water and sanitation

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Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments

RIVER EWR FOR DESKTOP BIOPHYSICAL NODES REPORT

FINAL
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Department of Water and Sanitation
Chief Directorate: Water Ecosystem Management

PROJECT NUMBER**:** WP 11387

River EWR for Desktop Biophysical Nodes Report

CLASSIFICATION OF SIGNIFICANT WATER RESOURCES AND DETERMINATION OF RESOURCE QUALITY OBJECTIVES FOR WATER RESOURCES IN THE USUTU TO MHLATHUZE CATCHMENTS

July 2022

REFERENCE
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	WEM/WMA3/4/00/CON/CLA/0123, volume 2	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 2: Estuaries**
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Shaded Grey indicates this report.

APPROVAL

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EXECUTIVE SUMMARY

BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in the Government Gazette no. 33541 as of Regulation 810. The WRCS is a step-wise process, whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account, the current state of the water resource, the ecological, social, and economic aspects that are dependent on the resource. Once significant water resources have been classified through the WRCS, Resource Quality Objectives (RQOs) have to be determined to give effect to the class.

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS), initiated a study to determine the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation, and contain a number of protected areas such as natural heritage sites, cultural and historic sites, as well as other conservation areas that need protection.

STUDY AREA

The study area is the Usutu to Mhlathuze Catchment, which has been divided into six drainage areas, as well as secondary catchment areas:

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay and Lake Sibaya).

PURPOSE OF THIS REPORT

The purpose of this report is to document the results of a component of Task 3: Quantify Basic Human Needs (BHN) and Ecological Water Requirements (EWR). The component represented in this report is the determination of EWRs at those biophysical nodes for which a desktop estimation model will be used.

RESOURCE UNITS: ECOCLASSIFICATION

EcoClassification consists of three basic steps as follows (Kleynhans and Louw, 2007):

- Determination of Present Ecological State (PES) (DWS, 2022).
- Determination of Ecological Importance and Sensitivity (EIS) (DWS, 2022).
- Deriving the Recommended Ecological Category (REC).

Biophysical nodes for which EWR assessments must be undertaken have been selected and are summarised in the table below.

Biophysical nodes per secondary catchment

Secondary catchment	Number of Integrated Unit of Analysis (IUAs)	Number of nodes representing Resource Units	Desktop EWR	Existing EWR sites as key nodes	Extrapolated from EWR sites
W1	7 (W11, W12-a, W12-b, W12-c, W12-d, W12-e, W13)	12	9	3	0
W2	3 (W21, W22, W23)	15	7	4	4
W3	4 (W31-a, W31-b, W32-a, W32-b)	12	8	1	3
W4	5 (W41, W42-a, W42-b, W44, W45)	9	7	1	1
W5	4 (W51, W52, W55, W57)	13	11	1	1
W7	2 (W70-a, W70b)	0	0	0	0
W2&W3	1 (IUA St Lucia)	0	0	0	0
TOTAL	**26**	**61**	**42**	**10**	**9**

For the 42 nodes requiring a desktop assessment of the EWR, the PES and EIS are used to derive the REC according to established rules. Information based on the sources and causes of the problems (whether flow-related or non-flow related) are utilised to derive the Ecological Category for which a desktop model will be applied to estimate the EWRs.

Eighteen of the 42 nodes require the PES to be improved (i.e. the REC is a higher Ecological Category than the PES) based on a High or Very High importance. Of these 18 nodes, seven nodes require this improvement to be achieved by improvement in flow. This may be a partial improvement (i.e. a half Ecological Category improvement where the other half is achieved by mitigating non-flow related activities) or a full category improvement.

RESOURCE UNITS DESKTOP EWR ESTIMATION AND RESULTS

The estimation of EWRs in this study applies Version 2 of the Revised Desktop Reserve Model (RDRMv2). The RDRM is a Desktop application of the Habitat-Flow Stressor-Response Ecological Water Requirement Methodology. The RDRM explicitly includes the links and relationships between hydrology, hydraulics and hydraulic-habitat, and ecological response. The RDRMv2 runs within the Spatial and Time Series Information Modelling (SPATSIM) software.

The EWR results are provided (as part of e-data provided as a deliverable for this study) in the following formats as text files named according to the biophysical node:

- RDRMv2 generated reports.
- Assurance rules for EWR low flows and total flows (in 10^6 m^3).
- Time-series of monthly EWR low and total flows (in 10^6 m^3)[1].

Generally, the ranges of recommended EWRs expressed as percentages of the Naturalised Mean Annual Runoffs (MARs) range from, for B, B/C, C and D ECs: 30.2 to 46.0, 38.7 to 49.9, 29.6 to 46.1, and 29.7 to 33.1. While there is a general overall reduction in proportion of MAR with

[1] Note, total flow time-series are not constrained to PD for any of the biophysical nodes, whereas Flow Duration Curves (FDCs) are.

reducing EC, there is no clear / simple relationship, since EWRs are also a function of the links/relationships between *inter alia* hydrological, hydraulic, and ecological characteristics as well as Present Day (PD) flows (when constrained), which vary for the different biophysical nodes. The RDRMv2 is developed to explicitly account for these links/relationships at the Desktop level of assessment.

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TERMINOLOGY AND ACRONYMS

BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
DEM	Digital Elevation Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirement
FDC	Flow-Duration Curve
GIS	Geographical Information System
IUA	Integrated Unit of Analysis
MAR	Mean Annual Runoff
Nat	Natural
NWA	National Water Act
PD	Present Day
PES	Present Ecological State
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
RU	Resource Unit
SPATSIM	Spatial and Time Series Information Modelling
SQ	Sub-quaternary
SQR	Sub-quaternary reach
SRTM	Shuttle Remote Topography Mission
WQ	Water Quality
WRCS	Water Resource Classification System

SPELLING

There are multiple references to the spelling of various Rivers, Lakes, Dams and Estuaries, depending on the source of information. For the purposes of this report, the following Table presents the selected spelling of indicated water resources and places.

Selected Spelling for this Study	Alternate spellings
Usutu River	Usuthu River
Mhlathuze River	Mhlatuze, uMhlatuze River
Pongola (river, Town & Pongolapoort Dam)	Phongola, Phongolo
Lake Sibaya	Lake Sibiya, Lake Sibhayi, Lake Sibhaya
Eswatini	eSwatini
Umfolozi River	Mfolozi River
Amatigulu River	Amatikulu, Matigulu River
Goedertrouw Dam	Lake Phobane
Mfuli River	Mefule River
aMatigulu/iNyoni Estuary	
Sibiya Estuary	
Mlalazi Estuary	
uMhlathuze /Richards Bay Estuary	
iNhlabane Estuary	
uMfolozi/uMsunduze Estuary	
St Lucia Estuary	
uMgobezeleni Estuary	
Kosi Estuary	
Hluhluwe Game Reserve	
iMfolozi Game Reserve	
Ithala Game Reserve	
Ndumo Game Reserve	
Tembe Elephant Reserve	
iSimangaliso Wetland Park	
Kosi Bay and Coastal Forest Area	
uMkhuze Game Reserve	

Note:

The spelling of the Rivers, Lakes, Dams and Estuaries provided in the DWS PESEIS (https://www.dws.gov.za/iwqs/rhp/eco/PESEIS_secondary.aspx) database will not be changed based on the above when used in presentation of database tables and results from the database.

