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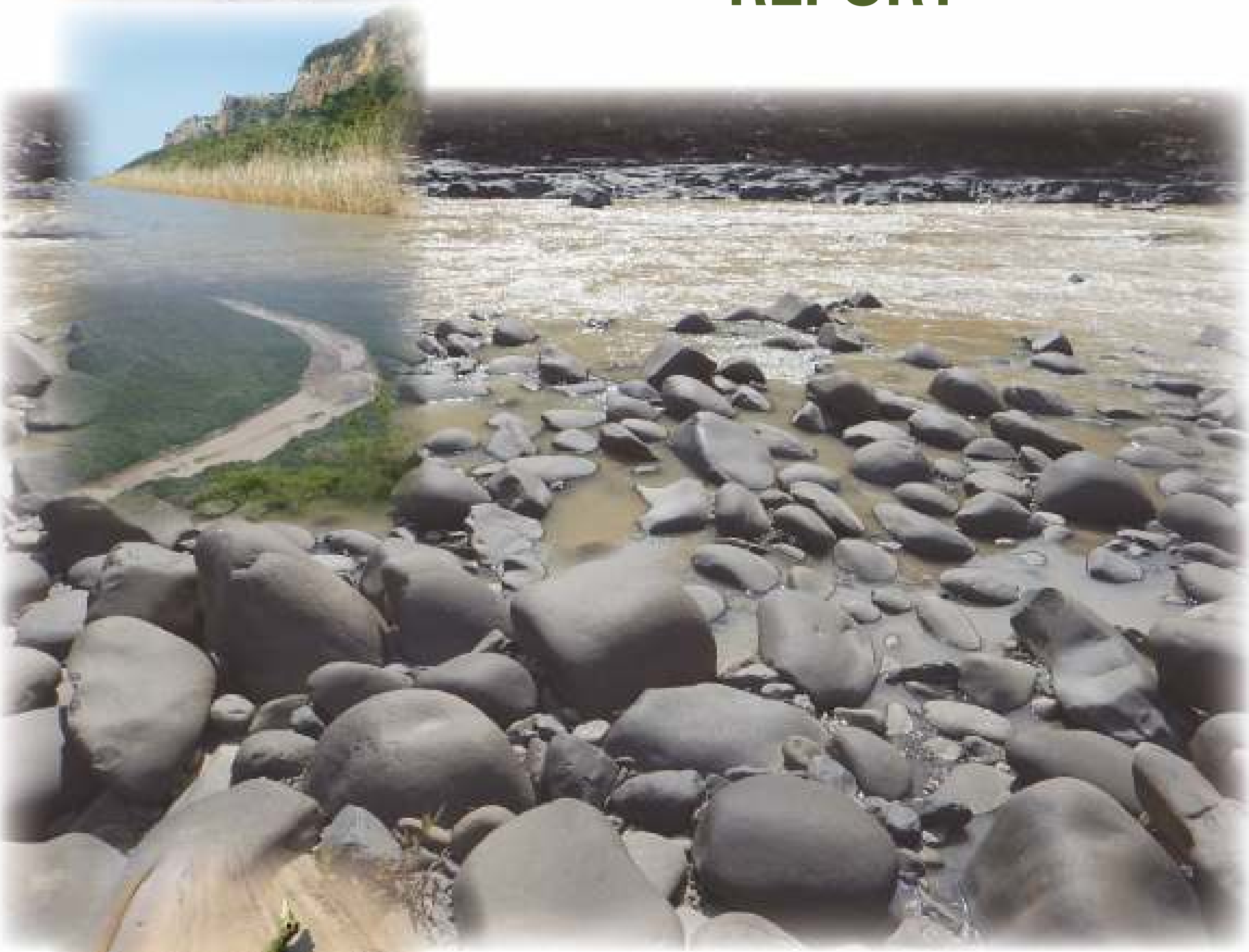
WP 11004

DETERMINATION OF WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES FOR THE WATER RESOURCES IN THE MZIMVUBU CATCHMENT

WETLANDS AND GROUNDWATER RQO REPORT



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EXECUTIVE SUMMARY

BACKGROUND

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity.

The main aims of the project, as defined by the Terms of Reference (ToR), are to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWR) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

This purpose of this report is to describe the Wetland and Groundwater RQOs for the study area, and more specifically qualify and quantify RQOs for wetlands and groundwater sources within the Mzimvubu (T3) primary catchment in keeping with part of Step 6 of the procedures to operationalise Resource Directed Measures (DWS, 2016).

STUDY AREA

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributaries and the estuary at Port St Johns. Several hundred wetlands occur within the Mzimvubu (T3) primary catchment.

RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The *National Water Resource Strategy* (NWRS) therefore stipulates that "Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota".

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios to inform the Water Resource Class and RQOs define and/or describe the Water Resource Class.

Links between RQOs and the Water Resource Class and operational scenarios

WETLAND RESOURCE QUALITY OBJECTIVES

Due to the high number of wetlands within the T3 primary catchment and following the recommendations and method guidelines of DWS (2016), specific RQOs were only determined for priority wetlands of High or Very High importance, although the detail of these were constrained by the availability of existing data. Broad-scale catchment and sub-catchment RQOs were determined for all other wetlands. Broad level narrative RQOs for wetlands across the Water Management Area (WMA) were determined at the quaternary catchment scale, and focussed on averages of Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) categories, mostly from the PESEIS database (DWS, 2014a). These broad scale narrative RQOs specify that the average quaternary level PES and EIS should be maintained and not permitted to deteriorate, and have been developed so that all wetlands, even those of a low priority, have some measure of protection. The data that underpin these broad scale RQOs are shown in **Tables 3.1** and **3.2** and **Figures 3.1** and **3.2.**

Catchment level RQOs were developed at the sub-quaternary (SQ) scale and are listed in **Table 3.3.** These specify more detail and at a finer scale than the broad level RQOs and should be used in preference to them. Catchment level RQOs rely on PESEIS data (DWS, 2014a) for low or moderate priority wetlands (an improvement from broad scale RQOs only due to finer scale and not a quaternary average) and verified data using a similar but expanded method of the PESEIS rationale (to include all wetlands within a SQ catchment). Data used to determine catchment level RQOs are outlined in **Table 2.1**.

More detailed RQOs were developed for wetlands of High or Very High priority. Floodplain RQOs are listed in **Table 3.4** while RQOs for High priority channelled and unchannelled valley bottoms, flats and seeps are listed in **Table 3.5**. These were highlighted as priority during the Ecostatus and EWR determination for wetlands process (DWS, 2017a). As detailed data of these high priority individual wetlands were limited, Google Earth© was used to conduct level 1 WET-Health assessments (MacFarlane et al., 2007) for floodplains and to verify PES ratings and wetland metrics in the PESEIS database for channelled valley bottom wetlands. Updated metrics were applicable to all wetlands within a SQ and included wetland habitat modification and wetland continuity (fragmentation and connectivity) modification.

It should be stressed that although RQOs at different levels have been determined, all should be taken into consideration in a tiered fashion. To clarify this approach an example of SQ T35G-06099 is given: The wetlands in this SQ occur in the T35G quaternary catchment and therefore have broad level RQOs that specify that the average PES of a B/C category and EIS of "High" be maintained (**Tables 3.1** and **3.2** and **Figures 3.1** and **3.2**). In addition, the catchment level RQOs specify narrative measures for the SQ T35G-06099 according to **Tables 3.3** (RQOs) and **2.1** (Data supporting RQOs). These RQOs pertain to measures for water quantity, water quality, habitat, biota and ecosystem services for the SQ. One of the habitat RQOs related to integrity and condition specifies that the PES category of wetlands within this SQ must be maintained according to those listed in **Table 2.1**, which is a category B. Since this is a higher confidence measure than the quaternary average of a B/C category, it will take precedence. Similarly, the RQO related to EIS, as a measure of ecosystem services, will be “Very High”, rather than the quaternary average of “High”. However, this SQ also belongs to one of the high priority floodplains – Gatberg Floodplains – and will therefore also have more detailed RQOs as specified in **Table 3.4**. These will be in addition to those already given, and where overlap exists, precedence should be given to more detailed RQOs that are based on higher quality and confidence data.

GROUNDWATER RESOURCE QUALITY OBJECTIVES

Criteria such as hydrogeology, borehole yields, groundwater use, water quality and groundwater contribution to baseflow are described per Groundwater Resource Unit (GRU) in this document. Monitoring recommendations are presented based on the groundwater RQOs presented in the relevant chapter for GRUs 1 to 14. Narrative groundwater RQOs are provided for water levels, abstraction, baseflow reduction, and selected water quality parameters, while numerical RQOs are also presented.

Based on the level of groundwater stress (stress index of abstraction to aquifer recharge), the following catchments can be considered as priority areas for monitoring *abstraction and groundwater levels*:

Catchment	Stress Index	Priority
T31F	0.341	Moderate
T33A	0.371	Moderate

Based on the degree of *baseflow reduction* across the study area, the following catchments have been identified where low flow monitoring via gauging stations is relevant in order to evaluate how streamflow reduction activities impact on ecological requirements:

Catchment	Baseflow Reduction	Priority
T35F	43.85	Moderate
T35C	30.43	Moderate

Over large parts of the study area insufficient *water quality data* exist to characterise groundwater quality based on nitrates and fluoride. The T33-T36 Tertiary catchments lack sufficient data. Due to the prevalence of doleritic intrusions, fluoride levels may be elevated. The degree of removal of vegetation and sanitation practices also suggest that elevated nitrates may be of localised concern.

Catchments T35K and T33H have a high proportion of boreholes with elevated salinities. No obvious geological reason for these pockets of salinities exists, and such areas need to be delineated to identify naturally occurring salinity from contamination processes.

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LIST OF ABBREVIATIONS

AIPs	Alien Invasive Plants
BHNR	Basic Human Needs Reserve
CGS	Council for GeoScience
DWA	Department Water Affairs (Name change from DWAF applicable after April 2009)
DWAF	Department Water Affairs and Forestry
DWS	Department Water and Sanitation (Name change from DWA applicable after May 2014)
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GA	General Authorization
GRAII	Groundwater Resource Assessment Phase II
GRDM	Groundwater Reserve Determination Method
GRU	Groundwater Resource Unit
GW	groundwater
HGM	hydrogeomorphic
NEMA	National Environmental Management Act
NFEPA	National Freshwater Ecosystem Priority Area
NGA	National Groundwater Archive
NWA	National Water Act
NWRS	National Water Resources Strategy
PES	Present Ecological State
PESEIS	Present Ecological State, Ecological Importance and Sensitivity
Quat	Quaternary catchment
RUs	Resource Units
SFR	Streamflow reduction
SQ	Sub Quaternary
SANBI	South African National Biodiversity Institute
TDS	Total Dissolved Solids
ToR	Terms of Reference
TEC	Target Ecological Category
WARMS	Water Allocation Registration Management System
WMA	Water Management Area
wq	Water quality
WRCS	Water Resource Classification System
WR2012	Water Resources 2012
WRSM2000	Water Resources Simulation Model 2000. The Pitman Model with Sami Model Groundwater interactions
ZQM	National Groundwater Quality Monitoring Network database

GLOSSARY

Aquifer recharge	The volume of recharge that enters the regional aquifer after interflow losses and is available to groundwater users.
Baseflow	The volume of low flow generated from subsurface pathways, including interflow and groundwater baseflow.
Depression	This is a closed basin where water accumulates, usually with a concave shape, but sometimes very flat, in which case it is called a pan and can be confused with a flat wetland. When the shape of the basin is concave it is usually referred to as a pool or a lake.
Channelled valley bottom wetland	This is a wetland area on the valley floor that is divided by and typically elevated above a stream channel, which makes that this wetland generally drains faster than an unChannelled valley bottom wetland. Water inputs to these areas are from adjacent valley side slopes and from the overtopping of the channel during floods.
Ecological Category (EC)	ECs are determined for all components of the ecosystem for driver (abiotic) and response (biotic) components. These are integrated into an overall or integrated state called the EcoStatus. This level of information with the entire component ECs is only available when detailed studies are undertaken. For more desktop type studies, only a single EC may be available which represent the EcoStatus. **Whenever an EC is referred to without specifying that it is applicable to a specific component, this will always refer to the EcoStatus.**
Ecological Importance and Sensitivity (EIS)	Key indicators in the ecological classification of water resources. Ecological importance relates to the presence, representativeness and diversity of species of biota and habitat. Ecological sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels and physico-chemical conditions.
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.
EcoStatus	EcoStatus is defined as the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and is capacity to provide a variety of goods and services.
Flat	These represent areas where the groundwater is near the surface, mostly on coastal plains. Their main input of water is from rainfall. The flow is imperceptible and these wetlands are basically a transition between a depression and a valley bottom wetland.
Floodplain	This is a flat wetland area adjacent to a river channel in its lower reaches that is subject to periodic inundation due to flood events in the wet season. These flood events can be quite turbulent and leave many marks in the landscape, such as levees, oxbow lakes and depressions where fine sediment is deposited.
Groundwater baseflow	The volume of baseflow generated from the regional aquifer.

Interflow	The volume of baseflow generated prior to entering the regional aquifer.
Present Ecological State (PES)	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses *viz*. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.
Recommended Ecological Category (REC)	The Recommended Ecological Category is the future ecological state (Ecological Categories A to D) that can be recommended for a resource unit depending on the EIS and PES. The REC is determined based on ecological criteria and considers the EIS, the restoration potential of the system and attainability thereof.
Resource Quality Objectives (RQOs)	RQOs are numeric or descriptive goals that can be monitored for compliance to the WRC, for each part of each water resource.
Slope seepage	This is wetland area located on gentle to steep slopes, driven by discharge of groundwater or by water percolating through the upper layers of the soil layer. Slope seepages generally feed into drainage basins or rivers.
Stress index	The ratio of groundwater use to recharge or aquifer recharge.
Sub-quaternary catchments (SQ)	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary or quinary level.
Unchannelled valley bottom wetland	This is a wetland area on a valley floor that is connected to a drainage network, but without a major channel running through it. It is characterized by the prevalence of diffuse flow, which is at or near the surface especially after rainfall events. Water mainly enters the wetland through an upstream channel, but sometimes also from adjacent slopes.
Valleyhead seepage	This is a typical concave wetland area located on gentle sloping land on a valley floor at the head of a drainage line. Water input is mainly from subsurface flow.
Water Resource Class (WRC)	The Water Resource Class is representative of those attributes that the DWS (as the custodian) and society require of different water resources. The decision-making toward a WRC require 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 each 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.
Water Resource Classification System (WRCS)	The Water Resource Classification System is a defined set of guidelines and procedures for determining the different classes of water resources (South African National Water Act (Act 36 of 1998) Chapter 3, Part 1, Section 2(a)). The outcome of the Classification Process will be the setting of the class, Reserve and Resource Quality Objectives by the Minister or delegated authority for every significant water resource (river, estuary, wetland and aquifer) under consideration. This class, which will range from Minimally used to Heavily used, essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised.

1 INTRODUCTION

1.1 BACKGROUND

The National Environmental Management Act (NEMA; Act No. 107 of 1998) came into force in 1998. The objective of this Act is to provide for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state; and to provide for matters connected therewith. These principles are required to be taken into account by any organ of state in the exercise of any power that may impact on the environment.

Chapter 2(5) (3) of the National Water Act (NWA; Act No. 36 of 1998) provides the framework for the protection, use, development, conservation, management and control of water resources for the country as a whole. It also provides the framework within which water will be managed at regional or catchment level, in defined Water Management Areas (WMAs). The NWA additionally recognises that the entire ecosystem, and not just the water itself, in any given water resource, constitutes the resource and as such needs to be conserved. The National Water Resource Strategy (NWRC) is binding on all authorities and institutions exercising powers or performing duties under this Act. Chapter 3 (12) of the NWA states that the Minister of Water and Sanitation may prescribe for classifying water resources, provide for such other matters relating to the protection, use, development, conservation, management and control of water resources, as the Minister considers necessary.

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity. These activities will guide the management of the T3 Mzimvubu primary catchment toward meeting the departmental objectives of maintaining, and if possible, improving the present state of the Mzimvubu River and its four main tributaries, namely the Tsitsa, Thina, Kinira and Mzintlava. This project is driven by threatened ecosystem services in the Mzimvubu catchment, due to the variety of inappropriate land uses and alien plant infestation that result in extensive erosion and degradation. Degradation can be observed in soil erosion, damage to infrastructure, water supply shortages and loss of grazing.

The Department of Water and Sanitation (DWS) has initiated a study to determine Classes and associated RQOs for the Mzimvubu catchment in WMA 7.

The main aims of the project, as defined by the Terms of Reference (ToR), are to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and

- review work previously done on Ecological Water Requirements (EWR) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

This report addresses the conservation and management of the wetland and groundwater components of the water resource through the derivation of RQOs for these resources.

1.2 STUDY AREA OVERVIEW

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributaries and the estuary at Port St Johns. The river reaches sizeable proportions after the confluence of these four tributaries in the Lower Mzimvubu area, approximately 120 km from its source, where the impressive Tsitsa Falls can be found near Shawbury Mission. The Mzimvubu catchment and river system lies along the northern boundary of the Eastern Cape and extends for over 200 km from its source in the Maloti-Drakensberg watershed on the Lesotho escarpment to the estuary at Port St Johns. The catchment is in Primary T, comprises of T31–36 and stretches from the Mzimkhulu River on the north-eastern side to the Mbashe and Mthatha river catchments in the south. The Mzimvubu river catchment is found in WMA 7, i.e. the Mzimvubu to Tsitsikamma WMA. Several hundred wetlands occur within the T3 primary catchment (**Figure 1.1**).

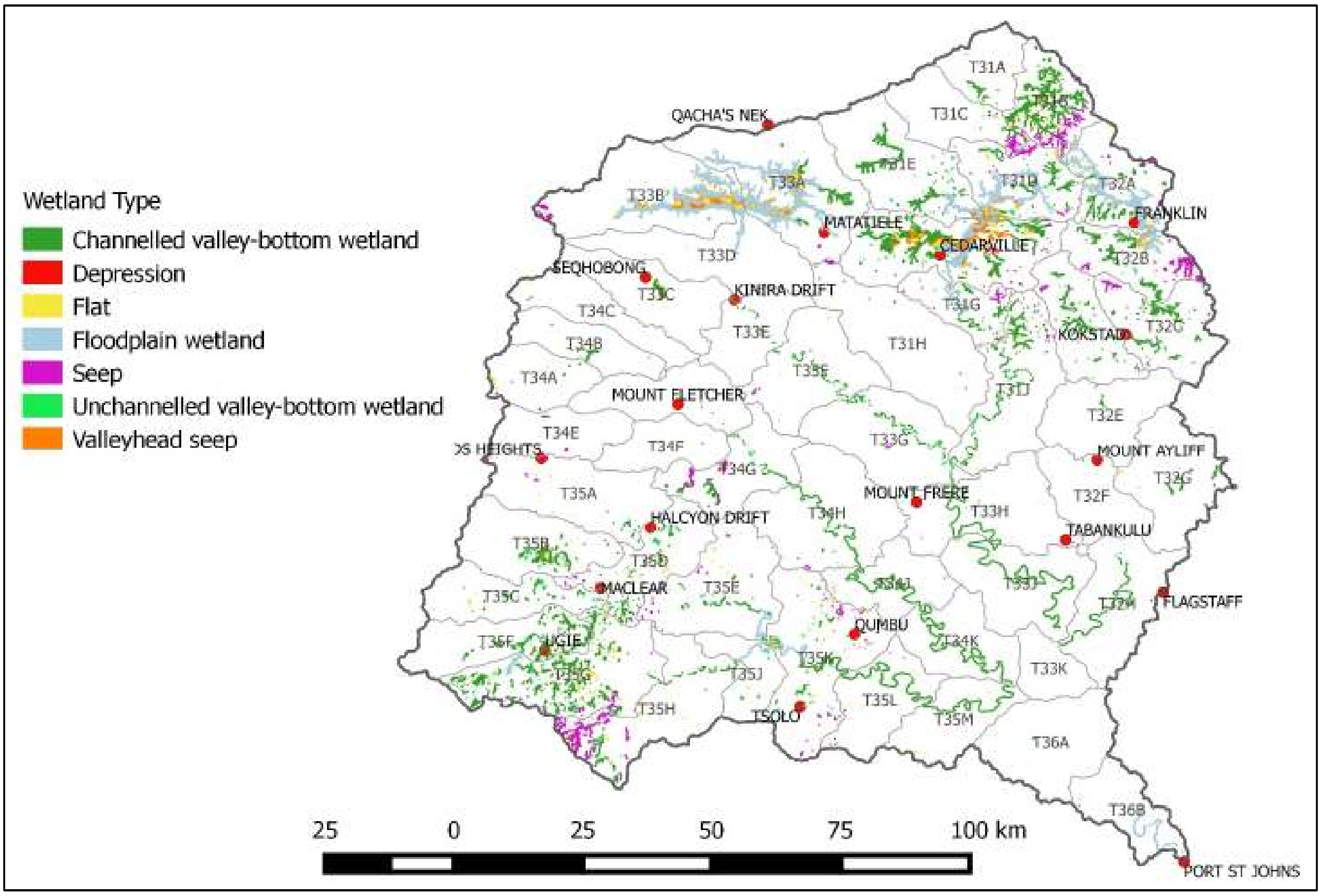

Figure 1.1 Study area: T3 primary catchment showing quaternary catchments and distribution of wetland types (Nel et al., 2011)

1.3 STUDY PROJECT PLAN

The Mzimvubu study is being undertaken according to the Project Plan in **Figure 1.2** with each step broken down into sub-steps. This report pertains to the RQO qualification and quantification part of Step 6.

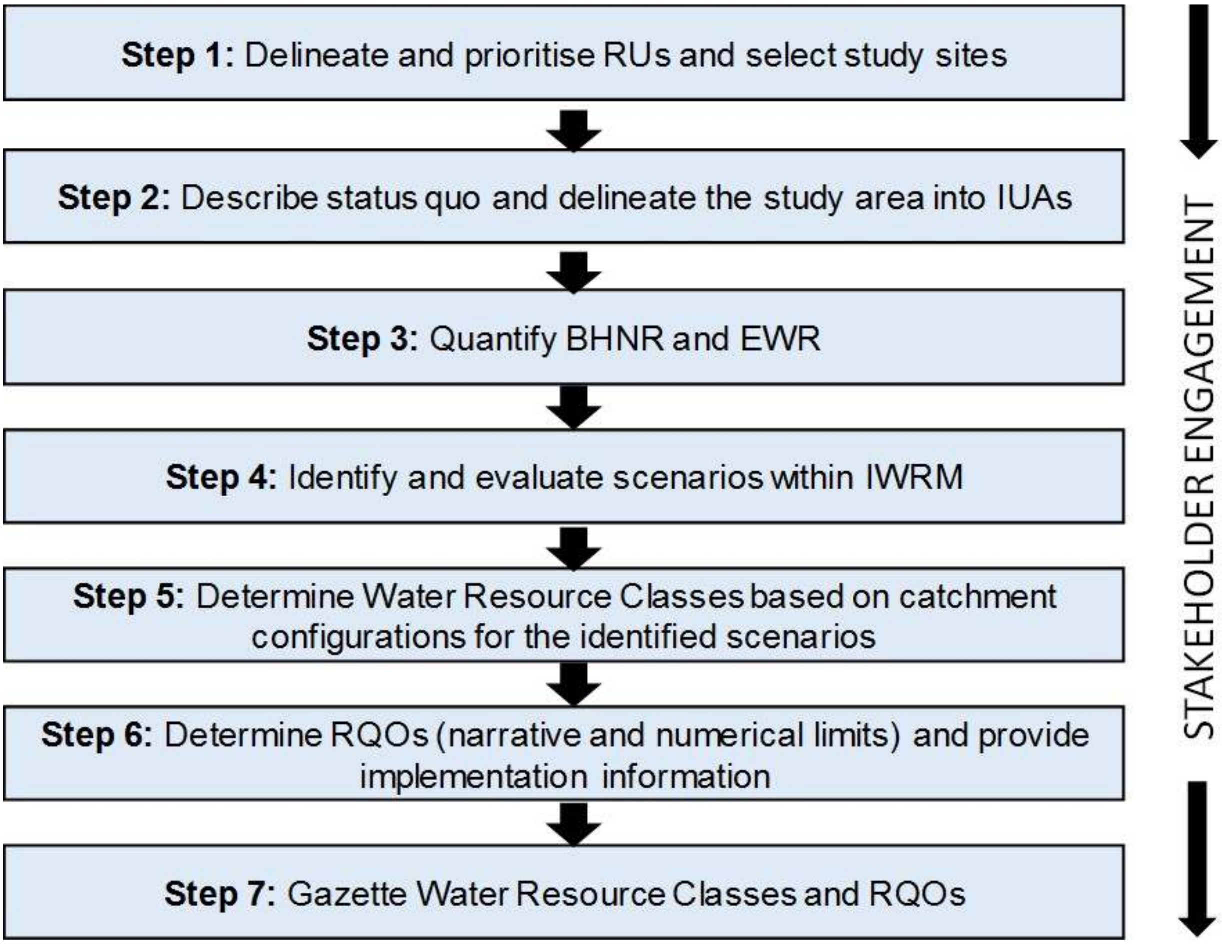

Figure 1.2 Project plan for the Mzimvubu Classification and RQO study

1.4 INTRODUCTION TO RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The *National Water Resource Strategy* (NWRS) therefore stipulates that "Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota".

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios to inform the Water Resource Class and RQOs define and/or describe the Water Resource Class (**Figure 1.3**).

Figure 1.3 Links between RQOs and the Water Resource Class and operational scenarios

1.5 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to document the RQOs for Wetlands and Groundwater for the study area. The report structure is outlined below.

Chapter 1: Introduction
This chapter provides an overview of the study area and objectives of the study.

Chapter 2: Approach – Wetlands RQOs
This chapter outlines the general approach to determining the RQOs for wetlands.

Chapter 3: Wetland RQOs
This chapter outlines the wetland RQOs, both narrative and numerical, for wetland at different scales.

Chapter 4: Approach – Groundwater RQOs
This Chapter outlines the general approach to determining the RQOs for groundwater

Chapter 5: Groundwater RQOs
This chapter outlines the narrative and numerical groundwater RQOs for the study area.

Chapter 6: Conclusions and Recommendations
Result are summarised and discussed in this chapter.

Chapter 7: References

2 APPROACH: WETLAND RESOURCE QUALITY OBJECTIVES

2.1 BACKGROUND

Due to the high number of wetlands within the T3 primary catchment (**Figure 1.1**), it is unrealistic to implement and monitor RQOs for each individual wetland. Following the recommendations and method guidelines by DWS (2016), specific RQOs are only set for priority wetlands of High or Very High priority or importance, although these were constrained by the availability of existing data. The overall, integrated process of determining RQOs for wetlands is shown in **Figure 2.1**. The objective of the wetland component is to specify RQOs for wetlands at both a catchment level as well as prioritised individual wetland Resource Units (RUs; prioritisation was conducted as part of the delineation and status quo reporting task, refer to DWS (2017b)). Catchment-level RQOs provide broad level objectives for wetland management within the WMA. RQOs for priority individual wetland RUs are dependent on available baseline data, and where such data are available, this enables the specification of numeric as well as narrative RQOs to manage these systems according to the desired ecological condition.

