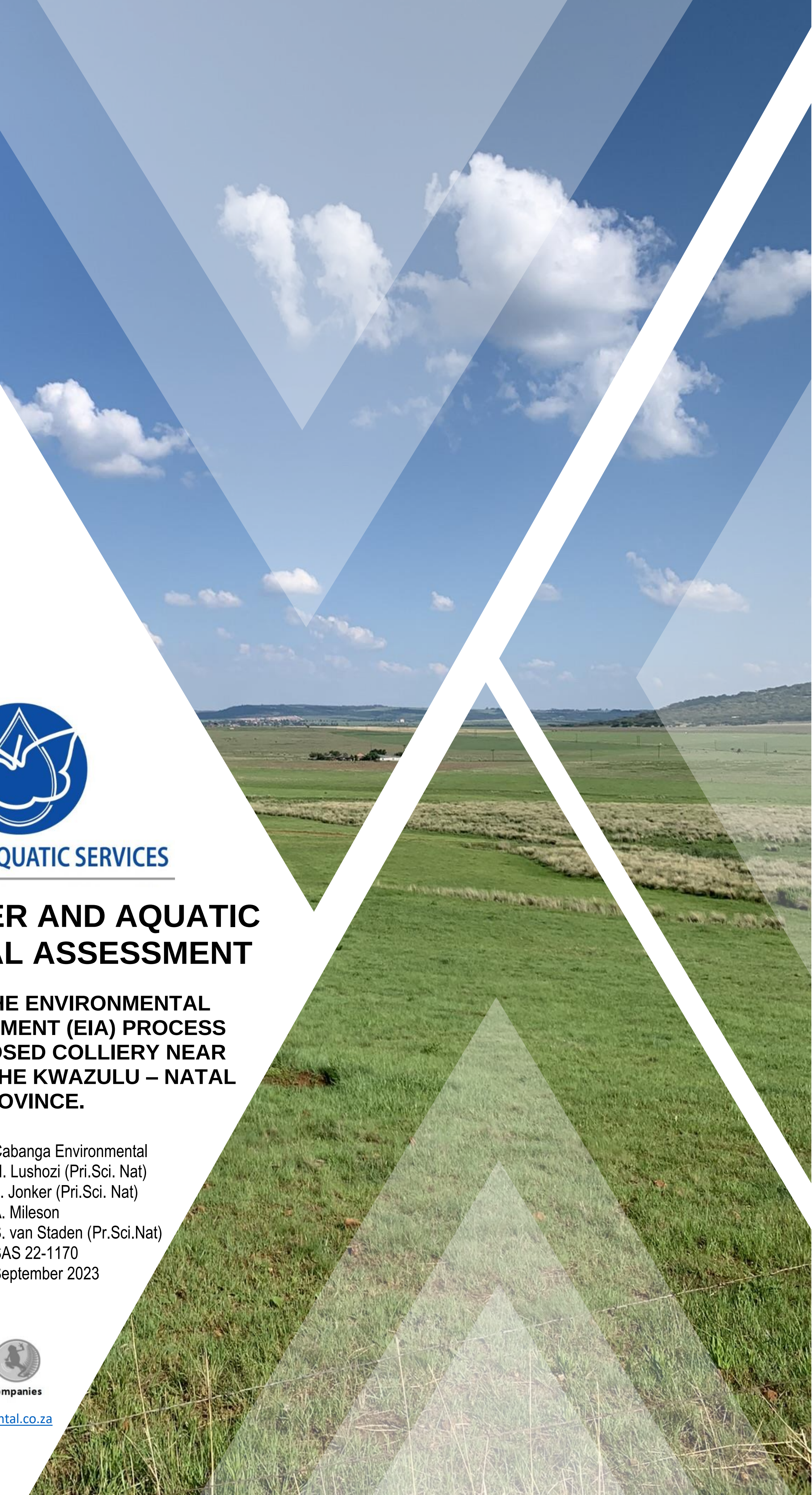


SCIENTIFIC AQUATIC SERVICES

FRESHWATER AND AQUATIC ECOLOGICAL ASSESSMENT

AS PART OF THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROCESS FOR THE PROPOSED COLLIERY NEAR NEWCASTLE IN THE KWAZULU – NATAL PROVINCE.

Prepared for:	Cabanga Environmental
Report author:	N. Lushozi (Pri.Sci. Nat)
	L. Jonker (Pri.Sci. Nat)
Report reviewers:	A. Mileson
	S. van Staden (Pr.Sci.Nat)
Report Reference:	SAS 22-1170
Date:	September 2023

Part of the SAS Environmental Group of Companies

Website: http://www.sasenvironmental.co.za

EXECUTIVE SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a freshwater ecosystem assessment as part the Environmental Impact Assessment (EIA) process for the proposed colliery in Newcastle, in the KwaZulu-Natal Province. The proposed project is hereafter referred to as the "proposed Newcastle colliery". The proposed Newcastle colliery includes the development of opencast and future underground mining areas as well as supporting infrastructure such as: open cast mining pits, stockpile areas, sorting plant area, wash bays, Pollution Control Dam (PCD), linear infrastructure (water pipelines, access roads and conveyors), surface infrastructure (workshop stores/offices, office area, general stores and guardhouse), stormwater management infrastructure (berms, culverts, in-pit sums and cut-off trenches) and proposed future underground mining.

During the assessment, various freshwater ecosystems which include wetlands (seep, unchannelled valley bottom and channeled valley bottom), rivers (Icawa River, Machini River and Inguduma River) and associated unnamed tributaries were identified within the investigation area and therefore assessed further as part of this study conducted in November 2022 during the spring season. The ecological integrity of the freshwater ecosystems ranged between Category A/B (Unmodified Modified/Largely Natural to Category C (Moderately Modified) due to absence of significant modifiers in the landscape. The ecological importance and sensitivity (EIS) of ranged between Low/Marginal and High with important ecological services including hydro-functional services to ecological functioning of downstream river systems.

The aquatic ecological assessment included five sites (NC1 – NC5) located on four different tributaries of the Ncandu River. These sites were chosen to best represent the Present Ecological State (PES) of the aquatic resources located in the eastern portion of the proposed open pit mining component as well as associated proposed infrastructure.

Water quality of all five selected sites was considered good, with largely natural Electrical Conductivity (EC), pH and Dissolved Oxygen (DO) concentrations observed during the site assessment, with only pH falling slightly below the Resource Quality Objectives (RQO) of the Ncandu River (DWS, 2022) at sites NC3 and NC4, and DO saturation falling below the 80 – 120% saturation recommended by the Target Water Quality Recommendations (TWQR) for Aquatic Ecosystems (DWAF, 1996) at site NC5.

Considering the Ecostatus Categories for both sites NC1 and NC2 on the Icawa River, the Instream and Riparian Index of Habitat Integrity (IHI) as well as the Diatom community integrity complied with the RQO of the Ncandu River (DWS, 2022) while the macro-invertebrate community integrity and fish community integrity borderline complied with the Category B/C RQO. Similarly, the Instream and Riparian IHI and Diatom community integrity Ecostatus Categories at site NC4 complied with the RQO, while the MIRAI Ecostatus did not comply with the RQO. At both sites NC5 and NC3, the Instream and Riparian IHI Ecostatus complied with the RQO, while the MIRAI Ecostatus did not comply with the RQO.

Overall, the Integrated Ecological Category at sites NC1 and NC2 on the Icawa River as well as site NC3 on an unnamed tributary was classified as a Category C at each site, complying with the Ecological Category to be maintained (Category B/C) for the Ncandu River (DWS, 2022).

The current mine layout has been optimised since the initial layout provided at the inception of the project (November 2022). The layout considers recommendations made in the initial freshwater and aquatic reports to avoid and minimize impacts. The final layout indicates that the mine pits will not encroach within the delineated wetlands and the impact on the wetlands is reduced in relation to the impact posed by the original layout. However, given the potential impacts associated with open cast mining in the landscape, it is the opinion of the specialist that mining underground identified resources and setting aside shallow resources to avoid open cast mining will significantly reduce potential impacts in the sensitive landscape and this is considered the most appropriate mining approach from a freshwater resource management point of view and the appropriateness of this strategy and setting aside of the shallower resources should be considered by the EAP, proponent and authorities in the decision making process.

Mining using open cast approach has a high potential to lead to changes to the quality and quantity of flows within the catchment, changing of pattern flow and timing of water in the landscape as well as alteration of the geomorphological regime and water quality supporting the freshwater resources associated with the site due to disturbances in the landscape. In addition, an open cast approach will likely lead to potential significant loss of aquatic biodiversity, freshwater functionality as well as goods and services provision. The significance of the freshwater ecosystems in the area, which form part of an important headwater catchment for larger river systems in the greater Newcastle area and are hydraulically linked to systems which are considered strategic water source areas. this fact must be considered in the planning and application process.

Therefore, as stated above, most appropriate method of freshwater ecological impact mitigation for this project would be that of setting aside the shallower coal and only planning for underground mining where the coal resources are deeper. Where avoidance is not deemed viable given the financial requirements / viability of the project and the need to ensure that mineral resources are extracted optimally and not sterilised, minimisation and mitigation of impacts is considered essential. As such, it is recommended that as far as possible, the current mine layout be minimised to an extent where the operations are still considered financially viable but in such a way to limit impacts to the receiving environment and to limit locations in the landscape to those that will not pose a long-term detrimental risk to the receiving freshwater resources of the region.

MANAGEMENT SUMMARY

Scientific Aquatic Services (SAS) was appointed to conduct a freshwater ecosystem assessment as part the Environmental Impact Assessment (EIA) process for the proposed colliery in Newcastle, in the KwaZulu-Natal Province, hereafter referred to as the “proposed Newcastle colliery”. From the boundary of the application area, the proposed Newcastle colliery is situated approximately 4 km east of the Newcastle Central Business District (CBD). The R34 is located approximately 1 km north-east to the closest point of the boundary. The proposed Newcastle colliery includes the development of mining areas and infrastructure such as: open cast mining pits, stockpile areas, sorting plant area, wash bays, Pollution Control Dam (PCD), linear infrastructure (water pipelines, access roads and conveyors), surface infrastructure (workshop stores/offices, office area, general stores and guardhouse), stormwater management infrastructure (berms, culverts, in-pit sums and cut-off trenches) and proposed future underground mining.

FRESHWATER ECOSYSTEM ASSESSMENT

To identify all freshwater ecosystems that may potentially be impacted by the activities associated with the proposed Newcastle colliery, a 500 m “zone of investigation” around the focus area, in accordance with Government Notice (GN) 509 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998) (NWA) was used as a guide in which to assess possible sensitivities of the receiving environment. This 500 m “zone of investigation” will henceforth be referred to as the ‘investigation area’. The assessment took the following approach:

- A desktop study was conducted, in which possible freshwater ecosystems were identified for on-site investigation, and relevant national and provincial databases were consulted;
- In addition, the freshwater ecosystems within the focus area were delineated and ground-truthed during a single site assessment conducted in November 2022. A detailed assessment of the delineated freshwater ecosystems was undertaken;
- The freshwater ecosystems were then classified according to the Ollis *et al*. (2013) classification system; and
- The characteristics of the freshwater ecosystems were defined including the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), Recommended Ecological Class (REC), Recommended Management Objective (RMO) and Best Attainable State (BAS).

During the assessment, the following freshwater ecosystems were identified within the focus area and potentially at risk from the proposed Newcastle colliery and therefore assessed further as part of this study. These were classified as follows:

Riverine Systems:

- The Inguduma River which flows in a south easterly direction was identified within the north-eastern corner of the focus area. The Inguduma River flows in a south-easterly direction and confluences with the Ncandu River approximately 8 km downstream;
- The Icawa River which flows in an easterly direction and confluences with the Inguduma River was identified north of the eastern focus area;
- Unnamed tributaries of the rivers in the focus area were identified and assessed as part of the field assessment; and
- The Ncandu River was also identified outside of the focus area but within the investigation area associated with the proposed Newcastle colliery.

Wetlands:

- Various wetlands were identified within the focus area of the proposed Newcastle colliery, these include: unchannelled valley bottom (UCVB), channelled valley bottom (CVB) and seep wetlands.

The summary of the assessment is shown below (Table A):

Table A: Summary of the assessment results.

Freshwater Ecosystem	Present Ecological State (PES) / Ecostatus	Ecoservices	Ecological Importance and Sensitivity (EIS)	Recommended Ecological Category / Recommended Management Objective / Best Attainable State
Inguduma River	Category C (Moderately Modified)	Moderate	High	REC Category: C BAS Category: C RMO: Maintain
Icawa River	Category C (Moderately Modified)	Low to Moderate	Moderate	REC Category: C BAS Category: C RMO: Maintain
Channelled valley bottom (CVB) wetlands	Category C (Moderately Modified)	Moderate to Moderately High	High	REC Category: C BAS Category: C RMO: Maintain
Unnamed tributaries	Category A/B (Unmodified Modified/Largely Natura)	Moderate	Moderately High	REC Category: B BAS Category: B RMO: Maintain/Improve
Unchannelled valley bottom (UCVB) wetlands	Category C (Moderately Modified)	Low to Moderately Low	Moderate	REC Category: C BAS Category: C RMO: Maintain
Seep Wetlands	Category B (Largely natural)	Low to Moderately Low	Low/Marginal	REC Category: B BAS Category: B RMO: Maintain/Improve

AQUATIC ECOLOGICAL ASSESSMENT

The results of the field assessment are presented in Section 5 of this report, and are summarised in the table below:

able B: Summary of the results of the instream aquatic ecological assessment on the tributaries of the Ncandu River.