GLOSSARY

Basic Human Needs	Water needs to be set aside for basic human needs such as drinking, food preparation, and health and hygiene purposes. This is referred to as the Basic Human Needs Reserve (BHNR).
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.
Integrated Unit of Analysis (IUAs)	An IUA is a homogeneous area that can be managed as an entity. It is the basic unit of assessment for the Classification of water resources, and is defined by areas that can be managed together in terms of water resource operations, quality, socio-economics and ecosystem services.
Resource Quality Objectives (RQOs)	RQOs are numeric or descriptive goals or objectives that can be monitored for compliance to the Water Resource Classification, for each part of each water resource. “The purpose of setting RQOs is to establish clear goals relating to the quality of the relevant water resources” (NWA, 1998).
Sub-quaternary reaches (SQR)	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary reach or quinary level.
Target Ecological Category (TEC)	This is the ecological category toward which a water resource will be managed once the Classification process has been completed and the Reserve has been finalised. The draft TECs are therefore related to the draft Classes and selected scenario.
Water Resource Class	The Water Resource Class (hereafter referred to as Class) is representative of those attributes that the DWS (as the custodian) and society require of different water resources. The decision-making toward a Class requires a wide range of trade-offs to be assessed and evaluated at a number of scales. Final outcome of the process is a set of desired characteristics for use and ecological condition of the water resources in a given catchment. The WRCS defines three management classes, Class I, II, and III, based on extent of use and alteration of ecological condition from the predevelopment condition.

1 INTRODUCTION

1.1 BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in Government Gazette 33541 as Regulation 810. The WRCS is a stepwise process whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account the current state of the water resource, the ecological, social and economic aspects that are dependent on the resource. Once significant water resources have been classified through the WRCS, Resource Quality Objectives (RQOs) must be determined to give effect to the class. The implementation of the WRCS therefore assesses the costs and benefits associated with utilisation versus protection of a water resource. Section 13 of the NWA requires that Water Resource Classes and RQOs be determined for all significant water resources.

Thus, the Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) initiated a study for determining the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation and contain a number of protected areas, natural heritage sites, cultural and historic sites as well as other conservation areas that need protection. There are five RAMSAR[2] sites within the catchment, which includes the world heritage site, St Lucia. The others are Sibaya, Kosi Bay, Ndumo Game Reserve and Turtle Beaches.

1.2 STUDY AREA

The study area is the Usutu to Mhlathuze Catchment that has been divided into six drainage areas and secondary catchment areas as follows (refer to the locality map provided as **Figure 1.1**):

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay estuary and Lake Sibaya).

Note that all assessments within Eswatini are excluded apart from the hydrological modelling required to assess any downstream rivers in South Africa that either run through Eswatini or originate (source) in Eswatini.

[2] A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention, also known as "The Convention on Wetlands", an intergovernmental environmental treaty established in 1971 by UNESCO in the Iranian city of Ramsar, which came into force in 1975.

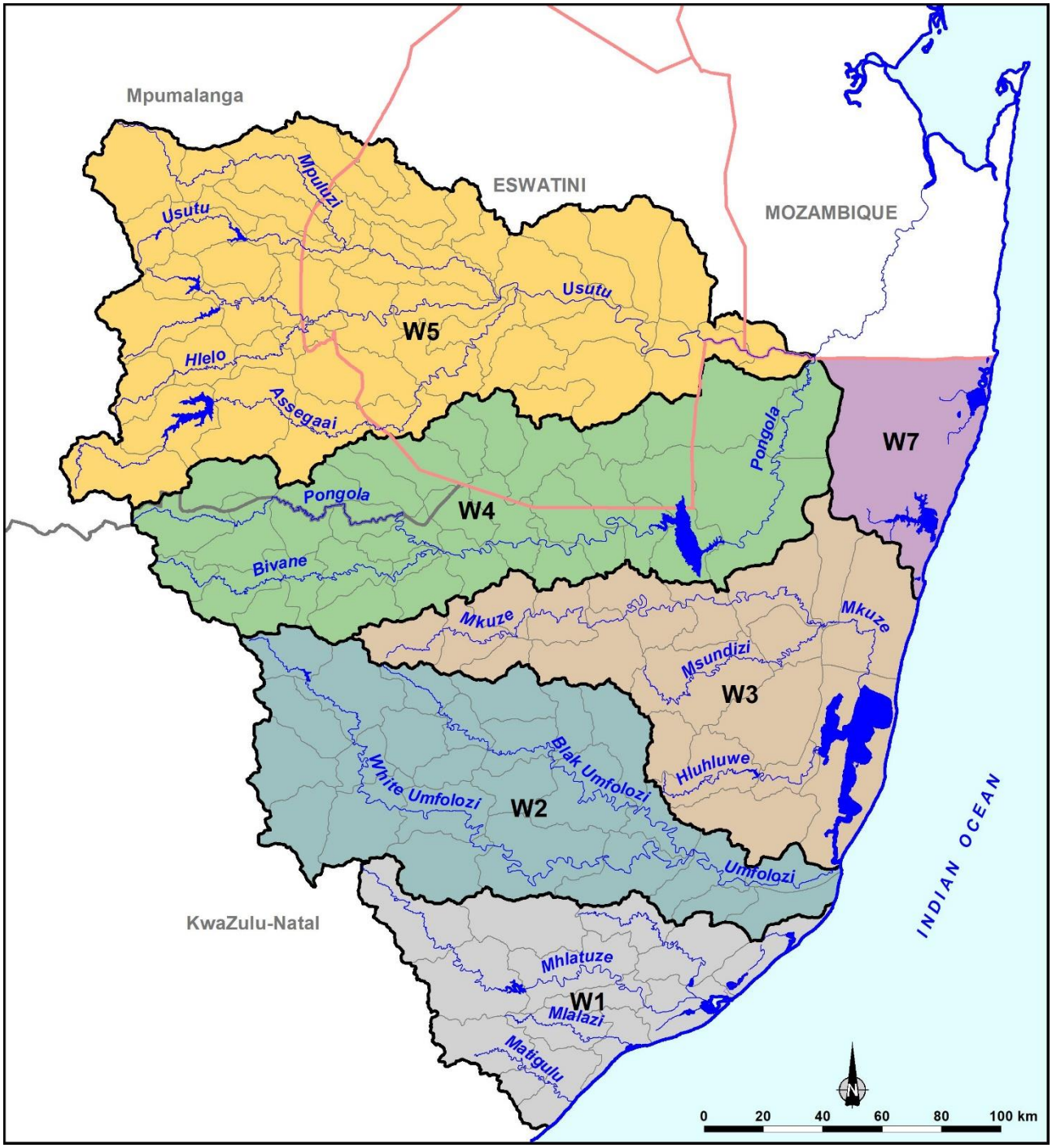

Figure 1.1 Locality Map of the Study Area

1.3 RESOURCE UNITS AND DESKTOP BIOPHYSICAL NODES

Resource Units (RUs) are described in the Status Quo Report for this study (DWS, 2022a). Each of the RUs is represented by biophysical nodes which are either desktop nodes, or EWR sites (**Figure 1.2**). This report focusses on the desktop nodes for which EWRs are estimated through a desktop model.

Figure 1.2 Desktop biophysical nodes and EWR sites

1.4 EWR ASSESSMENT FOR THE DESKTOP BIOPHYSICAL NODES

This report documents the quantification of the Ecological Water Requirements (EWRs) at the desktop biophysical nodes, i.e. sites requiring desktop EWR estimates. There are 82 biophysical nodes in the study area and an EWR is required at most of these nodes. Due to the large size of the study area and therefore large number of nodes, all EWRs cannot be determined at a detailed level. A prioritisation process (DWS, 2022b) was followed to identify those nodes or rivers requiring detailed assessments. Prioritisation also provided information regarding the level at which other nodes should be addressed. The biophysical nodes and type of EWR assessments that need to be undertaken at the nodes are provided in **Table 1.1**.

