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Resource Directed Management of Water Quality

MANAGEMENT INSTRUMENTS

Volume 4.2

Guideline for Determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and the Stress of the Water Resource

August 2006

Edition 2

water & forestry

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EXECUTIVE SUMMARY

"Providing guidance for determining Resource Water Quality Objectives, Allocatable Water Quality and Stress of the Water Resource"

What are Resource Water Quality Objectives (RWQOs)

RWQOs are the water quality components of the Resource Quality Objectives (RQOs) which are defined by the National Water Act as "clear goals relating to the quality of the relevant water resources." In the document, "Policy on the Resource Directed Management of Water Quality", RWQOs are defined as numeric or descriptive in-stream (or in-aquifer) water quality objectives typically set at a finer resolution (spatial or temporal) than RQOs to provide greater detail upon which to base the management of water quality.

Purpose of the Guidelines

This Guideline provides an approach to the determination of the Resource Quality Objectives, as they relate specifically to water quality, for South African freshwater resources. It also describes an approach for determining the allocatable water quality and the water quality stress of a water resource.

Relation to other RDMs management instruments

The guideline also provides an approach to integrate catchment visioning, water resource classification and the Reserve process into the water resource management process, through the determination of RWQOs.

Guiding principles

The determination of RWQOs is underpinned by the principle of sustainable development and was informed by the principles which formed the foundation for the following instruments:

- The Precautionary Principle,
- The default rule described in the Resource Directed Measures documentation,
- The National Water Resource Strategy, and
- Environmental rights as described in the South African Constitution (Act No. 108 of 1996)

The implications of these principles are that:

- The Department may not accept a deterioration in water quality from the present state, at least when determining RWQOs using a low confidence method,
- In areas of deteriorated water quality, the quality should be improved to the minimum sustainable Ecological Category,
- The default rule for other users is that the minimum desired category should be 'Tolerable', and
- RWQOs should be determined to that of meeting the Ecological and Basic Human Need Reserve (or better).

Levels of RWQO determination

Three levels of determining RWQOs are described:

- **Low confidence method** - RWQOs are based only on available data and information and there is limited possibility for new data collection to assess the present state. It is used to support individual licensing with small impacts in unstressed catchments or catchments of low ecological and user importance and sensitivity.

- **Medium confidence method** - RWQOs are based on specialist field studies and institutional stakeholders are involved in the process. It is used to support individual licensing with moderate impacts in relatively stressed catchments or catchments of high importance and sensitivity.
- **High confidence method** - RWQOs are based on extensive field data collection by specialists and characterised by intensive stakeholder involvement. It is used to support all compulsory licensing (in stressed catchments) or individual licensing having a large impact, or licences with small or large impacts in very important and/or sensitive catchments.

Methodology for determining RWQOs

The guideline describes the following steps for determining RWQOs:

- Determine the Ecological Water Quality Requirements (Reserve)
  - Delineate resource unit (spatial scale of RWQOs)
  - Determine present water quality state
  - Determine desired (attainable) water quality (ecological component of the catchment vision), and
  - Determine ecological specifications (water quality component of the Reserve)
- Determine User Water Quality Requirements
  - Identify water users
  - Assess present water quality with regards to water user requirements
  - Determine desired water quality (water user component of the catchment vision), and
  - Determine water user specifications
- Determine the Management Class for the water resource through integration.
- Establish RWQOs, through the integration of ecological and water user requirements for water quality.
- Establish time period of RWQOs, i.e. seasonal, short-term, or long-term water quality goals (RWQOs) for the resource unit.

Allocatable water quality

RWQOs provide the basis for determining the Allocatable Water Quality. This is defined as the maximum worsening change in any water quality attribute away from its present value that maintains it within a pre-determined range reflecting the desired future state (typically defined by a resource quality objective). If the present value is already at or outside the predetermined range, this indicates that none is allocatable and that (a) reduced pollution loads relating to the affected attribute(s) and/or (b) remediation of the resource may be necessary.

Determination of water quality stress

RWQOs also provide the basis for determining the water quality stress. Water quality stress is the difference between the present water quality and the RWQOs. The closer the present water quality is to the RWQOs, the higher is the degree of water quality stress of the water resource.

Annexures

The first annexure describes generic water quality limits for various water user categories (domestic, agricultural, recreational, etc.) in terms of Ideal, Acceptable, Tolerable and Unacceptable categories.

The last three annexures describe in detail the procedures for determining Resource Water Quality Objectives (RWQOs) at a Low, Medium and High levels of confidence.

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ACRONYMS

AEV	Acute Effect Value
CAS	Catchment Assessment Study
CEV	Chronic Effect Value
CMAs	Catchment Management Agencies
DEAT	Department of Environmental Affairs & Tourism
DWAF	Department of Water Affairs & Forestry
Ecospecs	Ecological Specifications
EI	Economic Importance
EIS	Ecological Importance and Sensitivity
EISC	Ecological Importance and Sensitivity Category
IWRM	Integrated Water Resource Management
NWA	National Water Act (36:1998)
PES	Present Ecological State
RDMs	Resource Directed Measures
RDMWQ	Resource Directed Management of Water Quality
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RWQOs	Resource Water Quality Objectives
SASS	South African Scoring System
SAWQG	South African Water Quality Guidelines
SI	Social Importance
TWQR	Target Water Quality Range
WAP	Water Allocation Plan
WMA	Water Management Area
WMS	DWAF water quality database
WQM	Water Quality Management
WRC	Water Research Commission

PREFACE

National Water Act (Act 36 of 1998)

Part 2: Classification of water resources and resource quality objectives

"Under Part 2 (of the Act) *the Minister is required to use the classification system established in Part 1* (of the Act) *to determine the class and resource quality objectives of all or part of water resources considered to be significant. The purpose of the resource quality objectives is to establish clear goals relating to the quality of the relevant water resources. In determining resource quality objectives 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. Provision is made for preliminary determinations of the class and resource quality objectives of water resources before the formal classification system is established. Once the class of a water resource and the resource quality objectives have been determined they are binding on all authorities and institutions when exercising any power or performing any duty under this Act."*

This Guideline provides an approach to the determination of the Resource Quality Objectives, as they relate specifically to water quality, for South African freshwater resources. This Guideline does not address Resource Quality Objectives for water quantity, habitat integrity and biotic characteristics.

SECTION 1: INTRODUCTION

1.1 What is in the RWQOs Guideline?

1.1.1 General overview of contents

Purpose and use of the RWQOs Guideline

Section 1 provides:

- An overview of the contents of the Guideline (Section 1.1.1)
- A description of the purpose of the Guideline and how to determine Resource Water Quality Objectives (RWQOs) (Section 1.1.2), and
- An overview of how to use the Guideline in conjunction with other Resource Directed Measures (RDMs) documents (Section 1.2).

Assumptions and exclusions

The focus of this document is on the determination of RWQOs for surface water resources; however the approach is considered generic and as such was developed with the other water resources, i.e. groundwater, estuaries, wetlands, lakes and reservoirs in mind. However, until progress is made regarding the development of a classification system for groundwater, estuaries, wetlands and reservoirs, it is difficult to fully integrate the vision, classification and Reserve process for these resources.

The methodology presented here applies to freshwater resources only. A policy for quality objectives for marine resources has been developed by the Department (DWAF, 2004b.

The RWQOs apply only to water quality and do not consider quantity, habitat, biota, etc. Water quantity is, however, considered as far as constituent loads are concerned.

Guiding Principles

Section 1.3 provides an overview of the principles which guide the decision-making process in determining RWQOs.

Important components of the approach presented in this report, are the over-arching requirements to ensure sustainable and equitable use of the water resource for the "optimum social and economic benefit" of the country. Coupled with this is the need for a transparent and participative approach to water resources management. These policy principles must underlie the approach to water resource management on a catchment basis (DWAF, 2003b).

Levels of RWQOs determination

Section 2 briefly describes each of the three levels of RWQOs methodologies, each method relating to a specific level of confidence:

- Low confidence method
- Medium confidence method, and
- High confidence method.

Rules for the selection of the appropriate method for different water use licensing situations are provided (Table 1). The level of confidence required for determining the RWQOs depends on, for example, the ecological importance and sensitivity (EIS) of the water resource, the scale and degree of the impact of proposed water uses, the urgency for determining RWQOs and the degree of 'acceptable' risk.

The low confidence method is typically used in data sparse catchments.

However, it is important to stress that applying a low confidence method can produce very accurate RWQOs, when sufficient, accurate water quality data are available.

Acceptable risk

RWQOs for a water resource are determined on the basis of acceptable risk, i.e. the less risk that one is prepared to accept of damaging the water resource and possibly losing the goods and services provided by it, the more stringent would be the objectives. A higher risk to the water resource might be accepted, in return for greater short-term utilisation, in which case the RWQOs would be determined at less stringent levels, but not to a level where the long-term sustainable use of the resource is compromised.

Generic methodology for RWQOs

Section 3 contains the "roadmap" - a first introduction to the generic methodology for RWQOs determination. The generic methodology and its relationship to water quality management are shown in Figures 3.1 – 3.3.

Detailed descriptions of methods

Annexures C-E provide more detailed procedures for the determination of RWQOs using either low, medium or high confidence methods.

1.1.2 Purpose of the RWQOs Guideline

What are RWQOs

RWQOs are the water quality component of the Resource Quality Objectives (RQOs) defined by the National Water Act (NWA) (36:1998), “as clear goals relating to the quality of the relevant water resources.” The integrated RDMs manual (DWAF, 1999a) defines an RQOs as “a numerical or descriptive statement of the conditions which should be met in the receiving water resource… in order to ensure that the water resource is protected.” The RWQOs outline both water user needs with respect to water quality, as well as their needs with respect to the disposal of water containing waste to the resource (a water use need). The process of determining RWQOs is consultative, but requires strong technical support” (DWAF, 2003a).

In the document, “Policy on the Resource Directed Management of Water Quality”, RWQOs are defined as numeric or descriptive (narrative) in-stream (or in-aquifer) water quality objectives typically set at a finer resolution (spatial or temporal) than RQOs that provide greater detail upon which to base the management of water quality (DWAF, 2005).

RWQOs should be seen as one component of Resource Quality Objectives, as defined in the NWA (36:1998, Chapter 3). These RWQOs should not be mistaken for Resource Quality Objectives (RQOs) which encompass all four components of the resource quality, namely water quantity, water quality, habitat integrity and biotic characteristics.

It must be noted that the NWA (36:1998) allows for the determination of preliminary [(1)] RQOs of water resources before the formal classification system is established.

Once RQOs have been published in the Gazette, or preliminary RQOs have been determined, they must be given effect (Section 15 of the NWA).

[(1)] ‘*Preliminary’* does not refer to the method or level of confidence used in determining the RQOs but rather their legal status as defined in the NWA (36:1998).

To do so, the Department or water management institutions (such as catchment management agencies) may also set narrative or quantitative "resource water quality objectives (RWQOs)". These may be set at a greater spatial resolution (i.e. closer together) and/or temporal resolution (i.e. more frequently monitored) than the RQOs (preliminary or otherwise) to which they may be linked. The purpose of these will be to provide greater detail upon which to base management of water quality aimed at achieving and sustaining compliance with resource quality objectives (DWAF, 2006).

RWQOs will not be gazetted as such but will provide the water quality input to the formal RQOs process. It would therefore be possible to have more RWQOs than RQOs if so desired.

Purpose of the Guideline

The aim of this Guideline is to provide a practical, consistent approach to the determination of RWQOs, by integrating the results of the Catchment Vision, and Resource Classification and Reserve, i.e. Resource Directed Measures (RDMs) (Figure 1.1), and to provide an approach to operationalising these RWQOs in the evaluation of licence applications through the allocatable resource.

Administrative Process

In the absence of Catchment Management Agencies (CMAs), RWQOs will typically be determined by the DWAF with the Regional Offices playing a prominent role.

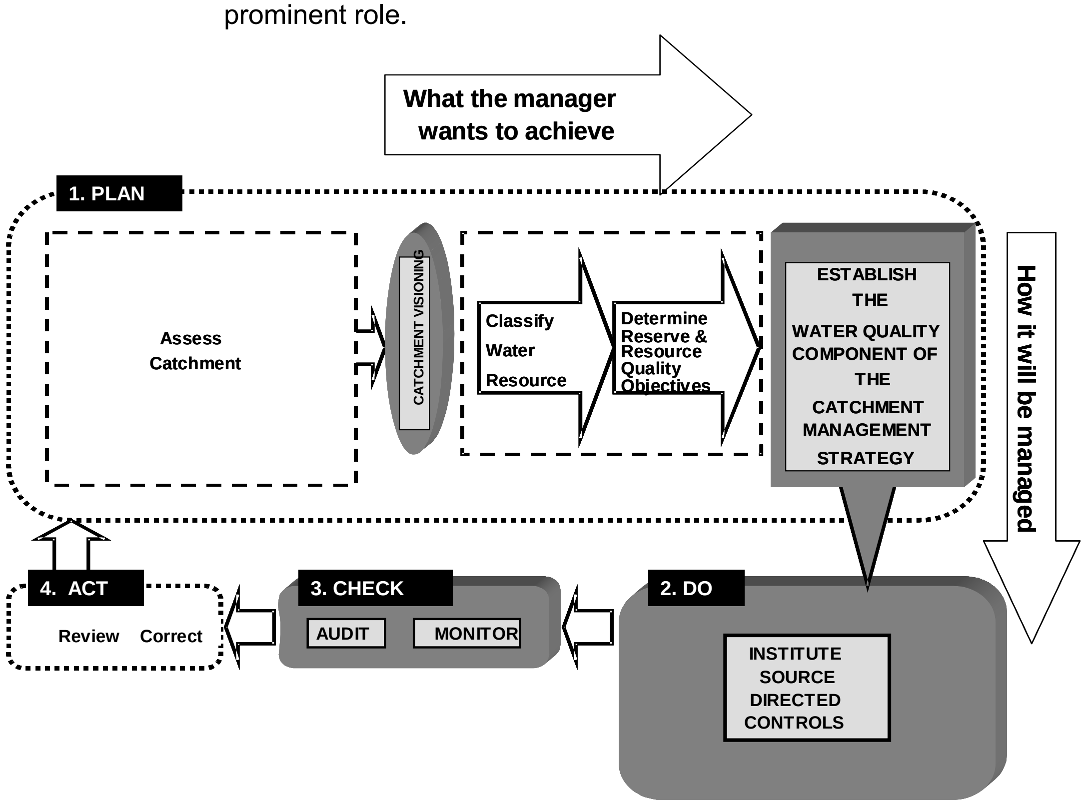

Figure 1.1: Water quality management business process (DWAF, 2003c)

1.2 Relation to other RDMs Management Instruments

1.2.1 Vision, Classification and Reserve

Resource Directed Measures

As mentioned in Section 1.1.2, this guideline provides an approach to the integration of visioning, classification and the Reserve process into the water resource management process, through the determination of RWQOs.

The following section provides a brief overview to each of these three components, highlighting some of the recent developments but, in particular, providing a reference to more detailed studies and manuals which will assist in the determination of RWQOs.

Catchment visioning

Society benefits immeasurably from rivers. In fact, human society exists only because water resources associated with water, and the goods and services that they provide are present and available in quantities that can support it (Karr, 1999). These goods and services include water supply; waste transport; processing and dilution; natural products (e.g. fish, reeds, medicinal plants); nature and biodiversity conservation; flood control; and places for rituals or spiritual needs.

The NWA (36:1998) acknowledges that water resources are ecosystems by providing for the protection of aquatic ecosystems. However, it is not necessary for a water resource to be left untouched to be functional. The intention of “environmentally sustainable water use” is one that balances water use with the protection of the resource in such a way that water resources are not degraded beyond recovery and to ensure that the aquatic ecosystems, if managed appropriately, continue to supply people with different goods and services into the future. Aquatic ecosystems cannot however offer the whole range of goods and services at the same time and in the same place. For example, if heavy use is made of water supply and waste disposal – then the ecosystem is unlikely to provide well for recreation, conservation or “a sense of place”. Therefore people need to be able to choose which services they want from ecosystems in time and space (DWAF, 2002c).

Why is a catchment vision important?

South Africa’s water resources are scarce and typically give rise to diverse and often competing interests. Within this management environment, a collective vision and co-operative spirit are needed to direct societal choice and action in a co-ordinated and peaceful fashion towards a notion of a better future.

What does catchment visioning offer?

Bringing the public into a participatory process and discovering how to sustain the energy of this process is complex and time-consuming. In the meantime, resource allocation and use must continue as resource-based businesses and livelihoods cannot wait for a perfect public participation process to be in place. The visioning process (DWAF, 2004a) provides a proxy for a process that incorporates the inputs of all interested parties. This enables the DWAF Regional Office to make an initial statement about a desired future state on behalf of the catchment community and other interested parties, in order to set the adaptive management process in motion.

What does catchment visioning offer?

The process has two main parts:

- Design a step-wise, low confidence method to generate a vision; and
- Indicate how the vision can be operationalised through a method known as Objectives Hierarchy. This method shows how the vision can be broken down into component management objectives.

The objectives hierarchy ensures that operational goals are developed in a way that demonstrates they are directly descended from the vision and, in this way, provides a pathway of accountability for both the water resource manager as well as civil society.

Visioning Approach

The approach to visioning/desired state setting, has elements that are important for Integrated Water Resource Management (IWRM) in South Africa:

- The catchment visioning process mimics the full participatory process. This approach sensitises users of the process to the intent and principles of visioning in a process involving full stakeholder participation and should streamline the transition from a low confidence to a more inclusive process.
- The vision must be context-specific. A vision embedded within context promotes buy-in and encourages the dialogue necessary to drive a consensus-based balance between different water resource users.
- The process is based on an opportunity to design the future. This approach is more conducive to capturing aspirations and prompting creative solutions.

Classification

In order to enable choices about the kinds and degrees of use of aquatic ecosystems, and therefore choices about the degree of ecosystem health and integrity, the NWA (36:1998, Section 12) makes provision for the development of a national classification system to classify all significant water resources. At present the national water resource classification system is still under development by the Department, with various interim approaches having been adopted since the implementation of the Act. The proposed approach to classifying a water resource is given below and in Figure 1.2.

In short, the classification system allows for the classification of a water resource in terms of aquatic ecosystem protection and water user requirements. These two components are summarised in a management class, for which the resource is managed.