Water Management Area: Pongoloa-Mtamvuma	
Quaternary Catchment: V31J	
Ecoregion: North-Eastern Uplands	
Weather Condition: Warm and clear	
Flows: Mixed flow	
Water Clarity: Discoloured to Clear	
Map: Locality of the Newcastle Colliery. For a detailed layout map see Figure 1, Section 1.	
Site Coordinates:	
NC1: 27°44'3.87"S	29°51'5.12"E
NC2: 27°44'28.10"S	29°52'59.42"E
NC3: 27°46'16.54"S	29°50'51.01"E
NC4: 27°45'1.87"S	29°52'13.18"E
NC5: 27°45'39.46"S	29°52'7.72"E

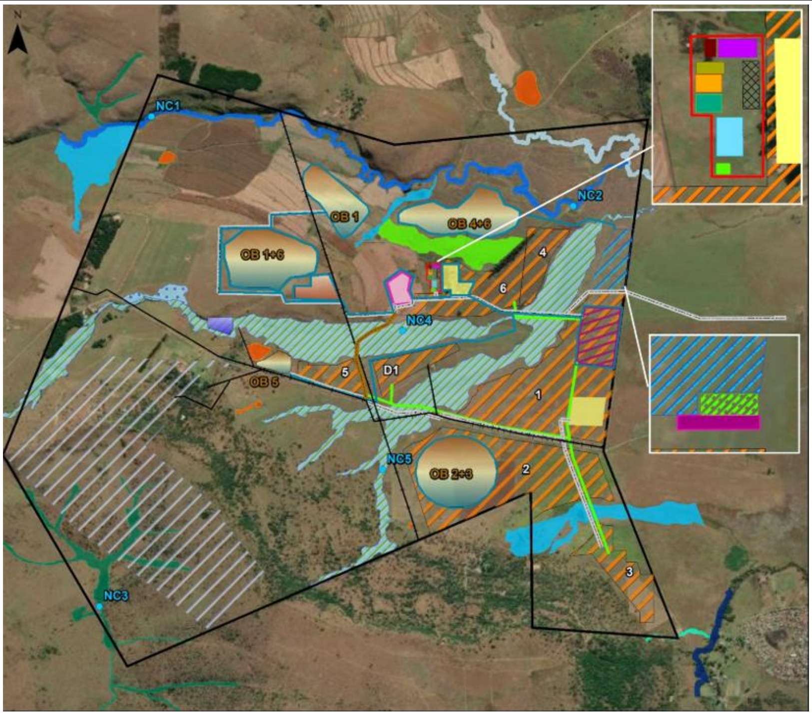


Table C: Summary of the *in-situ* Water quality results.

Assessment Sites	pH	Electrical Conductivity (mS/m)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Temperature (˚C)
Site NC1	8.53	11.0	85.1	6.2	21.1
Site NC2	8.53	10.1	109.8	8.4	22.0
Site NC3	6.25	8.3	101.8	7.32	27.0
Site NC4	6.34	10.7	84.3	5.7	28.3
Site NC5	8.44	11.0	68.1	5.6	25.3

Table D: Summary of the aquatic indices applied to each site.

Assessment Sites	Instream Index of Habitat Integrity (IHI)	Riparian IHI	Riparian Vegetation Response Assessment Index (VEGRAI)	Macro-Invertebrate Response Assessment Index (MIRAI)	Fish Response Assessment Index (FRAI)	Diatom Specific Pollution Sensitivity Index (SPI)	Integrated Ecological Category
Site NC1	86.2 (B)	68.5 (C)	87.0 (B)	59.6 (C/D)	59.7 (C/D)	Good Quality (B)	71.0 (C)
Site NC2	86.2 (B)		81.1 (B/C	58.4 (C/D)		Good Quality (B/C)	68.1 (C)
Site NC3	78.7 (B/C)	80.7 (B/C)	91.4 (A/B)	43.9 (D)	59.7 (C/D)	NA	67.2 (C)
Site NC4	81.4 (B/C)	74.3 (C)	NA	43.6 (D)	NA	Good Quality (B/C)	NA
Site NC5	81.4 (B/C)		NA	43.8 (D)	NA	NA	NA

The current mine layout has been optimised since the initial layout provided at the inception of the project (November 2022). The layout considers recommendations made in the initial freshwater and aquatic reports to avoid and minimize impacts. The final layout indicates that the mine pits will not encroach within the delineated wetlands and the impact on the wetlands is reduced in relation to the impact posed by the original layout. However, given the potential impacts associated with open cast mining in the landscape, it is the opinion of the specialist that mining underground identified resources and setting aside shallow resources to avoid open cast mining will significantly reduce potential impacts in the sensitive landscape and this is considered the most appropriate mining approach from a freshwater resource management point of view and the appropriateness of this strategy and setting aside of the shallower resources should be considered by the EAP, proponent and authorities in the decision making process.

Mining using open cast approach has a high potential to lead to changes to the quality and quantity of flows within the catchment, changing of pattern flow and timing of water in the landscape as well as alteration of the geomorphological regime and water quality supporting the freshwater resources associated with the site due to disturbances in the landscape. In addition, an open cast approach will likely lead to potential significant loss of aquatic biodiversity, freshwater functionality as well as goods and services provision. The significance of the freshwater ecosystems in the area, which form part of an important headwater catchment for larger river systems in the greater Newcastle area and are hydraulically linked to systems which are considered strategic water source areas. this fact must be considered in the planning and application process.

Therefore, as stated above, most appropriate method of freshwater ecological impact mitigation for this project would be that of setting aside the shallower coal and only planning for underground mining where the coal resources are deeper. Where avoidance is not deemed viable given the financial requirements / viability of the project and the need to ensure that mineral resources are extracted optimally and not sterilised, minimisation and mitigation of impacts is considered essential. As such, it is recommended that as far as possible, the current mine layout be minimised to an extent where the operations are still considered financially viable but in such a way to limit impacts to the receiving environment and to limit locations in the landscape to those that will not pose a long-term detrimental risk to the receiving freshwater resources of the region.

.

DOCUMENT GUIDE

The table below provides the specialist report requirements for the assessment and reporting of impacts on aquatic biodiversity in terms of Government Notice 320 as promulgated in Government Gazette 43110 of 20 March 2020 in line with the Department of Environmental Affairs screening tool requirements, as it relates to the National Environmental Management Act, 1998 (Act No. 107 of 1998).

No.	Requirements	Section in report
2.1	The assessment must be prepared by a specialist registered with the South African Council for Natural Scientific Professionals (SACNASP), with expertise in the field of aquatic sciences.	Front Page and Appendix G
2.2	The assessment must be undertaken on the preferred site and within the proposed development footprint.	Section 1 and 5
2.3	The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	
2.3.1	A description of the aquatic biodiversity and ecosystems on the site, including; a. aquatic ecosystem types; and b. presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns;	Section 3 and 5
2.3.2	The threat status of the ecosystem and species as identified by the screening tool;	Section 3 and 4
2.3.3	An indication of the national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area or sub catchment, a strategic water source area, a priority estuary, whether or not they are free-flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area); and	Section 3 and 4
2.3.4	A description of the ecological importance and sensitivity of the aquatic ecosystem including: a. the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and b. the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Section 4 and 5
2.4	The assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered appropriate.	Section 6
2.5	Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions:	Section 7
2.5.1	Is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Section 7
2.5.2	Is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	Section 7
2.5.3	How will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include: a. Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes); b. Will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns); c. What will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and d. To what extent will the risks associated with water uses and related activities change.	Section 7
2.5.4	How will the proposed development impact on the functioning of the aquatic feature? This must include: a. base flows (e.g. too little or too much water in terms of characteristics and requirements of the system); b. quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river); c. change in the hydrogeomorphic typing of the aquatic ecosystem (e.g. change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland); d. quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication); e. fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and	Section 7

	f. the loss or degradation of all or part of any unique or important features associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.).	
2.5.5	How will the proposed development impact on key ecosystems regulating and supporting services especially: a. flood attenuation; b. streamflow regulation; c. sediment trapping; d. phosphate assimilation; e. nitrate assimilation; f. toxicant assimilation; g. erosion control; and h. carbon storage.	Section 7
2.5.6	How will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator- prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	Section 7
2.6	In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered, in relation to: a. size of the estuary; b. availability of sediment; c. wave action in the mouth; d. protection of the mouth; e. beach slope; f. volume of mean annual runoff; and g. extent of saline intrusion (especially relevant to permanently open systems).	
2.7	**The findings of the specialist assessment must be written up in an Aquatic Biodiversity Specialist Assessment Report that contains, as a minimum, the following information:**	
2.7.1	Contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	Appendix G
2.7.2	A signed statement of independence by the specialist;	Appendix G
2.7.3	A statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 1 and 2
2.7.4	The methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;	Section 2 and Appendix C
2.7.5	A description of the assumptions made, any uncertainties or gaps in knowledge or data;	Section 1.3
2.7.6	The location of areas not suitable for development, which are to be avoided during construction and operation, where relevant;	Section 6
2.7.7	Additional environmental impacts expected from the proposed development;	Section 7
2.7.8	Any direct, indirect and cumulative impacts of the proposed development on site;	Section 7
2.7.9	The degree to which impacts and risks can be mitigated;	Section 7
2.7.10	The degree to which the impacts and risks can be reversed;	Section 7
2.7.11	The degree to which the impacts and risks can cause loss of irreplaceable resources;	Section 7
2.7.12	A suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies;	Section 6
2.7.13	Proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr);	Section 7
2.7.14	A motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a "low" aquatic biodiversity sensitivity and that were not considered appropriate;	
2.7.15	A substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not; and	Section 9
2.7.16	Any conditions to which this statement is subjected.	Section 9
2.8	The findings of the Aquatic Biodiversity Specialist Assessment must be incorporated into the Basic Assessment Report or the Environmental Impact Assessment Report including the mitigation and monitoring measures as identified, that are to be included in the EMPr.	
2.9	A signed copy of the assessment must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF TERMS

% DO sat	In aquatic environments, oxygen saturation is a ratio of the concentration of dissolved oxygen in the water to the maximum amount of oxygen that will dissolve in the water at that temperature and pressure under stable equilibrium.
Alien vegetation:	Plants that do not occur naturally within the area but have been introduced either intentionally or unintentionally. Vegetation species that originate from outside of the borders of the biome -usually international in origin.
ASPT	The average sensitivity of the aquatic community obtained by determining the sum of the sensitivity scores for each aquatic macro-invertebrate family observed and then dividing by the number of families present.
Biodiversity:	The number and variety of living organisms on earth, the millions of plants, animans and micro-organisms, the genes they contain, the evolutionary history and potential they encompass and the ecosystems, ecological processes and landscape of which they are integral parts.
Buffer:	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area.
Catchment:	The area where water is collected by the natural landscape, where all rain and run-off water ultimately flows into a river, wetland, lake, and ocean or contributes to the groundwater system.
Delineation (of a wetland):	To determine the boundary of a wetland based on soil, vegetation and/or hydrological indicators.
DO	Dissolved Oxygen is the amount of oxygen that is present in the water. It is measured in milligrams per litre (mg/L).
EC	Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge.
Ecoregion:	An ecoregion is a "recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterise that region".
EIS	Ecological importance refers to the diversity, rarity or uniqueness of the habitats and biota. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts.
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.
Facultative species:	Species usually found in wetlands (76%-99% of occurrences) but occasionally found in non-wetland areas.
FRAI	The FRAI is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers.
Gleying:	A soil process resulting from prolonged soil saturation which is manifested by the presence of neutral grey, bluish or greenish colours in the soil matrix.
Groundwater:	Subsurface water in the saturated zone below the water table.
Hydrology:	The study of the occurrence, distribution and movement of water over, on and under the land surface.
Hydromorphic soil:	A soil that in its undrained condition is saturated or flooded long enough to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).
Hydrophyte:	Any plant that grows in water or on a substratum that is at least periodically deficient of oxygen as a result of soil saturation or flooding; plants typically found in wet habitats.
IHAS	An assessment index to determine the suitability of the habitat at any assessment point for colonisation by aquatic macro-invertebrates.
IHI	The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region.
Indigenous vegetation:	Vegetation occurring naturally within a defined area.
MIRAI	MIRAI integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions.
Mottles:	Soils with variegated colour patterns are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.
Obligate species:	Species almost always found in wetlands (>99% of occurrences).
Perched water table:	The upper limit of a zone of saturation that is perched on an unsaturated zone by an impermeable layer, hence separating it from the main body of groundwater
Perennial:	Flows all year round.
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.
RDL (Red Data listed) species:	Organisms that fall into the Extinct in the Wild (EW), critically endangered (CR), Endangered (EN), Vulnerable (VU) categories of ecological status
RQIS	RQIS provides national water resource managers with aquatic resource data, technical information, guidelines and procedures that support the strategic and operational requirements for assessment and protection of water resource quality.
RWQO	*Guidelines set by the South African Department of Water and Sanitation (DWS), formerly DWA or DWAF, for various physico-chemical and biological parameters for various uses as well as ecosystem functioning.
SA RHP	The RHP serves as a source of information regarding the overall ecological status of river ecosystems in South Africa. For this reason, the RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterise the response of the aquatic environment to multiple disturbances.
SASS5	An index to determine the integrity of the aquatic macro-invertebrate community at any given assessment point.
Seasonal zone of wetness:	The zone of a wetland that lies between the Temporary and Permanent zones and is characterised by saturation from three to ten months of the year, within 50cm of the surface
SQR	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments).
Temporary zone of wetness:	the outer zone of a wetland characterised by saturation within 50cm of the surface for less than three months of the year
VEGRAI	VEGRAI is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results presented as Ecostatus Categories.
Watercourse:	In terms of the definition contained within the National Water Act, a watercourse means: • A river or spring; • A natural channel which water flows regularly or intermittently; • A wetland, dam or lake into which, or from which, water flows; and • Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse; • and a reference to a watercourse includes, where relevant, its bed and banks
Wetland Vegetation (WetVeg) type:	Broad groupings of wetland vegetation, reflecting differences in regional context, such as geology, climate, and soils, which may in turn have an influence on the ecological characteristics and functioning of wetlands.
WMS	WMS is a suite of computer programmes developed for the Department of Water and Sanitation to provide information for water resource monitoring and management in South Africa.
WULA	The National Water Act (Act 36 of 1998) gives the Department of Water and Sanitation the tools to gather the information that we need for the optimal management of our water resources. The registration of water use is one of these tools.

South African water quality guidelines volume 7, Aquatic ecosystems (DWAF, 1996): This reference provides percentage change guidelines as follows:

- **Electrical conductivity (EC)/Total Dissolved Solids (TDS)** concentrations should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year, and the amplitude and frequency of natural cycles in EC/TDS concentrations should not be changed;
- **pH values** should not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5 %, and should be assessed by whichever estimate is the more conservative.
- **Dissolved Oxygen (DO)** concentration should be 80% to 120% of saturation. In addition, for the purposes of this report, any spatial or temporal change exceeding 15% was considered significant.

Note that EC and pH comparisons refer to temporal comparisons. However, as no guidelines are available for spatial comparisons, the percentage change recommendations were applied to spatial comparisons. For the purpose of this report, a temporal or spatial change of 15% was considered significant with reference to DO.

Proposed water resource classes and resource quality objectives for Thukela catchments in the Pongola-Mtamvuna water management area (DWS, 2022). This publication provided updated classes and resource quality objectives of water resources for the Thukela catchment. The reserve for V31J (EWR 19, Ncandu River) applies. See Section 3 for further detail.

