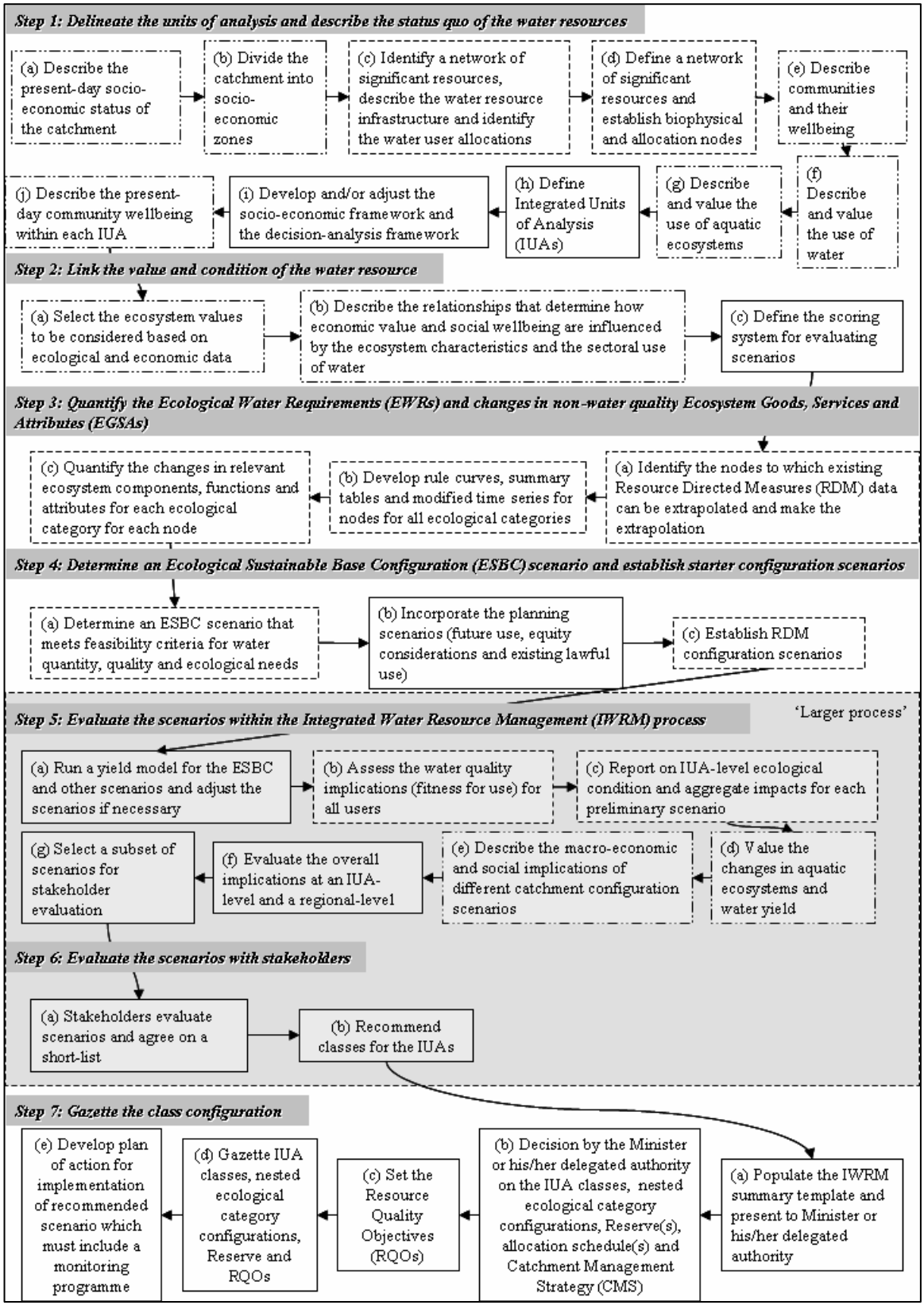

Figure 5-1 Proposed 7-step classification procedure (note that Steps 5 and 6 form part of the 'Larger Process')

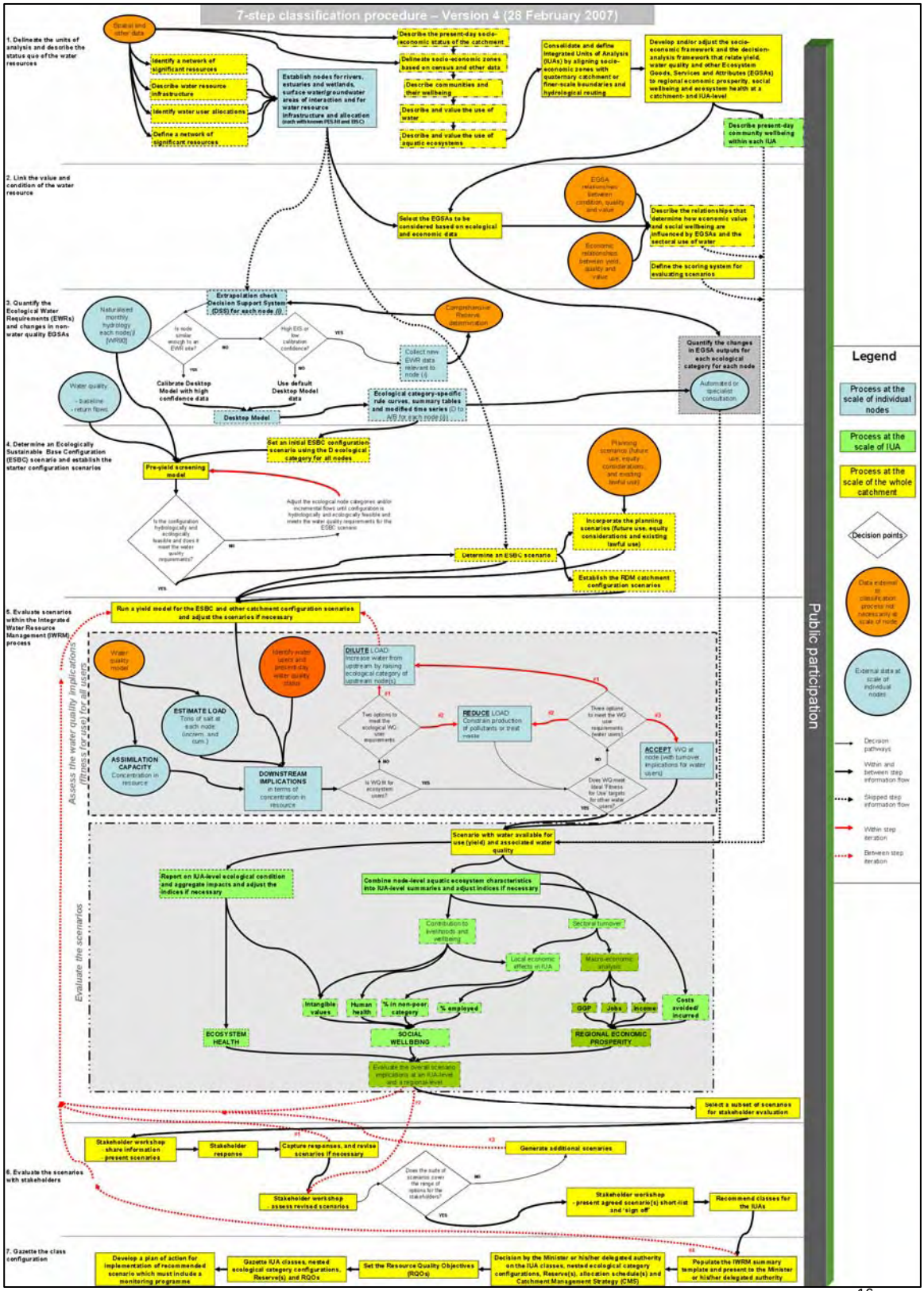

Figure 5-2 Information pathways for the proposed 7-step classification procedure[16]

[16] A larger version of this figure is available as an A3 foldout at the back of this report.

6 DESCRIPTION OF THE PROPOSED 7-STEP CLASSIFICATION PROCEDURE

Sections 7 to 13 of this volume provide descriptions of each sub-step involved in the proposed 7-step classification procedure. The aim of the descriptions is to outline the objectives of and information required for each step, the links to other steps and the required outcome of the step. This report will present the generic guidelines and procedures of the 7-step classification procedure. Further details and worked examples of each of the steps are presented in the accompanying volumes (Volume 2, Brown *et al*., 2007; Volume 3, Turpie *et al*., 2007 and Volume 4, Joubert *et al*., 2007). It is important to note however, that although the steps are described sequentially, in reality, many of the steps may occur simultaneously. Further, as mentioned previously, as the WRCS is an integral component of the IWRM environment, links to other IWRM processes are therefore also described where appropriate.

7 STEP 1: DELINEATE THE UNITS OF ANALYSIS AND DESCRIBE STATUS QUO OF THE WATER RESOURCES

The 2 objectives of Step 1 of the classification procedure are 1) to *delineate the units of analysis* and 2) *to describe the catchment status quo*. By '*units of analysis*' we mean the spatial units that will be defined as significant resources (as prescribed by the NWA). These resources may be defined at different spatial scales. The catchment *status quo* refers to the current condition of the significant resources, the current socio-economic status of the communities within the targeted catchment, current water use allocations, and the current status of the water resource infrastructure.

Step 1 therefore consists of the following sub-steps:

a. Describe the present-day socio-economic status of the catchment.
b. Divide catchment into socio-economic zones.
c. Identify a network of significant resources, describe the water resource infrastructure and identify the water user allocations.
d. Define a network of significant resources and establish the biophysical nodes and allocation nodes.
e. Describe communities and their wellbeing.
f. Describe and value the use of water.
g. Describe and value the use of aquatic ecosystems.
h. Define the Integrated Units of Analysis (IUAs).
i. Develop and/or adjust the socio-economic framework and the decision-analysis framework.
j. Describe present-day community wellbeing within each IUA.

In order to describe the 7-step classification procedure in an understandable form, the sub-steps have been defined in such a way as to represent the ecological (including hydrological, groundwater, and water quality), socio-economic and decision-analysis component information requirements for the 7-step procedure. The remainder of the report is therefore structured in such a way as to describe the objectives and information required for each sub-step, the link to other sub-steps and the required outcome for each sub-step, for the ecological, groundwater, hydrological and water quality component (hereinafter called the ecological component), the socio-economic component and the decision-analysis component of the classification procedure. These are described in Sections 7.1, 7.2 and 7.3 respectively, while Figure 7-1 presents the information pathways for Step 1. The ecological component sub-steps of Step 1 are presented as dashed lines in Figure 5-2 and Figure 7-1. The socio-economic sub-steps are presented as dotted and dashed lines, while the decision-analysis component and/or combined component sub-steps are represented as solid lines.

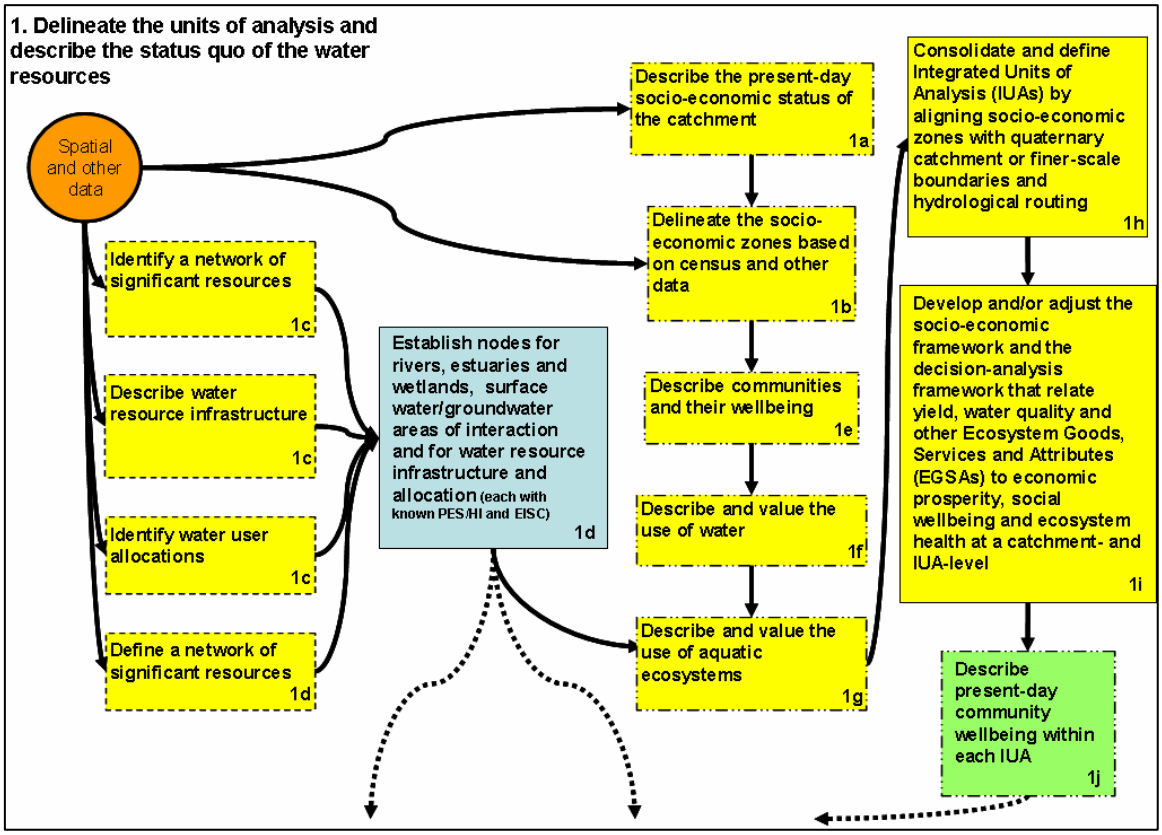

Figure 7-1 Information pathways for Step 1 of the classification procedure

7.1 Step 1: Ecological sub-steps for Step 1

For the ecological component of Step 1, two sub-steps (relating only to the ecological component) and one combined sub-step (combined with the socio-economic and decision-analysis component) are required. The predominantly ecological steps are:

- Step 1c: Identify a network of significant resources, describe the water resource infrastructure and identify the water user allocations; and
- Step 1d: Define a network of significant resources and establish the biophysical and allocation nodes.

The combined step that requires ecological input is:

- Step 1h: Define Integrated Units of Analysis (IUAs).

7.1.1 Step 1c: Identify a network of significant resources, describe the water resource infrastructure and identify the water user allocations

7.1.1.1 Objective and information required

The objective in *identifying a network of significant resources* is to delineate the resources that will be utilized for the Classification Process in a targeted catchment. Significant water resources are defined as those that are significant from a use perspective and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in water quality and quantity. Significant resources may include:

- mainstem rivers in each quaternary catchment;
- estuaries, as identified by a nationally-defensible estuarine classification system;
- wetlands, as identified by a nationally-defensible wetlands classification system;
- aquifers, as identified by a nationally-defensible groundwater classification system; and
- any other resources considered significant.

The objective of *describing the water resource infrastructure* is to ensure that the selection of biophysical and allocation nodes (see Section 7.1.2) takes account of existing water resource infrastructure for (later) modelling and allocation purposes. The description of water resource infrastructure may include:

- minor dams;
- major dams;
- farm dams;
- canals; and
- any other water resource infrastructure considered significant.

The objective of *describing the water user allocations* is to ensure that the selection of biophysical and allocation nodes (see Section 7.1.2) takes account of ELU for (later) modelling and allocation purposes. This information needs to be provided by the Chief Directorate: Integrated Water Resource Planning (CD: IWRP).

7.1.1.2 Required outcome

The outcome of Step 1c may include:

1. An identified network of significant resources for a targeted catchment including:

    - mainstem rivers in each quaternary catchment;
    - estuaries, as identified by a nationally-defensible estuarine classification system;
    - wetlands, as identified by a nationally-defensible wetlands classification system;
    - aquifers, as identified by a nationally-defensible groundwater classification system; and
    - any other resources considered significant.

2. A description of the water resource infrastructure for a catchment including:

    - minor dams;
    - major dams;
    - farm dams;
    - canals; and
    - any other water resource infrastructure considered significant.

3. A description of water user allocations including:

    - ELU.

7.1.2 Step 1d: Define a network of significant resources and establish the biophysical and allocation nodes

7.1.2.1 Objective and information required

The objective of *defining a network of significant resources* is to *establish* a suite of *biophysical and allocation nodes* that will be used as modelling points for the Classification Process in a

targeted catchment[17]. The nodes will be used to assess the response of the upstream resources to changes in water quality, quantity and timing. The biophysical nodes should be located at the end-points of ecosystem reaches that will allow for meaningful trade-offs between different parts of the catchment in terms of the quantity (volume and distribution) and quality of water that remains in the resource, and thus the quantity and quality of water available for off-stream use. The allocation nodes should account for ELU and for potential future use. The procedure for developing allocation nodes and linking them to biophysical nodes are as yet undeveloped.

The number of biophysical and allocation nodes should be sufficient to provide the scope for within catchment trade-offs, but will need to be constrained by the operational capacity of existing water resource models. It is suggested that an ideal number of biophysical nodes be between 40 and 60. This may, however, vary depending on individual catchment characteristics and ELU.

A three-step procedure is recommended for the establishment of biophysical nodes. These may include (where data are available):

1. The establishment of ecosystem-specific units (i.e. rivers, estuaries, wetlands and groundwater).
2. The identification of areas of interaction between ecosystem-specific units (i.e. river-estuary interactions, river-wetlands interactions, river-groundwater interactions, estuary-wetland interactions, estuary-groundwater interactions and groundwater-wetlands interactions).
3. Identification of nodes to account for interactions between ecosystem-specific units.

