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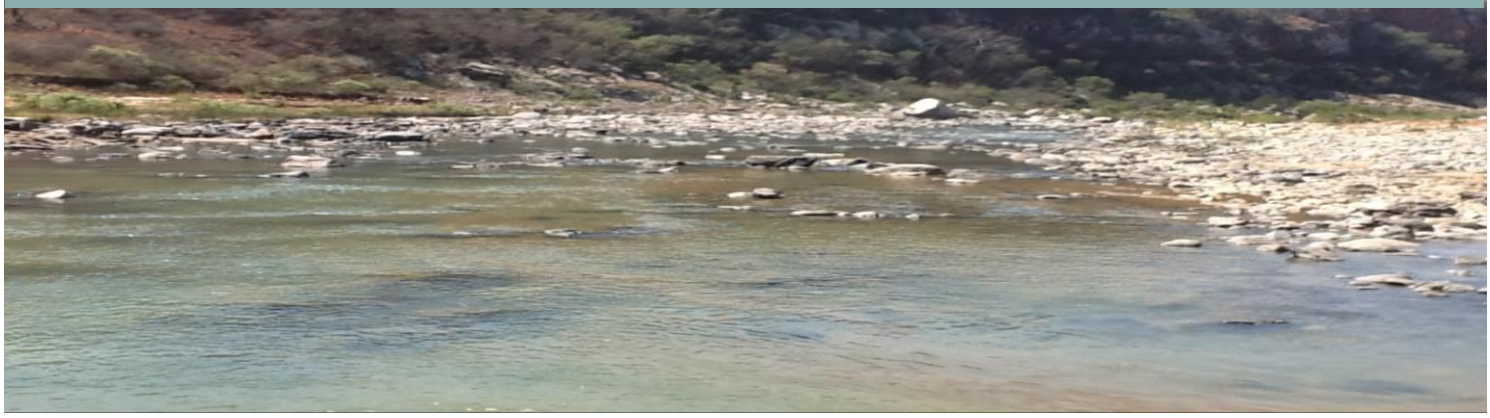
RESERVE DETERMINATION STUDIES FOR SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE USUTU/MHLATUZE WATER MANAGEMENT AREA
WP 10544

RIVER DELINEATION AND SITE SELECTION REPORT
FINAL

MAY 2014

Report No. RDM/WMA6/CON/COMP/0213



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Department:
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DEPARTMENT OF WATER AND SANITATION

CHIEF DIRECTORATE: WATER ECOSYSTEMS

CONTRACT NO. WP 10544

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Contract Title: Reserve determination studies for selected surface water, groundwater, estuaries and wetlands in the Usutu/Mhlatuze Water Management Area

Report Title Rivers Delineation and Site Selection Report

Author A Singh & C Brown

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1.9	30 May 2014	Final

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Study Leader

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Dr C Brown
Internal Reviewer

Client: Department of Water and Sanitation

Approved for the DWS:

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Chief Director: Water Ecosystems

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T Sibande	Tlou Consulting

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ABBREVIATIONS AND ACRONYMS

CRUZ	Coastal Research Unit Zululand
DWA	Department of Water Affairs
DRIFT	Downstream Response to Imposed Flow Transformations
DSS	Decision Support System
EF	Environmental Flow
EI	Ecological Importance
ES	Ecological Sensitivity
EISC	Ecological Importance and Sensitivity Category
ERQOs	Estuarine Resource Quality Objectives
EWR	Ecological Water Requirements
IFR	Instream Flow Requirement
IHI	Index of Habitat Integrity
IHyd	Hydrological Index
IWA	International Water Agreement
NWRCS	National Water Resource Classification System
PES	Present Ecological State
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
RHAM	Rapid Habitat Assessment Method
RHP	River Health Programme
RQS	Resource Quality Services (DWA)
RQOs	Resource Quality Objectives
TPCs	Thresholds of Potential Concern
WRCS	Water Resource Classification System
WMA	Water Management Area
WRCS	Water Resource Classification System

GLOSSARY OF TERMS

- ***Ecological Water Requirements*** (EWR) should be used instead of the term Instream Flow Requirements (IFR) for various reasons, including international acceptance of the former term.
- ***Ecological Categories.*** A distinction is made between Management Classes, which form part of the National Classification System, and Ecological Categories, which forms part of the Ecological Water Requirement assessment.
- ***Reserve*** refers to the modified EWR where operational limitations and stakeholder consultation are taken into account, also include both ecological and Basic Human Needs (BHN) requirements.
- ***Preliminary Reserve*** refers to Reserve signed off by the Minister or her representative in the absence of the Classification Process having been undertaken in the basin.
- ***Ecological Water Requirement Scenarios*** (EWRS) replaces the term Reserve Scenarios. EWRS is the term to use at all stages through the Reserve process until such time a decision has been made about the Reserve (at which time one of the EWRs will be selected as the Preliminary Reserve).
- ***Operational Scenarios*** refers to scenarios devised on the basis of issues other than ecological, i.e. availability of water, operational constraints in the system, other demands etc.
- ***Ecological Category*** (EC) replaces former terms used, namely: Ecological Reserve Category (ERC), Desired Future State (DFS) and Ecological Management Class (EMC).

1 INTRODUCTION

1.1 Purpose and structure of the rivers delineation and site selection report

This rivers delineation and site selection report describes the rivers of the study area in terms of their biogeography and type. It also provides information on the site selection process, and the sites selected, for intermediate-level Ecological Water Requirement (EWR) assessments for nominated rivers in the study area.

There is a substantial amount of spatially-explicit information on ecoregions and river type for the study area. This was used to identify 'significant' rivers and delineate them in accordance with the requirements of the Water Resources Classification System (WRCS; DWA 2006).

This report provides the following:

- Delineation of the rivers in the study area;
- Selection and identification of River EWR sites for Intermediate-level EWR assessments.

This rivers delineation and site selection report is a stand-alone document in support of the Intermediate and Rapid EWR assessments for rivers.

2 THE STUDY AREA

The study area originally comprised the Usutu-Mhlatuze WMA (as defined in the DWA - NRWS 1), which is situated in the northern portion of KwaZulu-Natal Province. The national WMA boundaries have changed since the project was awarded (DWA 2013a), and the Usutu-Mhlatuze WMA has been split into two, with the Usutu River catchment now forming part of the Inkomati–Usutu WMA, and the remaining rivers now forming the Pongola-Mzimkulu WMA (Figure 2.1).

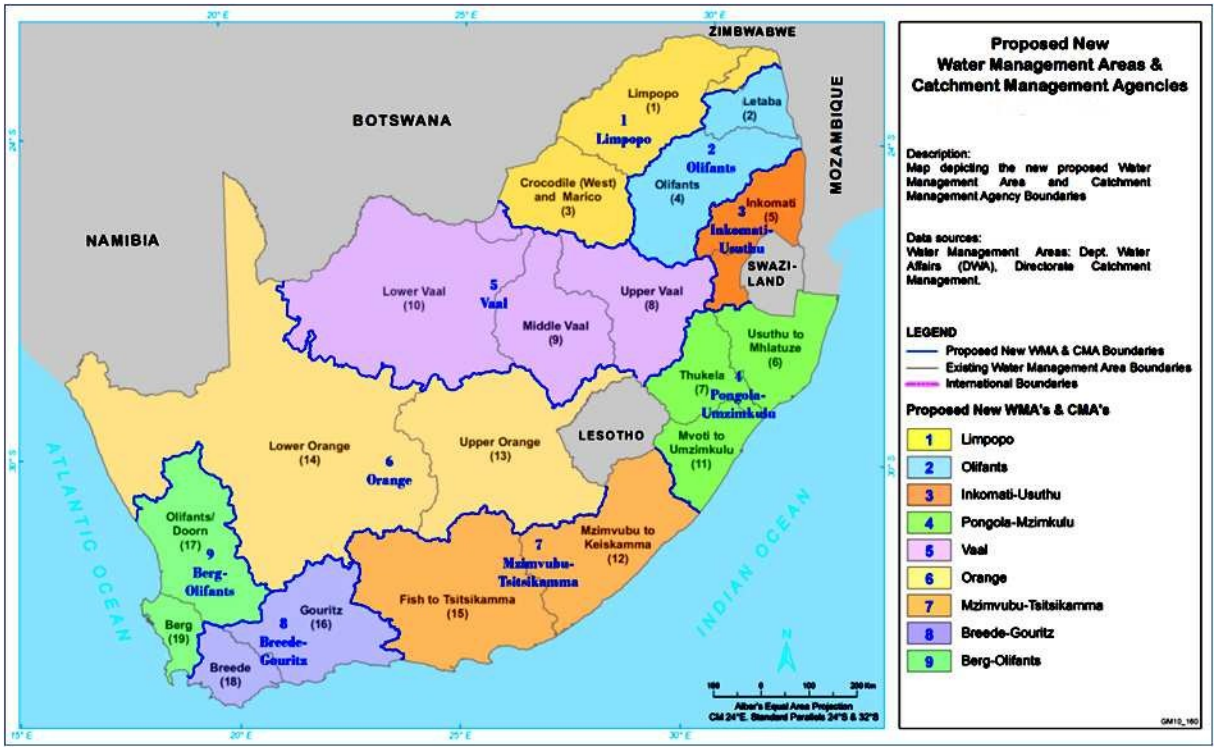


Figure 2-1 Map of the boundaries of the new Water Management Areas (NWRS; DWA 2013a)

The study area of this project, however, remains that indicated in the Inception Report, and includes the following catchment areas (Figure 2-2):

- Mhlatuze (W1)
- Mfolozi (W2)
- Mkuze (W3)
- Pongola (W4)
- Upper Usutu (W5)
- Lake Sibaya / Kosi (W7)

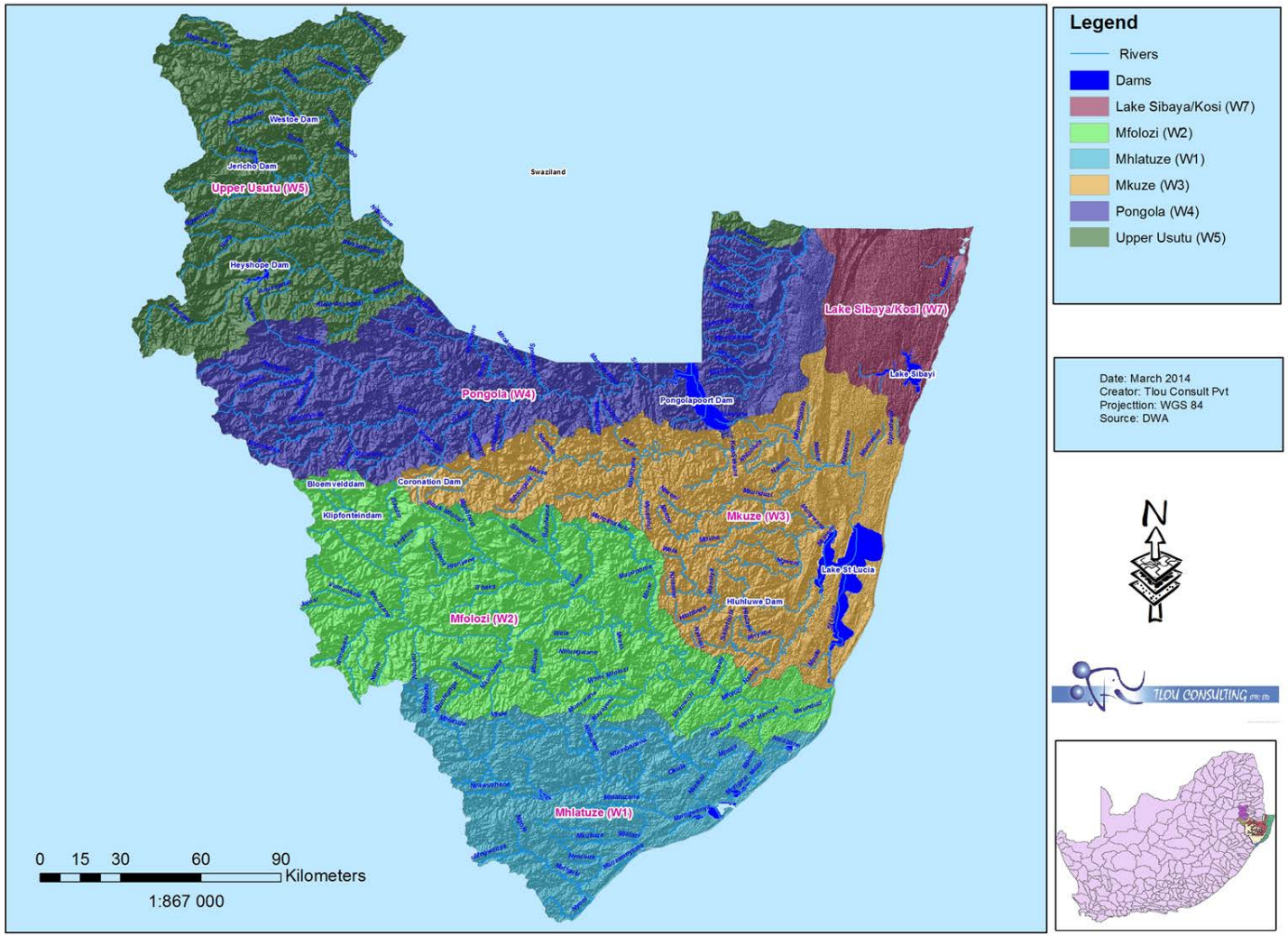


Figure 2-2 Map of the study area

3 NWRCS RIVER DELINEATION

The bulk of this information in this section was extracted from Anchor Environmental Consultants (2010) who did a delineation of the study area using the protocols stipulated in the National Water Resource Classification System (NWRCS) as part of their studies in 2010.