ACRONYMS

°C	Degrees Celsius.
%PTV	Percentage Pollution Tolerant Valves
ASPT	Average Score Per Taxon
BGIS	Biodiversity Geographic Information Systems
CBA	Critical Biodiversity Area
CSIR	Council of Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
DO	Dissolved Oxygen
DRDLR	Department of Rural Development and Land Reform's
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
EC	Ecological Class or Electrical Conductivity (use to be defined in relevant sections)
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMC	Ecological Management Class
EMPr	Environmental Management Program
ESA	Ecological Support Area
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Areas
FRAI	Fish Response Assessment Index
GDI	Generic Diatom Index
GIS	Geographic Information System
GN	Government Notice
GPS	Global Positioning System
HGM	Hydrogeomorphic
IHAS	Invertebrate Habitat Assessment System
IHI	Index of Habitat Integrity
KZN	KwaZulu-Natal
m	Meter
MAP	Mean Annual Precipitation
MIRAI	Macro-Invertebrate Response Assessment Index
MPRDA	Mineral and Petroleum Resources Development Act
MR	Mining Right
NA	Not Applicable
NBA	National Biodiversity Assessment
NEMA	National Environmental Management Act
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
PCD	Pollution Control Dam
PES	Present Ecological State
REC	Recommended Ecological Category
Ref	Reference
RHP	River Health Program
RMO	Resource Management Objective
RQIS	Research Quality Information Services
RQO	Resource Quality Objective
SACNASP	South African Council for Natural Scientific Professions
SANBI	South African National Biodiversity Institute

SAS	Scientific Aquatic Services
SASS5	South African Scoring System version 5
SPI	Specific Pollution sensitivity Index
SQR	Sub quaternary catchment reach
subWMA	Sub-Water Management Area
TDI	Trophic Diatom Index
TDS	Total Dissolved Salts
TWQR	Target Water Quality Recommendation
VEGRAI	Riparian Vegetation Response Assessment Index
WetVeg Groups	Wetland Vegetation Groups
WMA	Water Management Areas
WMS	Water Management System
WRC	Water Research Commission
WULA	Water Use License Application
ZOR	Zone of Regulation

1 INTRODUCTION

1.1 Background

Scientific Aquatic Services (SAS) was appointed to conduct a freshwater ecosystem and aquatic ecological assessment as part the Environmental Impact Assessment (EIA) process for the proposed colliery in Newcastle, in the KwaZulu-Natal Province, hereafter referred to as the “proposed Newcastle colliery” (Figures 1 - 3) and is located within the focus area which is defined as the footprint within which all proposed activities are located. From the boundary of the proposed footprint area, the proposed Newcastle colliery is situated approximately 4 km east of the Newcastle Central Business District (CBD). The R34 is located approximately 1 km north-east to the closest point of the boundary. Areas located east of the focus area are highly industrial with various industries, and some residential developments while areas west of the focus area are dominated by cultivation and recreational including tourism activities (lodges and a golf course).

The proposed Newcastle colliery includes the development of mining areas and infrastructure such as: open cast mining pits, stockpile areas, sorting plant area, wash bays, Pollution Control Dam (PCD), linear infrastructure (water pipelines, access roads and conveyors), surface infrastructure (workshop stores/offices, office area, general stores and guardhouse), stormwater management infrastructure (berms, culverts, in-pit sums and cut-off trenches) and proposed future underground mining. This infrastructure is located on the eastern portion of the focus area. In addition to this, potential future underground mining areas are located along the western portion of the focus area. The future underground mining areas along the western portion of the infrastructure were not assessed in field during the assessment and were only assessed at a desktop level.

To identify all freshwater ecosystems that may potentially be impacted by the activities associated with the proposed Newcastle colliery, a 500 m “zone of investigation” around the focus area, in accordance with Government Notice (GN) 509 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998) (NWA) was used as a guide in which to assess possible sensitivities of the receiving environment. This 500 m “zone of investigation” will henceforth be referred to as the ‘investigation area’. The purpose of this report is to define the ecology of the area in terms of freshwater ecosystems and aquatic ecology characteristics, including mapping of the freshwater ecosystems, discuss key ecological drivers and to define the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS), as well as the socio-cultural and ecological service provision of the freshwater ecosystems and aquatic ecology utilising current industry “best practice” assessment methods in order to ascertain what, if any, impact the activities will have on the freshwater ecosystems associated with the proposed Newcastle colliery. Additionally, this report aims to define the Recommended Management Objectives (RMO) and Recommended Ecological Category (REC) for the freshwater ecosystems.

The objective of the study is to provide detailed information considering the characteristics of the watercourses that are potentially affected and in consideration of the existing activities in the vicinity of the freshwater and aquatic ecosystems, to ensure the ongoing functioning of the ecosystem such that local and regional conservation requirements and the provision of ecological services in the local area are supported while considering the need for sustainable economic development. The Environmental Impact Assessment method supplied by the EAP was applied to identify potential impacts that may affect the freshwater ecosystems as a result of the proposed activities and aim to quantify the significance thereof. The impact assessment findings are presented in Section 7.

1.1.1 Project description[1]

The proposed Newcastle colliery is located over portions of the Farms Craig No 2989-HS, Glen Ashton No 8589-HS, Harwarden No 8915-HS, Waterfall No 3335-HS and Dumblane No 3317-HS, Kwa-Zulu Natal Province. The Prospecting Right Area comprises 3,269 hectares (Ha), which is also the subject of the Mining Right Application. Affected surface areas will not exceed 450 Ha and according to the proponent this area may be further reduced.

The Project comprises an initial open pit mining component, and a future underground mining component. Much of the prospecting was undertaken on the eastern portion of the Application Area, resulting in far more detailed information being available on this area than in the western portion of the Application Area. Available prospecting results indicate that there are coal reserves in the eastern portion can be mined by opencast methods, while the western portion is suitable for future underground mining.

A) Mining Method:

Open pit mining: Open pit mining in the eastern portion of the Site will comprise the roll-over mining of up to seven pits. The pits will be mined in sequence, and all seven pits will not be open at any given time. Given variable coal qualities, it is likely that more than one pit will have

[1] The project description was obtained from the Environmental Assessment Practitioner (EAP) (Cabanga Environmental).

to be open simultaneously, to allow for blending of different coal qualities on site, to meet the required product qualities.

Underground Mining: Where the coal seams are too deep and uneconomical for opencast mining, these will be mined by means of underground bord-and-pillar methods. Underground mine reserves will be accessed from the opencast highwalls, at the interface between opencast and future underground mine areas. An appropriate boundary pillar will be retained between the open cast and underground mining sections.

The future underground mining will likely be conducted by means of bord-and-pillar mining to an appropriate safety factor, to be advised by relevant specialists. No pillar extraction is proposed. The proposed underground mining areas are proposed within the western focus area, and these areas were only assessed at a desktop level during the field assessment.

Additional Prospecting: It is probable that additional drilling activities will be required in the western portion of the Site, to define the economic viability of mining the coal resource. These investigations will typically involve drilling of prospecting boreholes and undertaking analysis of the drill core. As the coal seams increase in depth below surface, drilling becomes more challenging. Specific management measures for continued studies to evaluate the coal in the western section of the application area are included in the Environmental Management Programme (EMPr) and assessed during the EIA Phase.

B) Mineral Processing:

Coal will be transported from the mining areas to the central processing area that will accommodate the crushing, screening and sorting plants. A combination of haulage via truck and haul roads, and a conveyor system is proposed to transport coal from the mining areas to the processing area. According to the proponent, once the mining operation has commenced, an in-pit crushing and screening plant is the preferred option.

C) Supporting Infrastructure:

Roads, security and access control: The Project will be accessed via an old farm road that intersects with the R34 road. From here, individual access / haul roads will provide access to individual project areas. Where possible, the road alignments will correspond to existing farm roads. Security and Access Control infrastructure will be required at the active mining areas, the processing area and the central infrastructure areas. The roads within the project area will be 6 m wide. The roads will be built with semi-mountable pavements and non- mountable pavements on both sides. They will also be equipped with all the required storm water systems and structures to prevent possible flooding. Measures to control dust will be applied, one of which will include regular spraying with water trucks.

Roads used to access pits will be rehabilitated once mining at the specific pit is complete; no redundant roads will be allowed to remain on site.

Administration Facilities: It is proposed to use the existing farm buildings on portion 1 of the farm Craig 2989 for office and administrative support functions to the mining operation for year 1 to year 8. In year 9, the mining of pit 6 will require alternative office and administration facilities to be established. In-pit containerised offices are proposed per layout.

Workshop and Stores: The workshop(s) and Stores facilities will be established next to the overburden dumps, towards the west of the infrastructure area. It is anticipated that Diesel storage and dispensing facilities will also be included in this area to facilitate on-site refuelling of mining vehicles. Diesel will be stored in bunded areas (either constructed concrete bunds, or self-bunded tanks). The refuelling apron will be on an impervious surface and drain to a sump with an oil separator.

All chemicals stored on site including lubricants, oils etc. will be managed in accordance with each chemical's Material Safety Data Sheet (MSDS). Access to these substances will be restricted to personnel who have been specifically trained in the storge, handling and use of the substances.

Waste Management: No mineral waste will be generated by the crushing and screening plants – carbonaceous shales, overburden and rocks excavated as part of the mining process will be returned to the base of the pit, compacted and covered as part of the rollover rehabilitation of each pit. This material is therefore not regarded as waste but invaluable input material to the rehabilitation process.

Normal domestic and office-type waste will be generated at the administration facilities, and throughout the site. General office waste will be separated at source into at least recyclable and non-recyclable waste and transported off-site by an appointed contractor for recycling / disposal as appropriate. Hazardous waste will only be generated at the workshop area. Designated hazardous waste bins will be provided on site, for the temporary storage of hazardous waste generated at the workshop (oily rags, used oil, used filters etc.).

Domestic waste will be collected initially in refuse bins that must be available at all active areas. Refuse bins will be regularly emptied to designated skips, to be located on an impervious surface and covered, at the central waste storage area. The central waste storage area is proposed near the workshop area. The central waste storage area must comply to the norms and standards for the storage of waste. Skips will be provided for (at least) hazardous waste, scrap metal, wood waste and general waste. Waste Management Contractors will be used to remove the waste off-site for disposal at landfill where recycling is not possible.

Provision of Power and Water: The crushing, screening and sorting plant requires about 0.3m³/hour of water for dust suppression. Water will also be required for potable use, ablutions and the laundry, washing of equipment and vehicles (at the wash bay) and dust suppression on haul roads. It is anticipated that 56 kilolitres of water per day will be used for dust suppression and other non-production purposes.

This water will either be obtained from the Newcastle Local Municipality or groundwater, or a combination of these.. If boreholes are to be used or established as a source of water, a modular water treatment plant may be established on site for the treatment of water that will be suitable for human consumption. Potable water will be sampled monthly for comparison to the SANS241:2015 drinking water standards.

Mining equipment will be diesel-driven, and a bunded diesel storage facility will be established near the workshop area, as mentioned above. Back-up power to the operations may also be supplied by diesel-generator. There are various Eskom powerlines traversing the site, and the Applicant will engage with Eskom to identify tie-in options: There is an existing 400kV line in the vicinity of the proposed workshop area (Majuba Venus 1), and another two existing 400kV lines (Tutuka Pegasus 1, and Mahuba Pegasus 1) bisecting the site.

Electricity requirements for the warehouse, stores and offices will be addressed by rooftop solar PV systems, or Eskom. Electricity requirements for the crushing, screening and sorting plant will be provided by Eskom, and the Applicant must engage with the power utility in this regard. Installed electrical capacity of the plant is 889kW.

The figures 1 - 3 below indicate the location of the focus and investigation area in relation to the surrounding environment. Figure 4 thereafter indicates the layout of the proposed Newcastle colliery. The western focus area (indicated in red below) associated with potential future underground was not assessed in field during the assessment and only assessed at desktop level.

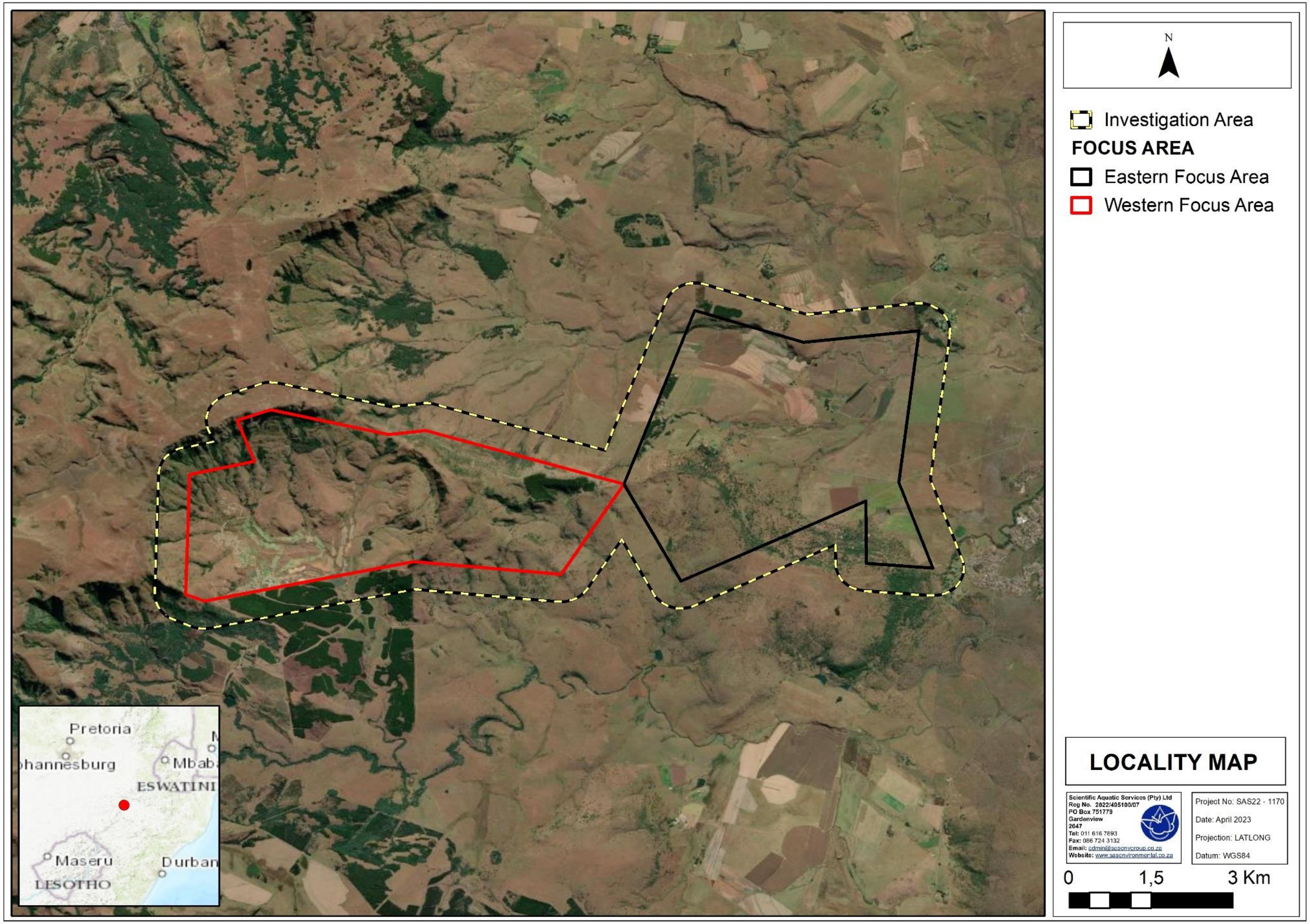


Figure 1: Digital satellite image depicting the location of the focus and investigation area in relation to the surrounding environment.

