REPORT NO.: RDM/WE/00/CON/ORDM/1016

DEVELOPMENT OF PROCEDURES TO OPERATIONALISE RESOURCE DIRECTED MEASURES

PROJECT NO: WP 10951

SOCIO-ECONOMIC AND ECOSYSTEM SERVICES TOOL ANALYSIS AND STANDARDISATION REPORT

OCTOBER 2016

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Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DEVELOPMENT OF PROCEDURES TO OPERATIONALISE RESOURCE DIRECTED MEASURES

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Professional Service Providers: Rivers for Africa eFlows Consulting (Pty) Ltd.

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REPORT AND DELIVERABLE INDEX

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REPORT SCHEDULE

Version	Date	Comments
First draft	October 2016	17 October 2016
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ACRONYMS AND ABBREVIATIONS

BHNR	Basic Human Needs Reserve
CD: WE	Chief Directorate: Water Ecosystems
DBSA	Development Bank South Africa
DWS	Department of Water and Sanitation
DWA	Department Water Affairs
DWAF	Department Water Affairs and Forestry
EC	Ecological Category
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GVA	Gross Value Added
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
NWRCS	National Water Resource Classification System
PESEIS	Present Ecological State and Ecological Importance-Ecological Sensitivity
PSP	Professional Service Provider
RDM	Resource Directed Measures
RQO	Resource Quality Objective
RU	Resource Unit
SCI	Socio-Cultural Importance
SQ	Sub Quaternary
TEC	Target Ecological Category
ToR	Terms of Reference
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study for the Development of Procedures to Operationalise Resource Directed Measures (RDM). Rivers for Africa eFlows Consulting (Pty) Ltd., in association with supporting specialists, was appointed as the Professional Service Provider (PSP) to assist the Department in undertaking this study.

1.2 STUDY OBJECTIVES

The study objectives as defined by the Terms of Reference (ToR) are as follows:

- Develop a framework for Reserve determination.
- Standardise methodologies for Reserve determination.
- Develop a framework for Water Resource Classification.
- Develop a framework for Resource Quality Objectives (RQOs).
- Develop a RDM Communications Framework.

In the ToR, the CD: WE also identified the need for the development of an Integrated RDM framework. The term operationalise was not defined clearly as part of the TOR, apart from the objectives stated above. However, a definition was presented by DWS and agreed by all as follows:

Provide the frameworks and methods to allow CD: WE to give effect to the Reserve, Classification and RQOs (i.e. give effect to RDM). It therefore includes the frameworks, steps, processes, methods and implementation and monitoring information. The operationalisation of RDM starts at planning and ends at corrective actions (though the continuum of the plan, do, check, act cycle) which will include implementation and monitoring guidelines and the provision of information for various line functions.

NB: Care should be taken to distinguish between the term "operationalise" as it is defined above and "operating" rules for dams etc. OR with operational scenarios.

1.3 PURPOSE OF THIS TASK

The aims and objectives for this task as addressed at the specialist workshops to consolidate and standardise RDM methods are provided below:

Aim: Standardise methodologies for Reserve determination. Note, methodologies required for Classification and RQO determinations which are not covered through the Reserve methodologies will also be included.

Objectives:

- Identify and standardise input and output for every sub-step (if relevant) of the Integrated Framework.
- Identify the range of tools and methods used in DWS and DWS related studies for each sub-step (if relevant).
- Evaluate the tools and methods according to a range of agreed criteria.

Approach:

These objectives were addressed during a workshop for river specialists during July 2016. Standardisation of methods focussed on standardising the inputs and outputs of the tools used in the sub-steps to define the information and data that is required to ensure continuity between the processes and steps. This will ensure that during all phases of the frameworks, the methods comply with the standardised inputs and outputs and that the linkages through the whole process are seamless.

1.4 PURPOSE OF THIS REPORT

During a range of specialist meetings (July 2016), available methods and methods for each of the sub-steps will be identified, evaluated and documented in a range of reports (RDM/WE/00/CON/ ORDM/0516 to RDM/WE/00/CON/ORDM/01116). This report serves to document the outcomes of the River method analysis and standardisation workshop specialist meeting (20 to 21 July 2016) (RDM/WE/00/CON/ ORDM/0516).

2 APPROACH

2.1 BACKGROUND

Currently Resource Directed Measures (RDM) consists of three major processes.

- Water Resource Classification System (DWAF, 2006).
- Determination of the Reserve (Louw and Hughes, 2002).
- Determination of RQOs (DWA, 2011).

Each of these processes consist of steps which were designed in 2002 (Reserve, Louw and Hughes, 2002), 2006 (Classification, DWAF, 2006) and 2011 (RQOs, DWA, 2011). These steps were gazetted (Gazette No. 19182, Notice No. 1091) on 17 September 2010. This gazette provides procedures (in the format of steps) for each of the RDM processes, which are largely similar to the initially designed steps for the Reserve and Classification. It must be noted however that the RQO steps and guideline appeared during 2011, i.e. after the gazette and differs significantly from the gazetted steps. During this project, the gazetted steps and the RQO guideline steps will be addressed.

Therefore, each of the RDM processes consists of gazetted steps, guidelines, methodologies and approaches and various methods and tools supporting the methodologies. There are inherent links, overlaps and complexities within all of the above. This situation is further complicated by having to deal with large study areas with many nodes (points of interest) requiring answers that may be either at a desktop level and/or more detailed level. Issues regarding confidence, uncertainty and decision-making on various aspects such as where the areas of focus should be in study areas, add to the complexities.

2.2 INTEGRATED FRAMEWORK

During a February 2016 specialist meeting, an Integrated Framework was designed and subsequently finalised (DWS, 2016). The Integrated Framework consists of eight steps. Each step is sub-divided into sub-steps described through a list of actions grouped together under various labels. The design and numbering of the flow diagrams are provided below:

Each individual step within the Integrated Framework is sub-divided according to sub-steps which represent the different components that need to be investigated during the process. Sub-steps are labelled and required actions are listed below each sub-step. The format is described below:

- Actions are listed in clear (not coloured) blocks which are labelled. The first numbering of the label will refer to the Step number and the second a sequential number. For example, a block numbered and labelled ‘1.4 Rivers’ will mean that the block represents the river component under Step 1. The four implies that this is the fourth block in the flow diagram. Essentially each block represents a sub-step which consists of a label and a list of actions. Reference is made to Step 1.4 as this is a secondary tier number, it represents a sub-step.
- These blocks are sometimes grouped together within a grey block which may have its own heading. The individual clear blocks are then labelled according to a next tier in the numbering, e.g. 1.4.1. This would mean that this block is part of Step 1, grouped within a grey block numbered 1.4 and would form the first block in the grey block, i.e. 1.4.1.
- The descriptions for these blocks are sub-steps. The reference in the report refers to these as Steps; however the numbering if a second tier (e.g. 1.1) will indicate that it is a sub-step. The numbering corresponds to the relevant flow diagram representing the relevant Integrated step.
- The actions that must be undertaken in each block are numbered from ‘1’ on.

- The descriptions of the actions in the report use a set of bullets as well as the numbers that can be cross-referenced to the flow diagram.
- Blocks with no numbers and shaded a light blue refer to KEY outputs (not all the outputs) of the step. These key outputs are those that are essential for use in the next step. This reflects the sequential manner of the Integrated Framework steps.

The integrated steps are provided in Figure 2.1.