The procedure recommended for the establishment of allocation nodes remains to be developed. Allocation nodes will, however, need to account for (at least) the following:

1. ELU.
2. Possible future use.
3. Position of biophysical nodes.

The procedure for the establishment of ecosystem-specific units (i.e. rivers, estuaries, wetlands and groundwater) is discussed for separately for rivers, estuaries, wetlands and groundwater in Sections 7.1.2.1.1, 7.1.2.1.2, 7.1.2.1.3 and 7.1.2.1.4 respectively.

7.1.2.1.1 Establishment of river nodes

River nodes need to be established with the objective of capturing the suite of biophysical and ecological features that characterise the target catchment's rivers at different scales. To this end, a multi-tiered approach to establishing the location and number of river nodes in a target catchment is recommended. It is recommended that a 9-Her procedure be followed to locate the river nodes within each IUA. The river nodes may capture the following:

- a broad-scale designation of the rivers' biophysical and ecoregional characteristics (e.g. Ecoregions, cf. Kleynhans *et al*., 2005);
- a broad-scale designation of the rivers' hydrological characters (e.g. Hydrological Index, cf. Hughes and Hannart, 2003);
- a broad-scale designation of the rivers' geomorphological characters (e.g. Geomorphic zones, cf. Rowntree and Wadeson, 1999);
- significant tributaries;
- Ecological Importance and Sensitivity Category (EISC);
- Present Ecological Status/Habitat Integrity (PES/HI); and
- existing RDM data (e.g. Ecological Water Requirement (EWR) sites).

[17] These will also be used in the compulsory licensing process.

In addition, the river nodes need to capture:

- existing water resource infrastructure (e.g. major dams);
- allocation nodes; and
- International Water Agreements (IWAs).

A rationalisation process may be required to reduce the number of nodes. The rationalisation process could follow a number of simple guidelines to achieve this; including:

- determining a minimum distance between nodes;
- determining a minimum contribution to naturalised Mean Annual Runoff (nMAR); and
- removing nodes nested within a quaternary catchment with no independent hydrological data (i.e. no other hydrology other than WR90 (Midgley *et al*., 1994))[18].

A river node table should be established that comprises the following information:

- node code (prefaced by R for river);
- geographic co-ordinates;
- tier at which the node was selected;
- quaternary catchment;
- description of biophysical or ecological zone (e.g. Ecoregion);
- description of hydrological character (e.g. Hydrological Index);
- description of geomorphological character (e.g. Geomorphic zone);
- PES;
- EISC;
- node order;
- Reserve Assurance Region (Hughes and Münster, 2000); and
- altitude range.

7.1.2.1.2 Establishment of the estuary node

The estuary node is placed at the downstream end of an estuary (i.e. its interface with the ocean). The estuary node is used to provide the relationships that will be used to predict the responses of the upstream estuarine ecosystem to changes in water quality, quantity and timing.

An estuary node table should be established that comprises the following information:

- node code (prefaced by E for estuary);
- geographic co-ordinates (including upstream, downstream and lateral boundaries);
- tier at which the node was selected;
- quaternary catchment;
- description of biophysical or ecological zone (e.g. Ecoregion);
- PES/HI;
- EISC;
- node order;
- Reserve Assurance Region (Hughes and Münster, 2000); and
- altitude range.

[18] The updated version of this data should be used as and when it becomes available.

7.1.2.1.3 Establishment of the wetlands nodes

Currently, there is no RDM wetlands methodology. As and when this becomes available, this needs to be incorporated into the classification procedure.

7.1.2.1.4 Establishment of groundwater nodes

The groundwater nodes need to be established with the objective of predicting probable surface water/groundwater (SW/GW) areas of interaction, specifically, of groundwater supplying water to rivers. To this end, a multi-tiered approach to establishing the location and number of SW/GW nodes in a target catchment is recommended. The SW/GW nodes may capture the following:

- lithological boundaries at aquifers and aquitards;
- groundwater contribution to base flow;
- geological faults;
- groundwater levels; and
- springs.

It is recommended that a six-tier procedure be followed to determine SW/GW areas of interaction that may include:

- groundwater response units;
- groundwater fed base flow;
- groundwater levels
- springs; and
- geological faulting.

A groundwater node table should be established that comprises the following information:

- node code (prefaced by SW/GW for surface water/groundwater areas of interaction);
- geographic co-ordinates;
- tier at which the node was selected;
- quaternary catchment;
- node order; and
- Reserve Assurance Region (Hughes and Münster, 2000).

7.1.2.2 Required outcome

The outcome of Step 1d may include (depending on data availability):

1. A defined network of significant resources including:
    - ecosystem-specific units (i.e. rivers, estuaries, wetlands and groundwater);
    - identified areas of interaction between ecosystem-specific units (i.e. river-estuary interactions, river-wetlands interactions, river-groundwater interactions, estuary-wetland interactions, estuary-groundwater interactions and groundwater-wetlands);
    - identified nodes to account for interactions between ecosystem-specific units; and
    - allocation nodes.

2. A suite of river nodes.

3. An estuary node.

4. A suite of wetland nodes.

5. A suite of SW/GW nodes.

6. Node tables for rivers, estuaries, wetlands and groundwater.

7.1.3 Define the Integrated Units of Analysis (IUA) (Step 1h)

7.1.3.1 Objective and information required

The objective of *defining IUAs* is to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios (see Section 11.2.2) and to report on ecological conditions at a sub-catchment scale (see Section 11.1.3). IUAs are therefore a combination of the socio-economic zones defined in Step 1b (see Section 7.2.2) and watershed boundaries, within which ecological information is provided at a finer scale. This requires that the nodes established in Step 1d (see Section 7.1.2) of the classification procedure be nested within the IUAs.

7.1.3.2 Required outcome

The outcome of Step 1h should include (at least):

- a defined set of IUAs for a target catchment;
- a list of the nested biophysical and allocation nodes within each IUA; and
- an integration point (node) at the IUA outlet at which socio-economically-relevant ecological data can be summarised.

7.2 Step 1: Socio-economic component

It is important to point out that prior to applying the socio-economic steps of the classification procedure; a suitable socio-economic evaluation framework needs to be developed for the Classification Process for the target catchment. The development of such a framework for the 'proof of concept' catchment (the Olifants/Doring catchment) is presented in Volume 3 (Turpie *et al*., 2007), while the decision-analysis framework that is used to assess the implications of different catchment configuration scenarios is presented in Volume 4 (Joubert *et al*., 2007). It would not be prudent to 'fix' the socio-economic evaluation framework in the classification procedure, and for this reason, Step 1i (see Section 7.2.6 and 7.3.1) makes provision for developing a new socio-economic evaluation framework, or for utilising or revising the socio-economic evaluation framework developed for the 'proof of concept' catchment. However, whatever socio-economic evaluation framework is utilised in the Classification Process, it should be able to assess the implications of different catchment configuration scenarios at an IUA-level on:

- economic prosperity (preferably in terms of the Total Economic Value (TEV) of aquatic ecosystem EGSAs and water use[19]);
- social wellbeing (preferably assessed in terms of the United Nations Sustainable Livelihood Framework that assesses social, physical, financial, human and natural capital); and
- ecological condition.

For the socio-economic component of Step 1, six sub-steps and two combined sub-steps are required. The four sub-steps are:

- Step 1a: Describe the present-day socio-economic status of the catchment;
- Step 1b: Divide the catchment into socio-economic zones;
- Step 1e: Describe communities and their wellbeing;
- Step 1f: Describe and value the use of water;

[19] Water use can be defined using the National Water Resource Strategy (NWRS) (DWAF, 2004) user sectors, conventional economic sectors utilised in macro-economic analyses and a typology of aquatic ecosystem users.

- Step 1g: Describe and value the use of aquatic ecosystems; and
- Step 1j: Describe the present-day community wellbeing within each IUA

The two combined sub-steps are:

- Step 1h: Define the Integrated Units of Analysis (IUAs); and
- Step 1i: Develop and/or adjust the socio-economic framework and the decision analysis framework.

7.2.1 Step 1a: Describe the present-day socio-economic status of the catchment

7.2.1.1 Objective and information required

The objective of describing *the present-day socio-economic status of the catchment* is to describe the target catchment's population, land use and economy as part of the status quo assessment. It is also required to divide the catchment into different socio-economic zones as part of Step 1b (see Section 7.2.2). This information can be accessed from a variety of sources, including the Census data from Statistics South Africa (StatsSA) and the CD: IWRP Information Management System (IMS) database. Information should be collected on:

- population characteristics (e.g. numbers, gender);
- land use (e.g. irrigation farming, mining, forestry); and
- proportional contribution by different water user sectors to the catchment and national economy (e.g. agriculture contributes ~35% to Olifants/Doring catchments gross geographic product (GGP)).

7.2.1.2 Required outcome

The outcome of Step 1a may include:

1. A table containing a list of important population descriptors for the catchment.
2. A map showing the target catchment land use, together with a table listing the different land uses and their relative areas.
3. A table containing the proportional contribution by water user sector to the target catchment and national economy.

7.2.2 Step 1b: Divide the catchment into socio-economic zones

7.2.2.1 Objective and information required

The objective of *dividing the catchment into socio-economic zones* is to predict and report the implications of different catchment configuration scenarios on social wellbeing, economic prosperity and ecosystem health at an appropriate spatial scale.[20] The spatial scale needs to be sufficiently broad so as to include members of society who are impacted by a change in resource class. It also needs to accommodate those members of society who are vulnerable, especially in the light of the national priorities for redress and poverty alleviation. This requires dividing society into relatively homogenous communities through delineating socio-economic zones and describing community wellbeing within each zone (Step 1e – see Section 7.2.3). It is recommended that:

- the process should be done spatially in such a way that any individual could identify his/her community and be able to identify with it;
- the process should reflect communities' relationships to water and aquatic resources;
- the delineation of socio-economic zones include the following considerations:

[20] The socio-economic zones will be used together with the ecological (including groundwater) and hydrological information to define IUAs (see Section 7.1.3).

- land tenure;
- predominant land use;
- aquatic ecosystems and rainfall patterns; and
- any other pertinent variables that create a pattern.

Once the delineation process is complete, the final socio-economic boundaries should be aligned with the quaternary catchment boundaries so as to facilitate integration with the ecological component and in so doing define IUAs (Step 1h – see Section 7.1.3).

7.2.2.2 Required outcome

The outcome of Step 1b may include:

1. A table containing a list of socio-economic zones for the target catchment including:
    a. an appropriate name; and
    b. A description of each zone that should include at least the dominant land tenure, land use, aquatic ecosystems, rainfall patterns and any other pertinent variables that create a pattern.

7.2.3 Step 1e: Describe communities and their wellbeing

7.2.3.1 Objective and information required

The objective of *describing communities and their wellbeing* within each socio-economic zone (identified in Step 1b – see Section 7.2.2) is to provide the baseline from which changes in social wellbeing can be estimated for each of the catchment configuration scenarios evaluated in Classification Procedure Steps 5 and 6 (see Sections 11 and 12). This requires describing the levels of financial, physical, human, social and natural capital available to each community, and constructing a measure or index of social wellbeing from the data collected in Steps 1a and 1b (see Sections 7.2.1 and 7.2.2 respectively). Community characteristics can be described using Census and other data and should be collected to provide proxies for social, physical, financial, human and natural capital such as:

- a description of household income which can be used to determine categories such as poor and non-poor communities (financial capital);
- employment (financial capital);
- access to services and infrastructure (e.g. access to piped water, sanitation) (physical capital);
- tenure (physical capital);
- level of education (human capital);
- community cohesion and organizational skills reflecting the degree to which communities are organised (social capital); and
- relationships with water and aquatic ecosystems (natural capital).

A measure or index of social wellbeing can be calculated from:

- income data (e.g. percentage of non-poor households in a socio-economic zone);
- measures of human health (using groups of health indicators such as % of population afflicted by tuberculosis or number of cases of malaria as a percentage of the population); and
- a utility score as a proxy measure of ‘satisfaction’ or ‘happiness’ derived from aquatic ecosystems.

7.2.3.2 Required outcome

The outcome of Step 1e may include:

1. A table describing the number of poor and non-poor people in each socio-economic zone.
2. A table containing a list of proxy data describing the social, physical, financial, human and natural capital for each socio-economic zone such as:
   a. a description of household income which can be used to determine categories such as poor and non-poor communities (financial capital);
   b. employment (financial capital);
   c. access to services and infrastructure (e.g. access to piped water, sanitation) (physical capital);
   d. tenure (physical capital);
   e. level of education (human capital);
   f. community cohesion and organizational skills reflecting the degree to which communities are organised (social capital); and
   g. relationships with water and aquatic ecosystems (natural capital).

7.2.4 Step 1f: Describe and value the use of water

7.2.4.1 Objective and information required

The objective of *describing and valuing the use of water* is to determine the way in which water is currently being used in each socio-economic zone (see Section 7.2.2), and to estimate the value generated by that use. This will provide the baseline from which the socio-economic implications of different catchment configuration scenarios can be assessed (see Section 11). Describing the use of water will require a typology of users. While a typology of users has been developed for the 'proof of concept' catchment (Volume 3, Turpie *et al*., 2007), it is recommended that whatever typology is utilised, it be aligned with the NWRS (DWAF, 2004). Once the typology of users has been defined, it will be necessary to describe the contribution of each water user sector to the economy.

The description of water use will require for each user sector for each socio-economic zone:

- the allocated volume; and
- the level of assurance.

To estimate the current use values an economic model (such as a Social Accounting Matrix (SAM)) will require information of the type presented in Table 7.1.

Table 7.1 Inputs required for user sectors for changes in economic value

Water Users	Data required
Agriculture	Number of hectares Water usage per hectare [m^3] Tonnes produced per hectare Annual production (Gross income) [Rands] Labour requirements per hectare [Number of employees] Annual capital requirements per hectare [Rands] Water Production Elasticity's [%]
Commercial Forestry	Number of hectares Water usage per hectare [m^3] Tonnes produced per hectare Annual production (Gross income) [Rands] Labour requirements per hectare [Number of employees (jobs)] Annual capital requirements per hectare [Rands]

Domestic Households	Total population [Numbers] Water use per person per annum [m^3] Current economic value of water Current cost of supply of water [R/kl] Direct labour multipliers [Numbers] Direct capital multipliers [R million]
Industry and Power	Current water usage [$10^6 m^3$] Current Gross Domestic Product (GDP) [R million] Direct labour multipliers [Numbers] Direct capital multipliers [R million]
Fisheries	Current production value [R million] Current cost of water Direct labour multipliers [Numbers] Direct capital multipliers [R millions]
Tourism	Number of tourist days Spending per tourist day [Rand per tourist per day] Direct labour multipliers [Numbers] Direct capital multipliers [R millions]
Real estate	Turnover in property sales attributed to aquatic environment (R per year) Direct labour multipliers [Numbers] Direct capital multipliers [R millions]

7.2.4.2 Required outcome

The outcome of Step 1f may include:

1. A table describing current use of water for each socio-economic zone for all appropriate user sectors including:
   a. the allocated volume; and
   b. the assurance of supply.
2. A table containing a list of the estimated turnover (and employment) for each socio-economic zone for all appropriate user sectors.

7.2.5 Step 1g: Describe and value the use of aquatic ecosystems

7.2.5.1 Objective and information required

The objective in *describing and valuing the use of aquatic ecosystems* is to determine the way in which aquatic ecosystems are currently being used in each socio-economic zone, and to estimate the value generated by that use. This will provide the baseline against which the socio-economic and ecological implications of different catchment configuration scenarios can be compared (see Section 11). It is important to point out that while EGSAs should be identified and described (at least in qualitative terms), a baseline value can often only be described for some of these, as the information required[21] is often not available without investing in a costly survey. It is also easier to measure changes in EGSA values relative to a reference point than computing a baseline value.

Various methods can be used to value EGSAs including:

- methods of quantifying direct consumptive use;
- replacement cost or cost avoided methods; and
- revealed preference methods.

[21] Future terms of reference for Reserve determination studies should be set up with these information requirements of the WRCS in mind.

7.2.5.2 Required outcome

The outcome of Step 1g may include:

1. A table listing the current use of aquatic EGSAs for each socio-economic zone.
2. A table containing the values of all utilised aquatic EGSAs for each socio-economic zone.

7.2.6 Step 1i: Develop and/or adjust the socio-economic framework and the decision-analysis framework

7.2.6.1 Objective and information required

The objective of this sub-step is to *develop and/or adjust the socio-economic framework and the decision-analysis framework* for a specific application of the Classification Process. For the socio-economic component of the classification procedure (see Section 7.3.1 for a discussion of the decision-analysis framework), this requires developing and/or adjusting the socio-economic framework that links changes in yield and ecosystem characteristics to socio-economic values (see Figure 7-2) to meet the specific requirements of the catchment targeted for classification. The current framework developed for the 'proof of concept' catchment predicts changes in socio-economic values with changes in yield and ecosystem characteristics for different catchment configuration scenarios. The current framework incorporates two sets of parameters:

- a configuration of aquatic ecosystem health categories among the water resources of the catchment with their associated flow regime; and
- a utilizable yield of water.

These two sets of parameters are generally inversely related, with increased aquatic ecosystem health requiring a reduction in utilizable yield. The yield, which is described in terms of the characteristics of water supplied to water users, influences the output of water user sectors. The catchment configuration scenarios also influence the output of EGSAs, from which a number of values are derived. Some of these values influence sectoral outputs and others are measured in terms of costs avoided or incurred. Sectoral outputs are then translated into measures of economic impact using a SAM, or a related input-output tool. Societal wellbeing is influenced by sectoral production, and also directly by ecosystem uses.