Management Class

The final management class of a water resource is a combination of the ecological requirements for the water resource and the requirements of other water users within the catchment. The ecological requirements are determined by assessing the present ecological state (PES) category (A-F) [(2)] and the recommended ecological category (REC) (A-D)

Ecological Categories:

- A – unmodified natural
- B – largely natural
- C – moderately modified
- D – largely modified
- E – seriously modified
- F – critically modified

Categories used to define the present ecological category (A-F) and the recommended ecological category (A-D), form the basis for assessing the ecological Reserve and associated ecological specifications for the Resource.

A classification that incorporates other water users within a catchment has not as yet been finalised by the Department. However, the categories of Ideal, Acceptable, Tolerable and Unacceptable have been widely used within the Department and are adopted in this document.

Based on the water resource protection requirements and the socio-economic goals of the water resource, the management class may be determined as a gradient in aquatic ecosystem health and other user requirements from Natural to Heavily used/impacted (DWAF, 2004d) (Figure 1.2).

- Natural - unimpacted,
- Moderately used/impacted - slightly to moderately impacted
- Heavily used/impacted - heavily impacted, and
- Unacceptable - unacceptably impacted.

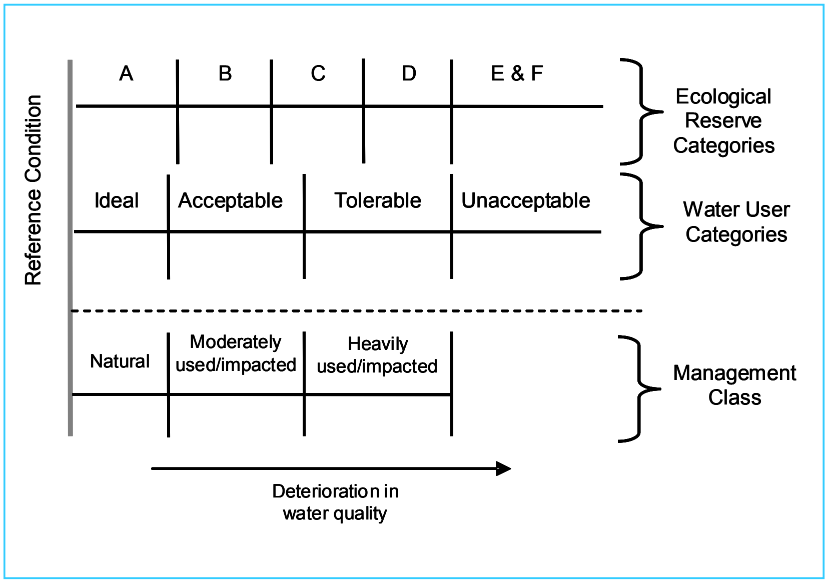

Figure 1.2: Mapping to a Management Class.

Note: The boundaries between Ideal, Acceptable, Tolerable and Unacceptable, as they relate to the ecological categories or management class have not been finalised and are only represented here schematically.

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(2) The revised water quality Reserve Methodology (Hughes, 2005) uses the terms “Natural”, “Good”, “Fair”, and “Poor” to describe water quality categories. However, the Department prefers that the Categories A-F be applied to the ecological category (water quality) instead of Natural – Poor, to ensure consistency in integration of ecological components. Similarly the water user categorisation should allow for a similar six tier categories to allow for integration with the A-F ecological categories (water quality).

Rationale of classification

The rationale to base a classification system on ecological health and integrity principles is because biological communities reflect not only the influence of the prevailing quality of the water, but also the effect of pollution episodes that may not be detected by routine chemical sampling. The inclusion of biological information in river classification should therefore reduce the risk of placing a river reach in the wrong class (NRA, 1991)

The classification system also considers other water users. The NWA calls for the efficient, equitable and sustainable use of the nation's water resources. These economic, social and ecological goals respectively, 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 aquatic 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.

However, these economic, social and ecological goals are potentially conflicting, and the Classification Process therefore requires trade-offs to be made in setting a management class (DWAF, 2006).

Classification framework

The framework for determining a preliminary class will be guided by the following requirements :

- Be consistent with the requirements of the NWA (36:1998);
- Be supported by key policies and principles adopted by DWAF;
- Aligned with the current philosophy and thinking around water resource classification;
- Based on available information and existing methods; and
- Be developed in such a way as to ensure that a seamless transition takes place once a water resource classification system is available for implementation.

Reserve process

It is not the intention of this document to repeat the considerable amount of work that has been undertaken by the Department in assessing the Reserve. The reader is referred to the Integrated and Specialist RDMs Manuals which have been prepared by DWAF.

RDMs Supporting Information

This guideline document should be used in conjunction with other guideline documents and manuals, such as:

- Water Quality Reserve Determination Methods (Hughes, 2005)
- Manual for Ecostatus Determination (Kleynhans et al., 2005)
- Catchment Assessment Study Guideline (DWAF, 2003a, b)
- Catchment Visioning Guideline (DWAF, 2006g)
- Integrated RDMs Manual (DWAF, 1999a)
- Reserve Determination Manuals (DWAF, 1999b)
- South African Water Quality Guidelines (DWAF, 1996)

1.3 Guiding Principles

Background

The determination of RWQOs incorporates ecological, social and economic interests across all components of water resources. Although this guideline provides a generic approach to the determination of objectives, with varying levels of detail and confidence, the approach is based upon a number of key principles adopted by the Department in numerous DWAF policy documents and in particular those described in the Resource Directed Management of Water Quality Policy (DWAF, 2006c). These principles are outlined below, together with the resultant implications of using these principles in the determination of the management class and the RWQOs.

Guiding Principles

The decision-making process used for the determination of preliminary RWQOs is driven by the principle of sustainable development, which is enabled by the principles of integration, equity between generations and dependence on aquatic ecosystems.

Environmental rights, South African Constitution (Act No. 108 of 1996), Section 24:

Everyone has the right :

a. To an environment that is not harmful to their health or well-being; and
b. To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that:
    - Prevent pollution and ecological degradation;
    - Promote conservation; and
    - Secure ecologically sustainable development and use of natural resources, while promoting justifiable economic and social development.

Precautionary Principle (DEAT, 1997):

A risk averse and cautious approach that recognizes the limits of current knowledge about the environmental consequences of decisions or actions.

Default Rule, DWAF (1999a) Resource Directed Measures:

The management class is determined in relation to the present state, but at a level which represents a goal of no further degradation for water resources which are slightly to largely modified, and at least a move toward improvement for water resources which are critically modified.

DWAF, National Water Resource Strategy (2002b:48)

Any water resource which demonstrates ‘Unacceptable’ conditions is deemed to be unsustainable. In these cases the management class will be determined as a minimum of ‘Heavily used/impacted’ (the lowest management class), and management will aim to rehabilitate the water resources to this state.

DWAF, National Water Resource Strategy (2002b:7)

Water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right, whilst water use for all other purposes will be subject to a system of administrative authorisation.

Finding a balance between the needs of downstream water users and upstream water use and development

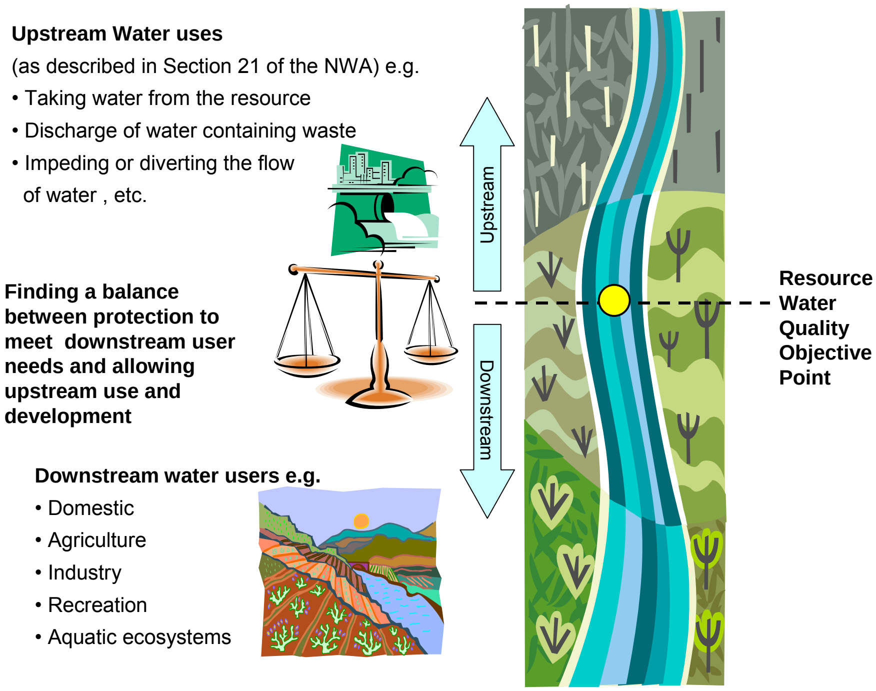


Figure 1.3: Illustration showing the difference between uses and users, as well as the RWQOs point (adapted from Van Wyk, 2006)

The site selected for setting RWQOs (Figure 1.3) affects both the upstream water ***uses*** and the downstream water ***users***. In setting RWQOs the Department strives to achieve a balance between protecting the water resource for the downstream users and allowing use and development of the water resource upstream of that point. For the downstream water users, the focus is on protecting the water quality in order to ensure a healthy functional aquatic ecosystem, while also meeting the water quality requirements of the other five recognised water user groups (domestic, agricultural, industrial and, recreation and aquatic ecosystems) downstream of the RWQOs point. However, the selected RWQO selected might also restrict the type and extent of water use upstream of the point. Water uses refer to those described in Section 21 of the NWA and includes uses such as the discharge of water containing waste (using some of the allocatable water quality) or taking water from a water resource (using some of the dilution capacity) (adapted from Van Wyk, 2006).

Implications of Principles to determining RWQOs

Based on the above principles, the following is implied:

- The Department may not accept deterioration in water quality from the present state, at least when determining RWQOs using the low confidence method, which due to the low level of confidence in the approach, by default adopts the Precautionary Principle.
- In areas of deteriorated water quality, the quality should be improved from an Ecological Category of 'E/F' to an ecological category of 'D' and a management class of 'Heavily used/impacted' (as a minimum).
- The default rule for other users is that the minimum desired category should be 'Tolerable'.
- RWQOs should be determined to (as a minimum) meet the Ecological and Basic Human Needs Reserve (or better).

SECTION 2: LEVELS OF RWQOS DETERMINATIONS

2.1 Levels of RWQOs determination methodologies

Descriptions of different levels

Descriptions of the three levels of confidence in determining RWQOs are shown in Table 2.1.

Rules for selection of appropriate level

The rules for selection of the appropriate level of RWQOs determination are summarized in Table 2.1 and Figure 2.1, and provided in more detail in Table 3.

Table 2.1: Levels of RWQOs determinations

Level	Characteristics	Use
Low confidence	Low confidence; based only on available data and information. Limited possibility of new data collection to assess present state	Individual licensing for small impacts in unstressed catchments or catchments of low ecological and user importance & sensitivity
Medium confidence	Medium confidence, specialist field studies, institutional stakeholder involvement	Individual licensing for low to moderate impacts in relatively stressed catchments or catchments of high importance and sensitivity
High confidence	Relatively high confidence, extensive field data collection by specialists, intensive stakeholder involvement	All compulsory licensing (stressed catchments). Individual licensing, for large impacts in any catchment. Small or large impacts in very important and/or sensitive catchments.

The following rationale (Figure 2.1) is applied in selecting the required level of RWQOs determination:-

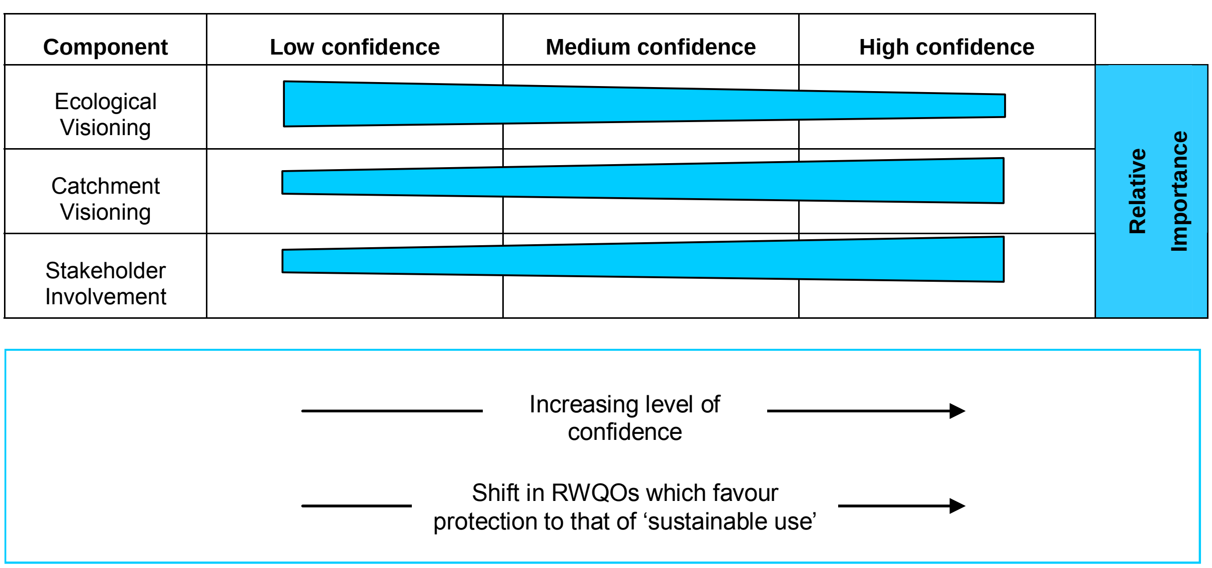


Figure 2.1: Varying level of importance of aspects in determining RWQOs.

Nature versus impact

The level of confidence required to determine RWQOs is seen to be based both on the nature of the catchment (ecological and user importance and sensitivity) and on the degree of impact (stress).

Stressed catchments

The level of confidence adopted (Low to High) in determining the RWQOs is based largely on the existing degree of stress of the water resource (See Section 5), i.e. RWQOs in low stressed catchments may be determined by a low confidence method, while RWQOs in a moderate to highly stressed catchment should be determined at a higher level of confidence using medium or high confidence methods.

However, the level of stress is often not known until the RWQOs are determined and the remaining allocatable resource assessed. As such, an assessment of the stress of a water resource should be seen as an iterative one, i.e. the level of confidence in determining RWQOs may be improved after an initial determination of the RWQOs.

Local expert knowledge and an understanding of the catchment are always important in assessing the initial degree of stress of a catchment, even when determining the RWQOs at a low confidence level.

Confidence

The assessment of confidence is a combination of the confidence in the data used in the RWQOs determination and in the process followed to determine the RWQOs.

- Assessment of the confidence in the data is based on an assessment of the datasets used (higher confidence allows for collecting data for variables of concern that are not monitored routinely - such as dissolved oxygen or toxic substances), specialist knowledge of how representative the data set is to characterise water quality in the whole water resource management unit, and statistical measures of central tendency, etc.
- Confidence is also a function of the process followed. The higher the level of confidence, the higher the level of stakeholder participation and consultation. For example, at a low level of confidence, the generic requirements of user sectors are considered while at a high level of confidence, the requirements of key individual users are considered. At a higher level of confidence, stakeholders participate actively in determining a vision for the catchment and agreement is sought on the RWQOs.

Assessing the degree of stress of a water resource is discussed in Section 5.

Methodology

The method used to derive RWQOs is described in Sections 3-5 with detailed descriptions in Annexures C - E.

SECTION 3: METHODOLOGY FOR RWQOS DETERMINATIONS

3.1 Road map of the RWQOs methodology

Description of each step

This section contains an overview of the methodology for determining RWQOs. A brief description is given of each step in the methodology, with indications of:

- The purpose of the step; and
- The differences between the different levels of RWQO determinations.

Approach

The following approach to the determination of RWQOs is proposed:

- Ecological Requirements (Reserve):
  - Delineate resource unit (spatial scale of the RWQOs)
  - Determine present water quality state
  - Determine desired (attainable) water quality (ecological component of the catchment vision)
  - Determine ecological specifications (water quality component of the Reserve)
- Water User Requirements
  - Identify water users
  - Assess present water quality with regards to water user requirements
  - Determine desired water quality (water user component of the catchment vision)
  - Determine water user specifications
- Determine the Management Class for the water resource through integration.
- Establish RWQOs, through the integration of ecological and water user requirements for water quality (Figure 3.3).
- Establish time period of RWQOs, i.e. seasonal, short-term, or long-term water quality goals for the resource unit.

The approach for determining RWQOs at a low confidence level, although incorporating ecological, social and economic considerations, may not involve intensive stakeholder participation. However, the Department must consider all permissible water uses when determining the RWQOs.

Parallel tasks

The two components for establishing the RWQOs, i.e. the ecological requirements and the water user requirements are indicated in Figure 3.1 and 3.2, and outlined above, as being two separate tasks. The subdivision of the process into two components is necessary due to the division in responsibilities in conducting the various components. The assessment of the ecological specifications is typically a function of the RDMs Directorate of the Department, while the assessment of water user specifications is a function of the Regional Office or, in the future, the Catchment Management Agency. These two components must however be seen as integrative, both contributing to the determination of the RWQOs. The process of developing a Catchment Vision addresses both the ecological and water user aspirations of stakeholders.

In this guideline document these two components of the vision supports the two parallel components of establishing the RWQOs. The ecological component of the Catchment Vision therefore informs the Ecological Requirements (Figure 3.1) and the water user component informs the Water User Requirements (Figure 3.2).