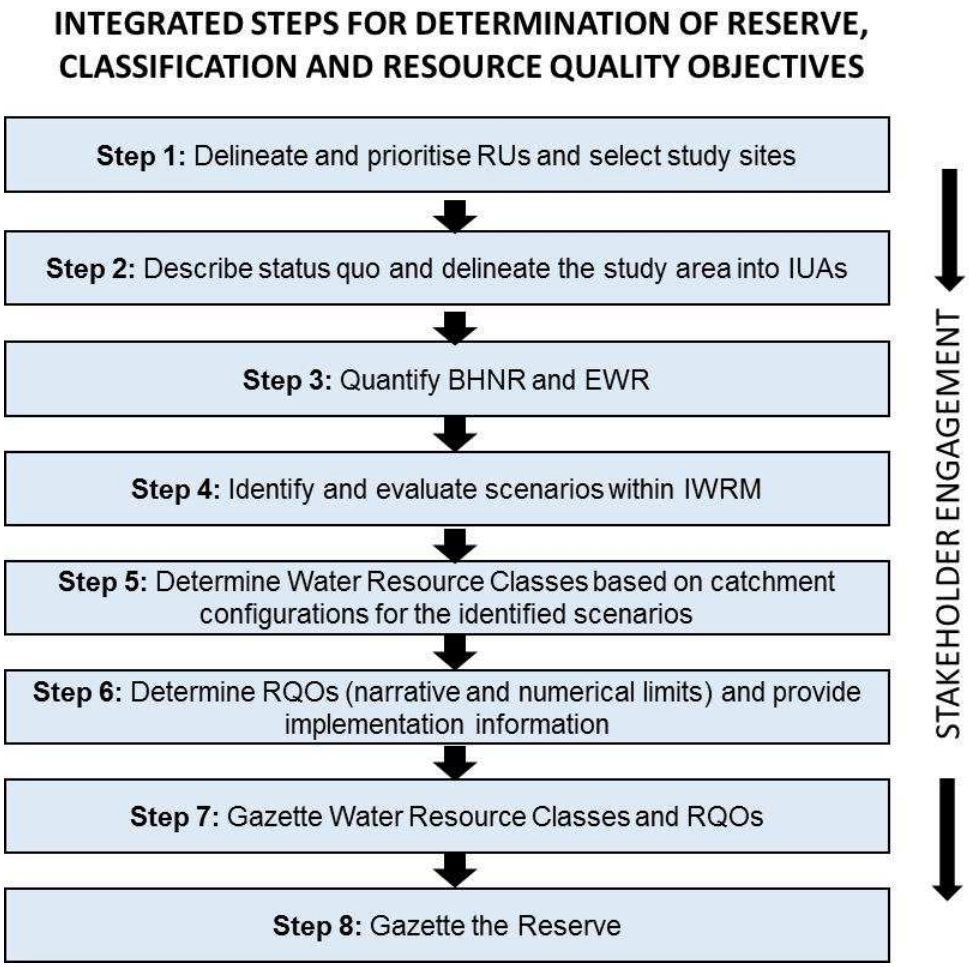

Figure 2.1 Integrated steps for the determination of the Reserve, Classification and Resource Quality Objectives

All numbering in this report will refer to the numbering in the flow diagram of each step illustrating the sub-steps as blocks and actions as a numbered list in the block.

2.3 STANDARDISATION OF TOOLS, METHODOLOGIES, METHODS AND APPROACHES

Since 1987, Instream Flow Requirements (now known as the Ecological Water Requirement) were considered by DWS in most water resource evaluations and investigations. Methods for determining environmental flow requirements were world-wide in its infancy. South Africa undertook research projects to evaluate existing methods and also developed one of the first holistic methods (King and Louw, 1998), the Building Block Methodology which catered for South African circumstances and DWS's requirements for Integrated Water Resource Management (IWRM). Since then, many methods and new methodologies have been developed to what has, since 1999, become known as the Ecological Water Requirement which is used to determine the Ecological Reserve. This method development largely focussed on rivers and estuaries.

During the last five years, application of Classification studies has resulted in further expansion of the Ecological Reserve methods as well as developing additional methods through application to cater for the demand set by the complexities of Classification and then Resource Quality Objectives.

The myriad of methods and tools being applied have presented challenges, mostly as the output of methods did not necessarily comply with standard requirements and could not be seamlessly used between different phases of related studies. It must be noted Reserve, Classification and RQO studies are undertaken under the auspices of IWRM and results from these studies must be compatible with the prevailing IWRM practices. This of course also implies that the input used in methods, especially around the driver components (hydrology, geohydrology, water quality etc.), require standardisation.

As many methods in some cases are available for application within these studies, the focus of this work would not be to select specific methods that may be used in RDM work, but to indicate whether these methods comply with a range of requirements and whether the input and output comply with the required standard. Tools that will be evaluated are those methods that have been in use in environmental flow requirement studies in South Africa with the specific emphasis of those used for RDM. International methods that have not been used in South Africa will not be evaluated.

2.4 CONSIDERATIONS FOR STANDARDISATION

The focus of this evaluation is on the standardisation of the inputs and outputs of each sub-step's actions rather than the method themselves. The key requirements for standardisation are:

- Aim to achieve coherent application throughout the RDM steps and processes.
- Application of RDM processes is part of IWRM - the prevailing water resource management activities need to define the focus.

Examples of inputs and outputs are:

- Inputs: Hydrology time series datasets, or databases such as PESEIS etc.
- Outputs: EWR time series and rule definitions; Ecological Categories A to F.

The approach to the standardisation of methods will focus on standardising the inputs and outputs of the methods used in the sub-steps to define the information and data that will flow between the processes and steps. This will ensure that during all phases of the activities in the frameworks, the methods comply with the standardised inputs and outputs and that the linkages through the whole process are seamless. It must be noted that the Excel spreadsheet has been designed to include all sub-steps and all actions. However, this may not be relevant, necessary, or practical to provide the input and output at this level for a particular action.

Note: Not all sub-steps may require standardised inputs although most would require standardised outputs.

2.5 TOOL IDENTIFICATION

Studies carried out for DWS (directly or indirectly) were considered and methods were identified that have been applied for the sub-steps and actions. Tools refer to any models, methods or systematic approaches and any of these will be referred to in this document as **METHODS.** The models could be detailed hydrological models, spreadsheet formulas, methodical procedures and techniques.

If a sub-step did not require a method, it was noted that it is not applicable. If methods are not available, this was identified as a gap.

Note:
- **Not all sub-steps or actions required a method.**
- **Actions were grouped in the sub-step if methods were applicable to these groups rather than per action.**
- **Note that if there are methods that have been used extensively in the past but which are now obsolete, these methods will not be evaluated, but will be provided in this report including the reasons why they are obsolete (e.g. TEACHA and BBM).**
- **Standard computer packages such as Google Earth, Microsoft Office suite of programmes, Statistica etc. are not RDM methods within the context of this study. Methods or models can be written using Excel as per example, but the method would be the method, not the computer package which is used.**

A generic set of criteria to rate the methods were identified and described (Section 2.7). The methods were rated using an Excel spreadsheet. **Note that not all criteria will be applicable to a method.**

TERMINOLOGY: TOOLS vs METHOD

The use of the word 'tools' created confusion as most people associated tools with computer models. Further in this report, the word '**method**' will rather be used to accommodate the confusion with regards to the tool terminology.

Tools refer to any models, methods or systematic approaches. The models could be detailed hydrological models, spreadsheet formulas, methodical procedures and techniques.

2.6 SPECIALIST WORKSHOP APPROACH

During the workshop, a step by step approach was followed to provide the necessary information for each step of the Integrated Framework which was presented as a series of Excel spreadsheets. The approach followed is given below:

- Determine whether there is standardised input that is relevant for the sub-step.
- Decide whether the standardised input is for the sub-step as a whole or if it is linked to the listed actions.
- Define the standardised input.
- Define the standardised output.
- Identify all tools (referring to models, approaches, methods) that are used for the sub-step.
- Some sub-steps may not have any specific tools as the output could be a qualitative description.
- Some actions within the sub-steps will often not have any action-specific tools and the specific actions can then be ignored.
- Evaluate the identified tools according to the given criteria. Note, that depending on the nature of the tool, all the criteria may not be valid and in these cases, the spreadsheet will not be populated.
- Transfer the information and all the added explanations in a MS Word report template.

2.7 EVALUATION CRITERIA

The criteria for the method evaluation, the evaluation manner and an explanatory comment are provided in Table 2.1 below.