Two levels of RQOs have thus been determined for the T3 wetlands:

- Catchment-level RQOs: Baseline EcoStatus and EIS data at the quaternary catchment and SQ catchment scales were developed for these RQOs.
- RQOs for high priority individual wetlands or wetland RUs: Developed for Very High priority wetlands with more detail than above.

The following summarises the process for RQO determination (see DWS; 2016a for more detail):

1. **Collate information on flow and non-flow related impacts**
   This requires collation of information on flow and non-flow related impacts identified in previous tasks (i.e. the delineation and wetland status quo reporting task, refer to DWS, 2017b).
2. **Select sub-components and indicators for RQO determination and monitoring**
   The main components of relevance to wetlands include water quantity, quality and habitat and biota. Sub-components and indicators should reflect those that are sensitive to actual or potential impacts and can be measured and monitored.
3. **Provide narrative RQOs for indicators of High Priority wetland RUs**
   This involves the preparation of narrative RQOs for sub-components and indicators identified as relevant in the previous action.
4. **Provide numeric RQOs for indicators of high Priority wetland RUs**
   This involves the preparation of numerical RQOs to complement the narrative RQOs but will be limited by existing baseline data.
5. **Provide broad level narrative RQOs for priority catchments**
   This involves the specification of generic management guidelines specific to regional scale sub-components.
6. **Provide broad level narrative RQOs for wetlands across the WMA**
   Generic management guidelines specific to the wetland regions should provide management and monitoring approaches for specific sub-components (relevant to the wetland types and risks of the relevant wetland region).

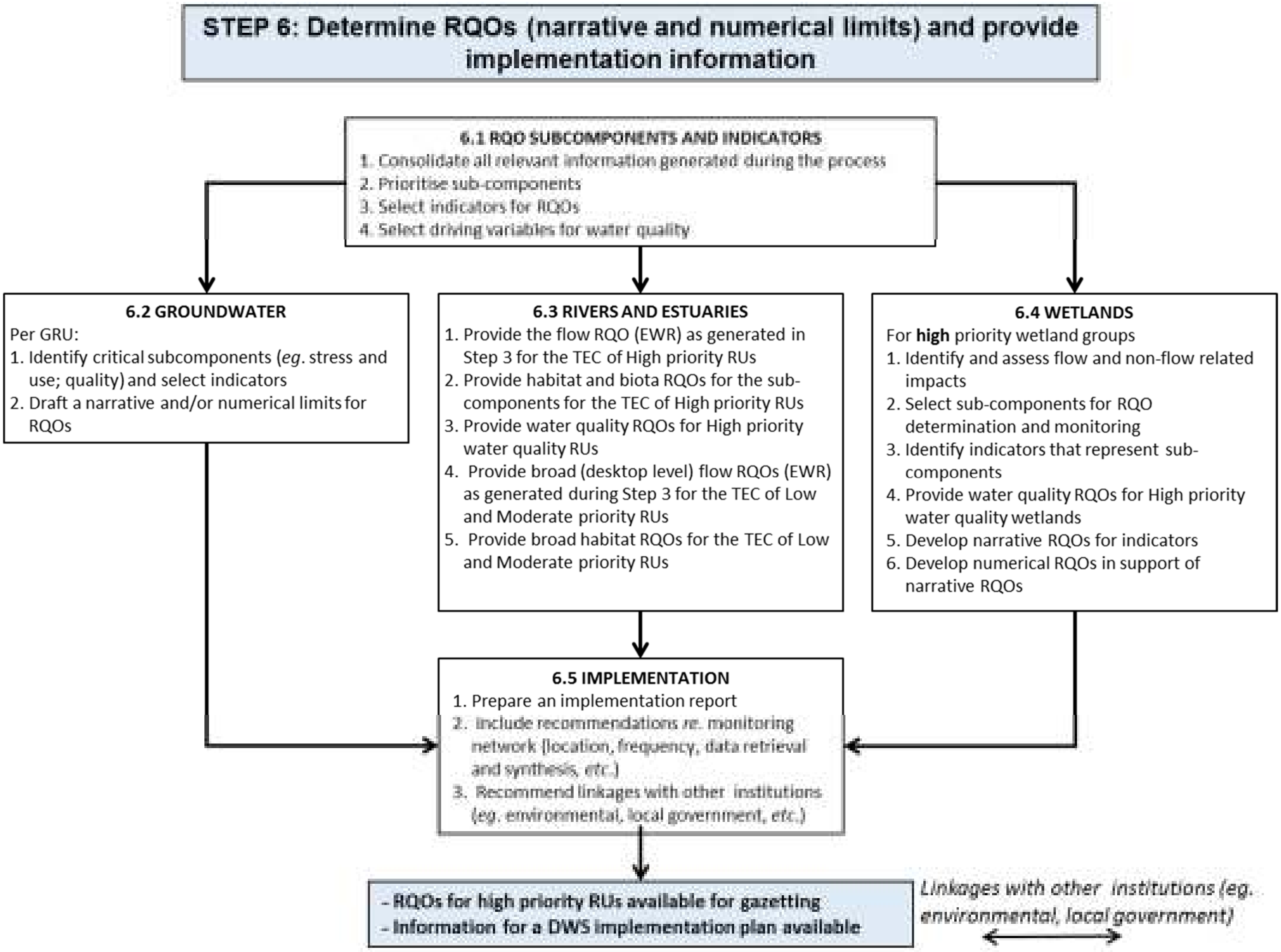

Figure 2.1 Illustration of the sub-steps for the process of RQO determination (DWS, 2016)

2.2 AVAILABLE DATA FOR DETERMINING RESOURCE QUALITY OBJECTIVES

Available information for the wetlands of the T3 catchment was sourced during the the, delineation and wetland status quo reporting task (DWS, 2017b), as well as the determination of Wetland Ecostatus and EWR tasks (DWS, 2017a). This included the selection of high priority wetlands or wetland groups based on ecological, socio-cultural and water resource use importance. The assessment of PES relied on existing metrics within the PESEIS database (DWS, 2014a), while the assessment of EIS relied on the identification and rating of biodiversity value, ecological importance, functional value, wetland sensitivity and risk of degradation.

2.3 BROAD LEVEL NARRATIVE RESOURCE QUALITY OBJECTIVES FOR WETLANDS ACROSS THE WMA

Broad level narrative RQOs were expressed as average PES and EIS categories within each quaternary catchment. These are meant to serve as generic management guidelines for the management and monitoring of wetlands and risks at the quaternary catchment scale, and are only meant for use in the absence of more detailed or finer-scale RQOs.

2.4 CATCHMENT LEVEL RESOURCE QUALITY OBJECTIVES FOR WETLANDS

Baseline information for wetlands at the SQ catchment scale was generated as part of the delineation and wetland status quo reporting task (DWS, 2017b), as well as the determination of Wetland Ecostatus and EWR tasks (DWS, 2017a). This included the selection of high priority wetlands or wetland groups based on ecological, socio-cultural and water resource use importance. The assessment of PES relied on existing metrics (both of the riparian/wetland metrics: riparian/wetland zone and zone continuity modification) within the PESEIS database (DWS, 2014a), while the assessment of EIS relied on the following actions:

- *Identification and rating of biodiversity value and ecological importance.* Specific criteria that define biodiversity value were rated, based on desktop information (e.g. RAMSAR status, condition including NFEPA (National Freshwater Ecosystem Priority Area), habitats for rare and endangered species (birds, frogs etc.), and critical biodiversity areas (Berliner and Desmet, 2007)).
- *Identification and rating of functional value.* Specific criteria that evaluate the functional value including socio-economic value; hydrological functioning (flow regulation, maintenance of base flows) and water quality amelioration were rated.
- *Identification and rating of sensitivity of each wetland unit.* Criteria used include size, hydrogeomorphic (HGM) type, known sensitive species or habitats, and degree of impact.
- *Rating the risk of degradation.* Risk to a wetland unit was based on land use and water demand.

The results are summarised in **Table 2.1**. Note that naming refers to the main river in the SQ to provide a measure of location of the wetlands. It is not possible to name the wetlands due to the vast numbers present in the T3 catchment.

Table 2.1 PES, EI, ES and EIS categories for wetlands at the SQ scale

Quat	SQ	Main river name	Wetland EI	Wetland ES	EIS	PES	Wetland priority
T31A	T31A-04712	Mzimvubu	HIGH	LOW	HIGH	C	2
T31B	T31B-04745	Krom	HIGH	MODERATE	HIGH	C	3
T31B	T31B-04868	Krom	VERY HIGH	MODERATE	VERY HIGH	B	2
T31B	T31B-04873		VERY HIGH	MODERATE	VERY HIGH	C	3
T31C	T31C-04796	Mngeni	HIGH	MODERATE	HIGH	C	2
T31C	T31C-04866	Mzimvubu	MODERATE	MODERATE	MODERATE	B/C	2
T31C	T31C-04879	Nyongo	MODERATE	VERY HIGH	VERY HIGH	C	3
T31D	T31D-04926	Mzimvubu	HIGH	MODERATE	HIGH	C	2
T31D	T31D-04936	Riet	VERY HIGH	MODERATE	VERY HIGH	C/D	3
T31D	T31D-05030	Riet	HIGH	LOW	HIGH	C	2
T31D	T31D-05060		HIGH	MODERATE	HIGH	D	2
T31D	T31D-05076	Mzimvubu	VERY HIGH	VERY LOW	VERY HIGH	C	3
T31E	T31E-04836	Tswereka	HIGH	MODERATE	HIGH	B	2
T31E	T31E-04910	Malithasana	HIGH	MODERATE	HIGH	D	2
T31E	T31E-04931	Tswereka	HIGH	HIGH	HIGH	C	2
T31E	T31E-05013	Tswereka	HIGH	MODERATE	HIGH	D	3
T31E	T31E-05055		VERY HIGH	MODERATE	VERY HIGH	C	3
T31F	T31F-05108		VERY HIGH	LOW	VERY HIGH	D	3
T31F	T31F-05111	Mzimvubu	HIGH	VERY LOW	HIGH	B	3
T31F	T31F-05112	Mzimvubu	VERY HIGH	LOW	VERY HIGH	C	3

Quat	SQ	Main river name	Wetland EI	Wetland ES	EIS	PES	Wetland priority
T31F	T31F-05134		VERY HIGH	MODERATE	VERY HIGH	D	2
T31G	T31G-05071	Mzimvubu	VERY HIGH	MODERATE	VERY HIGH	D	2
T31H	T31H-05177	Mvenyane	HIGH	LOW	HIGH	B	2
T31H	T31H-05324	Mvenyane	HIGH	VERY LOW	HIGH	C/D	2
T31J	T31J-05257	Mzimvubu	HIGH	MODERATE	HIGH	D	2
T31J	T31J-05551	Mzimvubu	HIGH	VERY LOW	HIGH	D	2
T31J	T31J-05582	Ngwekazana	HIGH	LOW	HIGH	D	2
T31J	T31J-05588	Mzimvubu	HIGH	MODERATE	HIGH	D	2
T32A	T32A-04907	Mzintlanga	VERY HIGH	MODERATE	VERY HIGH	D	3
T32A	T32A-04965	Mzintlava	VERY HIGH	MODERATE	VERY HIGH	C	3
T32B	T32B-05103	Mzintlava	VERY HIGH	MODERATE	VERY HIGH	C/D	2
T32B	T32B-05116		VERY HIGH	HIGH	VERY HIGH	C	4
T32B	T32B-05184	Mzintlava	VERY HIGH	MODERATE	VERY HIGH	D	2
T32C	T32C-05219	Mill Stream	HIGH	MODERATE	HIGH	C	2
T32C	T32C-05243	aManzamnyama	VERY HIGH	MODERATE	VERY HIGH	D	3
T32C	T32C-05273	Mzintlava	HIGH	HIGH	HIGH	D	3
T32C	T32C-05313	Mzintlava	HIGH	MODERATE	HIGH	B/C	4
T32C	T32C-05378		HIGH	MODERATE	HIGH	C/D	2
T32D	T32D-05172	Droewig	VERY HIGH	MODERATE	VERY HIGH	C	3
T32D	T32D-05352	Mzintlava	HIGH	MODERATE	HIGH	D	3
T32D	T32D-05373	Mzintlava	HIGH	MODERATE	HIGH	D/E	3
T32F	T32F-05464	Mzintlava	HIGH	LOW	HIGH	D	3
T32G	T32G-05536	Mzintlavana	HIGH	LOW	HIGH	C/D	2
T32G	T32G-05609	Mbandana	HIGH	LOW	HIGH	C	2
T32H	T32H-05842	Mzintlava	HIGH	LOW	HIGH	C	3
T33A	T33A-04887	Mafube	HIGH	HIGH	HIGH	C	2
T33A	T33A-04892	Kinira	HIGH	VERY LOW	HIGH	C	2
T33A	T33A-04898	Makomorin	HIGH	LOW	HIGH	B	2
T33A	T33A-04903	Kinira	HIGH	MODERATE	HIGH	C/D	2
T33A	T33A-04928		HIGH	MODERATE	HIGH	D	3
T33A	T33A-04983	Mafube	HIGH	MODERATE	HIGH	C	2
T33A	T33A-04990	Kinira	HIGH	LOW	HIGH	C	3
T33A	T33A-04991		HIGH	VERY LOW	HIGH	C	3
T33A	T33A-05011	Kinira	HIGH	LOW	HIGH	C	2
T33B	T33B-04912	Seeta	HIGH	VERY LOW	HIGH	C	2
T33B	T33B-04939	Mabele	HIGH	LOW	HIGH	C/D	2
T33B	T33B-04956	Mosenene	HIGH	LOW	HIGH	D/E	2
T33B	T33B-05005	Jordan	VERY HIGH	VERY LOW	VERY HIGH	D	2
T33B	T33B-05051	Mabele	HIGH	VERY LOW	HIGH	C/D	2
T33B	T33B-05066	Mabele	HIGH	VERY LOW	HIGH	D	2
T33B	T33B-05072		HIGH	VERY LOW	HIGH	C/D	2
T33C	T33C-05131	Morulane	HIGH	LOW	HIGH	C/D	2
T33D	T33D-05063	Kinira	VERY HIGH	VERY LOW	VERY HIGH	D	2
T33D	T33D-05106	Pabatlong	HIGH	VERY HIGH	VERY HIGH	C/D	2
T33D	T33D-05150	Kinira	HIGH	LOW	HIGH	C/D	2
T33E	T33E-05213	Kinira	HIGH	MODERATE	HIGH	C/D	2
T33E	T33E-05367	Somabadi	MODERATE	VERY HIGH	VERY HIGH	C/D	2
T33F	T33F-05285	Rolo	MODERATE	VERY LOW	HIGH	D	2
T33F	T33F-05326	Kinira	HIGH	VERY LOW	HIGH	C/D	2
T33F	T33F-05398	Kinira	HIGH	VERY LOW	HIGH	C/D	2
T33F	T33F-05439	Ncome	MODERATE	VERY LOW	HIGH	C/D	2

Quat	SQ	Main river name	Wetland EI	Wetland ES	EIS	PES	Wetland priority
T33G	T33G-05395	Kinira	HIGH	LOW	HIGH	C/D	2
T33G	T33G-05587	Cabazi	MODERATE	HIGH	HIGH	C/D	2
T33G	T33G-05659	Mzimvubu	MODERATE	MODERATE	MODERATE	B	3
T33H	T33H-05638	Mnceba	MODERATE	VERY HIGH	VERY HIGH	C	2
T33H	T33H-05680	Mzimvubu	MODERATE	LOW	HIGH	C	2
T33H	T33H-05803	Caba	HIGH	MODERATE	HIGH	C/D	2
T33H	T33H-05821	Mzimvubu	MODERATE	MODERATE	MODERATE	C	2
T33J	T33J-05834	Mzimvubu	MODERATE	LOW	MODERATE	C	2
T34A	T34A-05394	Vuvu	HIGH	HIGH	HIGH	B/C	2
T34A	T34A-05404	Thina	HIGH	VERY LOW	HIGH	C	2
T34A	T34A-05408	Khohlong	HIGH	VERY LOW	HIGH	C	2
T34A	T34A-05415	Thina	HIGH	VERY LOW	HIGH	B/C	2
T34B	T34B-05269	Nxotshana	HIGH	VERY LOW	HIGH	B/C	2
T34B	T34B-05275	Phiri-e-ntso	HIGH	VERY LOW	HIGH	B/C	2
T34B	T34B-05351	Thina	HIGH	VERY LOW	HIGH	C/D	2
T34B	T34B-05356	Thina	HIGH	LOW	HIGH	C/D	2
T34B	T34B-05385	Thina	HIGH	VERY LOW	HIGH	C/D	2
T34C	T34C-05168	Tinana	HIGH	VERY LOW	HIGH	B	2
T34C	T34C-05292	Tinana	MODERATE	LOW	HIGH	C	2
T34D	T34D-05412	Thina	HIGH	LOW	HIGH	C	2
T34D	T34D-05460	Thina	HIGH	LOW	HIGH	D	2
T34E	T34E-05495	Bradgate se Loop	HIGH	VERY LOW	HIGH	B/C	2
T34E	T34E-05503	Luzi	HIGH	VERY LOW	HIGH	C	1
T34E	T34E-05507	Luzi	HIGH	LOW	HIGH	C	2
T34F	T34F-05512	Luzi	HIGH	VERY LOW	HIGH	C	2
T34G	T34G-05543	Thina	HIGH	LOW	HIGH	C	2
T34G	T34G-05634	Nxaxa	VERY HIGH	LOW	VERY HIGH	C/D	2
T34G	T34G-05667	Thina	MODERATE	LOW	MODERATE	B/C	2
T34H	T34H-05598	Thina	HIGH	MODERATE	HIGH	D	2
T34H	T34H-05772	Thina	HIGH	LOW	HIGH	B	3
T34H	T34H-05826	Ngcothi	HIGH	LOW	HIGH	B/C	3
T34K	T34K-05835	Thina	HIGH	MODERATE	HIGH	B/C	3
T35A	T35A-05596	Tsitsana	HIGH	VERY LOW	HIGH	B/C	2
T35A	T35A-05648	Tsitsa	HIGH	LOW	HIGH	B	2
T35A	T35A-05750	Tsitsa	HIGH	VERY LOW	HIGH	C/D	2
T35B	T35B-05709	Pot	HIGH	VERY LOW	HIGH	B/C	2
T35B	T35B-05798	Pot	HIGH	LOW	HIGH	C/D	2
T35B	T35B-05815	Little Pot	VERY HIGH	LOW	VERY HIGH	C	2
T35C	T35C-05858	Mooi	HIGH	VERY LOW	HIGH	C	2
T35C	T35C-05874	Mooi	VERY HIGH	MODERATE	VERY HIGH	D	3
T35C	T35C-05930	Klein-Mooi	HIGH	VERY LOW	HIGH	C	2
T35D	T35D-05721	iTsitsa	HIGH	LOW	HIGH	D	2
T35D	T35D-05844	Mooi	HIGH	MODERATE	HIGH	B	3
T35E	T35E-05780	Gqukunqa	MODERATE	VERY LOW	MODERATE	B	2
T35E	T35E-05908	iTsitsa	HIGH	MODERATE	HIGH	C	4
T35E	T35E-05977	iTsitsa	MODERATE	HIGH	HIGH	C	4
T35F	T35F-05973	Kuntombizininzi	VERY HIGH	MODERATE	VERY HIGH	B	4
T35F	T35F-05999	Inxu	HIGH	LOW	HIGH	B/C	3
T35F	T35F-06020	Inxu	VERY HIGH	LOW	VERY HIGH	D	3
T35G	T35G-06002	Inxu	HIGH	LOW	HIGH	C	3
T35G	T35G-06021	Inxu	HIGH	VERY LOW	HIGH	C	3

Quat	SQ	Main river name	Wetland EI	Wetland ES	EIS	PES	Wetland priority
T35G	T35G-06069	Gatberg	VERY HIGH	LOW	VERY HIGH	B	4
T35G	T35G-06074	Gatberg	HIGH	VERY LOW	HIGH	B/C	4
T35G	T35G-06099	Gatberg	VERY HIGH	LOW	VERY HIGH	B	3
T35G	T35G-06100		MODERATE	VERY LOW	MODERATE	C	2
T35G	T35G-06108	Inxu	HIGH	LOW	HIGH	B	4
T35G	T35G-06118	Gatberg	VERY HIGH	MODERATE	VERY HIGH	B/C	4
T35G	T35G-06133		HIGH	LOW	HIGH	C	3
T35G	T35G-06135	Gqaqala	VERY HIGH	MODERATE	VERY HIGH	C	4
T35G	T35G-06148		HIGH	VERY HIGH	VERY HIGH	B	4
T35G	T35G-06169	Gqaqala	HIGH	LOW	HIGH	C	2
T35G	T35G-06179		HIGH	LOW	HIGH	C	2
T35H	T35H-06024	Inxu	MODERATE	LOW	MODERATE	C	2
T35H	T35H-06053	Inxu	MODERATE	MODERATE	MODERATE	C	2
T35H	T35H-06186	Umnga	HIGH	HIGH	HIGH	C	2
T35H	T35H-06240	KuNgindi	VERY HIGH	MODERATE	VERY HIGH	C	3
T35H	T35H-06282	Umnga	HIGH	MODERATE	HIGH	B	2
T35J	T35J-06106	Ncolosi	MODERATE	MODERATE	MODERATE	D	2
T35K	T35K-05897	Culunca	MODERATE	HIGH	HIGH	D	2
T35K	T35K-05904	Tyira	MODERATE	HIGH	HIGH	D	2
T35K	T35K-06037	iTsitsa	MODERATE	VERY HIGH	VERY HIGH	C	4
T35K	T35K-06167	Xokonxa	HIGH	MODERATE	HIGH	C	3
T35L	T35L-05976	iTsitsa	VERY HIGH	HIGH	VERY HIGH	C	4
T35L	T35L-06190	iTsitsa	HIGH	LOW	HIGH	B	4
T35L	T35L-06226	Ngcolora	HIGH	HIGH	HIGH	D	2
T35M	T35M-06187	iTsitsa	MODERATE	MODERATE	MODERATE	B	4
T35M	T35M-06275	Ruze	HIGH	MODERATE	HIGH	B	2
T36A	T36A-06250	Mzimvubu	MODERATE	LOW	MODERATE	C	4
T36B	T36B-06391	Mzimvubu	VERY HIGH	MODERATE	VERY HIGH	C/D	4

Quat: quaternary

2.5 RESOURCE QUALITY OBJECTIVES FOR HIGH PRIORITY INDIVIDUAL WETLAND RESOURCE UNITS

There are hundreds of wetlands within the Mzimvubu WMA and RQOs cannot be determined individually for all of them, hence groupings according to SQs (**Table 2.1**), but some are important enough to warrant more detailed information. These were highlighted in the Wetland EcoClassification Report (DWS, 2017a). As detailed data of these High and Very High priority individual wetlands were limited however, Google Earth© was used to conduct level 1 WET-Health assessments (MacFarlane et al., 2007) for floodplains and to verify PES ratings in the PESEIS database for Channelled valley bottom wetlands. The HGM types of wetlands with High or Very High priority are shown in **Figure 2.2**. HGM types were taken from NFEPA spatial data (Nel et al., 2011). High and Very High priority wetlands formed three distinct groupings of wetland HGM types. These were mainly 1) floodplain wetlands and a few associated Channelled valley bottoms and flats in the Matatiele (Kinira), Cedarville (Mzimvubu floodplain) and Ugie (Gatberg) areas, 2) higher density seep and Channelled valley bottom wetlands in zones 1 (especially quaternary T31B), 2 (especially quaternary T31D), 3 (especially quaternaries T3A-D) and 5 (especially in the Ugie and Maclear vicinity) in higher lying areas, and 3) Channelled valley bottom wetlands (which more likely are inset or bench floodplain features) along the main channels of the Tsitsa, Thina and Mzintlava rivers, mostly towards confined valley and gorge areas in the lower reaches.

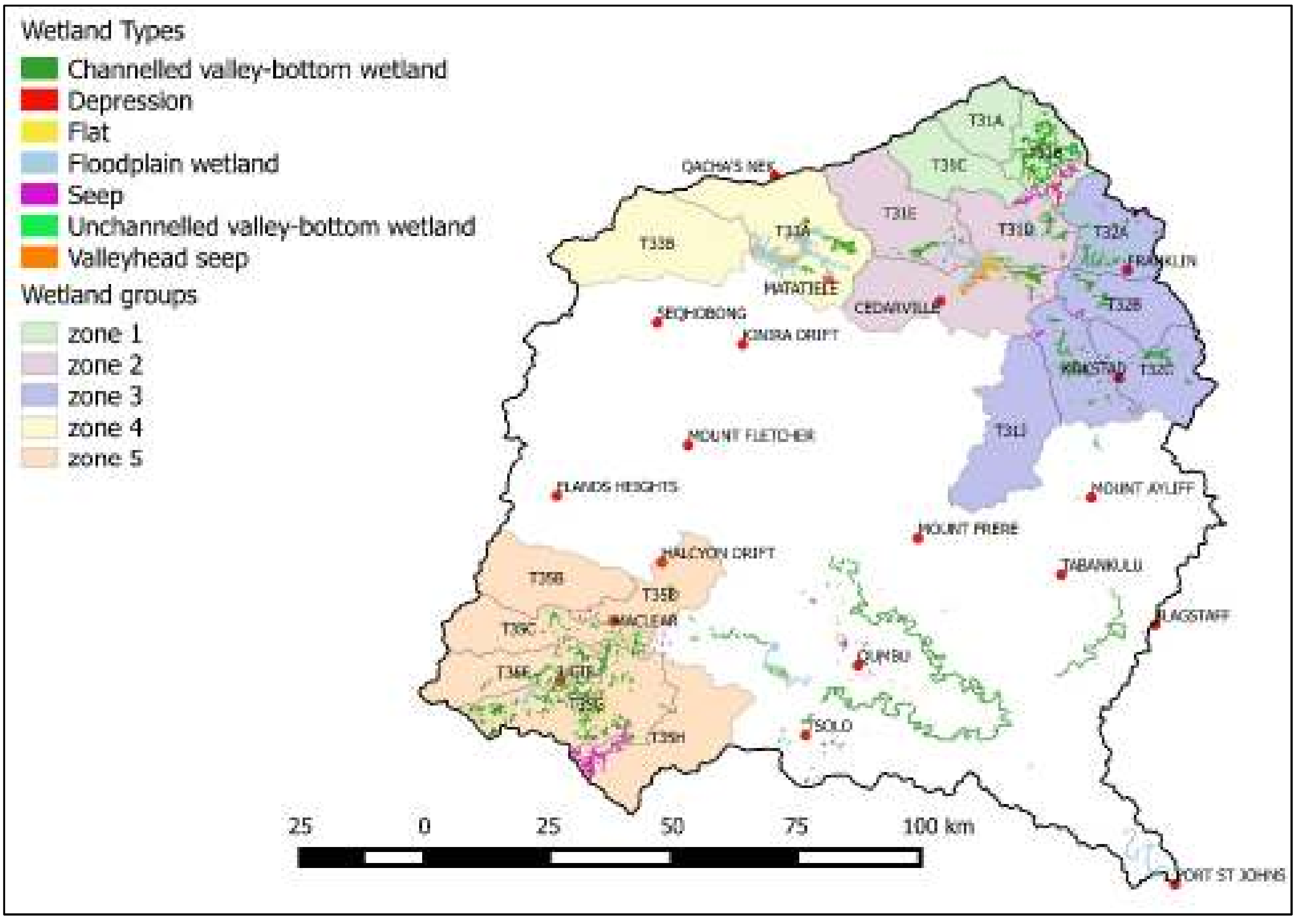

Figure 2.2 Wetland HGM types of High and Very High priority wetlands only

The vegetation component of WET-Health (Version 2) was used as a proxy for determining the PES for large floodplain complexes. Both the PES (based on the overall impact score) as well as the impact ratings were used to develop more detailed RQOs for important floodplains. The data are summarised here (and repeated from the Wetland EcoClassification Report; DWS, 2017a) since they underpin the RQOs outlined below.