7.2.6.2 Required outcome

The outcome for the socio-economic component of Step 1i may include:

1. An updated socio-economic evaluation framework for the target catchment.

7.2.7 Step 1j: Describe the present-day community wellbeing within each IUA

7.2.7.1 Objective and information required

The objective of this sub-step is to describe *the present-day community wellbeing within each IUA* using the index developed in Step 1e (see Section 7.2.3). This is to ensure that the ecological and socio-economic implications of different catchment configuration scenarios are reported at the same scale.

7.2.7.2 Required outcome

The outcome of Step 1j may include:

1. A description of the present-day community wellbeing within each IUA.

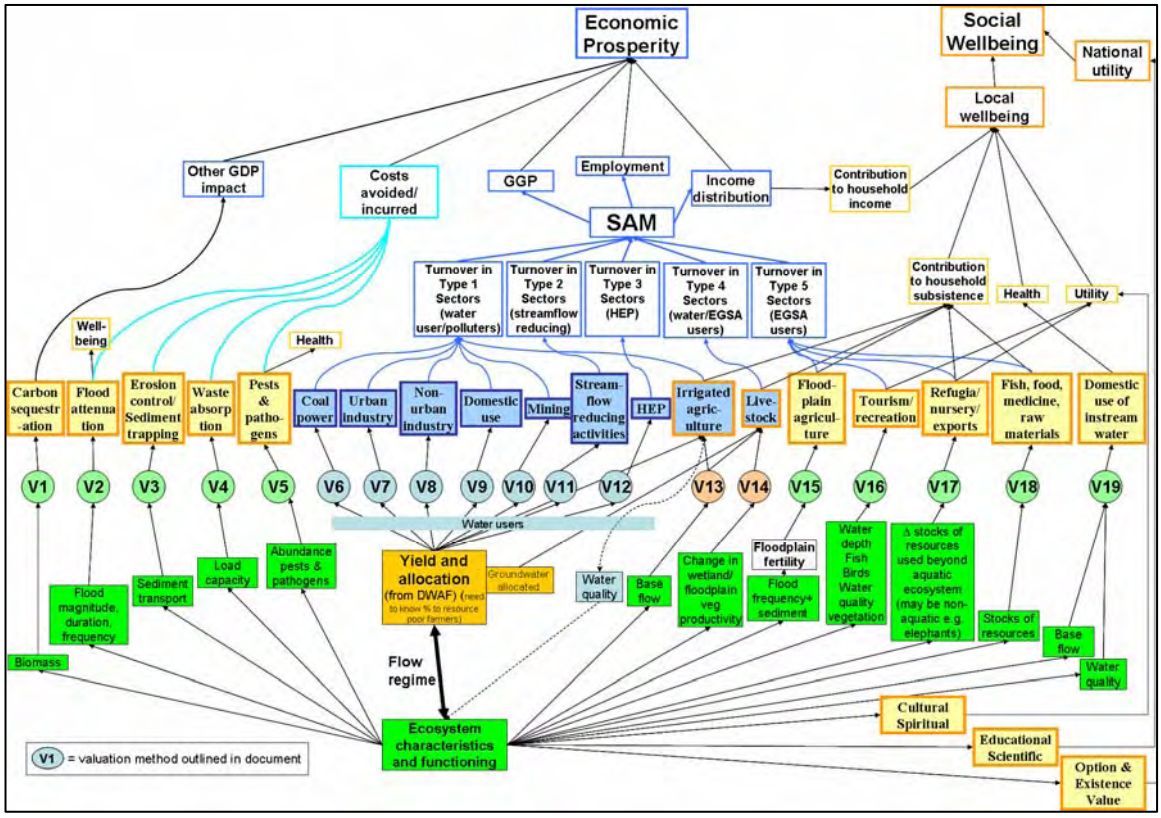

Figure 7-2 Information pathways for the proposed socio-economic valuation framework for the 'proof of concept' catchment (after Turpie *et al*., 2007)

7.3 Step 1: Decision-analysis component

It is important to point out that prior to applying the decision-analysis steps of the classification procedure; a suitable decision-analysis framework needs to be developed for the Classification Process for the target catchment. The development of such a framework for the 'proof of concept' catchment (the Olifants/Doring catchment) is presented in Volume 4 (Joubert *et al*., 2007). As for the socio-economic evaluation framework, it would not be prudent to 'fix' the decision-analysis framework in the classification process, and for this reason, Step 1i (see Section 7.3.1) makes provision for developing a new decision-analysis framework, or adjusting the decision-analysis framework developed for the 'proof of concept' catchment. However, whatever decision-analysis framework is utilised in a Classification Process, it should apply a technique that allows for the weighing up the advantages and disadvantages of alternatives. Further, it is recommended that an approach utilising Multi-Criteria Decision-Analysis (MCDA) be used together with the more conventional Cost-Benefit Analysis (CBA) approach in situation where all costs and benefits cannot justifiably be converted to monetary units (such as for the Classification Process).

MCDA and CBA may be considered as complementary methods, and both have been separately or jointly widely applied in water resource management. A flow chart suggesting when to use which method and some of the more obvious associated assumptions and caveats is given in Figure 7-3. Many authors have compared aspects of MCDA and CBA (cf. Joubert *et al*., 1997; Joubert, 2003; Hajkowicz, 2006). Most authors, however, agree that there are few instances where solely CBA can be used, and that the use MCDA is often required or recommended.

For the decision-analysis component of Step 1, one sub-step is required

- Step 1i: Develop and/or adjust the socio-economic framework and the decision analysis framework.

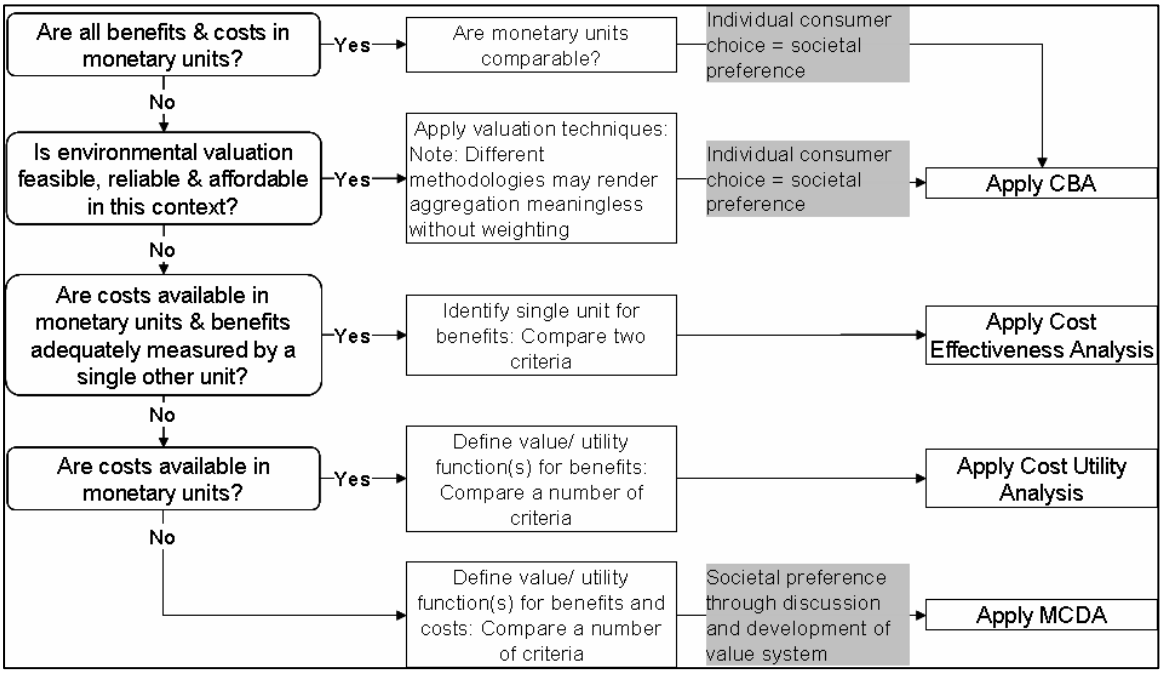

Figure 7-3 Choosing techniques for weighing up the advantages and disadvantages of alternatives (adapted from Hajkowicz, 2006 and Joubert, 2003)

7.3.1 Step 1i: Develop and/or adjust the socio-economic framework and the decision-analysis framework

7.3.1.1 Objective and information required

The objective of the decision-analysis component of this sub-step is to either *develop a new decision-analysis framework* for the catchment targeted for classification, or to apply or *adjust the decision-analysis framework*[22] *recommended* in this report. This decision will depend on the specific characteristics of the targeted catchment, and/or the preference of DWAF and/or the team appointed for the Classification Process. Whichever of the two options is chosen (i.e. develop a new decision-analysis framework or adapt and apply the decision-analysis framework presented in this report), the framework must allow for the assessment of the economic prosperity, social wellbeing and ecosystem health implications of different catchment configuration scenarios (see Section 11.3.1) within the context of historic redress of past imbalances, and must allow for assessments to be considered at various scales.

The decision-analysis component of Step 1i therefore requires two basic actions:

1. Develop and/or adjust the decision-analysis framework.
2. Problem structuring: selecting criteria and developing the value tree.

For the first action, the decision-analysis framework recommended for the classification procedure has five basic steps (Table 7.2). No further recommendations are made beyond these 5 steps in order that the decision-analysis framework remains generic and non-prescriptive.

[22] Draft electronic versions of the socio-economic evaluation framework and the decision-analysis framework have been developed.

Table 7.2 Recommended decision-analysis framework for the 7-step classification procedure

Decision-analysis framework step	Recommended parallel classification procedure step
1 Problem structuring: define the problem, choose criteria, identify alternatives	1
2 Develop scoring systems/indices	2
3a Technical evaluation of alternatives	5
3b Sensitivity and trade-off alternatives	5
4a Stakeholder evaluations	6
4b Sensitivity analyses	6
5 Decision-making	7

For the second action, the 'problem' is explored, and the criteria and alternatives for evaluation are selected or defined. Since Classification Procedure Step 4 (see Section 10) defines a suite of 'starter' scenarios for each IUA and for the catchment as a whole, and since these need to be evaluated both at the IUA-level and at the catchment-level (Steps 5 and 6) (see Section 11 and 12), it is recommended that a value tree be established at the IUA-level. An example of a value tree developed for the 'proof of concept' catchment, the Olifants/Doring (see Joubert *et al*., 2007) is given in Figure 7-2. It is instructive to note that it has become convention to evaluate impacts of scenarios, alternatives etc. on the basis of three main groups of criteria: social, ecological and economic. It is recommended that this approach be adopted in Step 1i of the classification procedure, as these groups of criteria relate in turn to the objectives of equity, sustainability and efficiency that are required by the NWA.

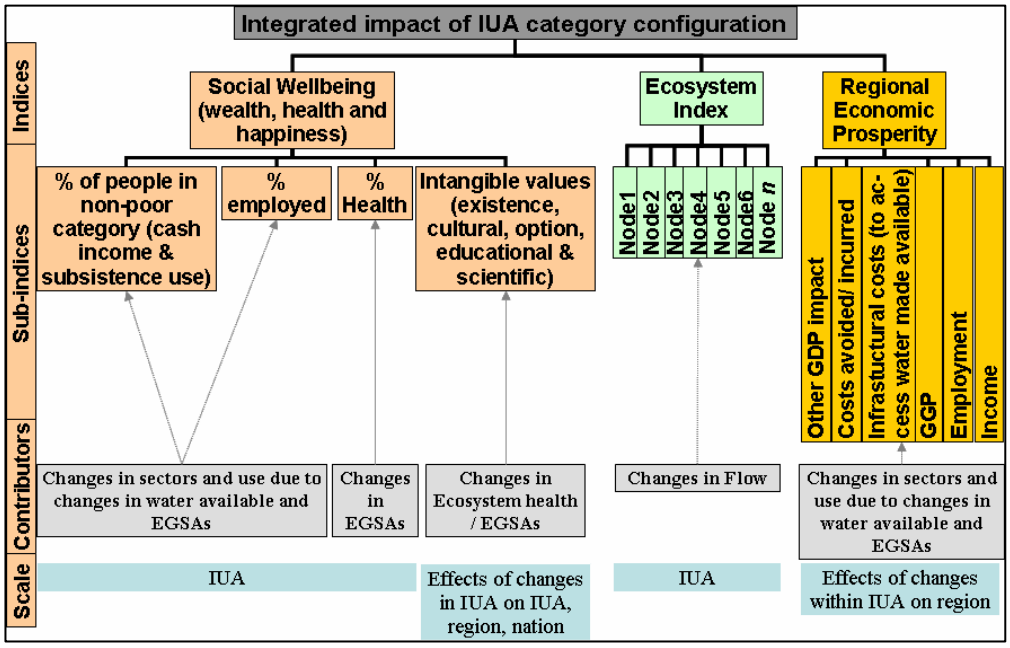

Figure 7-4 Example of a value tree. This value tree was developed for the Olifants/Doring catchment for evaluating catchment configuration scenarios for each IUA and the catchment (after Joubert *et al*., 2007)

7.3.1.2 Required outcome

The outcome for the decision-analysis component of Step 1i may include:

1. An updated decision-analysis framework for the target catchment.
2. Selected criteria and value tree for the target catchment based on a problem structuring exercise.

8 STEP 2: LINK THE VALUE AND CONDITION OF THE WATER RESOURCE

In Classification Procedure Steps 1f and 1g (Sections 7.2.4 and 7.2.5 respectively), the *present-day value* of the aquatic water use and sectoral water use is quantified. These steps therefore define a 'value baseline' against which *changes in value* can be assessed for different configurations (or scenarios) of management class (see Section 11). The ***primary objective*** of Classification Procedure Step 2 is to define the quantitative relationships that will link change in the configuration of MC scenarios to a resulting change in economic value and social wellbeing. It is important to point out, however, that due to financial and time constraints, it is unlikely that a comprehensive valuation of all aspects of water and aquatic ecosystems can be achieved during the Classification Process. A ***second objective*** of this step is therefore to rationalise those values by selecting a subset on which efforts can be concentrated for evaluating catchment configuration scenarios in Steps 5 (see Section 11) and 6 (see Section 12). Once a rationalised set of values has been identified, a transparent and defensible process must be followed to determine how economic values and social wellbeing are influenced by ecosystem characteristics and the sectoral use of water. Step 2 has as a ***third objective*** to determine the scoring system that should be used to evaluate the catchment configuration scenarios in later steps.

To address these three objectives, Classification Procedure Step 2 consists of the following sub-steps:

- Step 2a: Select the ecosystem values to be considered based on ecological and economic data;
- Step 2b: Describe the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and the sectoral use of water; and
- Step 2c: Define the scoring system for evaluating the scenarios.

Figure 8-1 presents the information pathways for Step 2 of the classification procedure.

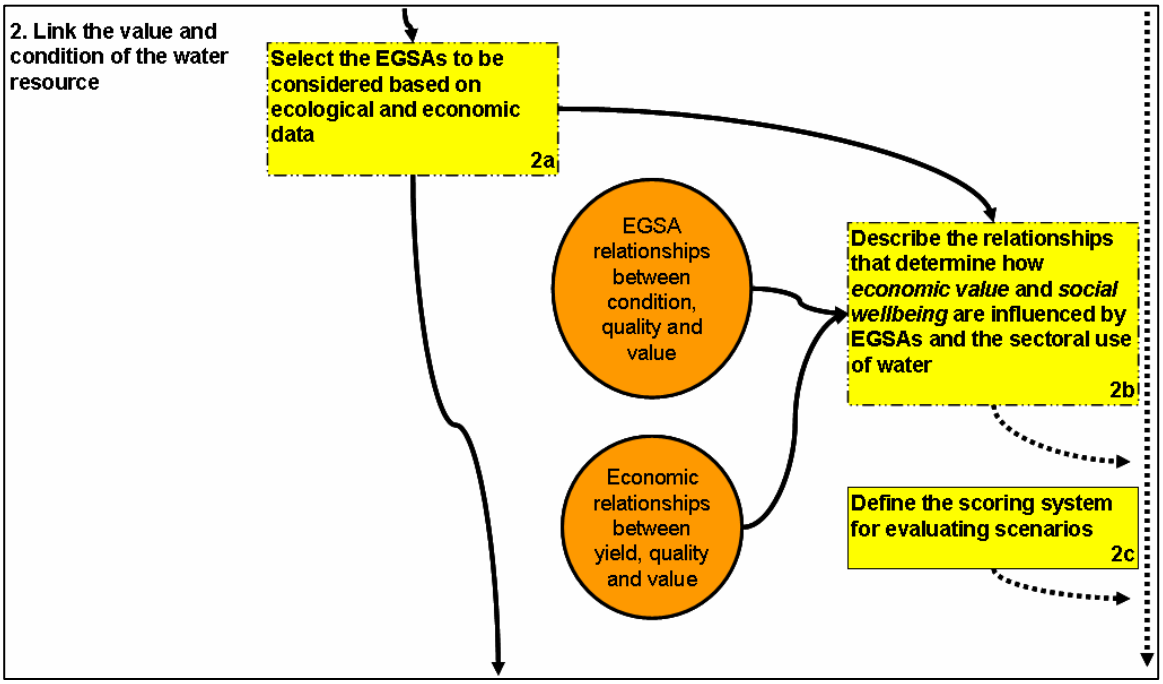

Figure 8-1 Information pathways for Step 2 of the classification procedure

8.1 Step 2: Socio-economic component

Two socio-economic sub-steps are required. These are:

- Step 2a: Select the ecosystem values to be considered based on ecological and economic data; and
- Step 2b: Describe the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and sectoral use of water.

One combined sub-step is required which is:

- Step 2c: Define the scoring system for evaluating the scenarios.