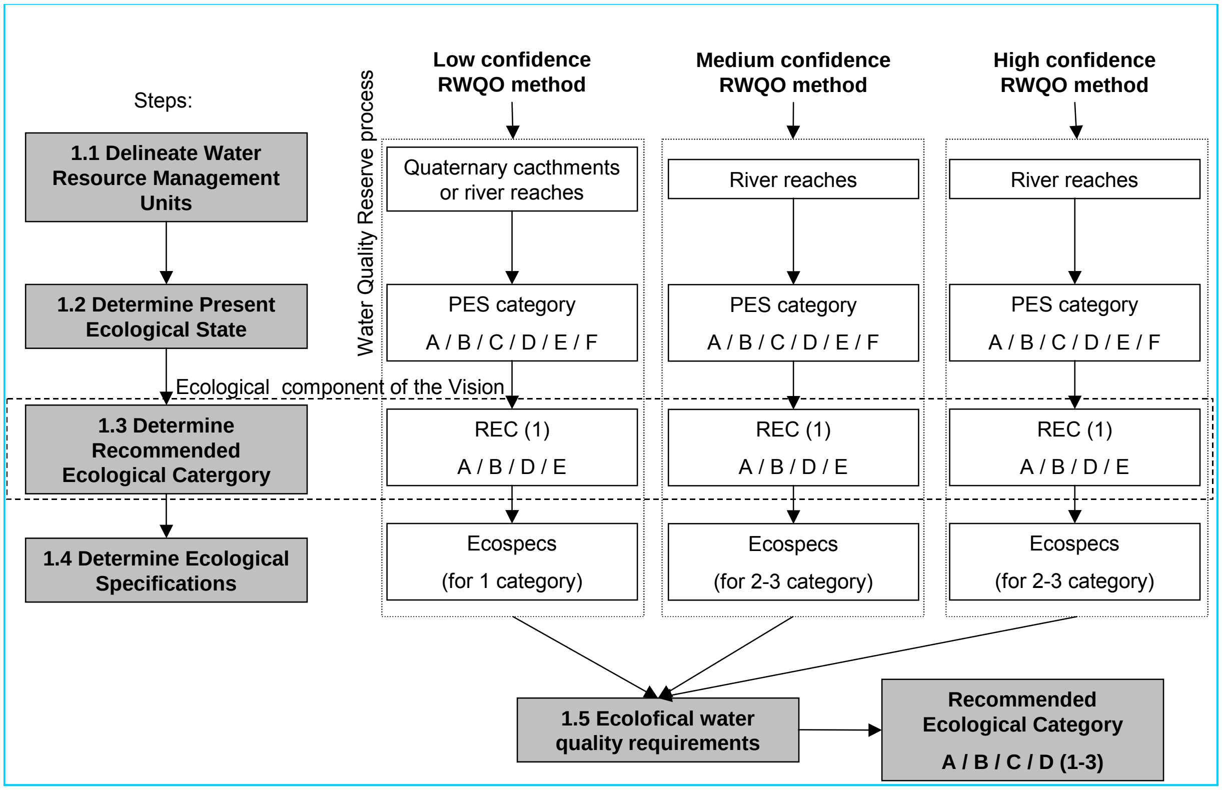
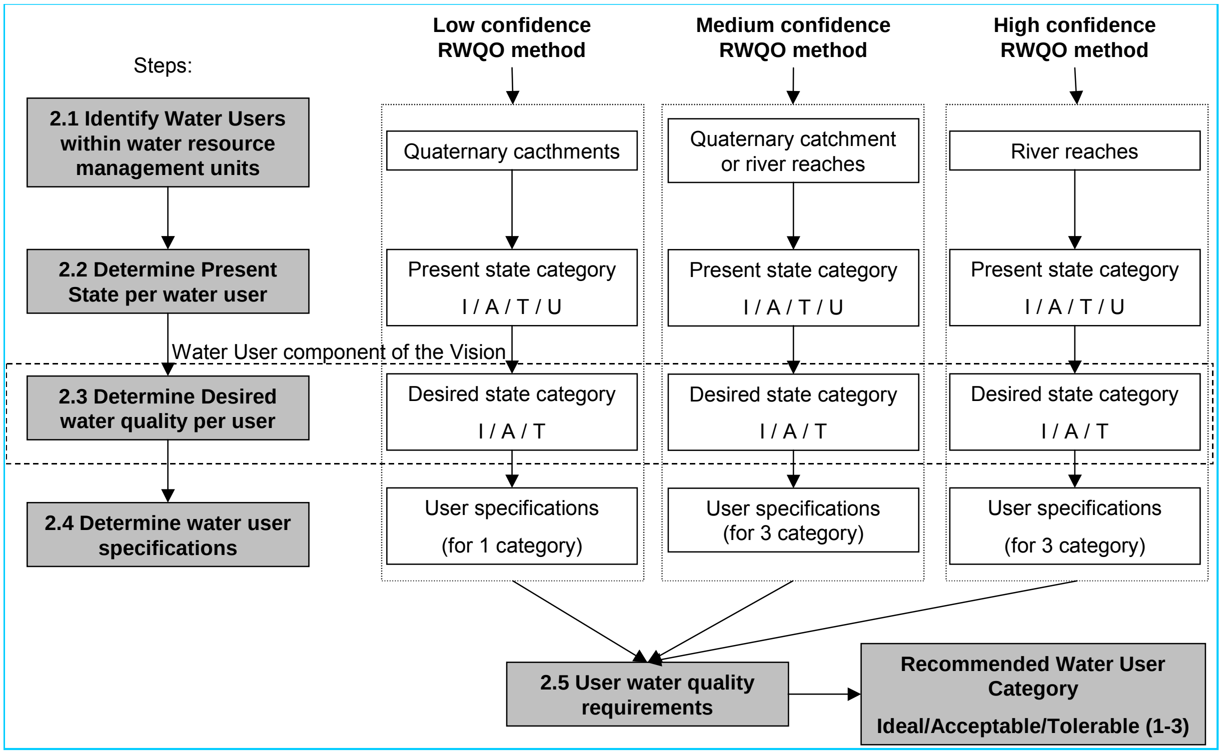


Figure 3.1: Generic procedure for determination of Ecological Requirements.



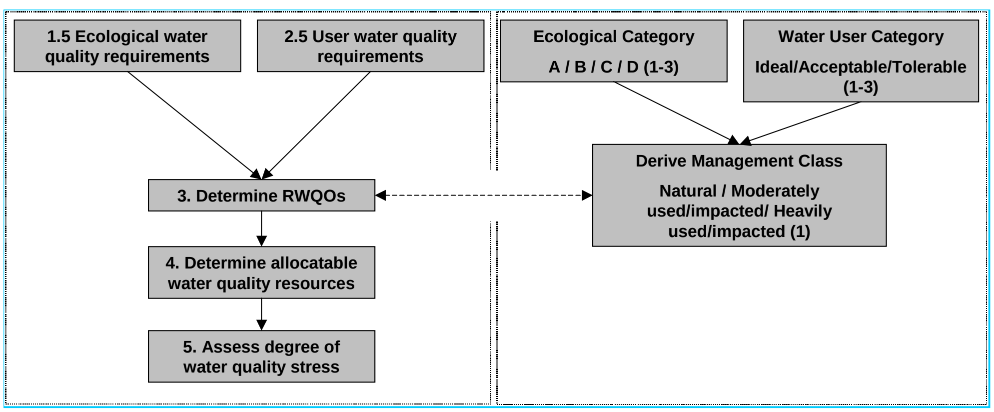


Figure 3.2: Generic procedure for determination of Water User Requirements.

Figure 3.3: Generic procedure for determination of RWQOs.

Note: (1-3) - Reflects the number of categories which may be selected during the Ecological Requirements process or the Water User Requirements process, based on the level of confidence adopted for determining RWQOs (i.e. low, medium or high confidence methods). See Annexures C-E for further details.

3.2 Ecological Requirements

Protection of water resources

The NWA (36:1998) makes provision for the protection of water resources through RDMs to ensure that the quality, quantity and assurance of water are protected, so as to meet basic human needs and to protect the structure and function of ecosystems, thereby securing ecologically sustainable development and utilisation.

The ecological requirements as outlined in steps 1.1-1.5 below are aimed at assessing the ecological component (water quality) of the Reserve. Only an overview is given here and it is not the authors' intention to repeat the Reserve Methodology. For more information the reader is referred to the Water Quality Reserve Determination Manual (DWAF, 1999b, DWAF, 2002c) and the RDMs Integrated Manual (DWAF, 1999a).

Step 1.1: Delineate water resource management units

Spatial scale

RWQOs must be determined for a defined spatial unit or water resource management unit whether it be a river reach, an eco-region, a quaternary catchment or a group of catchments.

The scale for which the RWQOs are determined is dependant upon:

- The level of confidence (low, medium or high)
- The required level of spatial detail
- The heterogeneity of the catchment, i.e. topography, land use, geology, ecology, etc.
- Spatial scale of available information, e.g. Reserve Determination, Catchment Vision, etc.
- Ecological similarity of the water resource with neighbouring catchments.

The Catchment Vision will be set at a catchment to sub-catchment level whereas RWQOs will be set at a sub-catchment to river reach level. Rapid (low confidence) Reserve determinations whether for surface or groundwater, are conducted at the level of a quaternary catchment, while Intermediate to Comprehensive (medium-high confidence) Reserve determinations can typically be conducted on smaller resource units, such as river reaches, eco-regions or geohydrological response units (DWAF, 2002c).

Ecoregions

The breakdown of a catchment into surface water resource management units for the purpose of determining ecological requirements, is done primarily on a biophysical basis, according to the occurrence of different ecological regions (ecoregions) within the catchment. The approach is based on delineating, on a biophysical or ecological basis, relatively homogenous units, within a larger resource which might require their own specification of RDMs (DWAF, 1999a). The geographic area used in generating the catchment vision (DWAF, 2006) is more related to serving the interests of a group of interested water users than on biophysical or ecological characteristics.

NWRCS - Network of significant resources

The procedure that is being developed for the National Water Resource Classification System (NWRCS) describes a comprehensive process and guiding rules to delineate a network of significant resources. If the water resources in a catchment have been classified as part of the NWRCS, then the network of significant resources should be used as the initial template for delineating water resource management units. These can then be subdivided into smaller water resource management units as required.

Geohydrological response units

For groundwater, water resource units are initially defined on the basis of geohydrological response units, relatively homogenous aquifer units based on geological conditions.

Guide

The following guide may be applied to the selection of the spatial scale of the Resource unit.

- Low confidence RWQOs determination – quaternary catchment / river reach
- Medium confidence RWQOs determination – river reach
- High confidence RWQOs determination – river reach

The same Resource unit should be used when assessing the ecological and water user requirements (Figure 3.4).

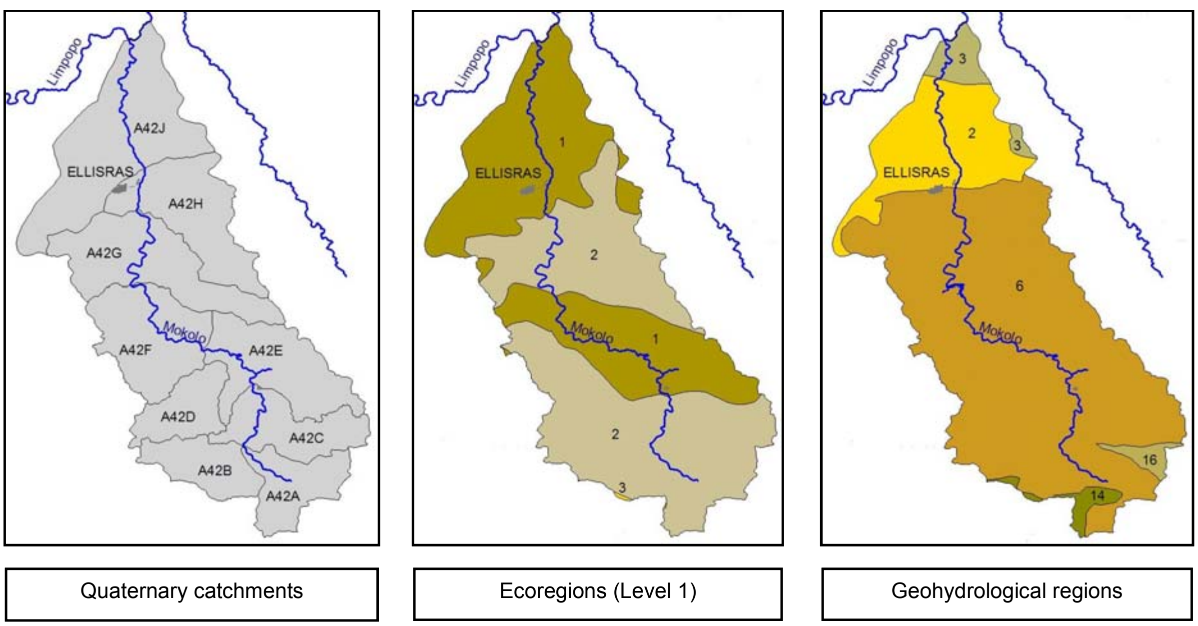


Figure 3.4: Defining water resource management units.

Step 1.2: Determine Reference and Present State

Reference conditions

Reference conditions describe the natural unimpacted characteristics of a water resource (DWAF 1999a), or the natural unimpacted conditions of the Water Resource Management Unit. The assessment of present state, the selection of the management class and the quantification of the Reserve and RWQOs, are all carried out relative to the reference conditions for that water resource (DWAF, 1999a).

Assessment of the state of the water resource

Step 1.2 entails a present state assessment of the resource water quality in terms of monitored water quality and the degree of modification of this quality from reference conditions.

Purpose of the present state assessment

The present state assessment is required for two purposes:

- Firstly to assess the **degree of modification**, (and hence the current degree of risk of irreversible damage), and if possible to identify whether the resource quality is stable within a particular assessment category, or the water resource is currently degrading due to past or present impacts;
- Secondly to identify what **may be achievable** in terms of the management class, in order to rule out unrealistic options when determining the Ecological Category in Step 1.5. Sometimes structural modifications to the water resource (such as dams or urban development), or short-term needs for economic development may be such that a higher class than the present one can not be practically achieved in the short- to medium-term. Hence the need for intermediate objectives as described in DWAF (2003a).

Ecological state

The ecological state provides a point from which the state of the water quality can be assessed. The ecological state considers, amongst others, the flow, inundation, water quality, stream bed condition, instream biota and riparian or stream bank condition.

The desktop model of Kleynhans (2000) provides an overview of the present ecological state category (PES) at a desktop level, established through local expert knowledge and by considering the above ecological attributes. Results for each quaternary catchment in the country are available from the Department.

Ambient water quality

An assessment of the present state or ambient water quality within the Water resource management unit should include:

i. Identifying water quality stations or monitoring points within the catchment. These may be DWAF stations, or belong to Water Boards, catchment forums, private companies or local authorities.

ii. Extract water quality data for these stations. This can be done either from the DWAF water quality database (WMS), from tools such as Water Quality on Disk (available from DWAF or the CSIR), or the water quality information systems of Water Boards, catchment forums, etc.

iii. Obtain water quality statistics for each of the monitored chemical parameters, e.g. pH, EC, TDS, Ca, Mg, K, Na, TAL, Cl, F, Si, SO_4, NH_4, NOx, KN, PO_4, TP
   a. Min – Max (range)
   b. 5^{th} – 95^{th} percentiles
   c. Median, mean

Ecological Assessment Categories

Based on an assessment of the present state, a present ecological state category can be assigned to the water resource management unit. The six ecological present state categories are identified simply as categories A-F, and are described in more detail in the Reserve Manuals (DWAF, 1999b).

Step 1.3: Determine the Recommended Ecological Category

Ecological visioning

To contextualise the present state of a water resource, it is important to have an idea of what is desirable for the water resource management unit. An understanding of what the ecological state of a river should be can provide water resource managers with direction for making decisions and implementing management actions.

Factors to consider

Many factors can be considered in determining the recommended ecological category for a particular water resource management unit, including:

- The ecological importance (in maintaining ecological diversity and functioning at local and wider scales) and sensitivity (ability to tolerate disturbances) of the system. The ecological importance and sensitivity of the water resource considers biodiversity, rarity, uniqueness, and fragility, from habitat, species and community perspectives.
- What can be achieved towards improvement of the resource water quality, given that some prior impacts or modifications may not be practically reversible due to technical, social or economic constraints.
- The strategic importance of the water resource for social and economic development.

Ecological Importance and Sensitivity

Ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity (or fragility) refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once this has occurred (resilience).

In determination of RDM, the following ecological aspects are considered as the basis for the estimation of ecological importance and sensitivity:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, intolerant species and species diversity.
- Habitat diversity, including specific habitat types such as reaches with a high diversity of habitat types, i.e. pools, riffles, runs, rapids, waterfalls, riparian forests, etc.
- The importance of the particular water resource management unit (e.g. river or reach of river) in providing connectivity between different sections of the whole water resource, i.e. whether it provides a migration route or corridor for species.
- The presence of conservation areas or relatively natural areas along the river section.
- The sensitivity (or fragility) of the system and its resilience (i.e. the ability to recover following disturbance) of the system to environmental changes are also considered. Consideration of both the biotic and abiotic components is included here.

Procedures for rating ecological importance and sensitivity are given in detail in each specialist manual (DWAF, 1999a, 1999b).

Ecological Assessment Categories

Based on an assessment of the desired state, a recommended ecological category (REC) can be assigned to the water resource management unit. The four recommended ecological categories are identified simply as categories A-D, and are described in more detail in the Reserve Manuals (DWAF, 1999b). Categories E and F are not considered as desired ecological states since they are significantly modified and are considered ecologically unsustainable in their present state.

Step 1.4: Determine Ecological Specifications

Ecological Specifications

The ecological specifications (so-called 'ecospecs') determined here are numeric descriptions of the ecological component (water quality) [3] of the RWQOs and define the output of a Reserve determination process.

The ecospecs describe the upper and lower boundaries of the selected ecological category (A-D), in terms of water quality. Typical chemical parameters for which ecospecs are described in a Reserve determination, include:

- Total dissolved solids (TDS) or Electrical Conductivity (EC)
- pH
- Dissolved oxygen
- Temperature
- Total suspended solids (TSS)
- Major ions – sodium, magnesium, calcium, potassium, chloride, sulphate, carbonate-bicarbonate
- Salts – $MgSO_4$, Na_2SO_4, $MgCl_2$, $CaCl_2$, NaCl, $CaSO_4$
- Nutrients – ammonia, total inorganic nitrogen, ortho-phosphate, total phosphorus
- Toxic substances
- Biological indicator water quality
- Chlorophyll *a* as an indicator of algal abundance

At a low confidence level, ecological specifications only need to be given for the recommended category. At a medium to high confidence level, ecological specifications are typically given for the recommended ecological category plus for one category up (unless recommended category is an 'A') and one category down. The implications of one category up and one down, on the water resource, are also given. The intention is to give the Department or CMA the opportunity to adequately integrate the ecological and water user components while being fully aware of the implications of their choice.

Step 1.5: Ecological Requirements

Output

The output of the ecological requirements is the ecological Reserve (water quality) or a proxy for the ecological Reserve, which defines the recommended ecological category with corresponding water quality ecological specifications. The ecological requirements will establish the:

- Present ecological category (A-F)
- Recommended ecological category (A-D), and
- Associated ecological specifications for specific water quality variables

Mapping Categories to Classes

Ecological categories may, in combination with the water user category, be mapped to a management class. The mapping route from the four ecological categories (A, B, C, D) system to the three class system (Natural, Moderately used/impacted, Heavily used/impacted) is as follows:

- A = Natural
- A/B, B, B/C = Moderately used/impacted
- C, C/D, D = Heavily used/impacted

The Reserve considers both the Ecological Requirements and Basic Human Needs. In this guideline document, the water quality requirements for Basic Human Needs are dealt with under domestic user requirements in Section 3.3.