2.5.1 Mzimvubu floodplains

The extent of the Mzimvubu floodplains near Cedarville that were assessed are shown in **Figure 2.3**. The vegetation component of WET-Health demonstrates an ecological category of D with a negative trajectory. The extent and nature of disturbances within the floodplains of this wetland complex are shown in **Table 2.2**. Agricultural use of the floodplains, as well as the damming of water, comprise the main impacts.

Table 2.2 Extent of disturbance within the Mzimvubu floodplains

Disturbance Class	Extent (%) of HGM			Total Extent (%)
	Floodplain 1	Floodplain 2	Floodplain 3	Wetland Complex
Infrastructure	3	3	2	2.6
Shallow flooding by dams	3	5	15	8.4
Agricultural activities / Crop lands	15	25	25	20.9
Perennial pastures	15	15	15	15.0
Canals / trenching /furrows	2	2	2	2.0
Old / abandoned lands	5	5	10	7.1
Dense alien vegetation patches.	3	3	3	3.0

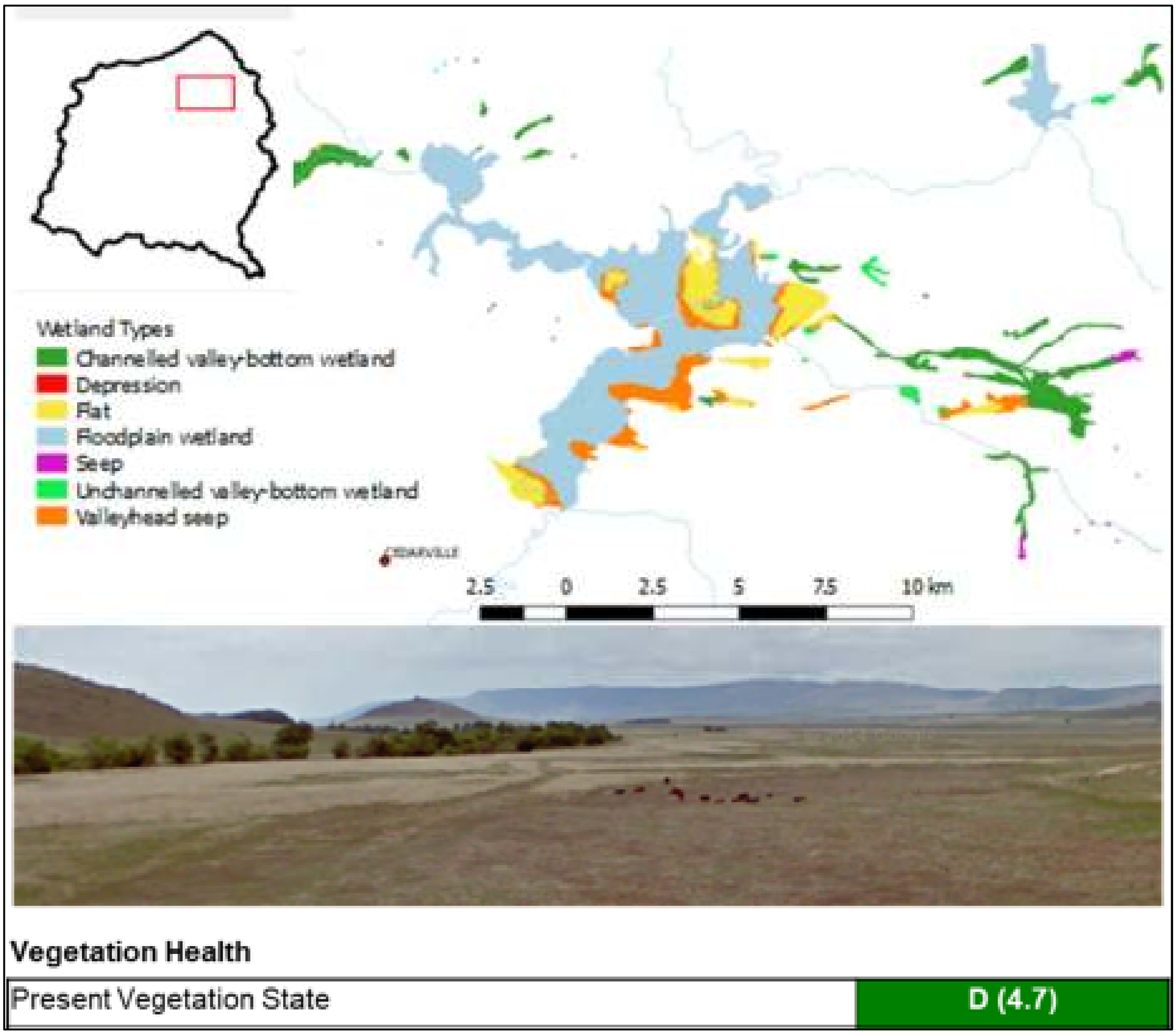

Figure 2.3 Mzimvubu floodplains that were assessed with WET-Health Level 2 using Google Earth©

2.5.2 Matatiele floodplains

The extent of the Matatiele floodplains that were assessed are shown in **Figure 2.4**. The vegetation component of WET-Health demonstrates an ecological category of D with a negative trajectory. The extent and nature of disturbances within the floodplains of this wetland complex are shown in **Table 2.3**. Agricultural use of the floodplains is the major impact.

Table 2.3 Extent of disturbance within the Matatiele floodplains

Disturbance Class	Extent (%) of HGM		Total Extent (%)
	Floodplain 1	Floodplain 2	Wetland Complex
Infrastructure	2	8	2.4
Shallow flooding by dams	2	5	2.2
Agricultural activities / Crop lands	35	25	34.3
Perennial pastures	15	10	14.7
Canals / trenching /furrows	2	2	2.0
Old / abandoned lands	10	5	9.7
Dense alien vegetation patches	3	3	3.0

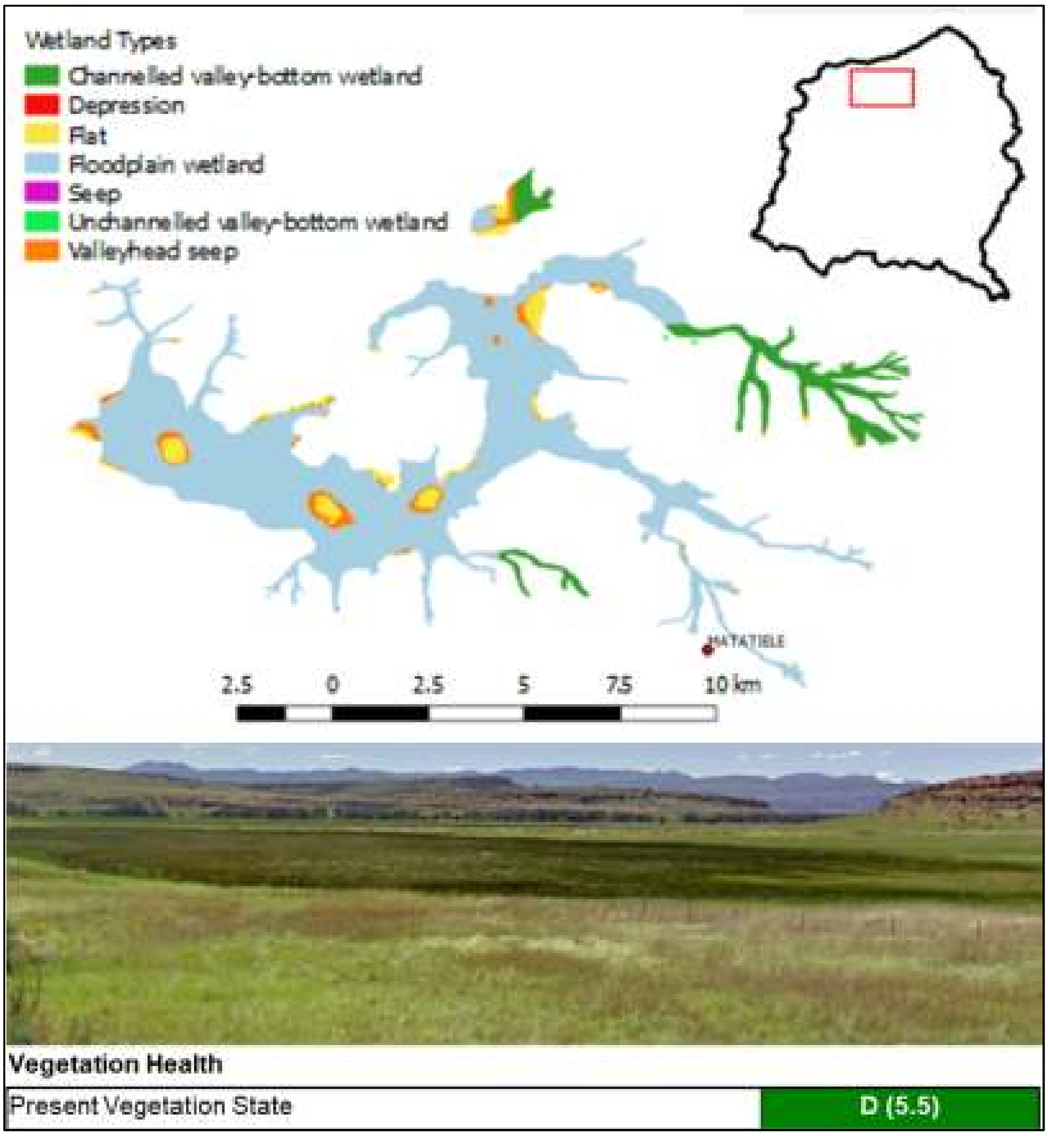

Figure 2.4 Mataiele floodplains that were assessed with WET-Health Level 2 using Google Earth©

2.5.3 Gatberg floodplains

The extent of the Gatberg floodplains near Ugie that were assessed are shown in **Figure 2.5**. The vegetation component of WET-Health demonstrates an ecological category of B with a stable trajectory. The extent and nature of disturbances within the floodplains of this wetland complex are shown in **Table 2.4**. Commercial forestry encroachment into wetlands and some agricultural use of the floodplains comprise the majority of impacts.

Table 2.4 Extent of disturbance within the Gatberg floodplains

Disturbance Class	Extent (%) of HGM		Total Extent (%)
	Floodplain 1	Floodplain 2	Wetland Complex
Infrastructure	1	1	1.0
Shallow flooding by dams	0	0	0.0
Agricultural activities / Crop lands	0	5	3.5
Perennial pastures	2	2	2.0
Canals / trenching /furrows	1	1	1.0
Old / abandoned lands	0	2	1.4
Dense alien vegetation patches.	0	1	0.7
Commercial plantations / forestry	10	10	10.0

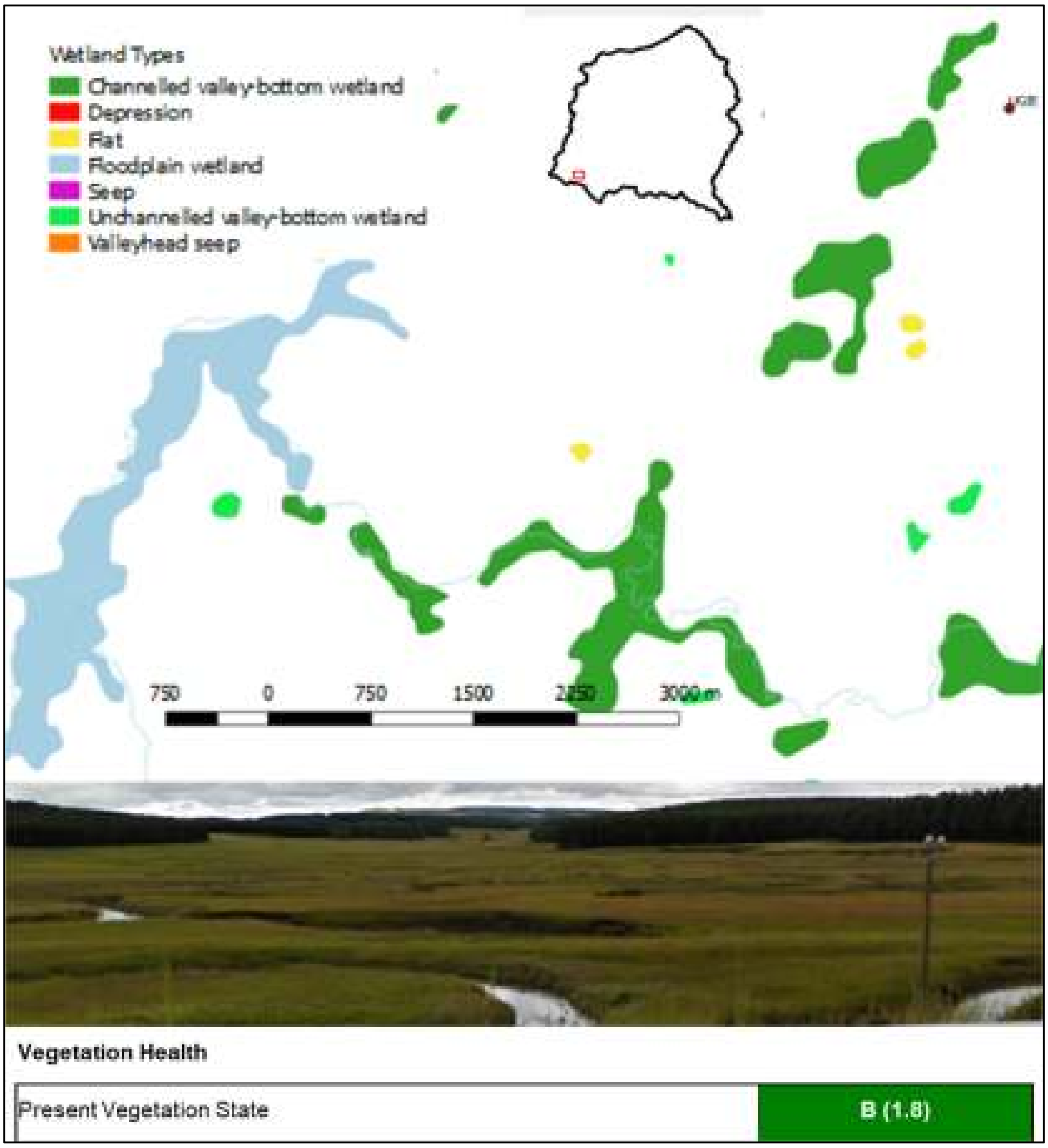

Figure 2.5 Gatberg floodplains that were assessed with WET-Health Level 2 using Google Earth ©

A summary of these high priority floodplains is shown in **Table 2.5** with the proposed Target Ecological Category (TEC) and strategies to achieve this category.

Table 2.5 Validated PES and proposed TEC for floodplain wetlands with High or Very High priority

Name	Includes SQs	Size (Ha)	Present vegetation state	TEC	How to achieve TEC
Mzimvubu floodplain	T31F-05112, T31F-05108, T31F-05111, T31D-05076, T31E-05013	2 678	D	C	1) Remove alien trees along the active channel; 2) restrict, reduce and manage agricultural activities within wetland; 3) no additional dams within wetland area.
Matatiele floodplain	T33A-04990, T33A-04991, T33A-05011	4 837	D	C	1) Remove alien trees along the active channel and wattle stands; 2) restrict, reduce and manage agricultural activities within wetland, especially floodplain manipulation; 3) no additional dams within wetland area; 4) restrict urban sprawl.
Gatberg floodplain	T35G06099, T35G06133, T35G-06118	198	B	B	1) Continue current management regime; 2) prevent additional forestry within wetlands; 3) restrict agricultural encroachment.

For high priority Channelled and unchannelled valley bottom wetlands, flats and seeps, PESEIS (DWS, 2014a) metrics for the riparian / wetland assessments were used as a starting point and were verified using Google Earth©. The assessment was based on the methodology of the PESEIS project i.e. the rating of wetland modification as well as habitat continuity modification, but focussed on the wetland components within each SQ. It should be noted that while the PESEIS project focussed directly on the delineated SQ (i.e. a section of river channel), this assessment focussed on all wetland components within the SQ catchment and included wetlands not necessarily directly linked to the main river of the delineated SQ. The results of this validation are shown in **Table 2.1** and **Table 3.6** for all wetlands with a priority of 3 or more. These wetlands therefore have higher confidence baseline EcoStatus and impact data, which enabled more detailed RQOs to be determined.

RQOs were not determined for high priority wetlands associated with main rivers i.e. group 3 above, which comprise channelled valley bottom wetlands (which more likely are inset or bench floodplain features) along the main channels of the Tsitsa, Thina and Mzintlava rivers, mostly towards confined valley and gorge areas in the lower reaches. RQOs for these wetlands are incorporated in the river RQOs.

3 WETLAND RESOURCE QUALITY OBJECTIVES

3.1 BROAD LEVEL NARRATIVE RESOURCE QUALITY OBJECTIVES FOR WETLANDS ACROSS THE WMA

The average EIS of quaternary catchments within the T3 primary catchment is listed in **Table 3.1**, and shown in **Figure 3.1**, while the average PES category is listed in **Table 3.2** and shown in **Figure 3.2**. In keeping with the *National Wetland Position Paper* (DWS, 2014b), which has proposed an objective that there be no net loss of wetland ecosystem, the broad scale narrative RQOs specify that the average quaternary level PES and EIS be maintained and not permitted to deteriorate.

Table 3.1 Average wetland EIS (calculated at the quaternary catchment scale) for quaternary catchments in the Mzimvubu WMA

Average EIS	Quaternary catchments
Low	T32E, T33K
Moderate	T33G, T33J, T35E, T35H, T35J, T35M, T36A
High	T31A, T31B, T31C, T31D, T31E, T31F, T31H, T31J, T32C, T32D, T32F, T32G, T32H, T33A, T33B, T33C, T33D, T33E, T33F, T33H, T34A, T34B, T34C, T34D, T34E, T34F, T34G, T34H, T34K, T35A, T35B, T35C, T35D, T35F, T35G, T35K, T35L
Very High	T31G, T32A, T32B, T36B

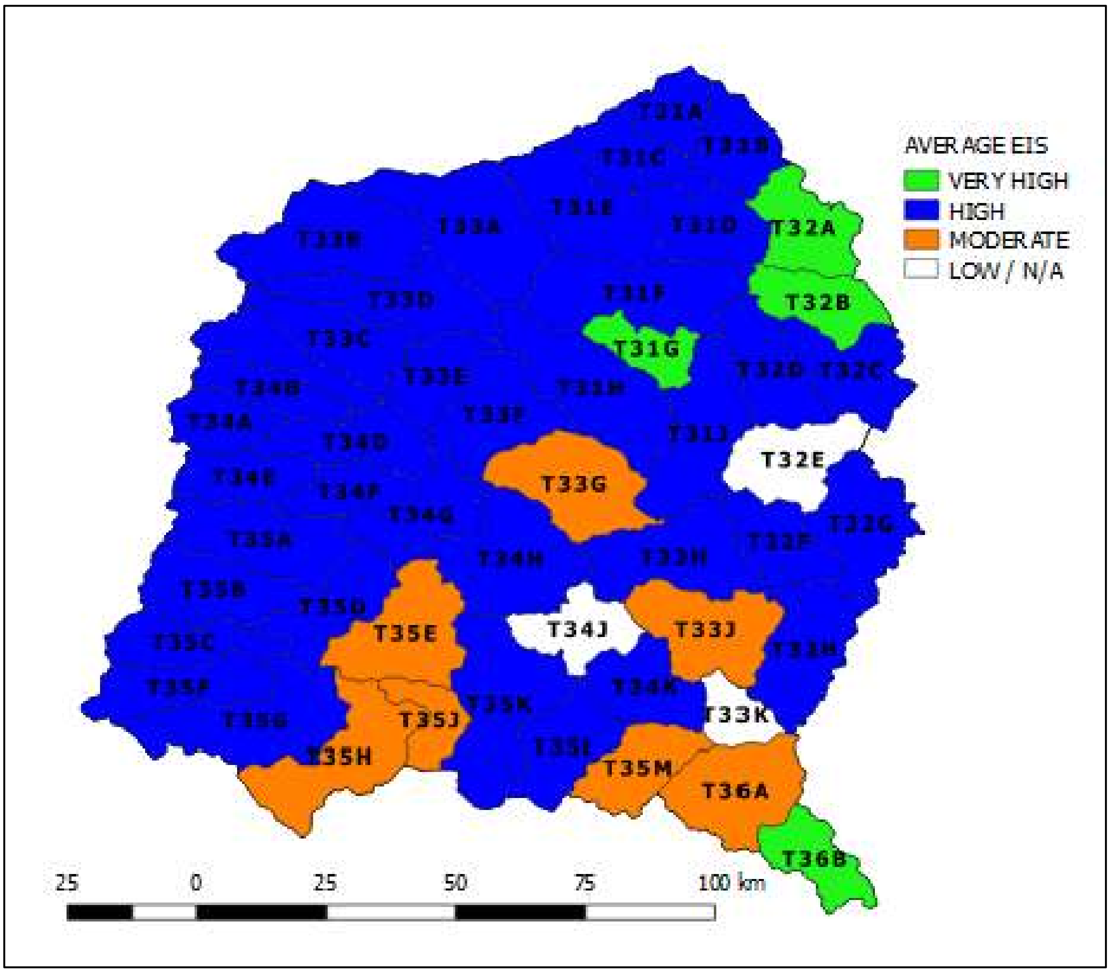

Figure 3.1 Average wetland EIS at the quaternary catchment scale

Table 3.2 Average wetland PES (calculated at the quaternary catchment scale) for quaternary catchments in the Mzimvubu WMA

Average PES	Quaternary catchments
B	T33K, T35M
B/C	T31B, T34A, T34C, T34K, T35E, T35G
C	T31A, T31C, T31E, T31F, T31G, T31H, T32G, T32H, T33A, T33G, T33H, T33J, T34B, T34E, T34F, T34G, T34H, T35A, T35B, T35D, T35F, T35H, T35L, T36A
C/D	T31D, T32A, T32B, T32C, T33C, T33D, T33E, T33F, T34D, T35C, T35J, T35K, T36B
D	T31J, T32D, T32E, T32F, T33B

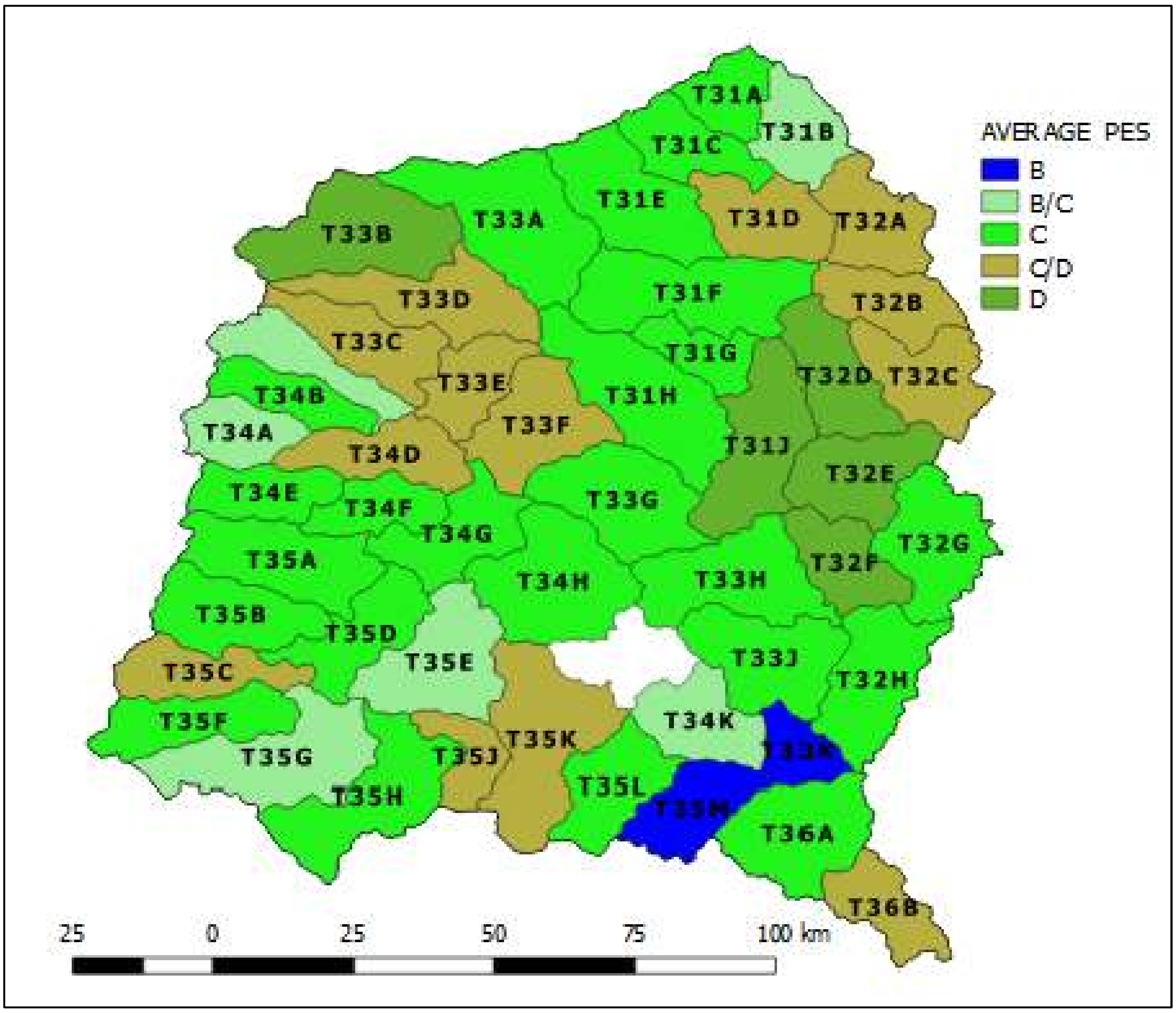

Figure 3.2 Average wetland PES category at the quaternary catchment scale

3.2 CATCHMENT LEVEL RESOURCE QUALITY OBJECTIVES FOR WETLANDS

Catchment level RQOs were developed at the sub-quaternary scale and are listed in **Table 3.3**.