8.1.1 Step 2a: Select the ecosystem values to be considered based on ecological and economic data

8.1.1.1 Objective and information required

The objective of *selecting the ecosystem values to be considered based on ecological and economic data* is to decide on the values on which to concentrate efforts for the catchment configuration scenario analysis in Steps 5 (see Section 11) and 6 (see Section 12). For the rationalisation process, it will be necessary to consider (at least) the following information:

- current value or changes in value of EGSAs and sectoral use of water likely to be significant;
- whether sufficient ecological data are available to estimate change; and
- whether sufficient socio-economic data are available to estimate change.

Given the present state of the science, it is unlikely that all of these changes can be specified to a high degree of numerical precision. Furthermore, because some of these values and changes might be challenged by stakeholders, it is important not to claim higher precision than is warranted. For these reasons, and on the grounds that it is often the *order of magnitude* of changes in value that count, rather than the precision of the numbers, it is recommended that a rough estimate of the current value or changes in value of EGSAs and sectoral use of water is better than no estimate. It is recommended that a table be constructed with the following (value) information:

- description of value;
- probable significance in the catchment;
- data requirements from the ecological component of the classification procedure;
- possibility of being able to obtain relevant ecological data;
- other data required (social, agronomic etc.); and
- possibility of being able to obtain other relevant data.

Following this, the types of value which will be excluded in later steps of the classification procedure should be noted with justification.

8.1.1.2 Required outcome

The outcome of Step 2a may include:

1. A list of ecosystem values; including:

    - current values or changes in value of EGSAs and sectoral use of water likely to be significant;

- ecological data available to estimate change; and
- socio-economic data available to estimate change.

2. A table of ecosystem values; including:

   - description of value;
   - significance in the catchment;
   - data requirements from the ecological component of the classification procedure;
   - relevant ecological data;
   - other data (social, agronomic etc.); and
   - other relevant data.

3. A list of ecosystem values to be taken forward in the classification procedure, together with a list of discarded ecosystem values and the justification for their exclusion.

8.1.2 Step 2b: Describe the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and the sectoral use of water

8.1.2.1 Objective and information required

The objective of *describing the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and the sectoral use of water* is to quantify the relationships that exist between outputs of EGSAs and sectoral productivity, between water supply and sectoral productivity, between outputs of EGSAs and social wellbeing, and between sectoral productivity and social wellbeing. This will allow for the estimation of the impacts of changes in ecosystems and sectoral productivity at an IUA-level for different catchment configuration scenarios (see Section 11).

The present-day value should be described as appropriate (see Sections 7.2.4 and 7.2.5), and may only be partially valued (e.g. the affected portion only). For the catchment configuration scenarios all values should be expressed as change from present-day, and in Rands per year. A common base-year will have to be agreed upon, e.g. all in 2006 Rands. Valuation should take place at the level of the IUA. Wherever possible, the values should be estimated based on existing catchment-specific information. For relationships where catchment-specific information does not exist, values may be estimated from a broader knowledge base in conjunction with reasonable and explicit assumptions. It is not possible to generalize these relationships in detail in this report, since the circumstances and data availability for different catchments will almost certainly require some modifications to be made each time the procedure is applied.

The descriptions and values may conveniently be categorized into four groups:

1. **sectoral turnover** (which contributes to economic prosperity as well as to social wellbeing);
2. EGSAs that result in **costs avoided/incurred** (and therefore contribute to economic prosperity);
3. **other EGSAs** (which contribute both to social wellbeing and to economic prosperity); and
4. **intangible use and non-use values**.

Figure 7-2 presents a graphical summary of these values to be considered.

For valuing sectoral use of water that contributes to social wellbeing and economic prosperity (see V6-V13 in Figure 7-2), the following could be considered:

- coal power;

- urban industry;
- non-urban industry;
- domestic use;
- mining;
- streamflow reducing activities;
- hydroelectric power; and
- irrigated agriculture.

For valuing EGSAs that result in costs avoided/incurred and contribute to social wellbeing and economic prosperity (see V1-V5 and V19 in Figure 7-2), the following could be considered:

- carbon sequestration;
- flood attenuation;
- erosion control and sediment trapping;
- waste absorption;
- pests and pathogens; and
- domestic use of instream water.

For valuing other EGSAs that contribute to social wellbeing and economic prosperity (see V14-V19 in Figure 7-2), the following could be considered:

- flow contribution to floodplain agriculture;
- livestock production;
- tourism and recreation;
- refugia, nursery areas and export of sediment and nutrients;
- value of harvested goods; and
- domestic use of instream water.

For valuing intangible use and non-use values that contribute to social wellbeing, the following could be considered:

- cultural and spiritual value;
- educational and scientific value; and
- option and existence value.

8.1.2.2 Required outcome

The outcome of Step 2b should include descriptions of the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and sectoral use of water and may include:

1. Descriptions and values of **sectoral use of water** that contributes both to social wellbeing and economic prosperity, including but not limited to:
    - coal power;
    - urban industry;
    - non-urban industry;
    - domestic use;
    - mining;
    - streamflow reducing activities;
    - hydroelectric power; and
    - irrigated agriculture.

2. Descriptions and values of **EGSAs that result in costs avoided/incurred** and contribute to social wellbeing and economic prosperity, including but not limited to:

    - carbon sequestration;
    - flood attenuation;
    - erosion control and sediment trapping;
    - waste absorption;
    - pests and pathogens; and
    - domestic use of instream water.

3. Descriptions and values of **other EGSAs** that contribute to social wellbeing and economic prosperity, including but not limited to:

    - flow contribution to floodplain agriculture;
    - livestock production;
    - tourism and recreation;
    - refugia, nursery areas and export of sediment and nutrients;
    - value of harvested goods; and
    - domestic use of instream water.

4. Descriptions and values of **intangible use and non-use values** that contribute to social wellbeing, including but not limited to:

    - cultural and spiritual value;
    - educational and scientific value; and
    - option and existence value.

5. Predictive relationships that estimate changes in social wellbeing for different catchment configuration scenarios based on, for example, numbers of jobs, proportion of non-poor households, health and happiness.

8.2 Step 2: Decision-analysis component

One decision-analysis component sub-step is required in Step 2:

- Step 2c: Define the scoring system for scenario evaluations.

8.2.1 Step 2c: Define the scoring system for evaluating scenarios

8.2.1.1 Objective and information required

The objective of this sub-step is to *define the scoring system* that can be used to *evaluate the* catchment configuration *scenarios* in Steps 5 and 6 (see Sections 11 and 12 respectively). As mentioned earlier, it has become convention to evaluate the implications of scenarios on the basis of three main groups of criteria: social, ecological and economic. For this and other reasons, it is recommended that the scoring system allow for the evaluation of the implications of catchment configuration scenarios in terms of social wellbeing, ecosystem health and economic prosperity. The scoring systems should therefore incorporate indices that account for (at least):

- social wellbeing;
- ecosystem health; and
- economic prosperity.

A social wellbeing score could be a combination of indices of:

- percentage of households in an IUA who are poor/non-poor;
- percentage of people employed in an IUA;
- descriptors/measures of human health in an IUA; and
- intangible values in the IUA (e.g. existence value).

An ecosystem health score could be a combination of indices of:

- ecological categories within an IUA; and
- IUA class.

An economic prosperity score could be a combination of indices of:

- gross geographic product (GGP);
- gross domestic product (GDP);
- costs avoided/incurred;
- infrastructural costs;
- income to poor households; and
- jobs.

8.2.1.2 Required outcome

The outcome of Step 2c should be a scoring system for the evaluation of scenarios in later steps of the classification procedure (i.e. Steps 5 and 6, Sections 11 and 12 respectively). The scoring systems should therefore incorporate indices that account for (at least):

- social wellbeing;
- ecosystem health; and
- economic prosperity.

A social wellbeing score could be a combination of indices of:

- percentage of households in an IUA who are poor/non-poor;
- percentage of people employed in an IUA;
- descriptors/measures of human health in an IUA; and
- intangible values in the IUA (e.g. existence value).

An ecosystem health score could be a combination of indices of:

- ecological categories within an IUA; and
- IUA class.

An economic prosperity score could be a combination of indices of:

- gross geographic product (GGP);
- gross domestic product (GDP);
- costs avoided/incurred; and
- infrastructural costs.

9 STEP 3: QUANTIFY ECOLOGICAL WATER REQUIREMENTS (EWRS) AND CHANGES IN NON-WATER QUALITY ECOSYSTEM GOODS, SERVICES AND ATTRIBUTES (EGSAS)

The *objective* of Step 3 of the classification procedure is to *quantify the EWRs* and to *describe the changes in non-water quality EGSAs*. While the quantification of EWRs is part of the Reserve determination process (see NWA, Chapter 3), the determination of the Reserve is part of the Classification Process [**S13**(**3**)]. However, given that there are existing 'signed-off' preliminary Reserves in many catchments, two situations may arise in a catchment targeted for classification. First, a Classification Process may occur in a catchment with an existing preliminary Reserve. Secondly, a Classification Process may occur where there is no existing Reserve. In the case of the second situation, a Reserve determination process would need to be instigated and incorporated into the Classification Process, in which case, standard Reserve procedures should be followed (DWAF, 1999). However, in the case of an existing preliminary Reserve (first situation) an extrapolation process would be required, and if necessary, high confidence EWR data collected.

The *objective in describing changes in the non-water quality EGSAs* is to provide the information that will be used in later steps of the classification procedure (see Sections 11 and 12) to assess the impacts of changes in catchment configuration scenarios on non-water quality EGSAs. To incorporate these objectives, Step 3 consists of the following sub-steps:

- Step 3a: Identify nodes to which existing Resource Directed Measures (RDM) data can be extrapolated and extrapolate;
- Step 3b: Develop rule curves, summary tables and modified time series for all nodes for all ecological categories; and
- Step 3c: Quantify the changes in relevant ecosystem components, functions and attributes for each ecological category for each node.

Figure 9-1 presents the information pathways for Step 3 of the classification procedure.

9.1 Step 3: Ecological sub-steps for Step 3

For the ecological component of Step 3, two sub-steps and one combined sub-step are required. These are:

- Step 3a: Identify nodes to which existing Resource Directed Measures (RDM) data can be extrapolated and extrapolate;
- Step 3b: Develop rule curves, summary tables and modified time series for all nodes for all ecological categories; and
- Step 3c: Quantify the changes in relevant ecosystem components, functions and attributes for each ecological category for each node.

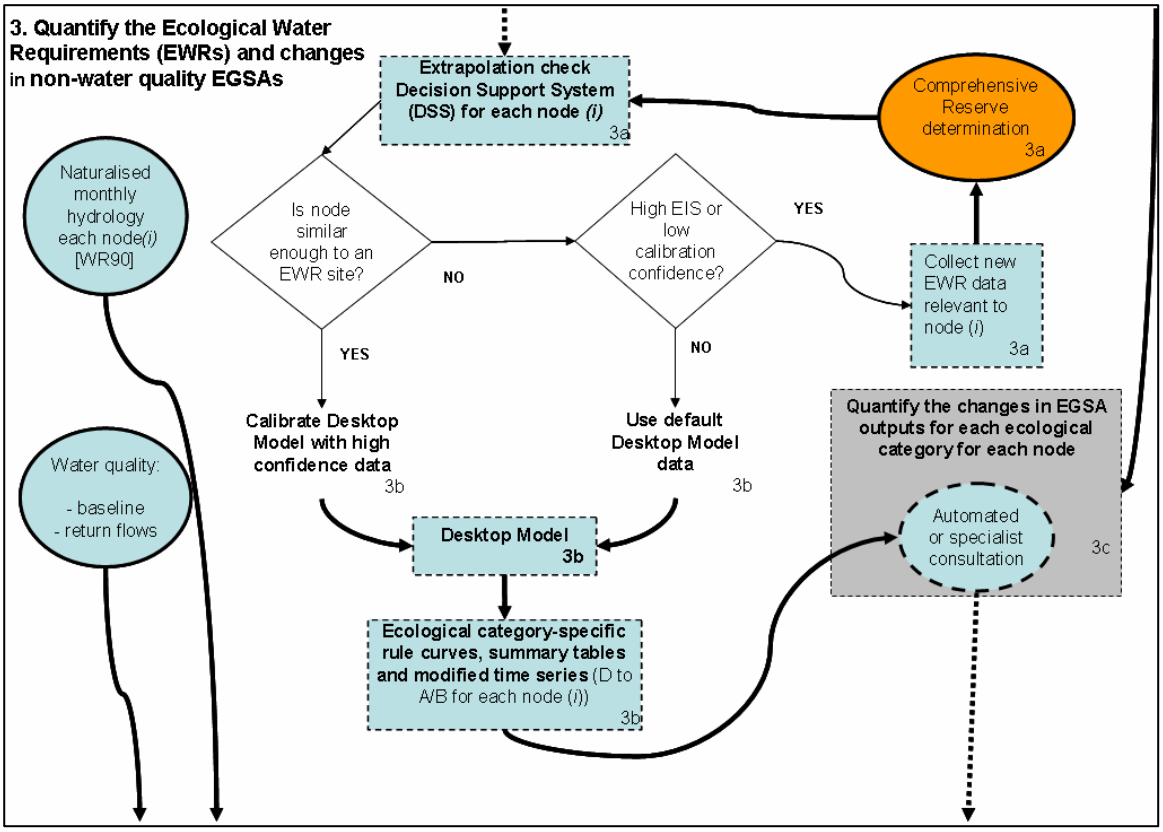

Figure 9-1 Information pathways for Step 3 of the classification procedure

9.1.1 Step 3a: Identify nodes to which existing Resource Directed Measures (RDM) data can be extrapolated and make the extrapolation

9.1.1.1 Objective and information required

The objective of *identifying nodes to which existing RDM data can be extrapolated and extrapolate* is to assess whether high-confidence Reserve data at established EWR sites can be extrapolated to any of the biophysical nodes established in Step 1d (Section 7.1.2). This should be followed by an extrapolation procedure based on the outcome of the assessment. In order to identify which nodes can be extrapolated to, a distinction needs to be made between:

- nodes that are suitable for extrapolation from high-confidence Reserve data; the EWR quantification for those nodes should be based on those data rather than a desktop model (e.g. Hughes and Hannart, 2003); and
- nodes that are not suitable for extrapolation from sites with high-confidence Reserve data; the EWR quantification for those nodes should be based on a desktop model (e.g. Hughes and Hannart, 2003).

Step 3a also has implications for Step 3c (see Section 9.1.3), in that changes in some biophysical EGSAs can only be provided:

- at nodes that are suitable for extrapolation from sites with high-confidence Reserve data; and
- for EGSAs that were considered during the Reserve determination process.

The procedure for determining whether existing Reserve data can be extrapolated to biophysical nodes should use a defensible extrapolation Decision-Support System (DSS). A draft procedure

like that being developed by Louw et al. (2006) should be followed, but will need to be updated as and when required. In essence, the procedure should allow for a consistent, transparent decision-making process to assess whether:

- the node being extrapolated to is sufficiently similar to an EWR site that has high-confidence Reserve data attached to it to allow for extrapolation; and
- the node being extrapolated to has a high EISC, in which case, high-confidence Reserve data should be collected for the target node.

As a minimum, however, the extrapolation procedure should account for:

- the high-confidence EWR site's and target node's biophysical and ecological characteristics;
- the high-confidence EWR site's and target node's hydrological characteristics; and
- the high-confidence EWR site's and target node's geomorphological characteristics.

9.1.1.2 Required outcome

The outcome of Step 3a may include:

1. A list of nodes to which information can be extrapolated; including a description of:

    - nodes that are suitable for extrapolation from high-confidence Reserve data; and
    - nodes that are not suitable for extrapolation from sites with high-confidence Reserve data.

2. A description of an extrapolation procedure that ensures that:

    - the node(s) being extrapolated to is/are sufficiently similar to an EWR site that has high-confidence Reserve data to allow for extrapolation; and
    - the node(s) being extrapolated to has/have a high EISC, in which case, high-confidence Reserve data should be collected for the target node(s).

9.1.2 Step 3b: Develop rule curves, summary tables and modified time series for all nodes for all ecological categories

9.1.2.1 Objective and information required

The objective of *developing rule curves, summary tables and modified time series for all nodes for all ecological categories* is to provide the EWRs for each node for each ecological category. These will be used in Steps 4 to 6 of the classification procedure. Step 3b requires generating the EWRs using models such as the Desktop Model (Hughes and Hannart, 2003) at nodes identified as not being suitable for extrapolation (see Section 9.1.1.2), and/or the generation of EWRs using the method used during the Reserve determination study (e.g. Flow Habitat Stressor Response (FHSR), Downstream Response to Instream Flow Transformations (DRIFT)) at nodes that are suitable for extrapolation (see Section 9.1.1.2). In the case of a catchment where there is no signed-off preliminary Reserve, a consistent procedure will need to be followed to assess the level of ecological Reserve assessment required (i.e. Comprehensive, Intermediate, Rapid, Desktop).

Ideally, the EWRs should be generated for each node for the maintenance of a full-suite of ecological conditions that will allow consideration of any ecological category from A/B to D for all resources. These should include:

- category A/B;
- category B;

- category C;
- category D; and where applicable
- intermediate categories (e.g. C/D, C/B).

9.1.2.2 Required outcome

The outcome of Step 3b may include:

1. EWR rule curves for each category for each node.
2. EWR summary tables for each category for each node.
3. Modified time series for each category for each node.

9.1.3 Step 3c: Quantify the changes in relevant ecosystem components, functions and attributes for each ecological category for each node

9.1.3.1 Objective and information required

The objective of Step 3c is to *quantify the changes in relevant ecosystem components, functions and attributes for each ecological category for each node* to help evaluate the socio-economic and ecological implications of different catchment configuration scenarios in later steps of the classification procedure (see Sections 11, 12 and 13). The required information on changes in ecosystem components, functions and attributes can be divided into five broad groups, *viz*:

1. Hydrological characteristics, which can be further divided into three groups:

    a. those for which system yield is required, and which can be determined using a water resources yield model;
    b. those for which a percentage change in volume can be provided from hydrological models/EWR results, e.g. water use; and
    c. those for which a combination of hydrology and hydraulics is required and which are unlikely to provided for the WRCS in the near future.