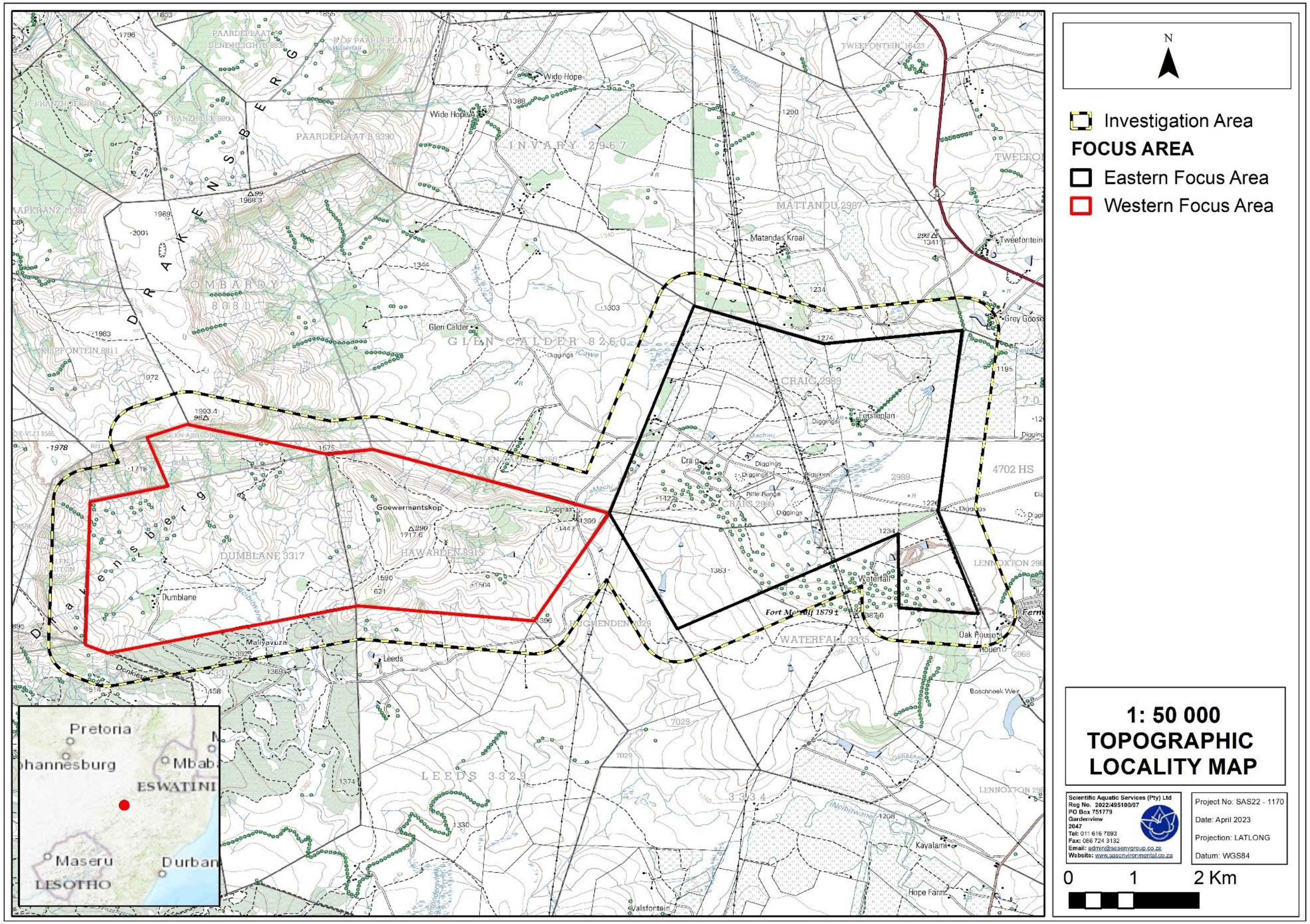


Figure 2: The focus and investigation areas associated with the proposed Newcastle colliery depicted on a 1:50 000 topographical map in relation to the surrounding environment.

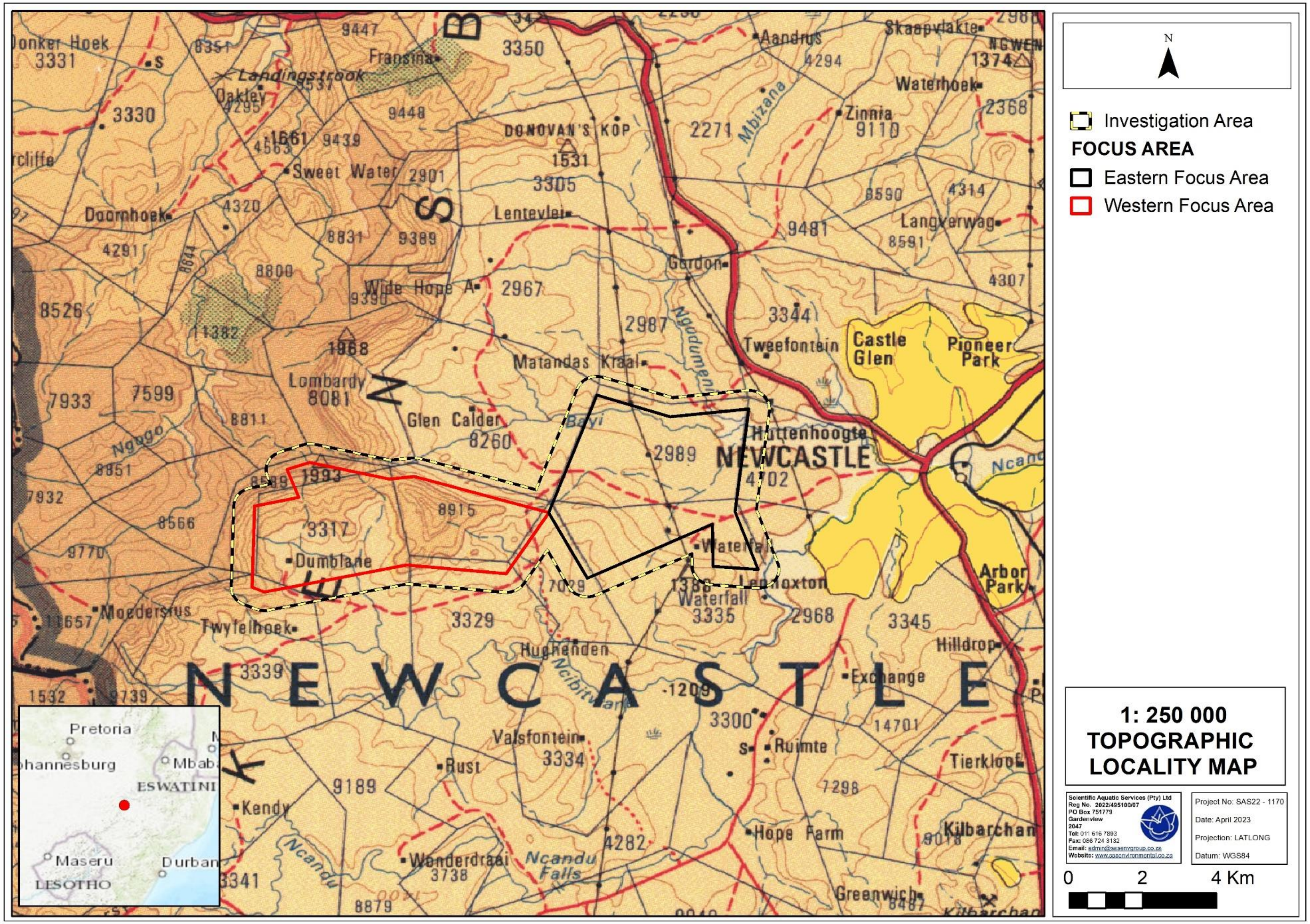


Figure 3: The focus and investigation areas associated with the proposed Newcastle colliery depicted on a 1:250 000 topographical map in relation to the surrounding environment.

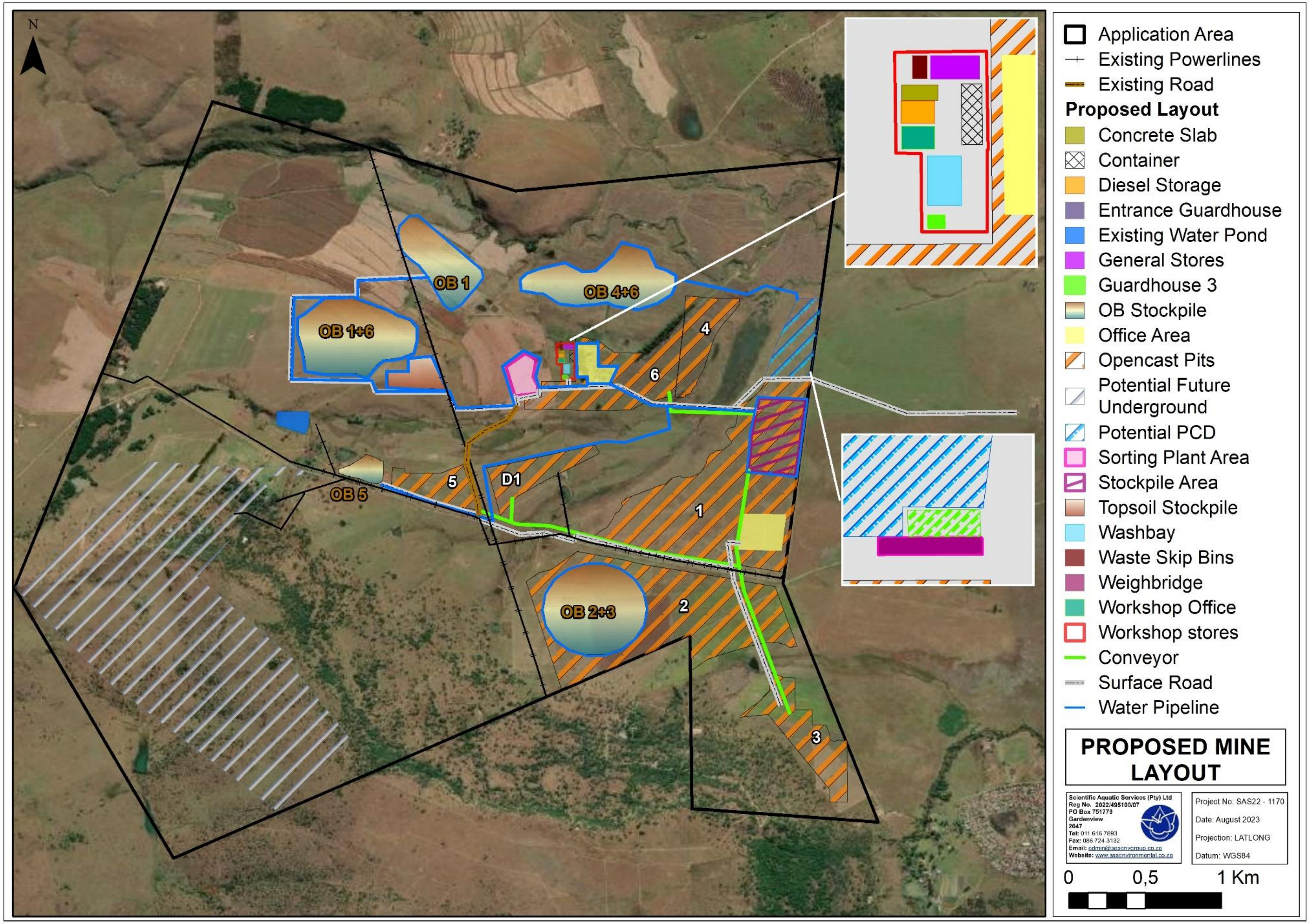


Figure 4: The layout of the proposed Newcastle colliery in relation to the surrounding environment.

1.2 Scope of Work

Specific outcomes in terms of this report are outlined below:

Freshwater Ecosystem Assessment:

- A background study of relevant national, provincial and municipal datasets (such as the National Freshwater Ecosystem Priority Areas [NFEPA] 2011 database; the Department of Water and Sanitation Research Quality Information Services [DWS RQIS PES/EIS], (2014) database, National Biodiversity Assessment (NBA) (2018), and the Guideline: Biodiversity Impact Assessment in KwaZulu-Natal (EKZN, 2013), were undertaken to aid in defining the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the freshwater ecosystems;
- All freshwater ecosystems within the investigation area were delineated using desktop methods in accordance with GN509 of 2016 as it relates to activities as stipulated in the National Water Act, 1998 (Act No. 36 of 1998) and verified where possible according to the "Department of Water Affairs and Forestry (DWAF)[2] (2005)[3]: A practical field procedure for identification of wetlands and riparian areas". Aspects such as soil morphological characteristics, vegetation types and wetness were used to verify the freshwater ecosystems;
- The freshwater ecosystem classification assessment was undertaken according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland systems (Ollis *et al*., 2013);
- The EIS of the freshwater ecosystems was determined according to the method described by Rountree and Kotze (2013);
- The PES of the freshwater ecosystems was assessed according to the resource directed measures guideline as advocated by Macfarlane *et al*., (2008);
- The freshwater ecosystems were mapped according to the hydrogeomorphic units in relation to the proposed Newcastle colliery. In addition to the freshwater ecosystem boundaries, the appropriate provincial recommended buffers and legislated zones of regulation were depicted where applicable;
- Allocation of a suitable RMO, REC and Best Attainable State (BAS) to the freshwater ecosystems based on the results obtained from the PES and EIS assessments; and
- To present management and mitigation measures which should be implemented going forward to assist in minimising the impact on the receiving environment.