As per the NWRCS, significant water resources are defined as: *Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in water quality and quantity* (DWAF 2007).

The primary objective of delineating the rivers in the study area was to identify relatively homogeneous areas in terms of biophysical characteristics so that information from representative sites can be extrapolated to similar sites.[1]

3.1 Procedure adopted

The procedures used to delineate the rivers are described in NWRCS (DWAF 2007). The NWRCS is a defined set of guidelines and procedures for determining the different classes of water resources - the delineation procedure is part of this. Emerging from the full Classification process will be, amongst other things, the hydrological specifications of the Ecological and Basic Human Needs Reserves for individual water resources, and a description of the condition these will be expected to maintain.

In the NWRCS, river nodes are placed at the downstream end of the river reach that they represent and for which a suite of relationships applies. These nodes should not be confused with EWR sites or RDM/RHP monitoring sites, as typically these sites are nested within a reach represented by a river node.

The NWRCS procedure for establishment of river nodes is summarized in Table 3-1. In this study we have excluded Tiers VIII-XI as these pertain to rationalisations that may or may not occur for Classification itself.

[1] Given the lack of availability of data, it was necessary to extrapolate low confidence estimates to other (not-so-similar) sites. This has further reduced the confidence for certain areas and has been indicated where appropriate.

Table 3-1 The NWRCS procedure for establishment of river nodes (DWA 2007) (MU=minimum unit).

Procedure for river node selection					
TIER	**Data/GIS layers**	**Filtering process**	**Explanation**	**MU**	**Aim**
I	Ecoregions Level I (Kleynhans *et al.* 2005)	Exclude Ecoregions that comprise < 5% of the total area of the primary catchment AND where >75% is represented elsewhere.	Place node at each Ecoregion/ quaternary catchment intersection where >75% of the upstream quaternary is comprised of a different Ecoregion from the downstream quaternary.	Quaternary catchments	Insert nodes
II	Hydrological index Classes (HydI) (Dollar *et al.* 2006) derived from the hydrological index (Hughes & Hannart 2003)	Hydl Class 1: HydI = 1 to 4 (perennial).	Place node at each Quaternary intersection where there is a change in HydI Class.		
		Hydl Class 2: HydI = 5 (seasonal).			
		Hydl Class 3: HydI = 6 to 9 (ephemeral).			
III	Geomorphic zones (Rowntree and Wadeson 1999[2]).	Group 1: Mountain Headwater, Mountain Stream, Transitional and Upper Foothills.	Place node at each quaternary intersection, where >75% of the upstream quaternary is comprised of a different geomorphic zone from the downstream quaternary. Place node at the head of the estuary.		
		Group 2: Lower Foothills.			
		Group 3: Lowland Rivers.			
		Group 4: Rejuvenated Floodplains			
IV	Tributaries	Two nodes: one for each river upstream of the confluence.	Place node at the nearest quaternary intersection on each river.		
V	Ecological Importance and Sensitivity Category (EISC)	Use EISC information (Kleynhans 2000) and augment with local data where applicable.	Place node at each quaternary intersection downstream of high or very high EISC.		
VI	Present Ecological Status (PES)/Habitat Integrity (HI)	Use PES information (Kleynhans, 2000) and augment with local data where applicable.	Place node at each quaternary intersection, where > 75% of the upstream quaternary is comprised of a different PES/HI from the downstream quaternary. If sub-quaternary data are available, then adjust the information accordingly.		
		Group 1: A and B.			
		Group 2: C.			
		Group 3: D.			
		Group 4: E and F.			

[2] These zones have been determined by DWA's Chief Directorate: Resource Quality Services (CD: RQS) for the 1:500 000 rivers coverage for the whole of South Africa, and are available on request from the CD: RQS.

Procedure for river node selection					
TIER	**Data/GIS layers**	**Filtering process**	**Explanation**	**MU**	**Aim**
VII	Infrastructure	This Tier comprises both establishment of river nodes and some rationalisation of previously established nodes.			
		Insertions.	a. Place a node at each DWAF gauging weir for which there is a hydrological record.	Sub-quaternary	
			b. Place a node at the upstream limit of the inundation of any major dam.		
			c. Place a node upstream of mines, towns or other localities likely to influence water quality.		
			d. Place a node at each quaternary intersection where the area covered by farm dams in the upstream quaternary is > 5 times that of the downstream quaternary.	Quat	
			e. Place a node on a river immediately upstream of the confluence with an Inter Basin Transfer (IBT).	Sub-quaternary level	
		Deletions.	Remove any nodes that are inundated by impoundments.		Delete nodes
			Remove any nodes that describe upstream sections for which no description is required, e.g. impoundments.		
VIII	RDM data	Comprehensive or Intermediate Reserve determinations.	Place a node at the nearest quaternary boundary downstream of each Ecological Water Requirement (EWR) site.		Insert nodes
IX	First level rationalisation	Minimum distance between nodes = 10 km.	Delete nodes that are less than 10 km (river length) apart. Retain the node that is closest to a quaternary intersection.	n/a	Delete nodes
		Minimum contribution to natural Mean Annual Runoff (nMAR) = 1%.	Delete nodes where the cumulative contribution to nMAR <1%.		
X	Water resource management/ planning/ allocation	Where applicable for hydrology/ water resource management/ planning/ allocation.	It is essential that ecological information can be provided at a scale (and locations) relevant to other procedures linked to the Classification Process. If these have not been captured in the node delineation process thus far, insert nodes at relevant positions as dictated by other procedures linked to the Classification Process.	Sub-quaternary	Insert nodes

Procedure for river node selection					
TIER	**Data/GIS layers**	**Filtering process**	**Explanation**	**MU**	**Aim**
XI	International Water Agreements (IWA)	Based on IWAs signed between South Africa and neighbouring countries.	Place node at each quaternary intersection where required for an IWA.	Sub-quat	

The following information was used for the delineation:

- Quaternary, secondary and primary catchment boundaries;
- Rivers on a 1:500000 scale;
- Level I Ecoregions;
- Geomorphic zones by Rowntree and Wadeson (1999) - from Chief Directorate Resource Quality Services, DWA;
- Hydrological Index Classes based on the hydrological index of Hughes and Hannart (2003) as modified by Dollar *et al.* (2006) and Brown *et al.* (2006);
- Ecological Importance and Sensitivity categories and Present Ecological Status – from DWA.

3.1.1 TIER I: Level 1 Ecoregions

River ecoregional classification, or typing, groups rivers according to similarities based on a top-down nested hierarchy. Using attributes such as physiography, climate, rainfall, geology and potential natural vegetation, 31 Level I ecoregions have been defined and described for South Africa (Kleynhans *et al.* 2005). Of these, nine occur in the study area (Figure 3-1;
).

The description of these ecoregions (Kleynhans *et al.* 2005) tends to be in terms of their physical and vegetation attributes, without any reference to biodiversity (see Appendix A). The assumption is, however, that the fauna and flora within an ecoregion are likely to be more similar to each another than to those in a different ecoregion. It is worth noting, however, that geomorphological zonation will also play a role, and thus it is unlikely that biotic assemblages will be uniform across an ecoregion.

Tier I nodes were allocated at quaternary boundaries where >75% of the upstream quaternary was comprised of a different Ecoregion from the downstream quaternary. This resulted in the allocation of 20 nodes for the catchment (Figure 3-3).

Table 3-2 Level 1 Ecoregions in the study area

#	ECOREGION	MAP (mm)	DEG (oC)	MAR (mm)	ALT (m)
3	Lowveld	400-800	20-22	40-150	200-800
4	North Eastern Highlands	400-1000	2-32	20 to >250	300-1300
10	Northern Escarpment Mountains	400-1200	<8-20	10-250	800-2500
11	Highveld	400-1200	14-18	10-250	1250-1750
12	Lebombo Uplands	400-800	20-22	20-150	100-400
13	Natal Coastal Plain	600-1200	20->22	40-250	0-100
14	North Eastern Uplands	400-1200	14-20	40->250	600-1750
15	Eastern Escarpment Mountains	400-1000	<8-18	10->250	1100-3100
17	North Eastern Coastal Belt	700-1000	16-22	60->250	0-700

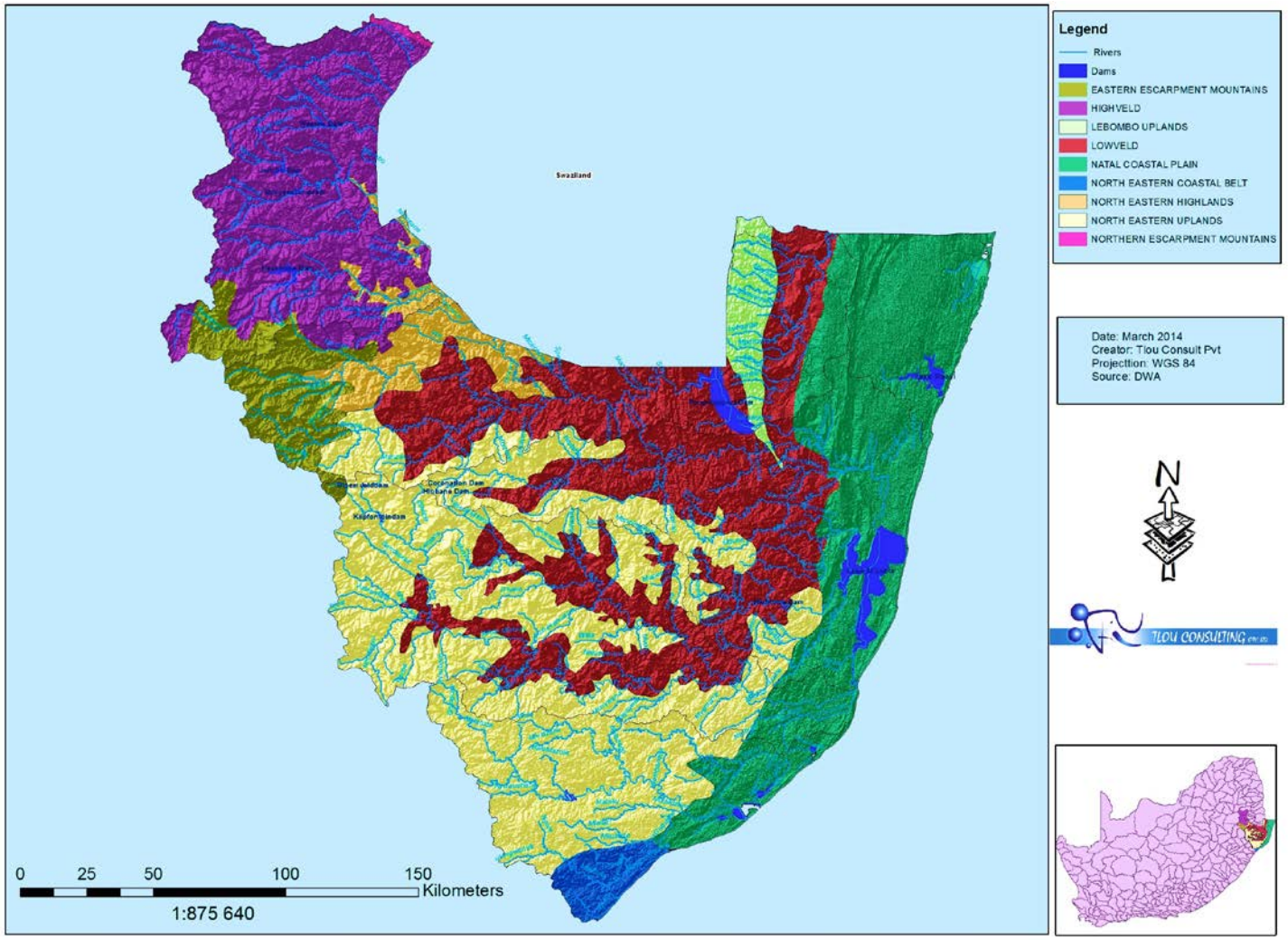


Figure 3-1 Level 1 Ecoregions in the study area (after Kleynhans *et al.* 2005)

3.1.2 Tier II: Hydrological Index Classes

Hydrological Index (Hydl) values determined by Hughes and Hannart (2003) to characterise hydrological variability at a quaternary catchment level throughout South Africa have been grouped into nine statistical classes using an automated version of the Worsley Likelihood Ratio test (Worsley 1979; Dollar et al. 2006; Table 3-3). The values for the hydrological index classes (Dollar et al. 2006) in the study area varied between 2 and 5, exhibiting permanently flowing characteristics.