Table 3.3 Catchment level RQOs for wetlands. RQOs apply to all SQs listed in Table 2.1

Component	Sub-component	RQO		Indicator	Motivation
		Narrative	Numerical		
Water quantity	Flow or inundation regime	Water quantity (i.e. flow and inundation regime) must maintain wetlands in good condition where practical.		Flow (water quantity) or inundation regime is sufficient to maintain the current PES.	Implementation of the EWR where possible.
	Species sensitive to flow	Water quantity (i.e. flow and inundation regime) must maintain populations of flow sensitive wetland species known to occur		Flow (water quantity) or inundation regime is sufficient to maintain the current PES.	
Water quality	Chemistry and sediments	Water quantity (i.e. chemistry and		Water quality is sufficient to	Implementation of the EWR

Component	Sub-component	RQO		Indicator	Motivation
		Narrative	Numerical		
		sediments) must maintain wetlands in good condition.		maintain the current PES.	where possible.
	Species sensitive to flow	Water quality (i.e. chemistry and sediments) must maintain populations of flow sensitive wetland species known to occur.		Water quality is sufficient to maintain the current PES.	
Habitat	Integrity and condition	The PES category of wetlands within each SQ must be maintained according to those listed in **Table 2.1**.	The PES score must be at least equal to the minimum value for the category: >92 for A, > 87.4 for A/B, > 82 for B, > 77.4 for B/C, > 62 for C, > 57.4 for C/D and > 42 for D.	PES	The NWRS (DWA, 2013) aims to address the loss of wetlands and to maintain healthy, functional ecosystems.
Habitat / Biota	Species / habitats sensitive to flow	Known or listed species or habitats sensitive to flow should be protected and the ES as listed in **Table 2.1** for each SQ should be maintained.		ES	Overall conservation of sensitive and important species and habitats (SANBI; DWS).
Biota	Threatened, endangered or endemic species	Known threatened, endangered or endemic wetland species should be protected and the EI as listed in **Table 2.1** for each SQ should be maintained.		EI	
Biota	taxon richness	Wetland species diversity and community health should be maintained.		Habitat condition is sufficient to maintain the current PES.	Is based on the premise that if the habitat is present and in good condition, the biota will be maintained.
Ecosystem services	Importance, sensitivity and demand	The ecosystem services of wetlands in a SQ must be maintained. A measure of this is the EIS, the category of which, must remain the same (or improve) within each SQ according to those listed in **Table 2.1**.		EIS	EIS advocated as a surrogate measure of ecosystem services at the SQ scale since it considers diversity (both habitat and species), sensitivity, risk and demand.

3.3 RESOURCE QUALITY OBJECTIVES FOR HIGH PRIORITY INDIVIDUAL WETLANDS

More detailed RQOs were developed for wetlands of High or Very High priority. Floodplain RQOs are listed in **Table 3.4** while RQOs for High priority Channelled and unchannelled valley bottoms, flats and seeps are listed in **Table 3.5**.

Table 3.4 RQOs for high priority floodplains

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
Mzimvubu Floodplains					
T31F-05112, T31F-05108, T31F-05111, T31D-05076, T31E-05013	Water quantity	Hydrology	The quantity and timing of inputs, and the distribution and retention patterns within the wetland must be maintained to avoid the loss of wetland hydrological function.	Data not available.	Wetland hydrology score. Detailed assessment of wetland hydrology using a PES tool.
		Shallow flooding by damming	The current extent of damming within the wetland complex should not be permitted to increase	The aerial extent of damming within the delineated wetland area shall not exceed 8.4% (refer to **Table 2.2**).	Impact score within WET-Health.
	Habitat	General wetland vegetation	The wetland vegetation must be maintained to ensure that the ecosystem structure and function are maintained.	Present condition is a D (impact score of 4.7), while the TEC is a C (impact score of 3.9 or less). The numerical criteria should equate to the same or improved value.	Impact score: Wetland vegetation score and PES as assessed with WET-Health.
		Loss / defragmentation due to direct agricultural activities	Direct agricultural activities and croplands should not be permitted to increase in extent within the wetland complex.	The aerial extent of agricultural activities and croplands within the delineated wetland area shall not exceed 20% (refer to **Table 2.2**).	Impact score (aerial extent) as assessed with WET-Health.
		Loss / defragmentation due to infrastructure, including canals, furrows and trenching	Additional development of infrastructure should not be permitted within the wetland complex.	The aerial extent of infrastructure, including canals, furrows and trenching, within the delineated wetland area	Impact score (aerial extent) as assessed with WET-Health.

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
				shall not exceed 5% (refer to **Table 2.2**).	
		Overall vegetation PES	The overall wetland PES as indicated by the vegetation component of WET-Health, must be maintained, or the TEC should be achieved.	Present condition is a D (impact score of 4.7), while the TEC is a C (impact score of 3.9 or less). The numerical criteria should equate to the same or improved value.	Wetland vegetation score and PES as assessed with WET-Health.
	Biota	Endangered crane species	Water quantity, vegetation condition and land use practices must be maintained so as to not cause any population decline.	Data exist but were not available for this assessment	Counts of the number of breeding pairs of crane species.
		Invasive alien vegetation	Invasive alien vegetation within the wetland complex should be kept in check so as not to increase in aerial extent.	The aerial extent of invasive alien vegetation within the delineated wetland area shall not exceed 3% (refer to **Table 2.2**).	Impact score (aerial extent) as assessed with WET-Health.
	Water quality	Detailed data of water quality indicators for this wetland were not available and no detailed RQOs related to water quality have been determined.			
Matatiele Floodplains					
T33A-04990, T33A-04991, T33A-05011	Water quantity	Hydrology	The quantity and timing of inputs, and the distribution and retention patterns within the wetland must be maintained to avoid the loss of wetland hydrological function.	Detailed data not available.	Wetland hydrology score. Detailed assessment of wetland hydrology using a PES tool.
		Shallow flooding by damming	The current extent of damming within the wetland complex should not be permitted to increase	The aerial extent of damming within the delineated wetland area shall not exceed 2.2% (refer to **Table 2.3**).	Impact score within WET-Health.
	Habitat	General wetland	The wetland	Present	Impact score:

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
		vegetation	vegetation must be maintained to ensure that the ecosystem structure and function are maintained.	condition is a D (impact score of 5.5), while the TEC is a C (impact score of 3.9 or less). The numerical criteria should equate to the same or improved value.	Wetland vegetation score and PES as assessed with WET-Health.
		Loss / defragmentation due to direct agricultural activities	Direct agricultural activities and croplands should not be permitted to increase in extent within the wetland complex.	The aerial extent of agricultural activities and croplands within the delineated wetland area shall not exceed 34% (refer to **Table 2.3**).	Impact score (aerial extent) as assessed with WET-Health.
		Loss / defragmentation due to infrastructure, including canals, furrows and trenching	Additional development of infrastructure should not be permitted within the wetland complex.	The aerial extent of infrastructure, including canals, furrows and trenching, within the delineated wetland area shall not exceed 4.5% (refer to **Table 2.3**).	Impact score (aerial extent) as assessed with WET-Health.
		Overall vegetation PES	The overall wetland PES as indicated by the vegetation component of WET-Health, must be maintained, or the TEC should be achieved.	Present condition is a D (impact score of 5.5), while the TEC is a C (impact score of 3.9 or less). The numerical criteria should equate to the same or improved value.	Wetland vegetation score and PES as assessed with WET-Health.
	Biota	Invasive alien vegetation	Invasive alien vegetation within the wetland complex should be kept in check so as not to increase in aerial extent.	The aerial extent of invasive alien vegetation within the delineated wetland area shall not exceed 3% (refer to **Table 2.3**).	Impact score (aerial extent) as assessed with WET-Health.
	Water quality	Detailed data of water quality indicators for this wetland were not available and no detailed RQOs related to water quality have been determined.			

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
Gatberg Floodplains					
T35G-06099, T35G-06133, T35G-06118	Water quantity	Hydrology	The quantity and timing of inputs, and the distribution and retention patterns within the wetland must be maintained to avoid the loss of wetland hydrological function.	Detailed data not available.	Wetland hydrology score. Detailed assessment of wetland hydrology using a PES tool.
		Shallow flooding by damming	Current damming within the wetland complex should remain absent.	The aerial extent of damming within the delineated wetland area shall not exceed 0% (refer to **Table 2.4**).	Impact score within WET-Health.
	Habitat	General wetland vegetation	The wetland vegetation must be maintained to ensure that the ecosystem structure and function are maintained.	Present condition is a B (impact score of 1.8). The numerical criteria should equate to the same or improved value.	Impact score: Wetland vegetation score and PES as assessed with WET-Health.
		Loss / defragmentation due to direct agricultural activities	Direct agricultural activities and croplands should not be permitted to increase in extent within the wetland complex.	The aerial extent of agricultural activities and croplands within the delineated wetland area shall not exceed 3.5% (refer to **Table 2.4**).	Impact score (aerial extent) as assessed with WET-Health.
		Loss / defragmentation due to commercial plantations or forestry	Commercial plantations or forestry should not be permitted to encroach or increase in extent within the wetland complex.	The aerial extent of commercial plantations or forestry within the delineated wetland area shall not exceed 10% (refer to **Table 2.4**).	Impact score (aerial extent) as assessed with WET-Health.
		Loss / defragmentation due to infrastructure, including canals, furrows and trenching	Additional development of infrastructure should not be permitted within the wetland complex.	The aerial extent of infrastructure, including canals, furrows and trenching, within the delineated wetland area shall not exceed 2% (refer to **Table 2.4**).	Impact score (aerial extent) as assessed with WET-Health.

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
		Overall vegetation PES	The overall wetland PES as indicated by the vegetation component of WET-Health, must be maintained, or the TEC should be achieved.	Present condition is a B (impact score of 1.8). The numerical criteria should equate to the same or improved value.	Wetland vegetation score and PES as assessed with WET-Health.
	Biota	Endangered crane species	Water quantity, vegetation condition and land use practices must be maintained so as to not cause any population decline.	Data exist but were not available for this assessment	Counts of the number of breeding pairs of crane species.
		Invasive alien vegetation	Invasive alien vegetation within the wetland complex should be kept in check so as not to increase in aerial extent.	The aerial extent of invasive alien vegetation within the delineated wetland area shall not exceed 1% (refer to **Table 2.4**).	Impact score (aerial extent) as assessed with WET-Health.
	Water quality	Detailed data of water quality indicators for this wetland were not available and no detailed RQOs related to water quality have been determined.			

Table 3.5 RQOs for High priority Channelled and unchannelled valley bottoms, flats and seeps

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
All SQs listed in **Table 3.6**.	Habitat	Habitat continuity / fragmentation / connectivity	Wetland connectivity and continuity within the SQ shall be maintained or improved.	Continuity modification ratings of 0 to 3 are to be maintained within the SQ. Ratings of 4 or 5 should to be remedied and improved.	A rating of habitat continuity modification from 0 to 5.
All SQs listed in **Table 3.6**.		Wetland habitat modification	Wetland habitats within the SQ shall be maintained or improved.	Wetland habitat modification ratings of 0 to 3 are to be maintained within the SQ. Ratings of 4 or 5 should to be remedied and improved.	A rating of wetland habitat modification from 0 to 5.
All SQs listed in **Table 3.6** where	Biota	Endangered crane species	Water quantity, vegetation condition and land use	Data exist but were not available for this assessment.	Counts of the number of breeding pairs of crane species,

SQs	Component	Sub-component	RQO		Indicator
			Narrative	Numerical	
cranes have been recorded.			practices must be maintained so as to not cause any population decline.		and distribution sightings.

Table 3.6 Verification of high priority wetland modification (WET MOD) and continuity (WET CONT) at the SQ scale

SQ	Main river name	Wetland type	Cranes*	WET MOD**	WET CONT***
T31B-04745	Krom	Channelled valley-bottom wetland	0	1	1
T31B-04873		Channelled valley-bottom wetland	1	1	1
T31C-04879	Nyongo	Flat	0	2	2
T31D-04936	Riet	Seep	1	2	1
T31D-05076	Mzimvubu	Floodplain wetland	1	2	2
T31E-05013	Tswereka	Unchannelled valley-bottom wetland	0	3	3
T31E-05055		Flat	1	2	2
T31F-05108		Flat	1	1	1
T31F-05111	Mzimvubu	Valleyhead seep	1	1	1
T31F-05112	Mzimvubu	Floodplain wetland	1	2	2
T32A-04907	Mzintlanga	Flat	1	2	2
T32A-04965	Mzintlava	Seep	1	2	2
T32B-05116		Channelled valley-bottom wetland	1	2	2
T32C-05243	aManzamnyama	Seep	1	2	2
T32C-05273	Mzintlava	Seep	0	3	3
T32C-05313	Mzintlava	Valleyhead seep	1	1	1
T32D-05172	Droewig	Channelled valley-bottom wetland	1	2	2
T32D-05352	Mzintlava	Channelled valley-bottom wetland	1	3	3
T32D-05373	Mzintlava	Channelled valley-bottom wetland	0	4	3
T32F-05464	Mzintlava	Channelled valley-bottom wetland	1	3	3
T32H-05842	Mzintlava	Channelled valley-bottom wetland	0	2	2
T33A-04928		Flat	0	1	2
T33A-04990	Kinira	Floodplain wetland	0	2	2
T33A-04991		Floodplain wetland	0	2	2
T33G-05659	Mzimvubu	Channelled valley-bottom wetland	0	1	1
T34H-05772	Thina	Channelled valley-bottom wetland	0	1	1
T34H-05826	Ngcothi	Channelled valley-bottom wetland	0	1	2
T34K-05835	Thina	Channelled valley-bottom wetland	0	1	2
T35C-05874	Mooi	Seep	1	2	3
T35D-05844	Mooi	Channelled valley-bottom wetland	1	1	1
T35E-05908	iTsitsa	Channelled valley-bottom wetland	1	2	2
T35E-05977	iTsitsa	Channelled valley-bottom wetland	0	2	2
T35F-05973	Kuntombizininzi	Channelled valley-bottom wetland	1	1	1
T35F-05999	Inxu	Channelled valley-bottom wetland	1	1	2
T35F-06020	Inxu	Channelled valley-bottom wetland	1	3	3
T35G-06002	Inxu	Flat	1	2	2
T35G-06021	Inxu	Flat	1	2	2
T35G-06069	Gatberg	Flat	1	1	2
T35G-06074	Gatberg	Flat	1	1	2
T35G-06099	Gatberg	Channelled valley-bottom wetland	1	1	2
T35G-06108	Inxu	Channelled valley-bottom wetland	1	1	1
T35G-06118	Gatberg	Floodplain wetland	1	1	2

SQ	Main river name	Wetland type	Cranes*	WET MOD**	WET CONT***
T35G-06133		Floodplain wetland	1	2	2
T35G-06135	Gqaqala	Flat	1	2	2
T35G-06148		UnChannelled valley-bottom wetland	0	0	0
T35H-06240	KuNgindi	Seep	1	2	2
T35K-06037	iTsitsa	Valleyhead seep	0	2	2
T35K-06167	Xokonxa	Channelled valley-bottom wetland	1	2	2
T35L-05976	iTsitsa	Seep	1	2	2
T35L-06190	iTsitsa	Channelled valley-bottom wetland	1	1	1
T35M-06187	iTsitsa	Channelled valley-bottom wetland	0	1	1
T36A-06250	Mzimvubu	UnChannelled valley-bottom wetland	0	2	2

Where: * 0 = cranes not recorded breeding in the area; 1 = crane breeding has been recorded in the area (data from NFEPA metadata, Nel et al., 2011)

** see below, based on DWS, 2014a

*** see below, based on DWS, 2014a

****POTENTIAL WETLAND MODIFICATION (all within the SQ)**

Modifications that indicate the potential that wetlands within the SQ may have been changed from the reference in terms of structure and composition that may influence functioning and processes occurring within. Also refers to wetlands as habitat for biota. Indicators are derived likelihoods that wetlands may have changed in occurrence and structure due to flow modification and physical changes due to agriculture, mining, urbanization, inundation, forestry etc. Based on land cover / land use information. The presence and impact of alien vegetation is also included. Impact ratings are essentially an 'average' or summary of the situation along the length of the SQ, e.g. sections may be better or worse and are as follows:

- 0 = None. Reference. No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.
- 1 = Small. The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.
- 2 = Moderate. The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.
- 3 = Large. The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.
- 4 = Serious. The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.
- 5 = Critical. The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.

*****POTENTIAL WETLAND HABITAT CONTINUITY MODIFICATION (all within the SQ)**

Modifications that indicate the potential that wetland connectivity may have been changed from the reference. Indicators include physical fragmentation, e.g. inundation by weirs, dams; physical removal by farming, mining, etc., presence of roads, urban areas. Impact ratings should indicate the likelihood that modifications may have an impact of a particular severity on wetland habitat lateral and longitudinal continuity. Ratings are essentially an 'average' or summary of the situation along the length of the SQ, e.g. sections may be better or worse as follows:

- 0 = None. Reference. No discernible impact, or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.
- 1 = Small. The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.
- 2 = Moderate. The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.
- 3 = Large. The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.
- 4 = Serious. The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.
- 5 = Critical. The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.

4 APPROACH: GROUNDWATER RESOURCE QUALITY OBJECTIVES

4.1 INTRODUCTION

Groundwater RQOs are developed to maintain the required groundwater contribution (groundwater baseflow) to the Ecological Reserve, which is assumed to equal the required maintenance low flow of rivers. The relevance off the groundwater RQOs to protect groundwater is two-fold; 1) to maintain and support the ecological requirements of the receiving surface water bodies; 2) to protect groundwater resources for the direct and indirect users of the groundwater.

The reduction of groundwater baseflow can occur due to abstraction by the interception of groundwater water flow which would normally discharge into rivers, or by abstraction near rivers, which creates drawdown and reverses groundwater gradients so that flow in the river in induced into the aquifer. Therefore, possible RQOs may stipulate the volume of abstraction that would cause an undesirable reduction in baseflow, or specific distances from a river, or specified distances from the surface water body where abstraction can take place.

Baseflow can also be impacted by afforestation and Alien Invasive Plants (AIPs), which can increase evaporation from groundwater if they occur in areas of shallow water table or reduce interflow from high lying areas. Selected indicators to monitor groundwater can be based on existing monitoring data, on simulated data if available, or extrapolation from other areas of similar hydrogeological conditions.

4.2 AVAILABLE DATA

The following literature sources and databases were accessed for groundwater information (**Table 4.1**).

Table 4.1 Literature sources and databases accessed during this study

Type of data	Data	Source
Catchment delineation	Quaternary catchment boundaries	WR2012
Groundwater discharge zones	Wetland location	National NFEPA Atlas 2011
Population	Population and water source	Statistics SA (referred to as Stats SA, 2012)
Climatic data	Rainfall	WR2012
Geology	Lithology and structures	Council for Geoscience (CGS) geological maps
Soils	Soil maps	WR2012
Hydrology	Flow data Baseflow	WR2012 GRA II (DWAF, 2006)

Type of data	Data	Source
Geohydrology	Harvest potential Exploitation potential Recharge Hydrochemistry Water levels Borehole yields	GRA II (DWAF, 2006) GRA II (DWAF, 2006) GRA II (DWAF, 2006) ZQM (National Groundwater Quality Monitoring Network) database, National Groundwater Archive (NGA) NGA NGA
Groundwater use	Licenced groundwater use Municipal water use Schedule 1 water use Livestock water use	WARMS (Water Allocation Registration Management System) Stats SA GRA II (DWAF, 2006)
Ecological Water Requirements	EWR data	Desktop and River EWR data from the Mzimvubu Classification and RQO study (DWS, 2017c; d)

4.3 METHODOLOGY

The approach used in developing the groundwater RQOs is shown in **Figure 4.1**.

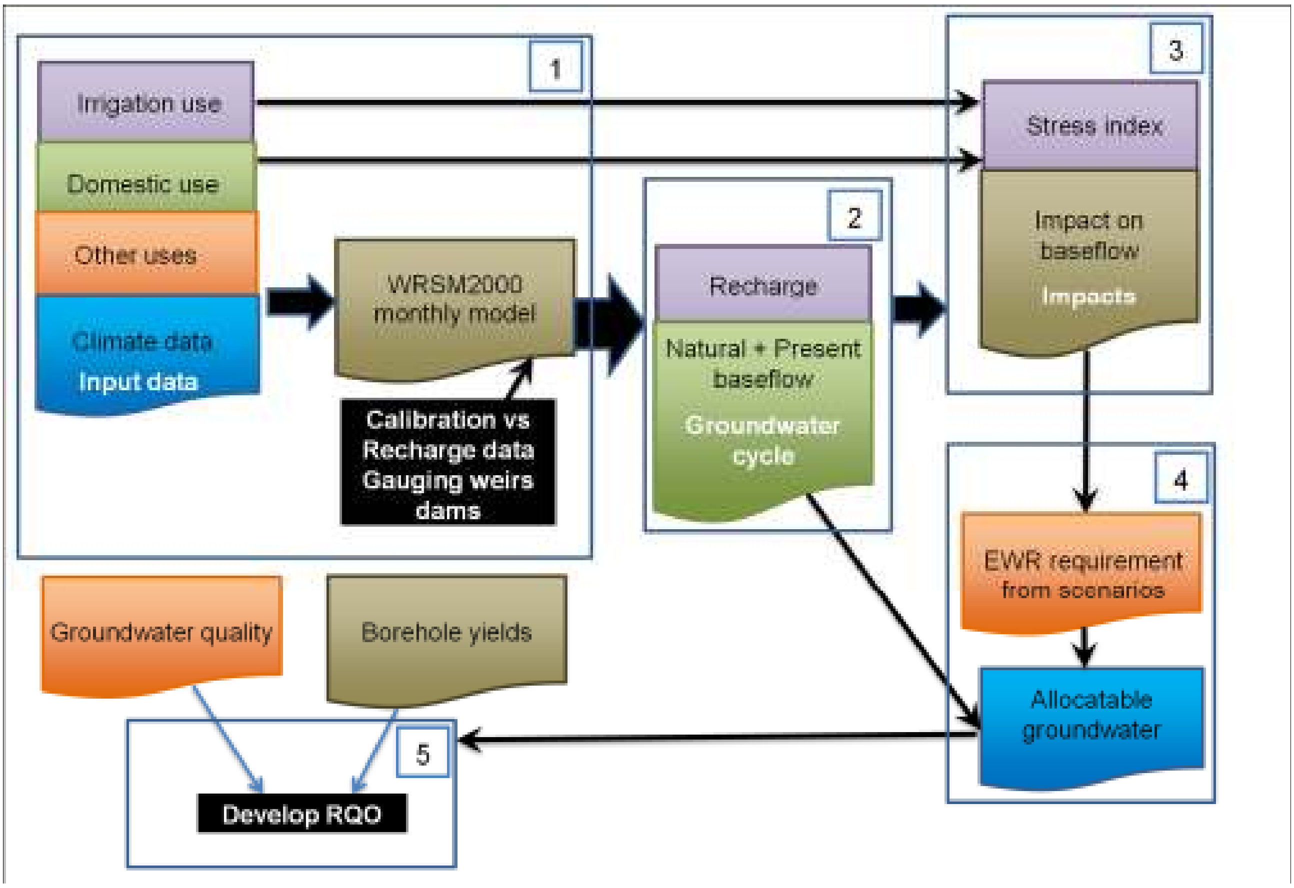

Figure 4.1 Approach to developing groundwater RQOs

The process followed to develop the RQOs from available data was a five-stage process:

1. Data on surface and groundwater use and climatic data, together with hydrological parameters were entered into the WRSM2000 model to quantify surface and groundwater

resources and interactions, such as recharge and baseflow and evapotranspiration from shallow groundwater. The data utilised was from WR2012 (Water Resources South Africa 2012), and groundwater use was from WARMS. The model was run from 1920 - 2012 and calibrated against DWA flow gauging data, dam volumes, and recharge data such as in the Groundwater Resource Assessment Phase II (GRAII) (DWAF, 2006). For groundwater, calibration included calibrating recharge, aquifer recharge and interflow to fit observed low flows, and baseflow depletion due to abstraction.

2. Since the calibrated flows include non-stationary hydrology due to temporal variations in abstraction and afforestation, they cannot be used to determine mean annual values. The surface and groundwater abstraction and afforestation were removed and WRSM2000 was run under virgin conditions. Data was extracted from the model to determine the water balance in terms of recharge, aquifer recharge, interflow, groundwater baseflow and evapotranspiration, both under virgin conditions and with groundwater abstraction at present day levels.
3. Present day groundwater use was divided by aquifer recharge to determine the stress index of the units. Impacts on baseflow were determined from baseflow reduction under present day abstraction relative to virgin baseflow.
4. The allocable groundwater was determined from the difference between present day abstraction and aquifer recharge.
5. Data from the above steps were utilised to develop qualitative and quantitative RQOs and estimate reductions in baseflow from further groundwater abstraction.

The following groundwater data were then synthesised for each quaternary catchment in each Groundwater Resource Unit (GRU) to determine the RQOs:

- Borehole yields
- Existing groundwater use and stress index (total use/aquifer recharge)
- The Harvest Potential of each catchment
- Recharge and aquifer recharge (which excludes the component of recharge lost as interflow and not available to groundwater users)
- Natural or virgin groundwater baseflow, interflow and total baseflow from WRSM2000
- The groundwater baseflow that would occur under present day groundwater abstraction and afforestation and AIPs from WRSM2000
- The mean annual baseflow under present day afforestation, AIPs and groundwater abstraction from WRSM2000

A significant shortcoming was that the available hydrology has never been calibrated for surface-subsurface interactions and no budget was available for this activity, hence the distributions between interflow and groundwater baseflow, and recharge and aquifer recharge, are of low confidence. The total volume of recharge was derived during GRAII.

More information regarding the groundwater task can be found in the relevant report for the study, i.e. the *Groundwater Report, Report No. WE/WMA7/00/CON/CLA/0817*.

4.4 CRITERIA USED FOR RESOURCE QUALITY OBJECTIVES

Table 4.2 is a summary table of the GRUs and the criteria that were concluded to be necessary for RQOs in each catchment.

Table 4.2 Summary of criteria used to set the groundwater RQOs

GRU	Quaternaries	Catchment	Baseflow	Quality	Groundwater level	Harvest Potential
1	T31A, T31C, T31E	Upper Mzimvubu		x		x
2	T31A, T31BT31C, T31D, T31E, T31G, T31H	Upper Mzimvubu		x		x
	T31F		x		x	x
3	T32A, T32B, T32C, T32D, T2E	Mzintlava		x		x
4	T33A	Upper Kinira	x	x		x
	T33B, T33C, T33D, T33E			x	x	x
5	T33F, T33G	Lower Kinira				x
6	T32F, T32G, T32H, T33K	Lower Mzintlava, Middle Mzimvubu, Mzintlavana		x		x
7	T34A, T34B, T34C, T34D, T34E, T34F	Upper Thina				x
8	T34G, T34H	Middlle Thina				x
9	T34J, T34K	Lower Thina		x		x
10	T35A, T35B, T35D, T35F, T35G,	Upper Tsitsa and Inxu		x		x
	T35C, T35H		x	x		x
11	T35E, T35H, T35J, T35K	Middle Tsitsa and lower Inxu	x	x		x
12	T35L, T35M	Lower Tsitsa		x		x
13	T36A, T36B	Lower Mzimvubu		x		x
14	T31J, T33J	Middle and lower Mzimvubu		x		x
	T33H			x		x

4.5 CLASSIFICATION OF CRITERIA IN RESOURCE QUALITY OBJECTIVES

4.5.1 Classification of groundwater status

To calculate the available groundwater resources, the standard DWS methodology (Parsons and Wentzel, 2007) was adopted to determine the stress index (groundwater use recharge), and a present status allocated according to the stress index. A fundamental flaw with this approach is that the use of recharge to calculate stress on groundwater resources ignores the fact that large part of recharge never enters the regional aquifers and is discharged as interflow from high lying regions, following rain events, or from saturated areas. Consequently, the stress index was calculated as the ratio of groundwater use to aquifer recharge, ignoring the interflow component not available to boreholes.