Table 1.1 Biophysical nodes and levels of EWR assessment per RU

RU number	RU Priority	Desktop Node & EWR sites	EWR level at node	Comment where applicable
W1 Secondary Catchment (Main River: Mhlathuze)				
W11-1	2	11-1	Desktop	
W11-2	2	EWR MA1	Detailed	Although a detailed level is not required, this site will be maintained as it could be important for estuary EWR assessment.
W12-1	2	EWR site 5 Upper Mhlathuze	Desktop with hydraulics	
W12-2	2	12-2	Desktop	
W12-3	4	12-3	Desktop	Combination of Desktop assessment and extrapolation from EWR site 5 which will result in higher confidence assessment than Rapid.
W12-4	2	12-4	Desktop	
W12-5	2	EWR8LowerMfule	Desktop with hydraulics	
W12-6	4	EWR3	Use existing gazetted results	As part of compulsory licensing, a total volume for EWRs have been gazetted (DWS, 2015) based on a detailed historical assessment.
W12-7	2	12-7	Desktop	
W12-8	4	EWR NS1 (EWR6LowerNseleni)	Detailed	Existing EWR site (to be reviewed) used during two previous EWR assessments.
W13-1	2	13-1	Desktop	
W13-2	2	13-2	Desktop	
W2 Secondary Catchment (Main River: Umfolozi)				
W21-1	3	21-1	Desktop	
W21-2	3	21-2	Desktop	
W21-3	2	21-3	Desktop	
W21-4	2	21-4	Desktop	
W21-5	4	EWR WM1	Detailed	Existing EWR site which will be reviewed.
W21-6	2	21-6	Extrap EWR BM?	Site appropriate for extrapolation to be determined later
W21-7	2	21-7	Extrap EWR BM?	
W21-8	2	21-8	Extrap EWR BM?	
W22-1	3	EWR BM1	Detailed	All three sites in the Black Mfolozi have low confidence for low flow hydraulics. This is not an area of very high priority the necessity of reviewing all three sites will be reviewed during the EWR assessment stage.
W22-2	2	EWR BM2	Detailed	
W22-3	2	22-3	Desktop	
W22-4	2	MB EWR	Detailed	See W22-2.
W22-5	3	22-5	Extrap EWR MB	Will be an improved EWR catering for the High priority.
W23-1	3	23-1	Desktop	
W23-2	2	23-2	Desktop	
W23-3	3	Estuary	n/a for rivers	
W3 Secondary Catchment (Main River: Mkuze)				
W31-1	3	31-1	Desktop	
W31-2	3	31-2	Desktop	

RU number	RU Priority	Desktop Node & EWR sites	EWR level at node	Comment where applicable
W31-3	4	31-3	Extrap from EWR MK 1	Very High priority dealt with detailed assessment in W31-4.
W31-4	4	EWR MK1	Detailed	Existing EWR site which will be reviewed.
W31-5	3	31-5	Extrap from EWR MK 1	
W31-6	4	31-6	Desktop	
W32_1	4	32-1	Extrap from EWR MK 1	Very High priority dealt with detailed assessment in W31-4.
W32-2	3	32-2	Desktop	
W32-3	3	32-3	Desktop	
W32-4	2	32-4	Desktop	
W32-5	3	32-5	Desktop	
W32-6	4	32-6	Desktop	Very High priority based on groundwater assessment (contribution to base flow) and does not require a detailed EWR assessment.
W32-7		Estuary	n/a for rivers	
W4 Secondary Catchment (Main River: Pongola - excluding Eswatini)				
W41-1	3	41-1	Desktop	
W41-2	3	41-2	Desktop	
W41-3	2	Estuary	n/a for rivers	
W42-1	3	42-1	Desktop	
W42-2	2	EWR UP1	Comprehensive	EWR assessment will be reviewed, and it caters for the High priority downstream.
W42-3	3	42-3	Extrap from EWR UP1	
W42-4	3	42-4	Desktop	
42-5	3	42-5	Desktop	
W43-1	3	43-1	Desktop	
W44-1	3	44-1	Desktop	
W45-1	4	Extrap from Floodplain requirements	n/a for rivers	
W5 Secondary Catchment (Main River: Usutu - excluding Eswatini)				
W51-1	2	51-1	Desktop	
W51-2	4	51-2	Extrap from EWR AS1	
W51-3	4	EWR AS1	Comprehensive	Existing EWR site (to be reviewed) used during two previous EWR assessments.
W51-4	3	51-4	Desktop	
W52-1	3	52-1	Desktop	
W53-1	3	53-1	Desktop	
W53-2	4	53-2	Desktop	No EWR site. If possible, field information for improved desktop assessment will be obtained for more detailed (than desktop) assessment.
W53-3	2	53-3	Desktop	
W54-1	4	54-1	Desktop	See W53-3.
W54-2	2	54-2	Desktop	
W55-1	3	55-1	Desktop	See W53-3.
W55-2	2	EWR Lush	Desktop with hydraulics	
W57-1	4	57-1	Desktop	Meeting EWRs will be dependent on it being provided and managed from Eswatini as this is the Usuthu River downstream of Eswatini. Until these processes have been established, a more detailed EWR is not required.
W7 Secondary Catchment (Kosi Bay and Sibaya Lake)				
W70-1	**4**	70-1	Kosi Lake requirements	
W70-2	**4**	70-2	Kosi Lake requirements	
W70-3	**3**	70-3	Sibaya Lake requirements	

A summary of the nodes per secondary catchment are provided in **Table 1.2**.

Table 1.2 Biophysical nodes per secondary catchment

Secondary catchment	Number of Integrated Unit of Analysis (IUAs)	Number of nodes representing RUs	Desktop EWR	Existing EWR sites as key nodes	Extrapolated from EWR sites
W1	7 (W11, W12-a, W12-b, W12-c, W12-d, W12-e, W13)	12	9	3	0
W2	3 (W21, W22, W23)	15	7	4	4
W3	4 (W31-a, W31-b, W32-a, W32-b)	12	8	1	3
W4	5 (W41, W42-a, W42-b, W44, W45)	9	7	1	1
W5	4 (W51, W52, W55, W57)	13	11	1	1
W7	2 (W70-a, W70b)	0	0	0	0
W2&W3	1 (IUA St Lucia)	0	0	0	0
TOTAL	**26**	**61**	**42**	**10**	**9**

The results of the desktop EWR assessments at 42 desktop biophysical nodes are provided in this report.

The Present Ecological State (PES) for the nodes is available as documented in DWS (2022a).

1.5 PURPOSE OF THIS REPORT

The purpose of this report is to document the results of a component of Task 3: Quantify Basic Human Needs (BHN) and EWR. The component represented in this report is the determination of EWRs at those biophysical nodes for which a desktop estimation model will be used. **Figure 1.3** provides the project plan for this study and illustrates where Task 3 fits within the project plan.