Table 3-3 Hydrological index classes after Worsley (1979) and Dollar et al. (2006)

Class	Hydrological index (HI) thresholds
1	HI ≤ 4.394
2	4.394 < HI ≤ 7.535
3	7.535 < HI ≤ 13.745
4	13.745 < HI ≤ 16.110
5	16.110 < HI ≤ 37.819
6	37.819 < HI ≤ 64.169
7	64.169 < HI ≤ 92.705
8	92.705 < HI ≤ 98.124
9	98.124 < HI

Tier II nodes should be allocated at quaternary boundaries where there is a change in HydI Class. In all cases, the required Tier II establishment had already been fulfilled in Tier I, and no additional nodes were added for Tier II.

3.1.3 Tier III: Geomorphologic zones

Ecoregional differences notwithstanding, streams and rivers change naturally along their length with respect to temperature, depth, current speed, substratum, turbidity (clarity) and chemical composition. These factors are important determinants of the distribution of the animals and plants, and thus the longitudinal physical and chemical changes are reflected in changes in the composition of the animal and plant communities. The result is a longitudinal biotic zonation that can be used to classify reaches of rivers. These zones are not discrete and attempts to define them in terms of a single variable have been unsatisfactory. Generally speaking, however, the rivers in South Africa can be divided into ten zones (Table 3-4).

Tier III nodes were inserted:

- at quaternary boundaries where >75% of the upstream quaternary was comprised a different geomorphic zone from the downstream quaternary. Where Tier III nodes coincided with Tier I or II nodes, no further nodes were inserted; and
- upstream of a change in ecosystem type, e.g. at the head of the estuary.

Allocation of Tier III nodes in accordance with the rules in Table 3-1 yielded 10 additional nodes for the catchment (**Figure 3-3**). Total nodes after Tier III = 30.

3.1.4 Tier IV: Significant tributaries

The number of nodes designated in the catchment increased markedly with this tier, mainly because each tributary requires the establishment of two nodes, i.e. one on each river upstream of the confluence.

For the purposes of the project, it was recommended that significant resources be defined as:

- Mainstem river courses in each quaternary catchment, which has been created for the whole country using the Department of Water Affairs, 1:500 000 GIS rivers coverage (http://www.dwa.gov.za/IWQS/gis_data/river/rivs500k.html); excluding 1st order tributaries (as defined by the 1:500 000 coverage).

The reduction in complexity afforded by the exclusion of 1st order tributaries was necessary in addressing the project at a realistic level of detail given the available data in the catchment for EWR assessments.

Allocation of Tier IV nodes in accordance with the rules in Table 3-1 yielded 12 additional nodes for the catchment (**Figure 3-3**). Total nodes after Tier IV = 42.

The Mfolozi and Mkuze catchments have fewer nodes compared to other catchments as a result of the exclusion of 1st order tributaries.

Table 3-4 Geomorphological zonal classification for South African rivers (Rowntree et al. 2000)

Zone	Code	Gradient Class	Characteristics of the channel features
Zonation associated with a normal profile			
Source zone	S	Not specified	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	A	>0.1	A very steep gradient stream dominated by vertical flow over bedrock within waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
Mountain stream	B	0.04 - 0.099	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types incluade cascades, bedrock fall, step-pools. Approximate equal distribution of 'vertical' and 'horizontal' flow components.
Transitional	C	0.02 - 0.039	Moderately steep stream dominated by bedrock or bolders. Reach types include, plane bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited floodplain development.
Upper Foothills	D	0.005 - 0.019	Moderately steep cobble bed or mixed bedrock-cobble bed channel, with plain bed, pool riffle or pool rapid reach types. Length of pools and riffle/rapids similar. Narrow floodplain of sand, gravel or cobble often present.
Lower Foothills	E	0.001- 0.005	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Flood plain often present.
Lowland River	F	0.0001-0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks
Zone	Zone Class	Gradient Class	Characteristic Channel Profile
B. Zones associated with a rejuvenated profile			
Rejuvenated bedrock fall / cascades		>0.02	Moderate to steep gradient, often confined channel (gorge) resulting from uplift in the middle to lower reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades, and pool-rapid.
Rejuvenated foothills	DEr	0.001 - 0.019	Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/ pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel activated only during infrequent flood events. A flood plain may be present between the active and macro-channel.
Upland flood plain	Fr	<0.005	An upland low gradient channel often associated with uplifted plateau areas as occur beneath the eastern escarpment.

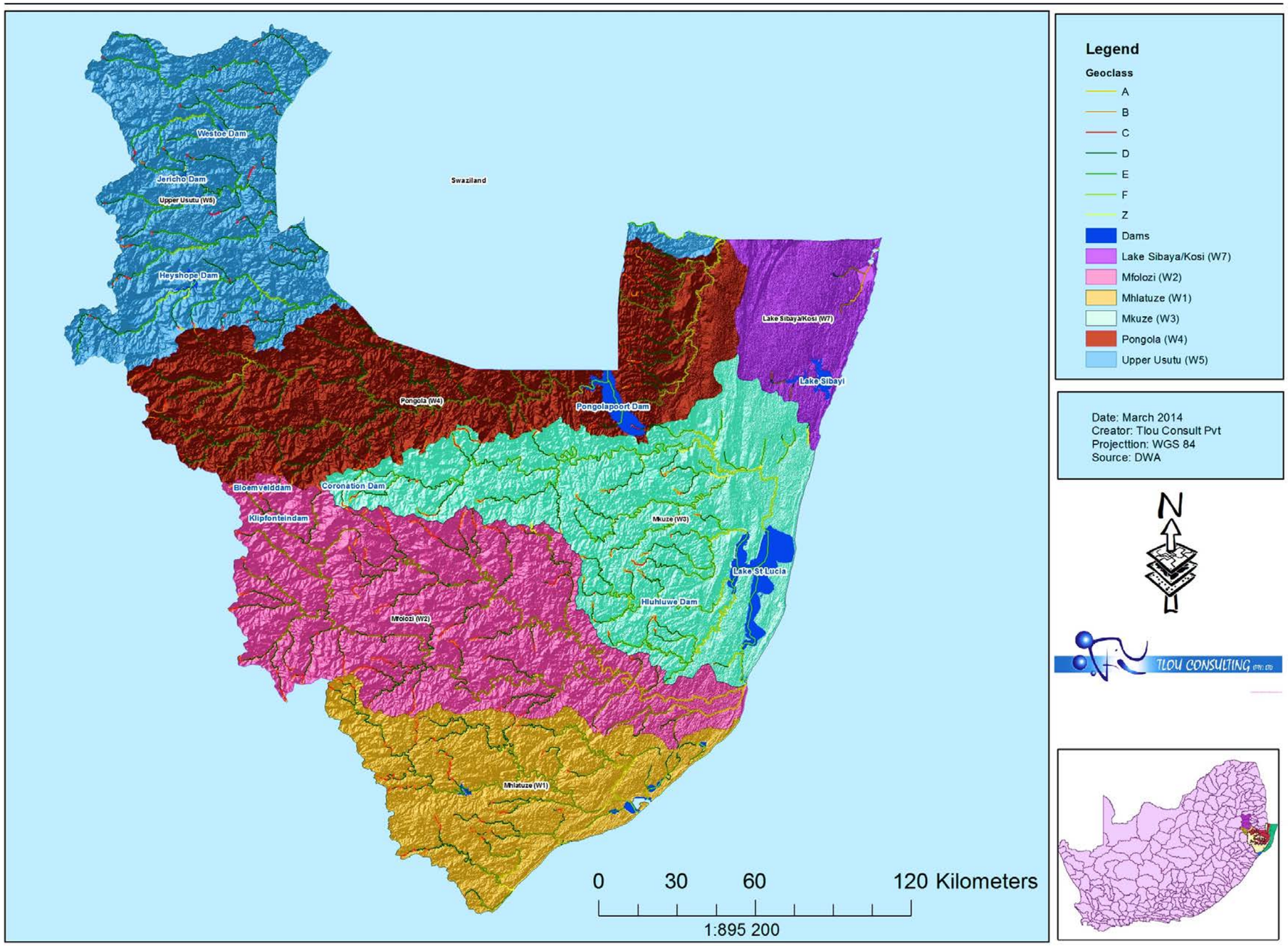


Figure 3-2 Geomorphological zonation of the study rivers

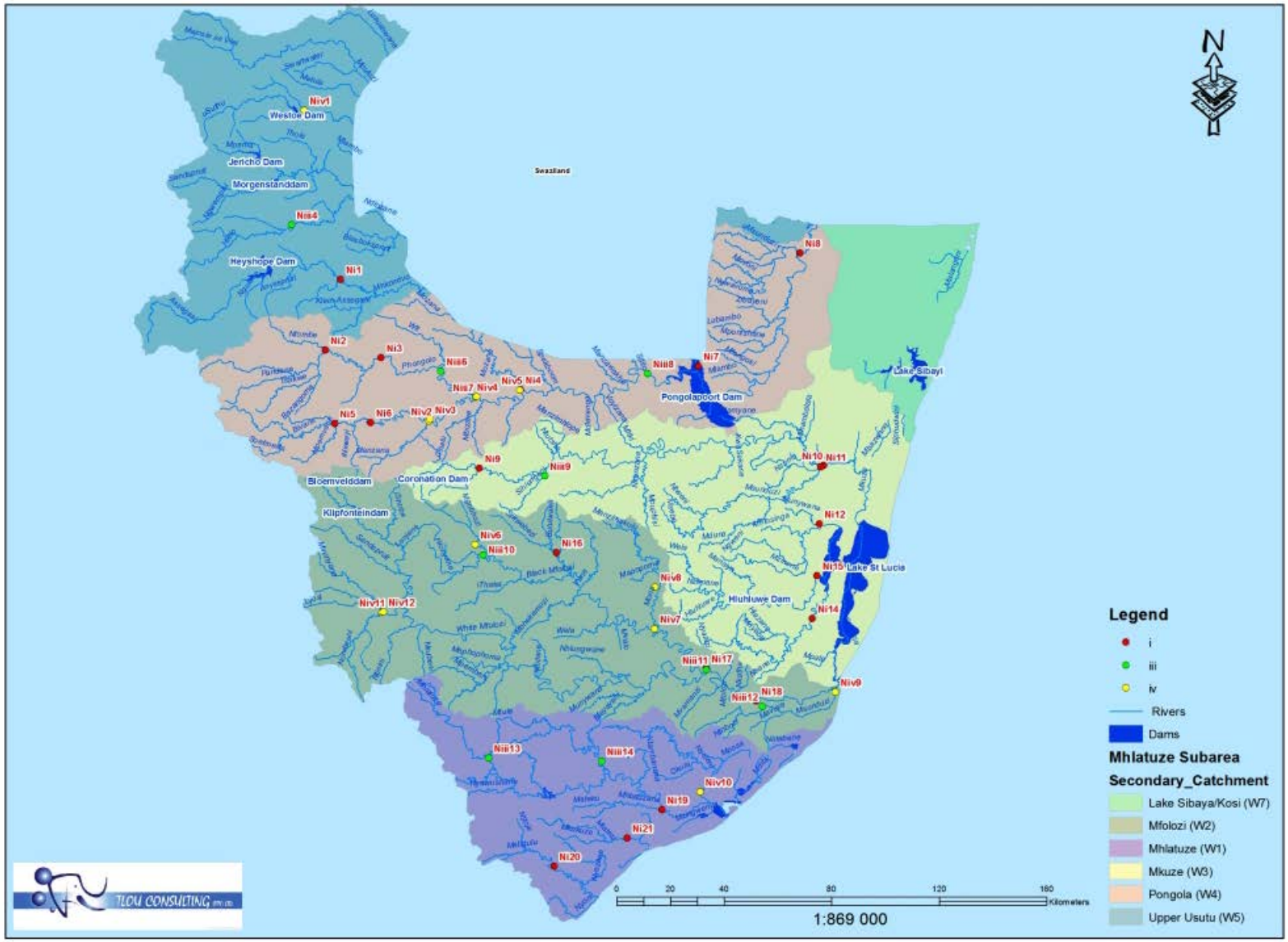

N
Swaziland
Westoe Dam
Jericho Dam
Morgenstanddam
Heyshope Dam
Pongolapoort Dam
Lake Sibayi
Bloemveldam
Coronation Dam
Klipfonteindam
Hluhluwe Dam
Lake St Lucia
Legend
i
iii
iv
Rivers
Dams
Mhlatuze Subarea
Secondary_Catchment
Lake Sibaya/Kosi (W7)
Mfolozi (W2)
Mhlatuze (W1)
Mkuze (W3)
Pongola (W4)
Upper Usutu (W5)
0 20 40 80 120 160
Kilometers
1:869 000
TLOU CONSULTING

Figure 3-3 Study area, with Tier I to IV node designations depicted

3.1.5 Tier V: Ecological Importance and Sensitivity (EISC)

The information used for the EISC was obtained from the desktop estimate of ecological importance and sensitivity developed for the national Water Situation Assessment Model (WSAM) to depict river integrity in South Africa (Kleynhans, 2000) (Figure 3-4). It was the opinion of the specialists on the team that the updated PES, EI & ES study would not have an effect on the position of nodes on the study area. The nodal delineation process was therefore not updated with the information from the recent DWA study (2013b) to update the PES, EI and ES of all rivers in South Africa.