---

[2] The Department of Water Affairs and Forestry (DWAF) was formerly known as the Department of Water Affairs (DWA) and subsequently as the Department of Water and Sanitation (DWS). For the purposes of referencing in this report, the name under which the Department was known during the time of publication of reference material, will be used.
[3] Even though an updated manual is available since 2008 (Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas), this is still considered a draft document currently under review.

Aquatic Ecological Assessment:

- To define the instream Ecostatus of the aquatic resources associated with the study area;
- To define the instream EIS of the aquatic resources within the study area;
- To provide information to guide the project so as to maintain the Ecostatus of the system in support of the EIS of the aquatic ecosystem;
- To provide information to guide the project to ensure that connectivity of the aquatic resources is maintained both laterally and longitudinally along all watercourses;
- To provide recommendations to ensure that no incision and erosion of the aquatic resources takes place as a result of the proposed mining and associated activities; and
- To provide recommendations to ensure that no significant persistent impact on water quality will take place.

Impact Assessment:

- The Environmental Impact Assessment (presented in Section 7) methodology supplied by the EAP was applied to identify potential impacts that may affect the freshwater and aquatic resources as a result of the proposed activities and aim to quantify the significance thereof; and
- To present management and mitigation measures which should be implemented going forward to assist in minimising the impact on the receiving environment.

1.3 Assumptions and Limitations

The following assumptions and limitations are applicable to this report:

Freshwater Ecosystem Assessment:

- The future underground mining areas along the western portion of the focus area were not assessed in-field during the assessment and were only considered at a desktop level. Therefore, in Section 4 (field results section) of the report, the 'Western Focus Area' will not be included in the findings;
- The south-eastern portion of the eastern focus area was not assessed on site due to access into the privately owned land not being granted at the time of the assessment. Therefore, assessment of this areas was only conducted at a desktop level as well as digital satellite imagery resulting in reduced confidence in the finding given that no ground-truthing was conducted at the time of the assessment. Similarly, the footprint associated with the 'probable access road' and the 'conveyor alternative' along the south-eastern corner of the focus area were also not assessed in-field during the

assessment as these were included in the layout following the field assessment, therefore additional field work for ground-truthing of these areas is considered necessary before any activities on site commence, should the project be approved;

- All freshwater ecosystems directly associated with the proposed Newcastle colliery were ground-truthed, however freshwater ecosystems within 500 m of the focus area were delineated in fulfilment of GN509 of the National Water Act, 1998 (Act No. 36 of 1998) using various desktop methods including use of topographic maps, historical and current digital satellite imagery and aerial photographs. Delineations prepared using desktop methods were ground-truthed where feasible;
- In addition to the above, where access was a limitation (privately owned land where access was not granted), verification points for freshwater ecosystems were located at points as close to the freshwater ecosystem as possible to be verified and, where necessary, the conditions at the exact point required were inferred or extrapolated. Despite this, these observations made are deemed sufficient to ensure that informed decision making can be undertaken;
- Global Positioning System (GPS) technology is inherently inaccurate and some inaccuracies due to the use of handheld GPS instrumentation may occur. If more accurate assessments are required, the freshwater ecosystems will need to be surveyed and pegged according to surveying principles and with survey equipment;
- Wetland, riparian and terrestrial ecosystem zones create transitional areas where an ecotone is formed as vegetation species change from terrestrial to obligate/facultative species. Within this transition zone, some variation of opinion on the freshwater ecosystem boundary may occur. However, if the DWAF (2008) method is followed, all assessors should get largely similar results;
- With regards to data sources used to provide background information on the sensitivity of the assessed areas, it is important to note that although all data sources provide useful and often verifiable, high-quality data, the various databases used do not always provide an entirely accurate indication of the focus area's actual site characteristics at the scale required to inform the environmental application process; and
- With ecology being dynamic and complex, certain aspects (some of which may be important) may have been overlooked. A more reliable assessment of the biota would require seasonal sampling, with sampling being undertaken under both low flow and high flow conditions. However, it is expected that the current conditions on site have been adequately assessed and considered based on the field observations and through utilisation of existing desktop information from various sources.

Aquatic Ecological Assessment:

- ***Reference conditions are largely unknown:*** The composition of aquatic biota in the study area, prior to disturbance is unknown. Current impacts largely consist of agricultural activities. For this reason, reference conditions are hypothetical, and are based on professional judgement and/or inferred from limited data available such as the Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database as discussed in Section 3.
- ***Ecological assessment timing:*** Aquatic and terrestrial ecosystems are dynamic and complex. It is possible that aspects, some of which may be important, could have been overlooked. A more reliable assessment of the biota would require seasonal sampling, with sampling being undertaken under both low flow and high flow conditions. However, the observations made in this study are deemed adequate to provide the information required to define the risk to the aquatic ecosystem in question, and to ensure that sufficient insight into management and mitigation measures is provided to adequately protect the system and to maintain the Ecostatus of the system;
- The future underground mining areas along the western portion of the application area were not assessed in-field during the assessment and were only considered at a desktop level. Therefore, in Section 5 (aquatic results section) of the report, the western focus area will not be included in the field findings.

1.4 Legislative Requirements and Provincial Guidelines

The following legislative requirements and relevant provincial guidelines were taken into consideration during the assessment. A detailed description of these legislative requirements is presented in Appendix B:

- Constitution of the Republic of South Africa, 1996[4];
- The National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) as amended;
- The National Water Act, 1998 (Act No. 36 of 1998) (NWA) as amended;
- Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998);
- Government Notice 704 as published in the Government Gazette 20119 of 1999 as it relates to the National Water Act, 1998 (Act No. 36 of 1998);

[4] Since 1996, the Constitution has been amended by seventeen amendments acts. The Constitution is formally entitled the 'Constitution of the Republic of South Africa, 19996". It was previously also numbered as if it were an Act of Parliament – Act No. 108 of 1996 – but since the passage of the Citation of Constitutional Laws Act, neither it nor the acts amending it are allocated act numbers.

- The National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA);
- The National Environmental Management: Biodiversity Act: Alien and Invasive Species Regulations, 2014;
- The Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA);
- Guideline: Biodiversity Impact Assessment in KwaZulu-Natal (EKZN, 2013);
- Government Notice 320 as promulgated in Government Gazette 43110 of 20 March 2020 in line with the Department of Environmental Affairs screening tool requirements, as it relates to the National Environmental Management Act, 1998 (Act No. 107 of 1998); and
- The Department of Environment, Forestry and Fisheries (DEFF), (2020) National Web-based Environmental Screening Tool (hereafter the “screening tool”).

2 ASSESSMENT APPROACH

2.1 Freshwater Ecosystem Definition

For the purposes of this investigation, the definition of a watercourse riparian and wetland habitats were taken as per that in the National Water Act, 1998 (Act No. 36 of 1998). The definitions are as follows:

A **watercourse** means:
(a) a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse,
and a reference to a watercourse includes where relevant, its bed and banks.

Wetland habitat is “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”

Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.

Thus, for the purposes of this investigation, the definition of a freshwater ecosystem is considered synonymous with the definition of a watercourse as per the National Water Act, 1998 (Act No. 36 of 1998) and the terms may be used interchangeably in this report.

2.2 Freshwater Ecosystem Field Verification

As mentioned in Section 1.3 use was made of historical aerial photographs, historical and current digital satellite imagery, topographic maps, and available provincial and national wetland databases to aid in the delineation of those portions of the freshwater ecosystems associated with the proposed Newcastle colliery following the field assessment. The following was taken into consideration when utilising the above during delineation:

- Linear features: since water flows/moves through the landscape, freshwater ecosystems often have a distinct linear element to their signature which makes them discernible on aerial photography or satellite imagery;
- Vegetation associated with freshwater ecosystems: a distinct increase in density as well as shrub size near flow paths;
- Hue: with water flow paths often show as white/grey or black and outcrops or bare soil displaying varying chroma created by varying vegetation cover, geology and soil conditions. Changes in the hue of vegetation with watercourse vegetation often indicated on black and white images as areas of darker hue (dark grey and black). In colour imagery these areas mostly show up as darker green and olive colours or brighter green colours in relation to adjacent areas where there is less soil moisture or surface water present; and
- Texture: with areas displaying various textures, created by varying vegetation cover and soil conditions.

The freshwater ecosystem delineation was verified in the field at pre-selected points, and this delineation took place according to the method presented in the "Updated manual for the identification and delineation of wetland and riparian resources" (DWAF, 2008). The foundation of the method is based on the fact that freshwater ecosystems have several distinguishing factors including the following:

- Landscape position;
- The presence of water at or near the ground surface;
- Distinctive hydromorphic soil;
- Vegetation adapted to saturated soil; and
- The presence of alluvial soil in stream systems.

A field assessment was undertaken in November 2022 during the Spring season, during which the presence of any riparian or wetland characteristics as defined by DWAF (2008) and by the National Water Act, 1998 (Act No. 36 of 1998) were noted (please refer to Section 4 of this report). In addition to the delineation process, detailed assessments of the delineated freshwater ecosystems were undertaken, at which time, factors affecting the integrity of the freshwater ecosystems were taken into consideration and aided in the determination of the functioning and the ecological and socio-cultural services provided by the freshwater ecosystems. A detailed explanation of the methods of assessment undertaken is provided in Appendix C of this report.

2.3 Sensitivity Mapping

All freshwater ecosystems associated with the proposed Newcastle colliery were delineated on a desktop basis, with these delineations being ground-truthed in the field at certain pre-selected points where possible with the use of a handheld Global Positioning System (GPS). Geographic Information System (GIS) was used to project these features onto digital satellite imagery and topographic maps. The sensitivity map presented in Section 6 should guide the design and layout of the proposed Newcastle colliery.

2.4 Aquatic Ecological Assessment

Best practice methods of assessment (detailed methods of assessment provided in Appendix C) were used to assess the aquatic ecological integrity of the study area based on water quality, instream and riparian habitat condition and biological impacts and integrity. All work was overseen by a South African River Health Program (SA RHP) accredited assessor. Factors investigated included the following:

- Visual conditions of the site, including an assessment of impacts at each site;
- Water quality variables were measured *in-situ* using the Aquaread Aquameter (AP – 700 series) probe. Parameters included: Dissolved Oxygen (DO), pH, Electrical Conductivity (EC) and temperature. Results are discussed against various guidelines as follows:
  - South African water quality guidelines volume 7, Aquatic ecosystems Target Water Quality Objectives (TWQR; DWAF, 1996);
  - The Resource Water Quality Objectives (RWQO) of the Thukela catchments in the Pongola-Mtamvuna water management area (WMA), specifically, the Ncandu River (DWS, 2022).
- The general habitat integrity of the site was assessed based on the application of the Index of Habitat Integrity (IHI), based on the protocol of Kleynhans *et al*. (2008);

- The integrity of the aquatic macro-invertebrate community was assessed using the South African Scoring System version 5 (SASS5) as defined by Dickens & Graham (2002), as well as through the application of the Macro-Invertebrate Response Assessment Index (MIRAI) Ecostatus tool as described by Thirion (2007). Aquatic macro-invertebrates expected within the system were derived from the DWS Resource Quality Information Services (RQIS) PES/EIS database;
- The integrity of the fish community was assessed using the Fish Response Assessment Index (FRAI) as described by Kleynhans (2007);
- Sampling of diatom communities was performed according to the methodology described by Taylor *et al.* (2007). Dominant species ecology was inferred from Taylor *et al*. (2007) and Omnidia software (Lecointe *et al.,* 1993) were used to calculate diatom index scores;
- The Ecological Importance and Sensitivity of the aquatic resources was determined according to the protocols of DWAF (1999).

2.5 Impact Assessment and Recommendations

Following the completion of the freshwater and aquatic ecological assessments, a pre-defined impact assessment methodology provided by the EAP was applied (please refer to Appendix D for the methods of approach) and recommendations were developed to address and mitigate impacts associated with the proposed Newcastle Colliery. Mitigation measures have also been developed to address issues in all phases throughout the life of the proposed activities. The detailed mitigation measures are outlined in Section 7 of this report, whilst the general management measures which are considered best practice mitigation applicable to a project of this nature, are outlined in Appendix F.

3 RESULTS OF THE DESKTOP ANALYSIS

3.1 Analyses of Relevant Databases

The following section contains data accessed as part of the desktop assessment and are presented as a “dashboard style” report (Table 1). The dashboard report aims to present concise summaries of the data on as few pages as possible to allow for integration of results by the reader to take place. Where required, further discussion and interpretation is provided.

It is important to note that although all data sources used provide useful and often verifiable, high-quality data, the various databases used do not always provide an entirely accurate indication of the assessed areas actual site characteristics at the scale required to inform the environmental authorisation and/or water use licensing application processes. Nevertheless, this information is considered useful as background information to the study, is important in legislative contextualisation of risk and impact, and was used as a guideline to inform the assessment and to focus on areas and aspects of increased conservation importance. It must, however, be noted that site verification of key areas may potentially contradict the information contained in the relevant databases, in which case the site verified information must carry more weight in the decision-making process. Actual site conditions at the time of the assessment may differ to the background information provided by various datasets. Please refer to Section 4 and Section 5 for details pertaining to the site investigation.

Table 1: Desktop data (from available databases only) relating to the character of the freshwater ecosystems within the investigation area.