Table 2.1 Criteria and evaluation

Criteria	Evaluation	Explanatory comment
Frequency of application of use	1 - Very Low 2 - Low 3 - Medium 4 - High 5 - Very High	Supply supporting information. Provide year since it has been in use and approximate number of studies.
Can the method be applied at a catchment level?	Yes/No	Some methods can only be applied at a site and have to be repeated for every site, i.e. the method was not designed to deal with e.g. 200 nodes. Provide explanation using the following: 1. Node or site 2 River reach 3 Catchment 4 Water Management Area
Is the method described?	Yes/No	If Yes, provide type of method description (user manuals, method description, and spreadsheet).
Indicate the status of publication of the method.	1 N/A 2 None 3 Internal 4 National 5 International	Describe the type of publication.
Are there existing training course?	Yes/No	If Yes, provide a description.
Is the method applicable to all levels of assessment (Desktop to Comprehensive)?	Yes/No	Note: Level refers to Desktop or Detailed and more specifically to the Reserve Levels of Desktop, Rapid, Intermediate, Comprehensive. Provide a description of the assessment level to which the method is applicable.
Time efficient (link to assessment level)	Provide evaluation in terms of a description in weeks and provide seasonality requirements if necessary	Provide explanatory comment and explain time limitations.
Is the data available to apply the method?	Always; Usually; Seldom; Never	Describe the reliance of method on monitored and/or measured data and pre-processing.
Compatibility	Yes/No	Can the method use the standardised input and does the method provide the results (output) according to the standardised requirements? In short, is the method compatible with the standardised input and output requirements? Please provide explanations.
Must software be purchased?	Yes/No	If Yes, indicate the approximate costs and any associated conditions.
License requirements	None; Simple; Complex, Duration limiting	Risk of use and administrative requirements.
Enhancement flexibility or adaptability of algorithms	1 Open script; 2 Open source; [Intellectual Property:] 3 DWS; 4 WRC;	Purpose of criteria is to indicate the risk of keeping method relevant.

Criteria	Evaluation	Explanatory comment
	5 Commercial	
Is the method validated and verified?	Yes/No	Is the tool/method's results validated and can it be verified against the conditions on the ground? Provide an explanatory comment for the reasoning.
Description of mathematical algorithms and model structure	Algorithm based; Detail explanation; Conceptual description; None	Provide an explanatory comment for the reasoning.
Is the model robust?	Yes/No	Will different numerical tools provide similar answers e.g.?
Does the method include an objective assessment of uncertainty such as may influence confidence?	Yes/No	If Yes, describe the process to quantify the uncertainty. If no, and there is a qualitative assessment of confidence (such as a rating by expert opinion): please describe.

3 STEP 1: DELINEATE AND PRIORITISE RUS AND SELECT STUDY SITES

Objective: The objective of this step is to identify high priority areas (previously referred to as hotspots[1]) as these would be the areas where more detailed work for the rest of the Integrated steps would focus on. These high priority areas are selected based on ecological, socio-cultural and water resource use importance and are often areas of high ecological importance where water resources are stressed or may be stressed in future. This is a key step as the Resource Units (RUs) information is gazetted with measured information and potentially higher confidence output. The prioritisation therefore acts as a filter to allow one to focus on specific areas in the various ecosystems. Integrated Step 1 (Figure 3.1) therefore involves the delineation and prioritisation of RUs. Study sites where more detailed field work is undertaken are selected within High priority RUs, i.e. sites can only be selected after the prioritisation process.

Integrated Step 1 contains six sub-steps. Ecosystem Services fall within sub-step 1.4 and discussed in this Chapter.

[1] A biodiversity/ecological hotspot is a biogeographic region which is a significant reservoir of biodiversity which is threatened with destruction (http://en.wikipedia.org/wiki/Biodiversity_hotspot). In the context used in the Desktop EcoClassification, the hotspot represents a quaternary catchment with a high Integrated Importance which could be under threat due to its importance for water resource use. These hotspots indicate areas where Reserve assessments should ideally result in high confidence recommendations and requires appropriate methods.

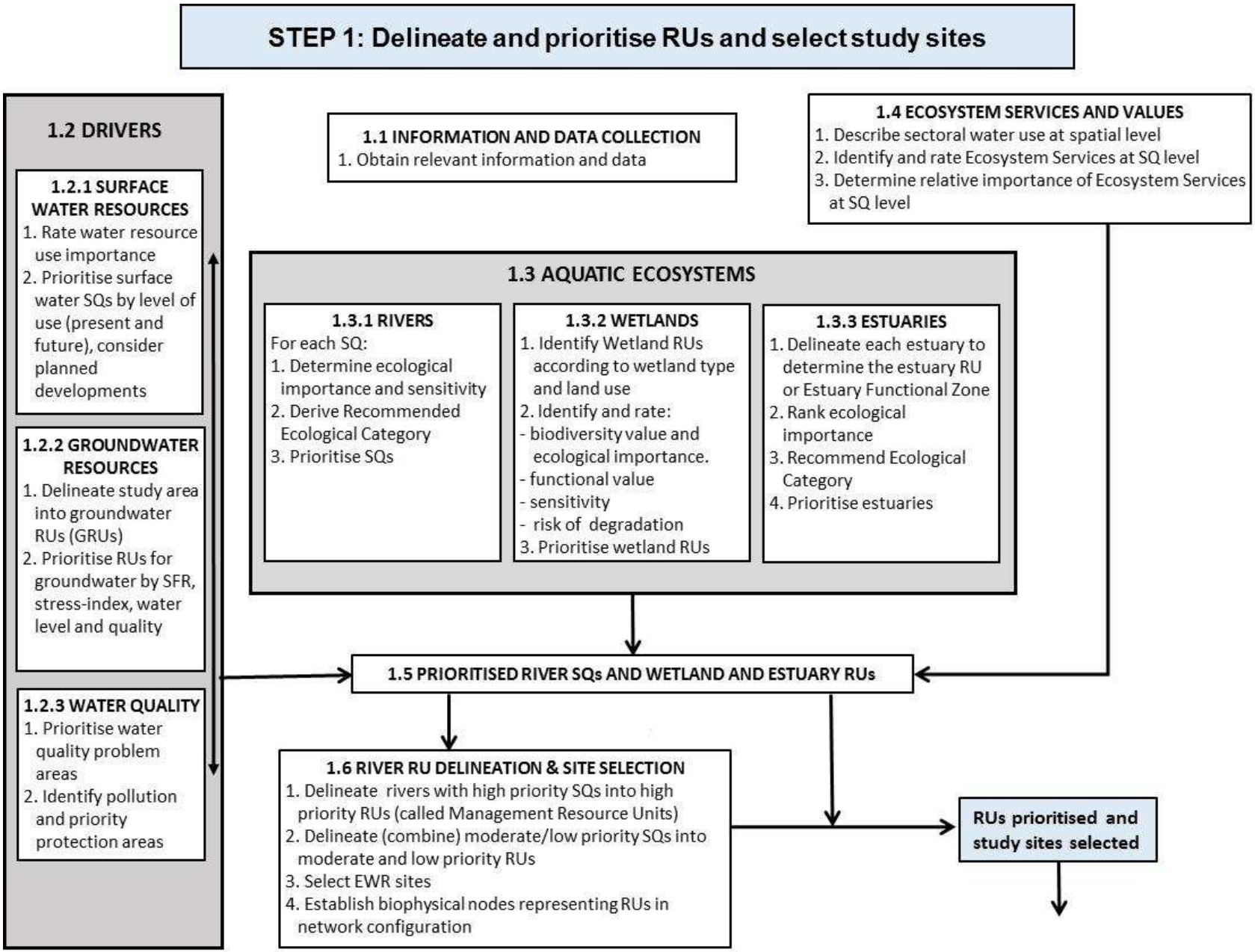

Figure 3.1 Illustration of the sub-steps for Integrated Step 1: Delineate and prioritise RUs and select study sites

3.1 STEP 1.4 ECOSYSTEM SERVICES AND VALUES: ACTIONS

Objective: The objective is to determine the Socio-Cultural Importance (SCI) which will provide another layer for the prioritisation of RUs

The bullets below describe the actions required.

- **1. Describe sectoral water use at spatial level**

This step builds on the analysis produced in Integrated Step 2 and describes the relationships that determine how value is influenced by sectoral use of water within the context of the resource that is abstracted. This work is undertaken for rivers, wetlands and estuaries.

- **2. Identify and rate Ecosystem Services at SQ level**

Based on the description of value and the rating, a list of high priority RUs can be generated and a narrative description explaining the importance of these RUs provided.