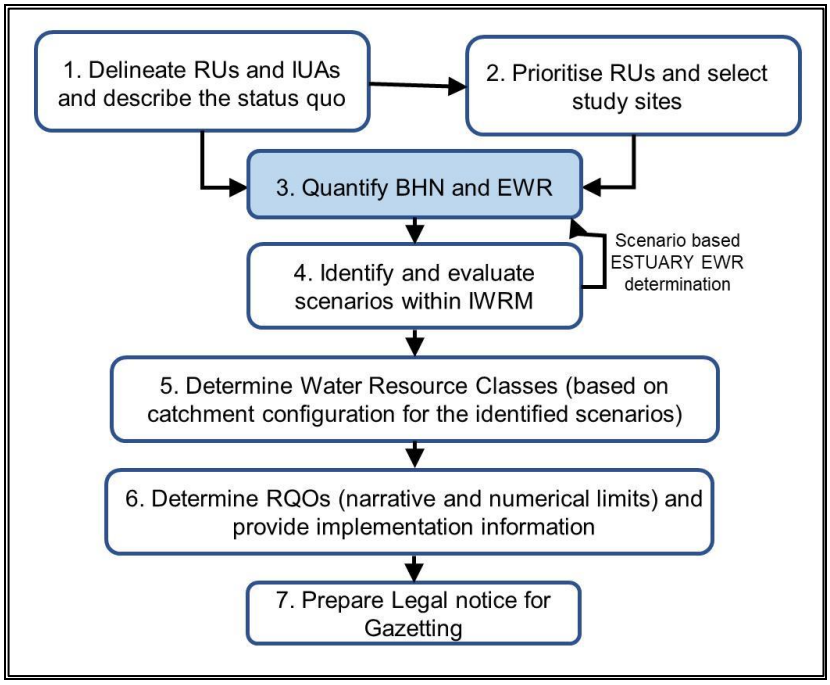

Figure 1.3 Project Plan for the Usutu-Mhlathuze Classification study

1.6 REPORT OUTLINE

The report outline is as follows:

- **Chapter 1** provides general background information on the study area and the Project Plan.
- **Chapter 2** provides the EcoClassification results for the Desktop Biophysical nodes.
- **Chapter 3** summarises the results of the EWR assessments using the Revised Desktop Reserve Model.
- **Chapter 4** provides the references.

2 RESOURCE UNITS: ECOCLASSIFICATION

2.1 DESKTOP ECOCLASSIFICATION APPROACH

EcoClassification consists of three basic steps as follows (Kleynhans and Louw, 2007):

- Determination of Present Ecological State (PES) (DWS, 2022a).
- Determination of Ecological Importance and Sensitivity (EIS) (DWS, 2022a).
- Deriving the Recommended Ecological Category (REC).

The Recommended Ecological Category (REC) is a recommendation from an ecological viewpoint which is considered within the decision-making process toward defining the Classes. The REC recommendation is based on either maintenance of the PES or an improvement thereof. Improvements are only considered if the EIS is HIGH or VERY HIGH. The PES is maintained if the EIS is LOW or MODERATE. The guidelines to derive the REC are based on the level of the PES and the EIS as indicated in **Table 2.1** (DWS, 2014a). Note, that in all cases the restoration potential and practicalities of ecological attainability of recommendations that require improvements, are considered.

Table 2.1 Guideline for setting RECs

PES	EIS	REC	Comment
A, A/B, B	High or Very High	A, A/B, B	The PES will be maintained as it is already in a good condition that will support the high EIS.
B/C	High or Very High	B	As this condition is close to a B, marginal improvement may be required as a B is sufficient to support the high EIS.
C	High or Very High	B	Attempts should be made to improve by a Category.
C/D	High or Very High	B/C	Attempts should be made to improve by a Category.
D	High or Very High	C	Attempts should be made to improve by a Category.
D/E, E, E/F, F	n/a	D	Any Category below a D should (if restoration potential still exists) be improved to at least a D to ensure a minimum level of sustainability. This is irrespective of the EIS. It is unlikely though that it would be practical to improve an F river to a D without considerable investment, effort and possibly physical rehabilitation of the river.

2.2 DESKTOP ECOCLASSIFICATION RESULTS FOR USE IN THE DESKTOP MODEL

During the review of the 2014 PESEIS results (DWS, 2014b) and provided in DWS (2022a), a master spreadsheet was developed that includes all the information required to derive the REC based on the guidelines presented in **Table 2.1**. The following steps were followed to determine the REC – all steps are documented in the spreadsheet, which is available as part of electronic information, i.e. e-data, for this study. It must be noted that this process forms part of the desktop level of EcoClassification (Kleynhans and Louw, 2007) and therefore the restoration capability could only be determined based on desktop level of information provided:

- Determine the PES and provide an Ecological Category (EC) for the EcoStatus.
- Provide the reasons for the PES. Focus on whether the issues are flow, non-flow, or water quality related. Flow related implies that the direct source and causes of the problem are in flow changes (e.g., decreased flow due to pumping for irrigation) or non-flow related (e.g., presence of alien vegetation).

- Determine the Ecological Importance and Sensitivity (EIS). The results are in Prioritisation report (DWS, 2022b).
- Derive the REC following the rules as provided in **Table 2.1**.
- Based on the primary drivers as well as more detailed information on the causes and sources provided in the Status Quo Report (DWS, 2022a), provide an indication whether the improvement is attainable (based on the restoration capability and effort).
- Provide the EC relevant for the desktop model output. The argument followed is that if flow is required to improve the PES to the REC, then the desktop model will be run for the REC. If improvement in flow is not required, i.e., the problems are non-flow related, then the desktop model will be run for the PES as no increased flows are required.

Table 2.2 summarises the results for the desktop biophysical nodes and forms the basis for the EWR estimation (see **Chapter 3**).

The description of the columns is as follows:

- Column 1: RU number.
- Column 2: Main river name.
- Column 3: PES according to the review of the PESEIS study results (DWS, 2022a).
- Column 4: EIS according to DWS (2022a).
- Column 5: Improve. Based on the rules provided in **Table 2.1**, an indication is provided of whether improvement is required.
- Column 6: REC. Based on the rules provided in **Table 2.1**, the REC is provided. This REC does not consider restoration potential or feasibility.
- Column 7: Primary driver. Based on the information in DWS (2022a), a summary is made on whether the causes and sources are flow- or non-flow-related measures. Non-flow related measures include water quality aspects.
- Column 8: Improvement attainable? Comments provided to indicate what would be required to improve the REC and whether it is attainable as well as information on whether the actions required would need flow- or non-flow-related measures.
- Column 9 EC for desktop model output: Considering all the information on the role that an improved flow regime would play in achieving the REC, the ECs for which the RDRM was run is provided.