Nodes were allocated at each quaternary/river intersection downstream of high or very high EISC reach (Figure 3-7).
Allocation of Tier V nodes in accordance with the rules in Table 3-1 yielded one additional node for the catchment. Total nodes after Tier V = 43.

3.1.6 Tier VI: Present Ecological Status (PES)/ Habitat Integrity (HI)

The information used for the PES/HI was obtained from the desktop estimate of PES developed for the national WSAM to depict river integrity in South Africa (Kleynhans, 2000) (Figure 3-5).
To avoid the over-allocation of nodes, the following PES/HI categories were combined:

- categories A and B; and
- categories E and F.

Thereafter, Tier VI nodes were allocated at quaternary boundaries where >75% of the upstream quaternary is comprised of a different PES/HI from the downstream quaternary. In some cases, the required Tier VI designation had already been fulfilled in Tier I to V, in which case no additional allocation was made. Allocation
with the rules in Table 3-1 yielded zero additional nodes for the catchment. Total nodes after Tier VI = 43.

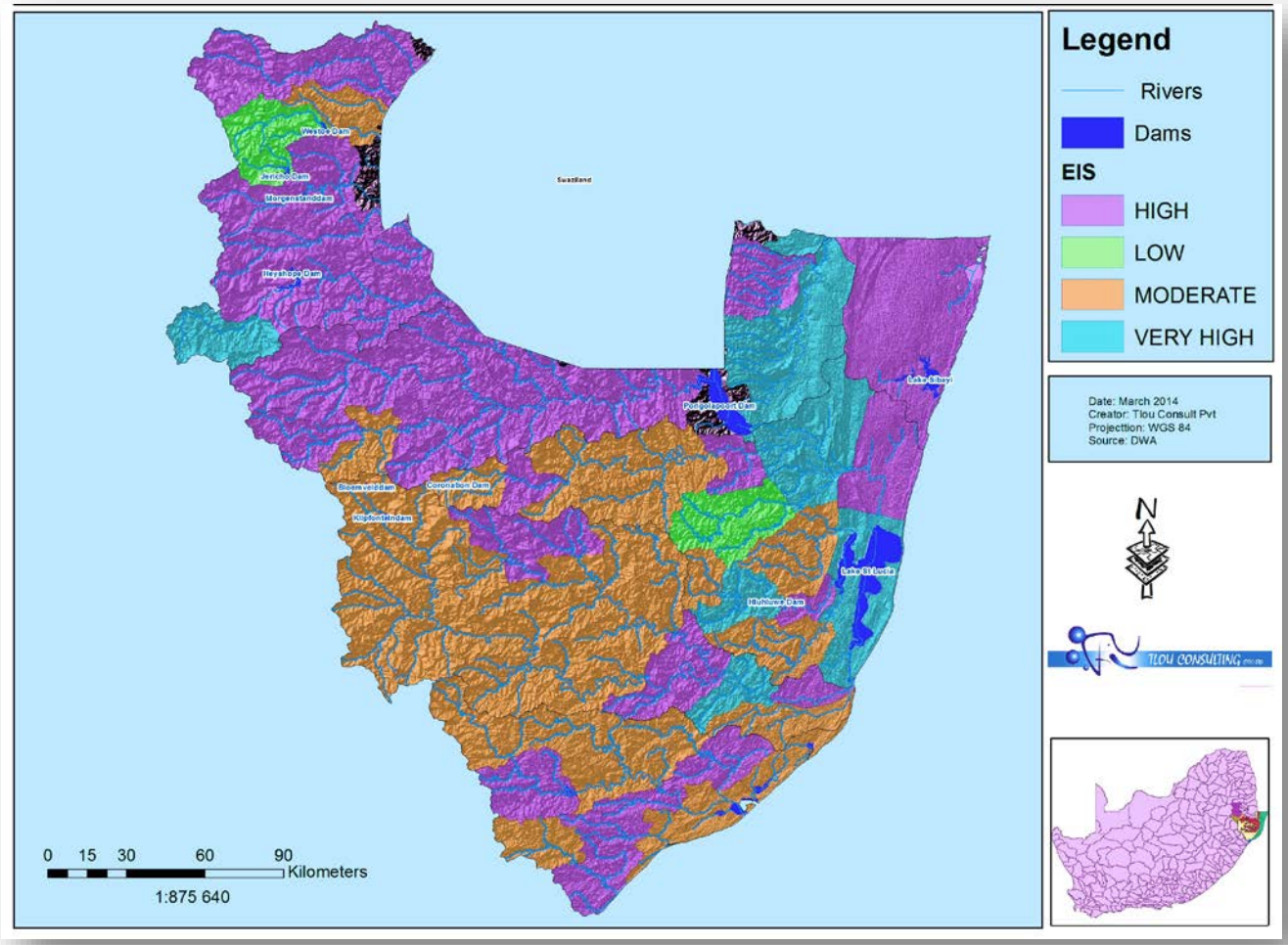


Figure 3-4 Ecological Importance and Sensitivity (EISC) of the study rivers (Kleynhans, 2000)

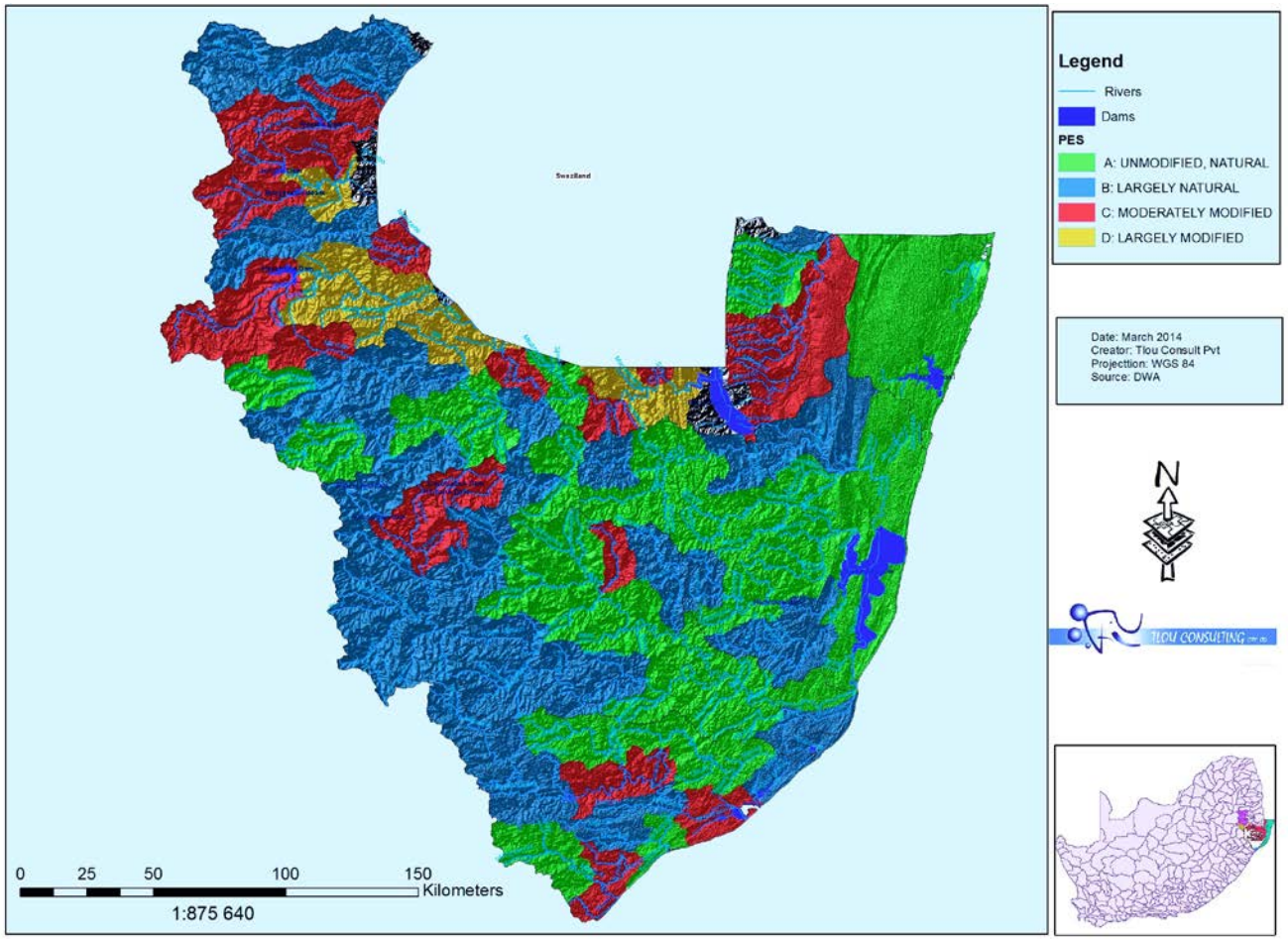


Figure 3-5 Present Ecological Status (PES) of the study rivers (Kleynhans, 2000)

3.1.7 Tier VI: Infrastructure

A description of the water resource infrastructure for the study area is provided in DWA (2004) (Figure 3-6).

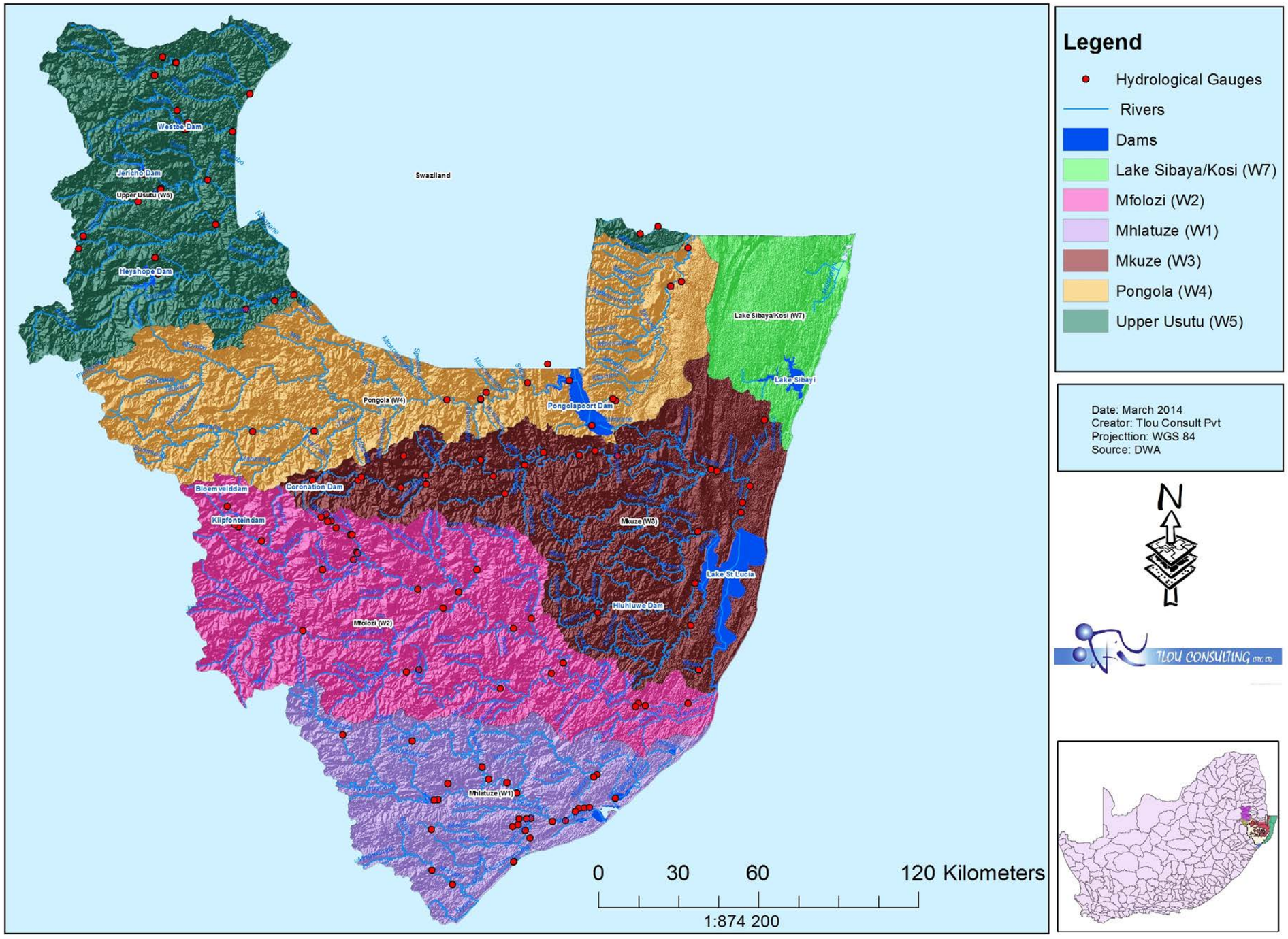
This tier comprises both a nodes augmentation and a node rationalisation exercise. Nodes should be added to the existing suite of nodes:

- at DWA gauging weirs;
- at the upstream end of major impoundments, e.g. Westoe Dam, Goedertrouw Dam, Mhlatuze Lagoon and Hluhluwe Dam;
- on a river immediately upstream of the confluence with an International Basin Transfer (IBT);
- on a river immediately upstream of the influence of a town, mine or other locale likely to have a major impact on water quality; and
- at the quaternary intersection where the area covered by farm dams in the upstream quaternary is >5 times that of the downstream qua ternary.

Nodes should be removed from the existing suite of nodes if:

- they are inundated by an impoundment; and
- they are located such that they will describe an upstream section of river for which no description is required, e.g. a dam.

Allocation and/or removal of Tier VII nodes in accordance with the rules in Table 3-1 yielded seven additional nodes for the catchment. One node was removed due to inundation by Pongolapoort Dam. Total nodes after Tier VII = 49.


Swaziland
Westoe Dam
Jericho Dam
Upper Usutu (W5)
Heyshope Dam
Pongola (W4)
Pongolapoort Dam
Lake Sibaya/Kosi (W7)
Lake Sibayi
Bloemveldam
Coronation Dam
Klipfontein dam
Mkuze (W3)
Lake St Lucia
Hluhluwe Dam
Mfolozi (W2)
Mhlatuze (W1)
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1:874 200
Legend
Hydrological Gauges
Rivers
Dams
Lake Sibaya/Kosi (W7)
Mfolozi (W2)
Mhlatuze (W1)
Mkuze (W3)
Pongola (W4)
Upper Usutu (W5)
Date: March 2014
Creator: Tlou Consult Pvt
Projecttion: WGS 84
Source: DWA
N
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Figure 3-6 DWA Gauging stations in the study area

3.2 NWRCS River Nodes

A total of 49 river reaches were defined in the study area. The results of Tier I to VI river node selection are depicted in Figure 3-7 and the attributes of the reaches represented by each node are given in Table 3-5.

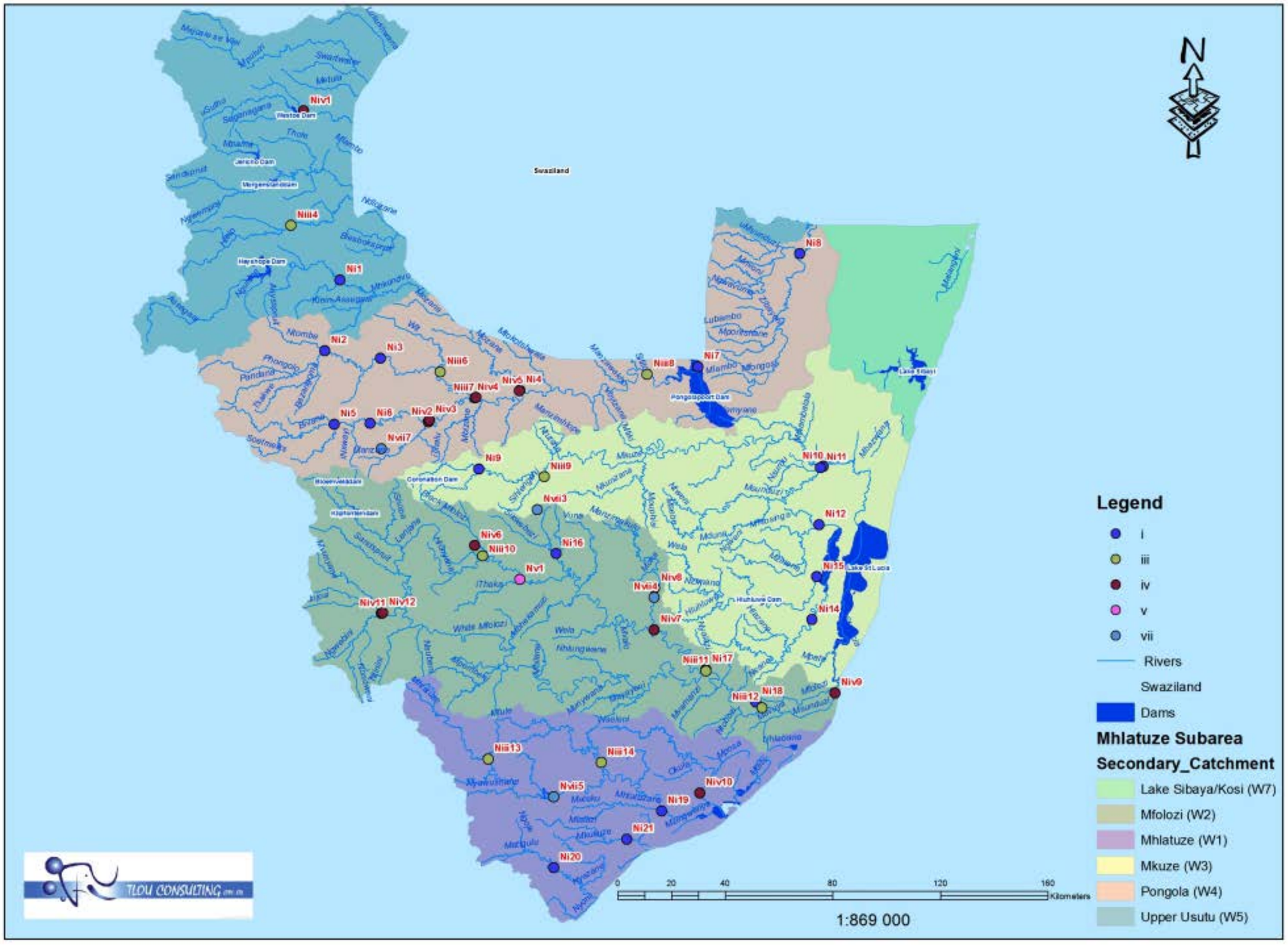

N
Swaziland
Legend
i
iii
iv
v
vii
Rivers
Swaziland
Dams
Mhlatuze Subarea
Secondary_Catchment
Lake Sibaya/Kosi (W7)
Mfolozi (W2)
Mhlatuze (W1)
Mkuze (W3)
Pongola (W4)
Upper Usutu (W5)
0 20 40 80 120 160
Kilometers
1:869 000
TLOU CONSULTING

Figure 3-7 Nodes delineated for the study rivers

Table 3-5 Key attributes of the reaches represented by each node

NO.	NODE	Quaternary	Ecoregion	Geomorph. zone	River name	X coordinate	Y coordinate	HI class	PES	EIS	Infrastructure
1	Ni4	W42L	Lowveld	LFH	Mozana	31,35625	-27.41635	2	C	HIGH	
2	Ni6	W41D	Lowveld	UFH	Bivane	30,8561	-27.52753	2	B	MODERATE	
3	Ni8	W43F	Lowveld	LLZ	Ngwavuma	32,29197	-26.96020	2	A	HIGH	
4	Ni16	W22E	Lowveld	UFH	SikweBezi	31,47766	-27.96254	3	A	HIGH	
5	Ni17	W22L	Lowveld	LFH	Black Mfolozi	31,97805	-28.34883	3	A	HIGH	
6	Niii6	W42E	Lowveld	UFH	Phongolo	31,09065	-27.35519	2	B	HIGH	
7	Niii7	W41G	Lowveld	UFH	Bivane	31,20714	-27.44259	2	A	HIGH	
8	Niii8	W44C	Lowveld	LFH	Phongolo	31,7824	-27.36285	2	C	HIGH	
9	Niii9	W31B	Lowveld	UFH	Mkuze	31,43851	-27.70555	3	B	HIGH	
10	Niii11	W21L	Lowveld	LFH	White Mfolozi	31,97911	-28.35399	4	A	HIGH	
11	Niv2	W41F	Lowveld	UFH	Manzana	31,0501	-27.52279	2	B	HIGH	
12	Niv3	W41E	Lowveld	UFH	Bivane	31,05372	-27.51596	2	A	HIGH	
13	Niv4	W42G	Lowveld	LFH	Phongolo	31,20912	-27.44075	2	A	HIGH	
14	Niv5	W42J	Lowveld	LFH	Phongolo	31,35428	-27.41834	2	B	HIGH	
15	Niv6	W22A	Lowveld	UFH	Black Mfolozi	31,20504	-27.93534	3	B	HIGH	
16	Niv8	W22K	Lowveld	LFH	Mona	31,80769	-28.21695	4	B	MODERATE	
17	Nvii4	W32E	Lowveld	LFH	Nzimane	32,0974	-28.10768	5	A	VERY HIGH	Hluhluwe Dam
18	Nvii7	W31G	Lowveld	LFH	Mkuze	31,95639	-27.61173	3	A	MODERATE	IBT
19	Ni1	W51C	North Eastern Highlands	LFH	Assegaai	30,75479	-27.04733	3	D	HIGH	
20	Ni3	W42D	North Eastern Highlands	LFH	Phongolo	30,89032	-27.30919	2	B	HIGH	
21	Niii4	W52B	Highveld	LLZ	Ohlelo	30,59102	-26.86572	2	B	HIGH	
22	Niv1	W54C	Highveld	LFH	Bonnie Brook	30,63386	-26.48266	2	B	MODERATE	
23	Nvii1	W54B	Highveld	LLZ	Usuthu	30,57825	-26.46128	2	C	LOW/MARGINAL	Westoe Dam
24	Nvii2	W53A	Highveld	LFH	Ngwempisi	30,48574	-26.74071	2	C	HIGH	Morgenstond Dam
25	Ni10	W31J	Natal Coastal Plain *Changed to Lowveld as >50% in Lowveld	LLZ	Mkuze	32,37049	-27.67097	4	B	VERY HIGH	
26	Ni11	W31L	Natal Coastal Plain	LFH	Msunduzi	32,36204	-27.67467	4	A	VERY HIGH	
27	Ni12	W32C	Natal Coastal Plain	LLZ	Mzinene	32,35727	-27.86522	5	A	MODERATE	
28	Ni14	W32G	Natal Coastal Plain	LLZ	Nylalazi	32,33392	-28.18285	5	B	MODERATE	
29	Ni15	W32F	Natal Coastal Plain	LLZ	Hluhluwe	32,34966	-28.03978	5	B	HIGH	
30	Ni18	W23A	Natal Coastal Plain	LLZ	Mfolozi	32,14562	-28.45770	3	A	VERY HIGH	
31	Ni19	W12E	Natal Coastal Plain	LFH	Mhlatuze	31,83037	-28.82204	3	B	HIGH	
32	Ni21	W13A	Natal Coastal Plain	LFH	Mlalazi	31,71411	-28.91608	3	B	HIGH	
33	Niii12	W23B	Natal Coastal Plain	LFH	Msunduzi	32,16677	-28.47670	3	A	MODERATE	
34	Niv9	W23C	Natal Coastal Plain	LLZ	Msunduzi	32,41066	-28.42763	3	B	MODERATE	
35	Niv10	W12H	Natal Coastal Plain	LLZ	Nseleni	31,95863	-28.76176	3	A	HIGH	
36	Nvii3	W32B	Natal Coastal Plain	LLZ	Mkuze	32,50882	-27.81470	3	A	HIGH	Lake St Lucia
37	Nvii6	W12F	Natal Coastal Plain	LLZ	Mhlatuze	32,00668	-28.80220	3	C	MODERATE	Mhlatuze Lagoon
38	Ni5	W41B	North Eastern Uplands	LFH	Bivane	30,73542	-27.53004	2	A	HIGH	
39	Ni9	W31A	North Eastern Uplands	UFH	Nkongolwana	31,21984	-27.67941	3	C	MODERATE	
40	Niii10	W22B	North Eastern Uplands	UFH	Hlonyane	31,23162	-27.97030	3	B	MODERATE	
41	Niii13	W12A	North Eastern Uplands	UFH	Mhlatuze	31,25158	-28.64861	3	B	MODERATE	
42	Niii14	W12C	North Eastern Uplands	UFH	Mfule	31,62934	-28.65987	3	A	MODERATE	
43	Niv7	W22J	North Eastern Uplands	LFH	Black Mfolozi	31,80621	-28.21650	3	A	MODERATE	
44	Niv11	W21E	North Eastern Uplands	LFH	Nondweni	30,89285	-28.16235	3	B	MODERATE	
45	Niv12	W21D	North Eastern Uplands	LFH	Mvunyane	30,89737	-28.16019	3	B	MODERATE	
46	Nv1	W22C	North Eastern Uplands	LFH	Black Mfolozi	31,35589	-28.04783	3	A	HIGH	
47	Nvii5	W12B	North Eastern Uplands	UFH	Mhlatuze	31,41476	-28.77518	3	B	HIGH	Goedertrouw Dam
48	Ni2	W42B	Eastern escarpment mountains	LLZ	Phongolo	30,70339	-27.28400	2	B	HIGH	
49	Ni20	W11A	North Eastern Coastal Belt	UFH	Matigulu	31,46986	-29.01161	3	A	MODERATE	