- **3. Determine relative importance of Ecosystem Services at SQ level**

A spreadsheet can be used to generate an overview of the types of aspects of socio-cultural importance that may be important per the rating and weighting of a range of criteria results in the relative importance score of Ecosystem Services at Sub Quaternary (SQ) level which leads to the prioritisation of Ecosystem Services. This feeds into the prioritisation step which integrates all the different importance evaluations.

3.2 STEP 1.4 ECOSYSTEM SERVICES AND VALUES: STANDARDISED INPUT AND OUTPUT

The standardised input and output for each action (if relevant) are provided in Table 3.1.

Table 3.1 Step 1.4: Standardised input and output per action

Action	Input	Output	Method
1. Describe sectoral water use at spatial level	Result of sub-step 2.7 that sets out Spreadsheet that ranks the rated SQs and prioritise based on importance		Results of Step 2 disaggregated into spatial components (economic zones) that are situated in IUAs
2. Identify and rate Ecosystem Services at SQ level	Defined SQ's and analysis of the SQs usually undertaken by using available mapping. Google Earth is typically used in conjunction with GIS based overlays that delineate SQs	Limited fieldwork may be undertaken to confirm assumptions. In some cases, more extensive fieldwork may be undertaken if the budget allows for this activity and if there is an identified requirement for more detailed and higher confidence analysis	Narrative Description of each SQ. Populated spreadsheet with set of aspects of the SQ that relate to socio-cultural importance. These are typically rated 1 - 5 indicative of importance
3. Determine relative importance of Ecosystem Services at SQ Level	Results of Action 2		Spreadsheet that ranks the rated SQs and prioritise based on importance with scores that are indicative of relative importance of the Ecosystem Services

3.3 STEP 1.4 ECOSYSTEM SERVICES AND VALUES: IDENTIFIED TOOLS AND EVALUATION PER ACTION

The evaluation of the SCI Spreadsheet tool used in Action 2: Identify and rate Ecosystem Services at SQ level is provided in Table 4.2.

Table 3.2 Step 1.4: Evaluation of SCI Spreadsheet tool

Criteria	Evaluation	Explanatory comment
Frequency of use of the application?	High	Used in multiple studies but not universally used.
Can the tool be applied at a catchment level?	Yes	
Is the method described?	Yes	Described in Reports associated with the Reserve studies, first used for Tugela.
Indicate the status of publication of the method	None	Not published but applied -see Tugela Report for first description.
Are there existing training courses?	Yes	Not a formal training course but the tool has been explained in a training format for DWS staff on a number of occasions over past years.
Is the method applicable to all levels of assessment (Desktop to Comprehensive)?	Yes	
Time efficient (link to assessment level)	1 week	Usually takes few days to a week to complete the spreadsheet for Rapid and Intermediate but this can be more for comprehensive. Time required is closely linked to size of project area.
Is the data available to apply the method?	Usually available. Dependant on aerial images. Sometimes these can be dated or not of the desired quality/resolution.	Needs further assessment from Google Earth etc.
Compatibility?	N/A	
Must software be purchased?	No	Access to Google Earth and Excel are sufficient.
Licencing requirements?	None	As per license for Microsoft Office.
Enhancement flexibility or adaptability of algorithms?	Open source	
Is the method validated and verified?	No	Not validated but often used as tool and found to be useful.
Descriptions available of mathematical algorithms and model structure?	None	Some internal weighting is applied but this is largely based on expert judgment.
Is the model robust?	Yes	The model is based on subjective judgment but can be scrutinised an easily checked by stakeholder groupings or peers to ensure that there is validity to assumptions being used.
Does the method include an objective assessment of uncertainty such as may influence confidence?	No	Usually accompanied by description of assumptions. Weighting is sometimes peer reviewed.

4 STEP 2: DESCRIBE STATUS QUO AND DELINEATE THE STUDY AREA INTO IUAs

Objective: The objective of this step is to define Integrated Units of Analysis (IUAs) and provide a status quo description of each IUA. An IUA is a homogenous catchment or linear section of river based on the similarity of ecological state, system operation, land use, etc. The status quo description therefore provides the information at a broad scale to inform the delineation of the IUAs. Basically, this step provides the baseline for the, National Water Resource Classification System (NWRCS) in the sense that it defines and describes the study area and its components. This step therefore includes the identification of the water resource operation in the study area, the identification of users and socio-economics issues, describing the status quo which represents the current condition of the various components (as illustrated in Figure 4.1), and then, through a process of comparing similar areas, delineate IUAs. The status quo information for the study area is then used to describe the status quo for each IUA.

Integrated Step 2 contains eight sub-steps. Socio Economics fall within sub-step 2.6 and discussed in this Chapter.

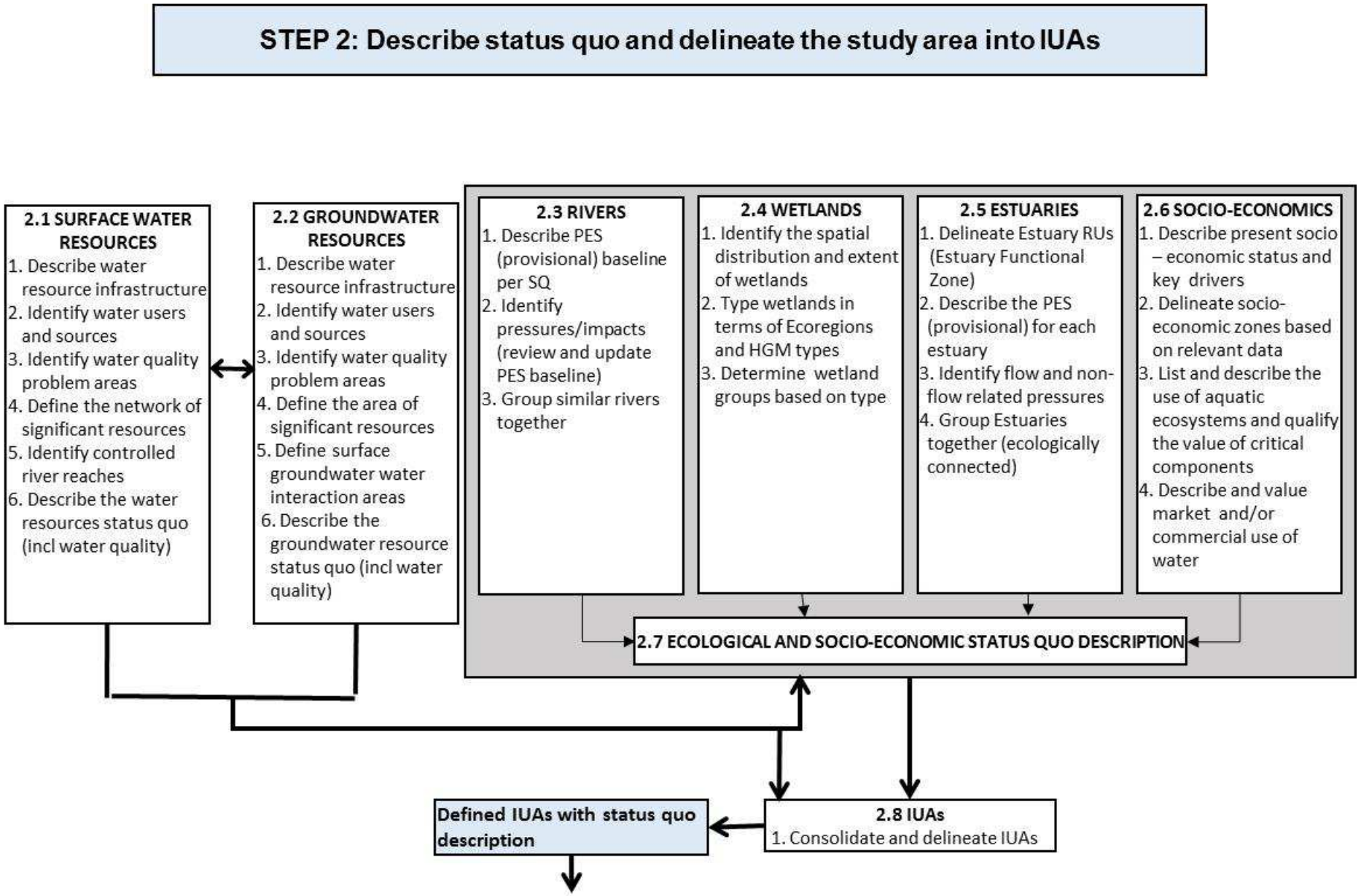

Figure 4.1 Illustration of the sub-steps for Integrated Step 2: Describe status quo and delineate the study area into IUAs

4.1 STEP 2.6 SOCIO-ECONOMICS: ACTIONS

Objective: The information needed to quantify and describe the socio-economic benefits that are derived from utilising the water resources in the study area is collated in this step.