[3] Ecospecs may also include numeric descriptions of flow, habitat, biota etc. and are not only defined for water quality.

3.3 Water User Requirements

Water User Requirements

Water user requirements, as outlined in Steps 2.1-2.5, aim to assess the Basic Human Needs Reserve (water quality), and to assess the other water quality requirements of other water users.

Step 2.1: Identify Water Users

Identify water users

All water users within the catchment must be identified, whether they are seen as an existing permissible water-use or not [(4)]. Water users may be grouped into the following categories (WRC, 1998, DWAF, 1996):

- Domestic
  - Drinking (health)
  - Food preparation
  - Bathing
  - Laundry
- Agriculture
  - Live stock watering
  - Irrigation
  - Aquaculture
- Industry
  - Category 1 (High water quality requirement)
  - Category 2 (Intermediate water quality requirement)
  - Category 3 (At least domestic water quality requirement)
  - Category 4 (Low water quality requirement)
- Recreation
  - Full contact
  - Intermediate contact
  - Non contact

It must be noted that only the major water user sectors are presented here. More detailed information may be collected on the user sector, e.g. under agriculture: irrigation - maize, tobacco, vegetables etc. Certain water users may have specific water quality requirements, e.g. tobacco is sensitive to elevated chloride concentrations.

Sources of information

Water users who are exercising existing lawful use within the Water resource management unit should be identified from the following sources:

- Registered water users – DWAF WARMS database
- Water Users Association
- Local knowledge of the catchment
- Site visit and/or field investigations
- Maps – orthophotos, satellite imagery, aerial photographs
- Land use database (1996) – currently being updated
- State of Rivers Reports

Catchment Assessment Study

If the Water resource management unit falls within an area where a catchment assessment study has been undertaken, this will provide valuable information as to the state of the catchment, existing water users and the desired water quality within the catchment. The reader is referred to the Water Quality Catchment Assessment Study Guideline (DWAF, 2003b).

[(4)] Note: RWQOs should take into account both permissible water uses and possible future water uses, however they may need to take cognisance of unlawful water uses, which may place additional stress on the water resource.

Step 2.2: Assess Present State per water user

Variables of concern

Based on the present water quality, identified water users and the permissible water uses within the catchment, the variables of concern must then be identified. The variables of concern are based on water user requirements and known sources of pollution within the Water resource management unit which may impact upon water quality. The variables of concern therefore provide key indicators to monitor changes in the water quality which would render the water unfit for a specified use.

For example, in areas of gold mining, turbidity, pH and sulphate (SO_4) may be high due to pollution of water resources – these would then be considered as variables of concern.

Tobacco farmers are known to require water quality with low chloride (Cl) concentrations. Accordingly, Cl would be a variable of concern in a catchment where tobacco farming takes place.

Key water quality constituents will fall into one of the following groups:

- Physical properties – pH, conductivity, suspended solids
- Cations – Na, K, Mg, Ca, NH_4
- Anions – Cl, SO_4, HCO_3, CO_3, NO_3, PO_4, OH
- Salts – $MgSO_4$, Na_2SO_4, $MgCl_2$, $CaCl_2$, NaCl, CaSO4
- Metals – e.g. Fe, Mn, Al, Zn, Cu, Ni, Cr, Co, Pb, Se
- Other inorganic constituents – e.g. B, Si, F, As
- Organic constituents

The Guideline for Monitoring and Auditing for RDMWQ (DWAF, 2006) also provides guidance on the selection of variables of concern and recommends an “essential” list of variables that are critical for the affected water users.

Water quality state

An assessment of the water quality within the water resource management unit should be compared to the South African Water Quality Guidelines, per water user sector, to identify the present state of the water quality.

Fitness for use categories

Water quality may be categorised as follows (Van Wyk, Moodley & Viljoen, 2002):

- Ideal
- Acceptable
- Tolerable
- Unacceptable

At present the DWAF Water Quality Guidelines (DWAF, 1996) only reflect the Target Water Quality Range (TWQR), which may be considered as Ideal water quality. The Water Quality Guidelines have been used as a basis for establishing generic water quality limits for each of the water user categories. The method used to covert the guidelines to categories is discussed in Annexure A.

Step 2.3: Determine Desired Quality per water user sector

Catchment Visioning

A catchment vision should be established to identify the current and future water user requirements and the desired state of the catchment through agreement with key stakeholders. The reader is referred to the Department's Catchment Visioning guideline (DWAF, 2004a) for details of how to go about establishing a catchment vision.

The requirements for catchment visioning depend on the level of detail adopted in determining the RWQOs.

- The low confidence determination, although considering existing, permissible uses, also considers future water uses through catchment visioning, but it does not consider a relaxation in water quality at the expense of socio-economic development.
- At a medium to high confidence level, catchment visioning and stakeholder participation in determining RWQOs is vital. A compromised (lower) water quality may be considered to ensure economic and social development while still ensuring sustainable utilisation of the water resource, i.e. relaxation in the fitness-for-use category from Ideal to Acceptable or Tolerable.

Relationship of visioning and objectives hierarchy with other RDMs-related management instruments

The interim version of the classification and RWQOs makes provision for a dual approach to defining objectives. The 'low confidence' option refers to a low confidence option where little or no information about the aquatic system is available for decision-making. For this approach, the precautionary principle is used to guide decisions. The medium to high confidence approach options are based on better (or more complete) information about the aquatic system.

The outputs from both of these options can be used as a compatibility cross-check against the outcomes of the objectives hierarchy process, i.e. the management objectives that stem from the vision.

The power of the process provided here lies in being able to derive technical operational management objectives that can be drawn back directly to the catchment vision, thus making the objectives and their outcomes answer to the 'heart and soul' of human aspirations with regard to the water resource.

About this approach

The reader should consult the Catchment Visioning document (DWAF, 2006f) for more detailed information on establishing a catchment vision.

Water user categories

At a low confidence level, the desired water user category, by default, is conservatively set to the present state provided the present state is better than the Tolerable category. If the present state is poorer than Tolerable, then the desired water user category is set (i.e. raised) to the Tolerable category.

The method does, however allow for some flexibility with regards to determining the water user category. At a low confidence level, *in the absence of data*, it is recommended that the desired water user category be conservatively set to the present state.

At a low confidence level, *with the availability of catchment specific water quality data* the water user category may be moved up or down from the present category provided the change can be justified and the reasons for the change are properly documented. At medium or high confidence levels, the desired water user category is set through stakeholder participation and may be moved up or down from the present category to Ideal, Acceptable or Tolerable.

It is important to stress that when a water user category is moved up or down from the present state, i.e. allowing for an improvement or deterioration in the water quality of the water resource management unit, the implications of such a change, on both the water resource and the water users, must be adequately known, understood and accepted.

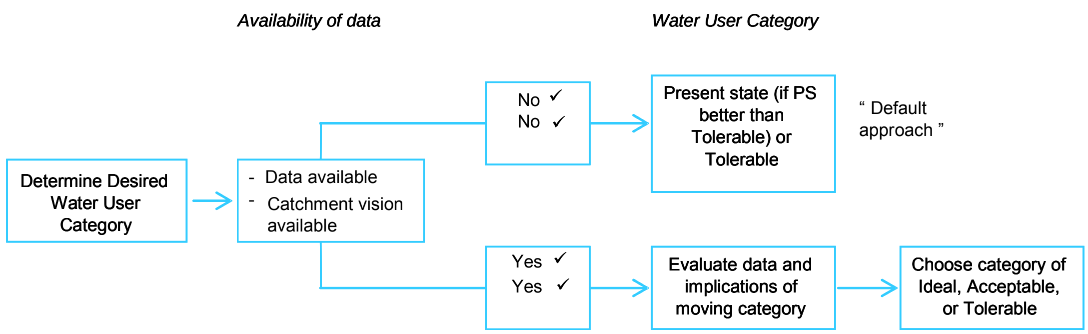


Figure 3.5: Flow diagram for selecting the desired water user category (low confidence method).

Step 2.4: Determine Water User Specifications

Water User specifications

The water user specifications are a numeric description of the water user requirements.

At a low confidence level these water user specifications are determined from the desired water user category (Step 2.3) and the associated generic water quality limits for that category (Annexure A). With increasing levels of confidence, the water user specifications for the selected water user category must be based on site specific water quality data and site specific water user requirements.

Since the ecological water quality requirements (Reserve) will provide details for one class up and one class from the present state, at a medium to high confidence method, the ecological specifications are available to assess the resultant implications of relaxed water quality requirements on the ecological component.

Water Quality Guidelines

The water quality requirements (Ideal, Acceptable, Tolerable) of the water users (at a low confidence level) is based upon the generic RWQOs determined from the South African Water Quality Guidelines for Domestic, Recreational, Agriculture, and Industry (DWAF, 1996).

The Basic Human Needs Reserve is currently determined for a Class 1 (Good) resource, based on the WRC Guidelines for Domestic Water Supplies (WRC, 1998). This water quality is less stringent than the TWQR (Ideal) for domestic use given in the South African Water Quality Guidelines (DWAF, 1996).

Target Water Quality Range

As a matter of policy, the Department strives to maintain the quality of South Africa's water resources in such a way that they remain within the No Effect Range (DWAF, 1996). The No Effect Range in the South African Water Quality Guidelines is referred to as the TWQR, categorised as the Ideal Water User Category.

Users of the South African Water Quality Guidelines should note that an important implication of setting the TWQR equal to the No Effect Range is that it specifies good or ideal water quality, instead of water quality that is merely acceptable to users.

Which users are considered

At a low confidence level, it is likely that all existing permissible water uses within the water resource management unit will be considered. However, with increasing levels of confidence and stakeholder participation, certain uses may be excluded, e.g. due to particularly stringent requirements that are not aligned with the catchment vision, or certain users may accept a poorer water quality than that specified for the water user category.

Step 2.5: User Requirements

Output

The output of the water user requirements is the Basic Human Needs Reserve (water quality), an assessment of the present water quality with regards to water user requirements and a statement of the desired water quality with corresponding water quality limits.

Water User Category

The water user category for domestic, agriculture, industry and recreation can be classified as :

- Ideal,
- Acceptable,
- Tolerable.

User category 'unacceptable' is not considered as a management category.

3.4 Resource Water Quality Objectives

Step 3: Determine RWQOs

Integration

The RWQOs are determined through the integration of the ecological and water user requirements, with the most stringent water quality or most sensitive water user, defining the RWQOs within the desired category or management class. The water use must be beneficial, in the public interest and promote the values described in Section 3(2) of the NWA (36:1998).

Time Frame

The temporal scale for the determination of RWQOs must always be defined. The temporal aspect in the determination of RWQOs plays a number of roles, as outlined below.

Duration of RWQO:
RWQOs must be determined for a specific time period, i.e. the duration over which RWQOs apply:

- Short-term – 2 years
- Medium-term – 2-5 years
- Long-term – > 5 years

For example, in instances where a water resource is significantly impacted, resulting in non-compliance with the determined RWQOs, the present water quality may be set as a short-term RWQOs ensuring no further deterioration in water quality, while the determined RWQOs are set as the medium- or long-term objective.

Compliance of water quality with the RWQO:

It is unlikely, and not expected, that in-stream water quality will comply with the RWQOs for 100% of the time. As such, a target of 95% compliance is recommended.

Period for which RWQO are determined:

RWQOs may be determined for the following periods:

- Annual – i.e. RWQOs apply for a complete hydrological year.
- Seasonal – i.e. RWQOs apply for a particular season within the year. Here the most sensitive season, e.g. dry season may apply.
- Monthly – i.e. RWQOs are determined for each month of the year.

Spatial scale

The spatial area or water resource management unit (i.e. river reach, quaternary catchment etc.) for which the RWQOs are determined must be clearly stated. The point where compliance to the RWQOs is measured is situated at the downstream end of the water resource management unit.

Classification

Based on the determined ecological and water user categories, a final management class can be determined. Management classes described in ecological and water user terms have been identified as Natural, Moderately used/impacted and Heavily used/impacted.

Mapping Categories to Management Classes

The mapping route from the four ecological categories (A, B, C, D) to the three water user categories and the management class is provided in Table 3.1.

Table 3.1: Mapping ecological and water user categories to management class (illustrated in Figure 1.2).

Ecological Category	Water User Category	Management Class
A	Ideal	Natural
B/C	Acceptable	Moderately used/impacted
C/D	Tolerable	Heavily used/impacted

* (approach to be finalised through the national classification system)

Review

The RWQOs once selected, should be reviewed against the following criteria to ensure their relevance and applicability within the water resource management unit:

- Present water quality – are RWQOs achievable against the present state or will it require considerable management intervention or re-engineering.
- Upstream and downstream water quality requirements.

Acceptance of the RWQOs

It is recommended that the final RWQOs should be signed off at a water management area (WMA) level to provide a formal record of decision.

The final RWQOs report should properly document:

- the level of confidence selected,
- the reasons for delineating the water resource management units,
- the variable of concern that were selected, the RWQOs that were developed, and
- the level of stakeholder participation in the process, etc.

The output of the Resource Water Quality Objectives Model (WQM 1.7.2.1) can be used to summarise the determined RWQOs.

Fate of RWQOs in the RQOs process

Although RWQOs are not formally gazetted, they provide essential input to the process of setting RQOs which are officially gazetted as part of the classification process.

SECTION 4: ALLOCATABLE WATER QUALITY

Background

The RWQOs provide the numeric or descriptive goals, within which the water resource must be managed. However, these water quality 'limits' can also assist the Department in assessing the extent of the remaining allocatable water quality within a water resource management unit, and how a possible licence application may impact upon this allocatable resource.

Allocatable water quality defined

In the RDMWQ Policy document, "Allocatable water quality" is defined as the maximum worsening change in any water quality attribute away from its present value, which maintains it within a pre-determined range that reflects the desired future state (typically defined by a resource quality objective). If the present value is already at or outside the predetermined range, this indicates that none is allocatable, and that (a) reduced pollution loads relating to the affected attribute(s), and/or (b) remediation of the resource, may be necessary.

It is also stated that it is the Department's policy to only use "Assimilative capacity" as a routine management instrument in the particular context of dilution capacity. The term "assimilative capacity" refers to the capacity of a water resource to assimilate disposed waste, through processes such as dilution, dispersion, and chemical and biological degradation, without water quality changing to the extent that fitness for use or ecosystem health is impaired (DWAF, 1995). Assimilative capacity depends on many factors and it is evident that quantifying assimilative capacity to the extent that this can translate into useful management instruments could be extremely complicated. It is therefore the Department's policy to use this as a routine management instrument only in the particular context of dilution capacity.

Approach

The accompanying RWQOs Model (WQM. 1.7.2.4) can be used to determine the RWQOs and the corresponding allocatable water quality for the water resource management unit. The allocatable water quality is calculated as the RWQOs minus the present state, i.e. RWQOs – present state. In this way, the allocatable water quality can be determined for each parameter of concern.

Allocatable = RWQOs – Present State

The 'Allocatable water quality' may be expressed in terms of the units in which the respective variables are measured, or as 'Allocatable loads', which are derived from the 'target flow'. The statistical confidence level in determining the allocatable water quality is based on the percentiles provided for the present state. The confidence in the allocatable loads is a function of the percentiles provided in the present state and the 'flow assurance'.

Allocatable water quality may in future be included in a water allocation plan as described in section 9(e) and section 45 of the National Water Act.

Selecting a 'target flow'

There are a number of options for selecting a 'target flow'. These include:

- Select the maintenance low flow that was determined as part of a Reserve study. The maintenance low flow is generally regarded as the flow that would occur for about 70% of the time, or
- If the present flow is more than the maintenance low flow then use the present flow (measured or use simulated present day flows), or
- In regulated rivers where capping flows have been specified as part of a Reserve study, the capping flows can be used.

The choice of the target flow is dependant on the specific flow conditions in the system where the RQOs are determined.

The target flow may also differ for different variables. This is done by identifying the critical condition or "reasonable worst case scenario" for a specific variable. For example, in the USA the critical condition for dissolved oxygen is taken as low flow summertime condition (typically the 7Q10 flow which is the lowest 7-day duration mean flow with a 10 year recurrence interval).

Salinity RWQOs may be specified for the low flow season/month.

Setting RWQOs at present state

In those instances where a water resource is significantly impacted, resulting in non-compliance with the determined RWQOs, the present water quality may be set as short-term RWQO. This would ensure that no further deterioration in water quality occurs, while the determined RWQOs are set as the medium- or long-term objective.

The implications of setting the RWQOs equal to the present water quality is that by default, no water quality is available for allocation. This may be the exact intention of the Department's or a CMA's Water Allocation Plan (WAP), that no further water quality be allocated and/or no new water use licences approved that would require a water quality allocation, until the RWQOs can be determined at a higher level of confidence, or new water quality data obtained for the water resource management unit.

Total allocatable water quality

The method determines the total allocatable water quality per variable. The Department needs to decide on how much (i.e. which portion) and to whom the allocatable water quality resource can be allocated to.

The total allocatable water quality can be allocated to one strategic user or it can be allocated proportionally to various users.

End-of-pipe discharge standards

General and/or special effluent standards are not always stringent enough to achieve the RWQO for a specific variable within a river reach or stream. It is therefore necessary to convert the RWQOs to an end-of-pipe discharge target concentration, to determine if imposing the general or special effluent standard will achieve the RWQO or not. If imposing the general or special effluent standard will not achieve the RWQO, a more stringent standard needs to be imposed in the licence condition, to ensure short- to long-term achievement of the RWQOs. If the general or special standards are stringent enough to ensure achieving the RWQOs, they should be imposed.

The guideline for converting RWQOs into end of pipe discharge standards, included as Annexure B, provides a standard method of converting the RWQOs into end-of-pipe discharge standards. The method is digitised as part of the RWQO Model (WQM 1.7.2.1).

SECTION 5: WATER QUALITY STRESS

What is water quality stress

Water quality stress is the difference between the present water quality and the determined RWQOs.

The European Environmental Agency (2003) defines 'water stress' as that which *"occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of fresh water resources in terms of quantity (aquifer over-exploitation, dry rivers, etc.) and quality (eutrophication, organic matter pollution, saline intrusion, etc.)"*.

Degree of stress

The closer the present water quality is to the RWQOs that have been set, the higher is the degree of water quality stress of the water resource.