Table 2.2 REC for the desktop biophysical nodes

RU no	Main river name	PES RU EC	EIS RU	Improve ?	REC	Primary driver	Improvement attainable?	EC for RDRM output
W1 (Mhlathuze)								
W11-1	Matigulu	**B**	High	No	**B**		n/a	**B**
W12-1	Mhlathuze	**B**	High	No	**B**		n/a	**B**
W12-2	Mhlathuze	**B**	High	No	**B**		n/a	**B**
W12-3	Mhlatuze	**C**	High	Yes	**B**	Flow, WQ, Non-flow.	Difficult	**C**
W12-4	KwaMazula	**C**	High	Yes	**B**	Flow, Non-flow.	Flow only by removing forestry in riparian. Rest of category will be achieved by non-flow mitigation.	**B/C**
W12-5	Mfule	**C**	High	Yes	**B**	Flow, Non-flow.	Difficult - mitigation will have to focus on non-flow aspects.	**C**
W12-7	Mhlatuzana	**B**	High	No	**B**		n/a	**B**

RU no	Main river name	PES RU EC	EIS RU	Improve ?	REC	Primary driver	Improvement attainable?	EC for RDRM output
W13-1	Mlalazi	C	High	Yes	B	Flow, WQ, Non-flow.	Difficult but can be achieved through non-flow mitigation and improvement of WWTW	C
W13-2	Manzamnyama	B/C	High	Yes	B	Flow, Non-flow.	Difficult as will require removal of commercial forestry.	B/C
W2 (Mfolozi)								
W21-1	White Mfolozi	C	High	Yes	B	Flow, WQ, Non-flow.	REC achieved by combination of flow and non-flow mitigation.	B/C
W21-2	White Mfolozi	B	High	No	B		n/a	B
W21-3	White Mfolozi	C	High	Yes	B	Flow, WQ, Non-flow.	Difficult - mitigation will have to focus on non-flow aspects.	C
W21-4	Nondweni	D	Moderate	No	D	WQ, Non-flow.	n/a	D
W22-3	Sikwebezi	C	High	Yes	B	Non-flow	Difficult but will have to be through non-flow mitigation only.	C
W23-1	Mfolozi	B	High	No	B		n/a	B
W23-2	Msunduzi	B	High	No	B		n/a	B
W3 (Mkuze)								
W31-1	Mkuze	C	High	Yes	B	Flow, WQ, Non-flow	REC achieved by combination of flow and non-flow mitigation.	B/C
W31-2	Mkuze	B	High	No	B		n/a	B
W31-6	Msunduzi	B	High	No	B		n/a	B
W32-2	Hluhluwe	B	High	No	B		n/a	B
W32-3	Nyalazi	B	High	No	B		n/a	B
W32-4	Nyalazi	C	High	Yes	B	Flow, WQ, Non-flow	Difficult as largely non-flow mitigation required centred around sedimentation and erosion problems.	C
W32-5	Mzinene	C	High	Yes	B	Flow, WQ, Non-flow	See above.	C
W32-6	Munywana	B	High	No	B		n/a	B
W4 (Pongolo)								
W41-1	Bivane	C	High	Yes	B	Non-flow, flow	REC achieved by combination of flow and non-flow mitigation.	B/C
W41-2	Manzana	B	High	No	B		n/a	B
W42-1	Phongolo	C	High	Yes	B	Flow, Non-flow (WQ)	Difficult. REC achieved by combination of flow and non-flow mitigation.	B/C
W42-4	Mozana	B	Moderate	No	B		n/a	B
W42-5	Phongolo	B	High	No	B		n/a	B
W43-1	Ngwavuma	C	Moderate	No	C	Non-flow (Flow, WQ)	n/a	C
W44-1	Phongolo	D	Moderate	No	D	Flow, WQ (non-flow)	n/a	D
W5 (Usutu)								
W51-1	Assegaai	C/D	High	Yes	B/C	Flow, Non-flow (WQ)	REC achieved by combination of flow and non-flow mitigation.	C
W51-4	Blesbokspruit	C	Moderate	No	C	Flow, Non-flow	n/a	C
W52-1	Hlelo	B/C	High	Yes	B	Non-flow, Flow	Difficult - extensive commercial forestry.	B/C
W53-1	Ngwempisi	D	Moderate	No	D	Flow, Non-	n/a	D

RU no	Main river name	PES RU EC	EIS RU	Improve ?	REC	Primary driver	Improvement attainable?	EC for RDRM output
						flow		
W53-2	Mpama	B/C	Moderate	No	B/C	Flow, Non-flow	n/a	B/C
W53-3	Ngwempisi	C	Moderate	No	C	Flow (non-flow, WQ)	n/a	C
W54-1	uSuthu	B	Moderate	No	B		n/a	B
W54-2	uSuthu	C	Moderate	No	C	Flow	n/a	C
W55-1	Mpuluzi	B/C	High	Yes	B	Flow, WQ (Non-flow)	Difficult - removal of instream dams will be required.	B/C
W55-2	Lusushwana	C	High	Yes	B	Non-flow, WQ, Flow	Difficult - dominated by non-flow activities.	C
W57-1	uSuthu	B/C	High	Yes	B	Flow	Difficult as no control over Eswatini flow management.	B

3 RUs: DESKTOP EWR ESTIMATION AND RESULTS

3.1 BACKGROUND

The estimation of EWRs in this study applies Version 2 of the Revised Desktop Reserve Model (RDRMv2). The RDRM is a Desktop application of the Habitat-Flow Stressor-Response Ecological Water Requirement (EWR) Methodology (referred to internationally as Environmental Flow Assessments). The RDRM explicitly includes the links and relationships between hydrology, hydraulics and hydraulic-habitat, and ecological response compared to the original Desktop Reserve Model (refer to Hughes and Hannart, 2003). Version 2 of the original RDRM (refer to Hughes *et al*., 2014) was refined under the auspices of a Water Research Commission (WRC) project (WRC, 2018).

3.2 APPROACH

3.2.1 Biophysical nodes and associated information provided

The biophysical nodes requiring Desktop EWR assessments are documented in DWS (2022b) and summarised with the PES and EC for desktop applications in **Table 2.2**. Nodes are located at RU catchment outlets directly below the RU catchment to represent tributaries or at the end of the most downstream sub-quaternary (SQ) within the RU. Most nodes were therefore located on rivers directly below confluences (i.e., additive inflows from upstream SQs).[3] Of the 42 nodes requiring Desktop EWRs (**Table 3.1**), hydraulic information is available from previous assessments from 2002/3 for three nodes and was used for the upper Mhlathuze (W12-1), lower Mfule (W55-2) and Lusushwana (W55-2); refer to Birkhead (2002; 2003). Seven of the nodes have an improved REC relative to the PES by half a category.

3.2.2 SPATSIM setup

The RDRMv2 runs within the Spatial and Time Series Information Modelling (SPATSIM) software. A new SPATSIM application was setup for the study area (which includes secondary catchments W1 to W5 in South Africa, with Geographical Information System (GIS) coverages for the SQ catchments, rivers, major dams, biophysical nodes and EWR[4] sites (refer to **Figure 3.1**). The RDRM application setup is readily transferable to other computers running SPATSIM.

[3] This affected the way in which localised channel or valley slopes were computed using remote sensing data - discussed later.
[4] Not addressed in this Desktop assessment.