*Changed the ecoregion for Ni10 (25) to reflect >50% of catchment in Ecoregion 3 – Lowveld.

4 SELECTION OF RIVER EWR SITES FOR INTERMEDIATE-LEVEL DETERMINATIONS

4.1 Why select EWR Sites

The river EWRs that are required as part of the Ecological Reserve determination are based on flow characteristics at a site, such as depth and velocity, linked to habitat requirements for key biota at that site. These sites are referred to as EWR Sites. To facilitate determination of the consequences for the riverine ecosystem of changes in flow, and thus changes in parameters such as depth or velocity, such EWR sites should ideally meet many criteria, the most important being that they should represent critical and varied habitats. Other criteria include (from Louw and Birkhead 1998):

- The locality of gauging weirs with good quality hydrological data
- The locality of the proposed and existing developments
- The locality and characteristics of tributaries
- The PES of the different river reaches
- The reaches where social communities depend on a healthy river ecosystem
- The suitability of the sites for follow-up monitoring
- The habitat diversity for aquatic organisms, marginal and riparian vegetation
- The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows
- Accessibility to the sites
- An area or site that could be critical for ecosystem functioning, e.g., riffle units
- The locality of geomorphologically representative sites.

4.2 Site selection process and team

The site selection process comprised three steps:

1. An evaluation of delineation data and grouping of similar river reaches;
2. Identification of possible locations for EWR sites based on availability of relevant information;
3. Field verification of short-listed EWR sites and final selection.

This study is limited to eight river Intermediate EWR sites. Thus, one of the main aims was to maximise the geographical coverage of the sites at which Intermediate EWRs will be done, so that the results of those assessments can be extrapolated to as much of the remaining catchment as possible.

4.2.1 An evaluation of delineation data and grouping of similar river reaches

The river reaches identified in Section 3.2 were grouped in terms of their geomorphological and biological similarities. Twelve groups of rivers (Groups A-L) were identified across the study area (Table 4-1).

The river reaches within each group were then in terms of where data that would be useful in an EWR assessment were available, such as (Table 4-1):

- DWA gauging data;
- RHP data;
- EWR data from previous Reserve studies.

Team members participating in the delineation and resource grouping process included:

- Adhishri Singh
- Cate Brown
- Alison Joubert
- Colleen Todd
- Washington Nyabeze
- James McKenzie
- Gary Marneweck.
- Heather Malan

4.2.2 Identification of possible locations for EWR sites based on availability of relevant information

Within each group, river reaches with potential as locations of EWR sites were identified. These were then further investigated using maps, and the locations of possible EWRs were identified on the basis of river characteristics, habitats and access to sites (Table 4-1).

Investigations of potential sites was undertaken by:

- Adhishri Singh
- Colleen Todd.

Thirty potential locations of EWR sites were identified on the following rivers (Table 4-1):

- Assegaai River
- Upper Pongola River
- Black Mfolozi River
- White Mfolozi River
- Mfolozi River
- Mkuze River
- Nyalazi River

Table 4-1 Assessment of river reaches in the study area

River group	NO.	TIER	NODE	QUAT	Eco region no.	ZONE	RIVER	HI class	PES	EIS	WATER RESOURCE INFRASTRUCTURE	DWA GAUGE	AVAILABILITY OF DATA	DESKTOP EVALUATION OF SITES
A	19	i	Ni1	W51C	4	LFH	Assegaai	3	D	HIGH		W5H035	JMBS EWR Site	Existing EWR site identified as potential study site.
	20	i	Ni3	W42D	4	LFH	Phongolo	2	B	HIGH				No suitable sites identified
B	22	iv	Niv1	W54C	11	LFH	Bonnie Brook	2	B	MODERATE		W5H025		No suitable sites identified
	24	vii	Nvii2	W53A	11	LFH	Ngwempisi	2	C	HIGH	Morgenstond Dam	W5 W5H038 W5H034		No suitable sites identified
C	26	i	Ni11	W31L	13	LFH	Msunduzi	4	A	VERY HIGH				No suitable sites identified
	31	i	Ni19	W12E	13	LFH	Mhlatuze	3	B	HIGH			Existing EWR 2	Existing EWR site identified as potential study site.
	32	i	Ni21	W13A	13	LFH	Mlalazi	3	B	HIGH		W1H004 W1H025		No suitable sites identified
	33	iii	Niii12	W23B	13	LFH	Msunduzi	3	A	MODERATE				No suitable sites identified
D	38	i	Ni5	W41B	14	LFH	Bivane	2	A	HIGH				No suitable sites identified
	43	iv	Niv7	W22J	14	LFH	Black Mfolozi	3	A	MODERATE		W2H024		No suitable sites identified
	44	iv	Niv11	W21E	14	LFH	Nondweni	3	B	MODERATE				No suitable sites identified
	45	iv	Niv12	W21D	14	LFH	Mvunyane	3	B	MODERATE				No suitable sites identified
	46	v	Nv1	W22C	14	LFH	Black Mfolozi	3	A	HIGH				Four potential sites identified
E	10	iii	Niii11	W21L	3	LFH	White Mfolozi	4	A	HIGH		W2H002		Two potential sites identified
	16	iv	Niv8	W22K	3	LFH	Mona	4	B	MODERATE		W2H025		No suitable sites identified
	17	vii	Nvii4	W32E	3	LFH	Nzimane	5	A	VERY HIGH	Hluhluwe Dam	W3H019		No suitable sites identified
	1	i	Ni4	W42L	3	LFH	Mozana	2	C	HIGH				No suitable sites identified
	5	i	Ni17	W22L	3	LFH	Black Mfolozi	3	A	HIGH		W2H001		No suitable sites identified
	8	iii	Niii8	W44C	3	LFH	Phongolo	2	C	HIGH		W4H003		No suitable sites identified
	13	iv	Niv4	W42G	3	LFH	Phongolo	2	A	HIGH				No suitable sites identified
	14	iv	Niv5	W42J	3	LFH	Phongolo	2	B	HIGH				No suitable sites identified
	18	vii	Nvii7	W31G	3	LFH	Mkuze	3	A	MODERATE	IBT	W3H029 W3H028		No suitable sites identified
F	21	iii	Niii4	W52B	11	LLZ	Ohlelo	2	B	HIGH				No suitable sites identified
	23	vii	Nvii1	W54B	11	LLZ	Usuthu	2	C	LOW/MARGINAL	Westoe Dam	W5H036 W5H037 W5H033 W5H032		No suitable sites identified
G	30	i	Ni18	W23A	13	LLZ	Mfolozi	3	A	VERY HIGH		W2H009	Previous rapid	Previous rapid site identified as potential study site.
	34	iv	Niv9	W23C	13	LLZ	Msunduzi	3	B	MODERATE				No suitable sites identified
	35	iv	Niv10	W12H	13	LLZ	Nseleni	3	A	HIGH		W1H022 W1H023	Existing EWR 6	Existing EWR site identified as potential study site.
	36	vii	Nvii3	W32B	13	LLZ	Mkuze	3	A	HIGH	Lake St Lucia	W3H008 W3H009 W3H014 W3H015 W3H016		No sites identified in floodplain area
	37	vii	Nvii6	W12F	13	LLZ	Mhlatuze	3	C	MODERATE	Mhlatuze Lagoon	W1H021 W1H036 W1H033 W1H031 W1H034 W1H035	Existing EWR site EWR 3 & 4	Sites did not look suitable, but since location was deemed important, site visit was proposed
	27	i	Ni12	W32C	13	LLZ	Mzinene	5	A	MODERATE		W3H010		No suitable sites identified
	28	i	Ni14	W32G	13	LLZ	Nylalazi	5	B	MODERATE		W3H011		One possible site identified
	29	i	Ni15	W32F	13	LLZ	Hluhluwe	5	B	HIGH		W3H002		No suitable sites identified
H	48	i	Ni2	W42B	15	LLZ	Phongolo	2	B	HIGH				No suitable sites identified
I	3	i	Ni8	W43F	3	LLZ	Ngwavuma	2	A	HIGH				No suitable sites identified
	25	i	Ni10	W31J	3	LLZ	Mkuze	4	B	VERY HIGH				Four potential sites identified
J	39	i	Ni9	W31A	14	UFH	Nkongolwana	3	C	MODERATE		W3H021 W3H022 W3H017		No suitable sites identified
	40	iii	Niii10	W22B	14	UFH	Hlonyane	3	B	MODERATE		W2H019 W2H028 W2H006		No suitable sites identified

River group	NO.	TIER	NODE	QUAT	Eco region no.	ZONE	RIVER	HI class	PES	EIS	WATER RESOURCE INFRASTRUCTURE	DWA GAUGE	AVAILABILITY OF DATA	DESKTOP EVALUATION OF SITES
	41	iii	Niii13	W12A	14	UFH	Mhlatuze	3	B	MODERATE		W1H024		No suitable sites identified
	42	iii	Niii14	W12C	14	UFH	Mfule	3	A	MODERATE		W1H005 W1H026		No suitable sites identified
	47	vii	Nvii5	W12B	14	UFH	Mhlatuze	3	B	HIGH	Goedertrouw Dam			No suitable sites identified
K	49	i	Ni20	W11A	17	UFH	Matigulu	3	A	MODERATE		W1H010		Four sites identified
L	2	i	Ni6	W41D	3	UFH	Bivane	2	B	MODERATE		W4H001		No suitable sites identified
	4	i	Ni16	W22E	3	UFH	SikweBezi	3	A	HIGH				No suitable sites identified
	6	iii	Niii6	W42E	3	UFH	Phongolo	2	B	HIGH				One potential site identified
	7	iii	Niii7	W41G	3	UFH	Bivane	2	A	HIGH		W4H013	IFR study for Bivane Dam	No suitable sites identified
	9	iii	Niii9	W31B	3	UFH	Mkuze	3	B	HIGH		W3H024		No suitable sites identified
	11	iv	Niv2	W41F	3	UFH	Manzana	2	B	HIGH				No suitable sites identified
	12	iv	Niv3	W41E	3	UFH	Bivane	2	A	HIGH				No suitable sites identified
	15	iv	Niv6	W22A	3	UFH	Black Mfolozi	3	B	HIGH		W2H013 W2H014 W2H015 W2H012 W2H016 W2H017 W2H018 W2H007		One potential site identified

- Mhlatuze River
- Nseleni River
- Matigulu River.

4.2.3 Field verification of short-listed EWR sites and final selection

The identified locations were visited between 16th and 24th September 2013. The site selection team comprised:

- Cate Brown
- Adhishri Singh
- Tobias Sibande.

Flow in the rivers at the time was moderate. The weather was excellent, and several alternative sites were visited before an EWR site was finally selected.