2. Biological components and processes, which can be further divided into two groups:

    a. those for which an index of change in abundance (or surrogate for abundance) from pre-development conditions can be derived from RDM studies, provided the information pertains to one or more of the sub-components of the ecosystems that were considered in the study; and
    b. those that require more detailed studies than are normally undertaken as part of a RDM study.

3. Physical components and processes, excluding water quality, that usually require more detailed studies than are normally undertaken as part of the RDM study.

4. Water quality characteristics for which a change in 'fitness for use' for a particular activity can be provided.

5. Structure and organisation of aquatic ecosystems, which can be further divided into two groups:

    a. those that are assumed to be related to ecological condition; and
    b. those for which the required information is not available.

Information on the hydrological changes can be provided by a water resources yield model. Information on the changes in biological components and processes can be provided for the nodes that the Extrapolation DSS (Step 3a – see Section 9.1.1) indicated could be assessed using

Comprehensive Reserve data.[23] Information on changes in physical components and processes are unlikely to be provided unless existing methods are improved, while information of water quality characteristics can be provided by a suitable water quality model. Information on changes in the structure and organisation of biological communities cannot be easily provided, and for this reason it is suggested that an assumption be made that a direct relationship exists between ecological category and the structure and organisation of biological communities. For example, assume that an A/B category represents 100% of value, and as one moves along the continuum to a B, C and D, the value declines.

9.1.3.2 Required outcome

The outcome of Step 3c may include:

1. A rationalised list of the EGSA information required for the socio-economic component of the classification procedure including:

    a. resource component (i.e. whole system/IUA, river, wetland, estuary, groundwater);
    b. EGSA considered (e.g. food, medicines);
    c. description of value (e.g. subsistence or commercial use);
    d. aspects considered (e.g. medicinal plants); and
    e. output from RDM studies (e.g. index of change in abundance from pre-development condition for reeds and sedges).

2. A list of biophysical and allocation nodes for which changes in EGSAs can be provided (i.e. for the whole system/IUA, river, wetland, estuary and groundwater).

3. A list of hydrological, biological, physical, water quality, and structure and organisational EGSA changes considered for the target catchment including:

    a. relevant IUA(s);
    b. relevant node(s);
    c. EGSA considered; and
    d. estimated change from pre-development conditions for each category (e.g. for IUA Doring Rangelands in the Olifants/Doring catchment, at node R20, 20-39% of the large endemic fish will be retained).

[23] If the relevant biological components and processes were not considered during the Reserve study, then it is unlikely that this information can be provided. This requires that future Terms of Reference for Reserve studies indicate that this information is required.

10 STEP 4: DETERMINE AN ECOLOGICALLY SUSTAINABLE BASE CONFIGURATION (ESBC) SCENARIO AND ESTABLISH STARTER CONFIGURATION SCENARIOS

The objective of Step 4 of the classification procedure is to *determine the ecologically sustainable base configuration scenario (ESBC) and to establish starter catchment configuration scenarios*. The legal requirement of an ecologically sustainable base is provided for by the Constitution (Turton, 2006), NWA and DWAF policy. The NWA stipulates that a resource should be managed to ensure that it may be used in an ecologically sustainable way. Further, RDM policy states that this minimum level of health should be at least a D category condition (DWAF, 1999)[24], or a Class III for water quality (DWAF, 1999), leading to an overall MC of 'Heavily utilised'. In the classification procedure, provision is made for determining this minimum level of health – the ESBC. For the purposes of this report, the ESBC scenario is defined as the *lowest theoretical level of protection required for the sustainable use of the entire catchment*.

The objective in *establishing starter catchment configuration scenarios* is three fold:

- to establish a feasible number of catchment configuration scenarios for assessment by the regulator (DWAF) and the stakeholders;
- to incorporate planning scenarios (future use, equity considerations, ELU); and
- to establish RDM starter catchment configuration scenarios (e.g. guided by the EcoClassification procedure).

The RDM starter catchment configuration scenarios and the ESBC scenario require a response on the part of water users, while the planning scenarios are prescriptive in terms of the yield required from the system.

To incorporate these objectives, Step 4 consists of the following sub-steps:

- Step 4a: Determine an ESBC scenario that meets feasibility criteria for water quantity, water quality, and ecological needs.
- Step 4b: Incorporate the planning scenarios (future use, equity considerations and existing lawful use); and
- Step 4c: Establish the RDM configuration scenarios.

Figure 10-1 presents the information pathways for Step 4 of the classification procedure.

10.1 Step 4: Ecological sub-steps for Step 4

For the ecological component of Step 4, two sub-steps and one combined sub-step are required. The ecological sub-steps include:

- Step 4a: Determine an ESBC scenario that meets feasibility criteria for water quantity, water quality, and ecological needs; and
- Step 4c: Establish the RDM catchment configuration scenarios.

The combined sub-step is:

- Step 4b: Incorporate the planning scenarios (future use, equity considerations and existing lawful use).

[24] The ESBC scenario is not scientifically designated limit.

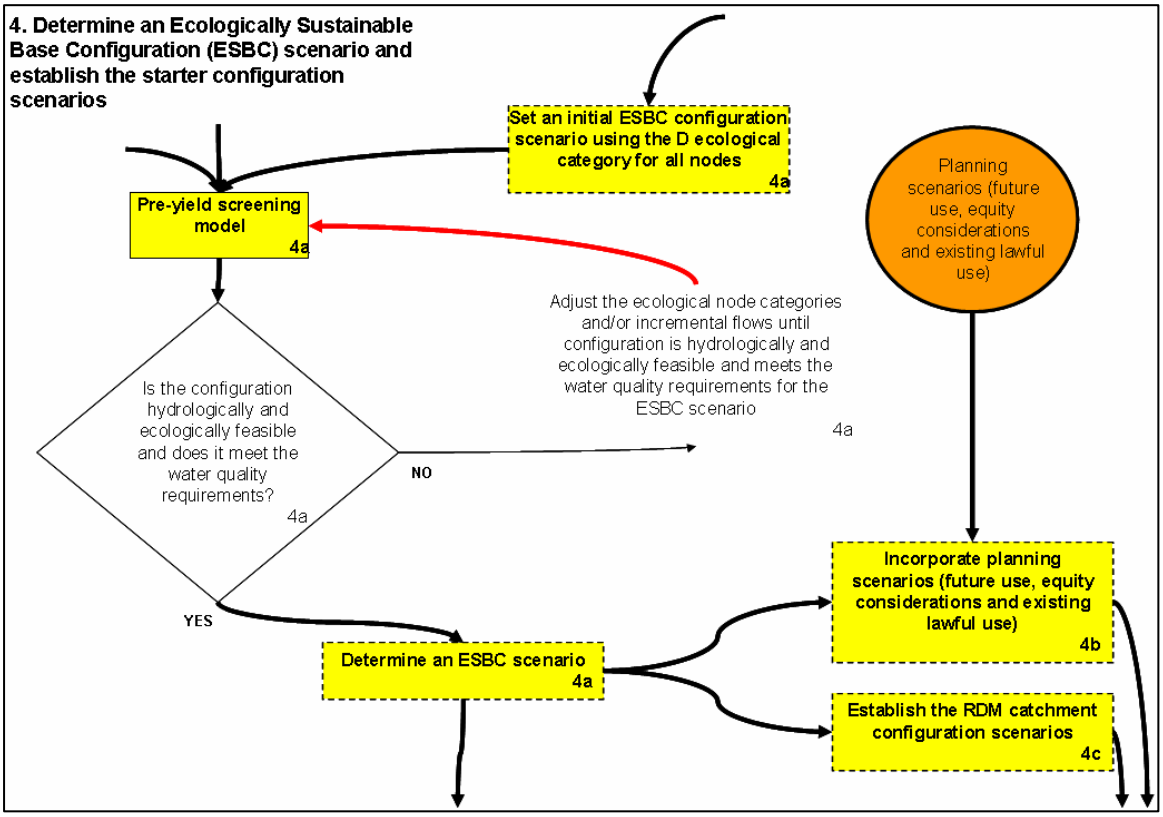

Figure 10-1 Information pathways for Step 4 of the classification procedure

10.1.1 Step 4a: Determine an ESBC scenario that meets feasibility criteria for water quantity, water quality and ecological needs

10.1.1.1 Objective and information required

The objectives of *determining an ESBC scenario and of testing its feasibility for water quantity, quality and ecological needs* are a) to meet the requirements of the NWA and of DWAF policy, and b) to ensure that the proposed ESBC catchment configuration scenario is feasible from a water quantity, quality and ecological perspective. If the initial ESBC scenario is not feasible,[25] an iterative process needs to be followed to determine a feasible ESBC scenario. In order to protect EWR requirements at the downstream end of a catchment, the EWRs (flow contributions) from the upstream portions also need to be stipulated. The ESBC scenario is therefore not a target scenario, as it needs to inform the lowest level of protection required for any of the other configuration scenarios.

The establishment of an ESBC scenario requires utilising the links established between flow and resource condition (see Section 9.1.3) to predict the condition of resources (including the estuary) in a catchment by moving sequentially upstream/downstream (and up gradient for groundwater) using a D category as the starting point at each node (Figure 10-2). This requires starting at the downstream end of a catchment, and working upstream in segments (defined by nodes), at each stage determining:

- the water quantity, distribution and quality requirements to maintain the downstream reaches in their minimum sustainable condition;

[25] The initial ESBC scenario simply begins by placing every node in ecological category D. This configuration is unlikely to be feasible from either a water quantity or water quality perspective, especially for the nodes lower down in the catchment.

- the ecosystem functions supporting the base condition (i.e. minimum sustainable condition) of the downstream/down gradient reaches; and
- the quantity, distribution and quality requirements to support the ecosystem functions identified above.

The base condition for each resource (i.e., each node) is then established either as a D category or as whichever higher category is required to maintain all the downstream nodes in at least a D category. This requires, for example, the lower main stem to be maintained in at least a D category. However, a higher-than-D category could result if:

- the Reserve required to maintain a downstream node in a D category would result in a better-than-D-category condition at the upstream nodes(s), or;
- ecosystem functions supporting the D category in the estuary, such as spawning or feeding grounds for anadromous fish, require a better-than-D category condition in the lower main stem.

It is important to note that in establishing the ESBC scenario, a calibrated hydrological and water quality model is required for the targeted catchment. However, in the absence of such, coarse-level cross-checks are possible based on the nMAR requested by the EWRs. It is instructive to note that one of the consequences of setting the ESBC scenario for sustainable utilisation based on RDM lower limits for riverine and estuarine condition is that the options for trade-offs in the resources higher in the catchment will be constrained by the need to support a D category or higher in that resource and the downstream resources.

A procedure is therefore needed to establish the ESBC scenario that allows for transparent and consistent decision-making. The procedure should incorporate at least the following information and steps:

- the cumulative EWRs for a suite of categories (A/B to D) for all nodes;
- the incremental EWRs for a suite of categories (A/B to D) for all quaternary catchments;
- incremental evaporative losses for all quaternary catchments;
- assigning all nodes a D category;
- testing the hydrological (water quality and quantity) feasibility of meeting a D category for all nodes, and;
    - where the node condition is not met, increasing the category of various upstream node(s), and/or increasing the category for the tributaries in an upstream quaternary catchment until the ESBC requirement is met for the whole catchment; and
- testing the ecological feasibility of the hydrologically-adjusted ESBC scenario.

10.1.1.2 Required outcome

The outcome of Step 4a may include:

- a hydrologically (water quality and quantity) and ecologically tested ESBC scenario that defines the lowest theoretical level of protection required for the sustainable use of the entire catchment.

10.1.2 Step 4b: Incorporate the planning scenarios (future use, equity considerations and existing lawful use)

10.1.2.1 Objective and information required

The objective of *incorporating the planning scenarios (future use, equity consideration and existing lawful use)* (utilising the allocation nodes established in Step 1d (see Section 7.1.2) developed outside the Classification Process is to develop a suite of catchment configuration scenarios for evaluation in Steps 5 and 6 (Sections 11 and 12). This is in order to:

- provide information on the quantity (volume and distribution) and quality of water that remains in the resource at each node; and
- provide information on the quantity (volume and distribution) and quality of water to determine the ecological category that would result.

This information is slightly different from the RDM catchment configuration scenarios (Step 4c – see Section 10.1.3) and the ESBC scenario (Step 4a – see Section 10.1.1) which will need to:

- determine the ecological category at each node and the ecological water requirements for maintaining that category; and
- evaluate the yield that would result.

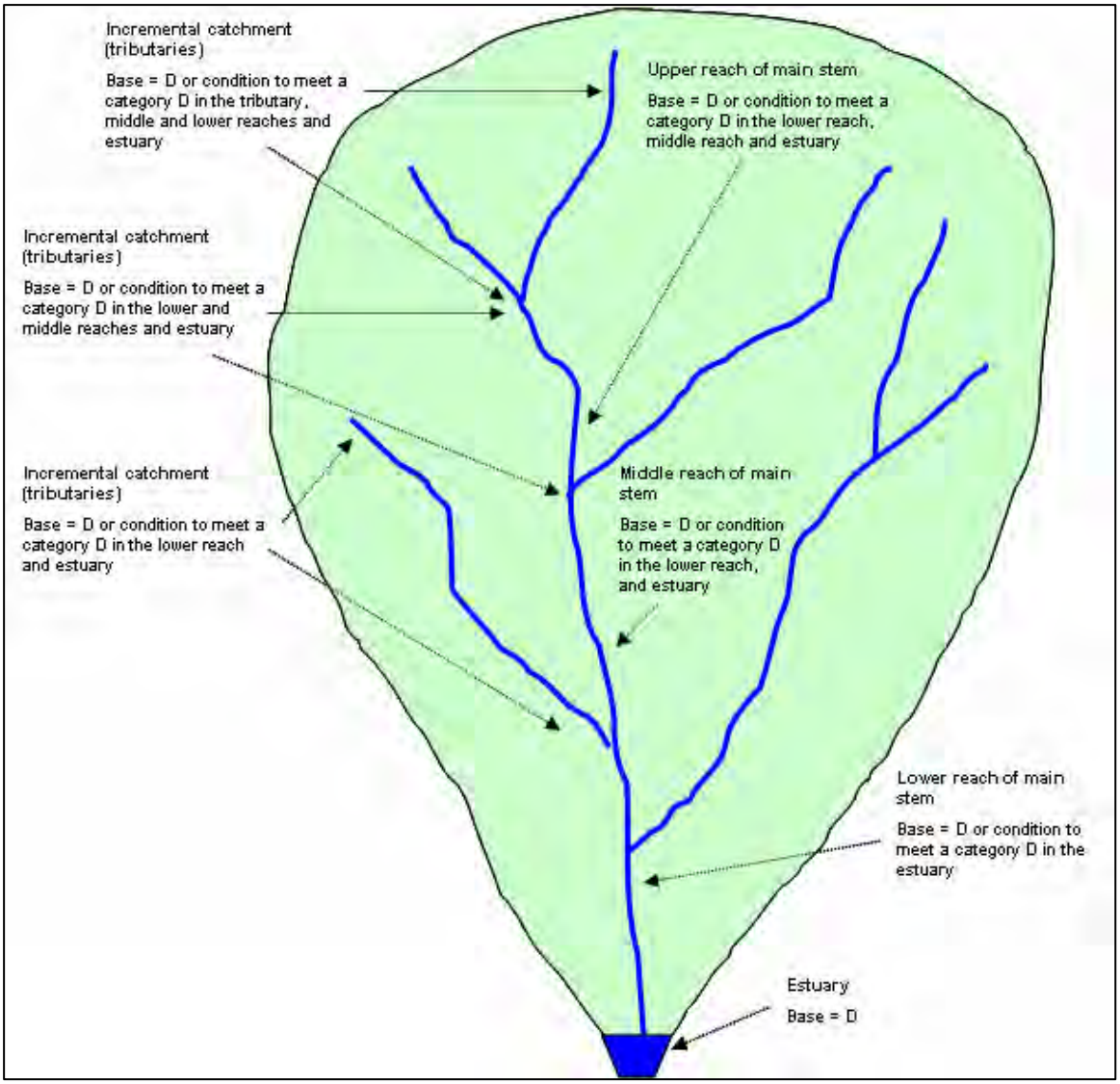

Figure 10-2 Schematic illustrating a downstream dependence on upstream condition for a hypothetical, simplified catchment (modified after Brown *et al.,* 2007)

The procedure for Step 4b needs to be developed and incorporated into the classification procedure as and when required.

10.1.2.2 Required outcome

The outcome of Step 4b may include:

- planning scenarios (e.g. future use, equity considerations and ELU) for the water allocation and biophysical nodes established in Step 1d with information on:
  - the quantity (volume and distribution) and quality of water that remains in the resource at each node; and
  - the quantity (volume and distribution) and quality of water to determine the ecological category that would result.

10.1.3 Step 4c: Establish the RDM configuration scenarios

10.1.3.1 Objective and information required

The objective is *establishing the RDM configuration scenario is* to provide a suite of RDM scenarios for evaluation in Classification Procedure Step 5 (see Section 11). The RDM catchment configuration scenarios should be based on those used in major RDM studies, e.g. Thukela

Reserve study. They should be grounded in EcoClassification (Louw *et al.,* 2006) and provide for the initial establishment of catchment configuration scenarios. These may be:

- Present Ecological Status (PES) catchment configuration, i.e. all reaches represented by nodes with EWRs to maintain PES;
- Recommended Ecological Category (REC) configuration, i.e. reaches represented by nodes with EWRs to maintain REC;
- Freshwater Conservation targets[26] overlain on REC configuration; and
- Freshwater Conservation targets overlain on PES catchment configuration.