It is advisable to undertake a cursory assessment of the likely alternative water resource management options and scenarios that will have to be evaluated in Integrated Step 4, prior to the collation of the *quantitative* socio economic data. The aim with this "forward-looking" approach is to ensure the data collation activity focusses on what will be relevant for the comparison of scenarios in Integrated Step 4 (It should be noted that in general information on possible options and alternatives are available from previous water resource planning investigations as well as catchment management and bulk water system reconciliation strategies.).

The bullets below describe the actions required.

- **1. Describe the present socio-economic status and key drivers**

This is largely a narrative description based on data available and will concentrate on key drivers in terms of the socio-economic profile.

- **2. Delineate socio-economic zones based on relevant data**

Use the data and description from Action 1 above to define relevant socio-economic zones. This is "high level" and much of the analysis will concentrate on describing settlement type and associated economic parameters. Communities associated with the settlement type and associated economic parameters will be described.

- **3. List and describe the use of aquatic ecosystems and qualify the value of critical components**

This will serve to better contextualise the communities as identified in Action 2 and list the likely ecosystem services that are water related and possibly important. Key components of ecosystem services that are not necessarily immediately bound to adjacent communities but that deliver value, e.g. regulating services, will be identified.

- **4. Describe and value status quo market and/or commercial use of water**

This will be a narrative analysis, supported where necessary with available value, expressed in Rands and cents. It is important that this is not overly detailed and must be restricted to informing and understanding of aspects associated with use of water and likely to be impacted by deviation from the status quo.

4.2 STEP 2.6 SOCIO-ECONOMICS: STANDARDISED INPUT AND OUTPUT

The standardised input and output for each action (if relevant) are provided in Table 4.1.

Table 4.1 Step 2.6: Standardised input and output per action

Action	Input	Comment	Output
1 Describe the present socio-economic status and key drivers	No standardised Input but standardised starting points include Census data, Google Earth, Topographic Mapping, land use activities etc.	Inputs used will depend on the project and on available material. Although there are likely to be common elements in terms of available data cross all parts of South Africa there may be some areas that have had recent focus and value added data over and above national or commonly available inputs could be found. An analysis of potentially available literature should form the cornerstone of the approach for this step	Narrative overview of the catchment and key economic drivers, potential "hotspots" identified
2 Delineate socio-economic zones based on relevant data	Output of analysis of Action 1	Actions 1 and 2 are potentially part of a seamless process and the various potential socio-economic zones are already being demarcated, even if in a preliminary manner, during the process of description of socio-economic status	Narrative description of separate zones based on land use and socio-economic criteria and overview of communities associated with the zones - link to IUAs
3 List and describe the use of aquatic ecosystems and qualify the value of critical components	Outputs of Action 1 and 2. Some fieldwork may be required to verify assumptions concerning potential ecosystem services		Narrative description of expected ecosystems and their importance to communities, disaggregated by socio-economic zones
4 Describe and value status quo market and/or commercial use of water	No standardised input but standardised starting points include known multipliers, values of key sectors from available data, employment numbers (direct and indirect)		Quantitative analysis of value of water by sector expressed as Gross Value Added (GVA)/ Gross Domestic Product (GDP), employment and payment to households. The opportunity costs associated with the negative values attached to the Waste Water Treatment Works (WWTWs) costs be reflected here as well.

4.3 STEP 2.6 SOCIO-ECONOMIC: IDENTIFIED TOOLS AND EVALUATION PER ACTION

No methods are relevant for this step.

5 STEP 3: QUANTIFY BHNR AND EWR

Objective: The objective of this step is to quantify the EWRs for different ecological states and set the Basic Human Needs Reserve (BHNR). These Ecological Water Requirements (EWRs) (Ecological Categories (ECs) and associated flow regime) are essential input into all the next steps and especially for the scenario evaluation. **Once a recommendation is made regarding the Target Ecological Category (TEC), the EWR determined during this step, which supports the TEC and the Class, will become the flow or hydrology RQO.**

During Integrated Step 3 (Figure 5.1), the BHNR and the EWR components that describe the Reserve, once the IUAs have been classified, are determined. EWRs are set at desktop level for the desktop biophysical nodes and at detailed level for the study sites (EWR sites) that are selected during Integrated Step 1. EWRs can be set for a range of ECs.

Note: Reference is made here to the EWR and not to the Ecological Reserve. The reason for this is that the Reserve can only be set once there is a decision on the Target Ecological Category which happens in later steps in the process.

Integrated Step 3 contains four sub-steps. The BHNR component falls within sub-step 3.2 and discussed in this Chapter.

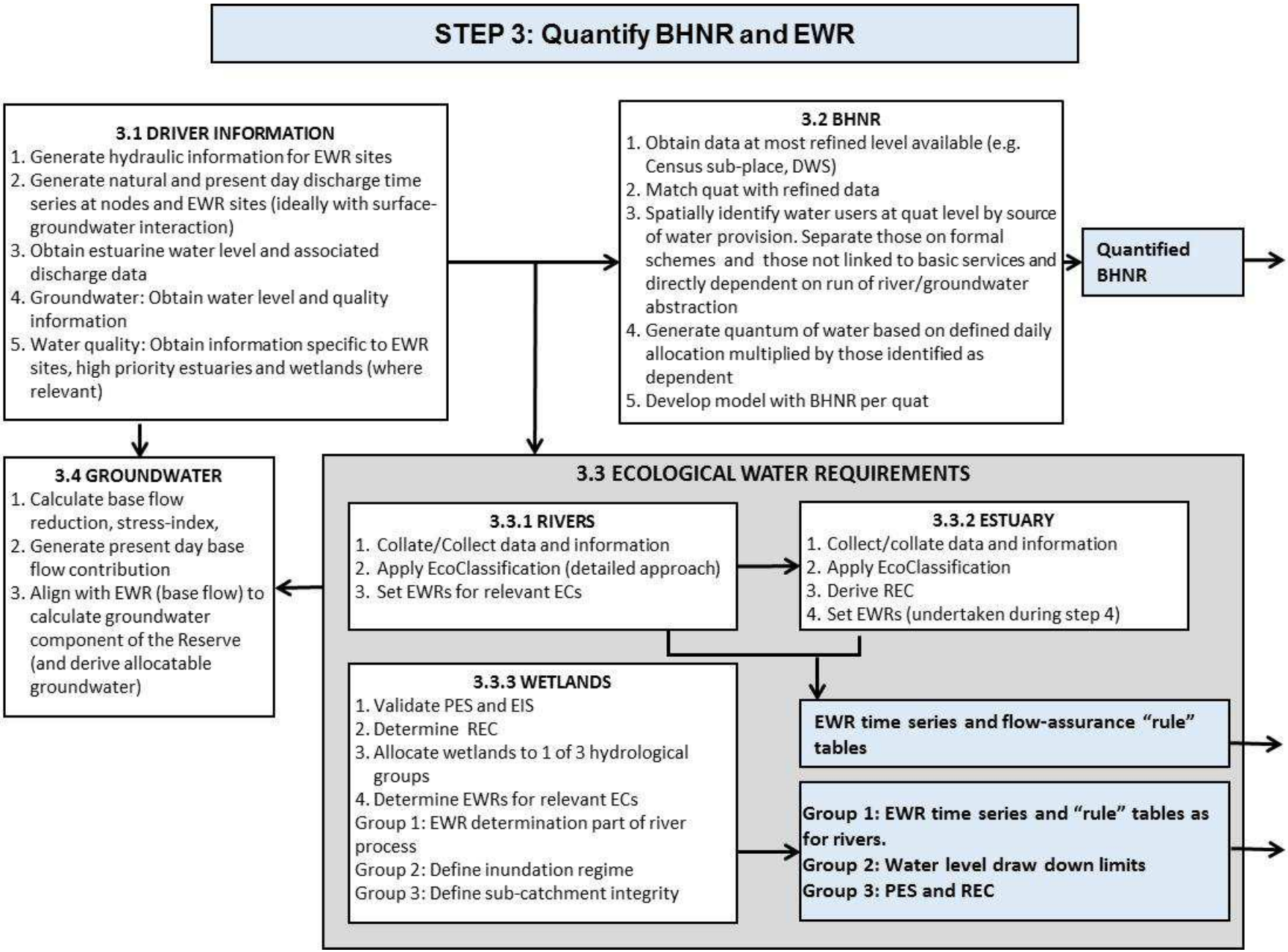

Figure 5.1 Illustration of the sub-steps for Integrated Step 3: Quantify BHNR and EWR

5.1 STEP 3.2: BHNR: ACTIONS

Objective: The objective is to quantify the BHNR from surface and/or groundwater.