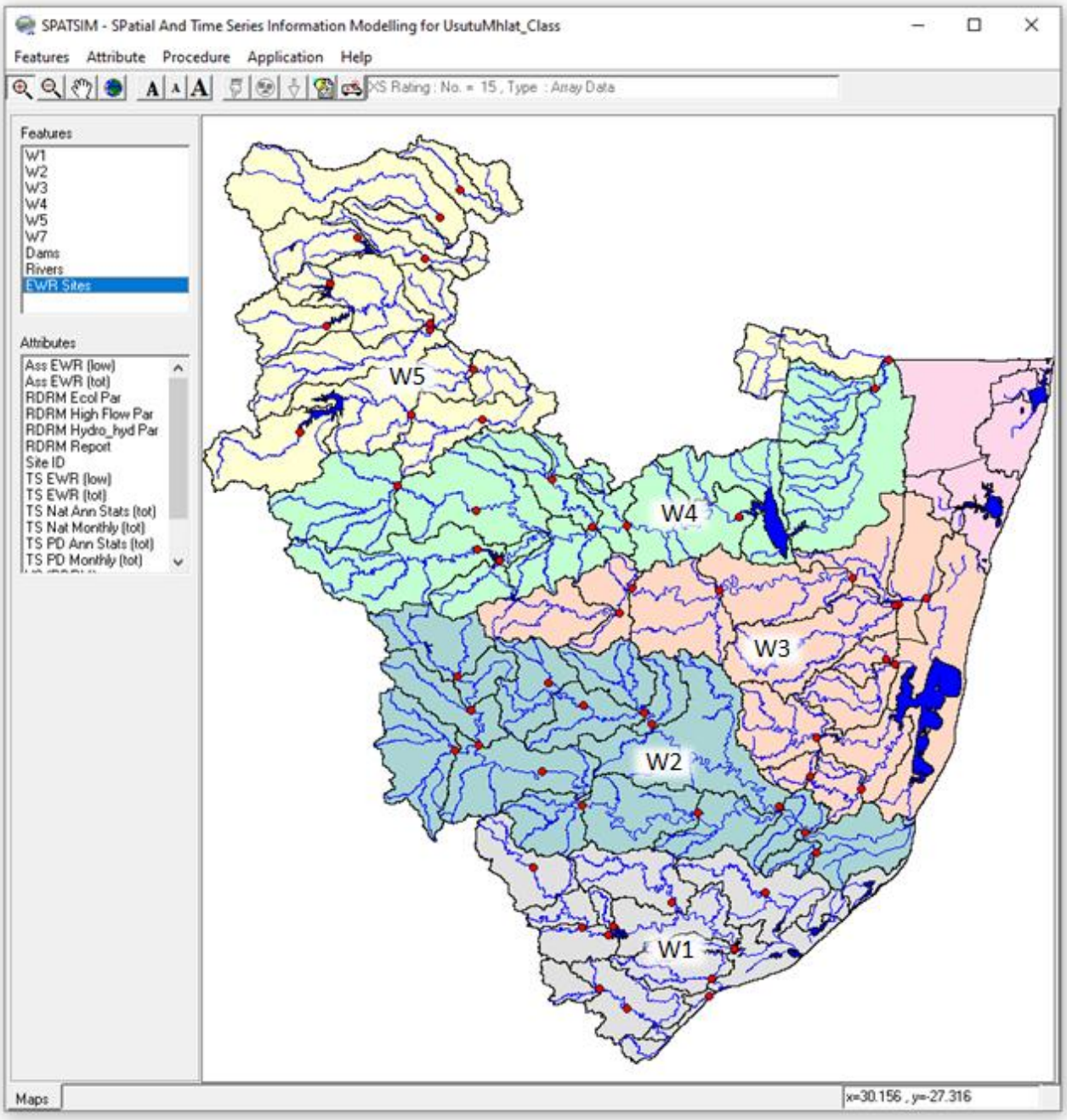

Figure 3.1 The Usutu to Mhlathuze Classification Project visual setup in SPATSIM; biophysical node and EWR sites are indicated as red markers

3.2.3 Data requirements and assessment

The RDRMv2, run as a Desktop application[5], has the following minimum data requirements:

- Hydrology:[6]
  - Timeseries of monthly natural flows.
  - Baseflow separation parameters (regionalised values used - see below).

[5] It can also be applied at higher levels of Reserve determination (e.g., Rapid III, Intermediate and Comprehensive), with the use of additional information, such as, for example, surveyed cross-sectional river profiles and modelled rating relationships; and externally-determined stress-discharge relationships.

[6] Provided by WRP Consulting Engineers; hydrological record periods vary for different catchments (W1: 1920 to 2003; W2 to W4: 1920 to 2019; W5: 1920 to 2013).

- Percentage point on the baseflow separated flow-duration curve, to determine the maximum baseflow for wet and dry seasons.

- Hydraulics:
  - Valley slope (longitudinal).
  - Geomorphological zone.
  - Catchment area.
  - Macro-channel width.
- Ecology:
  - Low and high percentile shifts in the stress index value relative to natural conditions, for the wet and dry seasons (default values were used which are computed in the ecological sub-model - see below).
  - The stress index value, in the range 0 to 10, corresponding to the threshold discharge for the onset / loss of fast flows, i.e., velocities ≥ 0.3 m/s (default values were used - see below).
  - The relative weighting of stress index-discharges for three velocity-depth classes, viz., fast-shallow, fast-intermediate, and fast-deep flow (default values were used - see below).

Default parameter values were used for the following variables in this Desktop assessment:

- Hydrology: Regionalised baseflow separation parameters (α and β values) which are available nationally at the quaternary catchment level (Hughes and Watkins, 2002).
- Ecology (refer to WRC, 2018):
  - Low flows:
    - Low and high percentile stress index values, which represent shifts from natural conditions and are computed in the ecological low flow sub-model.
    - Stress indices for the onset of fast flows and relative velocity-depth class weightings, which are available nationally at the sub-quaternary catchment level based on the presence or absence of fish species and invertebrate taxa.
  - High flows:
    - Parameter values for inter-and intra-annual flow events, which are computed in the high flow sub-model.

In addition to the monthly natural flows, timeseries of Present Day (PD) flows were also modelled and provided (refer to **Footnote 6**). The remaining parameters required for Desktop assessment were determined as follows:

- Hydrology:
  - The baseflow separated flow-duration curves were assessed (in the hydrology sub-model) to fix the percentage point (5 to 20) at which baseflows deviate - i.e., the point at which discharges are deemed to rise more sharply with reducing flow.
- Hydraulics:
  - Valley slopes were determined using the Shuttle Remote Topography Mission[7] (SRTM) 30 m Digital Elevation Model (DEM)[8]. The 1:500,000 rivers coverage published by the Department of Water and Sanitation was re-digitised for the study area using the SRTM DEM. The reason for this is to ensure that the rivers coverage corresponds to the lowest elevations in the underlying DEM, which is in-turn used to provide elevations for vertices along the river lines, and hence valley slopes. The SRTM DEM was pre-

[7] http://www2.jpl.nasa.gov/srtm/.
[8] Re-gridded to approximately 90 m cells.

processed[9] and drainage lines (corresponding in position to the 1:500,000 DWS rivers coverage) were digitised for the SQs requiring Desktop EWR estimation. Valley slopes were computed for the rivers coverage, and due to the 'low' resolution of the underlying DEM, average slopes were computed at the upstream, within, or at the downstream SQ boundaries (as appropriate to node position within the SQ). Where nodes correspond to the locations of dams, they were positioned upstream of the backup, and concomitant upstream slopes were calculated.

- The classified geomorphological zones, at a national level, are derived directly from valley slopes, and are subject to the resolution issues associated with the 1:500,000 rivers coverage-DEM, discussed above. The geomorphological zones corresponding to the 2-km averaged valley slopes and were determined using the gradient classification of Rountree and Wadeson (1999)[10].
- Catchment areas were provided by WRP Consulting Engineers.
- Macro-channel widths were measured using remote sensing imagery.

Where there were obvious disparities between the shape and bed roughness of the constructed channel shape (which is derived in the Desktop Model from the valley slope and corresponding geomorphological zone) and that noted from remote sensing imagery[11], the geomorphological zone was altered by one zone; the valley slope was also corrected to ensure compatibility with the geomorphological zone.

Generally, for all biophysical nodes assessed, the EWR requirements were constrained to PD flows. Exceptions, however, are where the REC is higher than the PES (due to improvements in the existing hydrological flow regime).

3.3 RESULTS

The EWR results are provided (as part of e-data provided as a deliverable for this study) in the following formats as text files named according to the biophysical node:

- RDRMv2 generated reports.
- Assurance rules for EWR low flows and total flows (in 10^6 m^3).
- Time-series of monthly EWR low and total flows (in 10^6 m^3)[12].