Aquatic ecoregion and sub-regions in which the Focus area is located		
Ecoregion	The entire eastern focus area and the eastern portion of the western focus area is situated within the North Eastern Uplands, while the western portion of the western focus area is located within the Eastern Escarpment Mountains.	
Catchment	Tugela	
Quaternary Catchment	V31J	
WMA	Pongola-Mtamvuna	
subWMA	Buffalo	
Dominant characteristics of the and Ecoregion Level 2 (Kleynhans *et al.*, 2007)		
	North Eastern Uplands	Eastern Escarpment Mountains
Ecoregion Level II	14.02	15.04
Dominant primary terrain morphology	Irregular undulating lowlands with hills	Low mountains
Dominant primary vegetation types.	North-eastern Mountain Grassland, Wet Cold Highveld Grassland, Moist Upland Grassland	Moist Cool Highveld Grassland, North-Eastern Mountain Grassland, Natal Central Bushveld, Moist Sandy Highveld Grassland
Altitude (m a.m.s.l)	700 - 1500	1100 – 2100
MAP (mm)	600 - 800	500 – 700
Coefficient of Variation (% of MAP)	20 - 30	<20 – 30
Rainfall concentration index	55 - 65	60 – 65
Rainfall seasonality	**Mid-Summer,** Early Summer	**Mid-Summer,** Early Summer
Mean annual temp (°C)	16 - 18	14 – 18
Winter temperature (July) °C	2 – 22	>10 – 20
Summer temperature (Feb) °C	12 - 28	10 – 26
Median annual simulated runoff (mm)	40 - 210	-

Ecological Status of the most proximal sub-quaternary reach (DWS, 2014)	
Sub-quaternary reach	V31J-02487 (Ncandu)
Point Proximity to Focus area	~ 500 m south east
Assessed by expert?	Yes
PES Category Median	Largely Modified (Class D)
Mean Ecological Importance	High
Mean Ecological Sensitivity	Very High
Default Ecological Class	Very High (Class A)
Stream Order	1

Detail of the Focus area in terms of the National Freshwater Ecosystem Priority Area (NFEPA) (2011)	
RIVER FEPA	The entire focus area and investigation area is indicated to be within a CODE 1 RIVER FEPA Catchment area. River FEPAs achieve biodiversity targets for river ecosystems and threatened fish species and were identified in rivers that are currently in a good condition. Although the FEPA status applies to the actual river reach within the sub-quaternary catchment the surrounding land and smaller stream network needs to be managed in a way that maintain the good condition of the river reach.
NFEPA Wetlands	According to the NFEPA database: ➢ There is one large natural channelled valley bottom wetland (CVB) with associated wetland flats, a natural unchannelled valley bottom wetland (UCVB) associated with a valleyhead seep and wetland flat, and a natural depression located within the eastern focus area and associated investigation area. ➢ A natural CVB, artificial CVB, artificial flat and UCVB is located within the western focus area. ➢ The natural features are considered in a natural or good ecological condition (Class AB), while the artificial features are considered heavily to critically modified (Class Z). ➢ The UCVB, valleyhead seep, wetland flat and depression located within the Eastern focus area as well as the CVB in the western focus area are considered important in terms of threatened crane species such as; wattled cranes (*Bugeranus carunculatus*), grey crowned crane (*Balearica regulorum*) and blue cranes (*Anthropoides paradiseus*). ➢ Furthermore, these wetlands as well as the CVB are classified as FEPA Wetlands and therefore, in terms of the NFEPA Implementation Manual (2011), mining (and/or prospecting) is not considered a compatible land use within a 1km (1000m) radius around a FEPA wetland.
Wetland Vegetation Type	The eastern focus area and a small portion of the western focus area falls within the Sub-Escarpment Grassland Group 4 (Kwa-Zulu Natal Highland Thornveld) considered endangered, and the majority of the western focus area falls within the Sub-Escarpment Grassland Group 3 (Kwa-Zulu Natal Highland Thornveld), considered critically endangered. Both wetland vegetation groups are considered Poorly Protected (EPL) (Mbona *et al*., 2015).
NFEPA Rivers	The NFEPA Rivers Database indicates the Ncandu River approximately 500 m south east of the focus area. The river is indicated by the database as well as the PES 1999 classification to be Largely Natural (B), and is indicated as a FEPA River, therefore a 1 km buffer is also recommended around the river.

National Biodiversity Assessment (2018): South African Inventory of Inland Aquatic Ecosystems (SAIIAE) (National Wetland Map 5 is included in the NBA)
The NBA (2018): SAIIAE indicates that there are several natural wetland features and artificial dams that are located within the focus and investigation areas. The database indicates 2 seep wetlands, 2 unchanneled valley bottom wetlands (UCVB) and numerous dams. The unchanneled valley bottom wetland is indicated to be affected by artificial features, a degraded river system, and roads which results in the wetland considered to be heavily to critically modified (Class D/E/F). The UCVB are currently critically endangered (Ecosystem Threat Status (ETS)), and poorly protected (Ecosystem Protection Level (EPL)). The 2 seep wetlands are considered in a natural or good ecological condition (Class A/B), it is critically endangered (ETS), and currently not protected (EPL). The Ncandu river condition is indicated as Largely Modified (Class D). The ETS of the river is critical (CR), and EPL is indicated as Not Protected (NP).

Importance according to the Mining and Biodiversity Guidelines (2013)	
The majority of the focus area is located within areas identified as being of **Highest Biodiversity Importance**, according to the Mining and Biodiversity Guidelines (2013). Portions of the western focus area and a small portion in the eastern focus area are considered to be of **Moderate Biodiversity Importance.** **Areas of Highest Biodiversity Importance** <u>Risk for mining:</u> Highest risk for mining. <u>Implications for mining:</u> EIA's and their associated specialist studies should focus on confirming the presence and significance of these biodiversity features, and to provide site-specific basis on which to apply the mitigation hierarchy to inform regulatory decision-making for mining, water use licenses, and environmental authorisations. If confirmed, the risk of fatal flaws is high. **Areas of Moderate Biodiversity Importance** <u>Risk for mining:</u> Moderate risk for mining. <u>Implications for mining:</u> EIAs and their associated specialist studies should focus on confirming the presence and significance of these biodiversity features (e.g., threatened species) not included in the existing datasets, and on providing site-specific information to guide the application of the mitigation hierarchy.	**KwaZulu Natal Biodiversity Spatial Planning (2016)** Several portions of the focus area are considered Irreplaceable Critical Biodiversity Areas (CBAs), and the central portion of the focus area is additionally considered an Ecological Support Area (ESA). The ESA is split into three ESA Local Corridors namely: Berg Landscape Local Corridor 5 and 6 and Chelmsford Nature Reserve Local Corridor. Some of these areas have been modified by current and historical agricultural activities dominant within the focus area. The **CBA Irreplaceable areas** are considered critical for meeting biodiversity targets and thresholds, and which are required to ensure the persistence of viable populations of species and the functionality of ecosystems. **ESAs** are considered areas which are functional, but not necessarily entirely natural, areas that are required to ensure the persistence and maintenance of biodiversity patterns and ecological processes within the CBA's. **Berg Landscape Local Corridor 5** connects CBA Irreplaceable terrestrial areas. **Berg Landscape Local Corridor 6** connects CBA Irreplaceable terrestrial and aquatic areas with a macro-corridor. **Chelmsford Nature Reserve Local Corridor** connects CBA Irreplaceable terrestrial and aquatic features with the Chelmsford Nature Reserve.
Strategic Water Source Areas (2017)	**National Web-based Screening Tool (Accessed 2023)**
The majority of the western focus area is located within the Northern Drakensberg SWSA for surface water. **Surface water SWSAs** are defined as areas of land that supply a disproportionate (i.e., relatively large) quantity of mean annual surface water runoff in relation to their size. They include transboundary areas that extend into Lesotho and Swaziland. The sub-national Water Source Areas (WSAs) are not nationally strategic as defined in the report but were included to provide a complete coverage.	The Screening Tool is intended to allow for pre-screening of sensitivities in the landscape to be assessed within the EA process. This assists with implementing the mitigation hierarchy by allowing developers to adjust their proposed development footprint to avoid sensitive areas. The overall aquatic biodiversity sensitivity for the focus area is **very high** due to the focus area being situated within an aquatic CBA (Confirmed with the KZN Spatial Planning), the western focus area located within the Northern Drakensberg SWSA, the presence of wetlands (confirmed by NFEPA and NBA Datasets), and the focus area located within a FEPA catchment.

CBA = Critical Biodiversity Area; CVB = Channelled Valley Bottom Wetland; DWS = Department of Water and Sanitation; EI = Ecological Importance; ES = Ecological Sensitivity; ESA = Ecological Support Area; EPL = Ecosystem Protection Level; ETS = Ecosystem Threat Status; FEPA = Freshwater Ecosystem Priority Area; m.a.m.s.l = Metres above Mean Sea Level; MAP = Mean Annual Precipitation; mm = millimetres; NFEPA = National Freshwater Ecosystem Priority Areas; PES = Present Ecological State; SAIIAE = South African Inventory of Inland Aquatic Ecosystems; SWSA = Strategic Water Source Area; UCVB = Unchannelled Valley Bottom Wetland; WMA = Water Management Area

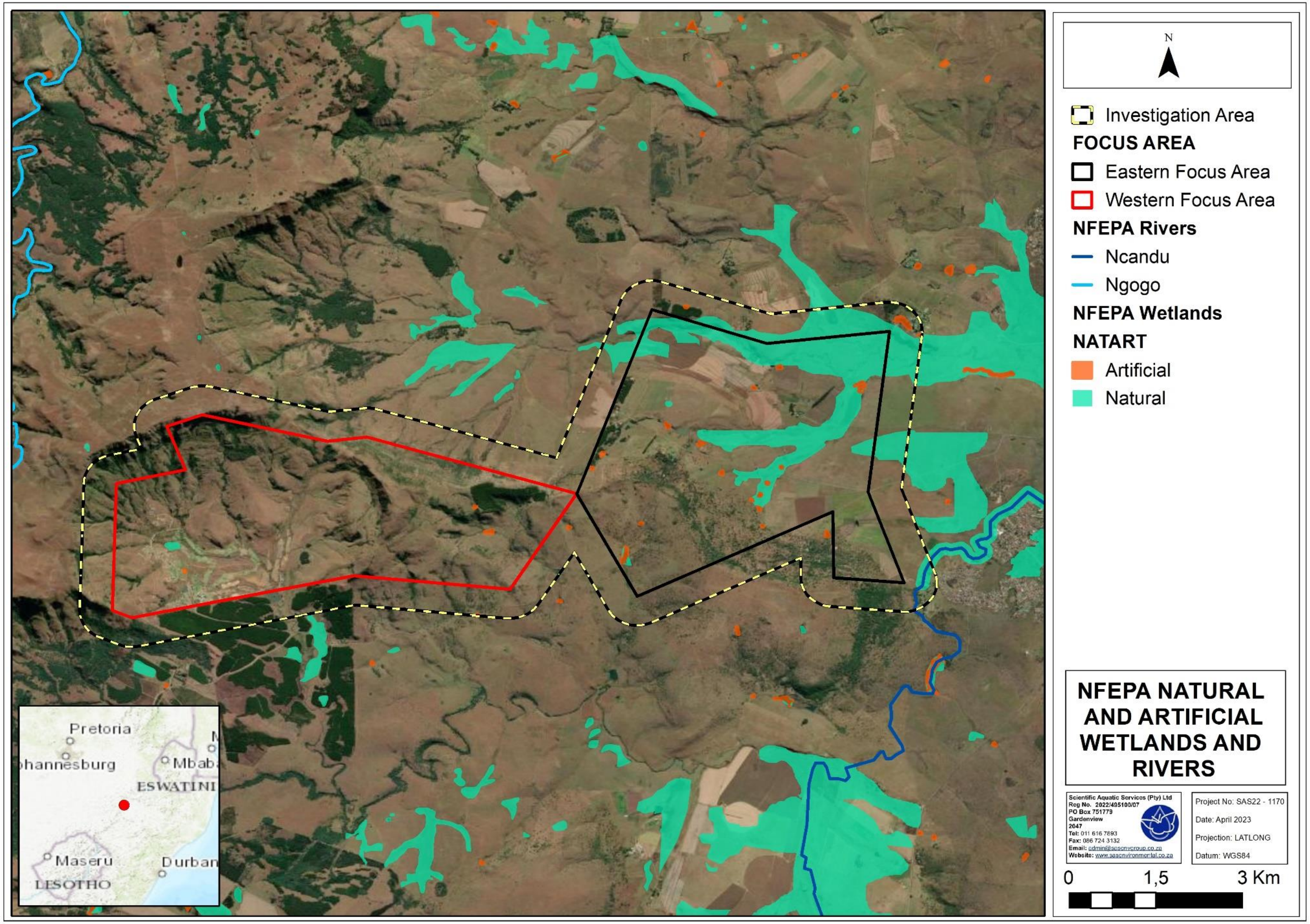


Figure 5: National Freshwater Ecosystem Priority Areas (NFEPA 2011) rivers and wetlands associated with the proposed Newcastle colliery.

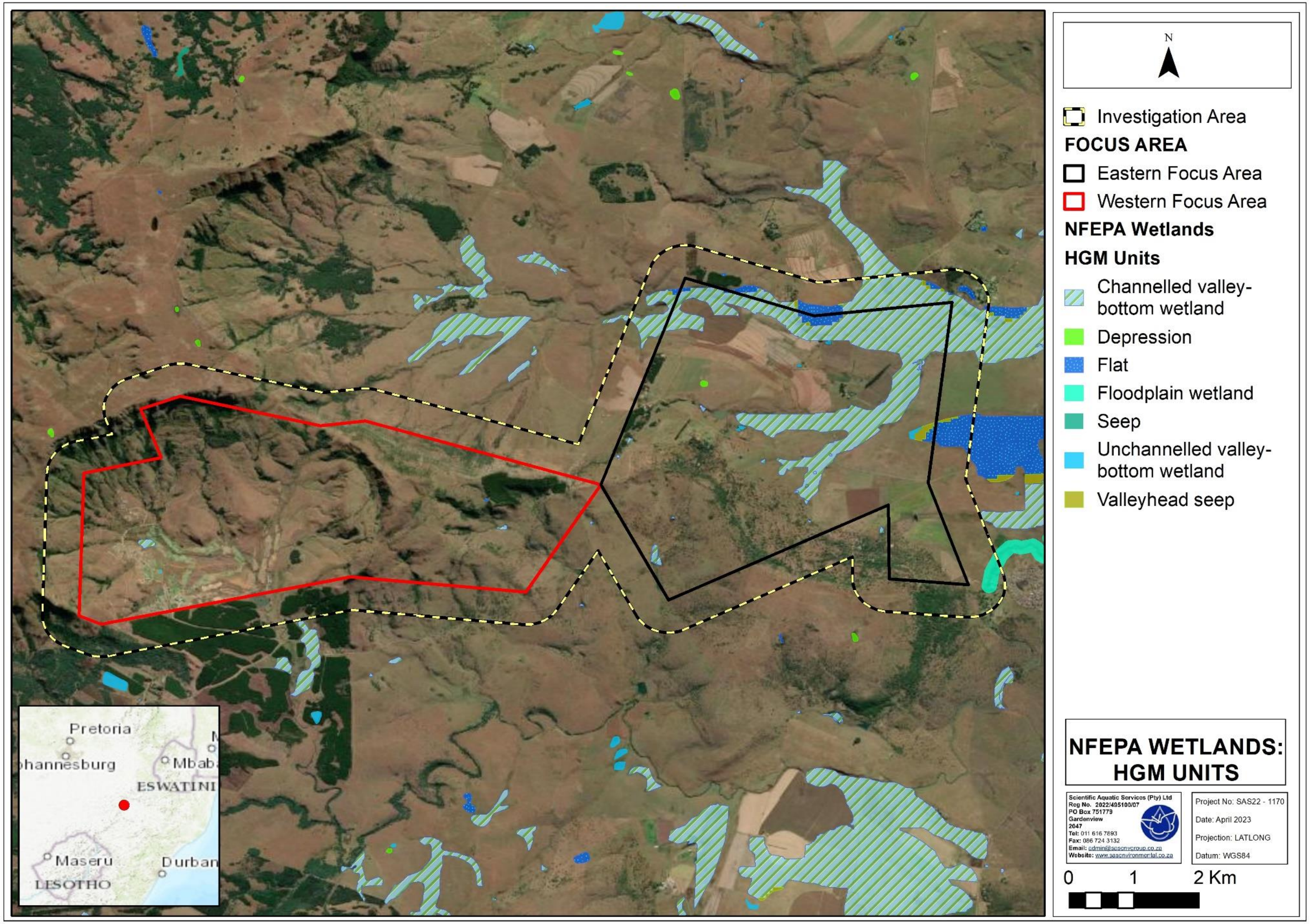


Figure 6: National Freshwater Ecosystem Priority Areas (NFEPA 2011) wetland HGM units associated with the proposed Newcastle colliery.