The bullets below describe the actions required.

- **1. Obtain data at most refined level available (e.g. Census sub-place, DWS)**

Data is obtained at the most refined level available e.g. Census sub-place and/or recent DWS data for water service schemes, and/or municipal data for quantum of water services delivered people serviced.

- **2. Match quaternary catchment with refined data**

SQs are matched with refined data. Population and water service data is very seldom available at an SQ level. It has to be manipulated, usually via GIS, to populate each SQ and describe level of access to water service.

- **3. Spatially identify water users at quaternary level by source of water provision. Separate those on formal schemes and those not linked to basic services and directly dependent on run of river/groundwater abstraction**

Spatially identify water users at SQ level by source of water provision. Separate those on formal schemes and those not linked to basic services and directly dependant on river/groundwater abstraction. Areas where groundwater may be stressed by abstraction can be identified.

- **4. Generate quantum of water based on defined daily allocation multiplied by those identified as dependent**

A model is set up to generate the quantum of water based on defined daily allocation and multiplied by those identified as dependant.

- **5. Develop model with BHNR per quaternary catchment**

The model with BHNR per SQ is expressed as a report.

The output of the BHNR is a quantified volume usually supplied as litres per day per person.

5.2 STEP 3.2 BHNR: STANDARDISED INPUT AND OUTPUT

The standardised input and output for each action (if relevant) are provided in Table 5.1.

Table 5.1 Step 3.2: Standardised input and output per action

Action	Input	Comment	Output	Comment
1. Obtain data at most refined level available (e.g. Census sub-place, DWS)	SQ data as GIS shape files, Census data	Data needs to be obtained at the most refined level available. This can usually be sourced directly from StatsSA. DWS has some data for a limited number for regions that may be more refined than that available from StatsSA and needs to be determined at the outset of the project. One of the questions that is asked in the national census is category of water supply to the household	The output is a populated catchment/project area with numbers of households and, by extrapolation, individuals as well as their primary source of water supply	The output will still be at the overall level of all areas potentially within the catchment/project area. There will not be a direct synchronicity between the population obtained from StatsSA and the geographical area of interest
2. Match quaternary catchment with refined population data	Data obtained in Action 1 is overlaid into quaternary catchments typically using a GIS package	The population derived from the National Census is matched with quaternary catchment boundaries. Boundaries are typically superimposed upon the smallest aggregations of National Census data available. The exercise can also be performed at the SQ catchment.	Populated quaternary catchments showing numbers of households and individuals within each	
3. Spatially identify water users at quaternary level by source of water provision. Separate those on formal schemes and those not linked to basic services and directly dependent on run of river/groundwater abstraction	The results of Action 2 are matched with the census data that indicates source of household water supply	The population figure may need to be updated based on population changes since the date of the last census. Annual population increases, or decreases, typical of the areas in question need to be applied to update the population figure	Quaternary catchments, or SQ catchments, are populated with the numbers of people not serviced from a formal water supply scheme. Those not serviced can be disaggregated into those that are dependent on ground water through borehole abstraction and those typically directly dependant on surface water	
4. Generate quantum of water based on defined daily allocation multiplied by those identified as dependent	Results of Action 3 that sets out the number of people per catchment unit of analysis likely to be dependant	This sets up the calculation by means of a simple arithmetical model whereby total population is multiplied by a predetermined allocation of water per day	The model expressed in terms of demand for water that can be equated to a BHNR is generated. Various demand parameters express in litres per capita per day can be applied. Typically, 60 litres per person per day is used	Other demand numbers can be used. The World Health Organization typically defines 25 litres per person per day as an absolute minimum
5. Develop model with BHNR per quaternary catchment	Results of Action 4	Figures can be supplied at mega litres per day. This is a simple arithmetical calculation	The output is the Water required per quaternary catchment to satisfy basic human needs	

5.3 STEP 3.2 BHNR: IDENTIFIED TOOLS AND EVALUATION PER ACTION

The evaluation of the GIS Based Analysis tool used in Action 2: Match quaternary catchment with refined data is provided in Table 5.2.

Table 5.2 Step 3.2: Evaluation of GIS Based Analysis tool

Criteria	Evaluation	Explanatory comment
Frequency of use of the application?	High	
Can the tool be applied at a catchment level?	Yes	Tool is GIS based and geographical scale is not a limit.
Is the method described?	No	Described in a number of reports that have been submitted describing how the basic human needs were derived for a particular catchment.
Indicate the status of publication of the method	Not published	
Are there existing training courses?	No formal courses but training has been undertaken for the purposes of explaining the tool.	
Is the method applicable to all levels of assessment (Desktop to Comprehensive)?	Yes	
Time efficient (link to assessment level)	Weeks 1	Tool is easy and time effective to apply by a competent GIS practitioner.
Is the data available to apply the method?	Yes	Data is obtained from StatsSA and GIS shape files for catchments, at all levels of dis-aggregation, are widely available.
Compatibility?	Yes	Data can be used for all applicable steps.
Must software be purchased?	No	Some free open source GIS software is available. Most software used is however acquired via purchase of a license.
Licencing requirements?	No	As above, free software is available but most GIS packages used are licensed.
Enhancement flexibility or adaptability of algorithms?	Open source	
Is the method validated and verified?	Yes	The method has been reviewed and approved for use by DWS.
Descriptions available of mathematical algorithms and model structure?	None	
Is the model robust?	Yes	
Does the method include an objective assessment of uncertainty such as may influence confidence?	Yes	Uncertainty with regard to population numbers or source of water use is qualified by StatsSA in its review and adjustment of the results of National Census.

6 STEP 4: IDENTIFY AND EVALUATE SCENARIOS WITHIN IWRM

Objective: Integrated Step 4 consists of the preliminary identification and description of operational scenarios within IWRM. The objective of this step is to identify scenarios (operational) which are then modelled to provide the output of a model in the formats required to evaluate the scenarios. Note that these scenarios could consist of any changes to the water resource in terms of quantity and quality. As such, it can include groundwater scenarios as well as water quality scenarios (those associated with waste water transfer works) amongst others. These scenarios are then tested with stakeholders and an agreed list of scenarios are finalised for further analyses. The scenarios are modelled (yield and system models) and the outputs are evaluated to determine a range of consequences which is then compared in order to rank the scenarios.

Integrated Step 4 contains seven sub-steps. Ecosystem Services fall within sub-step 4.4 and Economics within sub-step 4.5. Both are discussed in this Chapter.