The locations visited are indicated in Figure 4-1 and Table 4-2**,** and a photographic record with a short description of each site visited is provided in Appendix B**.**

Figure 4-1 Map of routes taken and sites visited for river site selection (indicated by the flags).

Table 4-2 Locations visited between 16th and 24th September 2013

River group	Node no.	Node	Quaternary	RIVER	Locations visited	Latitude	Longitude
A	19	Ni1	W51C	Assegaai	JMB2	27 0 3'44.22"S	30 0 59'19.68"E
C	31	Ni19	W12E	Mhlatuze	EWR 1	28°44'34.90"S	31°36'20.80"E
					EWR 2	28°44'49.00"S	31°44'50.80"E
D	46	Nv1	W22C	Black Mfolozi	Pot 1	27 0 56'8.96"S	31 0 12'18.94"E
					Pot 2	28 0 0'56.29"S	31 0 20'13.89"E
					Pot 3	28° 0'50.04"S	31°19'27.48"E
					Pot 4	28°27'22.05"S	32o2'04.21"E
					Pot 5	28°02'08.86"S	31o21'20.49"E
E	10	Niii11	W21L	White Mfolozii	Pot 1	28 0 13'59.76"S	31 0 11'7.36"E
					Pot 2	28 0 20'51.41"S	31 0 21'2.98"E
					Pot 3	28°20'19.35"S	31°22'27.92"E
G	30	Ni18	W23A	Mfolozi	Rapid site	28°22'10.98"S	32° 0'44.34"E
	35	Niv10	W12H	Nseleni	EWR 6	28 0 38'4.07"S	31 0 55'52.73"E
	37	Nvii6	W12F	Mhlatuze	Pot 1	28 0 48'3.14"S	31 0 57'23.52"E
					Pot 2 (EWR 4)	28 0 48'23.80"S	31 0 57'6.86"E
					Pot 3 (EWR 3)	28 0 50'40.79"S	31 0 52'13.00"E
	28	Ni14	W32G	Nylalazi	Pot 1	28°13'10.10"S	32°19'9.90"E
I	25	Ni10	W31J	Mkuze	Pot 1	27 0 36'29.04"S	32 0 5'22.00"E
					Pot 2	27 0 36'40.72"S	32 0 4'59.29"E
					Pot 3	27 0 35'31.37"S	32 0 13'0.94"E
					Pot 4	27°35'55.30"S	32°18'7.00"E
K	49	Ni20	W11A	Matigulu	Pot 1	29 0 1'33.52"S	31 0 29'31.22"E
					Pot 2	29 0 1'29.33"S	31 0 28'18.09"E
					Pot 3	29 0 1'13.58"S	31 0 28'11.75"E
					Pot 4	29° 2'36.60"S	31°30'39.50"E
L	6	Niii6	W42E	Phongolo	Pot 1	27°21'50.90"S	30°58'10.60"E
					Pot 2	27°18'33.62" S	30°53'51.85"E
	15	Niv6	W22A	Black Mfolozi	Pot 1A	27 0 55'3.71"S	31 0 13'7.99"E

4.3 Intermediate EWR sites

Based on the results of the field assessments, 8 sites were selected, representing 7 river groupings (Table 4-2). These are listed in Table 4-3 and shown on Figure 4-2. Photographs of the selected EWR sites are provided in Figure 4-3 to Figure 4-10.

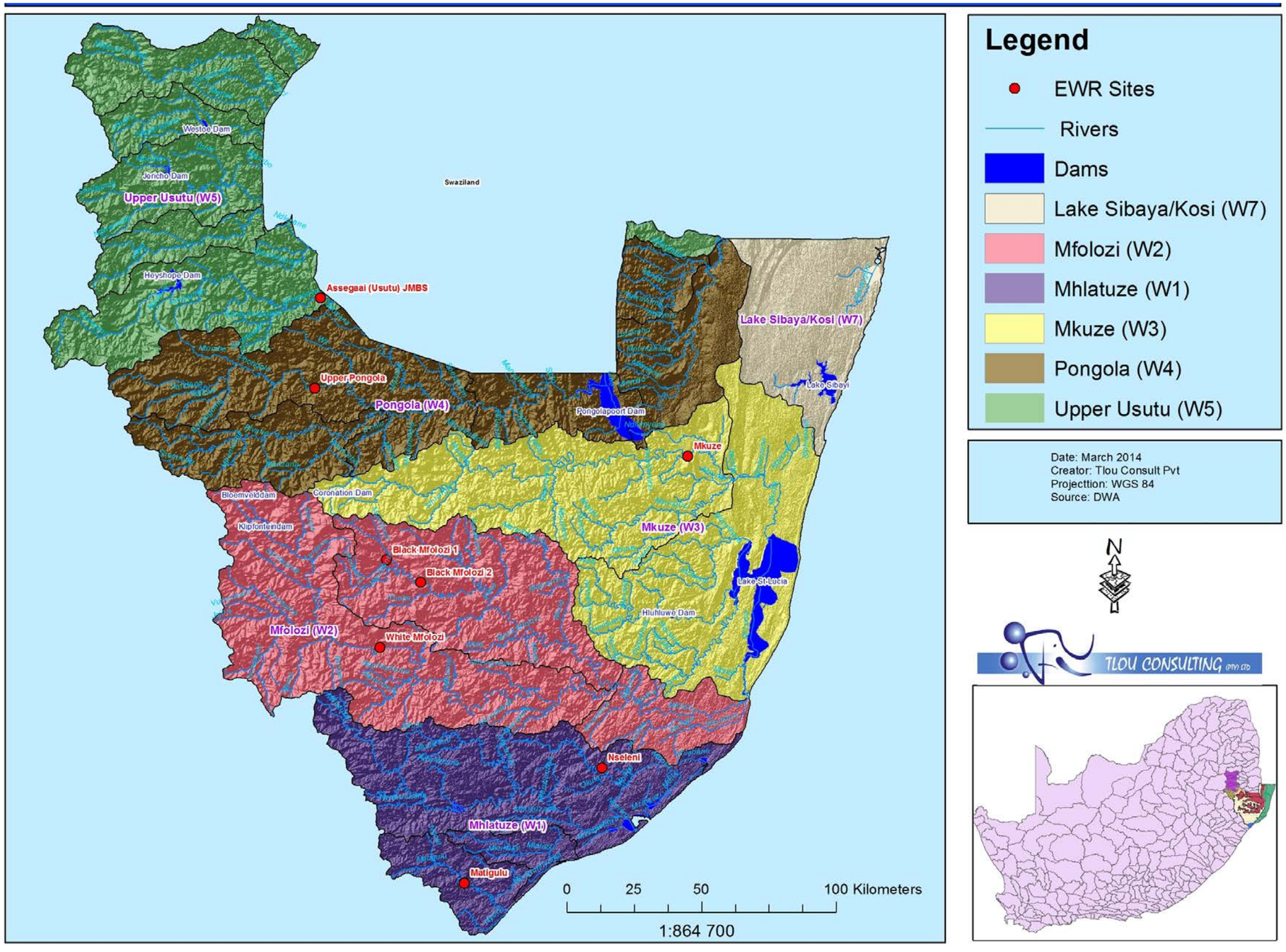
Table 4-3 EWR sites selected for intermediate EWR determinations

River group	Quaternary Catchment	River	Site Name	Description	Latitude	Longitude
A	W51D	Assegaai	EWR Site AS1	Downstream of Heyshope Dam, close to border with Swaziland. Good flow and habitat diversity	27º3'44.28"S	30º59'19.68"E
L	W42E	Upper Pongola	EWR Site UP1	Bedrock and riffles, good flow.	27º21'50.88"S	30º58'10.62"E
I	W31J	Mkuze	EWR Site MK1	Wide, sandy bed, with subsurface flow.	27º35'31.56"S	32º13'4.80"E
D	W22C	Black Mfolozi	EWR Site BM1	Bedrock and riffle section downstream of DWA gauging station W2H028. Distinct low flow channel and high flow zones	27º56'20.04"S	31º12'37.08"E
D	W22C	Black Mfolozi	EWR Site BM2	Distinct channel with bedrock and very large boulders	28º0'50.04"S	31º19'27.48"E
E	W21H	White Mfolozi	EWR Site WM1	Wide, flat river, with riffle area downstream of the old road drift/culvert	28º13'53.24"S	31º11'17.97"E
G	W12H	Nseleni	EWR Site NS1	Small river, with good habitat and relatively unimpacted	28º38'2.76"S	31º55'51.24"E
K	W11B	Matigulu	EWR Site MA1	Riffle downstream of old DWA gauging station.	29º1'12.36"S	31º28'13.44"E

Of the river groups identified in Table 4-1, five (Group B, C, F, H and J) do not have an EWR site located in them because:

- No suitable sites could be found as the rivers were either badly degraded or difficult to access (Group C and J);
- They comprised of river reaches situated in the headwaters of the Usutu Catchment where there are no proposed developments and which are low priorities for intermediate EWR assessments in the context of this study (Group B and F);

- They comprised of river reaches situated in the headwaters of the Pongola River (Group H) and where a more downstream EWR site was deemed more valuable for an intermediate level assessment.



Date: March 2014
Creator: Tlou Consult Pvt
Projecttion: WGS 84
Source: DWA

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Figure 4-2 Locations of intermediate EWR sites

Figure 4-3 EWR Site AS1 (Assegaai River at Zandbank 156HT/0)

Figure 4-4 EWR Site UP1 (Upper Pongola River at Bendor 211HT/1)

Figure 4-5 EWR Site MK1 (Mkuze River at Mkuze Game Reserve 17445)

Figure 4-6 EWR Site BM1 (Black Mfolozi at Ekuhlengeni 701HU/0)

Figure 4-7 EWR Site BM2 (Black Mfolozi at Stedham 867GU/0)

Figure 4-8 EWR Site WM 1 (White Mfolozi River at Langgewacht 235 GU)

Figure 4-9 EWR Site NS 1 (Nseleni River at Mhlana 16922/0)

Figure 4-10 EWR Site MA 1 (Matigulu River at Endondakusuka/Umlalazi)

5 REFERENCES

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Appendix A. DECRIPTION OF LEVEL 1 ECOREGIONS IN THE STUDY AREA

A.1. ECOREGION 3: LOWVELD

Primary boundary determinants:	This hot and dry region is characterised by plains with a low to moderate relief and vegetation consisting mostly of Lowveld Bushveld types. Open hills with high relief and low mountains with high relief are present towards the west on the boundary with the North Eastern Highlands. In the north Mopane Bushveld and Mopane Shrubveld occur.
General:	Several large perennial streams traverse this region, e.g. White and Black Umfolozi, Mkuze, Pongolo, Great Usutu, Komati, Crocodile, Sabie, Olifants, Letaba and Luvuvhu, but few perennial streams originate here.
Mean annual precipitation:	Moderate towards the west, but low over most of the region. Moderate variation.
Drainage density:	Mostly low, but high in some of the central areas.
Stream frequency:	Mostly low to medium but high in some of the central areas.
Slopes <5%:	>80% of the area.
	Median annual simulated runoff: Mostly low/moderate, but moderate in areas.
Mean annual temperature:	High to very high.
Area	56852.5 km^2.

A.2. ECOREGION 4: NORTH EASTERN HIGHLANDS

Primary boundary determinants:	This is a mountainous area characterised by closed hills and mountains with moderate to high relief and vegetation comprising North-Eastern Highveld Grassland and Lowveld Bushveld types. Patches with Afromontane Forest are scattered throughout the region.
General:	Transitional between the Lowveld and the Northern Escarpment. Towards the south, larger rivers such as the Usutu and Pongolo have some of their sources here, while perennial tributaries commonly contribute to the flow of larger rivers along the length of the region.
Mean annual precipitation:	Moderate to high. Variation moderate to low.
Drainage density:	Generally medium
Stream frequency:	Low/medium to medium high
Slopes <5%:	Varies from <20% to 25 – 50%.
Mean annual temperature:	Cool to moderate
Area:	16140.3 km^2.

A.3. ECOREGION 10: NORTHERN ESCARPMENT MOUNTAINS

Primary boundary determinants:	The topography of this high lying region is highly definitive and consists of closed hills and mountains with a moderate to high relief. Towards the east, a well-defined escarpment is present along the majority of the length of the region. Northeastern Mountain Grassland is the dominant vegetation type in the region with areas of Sour Lowveld Bushveld towards the east. Patches of Afromontane Forest occur regularly as an interrupted, thin band towards the eastern boundary.
General:	Drainage density is high and coefficient of variation of precipitation is very low. Rivers such as the Blyde, Sabie and Letaba have their sources here. Perennial tributaries of rivers such as the Crocodile, Komati and Olifants occur commonly in the region.
Mean annual precipitation:	High in most areas. Variation from low to very low.
Drainage density:	Low.