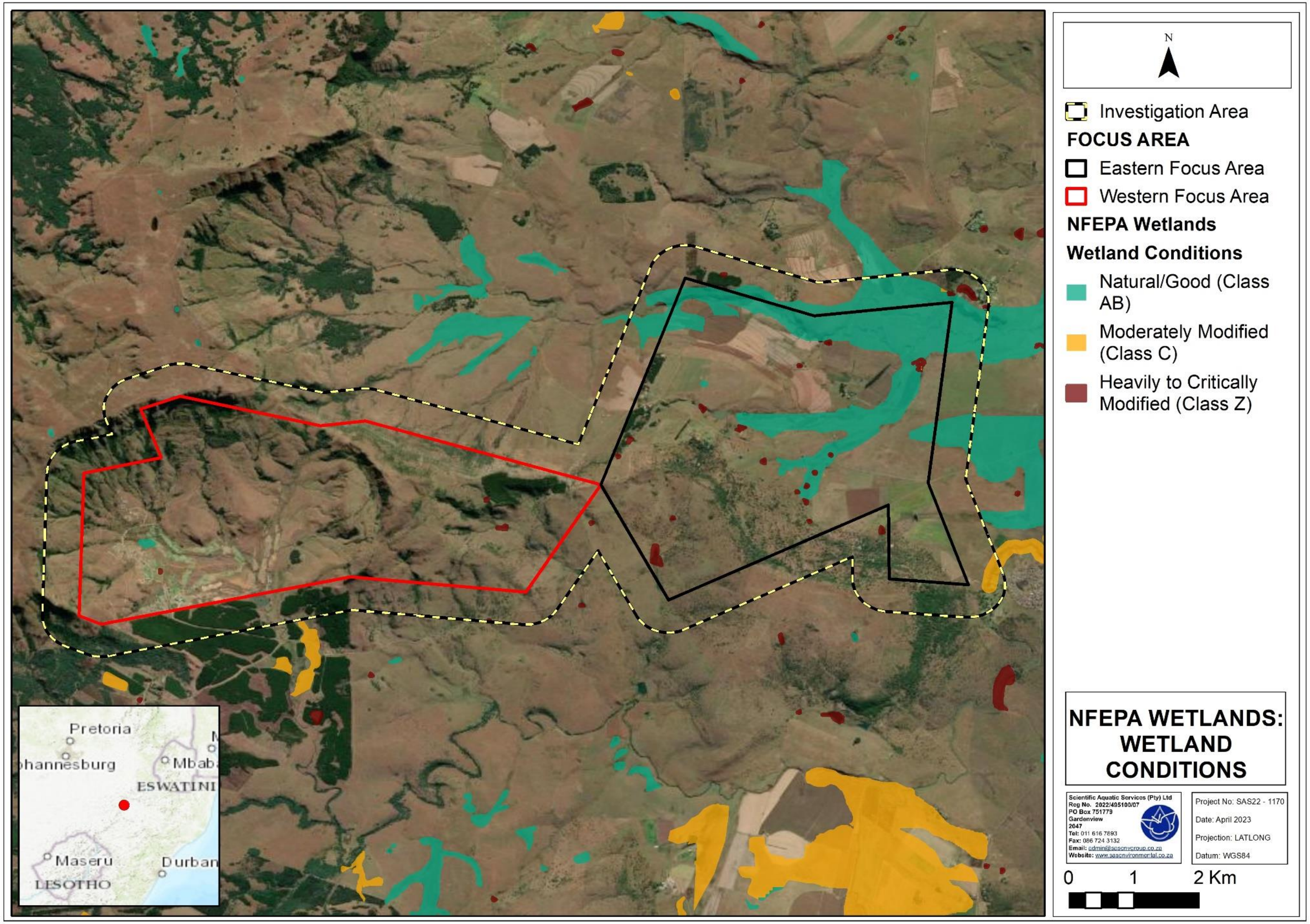


Figure 7: National Freshwater Ecosystem Priority Areas (NFEPA 2011) wetland conditions associated with the proposed Newcastle colliery.

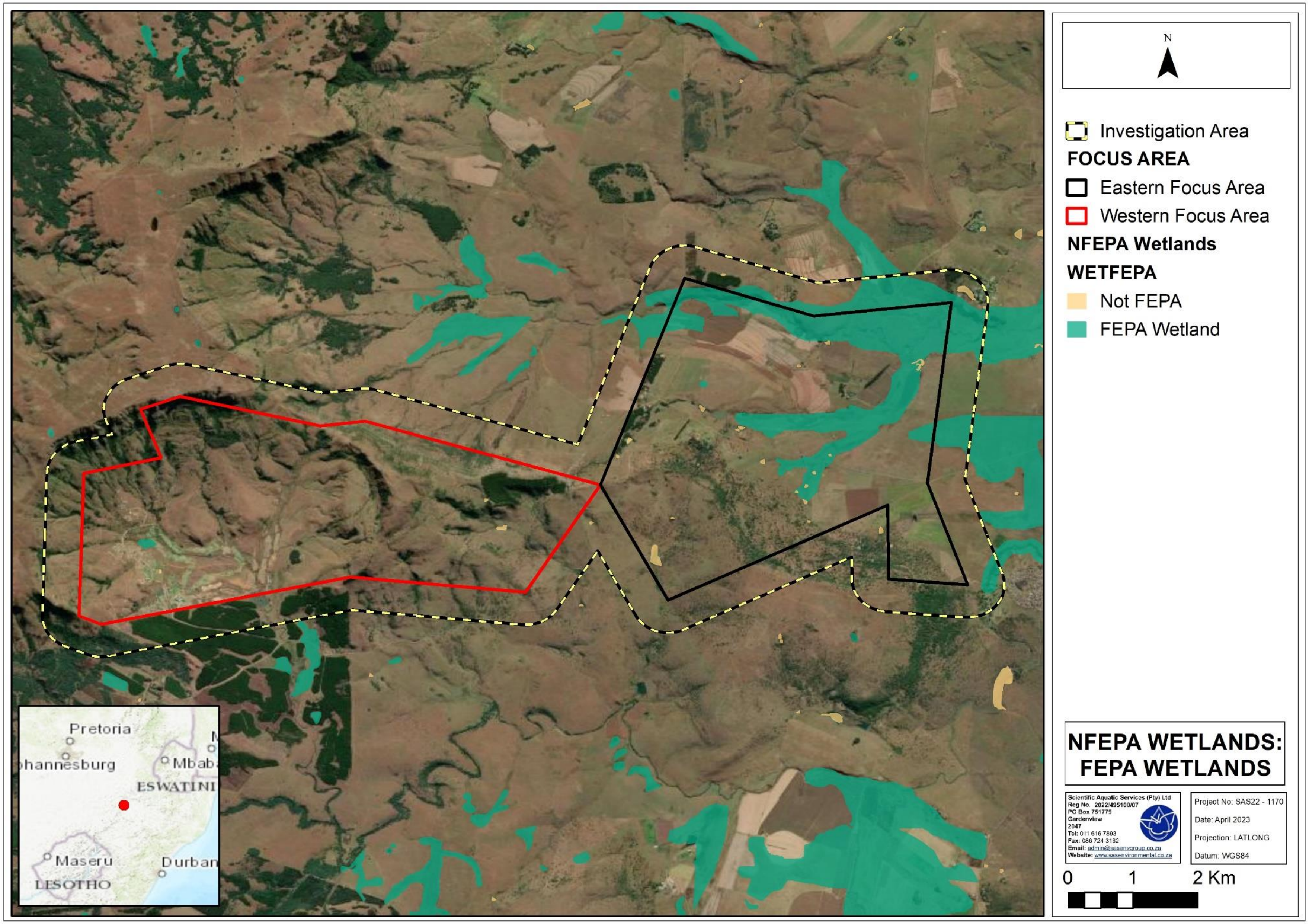


Figure 8: River FEPAs associated with proposed Newcastle colliery according to the Freshwater Ecosystem Priority Areas (NFEPA 2011).

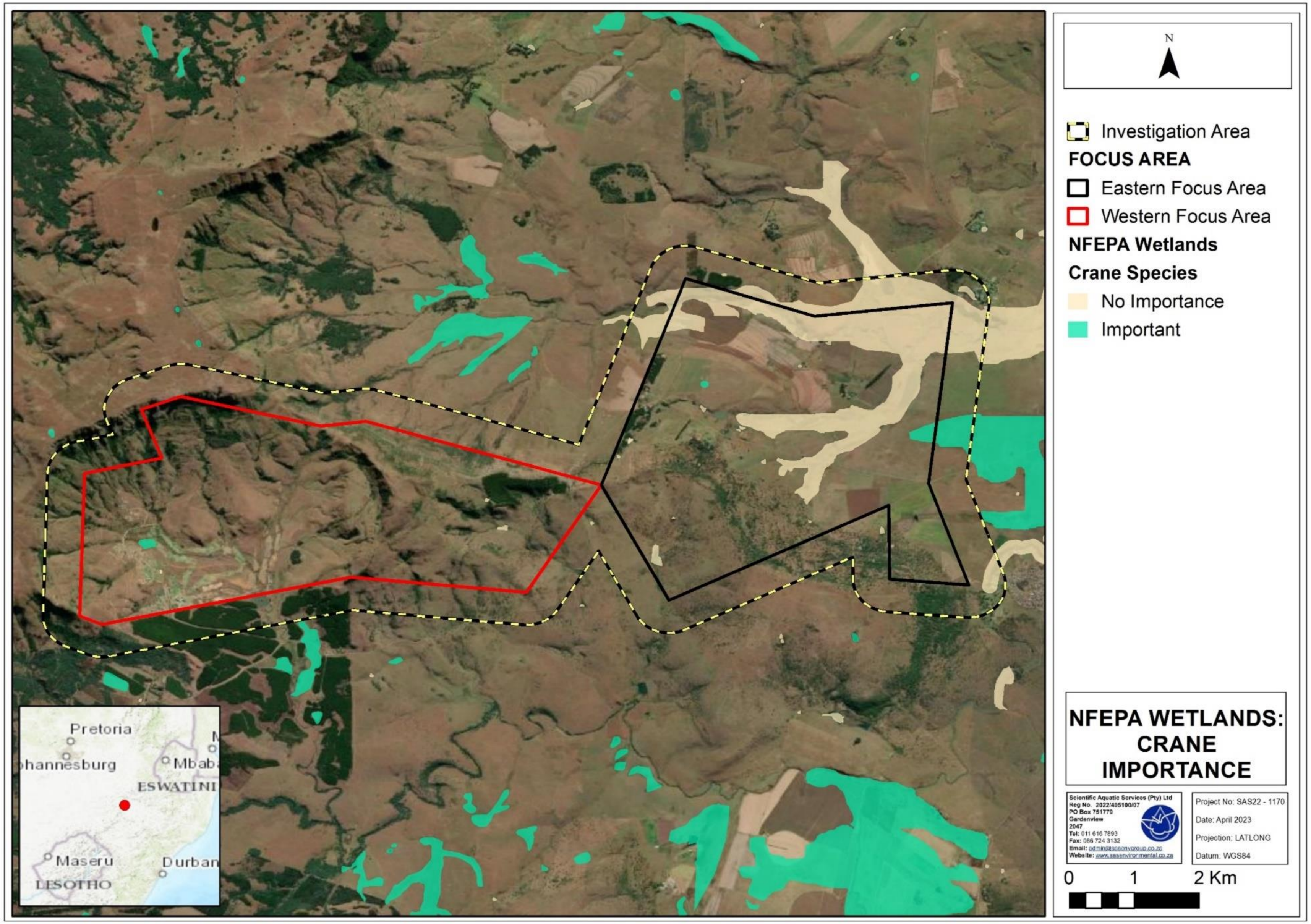


Figure 9: National Freshwater Ecosystem Priority Areas (NFEPA 2011) wetland crane species importance associated with the proposed Newcastle colliery.

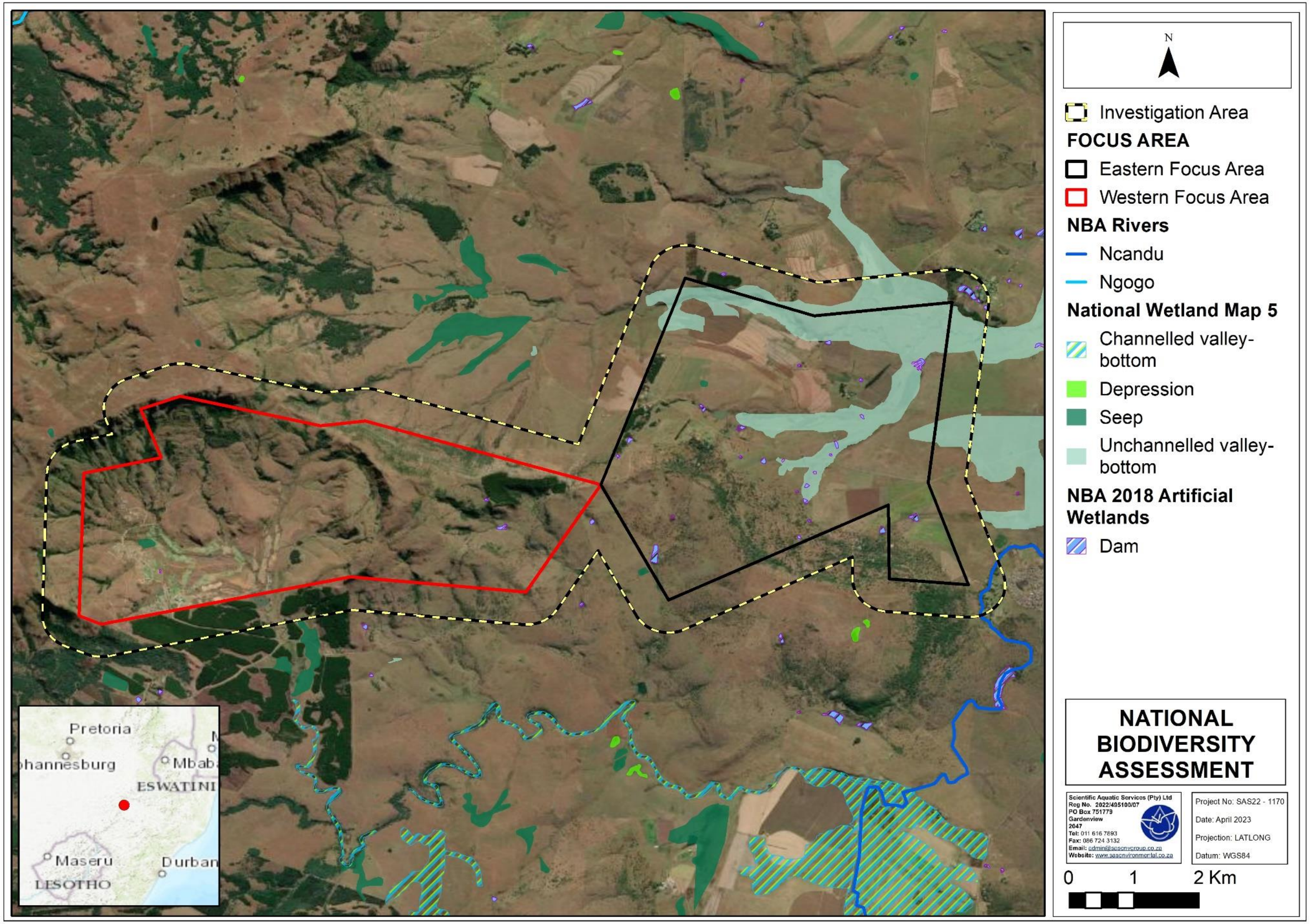


Figure 10: National Biodiversity Assessment (2018) wetlands and rivers associated with the proposed Newcastle colliery.