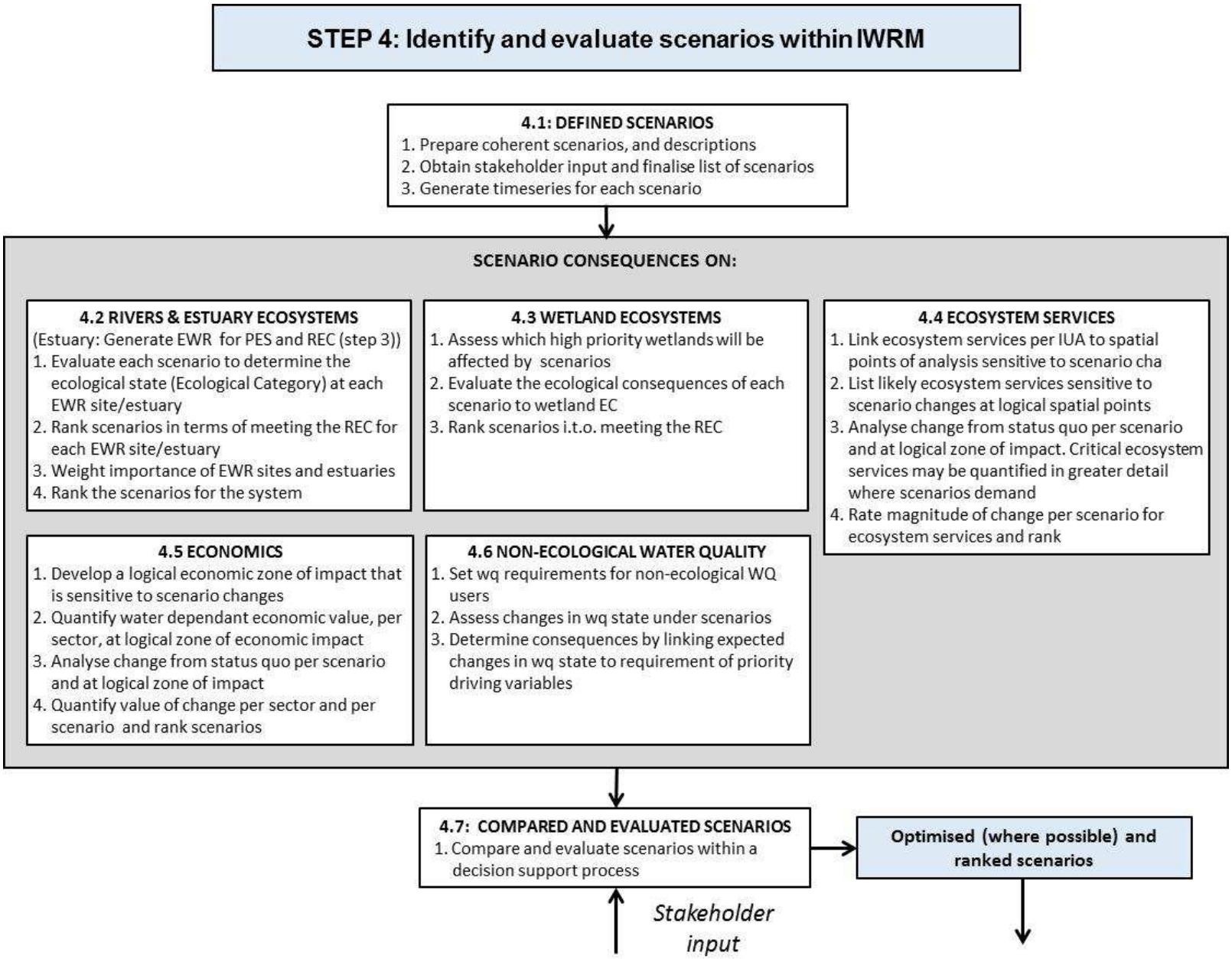

Figure 6.1 Illustration of the sub-steps for Integrated Step 4: Identify and evaluate scenarios within IWRM

6.1 STEP 4.4 ECOSYSTEM SERVICES: ACTIONS

Objective: The evaluation is undertaken to determine the consequences of operational scenarios on the current state of the Ecosystem Services.

The bullets below describe the actions required for each prioritized wetland.

- **1. Link ecosystem services per IUA to spatial points of analysis sensitive to scenario change**

For the ecosystem services spatial points of analysis (as defined by the ecological task and usually linked to EWR sites) and sensitive to scenario changes will be identified. Likely ecosystem services sensitive to scenario changes at logical spatial points are listed.

- **2. List likely ecosystem services sensitive to scenario changes at logical spatial points**

For the ecosystem services this is done at a specialist workshop with the input of qualified experts who are familiar with the project area. The method is followed for river, estuaries and wetlands. Ecosystem services are typically amalgamated into the appropriate service type, e.g. provisioning services and weighted. Critical ecosystem services may be quantified in greater detail where the impact of likely scenarios may demand this.

- **3. Analyse change from status quo per scenario and at logical zone of impact. Critical ecosystem services may be quantified in greater detail where scenarios demand**

For ecosystem services the magnitude of change per scenario will be rated and then the scenarios will be ranked. This is typically done in specialist workshop environment.

- **4. Rate magnitude of change per scenario for ecosystem services and rank**

Scenarios at different spatial points can be examined. Spatial points can be given a relative weight to adjudicate scenario preference.

6.2 STEP 4.4 ECOSYSTEM SERVICES: STANDARDISED INPUT AND OUTPUT

The standardised input and output for each action (if relevant) are provided in Table 6.1.

Table 6.1 Step 4.4: Standardised input and output per action

Action	Input	Comment	Output	Comment
1. Link ecosystem services per IUA to spatial points of analysis sensitive to scenario change	Description of scenarios and analysis of spatial spread of impact relative to ecosystem services		Narrative description of scenarios as they potentially relate to ecosystem services	
2. List likely ecosystem services sensitive to scenario changes at logical spatial points	Understanding of ecosystem services at the geographical locale under consideration and then list of ecosystem services likely to be generating value and linked to output of Action 1 - Scenarios	This may require fieldwork at the sites and interviews with the likely beneficiaries, or those suffering from impacts of dis-services, within the ambit of the identified geographical area. Particular attention should be paid to ecosystem services likely to change under the scenarios that have been mooted	Comprehensive and cohesive list of ecosystem services at points under consideration (EWR sites) with particular attention paid to those likely to change under mooted scenarios	
3. Analyse change from status quo per scenario and at logical zone of impact. Critical ecosystem services may be quantified in greater detail where scenarios demand	List of ecosystem services per output from Action 2. Input from specialists in terms of mooted ecological and associated change under scenarios being proposed	Ecosystem services can be listed in a spreadsheet and categorised in terms of services as defined by the Millennium Ecosystem assessment (provisioning, supporting, regulating, cultural). For some aspects of this analysis a consideration of different species and their potential reaction to change under scenarios can be considered. This is typically done in a specialist workshop with input from ecological specialist to guide an assessment of the types of changes associated with scenarios and reasons for such changes	Populated spreadsheet/table with analysis of changes to key ecosystem services per scenario with narrative description of reasons for change	The output can be in the form of a tool developed as a spreadsheet that lists all ecosystems services that will change under the mooted scenarios. Ecosystem services and their categories can be weighted to reflect importance within the context of the geographical areas under consideration. Ecosystem services can also be costed and the current value (expressed in ZAR) can be derived and then the changed value under mooted scenarios can be used to estimate the magnitude of impact. Various methods can be applied to estimate value
4. Rate magnitude of change per scenario for ecosystem services and rank	Output of 3 and model that lists all scenarios and their magnitude of change relative to one another		Table that summarises the magnitude of change per scenario with narrative summary of reasons for change	Ranked magnitude of change by scenario can be final output. This can be expressed in terms of change for a value representing status quo or in terms of monetary value

6.3 STEP 4.4 ECOSYSTEM SERVICES: IDENTIFIED TOOLS AND EVALUATION PER ACTION

The evaluation of the Ecosystem Services Magnitude of Change per Scenario tool used in Action 3: Analyse change from status quo per scenario and at logical zone of impact is provided in Table 6.2.