A summary of low and high flow EWR long-term requirements (which are computed from the monthly EWR time-series), naturalised and PD Mean Annual Runoff (MAR), and other supporting information, is provided in **Table 3.1**. For the seven nodes where an improvement of the PES is recommended, the Flow-Duration Curve (FDC) is not constrained based on PD hydrology.

Several nodes are located in wetland-type environments with no well-defined low flow channel, for which the RDRM was not explicitly developed. For these nodes, the full length of the river channel was assessed within the SQ to obtain an indication of channel widths along reaches where low flows appear to be contained within a defined channel. An example of such a node is W31-6, which for B REC has an EWR of 11.96 10^6 m^3 (59.3% naturalised MAR). Since this is notably

[9] Sinks filled and/or channels deepened.
[10] This results in geomorphological zones in the hydraulic component of the RDRMv2 that are compatible with the valley slopes from which they are derived, and no corrections are necessary.
[11] E.g., noted presence of rapids, whereas a relatively smooth channel (sandy) bed is predicted by hydraulic sub-model.
[12] Note, total flow time-series are not constrained to PD for any of the biophysical nodes, whereas FDCs are.

higher relative to the results for other nodes assessed (refer to **Table 3.1**), a range of alternative, but reasonable, parameter values were also assessed to check result sensitivity. Also, the sensitivity analysis available in the RDRMv2 was also used. The EWR results, however, did not change substantially; given this, a more detailed analysis based on field data is recommended to increase the certainty of this Desktop assessment, if required.

Hydraulic information from previous EWR assessments was available for biophysical nodes on the upper Mhlathuze (W12-1), lower Mfule (W55-2) and Lusushwana (W55-2). The RDRMv2 was applied without (i.e., Desktop hydraulics) and with surveyed and modelled hydraulic information. This resulted in an absolute average change in the total EWR requirement by 2.3% (max. of 3.9%); while this is only for these three sites, the small change is reassuring.

Excluding the above two nodes, the ranges of recommended EWRs expressed as percentages of the Naturalised MARs range from, for B, B/C, C and D ECs: 30.2 to 46.0, 38.7 to 49.9, 29.6 to 46.1, and 29.7 to 33.1. While there is a general overall reduction in proportion of MAR with reducing EC, there is no clear / simple relationship, since EWRs are also a function of the links / relationships between *inter alia* hydrological, hydraulic, and ecological characteristics as well as PD flows (when constrained), which vary for the different biophysical nodes. The RDRMv2 is developed to explicitly account for these links/relationships at the Desktop level of assessment.

Table 3.1 Summary of Desktop EWRs for desktop biophysical nodes in the Usutu to Mhlathuze River secondary catchments W1 to W5

Node	Sub-quaternary	River	Catchment area (km^2)	MAR			PES	REC	Constrain FDC[13]	EWR long-term requirements			
				10^6 m^3		PD (% Nat)				MAR low flows		MAR total flows	
				Nat	PD					10^6 m^3	% Nat	10^6 m^3	% Nat
Secondary catchment W1													
W11-1	W11A-03597	Matigulu	183.8	22.78	13.06	57.3	B	B	PD	4.68	20.6	7.16	31.4
W12-1	W12A-03153	Mhlatuze	309.5	32.15	23.32	72.5	B	B	PD	8.21	25.5	12.79	39.8
W12-2	W12B-03356	Mhlatuze	840.8	95.13	28.48	29.9	B	B	PD	22.83	24.0	37.90	39.8[14]
W12-3	W12B-03479	Mhlatuze	1055.0	125.08	162.13	139.6	C	C	PD	35.66	28.5	51.63	41.3
W12-4	W12B-03336	KwaMazula	92.0	12.87	9.89	76.8	C	B/C	Nat	4.40	34.2	6.12	47.6
W12-5	W12C-03303	Mfule	571.0	50.80	37.84	74.5	C	C	PD	16.12	31.7	20.54	40.4
W12-7	W12E-03526	Mhtatuzana	172.0	23.13	21.76	94.1	B	B	PD	6.86	29.6	8.76	37.9
W13-1	W13A-03609	Mlalazi	400.7	107.19	97.34	90.8	C	C	PD	31.46	29.4	41.20	38.4
W13-2	W13B-03774	Manzamnyama	162.5	42.57	3.72	8.7	B/C	B/C	PD	3.70	8.7	8.02	18.8[14]
Secondary catchment W2													
W21-1	W21B-02546	White Mfolozi	670.6	53.41	33.38	62.5	C	B/C	Nat	17.74	33.2	25.01	46.8
W21-2	W21B-02670	White Mfolozi	920.0	63.55	41.59	65.4	B	B	PD	17.88	28.1	29.52	46.4
W21-3	W21F-02727	White Mfolozi	1492.7	103.29	79.16	76.6	C	C	PD	24.47	23.7	40.80	39.5
W21-4	W21D-02815	Mvunyane	885.0	66.00	60.51	91.7	D	D	PD	10.85	16.4	19.85	30.1
W22-3	W22F-02726	Sikwebezi	475.9	69.08	60.58	87.7	C	C	PD	15.61	22.6	26.18	37.9
W23-1	W23A-03113	Mfolozi	9165.2	808.98	533.98	66.0	B	B	PD	219.47	27.1	353.70	43.7
W23-2	W23B-03250	Ntobozi	142.8	19.38	16.49	85.1	B	B	PD	6.12	31.6	8.36	43.2
Secondary catchment W3													
W31-1	W31B-02477	Mkuze	674.0	56.17	48.87	87.0	C	B/C	Nat	14.69	26.1	23.31	41.5
W31-2	W31D-02500	Mkuze	1135.1	99.66	89.19	89.5	B	B	PD	27.99	28.1	44.51	44.7
W31-6	W31L-02569	Msunduzi	1176.0	20.16	19.28	95.6	B	B	PD	8.64	42.9	11.96	59.3[15]

[13] Discharge constrained to not exceed Nat or PD on the FDC.
[14] > PD, since total flows are NOT constrained to PD in the long-term time-series; FDCs are, however, constrained.
[15] Refer to discussion in text.