- If the present state is less than the RWQO for a specific chemical parameter, the water resource is considered *unstressed* for that parameter (Figure 5.1a).
- If the present state is equal to or exceeds the RWQO for a specific chemical parameter, there is, in effect, no remaining allocatable water quality, and the water resource is considered *stressed* for that parameter (Figure 5.1b).

In the accompanying RWQO Model (WQM. 1.7.2.1), a proximity of the present state to within 10% of the RWQO, or in exceedance of the RWQO, is considered *stressed*.

As such, the degree of water quality stress includes all three components of water resource management, i.e. the ecological, social and economic aspects, thereby achieving a balance between socio-economic development and environmental protection.

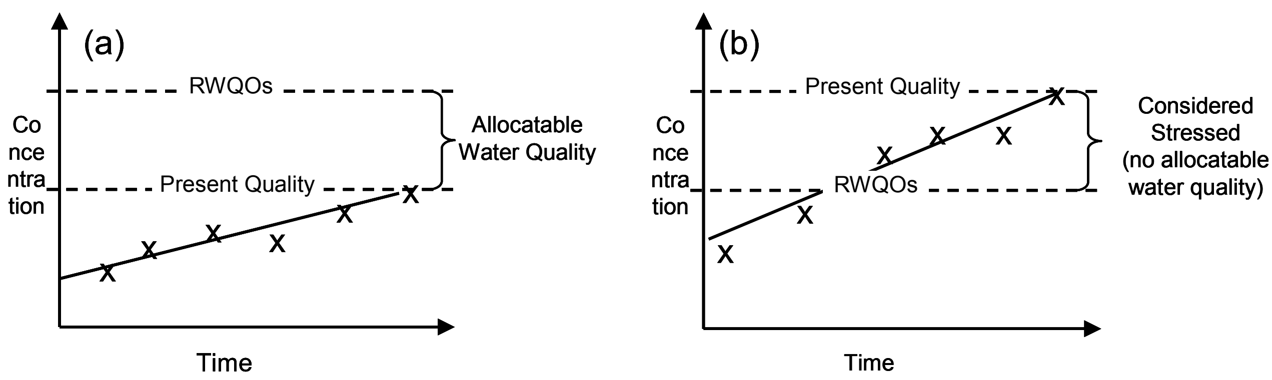


Figure 5.1: Schematic illustration of allocatable water quality in an unstressed and stressed resource.

Why is an assessment of water stress important

The degree of water quality stress of a water resource informs the Department as to:

- What level of detail is required in determining the RWQOs.
- Whether or not a licence can be issued, or a general authorisation considered, for an activity which may impact upon the water quality within the water resource management unit, without compromising the Reserve and existing permissible water uses.
- Whether or not compulsory licensing may be required within a water resource management unit, as per Chapter 4, Part 8 of the NWA (36:1998), to ensure equitable, sustainable and efficient use of water.
- Whether general or special effluent discharge standards will suffice as licence conditions for discharge.
- Other conditions for issue of general authorisations or licences which may be required for discharge or abstraction, as per Section 29 of the NWA (36:1998).

SECTION 6: SUMMARY OF RWQOS DETERMINATION METHODOLOGIES

Table 6.1: Master table of differences/similarities between RWQOs levels by steps

Step	Low Confidence Determination	Medium Confidence Determination	High Confidence Determination
1. Delineate water resource management units	Quaternary, Ecoregion Level II (hydrological ecoregions only)	Ecoregion Level II + stream classification	Ecoregion Level II + stream classification
2. Reference conditions	Default tables (water quality reserve), qualitative or semi-quantitative description	Qualitative or semi-quantitative description	Quantitative description
3. Present state	Historical water quality data, local experts	Historical water quality data plus water quality samples taken over one season	Historical water quality data plus water quality samples taken over one season, extensive literature and field work
4. Importance + sensitivity	Desktop EISC	EIS + field check Social Importance (limited survey)	EIS + field survey SI (extensive survey) Economic importance (extensive survey)
5. Assess desired state	"Default rule" i.e. no degradation from present state.	Consultative process, scenario evaluation	Consultative process, scenario evaluation
6. Determine ecological specifications	Default water quality tables	Intermediate water quality Reserve method	Comprehensive water quality Reserve
7. Determine user requirements	Present state provides point of departure from which to assess user requirements	Present state provides point of departure from which to assess user requirements	Present state provides point of departure from which to assess user requirements
8. Catchment Visioning	RWQOs process informs catchment visioning, no stakeholder involvement	Catchment visioning informs RWQOs process, stakeholder involvement important	Catchment visioning informs RWQOs process, stakeholder involvement essential
9. Determine management class	Ecological category and water user category mapped to management class	Ecological category and water user category mapped to management class	Ecological category and water user category mapped to management class
10. Determine RWQOs	Default rule, consider existing lawful users, strategic and international obligations, plus future user requirements. Most sensitive water user determines RWQOs.	Consider existing lawful users, strategic and international obligations, plus future user requirements. Relaxation in water quality considered.	Consider existing lawful users, strategic and international obligations, plus future user requirements. Relaxation in water quality considered.

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Annexure A:

Generic water quality limits for various water user categories

A.1. Conversion of South African Water Quality Guidelines to Fitness for Use Categories

Context

In South Africa, the South African Water Quality Guidelines (SAWQGs) have been developed as discrete values that depict the change from one category of fitness for use to another (DWAF, 1996). However, the SAWQGs recognise only one management category, namely the Target Water Quality Range (TWQR). Above this value / range, the categories describe an ever increasing negative impact with respect to the use of the water. Thus, for any resource it is necessary to determine whether or not the effect is acceptable to the user.

Assessment of water quality should be linked to management actions to enable managers of water resources to know where to focus the limited resources at their disposal. Van Veelen (2002) developed a protocol to derive and quantify water quality objectives for surface water resources such that it can be measured, which in turn represents the RQO. Aspects of this protocol were used to convert the SAWQGs to fitness for use categories for use in the RWQO model.

Brief overview of approach for setting the RWQOs

The water quality guidelines describe the "fitness for use" of a water resource, while the water quality objectives define "what management action is required" for a water resource. The fitness for use of water is a judgement as to how suitable the quality of water is for its intended use. The following fitness for use categories were linked to the SAWQGs:

- Ideal
- Acceptable
- Tolerable
- Unacceptable

Water quality state

Van Veelen (2002) suggested the development of a range of criteria that describe the change in water quality in terms of fitness for use, and not in terms of an effect on the water user. The fitness for use of water can range from being completely unfit for use to being 100% or ideally fit for a specific use (DWAF, 1996; WRC, 1998; Van Veelen, 2002). According to the SAWQGs (DWAF, 1996) and Van Veelen (2002), the fitness for use of a water resource can be expressed as:

- Ideal – the use of water is not affected in any way; 100% fit for use by all users at all times; desirable water quality; TWQR
- Acceptable – slight to moderate problems encountered on a few occasions or for short periods of time.
- Tolerable – moderate to severe problems are encountered; usually for a limited period only.
- Unacceptable – water cannot be used for its intended use under normal circumstances at any time.

Development of water quality guidelines linked to fitness for use categories

The Department of Water Affairs and Forestry (DWAF) strives to maintain the quality of water of South Africa's water resources such that it remains within the No Effect Range, also referred to as the TWQR in the SAWQGs. The TWQR is a management objective that is used to specify the ideal concentration range and / or water quality requirements for a particular constituent. This is the range of concentrations or levels within which no measurable adverse effects are expected on the health of the user, and should therefore ensure their protection.

As the fitness for use terms may have different meanings or interpretations for different water users, Van Veelen (2002) produced a set of colour-coded "rules" that can be used to derive fitness for use categories from the SAWQGs. The rules have been adapted to include the methodology for converting the SAWQGs to fitness for use categories.

Table A1.1: Rules for setting cut-off values for fitness for use ranges (adapted from Van Veelen, 2002)

USER CATEGORY AND EFFECT				FITNESS FOR USE CATEGORY
DOMESTIC	RECREATION	AGRICULTURE	ECOSYSTEM	(COLOUR)
Upper limit of TWQR. No health risk. No aesthetic effect.	Upper limit of TWQR. No health risk. No aesthetic effect.	Upper limit of TWQR. No reduction in yield. No special management practices.	Upper limit of TWQR. No impact.	Ideal (Blue)
Average of TWQR and Tolerable level. Slight health risk for sensitive individuals. Noticeable aesthetic effect but not objectionable.	Average of TWQR and Tolerable level. Slight health risk for sensitive individuals. Noticeable aesthetic effect, but acceptable.	Average of TWQR and Tolerable level. Only sensitive crops are affected, but no special management practices are required.	Average of TWQR and Chronic Effect Value (CEV). Some chronic effects may occur in sensitive species.	Acceptable (Green)
At Tolerable level / minimal health risk. Slight health risk for most individuals. Objectionable aesthetic effect to sensitive persons.	At Tolerable level / minimal health risk. Slight health risk for most individuals. Objectionable aesthetic effect to sensitive persons.	At Tolerable level / minimal health risk. Some yield loss is experienced or special management practices are required.	Upper limit of CEV. Some acute effects may occur in sensitive species.	Tolerable (Yellow)
Above Tolerable level. Significant health risk with short-term exposure. Aesthetically un-acceptable.	Above Tolerable level. Severe health risk. Aesthetically unacceptable.	Above Tolerable level. The economic viability of irrigation is questionable.	Above the CEV. Species diversity is significantly reduced and community as a whole is com- promised.	Unacceptable (Red)
Gross pollution or deviation from the norm.				Totally unfit for use

Conversion of the SAWQG to Fitness for Use of the Water Resource Categories

The TWQR has been used to define the Ideal category, while the upper limit of where negative effects are seen has been defined as the tolerable category. Assuming that a linear distribution in the data was used to derive the TWQRs (DWAF, 1996), the acceptable category was interpolated to be the average of the Ideal category (i.e. TWQR) and the tolerable level. The unacceptable category is regarded as any concentration / level above the upper limit (i.e. Tolerable).

The water quality limits for the following water uses are presented in Tables A1.2 - A1.12 of this Appendix:

- Domestic
- Agriculture (Livestock watering; Irrigation, Aquaculture)
- Recreation (Full contact, Intermediate contact, Non-contact)
- Industrial (Category 1, Category 2, Category 3, Category 4)

Link to the Reserve and Water Resource Classification for Aquatic Ecosystems

The RWQOs have to take into account the Reserve, which depends on the class of the water resource. The categories are:

A – unmodified natural

B – largely natural

C – moderately modified

D – largely modified

E – seriously modified

F – critically modified

The ecological classification system makes provision for six categories, A, B, C, D, E and F, of which categories A to D fall within the sustainable level, while categories E and F represent unsustainable conditions. The following relationship can be used to link the above ecological categories to the fitness for use categories (water quality assessment categories) (adapted from Van Veelen, 2002).

<table>
<tr><th>FITNESS FOR USE CATEGORY</th><th>COLOUR CODE</th><th>ECOLOGICAL CATEGORIES</th></tr>
<tr><td>Ideal</td><td>Blue</td><td>A</td></tr>
<tr><td rowspan="2">Acceptable</td><td rowspan="2">Green</td><td>B</td></tr>
<tr><td rowspan="2">C</td></tr>
<tr><td rowspan="2">Tolerable</td><td rowspan="2">Yellow</td></tr>
<tr><td>D</td></tr>
<tr><td>Unacceptable</td><td>Red</td><td>EF</td></tr>
</table>

Motivation for approach

The motivation for using the fitness for use ranges in association with the ecological categories (adapted from Van Veelen, 2002) is as follows:

- Category A: This category requires undisturbed conditions and an almost zero risk to the ecosystem. This means that not even short term excursions into the acceptable range can be tolerated.
- Category B: This category allows only a small risk of modification to the ecosystem. In essence, there may be no loss of species diversity, although the numbers of some sensitive species may be reduced. The acceptable level may result in chronic effects in sensitive species but will not cause acute effects. As long as there is a recovery period (at least 50% of the time in the ideal range) and the acceptable range is not exceeded, the requirements for Category B will most probably be met.
- Category C: This category allows a moderate risk of modification to the ecosystem. Some very sensitive species may be compromised from time-to-time, but survival should be possible in refugia. Short-duration excursions into the tolerable range may therefore be allowed, but on the whole the water quality should fall in the acceptable range.
- Category D: A large risk is accepted, but in general the ecosystem should not be modified excessively. Some sensitive species may be absent, but the ecosystem should still function adequately. The water quality will therefore mostly fall in the tolerable range, but no excursions into the unacceptable range are allowed.

References

Department of Water Affairs and Forestry (DWAF) 1996. *South African Water Quality Guidelines for Fresh Water. Edition 2. Volumes 1-7*. Department of Water Affairs and Forestry, Pretoria, Republic of South Africa.

Van Veelen, M. 2002. *The Development of Principles and Procedures for the Establishment of Water Quality Objectives for Aquatic Systems and Their Application on the Jukskei River System, Gauteng*. Ph.D. Thesis. Rand Afrikaans University.

Water Research Commission (WRC), 1998. *Quality of Domestic Water Supplies, Volume 1: Assessment Guide*. No. TT 101/98, Second Edition.

Generic water quality limits for various water user categories - as used in the Resource Water Quality Objectives Model

Table A1.2: Generic water quality limits for Domestic Use.

WATER QUALITY GUIDELINES FOR DOMESTIC USE					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg $CaCO_3$	200	300	600	>600
Turbidity	NTU	0.1	1	20	>20
CHEMICAL REQUIREMENTS					
Calcium	mg/l	10	150	300	>300
Chloride	mg/l	100	200	600	>600
Chlorine (upper)	mg/l	0.6	0.8	1.0	>1.0
Chlorine (lower)	mg/l	0.3	0.2	0.1	<0.1
Electrical Conductivity	mS/m	70	150	370	>370
Fluoride	mg/l	0.7	1.0	1.5	>1.5
Magnesium	mg/l	70	100	200	>200
Nitrate + Nitrite	mg N/l	6.0	10.0	20.0	>20.0
PH (upper)		9.5	10.0	10.5	>10.5
PH (lower)		5.0	4.5	4.0	<4.0
Potassium	mg/l	25	50	100	>100
Sodium	mg/l	100	200	400	>400
Sulphate	mg/l	200	400	600	>600
Total Dissolved Solids (TDS)	mg/l	450	1000	2400	>2400
Arsenic	mg/l	0.01	0.05	0.2	>0.2
Cadmium	mg/l	0	0.01	0.02	>0.02
Copper	mg/l	1.0	1.3	2.0	>2.0
Iron	mg/l	0.5	1.0	5.0	>5.0
Manganese	mg/l	0.1	0.4	4	>4
Zinc	mg/l	20	20	20	>20
BIOLOGICAL					
Total coli forms	per 100ml	0	10	100	>100
Faecal coli forms	per 100ml	0	1	10	>10

Reference: Quality of Domestic Water Supplies, Volume 1: Assessment Guide. (Water Research Commission, 1998).

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1.3: Generic water quality limits for Agricultural Use: Livestock Watering

WATER QUALITY GUIDELINES FOR AGRICULTURAL USE: LIVESTOCK WATERING					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
CHEMICAL REQUIREMENTS					
Calcium	mg/l	1000	1500	2000	>2000
Chloride	mg/l	1000	1750	2000	>2000
Fluoride	mg/l	2.0	4.0	6.0	>6.0
Magnesium	mg/l	500	700	1000	>1000
Nitrate	mg/l	100	250	400	>400
Nitrite		100	150	200	>200
Sodium	mg/l	2000	2250	2500	>2500
Sulphate	mg/l	1000	1250	1500	>1500
Total Dissolved Solids (TDS)	mg/l	1000	2000	3000	>3000
Aluminium	mg/l	5.0	7.5	10.0	>10.0
Arsenic	mg/l	1.0	1.25	1.5	>1.5
Boron	mg/l	5.0	27.5	50.0	>50.0
Cadmium	mg/l	0.01	0.02	0.02	>0.02
Chromium VI	mg/l	1.0	1.5	2.0	>2.0
Cobalt	mg/l	1.0	1.5	3.0	>3.0
Copper	mg/l	0.5	0.75	1.0	>1.0
Iron	mg/l	10.0	30.0	50.0	>50.0
Lead	mg/l	0.1	0.15	0.2	>0.2
Manganese	mg/l	10.0	30.0	50.0	>50.0
Mercury	ug/l	1.0	3.5	6.0	>6.0
Molybdenum	mg/l	0.01	0.015	0.02	>0.02
Nickel	mg/l	1.0	3.0	5.0	>5.0
Selenium	mg/l	0.05	0.063	0.075	>0.075
Vanadium	mg/l	1.0	2.0	2.0	>2.0
Zinc	mg/l	20	30	40	>40
BIOLOGICAL					
Faecal coliforms	per 100ml	200	600	1000	>1000

Reference: South African Water Quality Guidelines, Volume 5, Agricultural Water Use - Livestock watering (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1.4: Generic water quality limits for Agricultural Use: Irrigation.

WATER QUALITY GUIDELINES FOR AGRICULTURAL USE: Irrigation					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
CHEMICAL REQUIREMENTS					
Calcium	mg/l	1000	1500	2000	>2000
Chloride	mg/l	1000	1750	2000	>2000
Fluoride	mg/l	2.0	4.0	6.0	>6.0
Magnesium	mg/l	500	700	1000	>1000
Nitrate	mg/l	100	250	400	>400
Nitrite		100	150	200	>200
Sodium	mg/l	2000	2250	2500	>2500
Sulphate	mg/l	1000	1250	1500	>1500
Total Dissolved Solids (TDS)	mg/l	1000	2000	3000	>3000
Aluminium	mg/l	5.0	7.5	10.0	>10.0
Arsenic	mg/l	1.0	1.25	1.5	>1.5
Boron	mg/l	5.0	27.5	50.0	>50.0
Cadmium	mg/l	0.01	0.02	0.02	>0.02
Chromium VI	mg/l	0.1	0.55	1.0	>1.0
Cobalt	mg/l	1.0	1.5	3.0	>3.0
Copper	mg/l	0.5	0.75	1.0	>1.0
Iron	mg/l	10.0	30.0	50.0	>50.0
Lead	mg/l	0.1	0.15	0.2	>0.2
Manganese	mg/l	10.0	30.0	50.0	>50.0
Mercury	ug/l	1.0	3.5	6.0	>6.0
Molybdenum	mg/l	0.01	0.015	0.02	>0.02
Nickel	mg/l	1.0	3.0	5.0	>5.0
Selenium	mg/l	0.05	0.063	0.075	>0.075
Vanadium	mg/l	1.0	2.0	2.0	>2.0
Zinc	mg/l	1.0	3.0	5.0	>5.0
BIOLOGICAL					
Faecal coliforms	per 100ml	200	600	1000	>1000

Reference: South African Water Quality Guidelines, Volume 4, Agricultural Water Use - Irrigation (DWAF, 1996)
* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.
** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.
*** The limits presented above do not take into account site specific conditions.