The procedure followed to establish the RDM catchment configurations should take into consideration (at least):

- International Water Agreements (IWAs) and BHNs;
- ESBC scenario;
- PES/HI at each node;
- EISC at each node;
- Freshwater Conservation targets; and
- a rationalisation process.

10.1.3.2 Required outcome

The outcome of Step 4c should include:

- a suite of RDM-informed catchment configuration scenarios.

As a minimum, each RDM scenario should:

- stipulate an ecological category for each node and the ecological water requirements for maintaining that category;[27] and
- evaluate the yield that would result.

[26] These scenarios should be generated outside of the Classification Process, but will need to be incorporated into the classification procedure for each targeted catchment.
[27] Remembering that meeting the EWR for a given node depends on all the inflows to the upstream nodes as well.

11 STEP 5: EVALUATE SCENARIOS WITHIN THE INTEGRATED WATER RESOURCE MANAGEMENT (IWRM) PROCESS

As mentioned previously, the WRCS is necessarily an integral component of the IWRM environment. This means that the Classification Process is linked to other processes in the integrated planning of water resource protection, development and utilisation, and to processes for the management and control of water use. A key component of IWRM is therefore an iterative process of evaluating the catchment configuration scenarios developed in Step 4 within DWAF prior to the stakeholder evaluation process in Step 6 (see Section 12). The objective of Step 5 of the classification procedure is therefore to *evaluate scenarios within the integrated water resource management (IWRM) process* so that a subset of catchment configuration scenarios can be put forward for stakeholder evaluation in Step 6.

To incorporate these objectives, Step 5 consists of the following sub-steps:

- Step 5a: Run a yield model for the ESBC and other scenarios and adjust the scenarios if necessary;
- Step 5b: Assess water quality implications (fitness for use) for all users;
- Step 5c: Report on the IUA-scale ecological condition and aggregate impacts for each preliminary scenario;
- Step 5d: Value the changes in aquatic ecosystems and water yield;
- Step 5e: Describe the macro-economic and social implications of different catchment configuration scenarios;
- Step 5f: Evaluate the overall scenario implications at an IUA-level and a regional-level; and
- Step 5g: Select a subset of scenarios for stakeholder evaluation.

Figure 11-1 and Figure 11-2 present the information pathways for Step 5a and b, and 5c, d, e, f and g respectively.

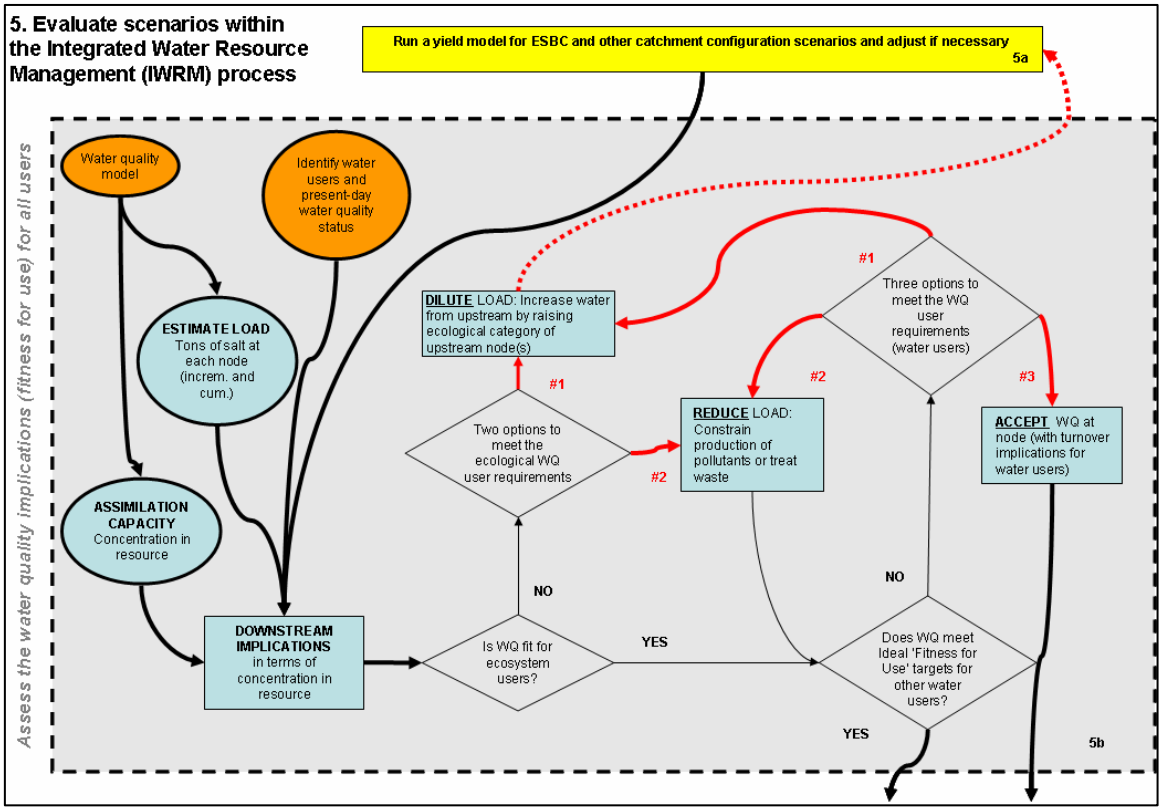

Figure 11-1 Information pathways for Step 5a and 5b of the classification procedure

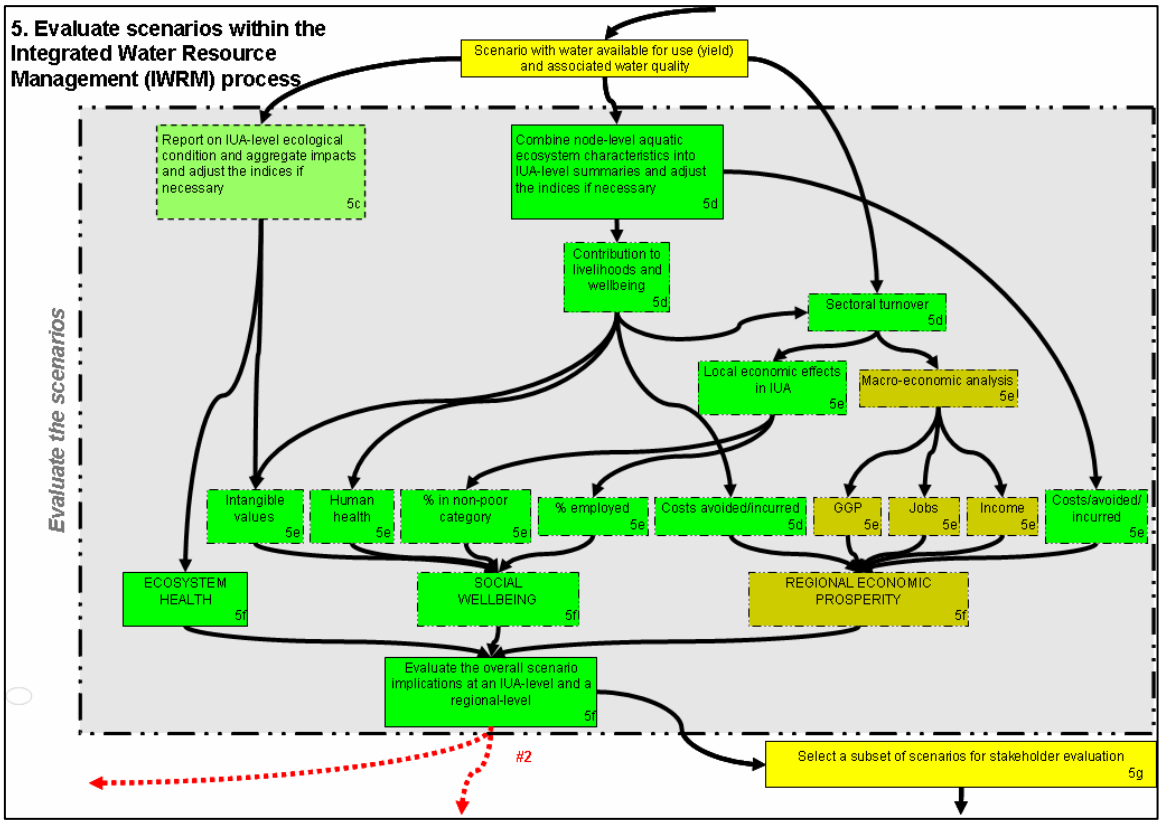

Figure 11-2 Information pathways for Steps 5c, 5d, 5e, 5f and 5g of the classification procedure

11.1 Ecological sub-steps for Step 5

For the ecological component of Step 5, two sub-steps and one combined sub-step are required. The two ecological sub-steps are:

- Step 5b: Assess the water quality implications (fitness for use) for all users; and
- Step 5c: Report on the IUA-scale ecological condition and aggregate impacts for each preliminary scenario.

The combined sub-step is:

- Step 5a: Run a yield model for the ESBC and other catchment configuration scenarios.

11.1.1 Step 5a: Run a yield model for the ESBC and other scenarios and adjust the scenarios if necessary

11.1.1.1 Objective and information required[28]

The objective of *running a yield model for the ESBC and other catchment configuration scenarios and adjusting the scenarios if necessary* is to test the operational feasibility of the scenarios generated in Step 4 (see Section 10), given the current water supply infrastructure and ELU in the target catchment. The scenarios will need to be adjusted where the EWR requirements fail[29].

11.1.1.2 Required outcome

The outcome of Step 5a may include:

- Adjusted catchment configuration scenarios for input into Step 5b and beyond.

11.1.2 Step 5b: Assess the water quality implications (fitness for use) for all users

11.1.2.1 Objective and information required

The objective of assessing the *water quality implications (fitness for use) for all users* of the ESBC and Other catchment configuration scenarios is to ensure that a particular catchment configuration scenario meets the 'fitness for use' categories established in the South African Water Quality Guidelines (SAWQG) (DWAF, 1996b)[30] for all users. To achieve these objectives, it will be necessary to:

1. Assess the present-day water quality requirements for all water users.
2. Assess the water quality implications of different scenarios for different users and adjust the scenarios where necessary to address 'fitness for use' requirements.

To assess the present-day water quality status, it will be necessary to identify all users[31] within a targeted catchment, assess their water quality requirements, and then assess whether the present-day water quality meets their requirements. This needs to be done for all IUAs and will require:

- identifying the water user sectors and sub-sectors for each IUA together with their water quality requirements;

[28] This procedure will need to be further developed with each application of the WRCS.
[29] Some of these will have been addressed in high confidence EWR studies.
[30] SAWQG are currently being revised, and should be incorporated as and when appropriate
[31] The user sectors are described in DWAF (1996b)

- identifying those water user sectors who have stricter requirements than those listed in the SAWQG (DWAF, 1996b);
- identifying generic water quality requirements for specific users;
- water quality data for each IUA; and
- assessing whether the present-day water quality meets the water user sector and sub-sector requirements for each IUA for at least the 50th and 95th percentile.

To assess the water quality implications of different catchment configuration scenarios for all users (including ecosystem use), the following procedure is recommended:

a. predict the Total Dissolved Salts (TDS) concentrations at each IUA outflow node utilising a suitable model;
b. check the salinity concentrations at the IUA outflow nodes against the water quality user requirements for the downstream IUA;
c. predict the concentrations of other constituents at the IUA outflow nodes;
d. check concentrations of other constituents at the IUA outflow nodes against the water quality user requirements for the downstream IUA;
e. assess options which may include:
    1. provide more water for dilution (implying a higher ecological category); and/or
    2. change the salt loads from the point- and non-point sources (implying management intervention to reduce loads); and/or
    3. change water user requirements (implying water users have to accept a poorer water quality and cope with the implications thereof);
f. iterate until a satisfactory solution is achieved for each catchment configuration scenario; and
g. package the data and provide to the socio-economist for use in Steps 5d and 5e of the classification procedure (see Sections 11.2.1 and 11.2.2).

11.1.2.2 Required outcome

The outcome of assessing the present-day water quality status for all water users (part of Step 5b) may include:

- a list of water user sectors and sub-sectors for each IUA and their water quality requirements;
- a list of water user sectors with stricter requirements than those listed in the SAWQG (DWAF, 1996b);
- a list of modified generic water quality requirements for specific users;
- water quality data for each IUA; and
- an assessment of whether the present-day water quality meets the water user sector and sub-sector requirements per IUA for at least the 50th and 95th percentile.

The outcome of assessing the water quality implications (fitness for use) of the catchment configuration for all users (part of Step 5b) may include:

- predicted TDS concentrations at the IUA outflow nodes;
- salinity concentrations at the IUA outflow nodes assessed against the water quality user requirements of the downstream IUA;
- predicted concentrations of other constituents at the IUA outflow nodes;
- checked concentrations of other constituents at the IUA outflow nodes against the water quality user requirements of the downstream IUA;
- assessed options that require one or more of the following decisions to be made (if necessary):
    - provision for more water for dilution (a higher ecological category);

- a requirement to change the salt loads from the point- and non-point sources (implying management intervention to reduce loads); and
- a change in the water user requirements (implying water users have to accept a poorer water quality and cope with the implications thereof);

- description of the iterative steps followed to achieve a satisfactory solution for each catchment configuration scenario; and
- data packaged for the socio-economist to be used in Steps 5c and 5d (see Sections 11.2.1 and 11.2.2) of the classification procedure.

11.1.3 Step 5c: Report on the IUA-scale ecological condition and aggregate impacts for each preliminary scenario

11.1.3.1 Objective and information required

It is important that the information and procedures used to define the IUA classes associated with each catchment configuration scenario be sufficiently precise to ensure the consistent designation of classes in different catchments by different individuals. Many of these are already captured in Steps 1 to 4 of the classification procedure. The objective of *reporting on IUA-scale ecological condition and aggregate impacts for each preliminary scenario* is therefore to ensure consistency in the designation of IUA classes between different catchments across South Africa. Guidelines will need to be developed in this regard, and it is recommended that these guidelines be developed through implementation of the WRCS. For the purposes of this report, however, preliminary guidelines are presented in Table 11.1.

11.1.3.2 Required outcome

The outcome of Step 5c may include:

- A report on the IUA-scale ecological condition and aggregate impacts for each preliminary catchment configuration scenario.

Table 11.1 Preliminary guidelines for determining the IUA class for a scenario (after DWAF, 2006c)

IUA class		**Percentage Ecological Category (EC) representation at units represented by biophysical nodes in an IUA**				
		≥A/B	**≥B**	**≥C**	**≥D**	**<D**
Class I		≥40	≥60	≥80	≥99	-
Class II		-	≥40	≥70	≥95	-
Class III	Either	-	-	≥30	≥80	-
	Or		-	-	100	-

11.2 Step 5: Socio-economic component

The socio-economic component of Step 5 comprises valuing the changes in aquatic ecosystems and water yield for different catchment configuration scenarios, describing the macro-economic and social implications of the scenarios and describing the overall implications of different catchment configuration scenarios in terms of the socio-economic evaluation framework presented in Step 1i (see Section 7.2.6). Two socio-economic sub-steps are required, these are:

- Step 5d: Value the changes in aquatic ecosystems and water yield; and
- Step 5e: Describe the macro-economic and social implications of different catchment configuration scenarios.

11.2.1 Step 5d: Value the changes in aquatic ecosystem and water yield

11.2.1.1 Objective and information required

The objective of valuing the *changes in aquatic ecosystem and water yield for all users* for each of the catchment configuration scenarios generated in Step 5a (see Section 11.1.1) and Step 5b (see Section 11.1.2) is to provide input into Step 5e (see Section 11.2.2) so that there is a solid basis for evaluating the social, economic and ecological trade-offs in the decision analysis process (Step 5f, see Section 11.3.1). This requires applying the relationships that were defined in Step 2b (see Section 8.1.2) to link value and condition to the socio-economic framework defined in Step 1i (see Section 7.2.6). The socio-economic framework should be set up either in the form of a spreadsheet model or utilising the programming language C++ or Delphi. The spreadsheet or model should be set up to receive relevant ecological and hydrological data for the different catchment configuration scenarios.

The valuation process should provide the changes in value for each of the scenarios emerging from Steps 5a and 5b for each IUA in terms of:

1. Changes in values of EGSAs that contribute to social wellbeing and economic prosperity that may include:

    a. flow contribution to floodplain agriculture;
    b. livestock production;
    c. tourism and recreation;
    d. refugia, nursery areas and export of sediment and nutrients;
    e. value of harvested goods; and
    f. domestic use of instream water.

2. Changes in values of EGSAs that result in costs avoided/incurred and contribute to social wellbeing and economic prosperity that may include:

    a. carbon sequestration;
    b. flood attenuation;
    c. erosion control and sediment trapping;
    d. waste absorption;
    e. pests and pathogens; and
    f. domestic use of instream water.

3. Changes in values of intangible use and non-use values that contribute to social wellbeing that may include:

    a. cultural and spiritual value;
    b. educational and scientific value; and
    c. option and existence value.

4. Changes in values of sectoral use of water that contribute to social wellbeing and economic prosperity that may include:

    a. coal power;
    b. urban industry;
    c. non-urban industry;

d. domestic use;
e. mining;
f. streamflow reducing activities;
g. hydroelectric power; and
h. irrigated agriculture.

11.2.1.1.1 Curtailment and assurance rules for assessing changes in sectoral output

In order to assess the implications of the potential changes in output for different sectoral uses of water for different catchment configuration scenarios, it will be necessary to apply assurance and curtailment rules in a water resource yield model. While this process will be performed as part of the classification procedure, it will need to be done on a case-by-case basis. To go through the above curtailment procedure for all users and for all possible catchment configuration scenarios could be very time consuming, but will be required to finalise the class determination.