Node	Sub-quaternary	River	Catchment area (km^2)	MAR			PES	REC	Constrain FDC[13]	EWR long-term requirements			
				10^6 m^3		PD (% Nat)				MAR low flows		MAR total flows	
				Nat	PD					10^6 m^3	% Nat	10^6 m^3	% Nat
W32-2	W32E-02865	Hluhluwe	405.8	23.90	23.67	99.0	B	B	PD	3.69	15.5	7.21	30.2
W32-3	W32G-02973	Nyalazi	162.0	11.80	11.78	99.9	B	B	PD	2.40	20.3	3.89	32.9
W32-4	W32G-03055	Nyalazi	356.4	25.92	25.92	100.0	C	C	PD	3.83	14.8	7.68	29.6
W32-5	W32C-02671	Mzinene	611.5	20.80	16.82	80.9	C	C	PD	3.82	18.4	7.23	34.8
W32-6	W32C-02612	Munywana	109.2	3.72	3.67	98.9	B	B	PD	0.92	24.6	1.64	44.1
Secondary catchment W4													
W41-1	W41E-02359	Bivane	1182.3	221.53	190.28	85.9	C	B/C	Nat	55.34	25.0	85.73	38.7
W41-2	W41F-02433	Manzana	343.0	45.09	43.56	96.6	B	B	PD	10.57	23.4	16.68	37.0
W42-1	W42B-02271	Phongolo	1191.0	264.38	237.40	89.8	C	B/C	Nat	52.03	19.7	102.96	38.9
W42-4	W42K-02272	Mozana	416.0	52.70	46.50	88.2	B	B	PD	14.40	27.3	22.37	42.4
W42-5	W42M-02352	Phongolo	5739.8	901.99	784.54	87.0	B	B	PD	180.04	20.0	335.16	37.2
W43-1	W43F-02072	Ngwavuma	632.0	26.95	26.86	99.7	C	C	PD	3.74	13.9	9.00	33.4
W44-1	W44D-02304	Phongolo	6966.2	942.03	654.62	69.5	D	D	PD	124.76	13.2	251.62	26.7
Secondary catchment W5													
W51-1	W51A-02082	Assegaai	633.9	99.61	89.91	90.3	C/D	C	Nat	27.31	27.4	40.96	41.1
W51-4	W51F-01986	Blesbokspruit	312.5	43.36	40.50	93.4	C	C	PD	12.59	29.0	17.98	41.5
W52-1	W52D-01862	Hlelo	874.4	97.06	78.34	80.7	B/C	B/C	PD	26.96	27.8	42.77	44.1
W53-1	W53A-01804	Ngwempisi	463.6	38.66	28.14	72.8	D	D	PD	8.03	20.8	12.80	33.1
W53-2	W53B-01694		48.8	5.05	4.00	79.1	B/C	B/C	PD	1.53	30.3	2.14	42.4
W53-3	W53E-01790	Ngwempisi	1575.9	181.14	100.52	55.5	C	C	PD	39.32	21.7	66.00	36.4
W54-1	W54B-01569	uSuthu	403.3	32.77	24.22	73.9	B	B	PD	9.05	27.6	15.07	46.0
W54-2	W54D-01593	uSuthu	779.0	79.46	32.29	40.6	C	C	PD	17.82	22.4	27.84	35.0
W55-1	W55E-01477	Mpuluzi	1130.0	128.96	110.43	85.6	B/C	B/C	PD	48.05	37.3	64.37	49.9
W55-2	W56A-01372	Lusushwana	234.8	39.48	36.19	91.7	C	C	PD	14.09	35.7	18.19	46.1
W55-7	W57K-01929	uSuthu	16388.0	2289.46	1434.03	62.6	B/C	B	Nat	487.89	21.3	922.46	40.3

MAR = Mean Annual Runoff (in million cubic metres, i.e., 10^6 m^3); Nat = Natural; PD = Present Day; PES = Present Ecological State; REC = Recommended Ecological Category; FDC = Flow-Duration Curve; Long-term requirements derived from monthly time-series (high flows are NOT CONSTRAINED in the RDRMv2 though the total FDCs are).

4 REFERENCES

Birkhead, A. 2002. Appendix: River hydraulics for Rapid III EWRs on the Pongola, Lusushawana and Mlomathi Rivers. 21 pp.

Birkhead, A. 2003. Appendix: River hydraulics for EWRs for the Mhlathuze, Nseleni and Mfule Rivers. 14 pp.

Department of Water and Sanitation (DWS), South Africa. 2014a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 3: EcoClassification and EWR assessment on the uMkhomazi, uMngeni, and Mvoti Rivers. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd.

Department of Water and Sanitation (DWS), South Africa. 2014b. A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQIS-RDM: http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx.

Department of Water and Sanitation (DWS), South Africa. 2022a. Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: Resource Units Prioritisation Report. Prepared by: WRP Consulting Engineers (Pty) Ltd. DWS Report: WEM/WMA3/4/00/CON/CLA/0322. May 2022.

Department of Water and Sanitation (DWS), South Africa. 2022b. Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: Status Quo and Delineation of Resource Units and Integrated Units of Analysis Report. Prepared by: WRP Consulting Engineers (Pty) Ltd. DWS Report: WEM/WMA3/4/00/ CON/CLA/0222. April 2022.

Hughes, D.A. and Hannart, P. 2003. A desktop model used to provide an initial estimate of the ecological instream flow requirements of rivers in South Africa. *Journal of Hydrology* **270(3-4)**, 167–181.

Hughes, D.A., Desai, A.Y., Birkhead, A.L. and Louw, D. 2014. A New Approach to Rapid, Desktop-Level, Environmental Flow Assessments for Rivers in South Africa. *Hydrological Sciences Journal* **59, no. 3-4**, 673–87. doi:10.1080/02626667.2013.818220.

Hughes, D.A. and Watkins, D. 2002. Continuous baseflow separation from time series of daily and monthly streamflow data. *Water SA* **29(1)**.

Kleynhans, C.J. and Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination. In River EcoClassification: Manual for EcoStatus Determination (version 2) Water Research Commission Report No. TT 333/08. Joint Water Research Commission and Department of Water Affairs and Forestry report, Pretoria, South Africa.

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

WRC (Water Research Commission). 2018. Refinement of the Revised Desktop Reserve Model Project K5/2539/2. Final Report Volume 1: RDRM Refinement – background and description. 53 pp.

5 APPENDIX A: COMMENTS AND RESPONSE REGISTER

No.	Sect	Comment	From	Addressed?
1a	Table 1.1 Pg 1-4	You really need to comment for each node/EWR site prioritised. Let's avoidleaving empty spaces.	M Mnisi	Cannot be filled in. The comment section is only for where there are specific comments required. The blank spaces have no comments. Heading changed to state Comment where applicable
1b	Title	Delete Estimation	M Mnisi	Done
2	Sec 3.3	I do not understand what you are trying to say here. "Low Flow EC of 42.9 10^6 m^3.	C Thirion	"EC" should read "EWR"; further error in stated value also corrected.
3	Whole report	My assumptions is that the following issues have been taken into consideration, if not they may need to be considered:	A Salagae	
		1) Pongola River flows passes through Swaziland and then Mozambique; hence transboundary related issues need to be fully considered.		As the client instructed, Classification does not include Swaziland. All hydrology will include Swaziland where flows are sourced or transit Swaziland
		2) The Pongolapoort Dam is flow regulated, as a result several issues needs to be considered such as different users downstream, and international obligations. Based on trends and climate change projections, Mozambique is and there is a likelihood of being prone to cyclones. Hence, needs for Dam safety and release for downstream consideration. This may impact on class consideration.		See above. Downstream releases are considered
		3) On the Pongola floodplain, downstream of the Dam, there are expansion of agricultural activities such as sugar cane and cotton farming. Such activities should be considered.		Yes
		4) There is filling in of sediment in the Pongolapoort Dam due to land use upstream such as cultivation and erosion. During flood release, depending on how and when it is done, fluvial deposit (sand) tends to fill and cover up some of the riparian zones making them unusable for recession agriculture. Also, if flood release is not efficient and effective, the channels between the river and pans are cut-off, resulting in fish spawning being ineffective which ultimately reduces fish in the pans, thereby impacting on the livelihoods that depend on fish for protein.		Considered it is assumed in the Pongola Floodplain work undertaken during 2014 which will be used during this study. Livelihood issues have been considered in the Socio-Cultural Importance.
		5) The issue of groundwater levels falling especially around the Kosi bay, is of concern as it is not clear if this is due to prolonged drought, or over abstraction for household use, or is it due to evapotranspiration from afforestation.		Yes

No.	Sect	Comment	From	Addressed?
4		Grammar changes and word inserts	C Thirion	Yes