TableA1.5: Generic water quality limits for Agricultural Use: Aquaculture.

WATER QUALITY GUIDELINES FOR AGRICULTURAL USE: AQUACULTURE					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg/l $CaCO_3$	50	175	300	>300
CHEMICAL REQUIREMENTS					
Alkalinity	mg/l $CaCO_3$	20	97.5	175	>175
Ammonia	Mg N/l (NH3)	0.03	0.3	1.0	>1.0
Chloride	mg/l	2	6	10	>10
Nitrate	mg/l	300	650	1000	>1000
Nitrite	mg/l	0.05	70.03	140.2	>140.2
pH (upper)		9.0	9.0	9.0	>9.0
pH (lower)		6.5	5.25	4.0	<4.0
Ortho-phosphate	mg/l	0.08	0.34	0.6	>0.6
Sulphide	mg/l	0	0	0.01	>0.01
Aluminium	Mg/l	0.03	0.07	0.1	>0.1
Chromium VI	mg/l	0.02	0.02	0.02	>0.02
Copper	mg/l	0	0.3	0.6	>0.6
Cyanide	Mg/l	0.02	0.11	0.2	>0.2
Iron	mg/l	0.01	0.88	1.75	>1.75
Lead	mg/l	0.01	1.08	2.15	>2.15
Manganese	mg/l	0.1	0.3	0.5	>0.5
Mercury	µg/l	1	140.5	280	>280
Selenium	mg/l	0.3	19	35	>35
ORGANIC AND GENERAL CHEMICAL REQUIREMENTS					
Dissolved oxygen (upper)	mg/l	8	16	20	>20
Dissolved oxygen (lower)	mg/l	6	5	4	<4
Total dissolved gas	mg/l	100	115	130	>130
Phenol	mg/l	1	13	25	>25

Reference: South African Water Quality Guidelines, Volume 6, Agricultural Water Use - Aquaculture (DWAF, 1996)
* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.
** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.
*** The limits presented above do not take into account site specific conditions.

Table A1.6: Generic water quality limits for Industrial Use: Category 1.

WATER QUALITY GUIDELINES FOR INDUSTRIAL USE: CATEGORY 1					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg/l $CaCO_3$	50	75	100	>100
Total Suspended Solids	mg/l	3	10	25	>25
CHEMICAL REQUIREMENTS					
Alkalinity	mg/l $CaCO_3$	50	175	300	>300
Chloride	mg/l	20	70	120	>120
Electrical Conductivity	mS/m	15	30	70	>70
PH (upper)		8.0	8.75	9.5	>9.5
PH (lower)		7	6.5	6	<6
Sulphate	mg/l	30	80	90	>90
Total dissolved salts	mg/l	100	200	450	>450
Iron	mg/l	0.1	0.56	1.0	>1.0
Manganese	mg/l	0.05	0.525	1.0	>1.0
Silicon	mg/l	5	12.5	20	>20
ORGANIC AND GENERAL CHEMICAL REQUIREMENTS					
COD	mg/l	10	30	50	>50

Reference: South African Water Quality Guidelines, Volume 3, Industrial Water Use (DWAF, 1996)
* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.
** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.
*** The limits presented above do not take into account site specific conditions.

Table A1.7: Generic water quality limits for Industrial Use: Category 2.

WATER QUALITY GUIDELINES FOR INDUSTRIAL USE: CATEGORY 2					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg/l $CaCO_3$	100	300	500	>500
Total Suspended Solids	mg/l	5	15	40	>40
CHEMICAL REQUIREMENTS					
Alkalinity	mg/l $CaCO_3$	120	360	600	>600
Chloride	mg/l	40	120	200	>200
Electrical Conductivity	mS/m	30	50	120	>120
PH (upper)		8	9	10	>10
PH (lower)		6.5	5.75	5	<5
Sulphate	mg/l	80	165	250	>250
Total dissolved salts	mg/l	200	350	800	>800
Iron	mg/l	0.2	1.1	2	>2
Manganese	mg/l	0.1	1.05	2	>2
Silicon	mg/l	10	25	40	>40
ORGANIC AND GENERAL CHEMICAL REQUIREMENTS					
COD	mg/l	15	40	70	>70

Reference: South African Water Quality Guidelines, Volume 3, Industrial Water Use (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1.8: Generic water quality limits for Industrial Use: Category 3.

WATER QUALITY GUIDELINES FOR INDUSTRIAL USE: CATEGORY 3					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg/l $CaCO_3$	250	375	500	>500
Total Suspended Solids	mg/l	5	20	50	>50
CHEMICAL REQUIREMENTS					
Alkalinity	mg/l $CaCO_3$	300	450	600	>600
Chloride	mg/l	100	150	200	>200
Electrical Conductivity	mS/m	70	120	250	>250
PH (upper)		8	9	10	>10
PH (lower)		6.5	5.75	5	<5
Sulphate	mg/l	200	250	300	>300
Total dissolved salts	mg/l	450	800	1600	>1600
Iron	mg/l	0.3	6.5	10	>10
Manganese	mg/l	0.2	6	10	>10
Silicon	mg/l	20	85	150	>150
ORGANIC AND GENERAL CHEMICAL REQUIREMENTS					
COD	mg/l	30	50	100	>100

Reference: South African Water Quality Guidelines, Volume 3, Industrial Water Use (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1.9: Generic water quality limits for Industrial Use: Category 4

WATER QUALITY GUIDELINES FOR INDUSTRIAL USE: CATEGORY 4					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg/l $CaCO_3$	1000	1000	1000	
Total Suspended Solids	mg/l	25	100	100	
CHEMICAL REQUIREMENTS					
Alkalinity	mg/l $CaCO_3$	1200	1200	1200	
Chloride	mg/l	500	500	500	
Electrical Conductivity	mS/m	250	250	250	
PH (upper)		10	10	10	
PH (lower)		5	5	5	
Sulphate	mg/l	500	500	500	
Total dissolved salts	mg/l	1600	1600	1600	
Iron	mg/l	10	10	10	
Manganese	mg/l	10	10	10	
Silicon	mg/l	150	150	150	
ORGANIC AND GENERAL CHEMICAL REQUIREMENTS					
COD	mg/l	75	75	75	

Reference: South African Water Quality Guidelines, Volume 3, Industrial Water Use (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1.10: Generic water quality limits for Recreational Use: Full Contact.

WATER QUALITY GUIDELINES FOR RECREATIONAL USE: FULL CONTACT					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Clarity	Secchi disk (m)	3	2	1	<1
CHEMICAL REQUIREMENTS					
PH (upper)		8.5	8.75	9.0	>9.0
PH (lower)		6.5	5.75	5	<5
BIOLOGICAL					
Faecal coliforms	per 100ml	130	1065	200	>200
F. streptococci	per 100ml	30	65	100	>100
Coliphages	per 100ml	20	60	100	>100
Enteric virusses	per 100ml	0	5	10	>10
Algae	µg/l Chl-a	15	22.5	30	>30
Algae	Units	6	6	6	>6

Reference: South African Water Quality Guidelines, Volume 2, Recreational Water Use (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site specific conditions.

Table A1/11: Generic water quality limits for Recreational Use: Intermediate Contact.

WATER QUALITY GUIDELINES FOR RECREATIONAL USE: INTERMEDIATE CONTACT					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Clarity	Secchi disk (m)	3	2	1	<1
BIOLOGICAL					
Faecal coliforms	per 100ml	1000	2500	4000	>4000
F. streptococci	per 100ml	230	485	700	>700
Algae	µg/l Chl-a	15	22.5	30	>30

Reference: South African Water Quality Guidelines, Volume 2, Recreational Water Use (DWAF, 1996)
* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.
** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.
*** The limits presented above do not take into account site specific conditions.

Table A1.12: Generic water quality limits for Recreational Use: Non-Contact.

WATER QUALITY GUIDELINES FOR RECREATIONAL USE: NON-CONTACT					
VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
BIOLOGICAL					
Algae	µg/l Chl-a	20	25	30	>30

Reference: South African Water Quality Guidelines, Volume 2, Recreational Water Use (DWAF, 1996)
* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.
** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.
*** The limits presented above do not take into account site specific conditions.

Annexure B:

Guideline for Converting RWQOs into End of Pipe Discharge Standards

B1.1 Definitions

Mixing Ratio (MR)	The mixing ratio (MR) is the rate of discharge (Q_w) divided by the rate of stream flow (Q_s). MR = Q_w/Q_s
Recommended Resource Directed Value (RRDV)	The recommended resource directed value (RRDV) is the individual end of pipe discharge standard protecting the resource for a specific MR and Class.
Maximum Allowable Resource Directed Value (MARDV)	The maximum allowable resource directed value (MARDV) it the individual end of pipe discharge standard protecting the resource for a specific MR and one class lower than the Class for the RRDV.
Source Directed Value (SDV)	The source directed value (SDV) represents the individual end of pipe discharge value that is achievable by using recognised treatment processes on a predominantly domestic (household) effluent. The SDVs were empirically determined by investigating discharge records from a large number of treatment facilities and it represents the 25th percentile value of the 25th percentile waste water treatment works (WWTW). In other words, the chosen plant performed better for 75% of the time, while 75% of the plants performed better than the chosen plant.
Existing General Standard (EGS)	The existing general standard (EGS) is the existing end of pipe discharge standard applicable in unlisted areas.
Existing Special Standard (ESS)	The existing special standard (ESS) is the existing end of pipe discharge standard applicable in all listed areas, including the special standard for phosphate.
TWQR	Target water quality range.
CEV	Chronic effect value
AEV	Acute effect value

B2: Calculations

Basic Formula

$$C_W = \frac{C_R(MR+1) - Cs}{MR}$$

where C_W = End of pipe discharge standard (RRDV or MARDV)

C_R = Desired maximum in stream concentration (RQOs)

MR = Mixing ratio

C_S = Receiving stream concentration

B2.1 Toxic substances

Mixing Ratio (MR)

Use the 5th percentile flow for the driest month of the year (Q_s) and the design capacity of the facility (Q_w) to determine the mixing ratio.

Receiving stream concentration (C_s)

Use the recommended standard provided in the table below as the background concentration, or zero (0) for all toxic substances, to determine C_s.

All figures to the nearest 0,001mg/ℓ, unless the value is less than 0,001mg/ℓ

							RECOMMENDED STANDARD	
Constituents	Unit	EGS	ESS	SDV	RRDV	MARDV	Short Term	Long Term
Aluminium	mg/ℓ	-	-	0,045	0,281	0,315	0,28	0,28
Arsenic	mg/ℓ	0,5	0,1	0,05	0,244	0,273	0,24	0,24
Cadmium	mg/ℓ	0,05	0,05	0,01	0,011	0,013	0,01	0,01
Chlorine	mg/ℓ	0,1	0	-	0,056	0,063	0,063	0,056
Chrome III	mg/ℓ	0,5	0,05	0,005	1,913	2,142	0,5	0,5
Chrome VI	mg/ℓ	0,05		0,005	0,375	0,420	0,05	0,05
Copper	mg/ℓ	1,0	0,02	0,01	0,009	0,010	0,01	0,01
Cyanide	mg/ℓ	0,5	0,5	0,03	0,206	0,231	0,21	0,2
Fluoride	mg/ℓ	1,0	1,0	0,1	1,350*	1,500*	1,0	1,0
Lead	mg/ℓ	0,1	0,1	0,05	0,013	0,015	0,015	0,013
Manganese	mg/ℓ	0,4	0,1	0,261	0,580*	4000*	0,4	0,4
Mercury	mg/ℓ	0,02	0,02	0,01	0,003	0,004	0,004	0,003
Phenol	mg/ℓ	0,1	0,01	-	0,938	1,050	0,1	0,1
Selenium	mg/ℓ	0,05	0,05	0,1	0,169	0,189	0,05	0,05
Zinc	mg/ℓ	5,0	0,3	0,098	0,068	0,076	0,076	0,068
Iron	mg/ℓ	-	0,3	0,187	-	-	0,3	0,3
Boron	mg/ℓ	1,0	0,5	0,288	-	-	1,0	1,0
Sulphides	mg/ℓS	1,0	0,05	-	-	-	1,0	1,0
COD	mg/ℓ	75	30	50	94	122	75	75
Susp Solids	mg/ℓ	25	10	15	33	37	25	25
pH		5,5-9,5	5,5-7,5	7,5 – 8,0	6,0 – 9,0	6,0 – 9,0	6,0 – 9,0	6,0 – 9,0
Temperature	° C	35	25	-	35	39	35	35
Orthophosphate	mg/ℓ	-	1,0	0,8	0,60	0,90	0,8	0,6
TDS	mS/m above intake	75	15%	-	90	190	75	75
Nitrate/Nitrate	mg/ℓ	-	1,5	7,0	15*	20*	15	20
Ammonia	mg/ℓ	10,0	1,0	2,0	11,6	27	10	10

*Domestic use determines value

Desired maximum in-stream concentration (C_R)

Use the following (refer to SA Water Quality Guidelines for Aquatic Ecosystem) to determine C_R:

Category A : 1,25 TWQR
Category B : 1,0 CEV
Category C : 1,25 AEV
Category D : 1,40 AEV (Jooste, 1999)

B2.2 System variables

Mixing Ratio (MR)

Use the average daily flow of the 5th percentile year (Q_s) (i.e. the total flow for the driest year on record ÷ 365), and the design capacity of the facility to (Q_w) determine the MR.

Receiving stream concentration (C_s)

Use the reference condition for the receiving water body to determine C_s. This should be determined from long-term records, and calculated as the median value for low flow periods (winter in the summer rainfall area, and summer in the winter rainfall area).

Desired maximum in-stream concentration (C_R)

Use the reference condition plus the maximum allowable variation for the chosen class, as given in the latest RDMs documentation to determine C_R.

Example

Total Suspended Solids (values in mg/ℓ)

Category	Reference condition (C_s)	Maximum allowable in-stream value (C_R)
A	20	22 (+10%)
B	20	23 (+15%)
C	20	24 (+20%)
D	20	25 (+25%)

B3: Setting Individual End-of-Pipe Discharge Standards

Possible outcomes

There are three possible outcomes from the calculation of the RRDV and the MARDV, considering the SDV. For each of these a different end of pipe discharge standard is set as shown below:

Outcome	**End of pipe discharge standard**
SDV ≤ RRDV	RRDV
RRDV < SDV ≤ MARDV	SDV
MARDV < SDV	MARDV

In all cases where the end of pipe discharge standard is set as higher than the RRDV, this standard is a short-term standard, and the RRDV is the long-term standard that should be strived for.

Irrespective of what the outcome of the above is, if the end of pipe discharge standard exceeds the existing general effluent standard or the special effluent standard (in unlisted or listed areas), the existing effluent standard is set as the end of pipe discharge standard.

Receiving stream concentration (C_s)	Use the reference condition for the receiving water body to determine C_s. This should be determined from long-term records, and calculated as the median value for low flow periods (winter in the summer rainfall area, and summer in the winter rainfall area).
Desired maximum in-stream concentration (C_R)	Use the reference condition plus the maximum allowable variation for the chosen class, as given in the latest RDMs documentation to determine C_R.

B4: Default Standards

Mixing Ratio (MR) < 2	When the MR is less than 2, the values for the short-term and long-term individual end of pipe discharge standards in the default tables should be used.
Insufficient data	When enough data are not available for a catchment to perform the calculations, the values for class B in the default tables should be used to set individual end of pipe discharge standards.

Annexure C:

Procedure for the Low confidence DETERMINATION of RWQOs

Introduction

A low confidence RWQO determination is undertaken when there are no or very limited water quality data available for the water resource management unit. The scope for collecting new data to assess the present state is generally very limited. The low confidence method is used in the consideration of individual licences likely to have a small impact in an unstressed catchment or a catchment with low importance and sensitivity. Stakeholder involvement is not a requirement and is limited to consultation with institutions normally involved in the water use licensing process.

When to use

This approach is to be used when no data are available, or only a minimal ecological data set (present state) (Section 2) is available, and assumes data for water quality, SASS and in-stream habitat, and/or fish and/or riparian habitat are available at the level of:

- a Rapid Ecological Reserve determination; or
- State of Rivers Report.

If no data are available, then a low confidence ecological present state assessment can be based on expert opinion and environmental clues (Kleynhans *et al*., 2005).

A water quality Reserve may not be available. If a Reserve determination has been undertaken for the Water resource management unit, then these results should be used instead of repeating section C.1.1.

A catchment assessment study (CAS) may not be available. However, if a desktop or more comprehensive CAS has been undertaken for the Resource unit, then these results should be used instead of repeating section C.1.2.

C.1 Method

C.1.1 Ecological Requirements

Delineate Resource unit

At a low confidence level, the determination of preliminary RWQOs can be done for a quaternary catchment subject to the availability of water quality data.

Refer to the five-step water quality reserve determination methodology for rivers described in Hughes (2005) and the Spatsim help files (Hughes, 2005).

Determine reference conditions

The reference, or natural, condition provides the site-specific benchmark against which the default "Natural" category boundary is assessed. The default benchmark tables (Hughes, 2005) were based on literature and available database information. For a low confidence water quality assessment the default "Natural" or A category boundary is used without modification as the reference condition.

Determine Present State

If no water quality data are available, then a low confidence present water quality state can be estimated using expert knowledge of the resource unit and environmental clues. The Physico-Chemical Driver Assessment Index (PAI) (Kleynhans *et al*., 2005) describes the use of environmental clues to assess the present water quality state in the absence of measured water quality data.

If limited water quality data are available (but less than the minimum number of observations required for a medium confidence assessment as described in Hughes (2005)), then an initial assessment of the present state of the water quality within the Resource unit should be made based on available water quality data. Water quality data should be selected for identified DWAF Water Quality Stations, and may be obtained from the DWAF Water Quality Database (WMS) or Water Quality on Disk.

The water quality data for the area should be analysed statistically to indicate for example the 5^{th} and 95^{th} percentiles, average and median values for each chemical parameter. The statistics required for each constituent are described in Hughes (2005).

The water quality results should then be compared against the water quality default tables in Hughes (2005) to determine the appropriate ecological category (A-F) for the water resource management unit. The selected ecological category, if required, may be evaluated against the desktop results of Kleynhans (2000).

Ecological Importance and Sensitivity (EIS)

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity. For a low confidence RWQOs determination, the EISC determined by Kleynhans (2000) should be used.