11.2.1.1.2 Estimating changes in irrigation areas[32]

In assessing the changes in value of the sectoral use of water for different catchment configuration scenarios, it is necessary to derive a procedure for estimating the change in irrigation area that will result from changes in water allocation or assurance and/or quality. For the Classification Process, this will need to be developed on a case-by-case basis.

11.2.1.2 Required outcome

The outcome of Step 5d may include (for each IUA):

1. Changes in values of sectoral use of water that contribute to social wellbeing and economic prosperity for each catchment configuration scenario, and attached to this value:

    - descriptions of the curtailment and assurance rules that were required for assessing changes in sectoral output; and
    - descriptions of the procedure used for estimating changes in irrigation area.

2. Changes in values of EGSAs that result in costs avoided/incurred and contribute to social wellbeing for each catchment configuration scenario.

3. Changes in values of EGSAs that contribute to social wellbeing and economic prosperity for each catchment configuration scenario.

4. Changes in values of intangible use and non-use values that contribute to social wellbeing for each catchment configuration scenario.

11.2.2 Step 5e: Describe the macro-economic and social implications of different catchment configuration scenarios

11.2.2.1 Objective and information required

The objective of *describing the macro-economic and social implications of different catchment configuration scenarios* is to evaluate their implication for the broader economy and for society, and this is typically done at the regional scale. It is recommended that the measures used to assess the macro-economic and social implications of different catchment configuration scenarios be derived using a Social Accounting Matrix (SAM). It is also proposed that any activities, whether water user activities or aquatic ecosystem user activities that have impacts on any sectors in the

[32] A similar process may be required for other water user sectors

economy, be included in a macro-economic analysis of impacts. There are other values that impact on the economy, such as those incurring human health costs and infrastructural costs. It is proposed that these be dealt with separately, so as not to include them as value added to national income, as this would be potentially misleading. For example, the increase in infrastructural damage due to floods actually leads to an increase in economic output. However, these damages represent financial resources that could be directed to other social causes. It is therefore recommended that damage costs be calculated separately and the macro-economic analysis considers only those changes in sectoral outputs that are a result of changes in water supply and ecosystem health.

The information required for the macro-economic component of this sub-step includes changes in turnover generated in the different sectors under different catchment configuration scenarios (Step 5d - see Section 11.2.1), and a set of 'multipliers'. Multipliers are commonly used to compute the nature and extent of the impact of a change in a specific economic quantity (e.g. exports) on another economic quantity or quantities (e.g. production output or employment). These multipliers can be derived from input-output models developed by professional econometricians. Direct, indirect and induced multipliers should be calculated for each economic sector. The so-called 'direct multiplier' measures the effect occurring in a specific sector, whilst the 'indirect multiplier' measures those effects occurring in the different economic sectors that link backwards to this sector due to the supply of intermediate inputs. The 'induced effect' on the other hand refers to the chain reaction triggered by the salaries and profits (less retained earnings) that are ploughed back into the economy in the form of private consumer spending.

The following multipliers could be calculated as part of Step 5e:

- economic growth (i.e. the impact on GDP);
- job creation (i.e. the impact on labour requirements);
- impact on capital formation; and
- income distribution (i.e. the impact on low-income, poor households and the total income households).

The type of input-output model recommended for the classification procedure is a SAM. A SAM is a matrix that depicts the linkages that exist between all of the different role players in the economy i.e. business sectors, households and government. A SAM is very similar to the traditional input-output table in the sense that it reflects all of the inter-sectoral linkages that are present in an economy. However, in addition to these inter-sectoral linkages, a SAM also reflects the activities of households, which are the basic unit where significant decisions are taken regarding important economic variables such as expenditure and savings. By combining households into meaningful groups, the SAM makes it possible to clearly distinguish between these household groups, and to study separately the economic welfare of each household group.

The information required for the social component of this sub-step (social implications) can be sourced from the outputs of Step 5d (see Section 11.2.1) and the SAM. This can be used to assess the local economic affects for each IUA in terms of changes in the percentage in the non-poor category, percentage employed, health, and happiness (see Section 11.3.1). This information can be used to assess, in part, the implications of the scenarios on social wellbeing, and can ultimately contribute to an overall assessment of the scenarios (Step 5f - see Section 11.3.1).

11.2.2.2 Required outcome

The outcome of Step 5e may include:

1. The macro-economic implications of different catchment configuration scenarios for targeted sectors (including ecosystem-dependent sectors) measured using:[33]

    - surplus value [R];
    - GDP [R];
    - capital [R];
    - low income households [R];
    - total households [R];
    - total employment [numbers of people]; and
    - direct employment [numbers of people].

2. The social implications of different catchment configuration scenarios for targeted sectors (including ecosystem-dependent sectors) measured using:

    - changes in the number of jobs;
    - changes in the proportion of non-poor households;
    - changes in health; and
    - changes in happiness.

11.3 Step 5: Decision-analysis component

The decision-analysis component[34] of Step 5 requires two sub-steps. These are:

- Step 5f: Evaluate the overall scenario implications at an IUA-level and a regional-level; and
- Step 5g: Select a subset of scenarios for stakeholder evaluation.

11.3.1 Step 5f: Evaluate the overall scenario implications at an IUA-level and a regional-level

11.3.1.1 Objective and information required

The objective of Step 5f of the classification procedure is to *provide a basis for evaluating the implications of each scenario at both an IUA-level and a regional-level*. In terms of the decision-analysis component of the classification procedure, the following needs to be noted:

- a sufficient range of scenarios should be evaluated to enable the selection of a range of them for evaluation by stakeholders in Step 6a (see Section 12.1.1);
- the decision-analysis framework adopted in Step 1i (see Section 7.3.1) and the scoring system developed in Step 2c (see Section 8.2.1) (i.e. scores for social wellbeing, ecosystem health and economic prosperity) should be applied;
- an overall evaluation of the catchment configuration scenarios requires that the indices adopted in Step 2c (see Section 8.2.1) are aggregated at a number of different levels of the value tree and geographic scales. Therefore, weights need to be found for each of these aggregation steps. The elicitation of weights or the development of a weighting system is part of the development of the scoring system (Step 1i) (see Section 7.3.1). Their derivation however, is achieved as part of Step 5f;
- sensitivity analyses of the results should be undertaken. Sensitivity analysis could be undertaken to ensure that the more robust alternatives are selected for further evaluation, or, in order to anticipate the likely preferred scenarios of identified stakeholder groups; and

[33] Relative to present-day.
[34] In reality, it is likely that the socio-economic and ecological specialists will be involved in both Step 5f and 5g.

- each of the 'starter' catchment configuration scenarios should be compared in the same way: i.e. the scenarios should be evaluated using the same decision-analysis evaluative framework.

If the appropriate quantitative data are available (i.e. generated in Steps 5a to 5e, Sections 11.1.1 to 11.2.2), scoring of scenarios can be more-or-less an automatic step, as the data can be directly converted to scores for the various indices based on the framework developed in Step 1i and the scoring system developed in Step 2c.

11.3.1.2 Required outcome

The outcome of Step 5f may include:

1. IUA-level assessments of different catchment configuration scenarios for:

    a. social wellbeing;
    b. ecosystem health;
    c. economic prosperity;
    d. overall score.

2. Catchment-level assessments of different catchment configuration scenarios for:

    a. social wellbeing;
    b. ecosystem health;
    c. economic prosperity;
    d. overall score.

3. Report on the sensitivity analysis.

11.3.2 Step 5g: Select a subset of scenarios for stakeholder evaluation

11.3.2.1 Objective and information required

The objective of Step 5g is to *reduce the number of scenarios* from the full suite of catchment configuration scenarios (considered in Step 5f - see Section 11.3.1) down to a subset that can be realistically dealt with in the *stakeholder evaluation procedure*. The procedure for selecting a subset of scenarios is not prescribed here, as this will be at the discretion of DWAF. However, as a general guideline, it is recommended that the best and second best scenarios need to be included, and that any 'dominated' scenarios should be excluded.[35] Further, it is recommended when applying this step of the classification procedure, DWAF attempt to anticipate stakeholders' needs or have prior knowledge of these through the broader IWRM process.

11.3.2.2 Required outcome

The outcome of Step 5g may include:

1. A selected subset of catchment configuration scenarios for stakeholder evaluation, together with reasons for their inclusion.

[35] Dominated scenarios are those which perform worse than the other scenarios on all criteria.

12 STEP 6: EVALUATE THE SCENARIOS WITH STAKEHOLDERS

The objective of Classification Procedure Step 6 is to evaluate the subset of scenarios selected in Step 5g (see Section 11.3.2) together with the stakeholder scenarios, and to agree on an overall preferred catchment configuration scenario or a shortlist of scenarios for the Minister's consideration in Step 7a (see Section 13.1.1). This is followed by DWAF recommending the IUA classes in Step 6b (see Section 12.1.2). It is important to point out, however, that Step 6 is not the only point of contact with the stakeholders in the classification procedure. Stakeholder involvement occurs from Step 1 (Figure 5-2) and is an integral part of the larger compulsory licensing process. A description of the stakeholder process for the compulsory licensing process is beyond the scope of this report, but will need to be incorporated into the classification procedure as and when it becomes available. The recommended guidelines described in this report for Step 6 therefore focus specifically on the classification component of the stakeholder process (which forms part of the larger compulsory licensing process).[36]

To incorporate these objectives, Step 6 consists of the following sub-steps:

- Step 6a: Stakeholders evaluate scenarios and agree on a short-list; and
- Step 6b: Recommended classes for the IUAs.

Figure 12-1 presents the information pathways for Step 6 of the classification procedure.

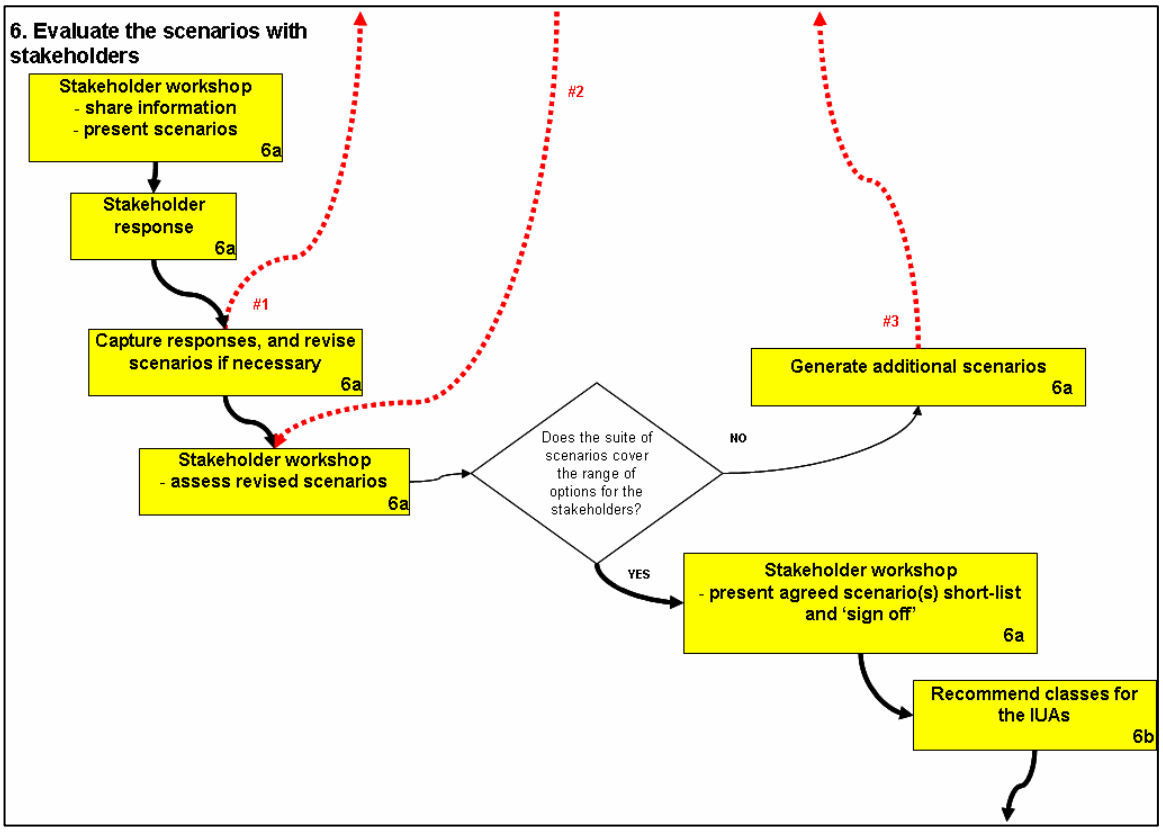

Figure 12-1 Information pathways for Step 6 of the classification procedure

[36] See Joubert et al. (2007) for guidelines on the broader stakeholder engagement process.

12.1 Step 6: Decision-analysis component

The decision-analysis component of Step 6 requires two sub-steps. These are:

- Step 6a: Stakeholders evaluate scenarios and agree on a short-list; and
- Step 6b: Recommends classes for the IUAs.

12.1.1 Step 6a: Stakeholders evaluate scenarios and agree on a short-list

12.1.1.1 Objective and information required

The objective of Step 6a is for the stakeholders *to evaluate scenarios and agree on a short-list*. This involves assessing the subset of scenarios selected for evaluation in Step 5g (see Section 11.3.2), as well as scenarios generated/requested by stakeholders. As this evaluation process is as yet untested, the procedure recommended here has been kept as generic as possible.

It is likely that a number of stakeholder workshops will be held. These will include a suite of workshops whose purpose is to present to stakeholders the initial subset of scenarios selected in Step 5g. Following the first information-sharing workshop(s), stakeholders should be encouraged to go away, think about the scenarios and submit comments on them. The comments may refer to a number of different issues, but of concern are a) whether the subset of catchment configuration scenarios includes a wide enough range for the stakeholders and b) whether the evaluation criteria cover all the relevant issues of concern. DWAF can use these comments to guide the generation of additional catchment configuration scenarios if necessary, and to obtain the necessary information regarding issues of concern if these have not been adequately covered.

Following the stakeholder response to the first suite of workshops, a second set of workshop(s) may be required where a revised set of catchment configuration scenarios (including those requested by the stakeholders) could be presented to the stakeholders and further comment elicited. During these workshops, the stakeholders could be asked to consider whether the suite of scenarios being assessed now covers the range of options they require. If the range of scenarios does cover the stakeholders' preferred options and the criteria do cover the issues of concern, the stakeholders may proceed to evaluate the scenarios. If the scenarios do not cover the range of options for the stakeholders, additional scenarios will need to be generated iteratively.

Once the stakeholders have agreed that the suite of scenarios covers the range of options they require, the scenarios need to be evaluated by the stakeholders (by scoring or ranking them). From this process, the workshop facilitator/technical team may select a scenario that best satisfies all concerned (based on the scores) or may generate a short-list that best represents the broad views of the stakeholders. Ideally, the short-list should be presented to the stakeholders directly at this workshop (i.e. the scenario scores should be captured and analysed at the workshop) for initial comment. Depending on the degree of trust and credibility of the process, the document containing the preferred scenario or short-list of scenario should first be distributed as a draft for comment, and another workshop may be necessary in order to finalise it. Alternatively, if there has been general consensus on the preferred scenario, stakeholders may only wish to receive a copy of this document. The technical specialists should also clearly indicate the results of the stakeholder engagement process and the stakeholders' views of the scenario(s) to be recommended to the Minister. This document should then be 'signed-off' by the stakeholders and by DWAF.

Guidelines for the rating of scenarios by stakeholders, the presentation of scenarios, for eliciting stakeholder weights and the scoring of scenarios are presented in Joubert et al. (2007).

12.1.1.2 Required outcome

The outcome of Step 6a may include:

1. A short-list of final scenarios agreed-on and signed-off both by the relevant stakeholders and by DWAF together with reasons for their selection.

12.1.2 Step 6b: Recommend classes for the IUAs

12.1.2.1 Objective and information required

The objective of Step 6b is to assess the outputs of Step 6a (see Section 12.1.1) and to put forward DWAF's recommendations for the catchment configuration scenarios and IUA classes. Guidelines for this sub-step have not been prescribed here, as they will be developed during the early applications of the WRCS in the Classification Process.

12.1.2.2 Required outcome

The outcome of Step 6b may include:

1. DWAF-recommended IUA classes for the Minister's consideration in Step 7a (see Section 13.1.1).

13 STEP 7: GAZETTE THE CLASS CONFIGURATIONS

The objective of Classification Procedure Step 7 is to publish the class configurations and their associated RQOs in the Government Gazette as required by the NWA:

Section 13.

1. The Minister having prescribed a system for classifying water resources, must as soon after as is reasonably practicable, subject to subsection (4), by notice in the *Gazette,* determine for all or part of every significant resource:
   (a) a class in accordance with the prescribed classification system;
   (b) RQOs based on the class determined in terms of paragraph (a).
2. A notice in terms of subsection (1) must state the geographical area in respect of which RQOs will apply, the requirements for achieving the objectives, and the dates from which the objectives will apply.
3. The objectives determined in terms of subsection (1) may relate to:
   (a) the Reserve;
   (b) the instream flow;
   (c) the water level;
   (d) the presence and concentration of particular substances in the water;
   (e) the characteristics and quality of the water resource and the instream and riparian habitat;
   (f) the characteristics and distribution of aquatic biota;
   (g) the regulation or prohibition of instream or land-based activities which may affect the quantity of water in or quality of the water resources; and
   (h) any other characteristic of the water resource in question.
4. The Minister needs to publish in respect of each water resource a notice in the *Gazette* setting out the details of the above (paraphrased), invite and consider written comments.