Once a stress index was calculated, each quaternary was assigned a groundwater (GW) present status based on the volume of groundwater abstracted compared to the volume recharged (stress index). The categories in **Table 4.3** were used to determine the present status of groundwater.

Table 4.3 Terminology and classes used during the classification process

GW present status	Description	Stress index	Water Resource Category
A	Unmodified, pristine conditions	≤ 0.05	Natural
B	Low volume GW usage, largely natural conditions, no negative impacts apparent	0.05 – 0.2	Good
C	Moderate volumes of GW usage, little or no negative impacts apparent	0.2 – 0.4	Fair
D	High volumes of GW usage, but with little apparent negative impact	0.4 – 0.65	Poor
E	Stressed system due to over-abstraction of GW or inappropriate land-use	0.65 – 0.95	
F	Critical over-abstraction of GW or highly sensitive hydrological environment	>0.95	

4.5.2 Abstraction

According to the degree of abstraction relative to the resource, as determined by the stress index, groundwater use can be described according to the categories in **Table 4.3**. However, abstraction impacts on baseflow vary not only according to the volume abstracted, but the proximity of abstraction to the river. Groundwater abstraction can deplete both groundwater storage and groundwater baseflow in a non-linear fashion depending on the transmissivity and storativity of the aquifer, the distance from the stream channel and the time since pumping started and the volume of recharge in that month. Using the methodology utilised in the WRSM2000 model (Pitman model; Pitman et al., 2006), distance and time curves for the impact of groundwater abstraction on baseflow show the following: For an aquifer with a transmissivity of 10 m^2/day and a storativity of 0.01, at a distance of 200 m from a river, over 90% of abstraction would be from groundwater stored for 100 days without recharge. The remainder of the abstraction would originate as baseflow depletion. Hence at 200 m the impacts of abstraction on baseflow would be low. At 100 m distance, 50% of abstraction would be from baseflow depletion. This distance, i.e. 100 m from a stream, was therefore selected as the general distance from which to restrict groundwater abstraction and streamflow reduction (SFR) activities in the absence of local data and in areas where baseflow reduction may be an issue.

4.5.3 Baseflow

In GRUs where baseflow reduction is greater than 30%, whether due to afforestation, AIPs or groundwater abstraction, it is considered necessary to monitor baseflow due to potential impacts on the ecology. Monitoring baseflow can take the form on monitoring dry season flows at gauging stations and comparing flows to natural flows utilising flow duration curves, or via simulation of impacts on low flows by model simulation of changes in land or water use. Where an EWR low flow has been set, this low flow can be used as a numerical low flow at the nearest downstream gauging station.

4.5.4 Water level

Setting water levels as an RQO is problematic since water levels vary by borehole location in terms of topography, pumping rates and aquifer hydraulic parameters. Hence, water level below surface is a site-specific variable which cannot be stipulated for an entire catchment.

In addition, monitoring water level provides only localised information, and monitoring water levels, for example, “within 50 m of a river to ensure water levels do not drop more than 0.5 m”, requires having a dense network of *regularly monitored* boreholes within 50 m of a river; so as to prevent only point data is being gathered and used. It is therefore not feasible for monitoring activities at catchment scale. Monitoring baseflow in catchments where groundwater is linked to rivers provides an integrated response of processes within the entire catchment, and where gauging weirs exist this data is already being collected. Hence monitoring flow in dry months and undertaking hydrograph separations in high flow periods provides a time series of information on the maintenance of ecological flows. In catchments where groundwater levels are below stream levels, only groundwater levels can provide information on storage levels in an aquifer.

Monitoring water levels is not necessary where baseflow reduction occurs due to afforestation and AIPs, which reduce interflow from high lying areas. Where groundwater is underutilised relative to recharge, dropping water levels are not expected, hence monitoring is not necessary, except as a record of background water level and its natural fluctuations, since the risk of a regional drop in water levels is unlikely. Monitoring of water levels should be prioritised in areas where the stress index is greater than 0.2, especially where the abstraction has had a significant impact on baseflow.

Where monitoring is necessary, the specific water level is borehole dependent and the critical issue is whether dry season water levels show a trend of decline over several years rather than an absolute level. This may occur in one borehole due to localised pumping but may not be applicable to an entire catchment.

4.5.5 Water quality

Groundwater water quality data is limited for many quaternary catchments, hence it is not possible to derive meaningful statistics such as ranges, medians etc.. The number of samples falling into each DWS water quality class is listed as a percentage for a catchment. Water quality classes are defined by DWS as shown in **Table 4.4** and are linked to potability of water. Where boreholes of a quality worse than Class II are present, monitoring is recommended.

Groundwater quality class was allocated according to the following criteria:

Class I: 95% of samples of water quality Class 0 and 1
Class II 75% of samples of water quality Class 0-2
Class III: <75% of samples Class 0-2

Table 4.4 DWS Water Quality classes

Water quality class	Description	Drinking health effects
Class 0	Ideal water quality	No effects, suitable for many generations.
Class 1	Good water quality	Suitable for lifetime use. Rare instances of sub-clinical effects.
Class 2	Marginal water quality, water suitable for short-term use only	May be used without health effects by majority of users, but may cause effects in some sensitive groups. Some effects possible after lifetime use.
Class 3	Poor water quality	Poses a risk of chronic health effects, especially in babies, children and the elderly. May be used for short-term emergency supply with no alternative supplies available.
Class 4	Unacceptable water quality	Severe acute health effects, even with short-term use.

4.5.6 RQOs for catchments with no surface groundwater interactions

Due to the relatively high rainfall of the study area and the rugged topography, every catchment generates both interflow and groundwater baseflow, hence the potential to impact on baseflow via afforestation, AIPs, SFR activities and groundwater abstraction exists in every quaternary catchment.

5 GROUNDWATER: RESOURCE QUALITY OBJECTIVES

RQOs are presented per Groundwater Resource Unit.

5.1 GRU 1 AND GRU 2: UPPER MZIMVUBU

5.1.1 Hydrogeology

GRUs 1 and 2 are distinguished by the rugged escarpment zone of the South-eastern Highlands. GRU 1 is the rugged escarpment zone of the headwater of the catchments, whose function is largely as a source of interflow. GRU 2 is the larger portion of the catchments below the escarpment. Data are not available on the scale required to distinguish their recharge and groundwater use characteristics, hence they are combined. They cover catchments T31A (Mzimvubu), T31C (Mingeni and Nyongo), T31E (Tswereka), T31B (Krom), T31D (Riet and Mzimkulu), T31H (Myenyane), T31F and T31G (Mzimkulu). Quaternary catchment T31F contains the town of Cedarville.

The GRUs consists of rural areas, with dryland irrigation and some irrigated lands in the lower reaches of T31E, T31D, F and G. Some afforestation exists in the upper reaches of T31A and B. T31A, B and F are heavily dependent on groundwater (> 65%).

Rocks of the Clarens, Elliot and Molteno Formations underlie the Escarpment watershed of GRU 1, and rocks of the Tarkastad Subgroup underlies GRU 2, along with extensive quaternary cover in the flat lands between Matatiele, Cedarville and Swartberg (**Figure 5.1**).

The yield characteristics are shown in **Table 5.1**. Yields are relatively high, making localised overexploitation possible.

Table 5.1 Borehole yields in GRU 1 and GRU 2

Quaternary	T31A	T31B	T31C	T31D	T31E	T31F	T31G	T31H
No of boreholes	1	12	16	16	35	49	6	27
Median yield (l/s)	1.04	0.96	1.48	0.83	2.4	2	2.7351	0.5
% of boreholes > 2 l/s	0	33.3	43.8	31.3	51.4	49	66.667	25.9

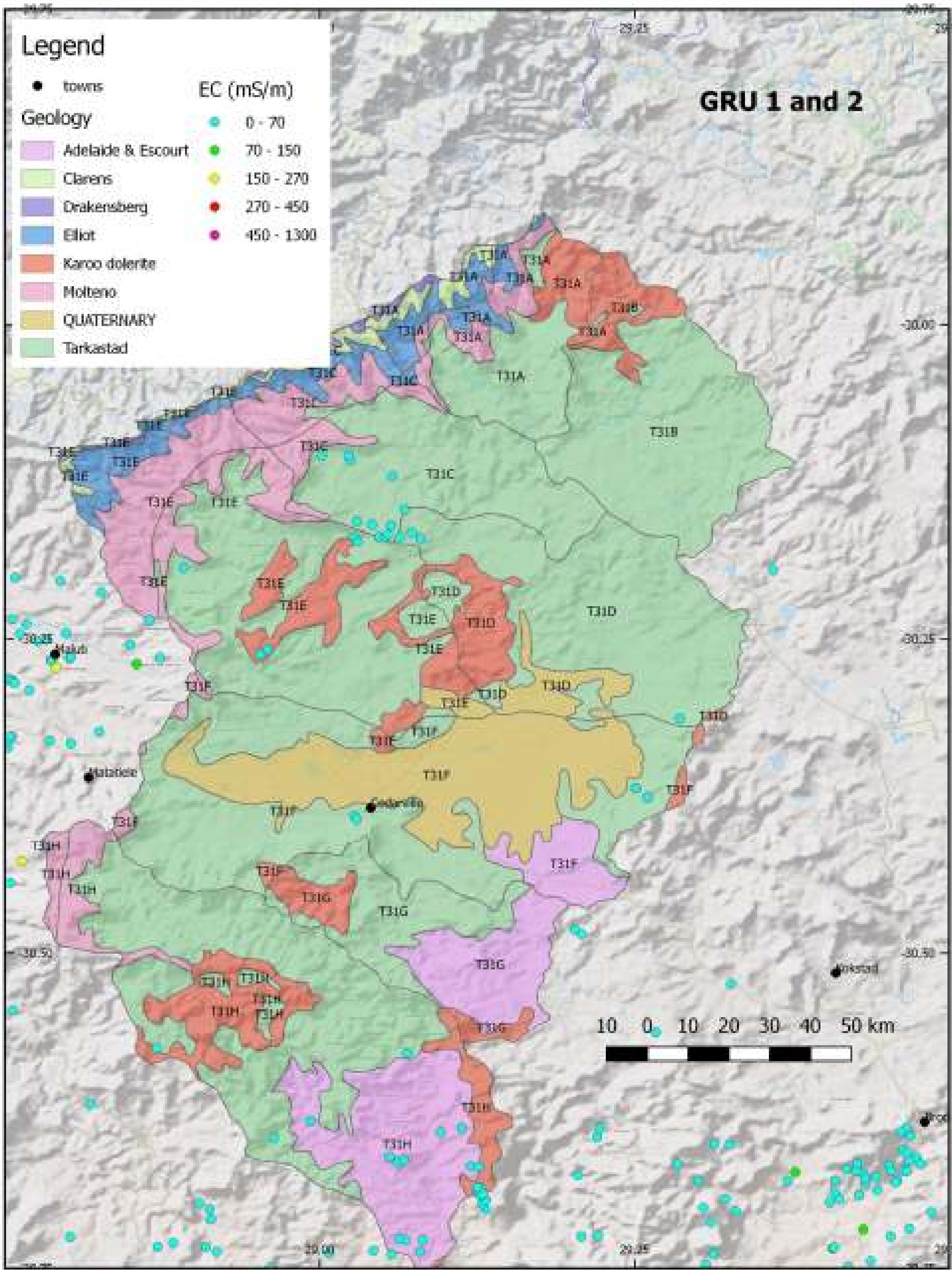

Figure 5.1 Upper Mzimvubu GRU 1 (Molteno, Elliot, Clarens and Drakensberg Formations) and GRU 2 (Tarkastad and Adelaide Subgroups)

5.1.2 Groundwater use and resources

Groundwater use in these GRUs is minimal except in T31F due to use near Cedarville. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <30%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.2**).

Table 5.2 Groundwater use and resources in GRU 1 and 2

Quaternary	T31A	T31B	T31C	T31D	T31E	T31F	T31G	T31H
Recharge (Mm^3)	56.02	44.82	45.32	32.83	36.5	29.66	43.55	44.45
Aquifer Recharge (Mm^3)	7.858	9.678	9.731	9.282	10.339	9.49	9.939	9.622
Harvest Potential (Mm^3)	3.62	5.03	5.08	6.22	8.47	10.41	3.26	9.9
Total use (Mm^3)	0.02	0.027	0.154	0.213	0.135	3.243	0.099	0.361
Stress Index	0.002	0.002	0.006	0.022	0.008	0.341	0.009	0.022
GW Present Status	A	A	A	A	A	C	A	A

5.1.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Elevated fluorides and nitrates can exist in T31D and E (**Table 5.3**). An empty block signifies too few data points for an assessment.

Table 5.3 Borehole water quality in GRU 1 and 2

Quaternary	Class per variable	T31A	T31B	T31C	T31D	T31E	T31F	T31G	T31H
Integrated water quality (wq) Class		I	I	I	II	II	I	I	I
Total Dissolved Solids (TDS) quality class %	0			100	100	100	100	100	100
	1								
	2								
	3								
	4								
Nitrate quality class %	0	100	100	100	93	83	97	88	100
	1	0	0	0	7	0	3	13	0
	2	0	0	0	0	0	0	0	0
	3	0	0	0	0	17	0	0	0
	4	0	0	0	0	0	0	0	0
Fluoride quality class %	0	100	100	100	87	100	76	100	100
	1	0	0	0	7	0	21	0	0
	2	0	0	0	7	0	3	0	0
	3	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0

5.1.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Only 9-22% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.4**). No significant baseflow reduction occurs.

Table 5.4 Groundwater contribution to baseflow in GRU 1 and 2

Quaternary		T31A	T31B	T31C	T31D	T31E	T31F	T31G	T31H
Baseflow	Groundwater baseflow (Mm^3)	1.08	1.86	1.77	1.91	2.83	3.31	0.59	5.31
	Interflow (Mm^3)	7.82	8.51	8.67	8.96	13.49	14.57	6.25	18.19
Total Base flow (Mm^3)		8.9	10.37	10.44	10.87	16.32	17.88	6.84	23.5
Use (Mm^3)		0.02	0.027	0.154	0.213	0.135	3.243	0.099	0.361
Present day Baseflow (Mm^3)		8.48	10.26	10.24	10.83	15.86	17.73	6.68	22.4
Baseflow reduction (%)		4.72	1.06	1.92	0.37	2.82	0.84	2.34	4.68

5.1.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal except in T31F where irrigation takes place. The high borehole yields make localised over-abstraction possible, but unlikely to have a regional scale impact. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides in some localities can be associated with doleritic intrusions and removal of vegetation.

The abstractable volume of groundwater is based on the Harvest Potential, which is higher than the aquifer recharge in T31F and H. RQOs are listed in **Table 5.5**.

Table 5.5 Groundwater RQOs for GRU 1 and 2

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T31A-E, T31G-H	All users to comply with existing allocation schedules, including GA* and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes.	Due to low groundwater stress, no numerical limits are set.
T31F	All users to comply with existing	Due to groundwater contribution to	Water level monitoring required near	No water quality monitoring	The remaining Allocable groundwater is 5.21

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
	allocation schedules¸ including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	baseflow, abstraction within 100 m of perennial rivers should be restricted to use less than the GA.	Cedarville and areas of high abstraction. No downward trend of static water level should be seen over a period of 5 years.	required.	Mm^3/a. Note allocable = 65% of aquifer recharge – Reserve.

GA: General Authorization

5.2 GRU 3: UPPER MZINTLAVA

5.2.1 Hydrogeology

This GRU occupies the area from the catchment watershed to Mount Ayliff. It contains catchments T32A and B (Mzintlava), T32C (Manzamnyama and Mzintlava), T32D (Droewig and Mzintlava), and T32E (Mvalweni and Mzintlava). T32C includes the town of Kokstad.

The GRUs consist of rural areas, with dryland irrigation and some irrigated lands in T32A–C near Franklin, Swartberg and Kruisfontein, downstream to Kokstad. Some afforestation exists in T32C. T32A is heavily dependent on groundwater (> 65%).

Rocks of the Tarkastad Subgroup underlie the upper reaches of T32A, otherwise the GRU is underlain by mudstones and sandstones of the Adelaide Subgroup. Extensive outcrop of dolerite sheets occur across the GRU (**Figure 5.2**).

The yield characteristics are shown in **Table 5.6**. Yields are relatively high, making localised overexploitation possible.

Table 5.6 Borehole yields in GRU 3

Quaternary	T32A	T32B	T32C	T32D	T32E
No of boreholes	19	7	16	26	39
Median yield (l/s)	1.56	1.53	1	1.28	1.6
% of boreholes > 2 l/s	31.6	28.6	31.3	34.6	38.5

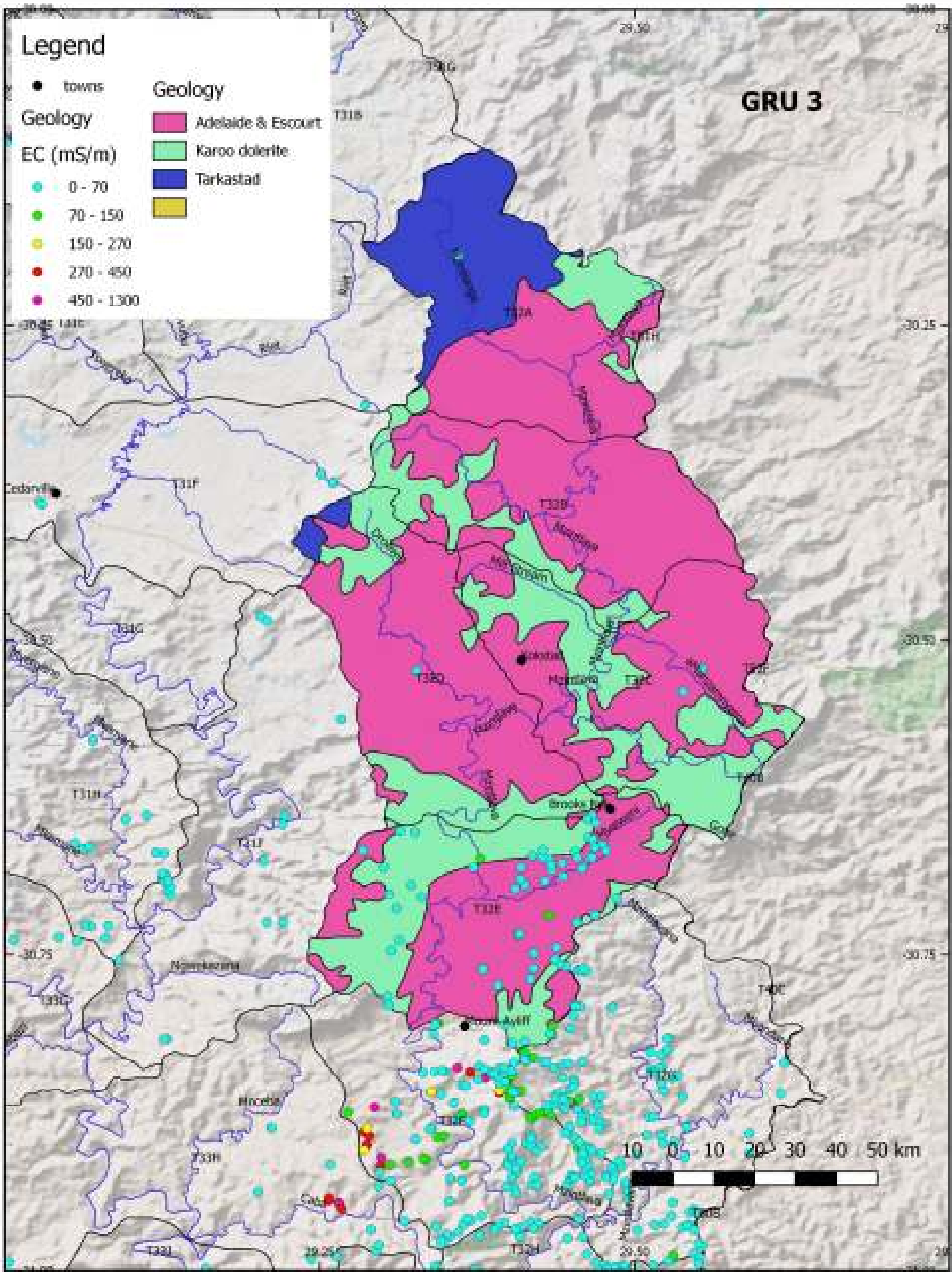

Figure 5.2 Upper Mzintlava GRU 3

5.2.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <30%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.7**).

Table 5.7 Groundwater use and resources in GRU 3

Quaternary	T32A	T32B	T32C	T32D	T32E
Recharge (Mm^3)	38.59	42.92	40.2	39.7	49.33
Aquifer Recharge (Mm^3)	10.488	10.128	10.086	12.525	9.736
Harvest Potential (Mm^3)	5.26	4.18	5.07	4.77	5.21
Total use (Mm^3)	0.8	0.048	0.123	0.115	0.732
Stress Index	0.076	0.004	0.008	0.007	0.067
GW Present Status	B	A	A	A	B

5.2.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Elevated fluorides and nitrates can exist in T32C-E (**Table 5.8**).

Table 5.8 Borehole water quality in GRU 3

Quaternary	Class per variable	T32A	T32B	T32C	T32D	T32E
Integrated water quality (wq) Class		I	I	I	II	I
Total Dissolved Solids quality class %	0	100	100	100	100	86
	1	0	0	0	0	9
	2	0	0	0	0	0
	3	0	0	0	0	0
	4	0	0	0	0	5
Nitrate quality class %	0	100	100	100	100	86
	1	0	0	0	0	9
	2	0	0	0	0	0
	3	0	0	0	0	0
	4	0	0	0	0	5
Fluoride quality class %	0	86	100	93	75	100
	1	7	0	0	6	0
	2	7	0	0	0	0
	3	0	0	7	13	0
	4	0	0	0	6	0

5.2.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer the remainder originating as interflow (**Table 5.9**).

Table 5.9 Groundwater contribution to baseflow in GRU 3

Quaternary		T32A	T32B	T32C	T32D	T32E
Baseflow	Groundwater baseflow (Mm^3)	2.45	2.35	2.91	2.65	3.39
	Interflow (Mm^3)	15.99	15.14	18.48	11.38	14.65
Total Base flow (Mm^3)		18.44	17.49	21.39	14.03	18.04
Use (Mm^3)		0.8	0.048	0.123	0.115	0.732
Present day Baseflow (Mm^3)		18.03	16.77	20.36	13.63	17.39
Baseflow reduction (%)		2.22	4.12	4.82	2.85	3.60

5.2.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The high borehole yields make localised over-abstraction possible, impact on a regional scale is unlikely. The groundwater component of baseflow is low, hence the potential of groundwater abstraction impacting on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides in some localities can be associated with doleritic intrusions and the removal of vegetation.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.10**.

Table 5.10 Groundwater RQOs for GRU 3

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T32A-E	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes have elevated natural fluoride levels and fluoride needs to be tested for domestic boreholes.	Due to low groundwater stress, no numerical limits are set.

5.3 GRU 4: UPPER KINIRA

5.3.1 Hydrogeology

This area forms GRU 4, the upper Kinira, from the catchment watershed to T33E. It contains catchments T33A (upper Kinira and its tributaries), T33B (Mabele and tributaries), T33C (Monulane), T32D (Pabatlong and Kinira), and T32E (Kinira and Somabadi). The towns of Maluti and Matatiele are located in T33A.

The GRUs consists of rural areas, with dryland irrigation. T33D is heavily dependent on groundwater (> 65%). Rocks of the Drakensberg, Clarens and Elliot Formations underlie the Escarpment watershed in the west, while the underlying Molteno Formation and Tarkastad Subgroup are exposed in the east. Quaternary cover underlies the Mabele in T33A and B (**Figure 5.3**).

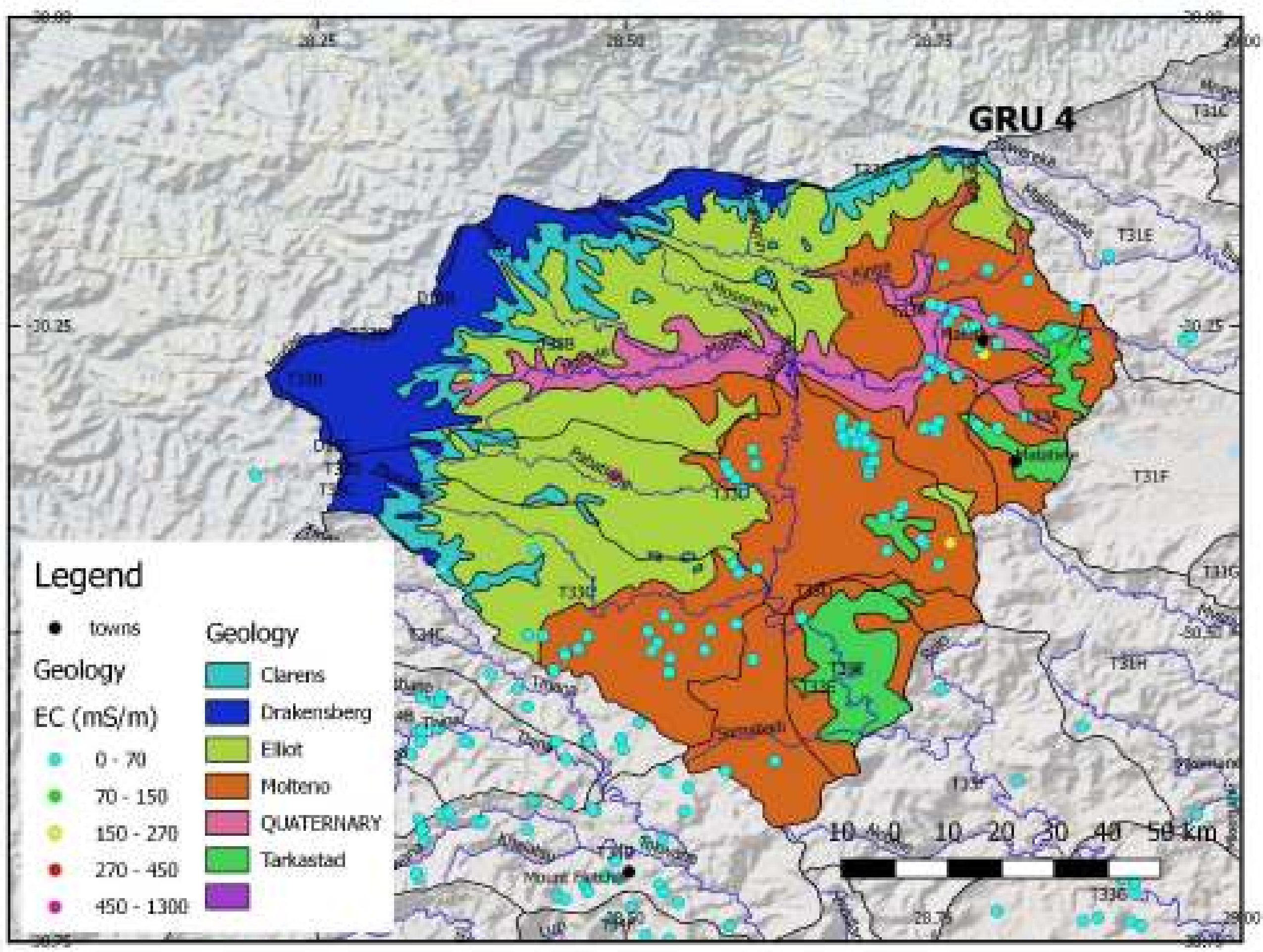

Figure 5.3 Upper Kinira GRU

The yield characteristics are shown in **Table 5.11**. Yields are relatively high, making localised overexploitation possible.