Determine Desired (Attainable) State

To determine the desired ecological category, the following steps are proposed:

- Determine the EISC
- Determine whether the present state should be improved (and if so, by how much) or maintained (which could still require restoration management, depending on the trajectory of change.
- Determine what would be necessary to address the causes.
- Determine how difficult it would be to address the causes (restoration/ reversibility potential).
- Determine the attainable ecological category for each component considering the ecological aims, and the difficulty of achieving the aims (DWAF, 2002c).
- The output resulting from the above should be two ecological categories, one ecological category attainable in the short-term (up to 5 years) and a second ecological category attainable in the medium- to long-term (between 5 to 10 years).

Describe Ecological Specifications

Each of the ecological categories is associated with a level of ecosystem health and integrity and the potential to offer a particular range of goods and services. The task of the ecological Reserve assessment is to provide quantified and descriptive information about the concentrations of water quality variables which:

- Describe the desired ecological category (A to D) of the system, and
- Provide numeric input into quantifying the management class.

The quantified and descriptive information is provided in the form of ecological specifications, termed "Ecospecs" (DWAF, 2002c)

Mapping Categories to Classes

Ecological categories may, in combination with the water user category, be mapped to a management class, i.e. Natural, Moderately used/impacted, Heavily used/impacted. The mapping route from the four categories (A, B, C, D) system to the three class system (Natural, Moderately used/impacted, Heavily used/impacted) is as follows:

- A = Natural
- A/B, B, B/C = Moderately used/impacted
- C, C/D, D = Heavily used/impacted

C.1.2 Other (Human) Water User Requirements

Identify Water Users

All water users within the Resource unit should be identified, e.g. domestic, agriculture, industry, recreation etc. At a low confidence level this may be as detailed as simply identifying the water user sector, e.g. Industry – Category 3. This may be carried out as part of a desktop Catchment Assessment Study (CAS).

Determine the parameters of concern

Identify the physical, chemical and/or biological parameters of concern within the Resource unit, based on the identified user sectors, e.g. for contact recreation microbiological parameters such as faecal coli forms are important. As such, RWQOs in such a Resource unit must include levels for *E. coli*.

Determine Present State

From the available water quality data, an assessment must be made as to the present state of the water quality with regards to all permissible water uses within the Resource unit. Such uses include:

- Basic Human Needs
- Permissible water uses
- Strategic Water Use
- International water use
- At a low confidence level, future water users can be considered in the RWQOs Model. As such, the relative role of catchment visioning in setting RWQOs at a desktop level is small.

Based on the default water quality guideline tables (Annexure A), a corresponding water user category can be assigned to the present water quality within the Resource unit. At a low confidence level this simply entails a comparison of present water quality against the default water quality guideline tables for Ideal, Acceptable, Tolerable, Unacceptable (Annexure A).

Determine Desired Water Quality

An assessment must be made as to what category of water quality is desired for use within the Resource unit, i.e. (Ideal, Acceptable, Tolerable). Note: Category 'Unacceptable' is not considered a desired category

In assessing the desired water quality at a low confidence level only existing water users could be considered, i.e. water user requirements which drive the determination of RWQOs and the corresponding Management Class, must include:

- Basic human needs (Reserve)
- Strategic water use requirements
- International water use requirements
- Existing lawful water use requirements.

In the absence of actual water quality data for the resource unit, the precautionary principle must be applied. Therefore, at a low confidence level the desired water user category may be set conservatively to the present state (provided it is better than Tolerable) or Tolerable. Alternatively, if sufficient information is available, the Department may motivate a better or poorer category than present state, e.g. in line with the catchment vision, from e.g. a present water quality category of 'Tolerable' to a desired water quality category of 'Acceptable'.

Water User Specifications

The desired water user category (Ideal, Acceptable, Tolerable) can be described by quantitative and descriptive information goals, provided in the form of water user sector specifications. These generic water user sector RWQOs are based on the DWAF Water Quality Guidelines (Annexure A).

C.1.3 RWQOs

Integration

The ecological specifications derived in Section C.1.1 must be compared against the water user specifications determined in Section C.1.2, i.e. the Water Quality Guidelines for each of the identified users, i.e.

- Ecological requirements (Reserve)
- Basic Human Needs (Reserve)
- Permissible water uses
- Strategic Water Use
- International water use
- Future use

By default, at a low confidence level, the most stringent water quality requirements or most sensitive user, defines the RWQOs.

Derive Management Class

The management class is determined for the Resource unit. In the absence of the national classification system, the management class can be given for both the ecological and water use categories, e.g.

- Ecological – Good
- Water Use – Ideal

Or mapped to a single management class (See Table 2, Section 3.4) of:

- Natural
- Moderately used/impacted
- Heavily used/impacted

Annexure D:

Procedure for the Medium Confidence DETERMINATION of RWQOs

Introduction

The medium confidence method is a determination that is undertaken when there are sufficient water quality data available for the resource unit to assess the present water quality status (refer to "number of data points" below). There is generally scope for collecting additional data for those variables of concern that are not routinely monitored in the Water resource management unit. The medium confidence method is used in the consideration of individual licences that could possibly have moderate impacts in relatively stressed catchments or in catchments with medium to high importance and sensitivity.

When to use

This approach is to be used when there are sufficient water quality data to assess the present water quality status. Data for water quality, SASS and in-stream habitat, and/or fish and/or riparian habitat are available at the level of:

- An Intermediate Reserve determination (medium confidence water quality reserve determination); or
- State of Rivers Report.

If a CAS has been undertaken at a scale that is compatible with the water resource management unit, then these results should be used instead of repeating section D.1.2.

D.1 Method

D.1.1 Ecological Requirements

Delineate Resource unit

At medium confidence level, the determination of preliminary RWQOs can be done for a river reach subject to the availability of water quality data for that reach. The delineation of the resource units is based on Ecoregion Level II boundaries and stream classification. The locations of significant point and non-point sources, dams and tributaries are also considered when delineating resource units because these can substantially modify the water quality in a resource unit.

Refer to the five-step water quality Reserve determination methodology for rivers described in Hughes (2005) and the Spatsim help files (Hughes, 2005).

Water quality data required for assessment of the ecological

The water quality data requirements to undertake the water quality component of an ecological water reserve assessment are the following (Hughes, 2005).

(*indicates that the variable is optional)

WATER QUALITY VARIABLES	REFERENCE CONDITION	PRESENT ECOLOGICAL STATE
Inorganic salts:		
Data: Ca, Mg, K, Na, Cl, SO_4	Calculate 95% of reference data.	Calculate 95% of present state data.
Calculate inorganic salt concentrations: $MgSO_4$, Na_2SO_4, MgCl, $CaCl_2$, NaCl, $CaSO_4$	Compare to default boundary table.	Compare to relevant boundary table.
Data analysis: $MgSO_4$, Na_2SO_4, MgCl, $CaCl_2$, NaCl, $CaSO_4$	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Nutrients:		
Data: NH_4, NO_2+NO_3, PO_4	Calculate 50% of reference data	Calculate 50% of present state data
Calculate TIN (NH_4+NO_2+NO_3)	Compare to default boundary values	Compare to relevant boundary table
Data analysis: TIN and SRP	Recalibrate boundary table if necessary	Assign category. Adjust accordingly using Chl-*a* data. Calculate confidence level.
System variables:		
DO	Calculate 5% of reference data	Calculate 5% of present state data
	Compare to default boundary values.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
pH	Calculate 5% and 95% of reference data.	Calculate 5% and 95% of present state data.
	Compare to default boundary values.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Turbidity*	Method not yet developed.	Method not yet developed.
Temperature* **Data:** If no water temperature data are available, calculate daily water temperature from air temperature	Calculate monthly 10% and 90% of reference data.	Calculate monthly 10% and 90% of present state data.
	Calculate the upper and lower boundaries of the categories.	Compare to boundaries obtained for reference condition.
	Summarize results in benchmark table.	Assign category. Calculate confidence level.
TDS / EC	Method under development.	Method under development.

Toxic substances:		
Data: NH_3 (calculate from NH_4 data), Al, As, Atrazine, Cd, Cr, Cu, Cyanide, Endosulfan, F, Pb, Phenol, Hg	Calculate 95% of reference data.	Calculate 95% of present state data.
	Compare to default boundary table.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Biological response variables:		
SASS **Data:** SASS scores and ASPT scores	Assess whether ASPT score from Reference site is >5% different to default Natural boundary.	Compare ASPT scores from resource unit with relevant boundary table.
	Recalibrate boundary if necessary.	Assign category.
CHL-*a** **Data:** Phytoplankton (µg/ℓ) and periphyton (mg/m^2)	Calculate 50% of reference data	Calculate 50% of periphyton data and mean of phytoplankton data.
	Compare to default boundary table.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Toxicity	Method not yet developed.	Method not yet developed.

Number of data points

Use a minimum of 25 samples collected over a 1-3 year period at the present state site and the reference site, including wet and dry seasons, to calculate the relevant percentile concentrations (Hughes, 2005).

Determine reference conditions

The reference, or natural, condition provides the site-specific benchmark against which the default "Natural" category boundary is assessed. The default benchmark tables presented in Hughes (2005) were based on literature and available database information. For a medium confidence ecological water quality assessment the default "Natural" or A category boundary values should be reviewed and modified using observed water quality data and qualitative descriptions.

The relevance of the default benchmark tables is determined by the presence of water quality data for a reference site. If the relevant statistics at the reference site fall within the default "Natural" or A category then the default benchmark table is accepted for the present status assessment. If the reference site statistics fall outside the "Natural" range, then the benchmark table is modified to account for the new "Natural" or A category range. Rules for modifying the default benchmark tables for the different water quality variables, are given in Hughes, 2005.

If an data are not available for an unimpacted site, then:

- Pre-impact data from the present state site can be used, provided data can be extrapolated from present day data and there is evidence of a trajectory of change, or
- Based on expert judgement of natural conditions.

In many resource units, and particularly in the lower reaches of rivers, there are no unimpacted sites, and reference conditions are difficult to infer. Data can be used from neighbouring catchments within the same ecoregion or any acceptable approximation of the natural condition.

Determine Present State

The present ecological state (PES) is the measured, current water quality for each water resource management unit and in many cases provides the point of departure for the development of any management objectives.

Hughes (2005) provides methods for linking chemical and biotic response data to a present ecological state category - Natural, Good, Fair, or Poor. Only data from 1-3 years prior to the assessment of the present status should be used. If the data record is poor (less than a monthly sampling frequency), then data from up to, but no longer than, 5 years prior to the assessment can be used.

The water quality data at the present state site should be analysed statistically to indicate for example the 5^{th} and 95^{th} percentiles, average and median values for each chemical parameter. The statistics required for each constituent are described in Hughes (2005). Refer to the different constituents for the rules to determine the present state category using the default benchmark tables, or the modified benchmark tables if they were adjusted for reference conditions.

Ecological Importance and Sensitivity (EIS)

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity. For a medium confidence RWQO determination, the EIS must be determined by an aquatic ecologist with knowledge of the area using the methods developed by Kleynhans (2000). The EIS should be checked against field data.

Recommended Ecological Category (REC)

The generic steps required to determine the Recommended Ecological Category (REC) include:

1. Determine reference water quality conditions.
2. Determine the present water quality status (PES).
3. Determine the trajectory of change in water quality, and whether these changes are short- or long-term.
4. Determine critical causes for the present water quality status and/or the trajectory of change, and the sources of these changes.
5. Determine the ecological importance and sensitivity categories (low, moderate, high, very high) in terms of water quality and state the confidence in the evaluations.

6. Determine whether the present water quality state can be improved (if so, by how much), or maintained (which could still require restoration management, depending on the trajectory of change).
7. Determine what would be required to address the causes.
8. Determine how difficult it would be to address the source (restoration/reversibility potential).
9. Determine the Recommended Ecological Category (REC) for water quality and the other ecosystem components considering the ecological aims, and the difficulty of achieving these aims.

The above steps are generally conducted in collaboration with a small team of aquatic specialists where key components of the ecosystem (e.g. water quality, water quantity, biota, etc.) are considered. The output resulting from the above should be two recommended ecological categories, one ecological category attainable in the short-term (up to 5 years) and a second ecological category attainable in the medium- to long-term (between 5 to 10 years).

Describe Ecological Specifications

Each of the ecological categories is associated with a level of ecosystem health and integrity and the potential to offer a particular range of goods and services. The task of the ecological Reserve assessment is to provide quantified and descriptive information about the concentrations of water quality variables which:

- Describe the recommended ecological category (A to D or Natural to Fair) of the system, and
- Provide numeric input into quantifying the management class.

The quantified and descriptive information is provided in the form of ecological specifications, termed “Ecospecs” (Hughes, 2005) and is specified for the recommended ecological category as well as for the categories above and below the REC.

Mapping Categories to Classes

Ecological categories may, in combination with the water user category, be mapped to a management class, i.e. Natural, Moderately used/impacted or Heavily used/impacted. The mapping route from the four categories (A, B, C, D) system to the three tiered management class system (is as follows:

- A = Natural
- A/B, B, B/C = Moderately used/impacted
- C, C/D, D = Heavily impacted

If the Natural/Good/Fair/Poor categories were used in a historical ecological water quality requirements determination, then the ecological categories can be mapped to the management class as follows:

- Natural = Natural
- Good = Moderately used/impacted
- Fair = Heavily impacted

D.1.2 Water User Requirements

Identify Water Users

Within the water resource management unit, all water user sectors and water uses within each sector should be identified, e.g. domestic, agriculture (e.g. irrigation of tobacco, aquaculture of warm water fish species, etc.) industry (power generation, canning industry, etc.), recreation (e.g. swimming, canoeing, hiking, etc.). At a medium confidence level, this may be as a detailed listing of the generic water uses within each water user sector present in the water resource management unit, and providing an estimate of the amount of water used by the different sectors. This information should be available from a Catchment Assessment Study (CAS).

Determine the parameters of concern

Identify the physical, chemical and/or biological parameters of concern within the water resource management unit, based on the identified user sectors and the user categories, e.g. tobacco farming in the irrigation water user sector is sensitive to Chloride (Cl). Therefore, RWQOs in that water resource management unit must include an assessment of Cl.

The water user sectors, user categories with the sectors and the parameters of concern should be confirmed through a limited, but effective stakeholder consultation process. At a medium confidence level, stakeholder consultation can be limited to key stakeholder groupings such as organised agriculture, chambers of commerce, industry associations, government departments, local authorities, etc.

Determine Present State

From the available water quality data, as derived in Section D.1.1 an assessment must be made of the present state of the water quality with regards to all permissible water uses within the Resource unit. Such uses include:

- Basic Human Needs
- Permissible water uses
- Strategic Water Use
- International water use
- Future water uses. As such it is necessary for the Region to have considered the types of water users required in the catchment in the future through a catchment visioning exercise.

At a medium confidence level, additional water quality data can be collected over one season for:

- Key parameters for which no or very limited data exist (e.g. E. coli); or
- At sites where key impacts occur (large abstractions or discharges).

In some cases it may not be practical to collect additional data (e.g. due to budget or time constraints). Under these circumstances, simple mass balance models can be used to estimate the present water quality state using known inputs and flow patterns in the water resource management unit.

Determination of the present state at a medium confidence level entails a comparison of present water quality against the water quality requirements of user sectors and their user categories (Annexure A).

Based on the user water quality requirements, a corresponding water user category can be assigned to the present water quality within the water resource management unit.

Social Importance (SI)

The social importance of a river is an expression of its importance in a social context for the local and wider communities. The Social Importance should be determined by a domain specialist using data collected from a limited social survey of the local and wider communities and available information.

Catchment Visioning

Catchment Visioning plays an important role in the medium confidence level because it informs the RWQOs process. The effective involvement of institutional stakeholders is important for the process.

Determine Desired Water Quality

An assessment must be made as to what category of water quality is desired for use within the water resource management unit, i.e. (Ideal, Acceptable, Tolerable). Note: Category 'Unacceptable' is not considered a desired category

In assessing the desired water quality at a medium confidence level, existing and future water users should also be considered, i.e. water user requirements which drive the determination of RWQO and the corresponding Management Class, must include:

- Basic human needs (Reserve);
- Strategic water quality requirements (if these exist);
- International water quality requirements;
- Existing lawful use water quality requirements; and
- Future user water quality requirements.

At a medium confidence level, the precautionary principle can be used to set the desired water user category equal to the present status provided that the present status is equal to a Tolerable category or better. Alternatively, if sufficient information is available, the Department may motivate for a better, or poorer, water quality category, e.g. in line with the catchment vision, from e.g. a present water quality category of 'Tolerable' to a desired water quality category of 'Acceptable'. Determination of the desired water quality is carried out in collaboration with key institutional stakeholders.

Assessing the desired state also involves the evaluation of alternative scenarios where the upstream and downstream water quality and classification are taken into account. At a medium confidence level, scenario analysis can be undertaken using simple modelling tools and professional judgement.

Water User Specifications

The desired water user category (Ideal, Acceptable, Tolerable) can be described in terms of quantitative and descriptive information goals, and the information provided in the form of water user category specifications. These water user category RWQOs are based on the DWAF Water Quality Guidelines (Annexure A) and WRC Water Quality Guidelines for Domestic water supply (Annexure A), and any modifications to these resulting from specifying site specific user requirements.

D.1.3 RWQOs

Integration

The ecological specifications derived in Section D.1.1 must be compared against the water user specifications determined in Section D.1.2, i.e. the Water Quality Guidelines for each of the identified users, i.e.

- Ecological requirements (Reserve);
- Basic Human Needs (Reserve);
- Permissible water uses;
- Strategic Water Use;
- International water use; and
- Future use.

By default, at a high confidence level, the most stringent water quality requirements or most sensitive user may not necessarily define the RWQO.

Due to the high level of confidence and stakeholder participation, certain uses may be excluded, e.g. due to particularly stringent requirements that are not aligned with the catchment vision, or certain individual users may accept a poorer water quality than specified for the water user category.

Derive Management Class

The management class is determined for the water resource management unit. In the absence of the national classification system, the management class can be given for both the ecological and water use categories, e.g.

- Ecological – Good
- Water Use – Ideal

Or mapped to a single management class (See Table 3.1, Section 3.4) of:

- Natural
- Moderately used/impacted
- Heavily used/impacted

Annexure E:

Procedure for the High Confidence Determination of RWQOs

Introduction

The high confidence method is a determination that is undertaken when there is a good set of water quality data available for the water resource management unit on which to base an assessment of the present water quality status for ecosystems and other water users. There is scope for collecting additional data for those variables of concern that are not routinely monitored in the water resource management unit and there is an extensive process of stakeholder involvement in developing a catchment vision and user water quality requirements. The high confidence method is used in the consideration of individual licences that have the potential to cause a high impact in a stressed catchment, or in a catchment with a high importance and sensitivity.