Stream frequency: Mostly medium to high.
Slopes <5%: <20%.
Mean annual temperature: Cool to moderate.
Area: 10441.3 km^2.

A.4. ECOREGION 11: HIGHVELD

Primary boundary determinants: Plains with a moderate to low relief, as well as various grassland vegetation types (with moist types present towards the east and drier types towards the west and south), define this high lying region.
General: Several large rivers have their sources in the region, e.g. Vet, Modder, Riet, Vaal, Olifants, Steelpoort, Marico, Crocodile (west), Crocodile (east) and the Usutu.
Mean annual precipitation: Rainfall varies from low to moderately high, with an increase from west to east. Variability is moderately high in the west, decreasing to low in the east.
Drainage density: Mostly low, but medium in some areas.
Stream frequency: Low to medium.
Slopes <5%: >80%, but 20-50% in a few hilly areas.
Mean annual temperature: Hot in the west and moderate in the east.
Area: 163615.1 km^2.

A.5. ECOREGION 12: LEBOMBO UPLANDS

Primary boundary determinants: Closed hills and mountains define this long, thin region with a moderate to high relief.
General: Lebombo Arid Mountain Bushveld dominants the vegetation. Geologically, basalts and rhyolites are also distinctive. Several large rivers traverse this region, e.g. Olifants, Sabie, Crocodile, Komati, Great Usutu, Pongolo and Mkuze. However, no perennial streams originate in this region. Variation high (north) to low (south).
Mean annual precipitation: Moderate to low in the north to moderate to high in the south
Drainage density: Medium.
Stream frequency: Medium to high in the north to high to medium in the south.
Slopes <5%: <20%.
Mean annual temperature: High to very high.
Area: 5365.5 km^2.

A.6. ECOREGION 13: NATAL COASTAL PLAIN

Primary boundary determinants: This is a low-lying area, characterised by plains with a low relief.
General: Coastal Bushveld/Grassland dominates the vegetation. Large rivers such as the Mfulozi, Mkuze and Mhlatuze traverse this region. Stream frequency is low to medium and few perennial streams originate in this region.
Mean annual precipitation: Moderate to high. Variation is low to moderate.
Drainage density: Low.
Stream frequency: Low to medium.
Slopes <5%: >80%.
Mean annual temperature: High to very high.
Area: 8273 km^2.

A.7. ECOREGION 14: NORTH EASTERN UPLANDS

Primary boundary determinants: This region is very diverse with lowlands, hills and mountains with moderate and high relief, as well as closed hills and mountains with moderate and high relief, being the defining characteristics.

General:	Grasslands and Bushveld types, mainly Natal Central Bushveld and Valley Thicket characterize the vegetation. Large rivers such as the Thukela, Mooi and Buffalo traverse this region while the Mhlatuze has its source in the region.
Mean annual precipitation:	Moderate to moderately high.
Drainage density:	From west to east, it varies from low, medium to high
Stream frequency:	Generally varying from east to wet from low/medium, medium/high to very high.
Slopes <5%:	Varying from west to east; 50-80%, 20-50% and <20%
Mean annual temperature:	Moderate to high.
Area:	33593.7 km^2.

A.8. ECOREGION 15: EASTERN ESCARPMENT MOUNTAINS

Primary boundary determinants:	This high lying area is characterized by closed hills, mountains with moderate and high relief with prominent escarpments towards towards the east.
General:	The vegetation consists of a range of grassland types with Afro Mountain and Alti Mountain Grasslands being the defining types. Several major South African rivers have their sources in this regions, e.g. Orange, Caledon, Wilge, Thukela, Buffalo, Mooi, Mzimkulu, Mzimvubu, Mgeni and Mkomazi.
Mean annual precipitation:	Moderate to very high.
Drainage density:	Medium
Stream frequency:	Medium high
Slopes <5%:	Generally <20%
Mean annual temperature:	Very low to moderate.
Area:	66504.8 km^2.

A.9. ECOREGION 17: NORTH EASTERN COASTAL BELT

Primary boundary determinants:	A diversity of terrain morphological types occur with closed hills and mountains with moderate to high relief being the most definitive.
General:	Altitude varies from sea level to 700m.a.m.s.l. Vegetation types consist of Valley thicket and a variety of Grassland and Bushveld types. Rivers such as the Mgeni, Mkomazi and Mzimkulu flow through this ecoregion.
Mean annual precipitation:	Predominantly high.
Drainage density:	Medium to high
Stream frequency:	Medium/high to very high
Slopes <5%:	Predominantly <20%
Mean annual temperature:	High
Area:	12476.8 km^2.

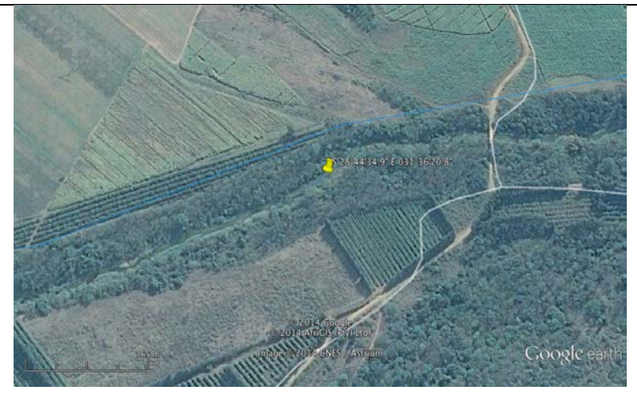
Appendix B. PHOTOGRAPHIC RECORD OF SITES VISITED FOR SITE SELECTION

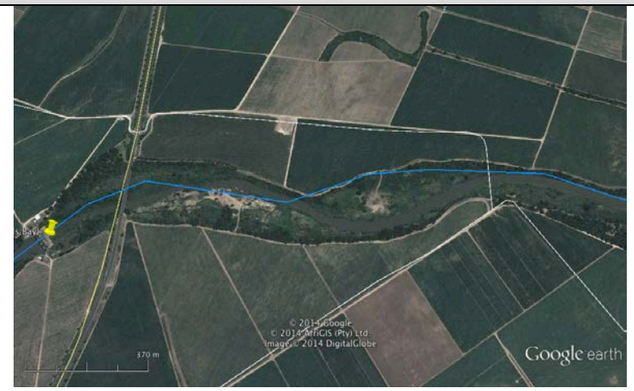
Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Matigulu 1	S 29°01'33.5" E 031°29'31.2"	Although below a gauging weir, reach is multi-channelled & wide. Difficult for hydraulics	Not suitable for EWR site	
Matigulu 2	S 29°01'29.3" E 031°28'18.1"	Multi-channelled and wide. Difficult for hydraulics	Not suitable for EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Matigulu 3	S 29°01'13.6" E 031°28'11.7"	The EWR site is on a fairly straight section of the river. Accessible and seems fairly safe. There are a variety of habitats. In a controlled section with bedrock. Relatively low impact from sugarcane. Cons- there is a double channel upstream and downstream. Abstraction takes place above the site at the gauging weir. Cattle grazing & domestic usage, such as washing.	Recommended EWR site	
Matigulu 4	S 29°02'36.6" E 031°30'39.5"	Deep river. Diversity of habitats reduced. Difficult to gain access	Not suitable for EWR site	
Black Mfolozi Pot 1	S 27°56'20.2" E 031°12'37.0"	Site has good access. Weir above the site. Bedrock. Distinct low and high flow zones. Range of habitats. Some cattle grazing at site. Recommended EWR Site	Recommended EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Black Mfolozi Pot 2	S 27°55'03.1" E 031°13'07.9"	Good site. Good habitat diversity. Not good for high flow surveys	Not a potential EWR site	
Black Mfolozi Pot 3	S 28°00'50.1" E 031°19'27.4"	Good site. Bedrock. Medium boulders. Varierty of habitats. Recommended EWR site		

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Black Mfolozi 4- below road D780	S28°27'22.05" E032°2'04.21"	Wide river with sandy river bed. Site upstream of sugar plantations	Not suitable EWR site.	
Black Mfolozi 5	S28°02'08.86" E031°21'20.49"	Site was good, with a range of habitats. Bedrock and boulders with a riffle area. Large pools. The site is impacted due to settlements and cattle. Safety at site is an issue	Not suitable EWR site.	
Mfolozi Existing Rapid	S 28°22.183' E 032°00.739'	This site is now enclosed with the Somkhele Colliery. Cannot get access to site.	No suitable EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Assegaai River	S 27°03'44.2" E 030°59'19.7"	Was an exisiting EWR site (JMBS2) for the Joint Maputo Basin Study. Site condition good. Good habitats. Benchmarks found. Exisiting data at site. Use this site as EWR site		
Mhlatuze EWR 1	S 28°44'34.9" E 031°36'20.8"	Site below Goedertrouw Dam, experiences very high flow due to releases made for downstream users. Site enclosed by sugarcane. Cannot get access to site.	Not suitable for EWR site	
Mhlatuze Ewr 2	S 28°44'49.0" E 031°44'50.8"	At EWR 2, flows high. No diversity of habitats. River has poor water quality. Reduced flow below weir.	Not suitable for EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Mhlatuze Pot 1	S 28°48'03.1" E 031°57'23.5"	Site below the Mhlatuze weir. Large abstractions take place at weir. Lower part of river, difficult to access due to sugarcane plantations and thick vegetation. Sandmining also in the reach below the weir. Flow still high and no diversity of habitat.	Not suitable for EWR site	
Mhlatuze Pot 2 (ewr 4)	S 28°48'23.8" E 031°57'06.7"	Site above Mhlatuze weir. Flows very high as river used to transport water for Mhlatuze & Richards Bay abstraction. No suitable habitat		
Mhlatuze Pot 3 (ewr 3)	S 28°50'40.8" E 031°52'13.0"	Thick riparian vegetation, high flows, no riffles present		

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Mkuze Pot 1 (fish Data)	S 27°36'29.0" E 032°05'22.0"	Site was an existing RHP site, with fish data available. Typical sandy bed of the Mkuze system. Range of habitat types. Sandmining activities at site.	Not suitable as EWR site location.	
Mkuze Pot 2	S27°36'40.72" E032°4'59.29"	Sandmining at site.	Not suitable as EWR site location.	
Mkuze Pot 3	S 27°35'31.5" E 032°13'04.8"	Wide river, with sandy base. Much subsurface flow. Upstream of the site the river bends, slowing the flow at the site. Riparian vegetation is good. During site selection pools of water were visible. Site in nature reserve. Site is also an existing RHP site W3MKZ-DNYDR, with fish data available. Recommended EWR site		

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Mkuze Pot 4	S 27°35'31.1" E 032°02'32.3"	Site on P236. Had good habitat and was in a good condition, however there was no access to the river.	Suitable EWR site, but no access	
Mkuze Bridge To Consider	S 27°35'55.3" E 032°18'07.0"	Site on the road bridge on way out of Nature Reserve. Narrowed channel, impacted by road bridge. Bridge restrict flow. Prone to bank erosion.		
Nseleni Rec Site	S 28°38'02.7" E 031°55'51.1"	This was a previous Reserve site. EWR6 on the Mhlatuze study. Channel is small and not impacted. Site has good range of habitats.	Recommended EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Pongola Upper Reach	S27°21'50.88" E030°58'10.62"	Site has a range of habitats, with riffles, pools and riparian vegetation. Suitable for hydraulic surveys.	Recommended EWR site	
Pongola Pot 1	S27°18'33.62" E030°53'51.85"	Site next to R33. Sandy bed. Impacts from road bridge few metres downstream	Not suitable as location of EWR site	
White Mfolozi Pot 1	S 28°13'59.8" E 031°11'07.4"	Site below gauging weir. Although below a road bridge the culverts are large enough not to impede flow. Good habitat, distinct high and low flow zones. Suitable for hydraulic surveys	Recommended EWR site	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
White Mfolozi Pot2	S 28°20'51.4" E 031°21'02.9"	Accessibility was a problem.	Not suitable location for EWR site	
White Mfolozi at R66 bridge	S28°20'19.35" E031°22'27.92"	Wide, multichannelled river. Impacted by livestock and road bridge. Upstream of road bridge, river is wide with alluvial bed.(Picture of downstream view)	Not suitable location for EWR site	
Hluhluwe	28° 8'6.83"S 32°18'18.39"E	River flows through sugarcane plantations. Thick vegetation encroaching river. Narrow river with reduced habitat diversity.	Not suitable location for EWR site.	

Site	Coordinates	Description of site	Suitability as EWR site	Photographs
Nyalazi	28°13'10.10"S 32°19'9.90"E	Difficulty to access site. No riffle areas	Not suitable location for EWR site