Table 5.11 Borehole yields in GRU 4

Quaternary	T33A	T33B	T33C	T33D	T33E
No of boreholes	78	8	26	64	24
Median yield (l/s)	2.7501	1.9	0.91	1.26	0.9
% of boreholes > 2 l/s	55.128	50	26.9	31.3	29.2

5.3.2 Groundwater use and resources

Groundwater use in the GRU is minimal, except for T33A around Matatiele. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <30%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.12**).

Table 5.12 Groundwater use and resources in GRU 4

Quaternary	T33A	T33B	T33C	T33D	T33E
Recharge (Mm^3)	36	41.86	35	33.64	35.59
Aquifer Recharge (Mm^3)	9.012	10.189	9.211	9.237	10.602
Harvest Potential (Mm^3)	11.64	9.57	5.43	6.85	3.63
Total use (Mm^3)	3.431	0.161	0.4	1.342	0.299
Stress Index	0.371	0.005	0.024	0.119	0.021
GW Present Status	C	A	A	B	A

5.3.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Elevated fluorides and nitrates exist (**Table 5.13**).

Table 5.13 Borehole water quality in GRU 4

Quaternary	Class per variable	T33A	T33B	T33C	T33D	T33E
Integrated wq Class		I	I	I	II	I
TDS quality class %	0	88	100	100	93	100
	1	3	0	0	0	0
	2	0	0	0	0	0
	3	5	0	0	0	0
	4	0	0	0	2	0
Nitrate quality class %	0	100	100	67		100
	1	0	0	0		0
	2	0	0	0		0
	3	0	0	33		0
	4	0	0	0		0
Fluoride quality class %	0	86	100	100		67
	1	0	0	0		0
	2	0	0	0		0
	3	14	0	0		0
	4	0	0	0		33

5.3.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 15% of baseflow is from the regional aquifer the remainder originating as interflow (**Table 5.14**).

Table 5.14 Groundwater contribution to baseflow in GRU 4

Quaternary		T33A	T33B	T33C	T33D	T33E
Baseflow	Groundwater baseflow (Mm^3)	1.91	0.03	0.44	0.48	1.35
	Interflow (Mm^3)	28.98	28.91	15.92	20.03	6.93
Total Base flow (Mm^3)		30.89	28.94	16.36	20.51	8.28
Use (Mm^3)		3.431	0.161	0.4	1.342	0.299
Present day Baseflow (Mm^3)		28.65	28.81	16.34	18.78	8.28
Baseflow reduction (%)		2.56	0.45	0.12	3.80	0.00

5.3.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal, except for T33A around Matatiele. The high borehole yields make localised over-abstraction possible, but unlikely on a regional scale. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides in some localities can be associated with doleritic intrusions and the removal of vegetation.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.15**.

Table 5.15 Groundwater RQOs for GRU 4

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T33A	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to groundwater contribution to baseflow, abstraction within 100 m of perennial rivers should be restricted to use less than the GA.	Water level monitoring required near Matatiele and areas of high abstraction. No downward trend of static water level should be seen over a period of 5 years.	No water quality monitoring required.	The remaining allocable groundwater is 1.366 Mm^3/a. Note allocable = 65% of aquifer recharge – Reserve.
T33B-E	All users to comply with existing allocation schedules,	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to	Some boreholes have elevated natural nitrate and fluoride	Due to low groundwater stress, no numerical limits are set.

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
	including GA and Schedule 1, and individual licence conditions within the Harvest Potential.		baseflow, monitoring not required. Water level monitoring required near Matatiele in regional water supply boreholes.	levels, so nitrate and fluoride need to be tested for domestic boreholes.	

5.4 GRU 5: LOWER KINIRA

5.4.1 Hydrogeology

This area forms GRU 5, the lower Kinira between GRU 4 and the confluence with the Mzimvubu River. It contains catchments T33F and G of the lower Kinira River.

The GRUs consists of rural areas, with dryland irrigation. Some afforestation exists. The GRU is not very dependent on groundwater. Rocks of the Tarkastad and Adelaide Subgroups underlie most of the GRU (**Figure 5.4**).

The yield characteristics are shown in **Table 5.16**. Yields are relatively high, making localised over-exploitation possible.

Table 5.16 Borehole yields in GRU 5

Quaternary	T33F	T33G
No of boreholes	26	52
Median yield (l/s)	1.38	2.15
% of boreholes > 2 l/s	46.2	51.9

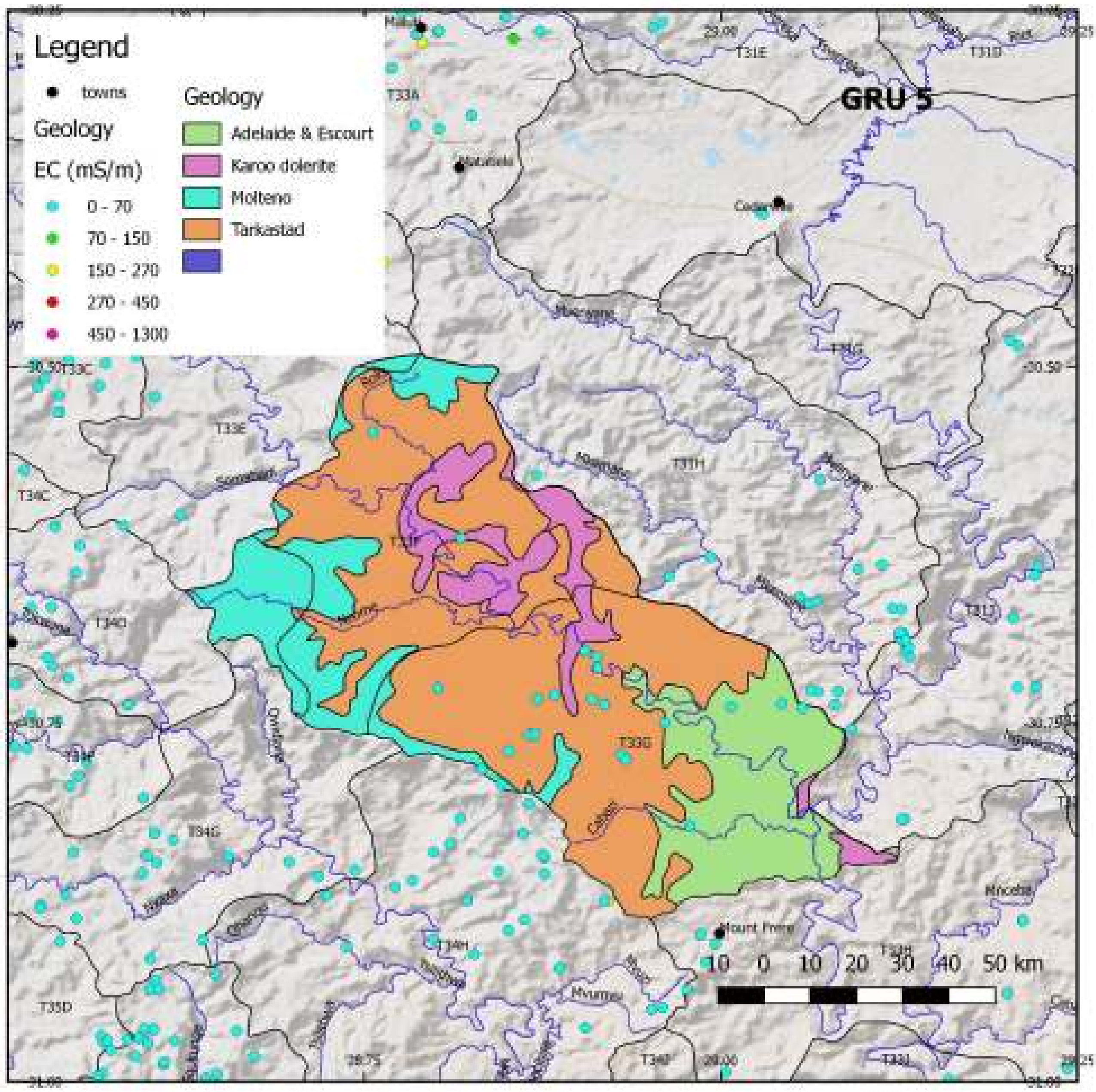

Figure 5.4 Lower Kinira GRU 5

5.4.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <20%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.17**).

Table 5.17 Groundwater use and resources in GRU 5

Quaternary	T33F	T33G
Recharge (Mm^3)	46.62	50.31
Aquifer Recharge (Mm^3)	9.867	9.451
Harvest Potential (Mm^3)	7.5	7.99
Total use(Mm^3)	0.294	0.35
Stress Index	0.025	0.031
GW Present Status	A	A

5.4.3 Water quality

Groundwater is generally of DWS Class 0, or Ideal to Good water quality (**Table 5.18**).

Table 5.18 Borehole water quality in GRU 5

Quaternary	Class per variable	T33F	T33G
Integrated wq Class		I	I
TDS quality class %	0	100	100
	1	0	0
	2	0	0
	3	0	0
	4	0	0
Nitrate quality class %	0	100	100
	1	0	0
	2	0	0
	3	0	0
	4	0	0
Fluoride quality class %	0	100	100
	1	0	0
	2	0	0
	3	0	0
	4	0	0

5.4.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer the remainder originating as interflow (**Table 5.19**).

Table 5.19 Groundwater contribution to baseflow in GRU 5

Quaternary		T33F	T33G
Baseflow	Groundwater baseflow (Mm^3)	3.27	3.85
	Interflow (Mm^3)	14.16	16.1
Total Base flow (Mm^3)		17.43	19.95
Use (Mm^3)		0.294	0.35
Present day Baseflow (Mm^3)		17.43	19.87
Baseflow reduction (%)		0	0.4

5.4.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The high borehole yields make localised over-abstraction possible but on a regional scale it is unlikely. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.20**.

Table 5.20 Groundwater RQOs for GRU 5

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T33E-F	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	No water quality monitoring required.	Due to low groundwater stress, no numerical limits are set.

5.5 GRU 6: LOWER MZINTLAVA

5.5.1 Hydrogeology

This area forms GRU 6, i.e. the lower Mzintlava from Mount Ayliff to below the confluence with the Mzimvubu River. It contains catchments T32F (Mzintlava), T32G (Mzintlavana), T32H (Mzintlava), and T33K (Mzimvubu). Mount Ayliff is located in T32F, and Flagstaff in T32H.

The GRUs consists of rural areas with some minor irrigated areas. Afforestation exists in T32F and G, but not in T33K. The GRU is not very dependent on groundwater (8–33%).

Rocks of the Ecca Group and Adelaide Subgroup underlie the GRU, with extensive outcrop of dolerite sills (**Figure 5.5**).

Yield characteristics are shown in **Table 5.21**. Yields are relatively high, making localised over-exploitation possible.

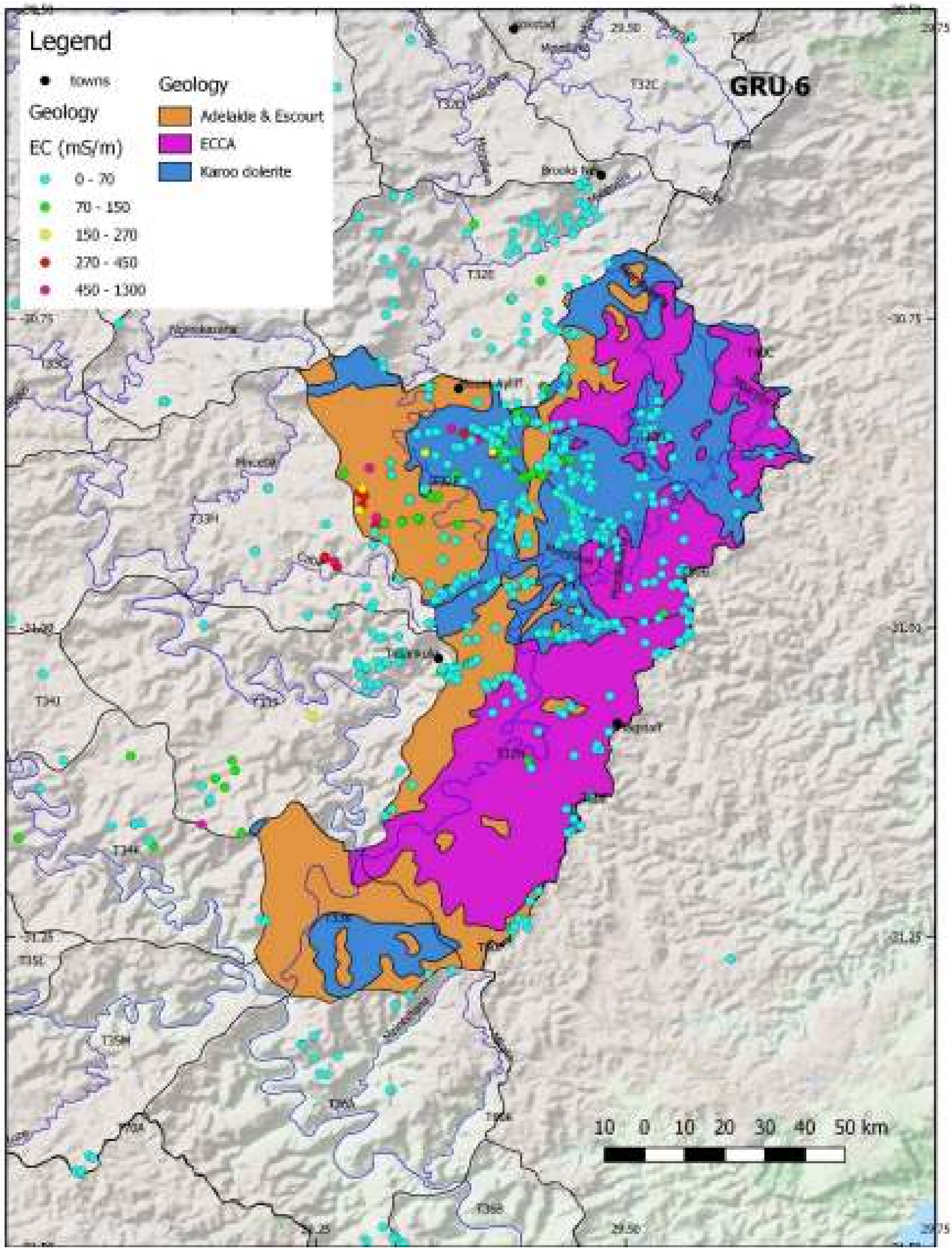

Figure 5.5 Lower Mzintlava GRU 6

Table 5.21 Borehole yields in GRU 6

Quaternary	T32F	T32G	T32H	T33K
No of boreholes	16	20	27	10
Median yield (l/s)	1.4	1.59	0.7	0.9
% of boreholes > 2 l/s	25	40	30	30

5.5.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.22**).

Table 5.22 Groundwater use and resources in GRU 6

Quaternary	T32F	T32G	T32H	T33K
Recharge (Mm^3)	63.37	52.56	56.52	51.48
Aquifer Recharge (Mm^3)	5.504	5.799	4.7	8.748
Harvest Potential (Mm^3)	4.04	5.96	6.16	2.3
Total use (Mm^3)	0.962	0.573	0.583	0.085
Stress Index	0.123	0.048	0.105	0.009
GW Present Status	B	A	B	A

5.5.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality, however pockets of saline water exist in T32F. The cause is uncertain. Elevated fluorides and nitrates may exist however insufficient data exists to verify this fact (**Table 5.23**).

Table 5.23 Borehole water quality in GRU 6

Quaternary	Class per variable	T32F	T32G	T32H	T33K
Integrated wq Class		II	I	I	I
TDS quality class %	0	73	87	95	100
	1	11	13	5	0
	2	0	0	0	0
	3	7	0	0	0
	4	6	1	0	0
Nitrate quality class %	0		0		
	1		100		
	2		0		
	3		0		
	4		0		
Fluoride quality class %	0		100		
	1		0		
	2		0		
	3		0		

Quaternary	Class per variable	T32F	T32G	T32H	T33K
	4		0		

5.5.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.24**).

Table 5.24 Groundwater contribution to baseflow in GRU 6

Quaternary		T32F	T32G	T32H	T33K
Baseflow	Groundwater baseflow (Mm^3)	3	4.08	4.41	1.51
	Interflow (Mm^3)	12.65	17.19	18.53	6.46
Total Base flow (Mm^3)		15.65	21.27	22.94	7.97
Use (Mm^3)		0.962	0.573	0.583	0.085
Present day Baseflow (Mm^3)		15.26	20.46	22.21	7.97
Baseflow reduction (%)		2.49	3.81	3.18	0

5.5.5 Critical characteristics for setting RQOs

Groundwater use in this GRU is minimal. The high borehole yields make localised over-abstraction possible, but unlikely on a regional scale. The goundwater component of baseflow is low, and the potential of groundwater abstraction impacting on baseflow is low. However, baseflow derived by interflow can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides are possible in some localities but insufficient data exists to ascertain this fact.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs for GRU 6 are shown in **Table 5.25**.

Table 5.25 Groundwater RQOs for GRU 6

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T32F-H, T33K	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes.	Due to low groundwater stress, no numerical limits are set.

5.6 GRU 7: UPPER THINA

5.6.1 Hydrogeology

GRU 7 consists of the rugged escarpment zone of the South-eastern Highlands. It contains catchments T34A (Thina), T34B (Phiri e ritso, Nxotshana and Thina), T34C (Tinana and Phipari), T34D (Tokwana and Thina), T34E (Bradgate se Loop and Luzi), and T34F (Luzi). Mount Fletcher is found in T34D.

The GRUs consists of rural areas, with some afforestation in T34B, D and E. Settlements are found in the upper reaches of T31A and B. The area is moderately dependent on groundwater (30–60%).

Rocks of the Drakensberg, Clarens, Elliot and Molteno Formations underlie the GRU (**Figure 5.6**). The yield characteristics are shown in **Table 5.26**. Yields are relatively high, except in T34A, making localised over-exploitation possible.

Table 5.26 Borehole yields in GRU 7

Quaternary	T34A	T34B	T34C	T34D	T34E	T34F
No of boreholes	4	24	18	45	1	11
Median yield (l/s)	0.33	0.81	0.5	1.11	2.27	0.55
% of boreholes > 2 l/s	0	25	33.3	31.1	100	27.3

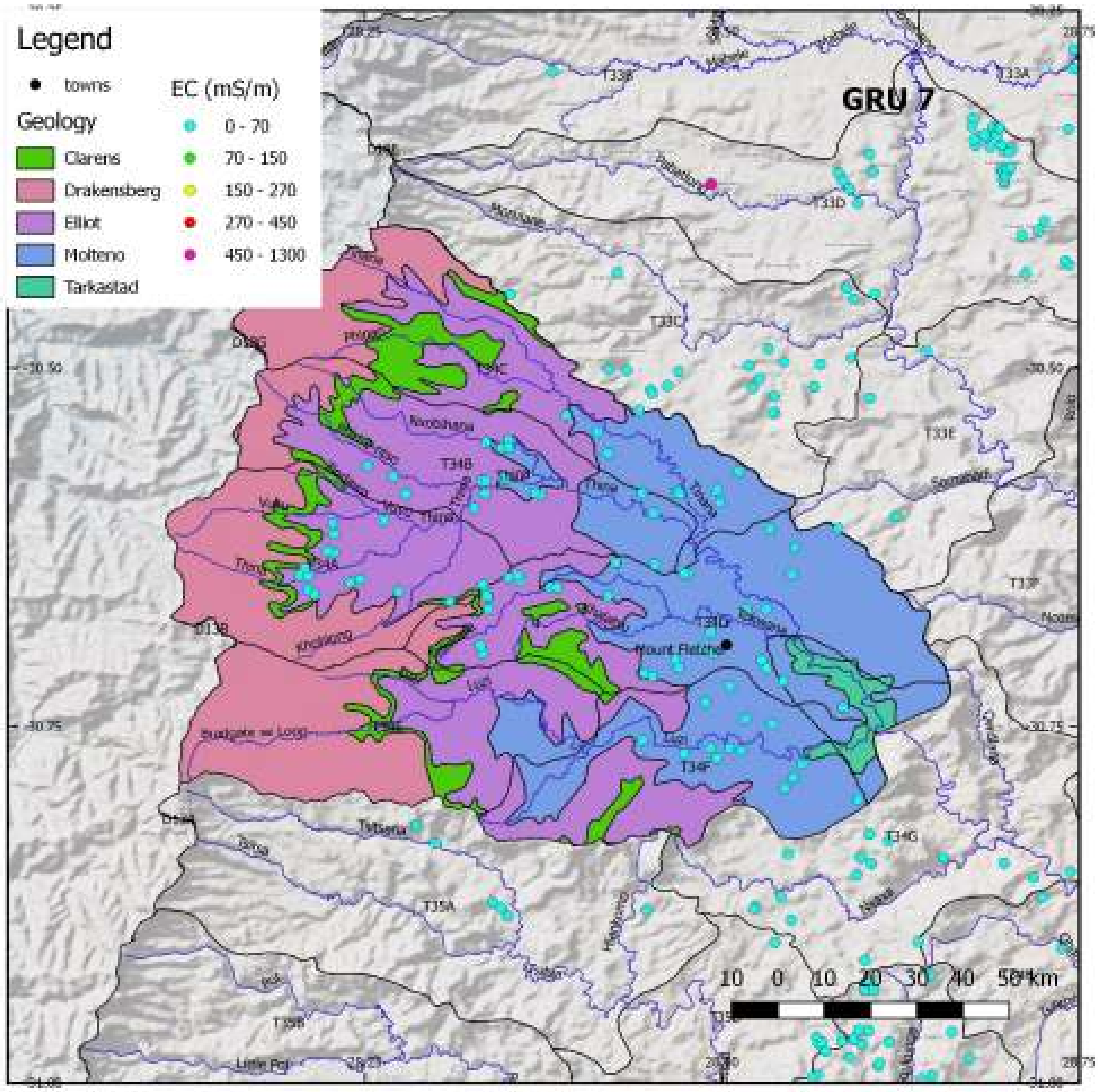

Figure 5.6 Upper Thina GRU 7

5.6.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/ aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.27**).

Table 5.27 Groundwater use and resources in GRU 7

Quaternary	T34A	T34B	T34C	T34D	T34E	T34F
Recharge (Mm^3)	85.55	77.15	67.53	79.37	84.76	83.98
Aquifer Recharge (Mm^3)	9.982	10.458	11	10.132	9.989	10.039
Harvest Potential (Mm^3)	6.81	3.33	5.77	4.93	6.83	3.29
Total use(Mm^3)	0.096	0.156	0.212	0.432	0.005	0.124
Stress Index	0.002	0.009	0.014	0.034	0	0.007
GW Present Status	A	A	A	A	A	A

5.6.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Elevated fuorides and nitrates may exist, but insufficient data is available to determine this (**Table 5.28**).

Table 5.28 Borehole water quality in GRU 7

Quaternary	Class per variable	T34A	T34B	T34C	T34D	T34E	T34F
Integrated wq Class		I	I	I	I		I
TDS quality class %	0	100	100	100	100		100
	1	0	0	0	0		0
	2	0	0	0	0		0
	3	0	0	0	0		0
	4	0	0	0	0		0
Nitrate quality class %	0			100	0	100	
	1			0	100	0	
	2			0	0	0	
	3			0	0	0	
	4			0	0	0	
Fluoride quality class %	0			100	100	100	
	1			0	0	0	
	2			0	0	0	
	3			0	0	0	
	4			0	0	0	

5.6.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 15% of baseflow is from the regional aquifer; the remainder originates as interflow (**Table 5.29**). No significant baseflow reduction occurs.

Table 5.29 Groundwater contribution to baseflow in GRU 7

Quaternary		T34A	T34B	T34C	T34D	T34E	T34F
Baseflow	Groundwater baseflow (Mm3)	0.19	0.11	0.15	2.17	0.38	0.75
	Interflow (Mm3)	11.75	11.24	11.75	14.31	12.73	10.96
Total Base flow (Mm3)		11.94	11.35	11.9	16.48	13.11	11.71
Use (Mm3)		0.096	0.156	0.212	0.432	0.005	0.124
Present day Baseflow(Mm3)		11.94	11.27	11.9	16.36	12.51	11.25
Baseflow reduction (%)		0.00	0.70	0.00	0.73	4.58	3.93

5.6.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The high borehole yields make localised over-abstraction possible, unlikely regionally. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides in some localities can be associated with doleritic intrusions and the removal of vegetation.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs for GRU 7 are shown on **Table 5.30**.

Table 5.30 Groundwater RQOs for GRU 7

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T34A-F	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	No water quality monitoring required.	Due to low groundwater stress, no numerical limits are set.

5.7 GRU 8: MIDDLE THINA

5.7.1 Hydrogeology

This area forms GRU 8, the Middle Thina from the confluence with the Luzi to T34H. It contains catchments T34G and T34H.

The GRUs consists of rural areas, with dryland irrigation. Significant afforestation exists, especially in T34H, which has resulted in significant baseflow depletion (17%) (DWS, 2017e). T34G is moderately dependent on groundwater.

Rocks of the Tarkastad Subgroup underlie most of the GRU, with the Molteno Formation underlying the high lying areas. and Adelaide Subgroup underlie most of the GRU (**Figure 5.7**).

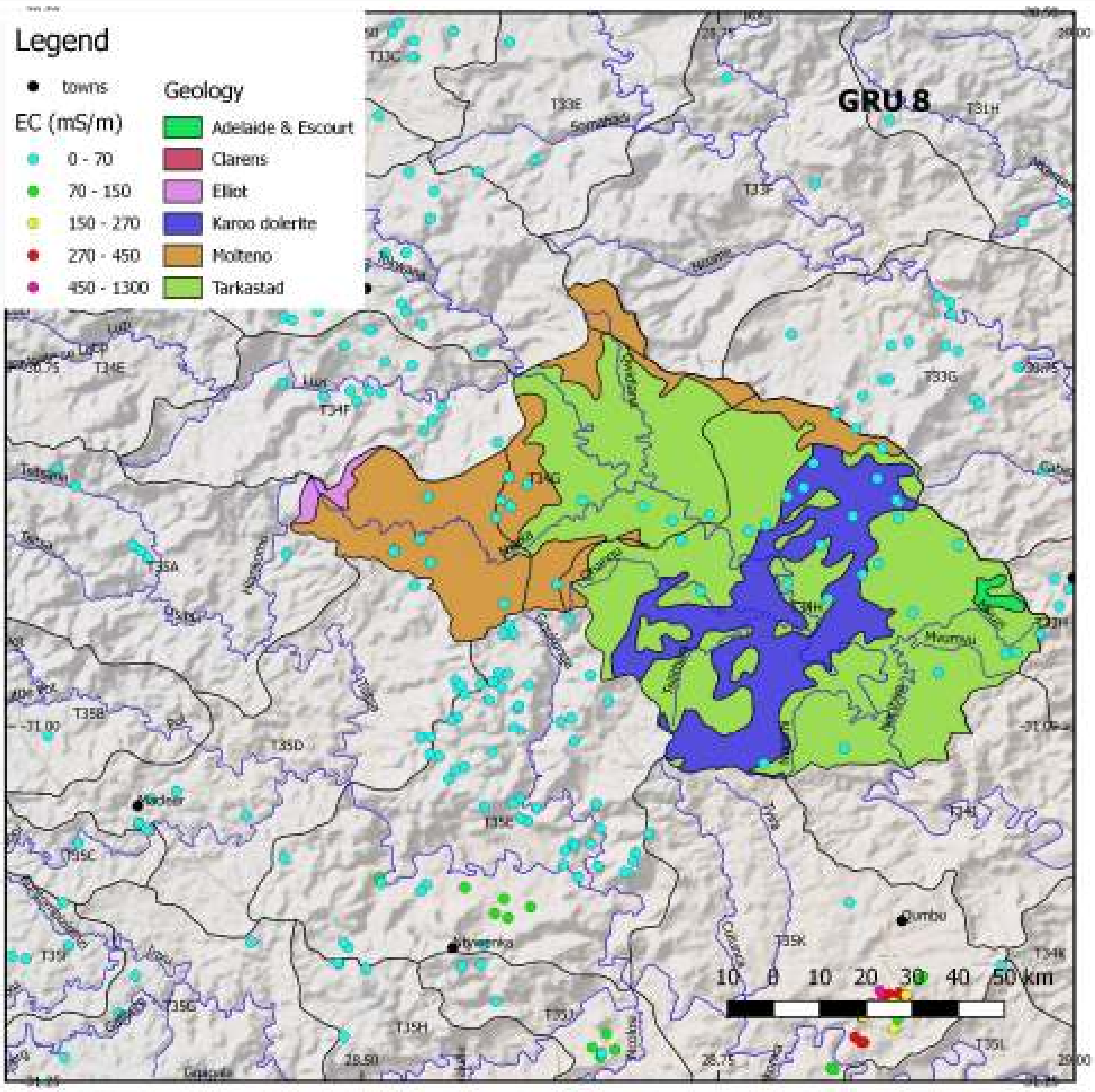

Figure 5.7 Middle Thina GRU 8

The yield characteristics are shown in **Table 5.31**. Yields are relatively high, making localised overexploitation possible.