Table 6.2 Step 4.4: Evaluation of Ecosystem Services Magnitude of Change per Scenario tool

Criteria	Evaluation	Explanatory comment
Frequency of use of the application?	Medium	
Can the tool be applied at a catchment level?	Yes	
Is the method described?	Yes	Described in various reports that have featured the method and its results.
Indicate the status of publication of the method	None	
Are there existing training courses?	Yes	Training for DWS staff in the application of the tool has taken place in various venues and at various times.
Is the method applicable to all levels of assessment (Desktop to Comprehensive)?	No	The tool requires a specialist workshop to be effective and this is unlikely to be undertaken at desktop level.
Time efficient (link to assessment level)	3 weeks	The tool is applied at a 1 - 2 day workshop but the preparatory work required to populate the tool need a number of week, depending on complexity of the catchment under consideration and number of spatial units of analysis to be applied.
Is the data available to apply the method?	Seldom	Data often needs to be accumulated by a level of primary research but some preliminary data can sometimes be sourced from literature reviews or personal/expert knowledge of the geographical unit of analysis.
Compatibility?	No	This is a final output.
Must software be purchased?	No	Spreadsheet (Excel) can be used.
Licencing requirements?	Simple	Microsoft Office or alternative license.
Enhancement flexibility or adaptability of algorithms?	Open source	
Is the method validated and verified?	No	Described in various reports that have featured the method and its results.
Descriptions available of mathematical algorithms and model structure?	None	
Is the model robust?	Yes	Requires a level of subjective judgment but is undertaken in peer review specialist workshop so there is multi-input oversight.
Does the method include an objective assessment of uncertainty such as may influence confidence?	No	Confidence in data and assessment can be included in narrative and qualified description of results but this cannot be linked to an objective assessment.

6.4 STEP 4.5 ECONOMICS: ACTIONS

Objective: The response of the economic activities that rely on the water resource used in and from the catchments is estimated in this step for each identified scenario. Since the aim with the evaluation of scenarios is to draw comparisons, it is advisable to select appropriate economic parameters for numerical quantification that are relevant to the area and the defined scenarios.

The focus of the economic analyses should be on estimating the relative economic changes (differences) that will be caused by the identified scenarios.

The bullets below describe the actions required.

- **1. Develop a logical economic zone of impact that is sensitive to scenario changes**

For the market/commercial aspect of abstracted water this sub-step will develop a logical economic zone of impact that is sensitive to scenario changes, but which is complimenting the identified IUAs. The sub-step will also quantify water dependant economic value, per sector, at logical zone of economic impact.

- **2. Quantify water dependant economic value, per sector, at logical zone of economic impact**

This sub-step will analyse change from status quo per scenario and at logical zone of impact. For the market/commercial aspect of abstracted water this is typically expressed as change from status quo in terms of Gross Value Added (GVA) and employment.

- **3. Analyse change from status quo per scenario and at logical zone of impact**

This sub-step will quantify the value of change per economic sector and per scenario and rank scenarios.

- **4. Quantify value of change per sector and per scenario and rank scenarios**

Scenarios at different spatial points can be examined. Spatial points can be given a relative weight to adjudicate scenario preference.

6.5 STEP 4.5 ECONOMICS: STANDARDISED INPUT AND OUTPUT

The standardised input and output for each action (if relevant) are provided in Table 6.3.

Table 6.3 Step 4.5: Standardised input and output per action

Action	Input	Comment	Output
1 Develop a logical economic zone of impact that is sensitive to scenario changes	Align zones to potential identified impacts and complimenting the IUAs		Zone of economic input that is sensitive to change under possible scenarios
2. Quantify water dependant economic value, per sector, at logical zone of economic impact	Data to populate a developed econometric model	The econometric model is based on the relevant provincial Social Accounting Matrix available from the Development Bank (DBSA)	Quantified GVA value and employment per economic sector and per component of sector per zone
3. Analyse change from status quo per scenario and at logical zone of impact	Scenario impact	Econometric model based on the Social Accounting Matrix.	Analysis of impact model expressed as a change in GVA and employment
4. Quantify value of change per sector and per scenario and rank scenarios	Output of Actions 1 - 3	Application of the econometric model	Quantified impact of scenarios per zone as output of macro-economic impact mode.

6.6 STEP 4.4 ECONOMICS: IDENTIFIED TOOLS AND EVALUATION PER ACTION

The evaluation of the Social Accounting Matrix based Econometric Impact tool is provided in Table 6.4. This tool is used in:

- Action 2: Quantify water dependant economic value, per sector, at logical zone of economic impact.
- Action 3: Analyse change from status quo per scenario and at logical zone of impact.

Table 6.4 Step 4.5: Evaluation of Social Accounting Matrix based Econometric Impact tool

Criteria	Evaluation	Explanatory comment	Additional Comment
Frequency of use of the application?	High	Multiplier model/tool based, number of variations on a theme.	
Can the tool be applied at a catchment level?	Yes	Where there are multiple provinces within a catchment it becomes more complex but not a fatal flaw.	
Is the method described?	No	Not described but commonly used.	
Indicate the status of publication of the method	2 None	Not published as a scientific paper but described in a number of project reports.	
Are there existing training courses?	Yes	Generic courses offered by consultancies that use the model are offered.	
Is the method applicable to all levels of assessment (Desktop to Comprehensive)?	Yes	Can be used but unlikely to be used at Desktop - large capital projects with feasibility analysis would include the use of a more complex econometric model.	In a large capital project more detailed information is required such as impacts on balance of payments and new capital formation which requires a more sophisticated model.
Time efficient (link to assessment level)	4 weeks		
Is the data available to apply the method?	Usually	Specialist knowledge is required as there is a need to know where to look for the data.	
Compatibility?			
Must software be purchased?	No		
Licencing requirements?	Open source		
Enhancement flexibility or adaptability of algorithms?	NA		
Is the method validated and verified?	No	It is regularly used and is deemed to be valid although independent verification has not occurred.	
Descriptions available of mathematical algorithms and model structure?	Conceptual description	Conceptual description is available from DBSA.	The Social Accounting Matrix model is available from the DBSA from which the multipliers are sourced for the specific econometric model.
Is the model robust?	Yes	Can be regularly updated as part of individual projects.	
Does the method include an objective assessment of uncertainty such as may influence confidence?	No	Reasonable confidence can be attached but objective assessment requirement not intrinsic to validity of the model.	

7 CONCLUSIONS

Tools for the socio-economic aspects of RDM operationalisation are available and used in a manner that is generally consistent with the level of effort required and the individual team members understanding of the resource areas or catchment in question.

For **Integrated Step 1** (Delineate and Prioritise Resource Units) there are no generally applicable tools but a Socio-Cultural Tool for comparative analysis of areas to determine comparative importance within the study area has been developed. Limited fieldwork may be undertaken to confirm assumptions. In some cases, more extensive fieldwork may be undertaken if the budget allows for this activity and if there is an identified requirement for more detailed and higher confidence analysis.

For **Integrated Step 2** (Description of the present socio-economic status and key drivers) a tool is not universally used but inputs are generally standardised. The inputs used will largely depend on the project and on available material. Although there are likely to be common elements in terms of available data across all parts of South Africa there may be some areas that have had recent focus and value added data over and above national or commonly available inputs could be found.

For **Integrated Step 3** (BHNR) an approach has been developed by the DWS and this is generally used. The approach is a simple mathematical model based on population present in the area and level of service delivery. Data needs to be obtained at the most refined level available. This can usually be sourced directly from StatsSA. DWS has some data for a limited number for regions that may be more refined than that available from StatsSA and needs to be determined at the outset of the project.

For **Integrated Step 4** (Identify and Evaluate Scenarios within IWRM) a range of tools are available. For Ecosystem Services these can be listed in a spreadsheet and categorised in terms of services as defined by the Millennium Ecosystem assessment (provisioning, supporting, regulating, cultural). For some aspects of this analysis a consideration of different species and their potential reaction to change under scenarios can be considered. This is typically done in a specialist workshop with input from ecological specialist to guide an assessment of the types of changes associated with scenarios and reasons for such changes. For economic analysis an econometric model is available and this is based on the relevant provincial Social Accounting Matrix available from the DBSA.

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9 APPENDIX A: REPORT COMMENTS REGISTER

Page Number	Chapter /Section /Step	Comment	Addressed in report?	Comment/explanation
Page 3.1	Table 3.1	In addition the umbrella starting point will be the Land-use activities within the area.	Yes	
Page 3.2	Table 3.1	Fieldwork is a must even at this early stage, as it gives the opportunity to identify and verify new activities on the ground. I suggest it reads: “fieldwork is required”	Yes	Field work is not necessary a must at this level of study. The comment now reads that some fieldwork is required.
	Table 4.1	This sounds like economic zones are separate from IUAs. Economic zones are part of the IUAs.	Yes	