When to use

This approach is to be used when there is a good water quality data set available to assess the present water quality status. Data for water quality, SASS and in-stream habitat, and/or fish and/or riparian habitat are available at the level of:

- A Comprehensive Reserve determination (high confidence water quality reserve determination);
- Comprehensive Catchment Assessment Study; and/or
- State of Rivers Report.

A high confidence water quality Reserve may not be available in which case the steps described in section E.1.1 need to be followed. If a water quality Reserve has been undertaken for the water resource management unit, then these results should be used instead of repeating section E.1.1.

A comprehensive catchment assessment study (CAS) may not be available in which case the steps described in section E.1.2 need to be followed. If a CAS has been undertaken at a scale that is compatible with the water resource management unit and a high level of detail, then these results should be used instead of repeating section E.1.2.

E.1 Method

E.1.1 Ecological Requirements

Delineate Resource unit

At a high confidence level the determination of preliminary RWQOs can be conducted for a river reach, subject to the availability of water quality data for that reach. The delineation of the resource units is based on Ecoregion Level II boundaries and stream classification. The locations of significant point and non-point sources, dams and tributaries are also considered when delineating resource units because these can substantially modify the water quality in a resource unit.

Refer to the five-step water quality reserve determination methodology for rivers described in Hughes (2005) and the Spatsim help files (Hughes, 2005).

Water quality data required for assessment of the ecological requirements

The water quality data requirements to undertake the water quality component of an ecological water reserve assessment are the following (Hughes, 2005). (*indicates that the variable is optional)

WATER QUALITY VARIABLES	REFERENCE CONDITION	PRESENT ECOLOGICAL STATE
Inorganic salts:		
Data: Ca, Mg, K, Na, Cl, SO_4	Calculate 95% of reference data.	Calculate 95% of present state data.
	Compare to default boundary table.	Compare to relevant boundary table.
Calculate inorganic salt concentrations: $MgSO_4$, Na_2SO_4, MgCl, $CaCl_2$, NaCl, $CaSO_4$ **Data analysis:** $MgSO_4$, Na_2SO_4, MgCl, $CaCl_2$, NaCl, $CaSO_4$	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Nutrients:		
Data: NH_4, NO_2+NO_3, PO_4	Calculate 50% of reference data	Calculate 50% of present state data
	Compare to default boundary values	Compare to relevant boundary table
Calculate TIN (NH_4+NO_2+NO_3) **Data analysis:** TIN and SRP	Recalibrate boundary table if necessary	Assign category. Adjust accordingly using Chl-*a* data. Calculate confidence level.
System variables:		
DO	Calculate 5% of reference data	Calculate 5% of present state data
	Compare to default boundary values.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
pH	Calculate 5% and 95% of reference data.	Calculate 5% and 95% of present state data.
	Compare to default boundary values.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Turbidity*	Method not yet developed.	Method not yet developed.
Temperature*	Calculate monthly 10% and 90% of reference data.	Calculate monthly 10% and 90% of present state data.
Data: If no water temperature are available, calculate daily water temperature from air temperature	Calculate the upper and lower boundaries of the categories.	Compare to boundaries obtained for reference condition.
	Summarize results in benchmark table.	Assign category. Calculate confidence level.
TDS / EC	Method under development.	Method under development.

WATER QUALITY VARIABLES	REFERENCE CONDITION	PRESENT ECOLOGICAL STATE
Toxic substances:		
Data: NH_3 (calculate from NH_4 data), Al, As, Atrazine, Cd, Cr, Cu, Cyanide, Endosulfan, F, Pb, Phenol, Hg	Calculate 95% of reference data.	Calculate 95% of present state data.
	Compare to default boundary table.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Biological response variables:		
SASS **Data:** SASS scores and ASPT scores	Assess whether ASPT score from Reference site is >5% different to default Natural boundary.	Compare ASPT scores from resource unit with relevant boundary table.
	Recalibrate boundary if necessary.	Assign category.
CHL-*a** **Data:** Phytoplankton (µg/ℓ) and periphyton (mg/m^2)	Calculate 50% of reference data	Calculate 50% of periphyton data and mean of phytoplankton data.
	Compare to default boundary table.	Compare to relevant boundary table.
	Recalibrate boundary table if necessary.	Assign category. Calculate confidence level.
Toxicity	Method not yet developed.	Method not yet developed.

Number of data points

Use a minimum of 60 samples collected over a 3 year period at the present state site and the reference site, including wet and dry seasons, to calculate the relevant percentile concentrations.

Determine reference conditions

The reference, or natural, condition provides the site-specific benchmark against which the default "Natural" category boundary is assessed. The default benchmark tables presented in Hughes (2005) were based on literature and available database information. For a high confidence ecological water quality assessment the default "Natural" or A category boundary values should be reviewed and modified using observed water quality data from a reference site.

The relevance of the default benchmark tables is determined by the presence of water quality data for a reference site. If the relevant statistics at the reference site fall within the default "Natural" or A category then the default benchmark table is accepted for the present status assessment. If the reference site statistics fall outside the "Natural" range, then the benchmark table is modified to account for the new "Natural" or A category range. Rules for modifying the default benchmark tables for the different water quality variables are described in Hughes (2005).

If data are not available for an unimpacted site, then:

- Pre-impact data from the present state site can be used, provided data can be extrapolated from present day data, and there is evidence of a trajectory of change; or
- Based on expert judgement of natural conditions.

In many water resource management units, and particularly in the lower reaches of rivers, there are no unimpacted sites, and reference conditions are difficult to infer. Data can be used from neighbouring catchments within the same ecoregion or any acceptable approximation of the natural condition.

Determine Present State

The present ecological state (PES) is the measured, current water quality for each water resource management unit and, in many cases, provides the point of departure for the development of any management objectives.

Hughes (2005) provides methods for linking chemical and biotic response data to a present ecological state category - Natural, Good, Fair, or Poor. Only data from 1-3 years prior to the assessment of the present status should be used. If the data record is poor (less than a monthly sampling frequency), then data from up to, but no longer than, 5 years prior to the assessment can be used.

The water quality data at the present state site should be analysed statistically to calculate for example the 5^{th} and 95^{th} percentiles, average and median values for each chemical parameter. The statistics required for each constituent are described in Hughes (2005). Refer to the different water quality constituents for the rules to determine the present state category using the default benchmark tables, or the modified benchmark tables if they were adjusted for reference conditions.

At a high confidence level, additional water quality data monitoring can be undertaken to collect data for variables that are not routinely monitored. The water quality database can be supplemented with additional data that monitors the response of the ecosystem to changes in water quality. Present state categories based on observed water quality should then be verified against the response of the ecosystem (Hughes, 2005). The RWQO process should be supported with an extensive review of the literature relating to water quality in the water resource management unit.

Ecological Importance and Sensitivity (EIS)

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity. For a high confidence RWQOs determination, the EIS must be determined using data collected during an extensive field survey by domain specialists (e.g. invertebrate, geomorphological, riparian vegetation specialists) and using the methods developed by Kleynhans (2000).

Recommended Ecological Category (REC)

The generic steps required to determine the Recommended Ecological Category (REC) include:

1. Determine reference water quality conditions.
2. Determine the present water quality status (PES).
3. Determine the trajectory of change in water quality, and whether these changes are short- or long-term in character.
4. Determine critical causes for the present water quality status, and/or the trajectory of change, and the sources of these changes.
5. Determine the ecological importance and sensitivity categories (low, moderate, high, very high) in terms of water quality, and state the level of confidence in the evaluations (see description above).

6. Determine whether the present water quality state can be improved (if so, by how much), or maintained (which could still require restoration management, depending on the trajectory of change).
7. Determine what would be required to address the causes.
8. Determine how difficult it would be to address the source (restoration/reversibility potential).
9. Determine the Recommended Ecological Category (REC) for water quality and the other ecosystem components considering the ecological aims, and the difficulty of achieving these aims.

The above steps are generally conducted in a workshop situation where each component of the ecosystem (e.g. water quality, water quantity, biota, etc.) is considered by their respective specialist teams. The output resulting from the above should be two ecological categories; one ecological category that is attainable in the short-term (up to 5 years), and a second ecological category that is attainable in the medium- to long-term (between 5 to 10 years).

Assessing the desired state also involves the evaluation of alternative scenarios where the upstream and downstream water quality and classification are taken into account. At a high confidence level, scenario analysis can be undertaken using catchment and river scale modelling tools and professional judgement.

Describe Ecological Specifications

Each of the ecological categories is associated with a level of ecosystem health and integrity and the potential to offer a particular range of goods and services. The task of the ecological water quality Reserve assessment is to provide quantified and descriptive information about the concentrations of water quality variables which:

- Describe the recommended ecological category (A to D or Natural to Fair) of the system, and
- Provide numeric input into quantifying the management class.

The quantified and descriptive information is provided in the form of ecological specifications, termed “Ecospecs” (Hughes, 2005) and is specified for the recommended ecological category as well as for the categories above and below the REC.

Mapping Categories to Classes

Ecological categories may, in combination with the water user category, be mapped to a management class, i.e. Natural, Moderately used/impacted or Heavily used/impacted. The mapping route from the four categories (A, B, C, D) system to the three tiered management class system (is as follows:

- A = Natural
- A/B, B, B/C = Moderately used/impacted
- C, C/D, D = Heavily used/impacted

If the Natural/Good/Fair/Poor categories were used in the ecological water quality requirements determination, then the ecological categories can be mapped to the management class as follows:

- Natural = Natural
- Good = Moderately used/impacted
- Fair = Heavily impacted

E.1.2 Water User Requirements

Identify Water Users

Within the water resource management unit, all water user sectors and water uses within each sector should be identified, e.g. domestic, agriculture (e.g. irrigation of tobacco, aquaculture of warm water fish species, etc.) industry (power generation, canning industry, etc.), recreation (e.g. swimming, canoeing, hiking, etc.). At a high confidence level, this should be as detailed as possible, listing the individual water users, grouped by water user sector, in the water resource management unit, and providing an estimate of the amount of water used by each user. This information should be available from a comprehensive Catchment Assessment Study (CAS).

Determine the parameters of concern

Identify the physical, chemical and/or biological parameters of concern within the water resource management unit, based on the identified user sectors, the user categories, and key individual water users, whether these users are considered to be exercising an existing lawful use or not.

The parameters of concern for the water user sectors, user categories within the sectors, and key individual users, should be confirmed through a comprehensive stakeholder consultation process. At a high confidence level, stakeholder consultation should include key stakeholder groupings such as organised agriculture, chambers of commerce, industry associations, government departments, local authorities, etc., as well as key individual water users.

Determine Present State

From the available water quality data, as derived in Section E.1.1 an assessment must be made of the present state of the water quality with regards to all permissible water uses within the Resource unit. Such uses include:

- Basic Human Needs
- Permissible water uses
- Strategic Water Use
- International water use
- Future water uses. As such it is necessary for the Region to have considered the types of water users required in the catchment in the future through a catchment visioning exercise.

At a high confidence level, additional water quality data should be collected over at least one hydrological year for:

- Key parameters for which no or very limited data exist (e.g. E. coli, toxic substances); or
- At sites where key impacts occur (large abstractions or discharges).

In some cases it may not be practical to collect additional data (e.g. due to budget or time constraints). Under these circumstances river water quality models can be used to estimate the present water quality state using known inputs and flow patterns in the water resource management unit.

Determination of the present state at a high confidence level entails a comparison of the present water quality against the water quality requirements of user sectors, their user categories and, where appropriate, key individual water users.

Based on the user water quality requirements, a corresponding water user category can be assigned to the present water quality within the water resource management unit.

Social Importance (SI) and Economic Importance (EI)

The social importance of a river is an expression of its importance in a social context for the local and wider communities. The Social Importance should be determined by a domain specialist using data collected from an extensive social survey of local and wider communities and their association with the river.

The Economic Importance of a river is an expression of its importance to support local and wider scale economic activities and growth in the region. A domain specialist using accepted methods and data collected during an extensive economic survey of the river and region must determine the Economic Importance.

Catchment Visioning

Catchment Visioning plays an important role in the high confidence level because it informs the RWQOs process. The effective involvement of institutional and other key individual stakeholders is critical to the process.

Determine Desired Water Quality

An assessment must be made as to what category of water quality is desired for use within the water resource management unit, i.e. Ideal, Acceptable, Tolerable. Note: Category 'Unacceptable' is not considered a desired category

In assessing the desired water quality at a high confidence level, both existing and future water users should be considered, i.e. water user requirements that drive the determination of RWQOs and the corresponding Management Class, must include:

- Basic human needs (Reserve);
- Strategic water quality requirements (if these exist);
- International water quality requirements;
- Existing lawful use water quality requirements; and
- Future user water quality requirements.

At a high confidence level, an extensive stakeholder consultation process is followed to set the desired water user category and to determine the consequences of this decision. In this process, different scenarios are evaluated using decision support tools such as catchment and river scale water quality models.

Water User Specifications

The desired water user category (Ideal, Acceptable, Tolerable) can be described in terms of quantitative and descriptive information goals, and the information provided in the form of water user category specifications. These water user category RWQOs are based on the DWAF Water Quality Guidelines (Annexure A) and WRC Water Quality Guidelines for Domestic water supply, and any modifications to these that might result from specifying site-specific user requirements as described below.

The boundary values in Annexure A should be reviewed during the stakeholder participation process to determine if these need to be adjusted for site-specific conditions or specific user requirements. The boundary values can be adjusted to be more stringent or less stringent provided that stakeholders can provide compelling reasons for the adjustment, and there is acceptance by the stakeholders of the potential impacts of adjusting the boundary values.

E.1.3 RWQOs

Integration

The ecological specifications derived in Section E.1.1 must be compared against the water user specifications determined in Section E.1.2, i.e. the Water Quality Guidelines for each of the identified users, i.e.

- Ecological requirements (Reserve)
- Basic Human Needs (Reserve)
- Permissible water uses
- Strategic Water Use
- International water use, and
- Future use

By default, at a high confidence level, the most stringent water quality requirements or most sensitive user may not necessarily define the RWQOs. Due to the high level of confidence and stakeholder participation, certain uses may be excluded, e.g. due to particularly stringent requirements which are not aligned with the catchment vision, or certain individual users may accept a poorer water quality than specified for the water user category.

Derive Management Class

The management class is determined for the water resource management unit. In the absence of the national classification system, the management class can be given for both the ecological and water use categories, e.g.

- Ecological – Good
- Water Use – Ideal

Or mapped to a single management class (See Table 3.1, Section 3.4) of:

- Natural
- Moderately used/impacted
- Highly used/impacted

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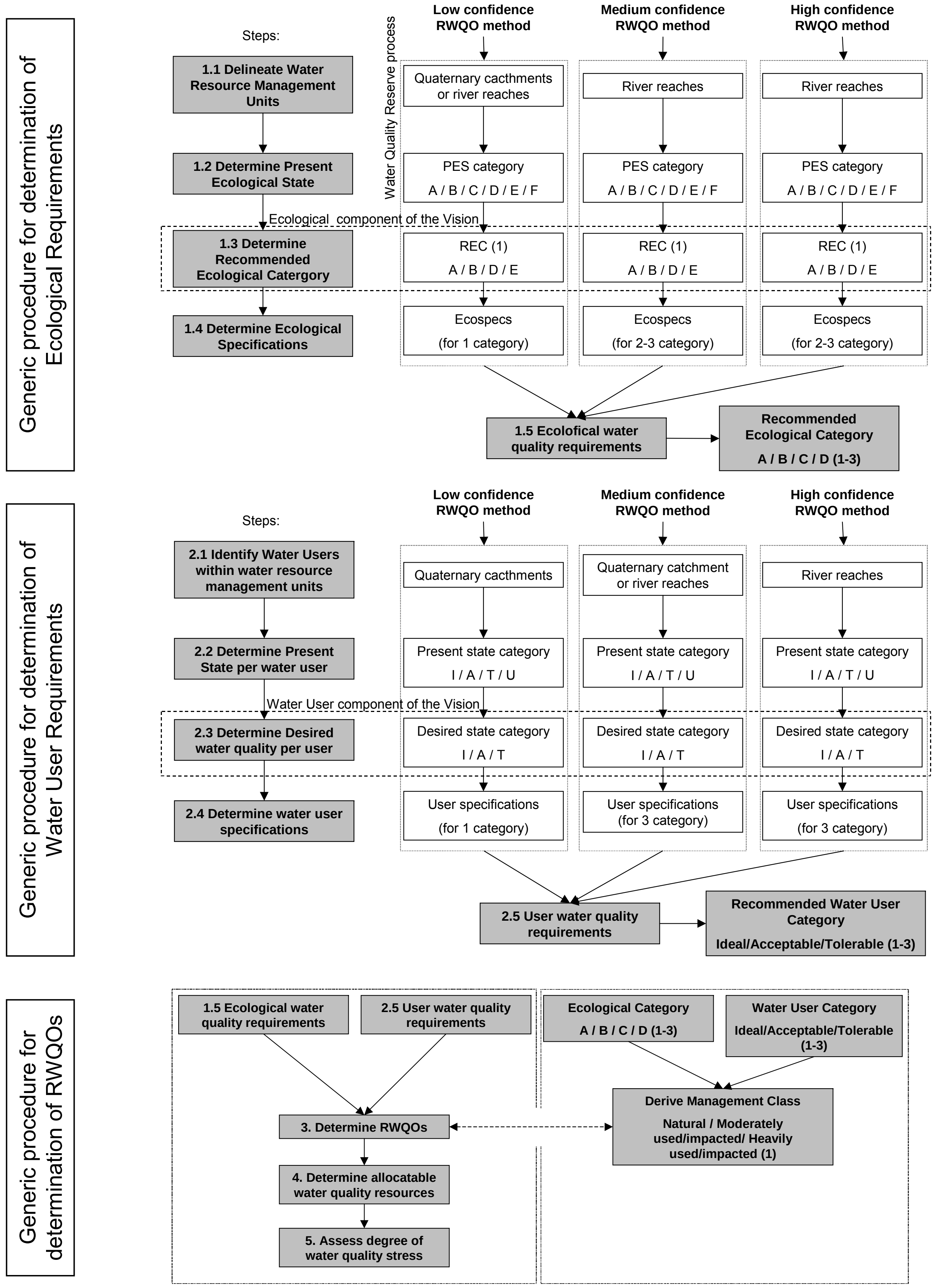
Generic procedures for determination of Ecological Requirements, Water User Requirements and RWQOs



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