Table 5.31 Borehole yields in GRU 8

Quaternary	T34G	T34H
No of boreholes	25	19
Median yield (l/s)	1.3	2
% of boreholes > 2 l/s	32	47.368

5.7.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.32**).

Table 5.32 Groundwater use and resources in GRU 8

Quaternary	T34G	T34H
Recharge (Mm^3)	86.38	84.79
Aquifer Recharge (Mm^3)	9.979	9.866
Harvest Potential (Mm^3)	5.74	9.35
Total use(Mm^3)	0.282	0.617
Stress Index	0.026	0.037
GW Present Status	A	A

5.7.3 Water quality

Groundwater is generally of DWS Class 0, or Ideal to Good water quality (**Table 5.33**).

Table 5.33 Borehole water quality in GRU 8

Quaternary	Class per variable	T34G	T34H
Integrated wq Class		I	I
TDS quality class %	0	100	95
	1	0	0
	2	0	0
	3	0	0
	4	0	0
Nitrate quality class %	0	100	
	1	0	
	2	0	
	3	0	
	4	0	
Fluoride quality class %	0	100	
	1	0	
	2	0	
	3	0	
	4	0	

5.7.4 Groundwater contribution to baseflow

Afforestation has had a moderate impact on groundwater baseflow in T34H. Less than 15% of baseflow is from the regional aquifer the remainder originating as interflow (**Table 5.34**).

Table 5.34 Groundwater contribution to baseflow in GRU 8

Quaternary		T34G	T34H
Baseflow	Groundwater baseflow (Mm^3)	2.56	4.56
	Interflow (Mm^3)	16.15	26.92
Total Base flow (Mm^3)		18.71	31.48
Use (Mm^3)		0.282	0.617
Present day Baseflow (Mm^3)		18.29	27.9
Baseflow reduction (%)		2.24	11.37

5.7.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The high borehole yields make localised over-abstraction possible, but unlikely on a regional scale. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs for GRU 8 are shown in **Table 5.35**.

Table 5.35 Groundwater RQOs for GRU 8

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T34G and H	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential .	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	No water quality monitoring required.	Due to low groundwater stress, no numerical limits are set.

5.8 GRU 9: LOWER THINA

5.8.1 Hydrogeology

This area forms GRU 9, the Lower Thina from GRU 8 to the confluence with the Tsitsa. It contains catchments T34J and T34K. The GRUs consists of rural areas. Some afforestation exists in T34J, with dependency on groundwater being low. Rocks of the Adelaide Subgroup Formation underlie most of the GRU, with the Tarkastad Formation underlying the upper reaches of T34J (**Figure 5.8**).

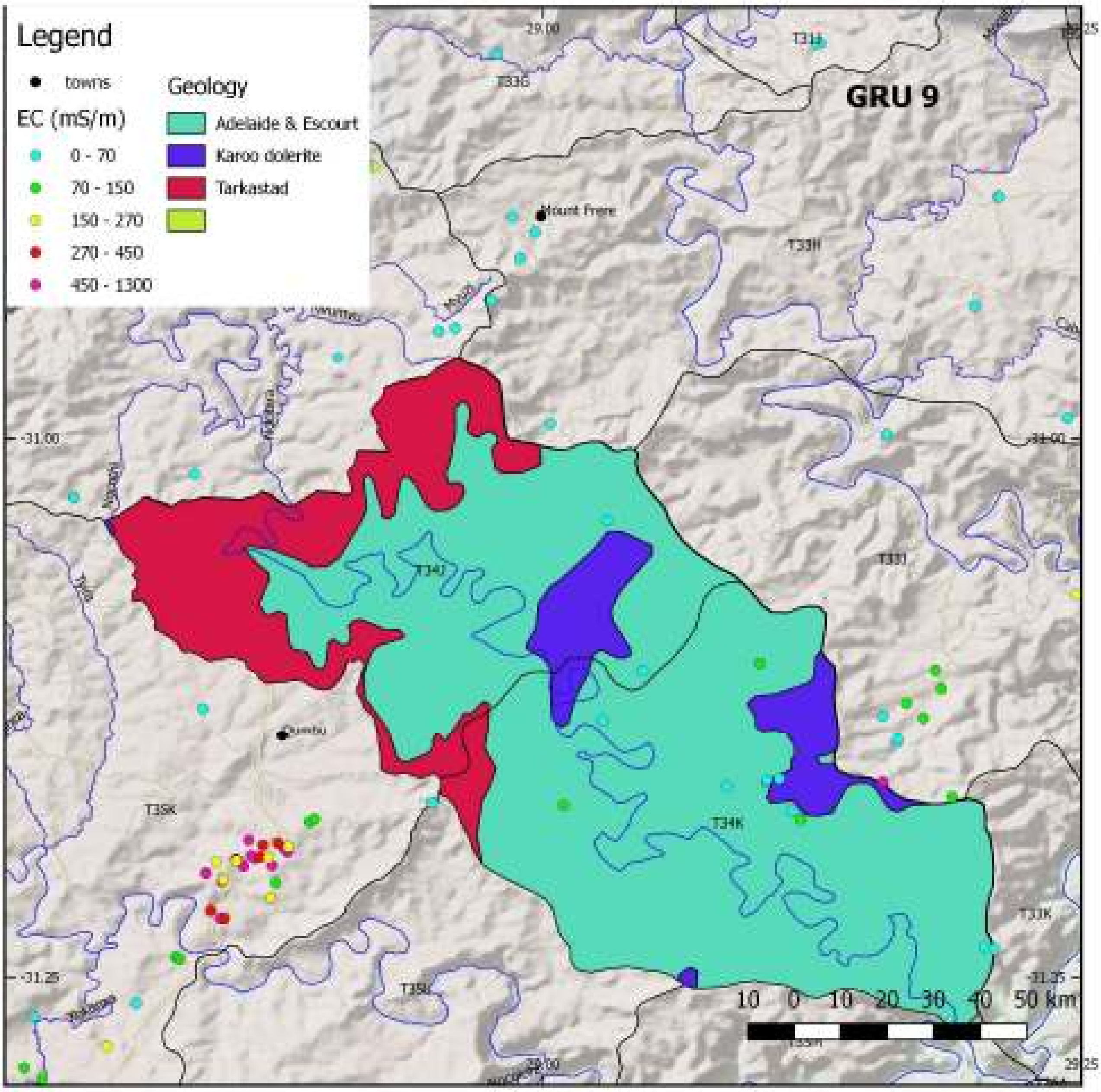

Figure 5.8 Lower Thina GRU 9

The yield characteristics are shown in **Table 5.36**. Yields are moderate, making localised overexploitation unlikely.

Table 5.36 Borehole yields in GRU 9

Quaternary	T34J	T34K
No of boreholes	21	16
Median yield (l/s)	0.55	0.51
% of boreholes > 2 l/s	23.8	12.5

5.8.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <33%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.37**).

Table 5.37 Groundwater use and resources in GRU 9

Quaternary	T34J	T34K
Recharge (Mm^3)	37.07	33.48
Aquifer Recharge (Mm^3)	10.69	10.91 7
Harvest Potential (Mm^3)	4.35	4.53
Total use(Mm^3)	0.016	0.406
Stress Index	0.001	0.011
GW Present Status	A	A

5.8.3 Water quality

Groundwater is generally of DWS Class 0, or Ideal to Good water quality (**Table 5.38**). Some poor quality groundwater exists in T34K, but the results are based on only 1 borehole so are not conclusive.

Table 5.38 Borehole water quality in GRU 8

Quaternary	Class per variable	T34J	T34K
Integrated wq Class		I	II
TDS quality class %	0	100	64
	1	0	18
	2	0	0
	3	0	0
	4	0	9
Nitrate quality class %	0		
	1		
	2		
	3		
	4		
Fluoride quality class %	0		
	1		
	2		
	3		
	4		

5.8.4 Groundwater contribution to baseflow

Abstraction has had a minimal impact on groundwater baseflow. Less than 15% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.39**).

Table 5.39 Groundwater contribution to baseflow in GRU 9

Quaternary		T34J	T34K
Baseflow	Groundwater baseflow (Mm^3)	2.15	2.25
	Interflow (Mm^3)	9.15	9.81
Total Base flow (Mm^3)		11.3	12.06
Use (Mm^3)		0.016	0.406
Present day Baseflow (Mm^3)		11.21	12.04
Baseflow reduction (%)		0.80	0.17

5.8.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The moderate high borehole yields make localised over-abstraction unlikely. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be significantly impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. High salinity exists in T34K, but the results are for only 1 borehole, so are not conclusive. The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs for GRU 9 are shown in **Table 5.40**.

Table 5.40 Groundwater RQOs for GRU 9

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T34J and K	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	No water quality monitoring required, however additional data on water quality is needed to identify water quality problem areas.	Due to low groundwater stress, no numerical limits are set.

5.9 GRU 10: UPPER TSITSA

5.9.1 Hydrogeology

GRU 10 consists of the rugged escarpment zone of the South-eastern Highlands of the upper Tsitsa catchments. It consists of catchments T35A (Tsitsa and Tsitsana), T35B (Pot and Little Pot), T35C (Mooi), T35D (Tsitsa, Pot and Mooi), T35F (Inxu), and T35G (Gatberg and Gqaqala). Maclear is located in T35D and Ugie in T35F.

The GRUs consists of rangelands and rural areas, with irrigated lands concentrated mostly in T35G. Significant afforestation exists, which has resulted in interflow depletion, especially in the Gat and Inxu catchments. The area is variably dependent on groundwater, with T35A, B, D and G being moderately dependent on groundwater (40–60%), and T35C and F not being dependent (3–4%).

Rocks of the Drakensberg, Clarens, Elliot and Molteno Formations underlie the GRU (**Figure 5.9**).

The yield characteristics are shown in **Table 5.41**. Yields are relatively high, making localised overexploitation a possibility.

Table 5.41 Borehole yields for GRU 10

Quaternary	T35A	T35B	T35C	T35D	T35F	T35G
No of boreholes	10	1	2	4	2	6
Median yield (l/s)	0.47	0.05	0.4	3.5	4.6	4.5
% of boreholes > 2 l/s	20	0	0	75	100	66.7

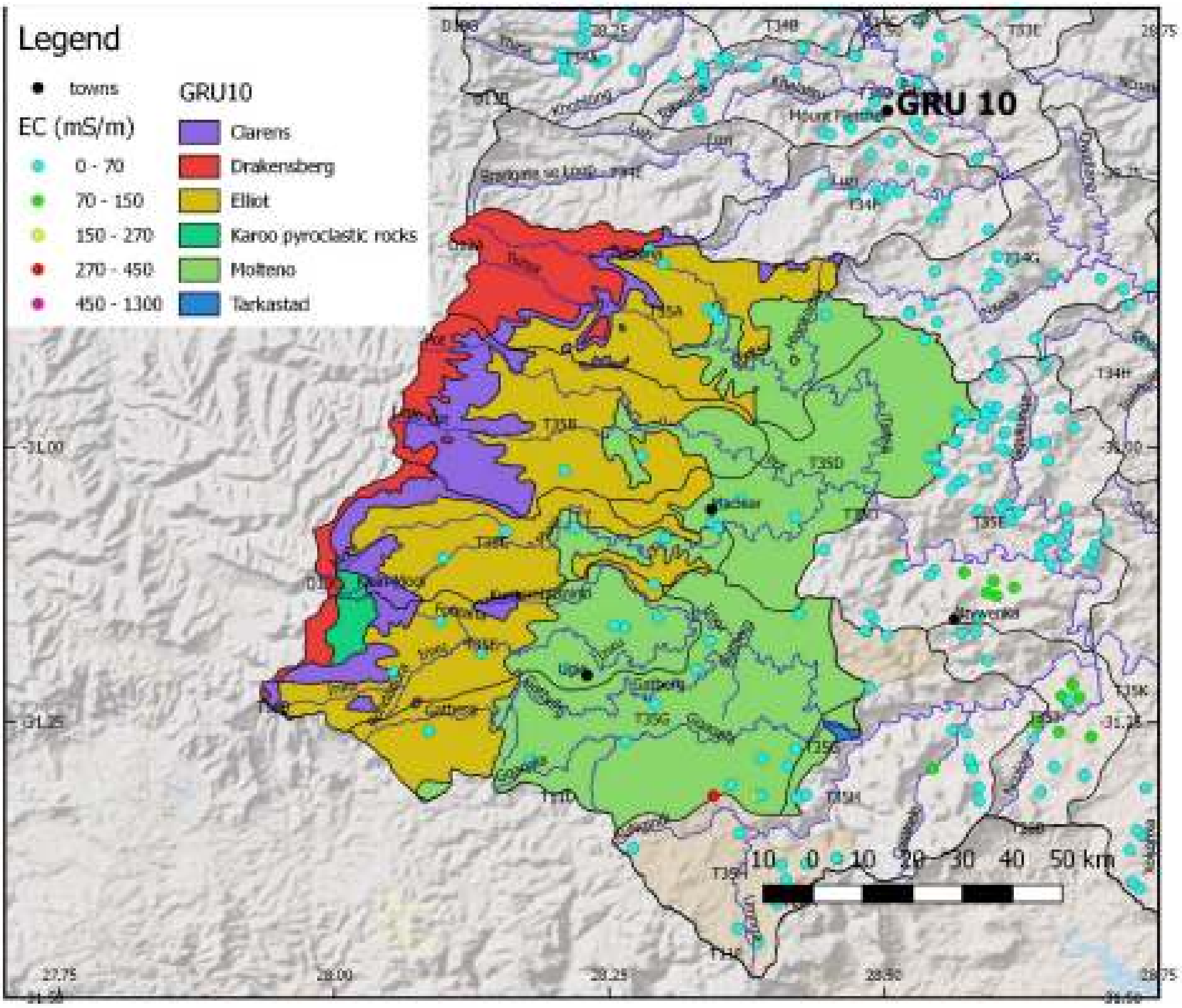

Figure 5.9 Upper Tsitsa GRU 10

5.9.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/ aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.42**).

Table 5.42 Groundwater Use and resources in GRU 10

Quaternary	T35A	T35B	T35C	T35D	T35F	T35G
Recharge (Mm^3)	92.37	93.13	114.27	77.79	85.63	67.62
Aquifer Recharge (Mm^3)	9.143	9.152	8.253	9.974	9.897	11.076
Harvest Potential (Mm^3)	9.34	6.04	11.02	5.5	5.57	7.9
Total use(Mm^3)	0.179	0.008	0.02	0.086	0.021	0.116
Stress Index	0.011	0	0.001	0.007	0.001	0.009
GW Present Status	A	A	A	A	A	A

5.9.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Insufficient water quality data exists for the GRU (**Table 5.43**).

Table 5.43 Borehole water quality in GRU 10

Quaternary	Class per variable	T35A	T35B	T35C	T35D	T35F	T35G
Integrated water quality (wq) Class		I	I				
TDS quality class %	0	100	100				
	1	0	0				
	2	0	0				
	3	0	0				
	4	0	0				
Nitrate quality class %	0		100				
	1		0				
	2		0				
	3		0				
	4		0				
Fluoride quality class %	0		100				
	1		0				
	2		0				
	3		0				
	4		0				

5.9.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU, however SFRs have caused significant baseflow depletion. Less than 15% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.44**).

Table 5.44 Groundwater contribution to baseflow in GRU 10

Quaternary		T35A	T35B	T35C	T35D	T35F	T35G
Baseflow	Groundwater baseflow (Mm^3)	0.94	1.21	1.27	0.98	1.22	1.64
	Interflow (Mm^3)	12.91	10.29	22.39	8.23	8.7	12.09
Total Base flow (Mm^3)		13.85	11.5	23.66	9.21	9.92	13.73
Use (Mm^3)		0.179	0.008	0.02	0.086	0.021	0.116
Present day Baseflow (Mm^3)		11.72	10.56	16.46	8.39	5.57	11.62
Baseflow reduction (%)		15.38	8.17	30.43	8.90	43.85	15.37

5.9.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. Yields are relatively high, making localised over-exploitation a possibility. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which has been significantly impacted by SFR activities, especially in T35C and T35F.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrates and fluorides in some localities can be associated with doleritic intrusions and the removal of vegetation, however insufficient data exists to assess the extent of this problem.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.45**.

Table 5.45 Groundwater RQOs for GRU 10

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T35A-B, T35D, T35G	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes. Insufficient data exists, and data collection is required.	Due to low groundwater stress, no numerical limits are set.
T35C, T35F	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual	Due to baseflow depletion, further SFR activities should be restricted to use less than the GA.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required	Some boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for	Low flows at T3H009 should not be less than an average of 8.92 Mm^3/a for T35C. T35F is ungauged and cannot be

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
	licence conditions within the Harvest Potential.			domestic boreholes. Insufficient data exists, and data collection is required.	monitored by flow measurements.

5.10 GRU 11: MIDDLE TSITSA

5.10.1 Hydrogeology

GRU 11 consists of the middle Tsitsa from GRU 10 to below Qumbu. It contains catchments T35E (Tsitsa), T35H (Umanga and Qwakele), T35J (Mooi), T35D (Qwakele and Ncolisi), and T35K (Tsitsa). Ntywenka is located in T35E, and Qumbu and Tsolo in T35K.

The GRUs consists of rural areas, with significant afforestation in T35J and K. The area is moderately dependent on groundwater (25–50%).

Rocks of the Molteno Formation and Tarkastad Subgroup underlie the GRU (**Figure 5.10**).

The yield characteristics are shown in **Table 5.46**. Yields are relatively high, making localised over-exploitation possible.

Table 5.46 Borehole yields for GRU 11

Quaternary	T35E	T35H	T35J	T35K
No of boreholes	51	37	20	98
Median yield (l/s)	1	1	0.6	1
% of boreholes > 2 l/s	41.176	40.5	25	31.6

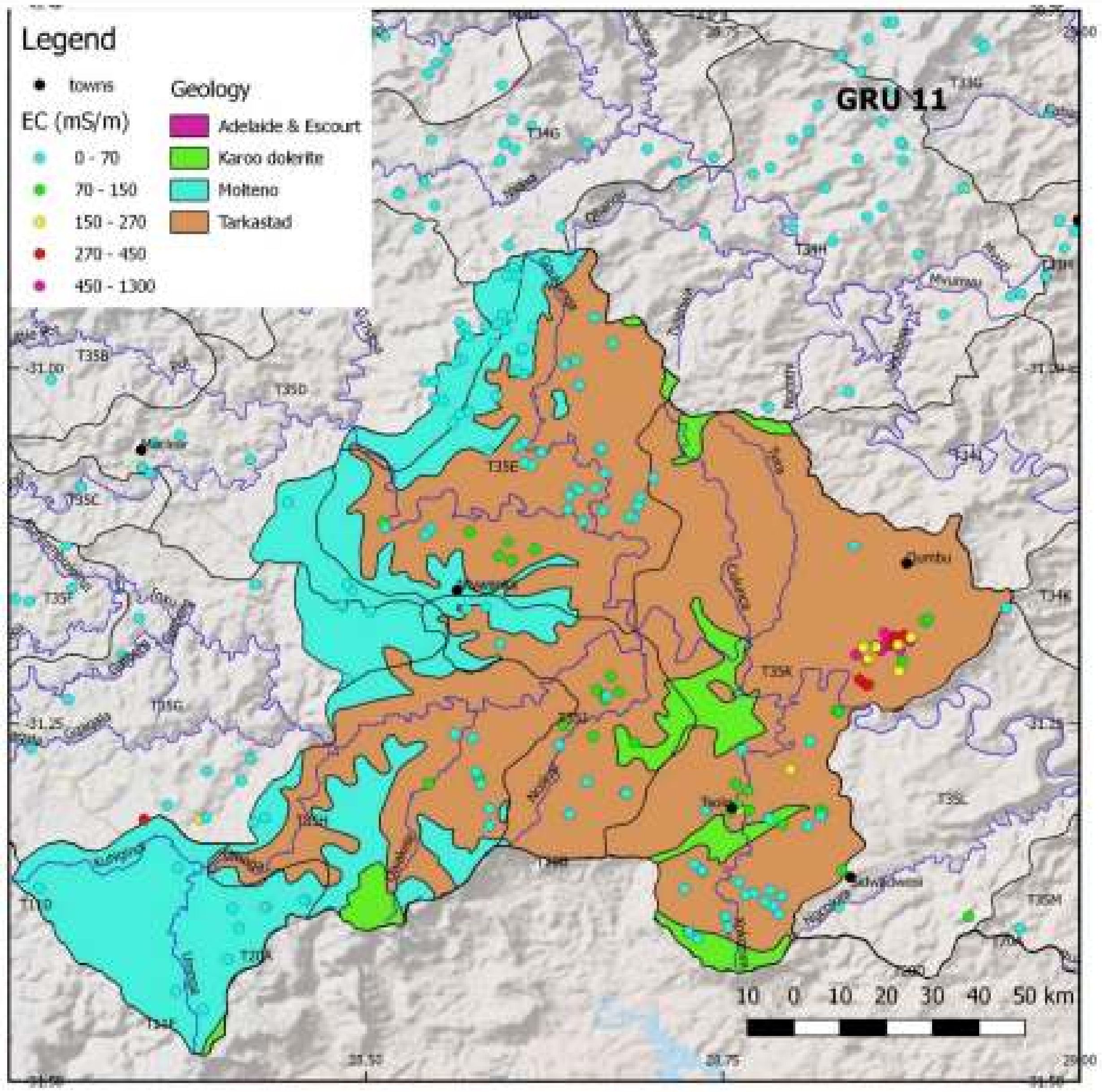

Figure 5.10 Middle Tsitsa GRU 11

5.10.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.47**).

Table 5.47 Groundwater use and resources in GRU 11

Quaternary	T35E	T35H	T35J	T35K
Recharge (Mm^3)	97.94	86.44	107.8	80.88
Aquifer Recharge (Mm^3)	8.738	9.645	8.893	10.147
Harvest Potential (Mm^3)	6.69	8.23	3.31	10.99
Total use(Mm^3)	0.217	0.42	0.246	1.596

Quaternary	T35E	T35H	T35J	T35K
Stress Index	0.019	0.039	0.016	0.149
GW Present Status	A	A	A	B

5.10.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Poor water quality exists in T35K near Qumbu. Insufficient water quality data exists for evaluating nitrate and fluoride levels (**Table 5.48**).

Table 5.48 Borehole water quality in GRU 11

Quaternary	Class per variable	T35E	T35H	T35J	T35K
Integrated wq Class		I	I	I	II
TDS quality class %	0	91	89	47	37
	1	9	11	47	24
	2	0	0	6	0
	3	0	0	0	14
	4	0	0	0	14
Nitrate quality class %	0		100	0	
	1		0	100	
	2		0	0	
	3		0	0	
	4		0	0	
Fluoride quality class %	0		100	100	
	1		0	0	
	2		0	0	
	3		0	0	
	4		0	0	

5.10.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU, however SFRs have caused moderate baseflow depletion. Less than 15% of baseflow is from the regional aquifer, with the remainder originating as interflow (**Table 5.49**).

Table 5.49 Groundwater contribution to baseflow in GRU 11

Quaternary		T35E	T35H	T35J	T35K
Baseflow	Groundwater baseflow (Mm^3)	1.82	1.98	0.37	1.73
	Interflow (Mm^3)	13.26	12.88	6.21	15.24
Total Base flow (Mm^3)		15.08	14.02	5.71	15.82
Use (Mm^3)		0.217	0.42	0.246	1.596
Present day Baseflow (Mm^3)		13.58	14.02	5.71	15.82
Baseflow reduction (%)		9.95	5.65	13.22	6.78

5.10.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The relatively high borehole yields make localised over-abstraction possible, although no regional impacts are expected. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which has been impacted by SFR activities in T35E, T35H and T35J.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrate and fluoride levels are possible in some localities and will be associated with doleritic intrusions and the removal of vegetation, however insufficient data exists to assess the extent of this problem.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.50**.

Table 5.50 Groundwater RQOs for GRU 11

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T35E, T35H-K	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to baseflow depletion, further SFR activities should be assessed in terms of baseflow depletion and downstream EWRs.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes. Insufficient data exists, and data collection is required.	Due to low groundwater stress, no numerical limits are set.

5.11 GRU 12: LOWER TSITSA

5.11.1 Hydrogeology

This area forms GRU 12, the Lower Tsitsa from GRU 8 to the confluence with the Thina. It contains catchments T35L and T35M.

The GRUs consists of rural areas. Some afforestation exists in T35L. Dependency on groundwater is low. Rocks of the Adelaide Subgroup Formation underlie most of the GRU, with the Tarkastad Subgroup underlying the upper reaches of T35L (**Figure 5.11**).