It is important to point out that Classification Procedure Step 7 needs to incorporate information from the Compulsory Licensing process and the Catchment Management Strategy (CMS) (e.g. CMS must be approved by Minister, and a plan of action needs to be developed for implementation of the recommended scenario). A description of this information is beyond the scope of this report, but will need to be incorporated into the classification procedure as and when it becomes available. The recommended guidelines described in this report for Step 7 therefore focuses specifically on the classification component of the gazetting process (which forms part of the larger compulsory licensing process).

To address these objectives, Classification Procedure Step 7 consists of the following sub-steps:

- Step 7a: Populate an IWRM summary template and present it to the Minister or to his/her delegated authority;
- Step 7b: Decision by the Minister or his/her delegated authority on the IUA classes, nested ecological category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS);
- Step 7c: Set the Resource Quality Objectives (RQOs);
- Step 7d: Gazette IUA classes, nested ecological category configurations, Reserve(s) and RQOs; and
- Step 7e: Develop a plan of action for implementation of recommended scenario which must include a monitoring programme.

Figure 13-1 presents the information pathways for Step 7 of the classification procedure.

13.1 Step 7: Decision-analysis component

The decision-analysis component of Step 7 requires 5 sub-steps. These are:

- Step 7a: Populate the IWRM summary template and present to Minister or his/her delegated authority;
- Step 7b: Decision by the Minister or his/her delegated authority on the IUA classes, nested ecological category configurations, Reserve, allocation schedule(s) and Catchment Management Strategy (CMS);
- Step 7c: Set the Resource Quality Objectives (RQOs);
- Step 7d: Gazette IUA classes, nested ecological category configurations, Reserves and RQOs; and
- Step 7e: Develop plan of action for implementation of recommended scenario which must include a monitoring programme.

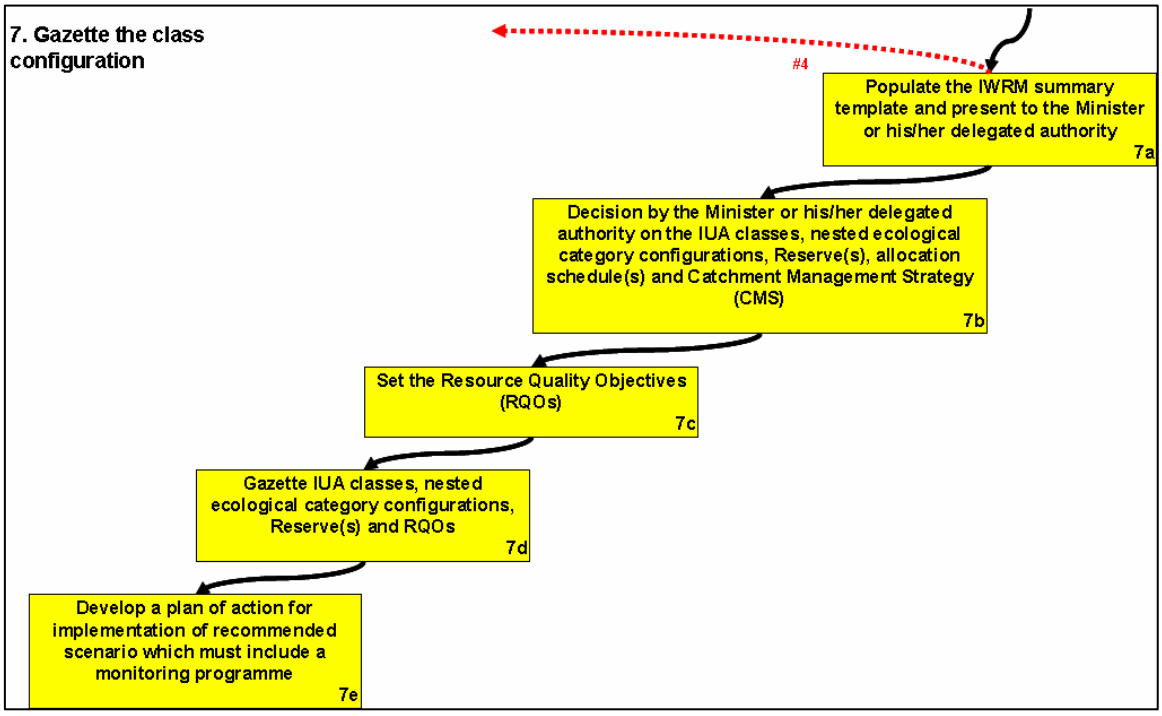

Figure 13-1 Information pathways for Step 7 of the classification procedure

13.1.1 Step 7a: Populate the IWRM summary template and present to Minister or his/her delegated authority

13.1.1.1 Objective and information required

The objective of Step 7a is to *present the relevant information from the Classification Process to the Minister or his/her delegated authority* for consideration. *It is recommended that this information take the form of an IWRM summary template* populated with DWAF's recommendations for the catchment configuration scenarios and IUA classes derived from Step 6b (see Section 12.1.2) *and* This summary template is not prescribed here, as it will be developed during the early applications of the WRCS in the Classification Process (and other aligned processes – e.g. compulsory licensing). However, a number of recommendations can be made in this regard, and these are presented in Table 13.1. It is important to note, however, that the IWRM summary template should include information from the larger IWRM process (e.g. Compulsory

Licensing), and therefore the outline of the IWRM summary template presented in Table 13.1 serves only as a starting point.

13.1.1.2 Required outcome

The outcome of Step 7a may include:

1. A populated IWRM summary template presented to the Minister or his/her delegated authority.

Table 13.1 Proposed IWRM summary template for Step 7a of the classification procedure

Section	Sub-section	Comment
1. Introduction	Description of catchment and IUAs.	Map of study area with nodes and IUAs depicted. Will include geographical area (i.e. co-ordinates), quaternary catchments and flow gauging weirs.
	Description of current water use in the catchment.	Broad summary of current equity, social conditions and economic activities in the catchment.
	Description of the 3 classes.	The classes gazetted as part of the WRCS gazette.
2. Record of decision	Nature of the proposed authorisation to be undertaken (water use applications).	A description of why the Classification Process was undertaken. Note that this may also include a description of why the Compulsory Licensing process was undertaken, but this recommended IWRM template focuses on the Classification component. The Compulsory Licensing component of the IWRM template will need to be added as and when it becomes available.
	Scope of the study.	Confidence of the results of the classification study.
3. Description of the stakeholder consultation process	Overall description of the process.	Narrative.
	Key aspects informing the class for each IUA.	
	Summary of catchment configuration scenarios short-listed by stakeholders.	
	Summary of key economic, social and ecological implications for stakeholders.	
	List of key stakeholder concerns about catchment configuration scenarios.	List specific concerns and potential conflicts amongst users together with decision to be taken by the custodian.
4. Recommended classes for each IUA	Recommended classes for each IUA.	Validity and period of revision of classes.
	Water balance for the catchment.	Described.
	Category configurations for each node in the catchment	IUA classes and nested category configurations making up the IUA class. Possibly also presented as a system/network diagram (see Brown *et al*., 2007; Figure 11.2 as an example).
	Socio-economic implications of the recommended classes.	Describe how they will deviate from the present socio-economic conditions.
	Allocation schedules.	Refer to Water Allocation Reform process for details as to how equity is addressed.
	Other relevant information.	Described.

5. Reserves (using existing Reserve template)	Description of water resource(s).	For a defined geographical area including the water management area (WMA), drainage region(s) and a short description of the resources and their location.
	Overall summary of quantity for the Reserve (%nMAR).	Described for each node for the configuration making up the class.
	Overall summary of quality Reserve.	General chemistry recommended, nutrient, physical, toxics and complex mixtures. This should be described at least at the IUA outlet node or at a finer scale where relevant and supported by information.
	Basic Human Needs.	Described for each node for the configuration making up the class.
	Applicability.	Section 21 of the NWA.
	Technical reports.	List of technical reports on the Reserve determination process including the level of confidence in the determination of the water quantity and quality Reserve, cumulative/incremental Reserves, location, implications and relative to nMAR, and .rul and .tab files.
6. Resource Quality Objectives	RQOs for each nested ecological category for each significant water resource (i.e. not just the IUA).	Listed.
7. Applicability to Section 21 of the NWA	Applicable sections of NWA.	Listed.
	Action required for extensions of applicability.	Listed.
8. Special conditions and limitations	Resources not considered.	Listed.
	Limitations.	Listed.
	Data limitations.	Listed (e.g. flooding).
	Punitive measures associated with class configuration.	List the proposed punitive measures that should be gazetted to assist DWAF and CMA to enforce class configuration.
	Restrictions of study.	Listed.
9. Methods applied	Classification procedure.	Listed and described.
	Reserve method.	Listed and described.
	Water quality method.	Listed and described.
	Basic Human Needs method.	Listed and described.
	Resource Quality Objectives method.	Listed and described.
10. Administrative information	Project management team	Listed.
	Peer review information.	To demonstrate scientific validity and good practice.
	RDM team and Professional Service Providers (PSP).	Listed.
11. Aspects included in the Catchment Management	Flow-related.	Listed and described.
	Non-flow related.	Listed and described.

Strategy (CMS) and Catchment Management Plan (CMP)	Operation rules.	Listed and described.
	Monitoring programme and implementation plan.	Listed and described.
12. Monitoring	Monitoring locations (geographical co-ordinates).	Listed and described.
	Aspects to be monitored.	Listed and described, but may include resource monitoring compliance to RQOs, water quality and allocation.
13. References	Specialist reports.	Listed and referenced.

13.1.2 Step 7b: Decision by the Minister or his/her delegated authority on the IUA classes, nested ecological category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS)

13.1.2.1 Objective and information required

The objective of Step 7b is for the *Minister to decide on IUA classes, nested ecological category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS)* based on information from a suite of catchment configuration scenarios (and other information from other DWAF IWRM processes) presented to his/her in the form of the IWRM template (Step 7a - see Section 13.1.1). This is procedure is not prescribed, as it depends on the discretion of the Minister or his/her delegated authority.

13.1.2.2 Required outcome

The outcome of Step 7b may include:

1. The Minister deciding on IUA classes, nested ecological category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS).

13.1.3 Step 7c: Set the Resource Quality Objectives (RQOs)

13.1.3.1 Objective and information required

The objective of Step 7c is to *set the Resource Quality Objectives (RQOs)* for the IUA classes and nested category configurations following a decision on these by the Minister in Step 7b (see Section 13.1.2). It is recommended that the RQOs only be established at this point, as it would be inefficient to establish RQOs for the entire suite of catchment configuration scenarios that are presented to the Minister in Step 7b. The process for determining the water quality component of RQOs (DWAF, 2006d) is well established, while the process for determining overall RQOs is described in DWAF (1999), and will not be repeated here. The RQOs established in Step 7c will need to be put forward for gazetting in Step 7d (see Section 13.1.4).

13.1.3.2 Required outcome

The outcome of Step 7c may include:

1. A recommended set of RQOs for gazetting in Step 7d (see Section 13.1.4).

13.1.4 Step 7d: Gazette IUA classes, nested ecological category configurations, Reserve(s) and RQOs

13.1.4.1 Objective and information required

The objective of Step 7d is to *gazette the IUA classes, nested ecological category configurations, Reserve(s) and RQOs*. Guidelines for this process are not prescribed, but will need to follow the requirements of the NWA.

13.1.4.2 Required outcome

The outcome of Step 7d may include:

1. The gazetted IUA classes, nested ecological category configurations, Reserve(s) and RQOs.

13.1.5 Step 7e: Develop plan of action for implementation of recommended scenario which must include a monitoring programme

13.1.5.1 Objective and information required

The objective of Step 7e is to *develop a plan of action for implementing the recommended scenario which must include a monitoring programme*. This plan will need to be developed with the objectives of the larger IWRM process in mind. For this reason, it is recommended that the procedure for developing this implementation plan be developed during the early applications of the WRCS in the Classification Process (and other aligned processes – e.g. Compulsory Licensing).

13.1.5.2 Required outcome

The outcome of Step 7e may include:

1. A plan of action for implementation of the recommended scenario including a monitoring programme.

14 ESTIMATED TIMEFRAMES FOR THE CLASSIFCATION PROCEDURE

The estimated timeframes for the classification procedure are presented in Table 14.1. The timeframes presented for each step assume that all the external information required for the Classification Process (e.g. allocation scenarios, Reserve information) is available.

Table 14.1 Estimated timeframes for the classification procedure steps

Step number	Estimated time required in months
1	3
2	3
3	3
4	3
5	2
6	6
7	3

15 REFERENCE LIST

Brown, C.A., **Ewart-Smith, J**., **Conrad, J**., **Rossouw, N**. **Dollar, E.S.J**. and **Nicolson, C.R**. 2007: *The development of the water resource classification system (WRCS). Volume 2. Ecological, hydrological and water quality guidelines for the 7-step classification procedure*. CSIR Report No. CSIR/NRE/WR/ER/2006/0187B/C. Department of Water Affairs and Forestry, Pretoria, 134pp.

Department of Water Affairs and Forestry (**DWAF**) 1996a: *Water law principles*. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry, (**DWAF**) 1996b: *South African Water Quality Guidelines* (second edition), *Volumes 1 to 5.* Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (**DWAF***)* 1997: *White paper on a national water policy for South Africa*, Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (**DWAF**) 1999: *Resource Directed Measures for Protection of Water Resources,* Version 1.0. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry*,* (**DWAF**) 2004: *National Water Resource Strategy: First Edition*. Department of Water Affairs and Forestry, Pretoria. September 2004.

Department: Water Affairs and Forestry (**DWAF**) 2005: *The development of a national water resource classification system. Inception report.* Contract Report for Department of Water Affairs and Forestry, by ESJ Dollar Consulting cc, Cape Town, 277pp.

Department: Water Affairs and Forestry (DWAF) 2006a: *A draft position paper on the development of a water resource classification system (WRCS): Draft discussion document*. Version 8. Department: Water Affairs and Forestry, Pretoria, 22pp.

Department: Water Affairs and Forestry (DWAF) 2006b: A briefing document on the institutional issues and potential arrangements for the water resource classification system (WRCS): *Draft discussion document*. *Version 2*. Department: Water Affairs and Forestry, Pretoria, 16pp.

Department: Water Affairs and Forestry (DWAF) 2006c: *Class definitions for gazetting: Draft discussion document*. Department: Water Affairs and Forestry, Pretoria, 16pp.

Department of Water Affairs and Forestry (DWAF), 2006d: *Guideline for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and the Stress of the Water Resource*. Version 2.3. Water Resource Planning Systems Series, Sub-Series No. WQP 1.4.3.1, Resource Directed Management of Water Quality. Pretoria.

Hajkowicz, **S.A.** 2006: *Taking a closer look at multiple criteria analysis and economic evaluation*. SEA News, Issue 21, July 2006. http://www.crcsalinity.com.au/newsletter/sea/SEANews21 .html.

Hughes, D.A. and **Münster, F**. 2000: *Hydrological information and techniques to support the determination of the water quality component of the ecological Reserve for rivers*. Water Research Commission Report No. 867/3/2000, Water Research Commission, Pretoria.

Hughes, D.A. and **Hannart, P**. 2003: A desktop model used to provide an initial estimate of the ecological instream flow requirements of rivers in South Africa. *Journal of Hydrology* 270, 167-181.

Joubert, A.R., Turpie, J.K., Brown, C.A., Manyaka, S.M., **Dollar, E.S.J.** and **Nicolson, C.R.** 2007: *The development of the Water Resource Classification System (WRCS). Volume 4. Decision-analysis (including the stakeholder engagement process) guidelines for the 7-step classification procedure*. CSIR Report No. CSIR/NRE/WR/ER/2006/0187D/C. Department of Water Affairs and Forestry, Pretoria, 66pp.

Joubert, A.R. 2003: *Multi-attribute value measurement and economic paradigms in environmental decision-making*. PhD thesis: University of Cape Town.

Joubert, **A.R.**, **Leiman**, **A.**, **de Klerk**, **H.**, **Katua, S.** and **Aggenbach, J.-C.** 1997: Fynbos (fine bush) vegetation and the supply of water: A comparison of multi-criteria decision analysis and cost-benefit analysis. *Ecological Economics* 22, 123-140.

Kleynhans, **C.J**., **Thirion**, **C**. and **Moolman**, **J**. 2005: *A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland*. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Louw, D., Kleynhans, C., Thirion, C., Todd, C., Birkhead, A. and **Hughes, D.** 2006**:** *The development of a decision support system (DSS) to address the issue of extrapolating ecological reserve (flow) information to other river locations*. Draft report, WRC research project K8-657, Pretoria, South Africa.

Midgley, D.C., Pitman, W.V. and **Middleton, B.J.** 1994: Surface Water Resources of South Africa 1990. Volume III, Drainage Regions D, F, Orange-Namaqualand, WRC Report No. 298/3.1/94, Water Research Commission, Pretoria.

Rowntree, K.M. and **Wadeson, R.A.** 1999: *A hierarchical geomorphological model for the classification of selected South African Rivers*. Water Research Commission Report No. 497/1/99, Water Research Commission, Pretoria, 334pp.

Turpie, J.K., **Dollar, E.S.J**., **Goldin, J**., **Mullins, W**., **Mallory, S**., **Rossouw, N., Joubert, A**.**R.** and **Nicolson, C.R.** 2007: *Socio-economic guidelines for the 7-step classification procedure.* CSIR Report No. CSIR/NRE/WR/ER/2006/0187C/C. Department of Water Affairs and Forestry, Pretoria, 113pp.

Turton, A. 2006: *An analysis of government policies that provide the context for the development of a Water Resource Classification System (WRCS): Draft discussion document*. *Version 2*. Department: Water Affairs and Forestry, Pretoria, 15pp.