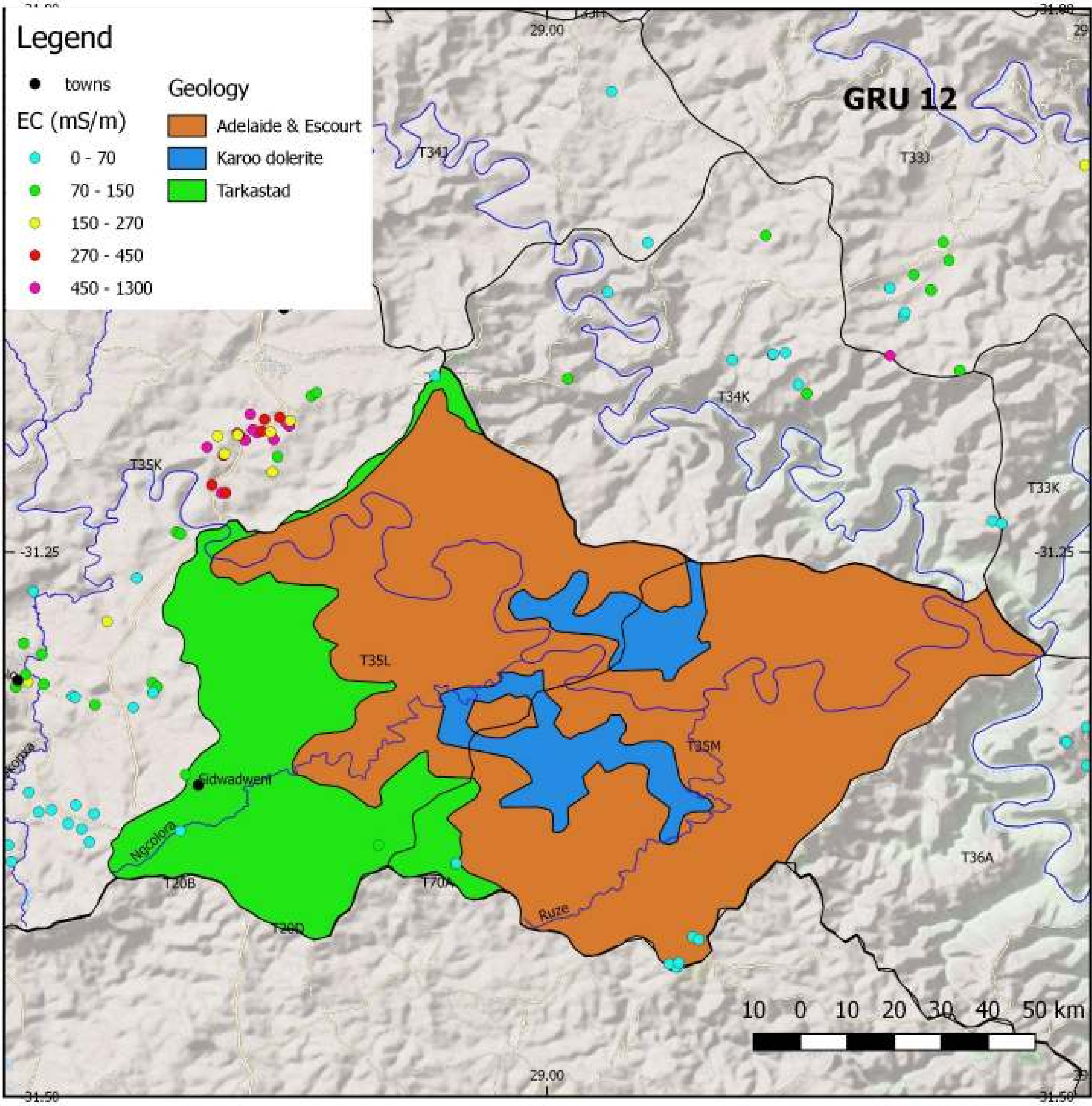

Figure 5.11 Lower Tsitsa GRU 12

The yield characteristics are shown in **Table 5.51**. Yields are relatively high, making localised over-exploitation possible.

Table 5.51 Borehole yields for GRU 12

Quaternary	T35L	T35M
No of boreholes	31	21
Median yield (l/s)	1.3	2.5
% of boreholes > 2 l/s	39	57.143

5.11.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <30%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.52**).

Table 5.52 Groundwater use and resources in GRU 12

Quaternary	T35L	T35M
Recharge (Mm^3)	38.08	54.38
Aquifer Recharge (Mm^3)	10.799	9.545
Harvest Potential (Mm^3)	5.13	4.17
Total use(Mm^3)	0.266	0.146
Stress Index	0.021	0.014
GW Present Status	A	A

5.11.3 Water quality

Groundwater is generally of DWS Class 0-1, or Ideal to Good water quality. Insufficient water quality data exists for evaluating the nitrates and fluorides (**Table 5.53**).

Table 5.53 Borehole water quality in GRU 12

Quaternary	Class per variable	T35L	T35M
Integrated wq Class		I	I
TDS quality class %	0	50	88
	1	50	13
	2	0	0
	3	0	0
	4	0	0
Nitrate quality class %	0		
	1		
	2		
	3		
	4		
Fluoride quality class %	0		
	1		
	2		
	3		
	4		

5.11.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.54**).

Table 5.54 Groundwater contribution to baseflow in GRU 12

Quaternary		T35L	T35M
Baseflow	Groundwater baseflow (Mm^3)	2.44	2.88
	Interflow (Mm^3)	10.51	11.69
Total Base flow (Mm^3)		12.95	14.57
Use (Mm^3)		0.266	0.146
Present day Baseflow (Mm^3)		12.86	14.52
Baseflow reduction (%)		0.69	0.34

5.11.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The relatively high borehole yields make localised over-abstraction possible; regional impacts are not expected. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrate and fluoride levels are possible in some localities and will be associated with doleritic intrusions and the removal of vegetation, however insufficient data exists to assess the extent of this problem.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.55**.

Table 5.55 Groundwater RQOs for GRU 12

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T35L-M	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes. Insufficient data exists, and data collection is required.	Due to low groundwater stress, no numerical limits are set.

5.12 GRU 13: LOWER MZIMVUBU

5.12.1 Hydrogeology

This area forms the Lower Mzimvubu catchment from the confluence of the Thina and Tsitsa to the sea. It contains catchments T36A and T36B. Port St Johns is located in this area at the coast.

The GRUs consists of rural areas. Some irrigation occurs in both catchments. Dependency on groundwater is low.

Rocks of the Adelaide Subgroup and Ecca Group underlie most of the GRU, with the Dwyka Group outcropping in T36B (**Figure 5.12**).

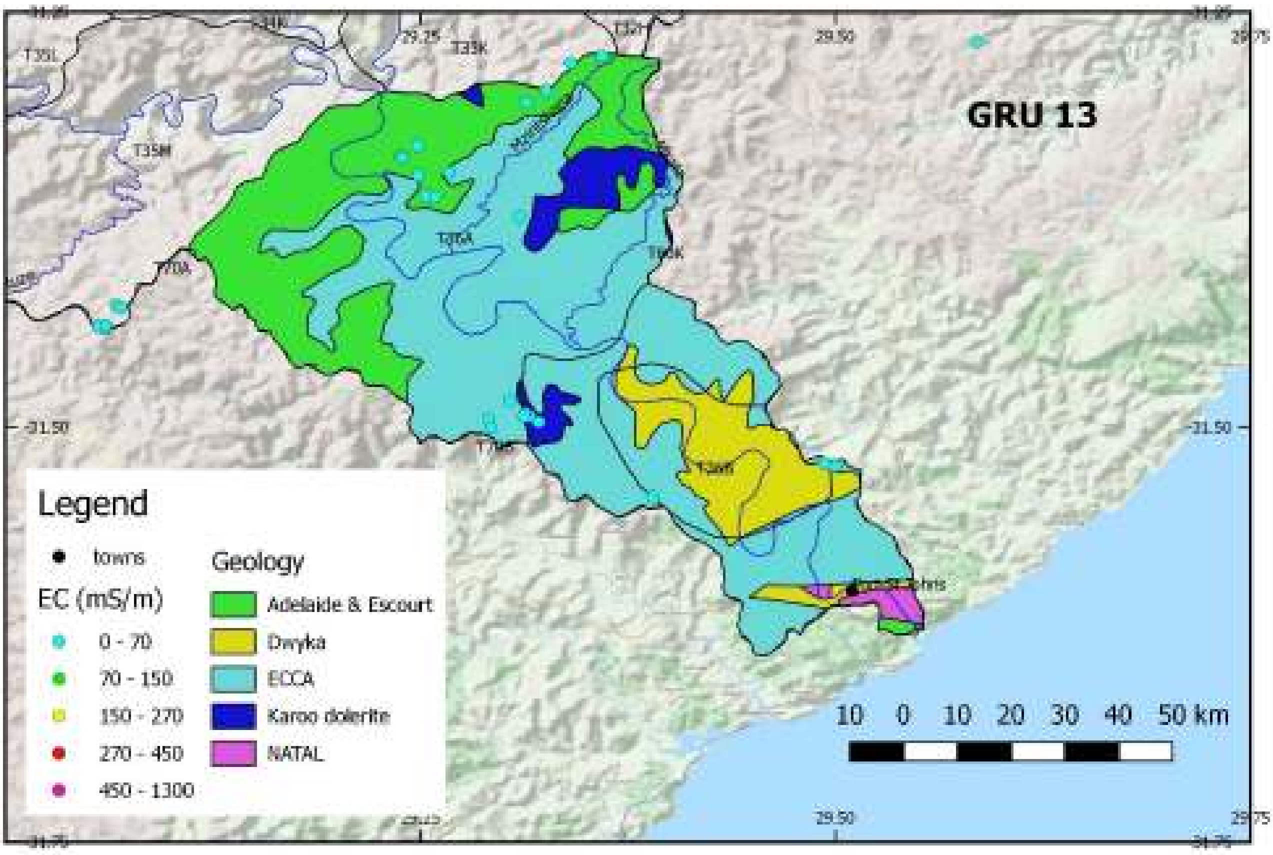

Figure 5.12 Lower Mzimvubu GRU

The yield characteristics are shown in **Table 5.56**. Yields are moderate, making localised over-exploitation unlikely, however, few data points are available and the assessment is of low confidence.

Table 5.56 Borehole yields for GRU 13

Quaternary	T36A	T36B
No of boreholes	3	7
Median yield (l/s)	0.33	0.3
% of boreholes > 2 l/s	0	14.3

5.12.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <15%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.57**).

Table 5.57 Groundwater use and resources in GRU 13

Quaternary	T36A	T36B
Recharge (Mm^3)	70.17	92.12
Aquifer Recharge (Mm^3)	12.693	9.188
Harvest Potential (Mm^3)	6.28	3.61
Total use(Mm^3)	0.109	0.043
Stress Index	0.002	0.001
GW Present Status	A	A

5.12.3 Water quality

Groundwater is generally of DWS Class 0, Ideal water quality. Insufficient water quality data exists for evaluating nitrate and fluoride levels (**Table 5.58**).

Table 5.58 Borehole water quality in GRU 13

Quaternary	Class per variable	T36A	T36B
Integrated wq Class		I	I
TDS quality class %	0	100	100
	1	0	0
	2	0	0
	3	0	0
	4	0	0
Nitrate quality class %	0		100
	1		0
	2		0
	3		0
	4		0
Fluoride quality class %	0		100
	1		0
	2		0
	3		0
	4		0

5.12.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer; the remainder originating as interflow (**Table 5.59**).

Table 5.59 Groundwater contribution to baseflow in GRU 13

Quaternary		T36A	T36B
Baseflow	Groundwater baseflow (Mm^3)	5	3.37
	Interflow (Mm^3)	22.55	15.24
Total Base flow (Mm^3)		27.55	18.61
Use (Mm^3)		0.109	0.043
Present day Baseflow (Mm^3)		27.5	18.51
Baseflow reduction (%)		0.18	0.54

5.12.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The moderate borehole yields make localised over-abstraction unlikely. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrate and fluoride levels are possible in some localities and will be associated with doleritic intrusions and the removal of vegetation, however insufficient data exists to assess the extent of this problem.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown in **Table 5.60**.

Table 5.60 Groundwater RQOs for GRU 13

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T36A-B	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Insufficient data exists, and data collection is required. Water quality is unlikely to be a problem.	Due to low groundwater stress, no numerical limits are set.

5.13 GRU 14; MIDDLE MZIMVUBU

5.13.1 Hydrogeology

GRU 14 consists of the middle Mzimvubu from T31J to the confluence with the Mzintlava River. It contains catchments T31J, T33H and T33J. Mount Frere is located in T33H, and Tabankulu in T33J.

The GRU consists of rural areas and dryland farming, with significant irrigation in T31J. Some afforestation exists in T33H and J. The area is not very dependent on groundwater (<25%).

Nickel deposits in T33H pose a moderate threat to groundwater if mining occurs. Rocks of the Adelaide Subgroup underlie most of the GRU, with significant outcrop of dolerite sheets (**Figure 5.13**).

The yield characteristics are shown in **Table 5.61**. Yields are relatively high, making localised over-exploitation possible.

Table 5.61 Borehole yields for GRU 14

Quaternary	T31J	T33H	T33J
No of boreholes	18	24	16
Median yield (l/s)	1.1	1.1	0.73
% of boreholes > 2 l/s	16.7	29	12.5

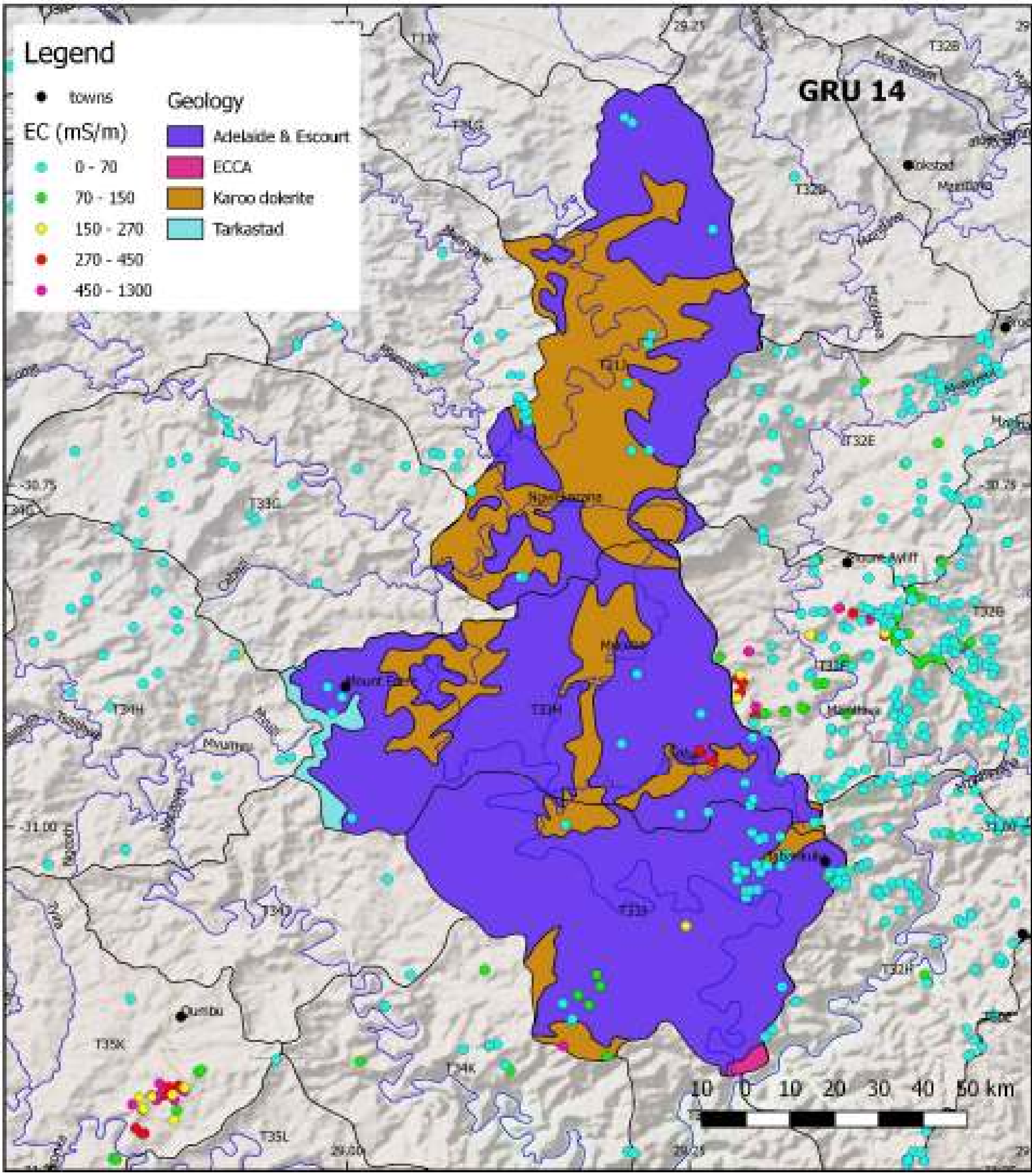

Figure 5.13 Middle Mzimvubu GRU 14

5.13.2 Groundwater use and resources

Groundwater use in the GRU is minimal. The stress index (use/aquifer recharge) is low and groundwater resources are under-utilised. Although recharge is high, the proportion reaching the regional aquifer is <30%, with the remainder generating baseflow via interflow or lost to evapotranspiration (**Table 5.62**).

Table 5.62 Groundwater use and resources in GRU 14

Quaternary	T31J	T33H	T33J
Recharge (Mm^3)	38.3	39.24	33.15
Aquifer Recharge (Mm^3)	10.275	10.636	9.383
Harvest Potential (Mm^3)	6.9	8.09	6.22
Total use(Mm^3)	0.181	1.222	0.222
Stress Index	0.01	0.101	0.016
GW Present Status	A	B	A

5.13.3 Water quality

Groundwater is generally of DWS Class 0-1, i.e. Ideal or Goodwater quality, except in T33H where unexplained high salinities exist. Insufficient water quality data exist for evaluating nitrate and fluoride levels (**Table 5.63**).

Table 5.63 Borehole water quality in GRU 14

Quaternary	Class per variable	T31J	T33H	T33J
Integrated wq Class		I	III	I
TDS quality class %	0	100	67	78
	1	0	0	20
	2	0	0	0
	3	0	17	0
	4	0	17	0
Nitrate quality class %	0		83	
	1		17	
	2		0	
	3		0	
	4		0	
Fluoride quality class %	0	83	83	
	1	0	17	
	2	17	0	
	3	0	0	
	4	0	0	

5.13.4 Groundwater contribution to baseflow

Groundwater abstraction has a minimal impact on groundwater baseflow in this GRU. Less than 20% of baseflow is from the regional aquifer, with the remainder originating as interflow (**Table 5.64**).

Table 5.64 Groundwater contribution to baseflow in GRU 14

Quaternary		T31J	T33H	T33J
Baseflow	Groundwater baseflow (Mm^3)	3.84	3.78	3.19
	Interflow (Mm^3)	15.57	16.44	14.1
Total Base flow (Mm^3)		19.41	20.22	17.29
Use (Mm^3)		0.181	1.222	0.222
Present day Baseflow (Mm^3)		19.31	19.94	17.09
Baseflow reduction (%)		0.52	1.38	1.16

5.13.5 Critical characteristics for setting RQOs

Groundwater use in the GRU is minimal. The relatively high borehole yields make localised over-abstraction possible. The groundwater component of baseflow is low, hence the potential of groundwater abstraction to impact on baseflow is limited. Baseflow is largely derived by interflow, which can be impacted by SFR activities.

The aquifers are of moderate vulnerability. Due to the rural setting, no regional threats to groundwater quality exist. Elevated nitrate and fluoride levels are possible in some localities and will be associated with doleritic intrusions and the removal of vegetation, however insufficient data exists to assess the extent of this problem.

The abstractable volume of groundwater is based on the Harvest Potential. Groundwater RQOs are shown on **Table 5.65**.

Table 5.65 Groundwater RQOs for GRU14

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
T31J T33J	All users to comply with existing allocation schedules, including GA and Schedule 1, and individual licence conditions within the Harvest Potential.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes may have elevated natural nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes. Insufficient data exists, and data collection is required.	Due to low groundwater stress, no numerical limits are set.
T33H	All users to comply with existing allocation schedules, including GA and	Due to the low groundwater use, monitoring	Due to the low groundwater use and low aquifer contribution to	Some boreholes have high salinities and salinities in boreholes	Due to low groundwater stress, no numerical limits are set.

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
	Schedule 1, and individual licence conditions within the Harvest Potential.	not required.	baseflow, monitoring not required.	needs to be evaluated for planned water supply boreholes.	

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 WETLANDS

Due to the high number of wetlands within the T3 primary catchment and following the recommendations and method guidelines by DWS (2016), specific RQOs were only determined for priority wetlands of High or Very High importance, although the detail of these were constrained by the availability of existing data. Broad-scale catchment and sub-catchment RQOs were determined for all other wetlands. Broad level narrative RQOs for wetlands across the WMA were determined at the quaternary catchment scale, and focussed on averages of PES and EIS categories, mostly from the PESEIS database (DWS, 2014a). These broad scale narrative RQOs specify that the average quaternary level PES and EIS should be maintained and not permitted to deteriorate, and have been developed so that at the least all wetlands, even low priority, have some measure of protection.

Catchment level RQOs were developed at the SQ scale. These specify more detail and at a finer scale than the broad level RQOs and should be used in preference to them. Catchment level RQOs rely on PESEIS data for low or moderate priority wetlands (an improvement from broad scale RQOs only due to finer scale and not a quaternary average) and verified data using a similar but expanded (to include all wetlands within a SQ catchment) method of the PESEIS rationale.

More detailed RQOs were developed for wetlands of High or Very High priority, including floodplains, channelled and unchannelled valley bottoms, flats and seeps. As detailed data of these very high priority individual wetlands were limited, Google Earth © was used to conduct level 1 WET-Health assessments (MacFarlane et al., 2007) for floodplains and to verify PES ratings and wetland metrics in the PESEIS database for channelled valley bottom wetlands. Updated metrics were applicable to all wetlands within an SQ and included wetland habitat modification and wetland continuity (fragmentation and connectivity) modification.

It should be stressed that although RQOs at different levels have been determined, all should be taken into consideration in a tiered fashion. To clarify this approach an example of SQ T35G-06099 is given: The wetlands in this SQ occur in the T35G quaternary catchment and therefore have broad level RQOs that specify that the average PES of a B/C category and EIS of “High” be maintained. These RQOs pertain to measures for water quantity, water quality, habitat, biota and ecosystem services for the SQ. One of the habitat RQOs related to integrity and condition specifies that the PES category of wetlands within this SQ must be maintained according to those listed, which is a category B. Since this is a better measure that the quaternary average of B/C it will take precedence. Similarly, the RQO related to EIS, as a measure of ecosystem services, will be “Very High”, rather than the quaternary average of “High”. However, this SQ also belongs to one of the high priority floodplains – Gatberg Floodplains – and will therefore also have more detailed RQOs. These will be in addition to those already given, and where overlap exists, precedence should be given to more detailed RQOs that are based on higher quality data.

6.2 GROUNDWATER

Recommendations are presented in the form of identifying priority area for monitoring of criteria such as water levels and abstraction, baseflow reduction, and groundwater selected water quality parameters.

6.2.1 Priority monitoring areas for water level and abstraction

Based on the level of groundwater stress (stress index of abstraction to aquifer recharge), the following catchments can be considered as priority areas for monitoring abstraction and groundwater level:

Catchment	Stress Index	Priority
T31F	0.341	Moderate
T33A	0.371	Moderate

6.2.2 Priority monitoring areas for baseflow reduction

Based on the degree of baseflow reduction across the study area, the following catchments have been identified where low flow monitoring via gauging stations is relevant in order to evaluate how SFRs impact on the EWRs:

Catchment	Baseflow Reduction	Priority
T35F	43.85	Moderate
T35C	30.43	Moderate

6.2.3 Priority monitoring areas for water quality

Over large parts of the study area insufficient data exist to characterise groundwater quality based on nitrates and fluoride. The T33-T36 Tertiary catchments lack sufficient data. Due to the prevalence of doleritic intrusions, fluoride levels may be elevated. The degree of removal of vegetation and sanitation practices also suggest that elevated nitrates may be of localised concern

Catchments T35K and T33H have a high proportion of boreholes with elevated salinities. No obvious geological reason for these pockets of salinities exists, and such areas need to be delineated to identify naturally occurring salinity from contamination processes.

7 REFERENCES

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APPENDIX A: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment
K. Majola, DWS – 8 May 2018				
Page 4-3: second paragraph; Bullet 4	Recharge and aquifer recharge (which excludes the component of recharge lost as interflow and not available to groundwater users).	By definition, Recharge is the water that reaches the saturated zone thus continuously replenishing the aquifer; so is it appropriate to use the word *recharge* when we are including the water that gets lost as interflow after infiltration? This question applies to all other parts of the document where this word is used as such.	No	Recharge estimates, such as those in GRAII include the component of recharge lost to interflow and not available to boreholes. Recharge replenishes the saturated zone, but the entire saturated zone is not part of the regional aquifer. High lying springs are discharge from a saturated zone, but from a perched and not regional aquifer.
Page 4-3: second paragraph; Bullets 5 and 6		Do the terms "*Groundwater contribution to Baseflow*" on Bullet 5 and "*Groundwater Baseflow*" on Bullet 6 imply the same thing? If that's the case I would suggest the use of one just to avoid confusion, otherwise an explanation will suffice.	Yes	
The total Aquifer Recharge estimated for the study area.		How does it compare to the Aquifer Recharge values estimated from GRA II and other previous studies undertaken in the area?	No	GRAII provided total recharge based on the Chloride method, not all of which is recharge to the regional aquifer. The evidence of this is that high recharge occurs, but borehole yields are low and groundwater resources limited. Aquifer recharge is related to the resource, hence lower than the total recharge in GRAII.

<table>
<tr><th>Page / Section</th><th>Report statement</th><th>Comments</th><th>Changes made?</th><th>Author comment</th></tr>
<tr><td>Page 5.3: Table 5.3.</td><td>TDS, Nitrate and Fluoride</td><td>Are these the only elements considered in this assessment of groundwater quality or others were looked at but not included in the Tables? This question applies to the quality Tables for all the other GRUs.</td><td>No</td><td>These are the only constituents analysed in sufficient quantity to make any analysis possible. In the Groundwater Report it was noted that even the number of analyses for these constituents, especially N and F are very limited so no meaningful statistical analyses are possible.

For example, the table below shows how few catchments have any arsenic analysis. For most of the catchments the analyses are far too few to determine means, medians and percentiles.

<table>
<tr><th>Row Labels</th><th>Count of As-Diss-Water (ARSENIC) (mg/L) Result</th></tr>
<tr><td>T31A</td><td>1</td></tr>
<tr><td>T31B</td><td>6</td></tr>
<tr><td>T31C</td><td>2</td></tr>
<tr><td>T31D</td><td>12</td></tr>
<tr><td>T31E</td><td>8</td></tr>
<tr><td>T31F</td><td>17</td></tr>
<tr><td>T31G</td><td>7</td></tr>
<tr><td>T31H</td><td>1</td></tr>
<tr><td>T31J</td><td>8</td></tr>
<tr><td>T32A</td><td>9</td></tr>
<tr><td>T32B</td><td>4</td></tr>
<tr><td>T32C</td><td>7</td></tr>
<tr><td>T32D</td><td>9</td></tr>
<tr><td>T33A</td><td>3</td></tr>
<tr><td>T35C</td><td>5</td></tr>
<tr><td>T35D</td><td>1</td></tr>
<tr><td>Grand Total</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Page 5-11: Table 5.15.</td><td></td><td>I suggest re-arrangement of Rows to start with T33A and put T33B-E in the last Row, unless there’s a reason for the current order.</td><td>Yes</td><td></td></tr>
</table>

Page / Section	Report statement	Comments	Changes made?	Author comment
Page 5-29: first sentence.		Please rectify T5G to T35G, presumably.	Yes	
Page 5-31, Section 5.9.5, second sentence.	The moderate borehole yields make localized over-abstraction unlikely.	This sentence contradicts the one on Page 5-29 which says *"Yields are relatively high, making localized overexploitation a possibility."* But they are both talking about GRU 10. Please rectify.	Yes	