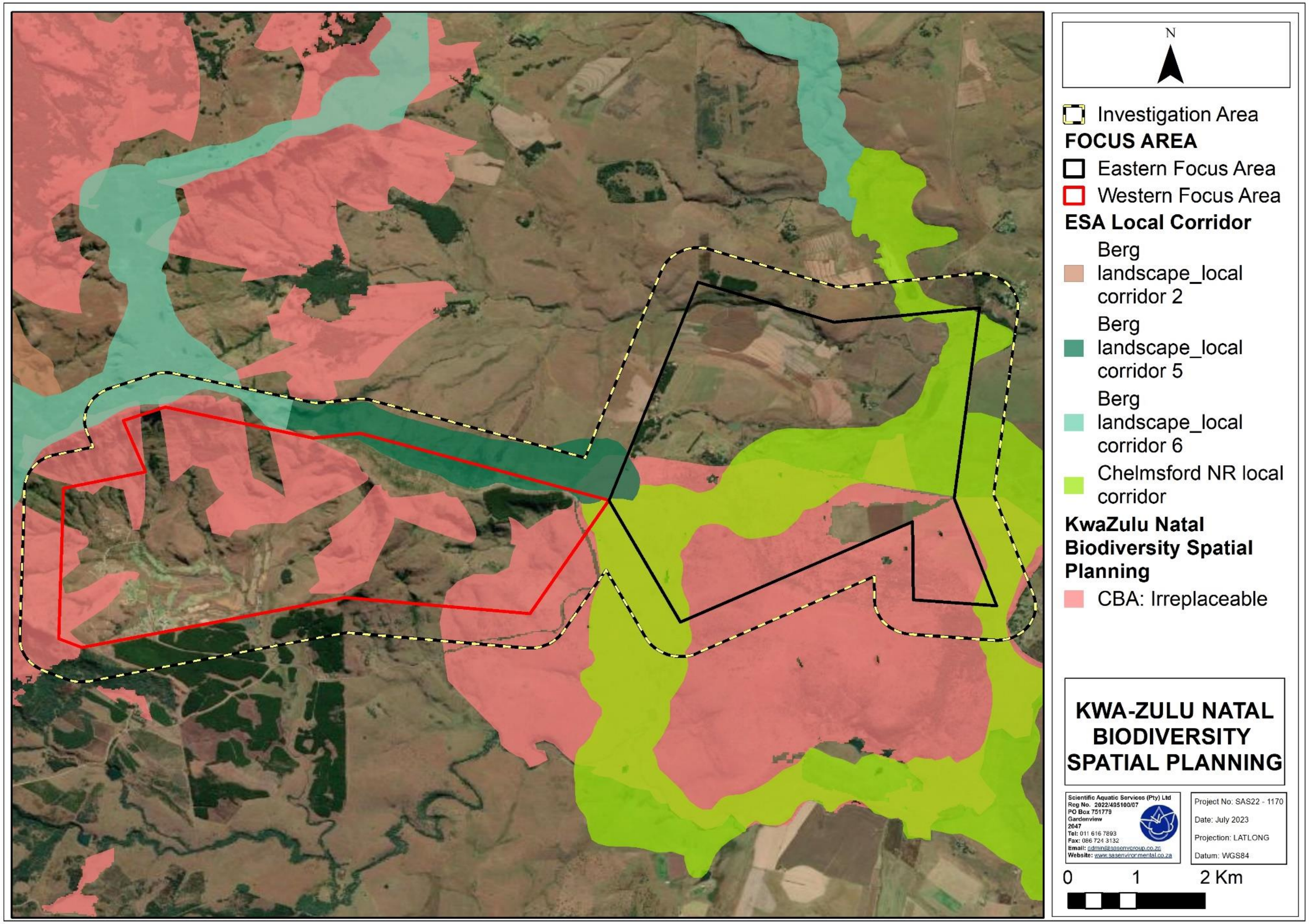


Figure 11: KwaZulu-Natal (KZN) biodiversity spatial planning associated with the proposed Newcastle colliery.

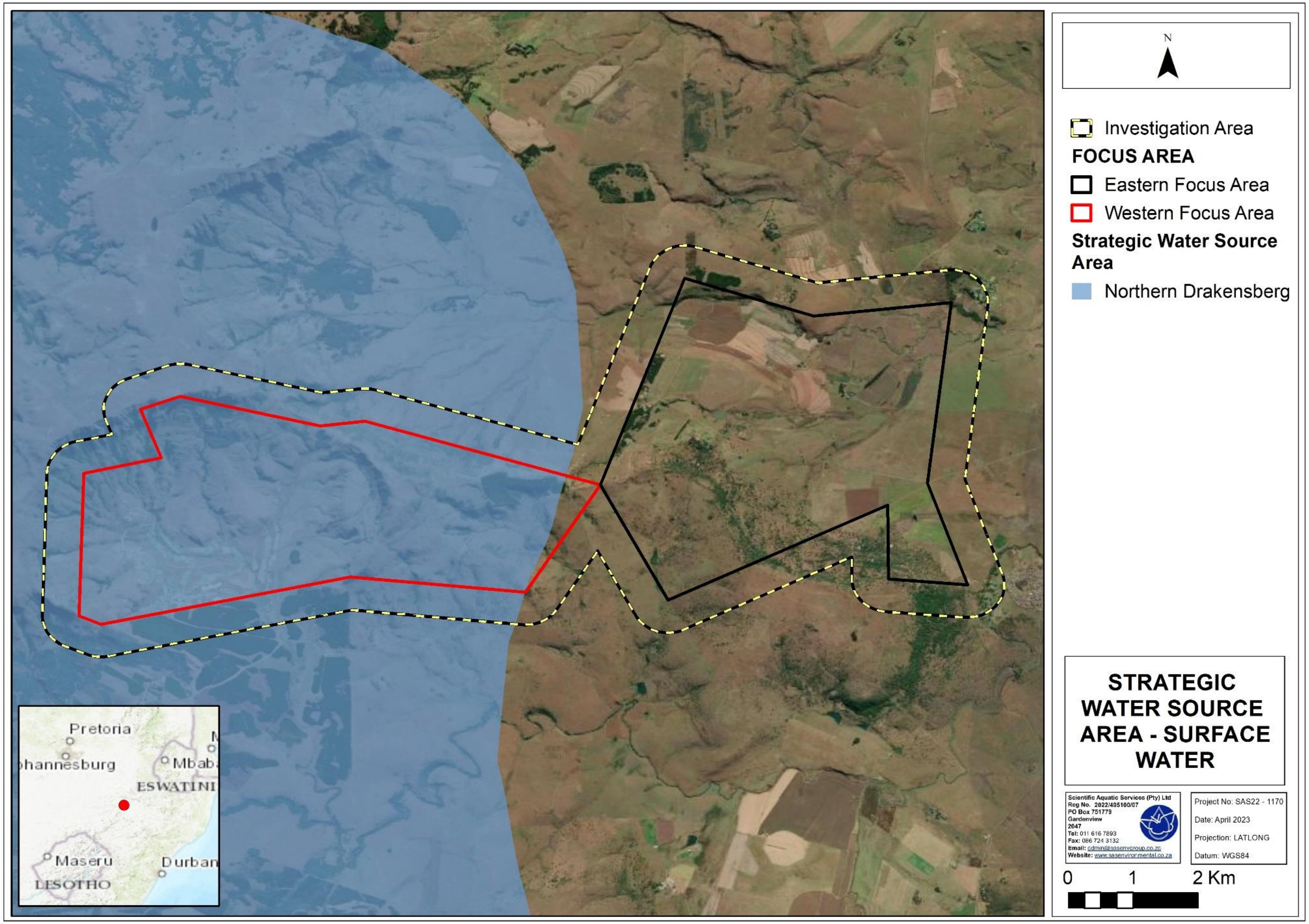


Figure 12: Strategic water source area (surface water) associated with the proposed Newcastle colliery.

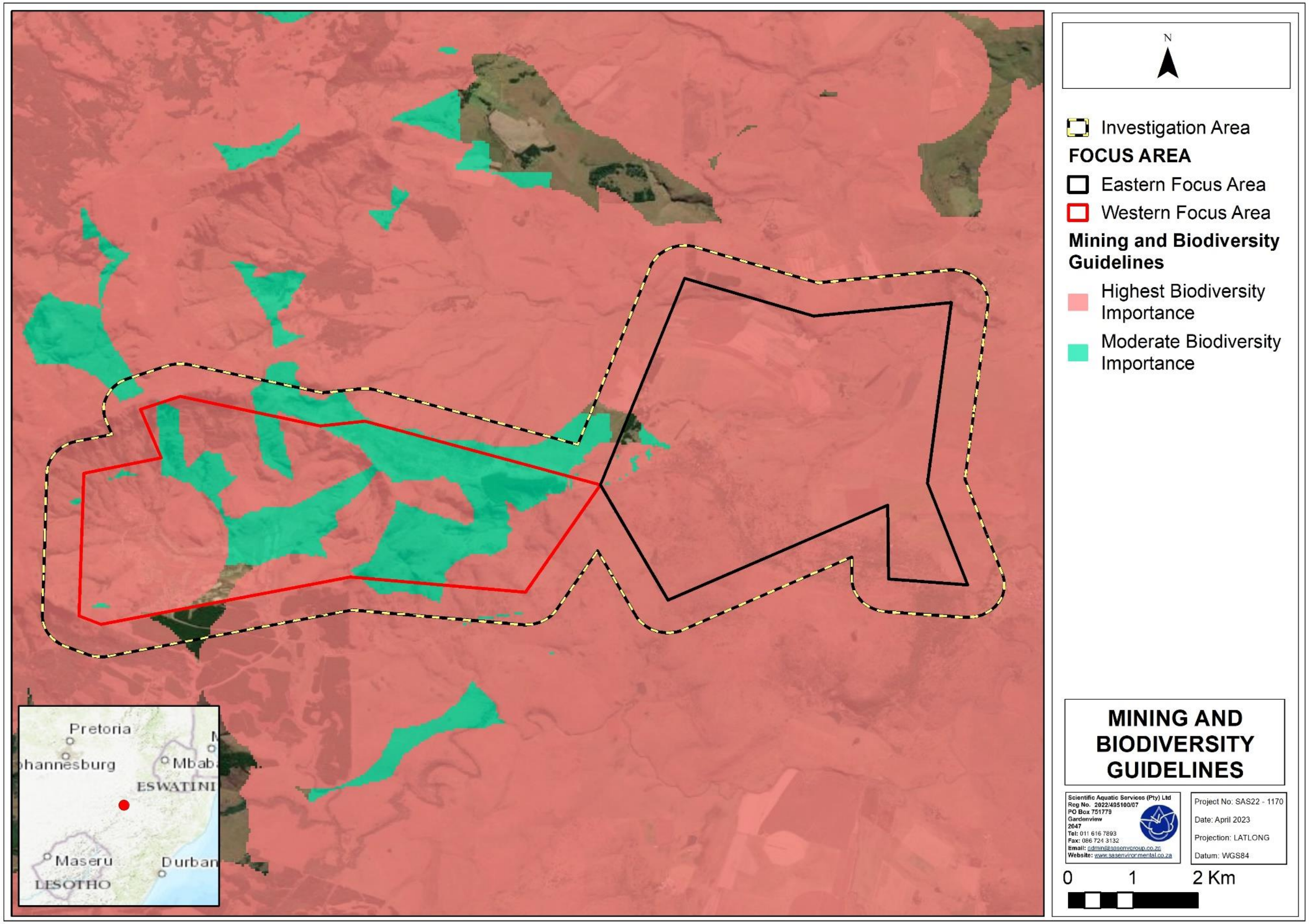


Figure 13: Mining and biodiversity guidelines associated with the proposed Newcastle colliery.

3.2 Ecological status of sub-quaternary catchments [Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES/EIS database]

The PES/EIS database, as developed by the DWS RQIS department, was utilised to obtain additional background information on the project area. The information from this database is based on information at a sub-quaternary catchment reach (SQR) level, with the descriptions of the aquatic ecology based on the information collated by the DWS RQIS department from all reliable sources of reliable information such as SA RHP sites, Ecological Water Requirements (EWR) sites and Hydro Water Management Systems (WMS) sites. The entire eastern focus area and the eastern portion of the western focus area is situated within the North-Eastern Uplands, while the western portion of the western focus area is located within the Eastern Escarpment Mountains. Both reaches of the Ncandu River (V31J-02487) fall within the North-Eastern Uplands Ecoregion.

According to the PES/EIS database as developed by the DWS RQIS department, the following fish species (Table 2) and macro-invertebrate taxa (Table 3) have previously been reported or expected from Sub-Quaternary Catchment Reach (SQR) V31J-02487. Table 4 provides a summary of the ecological states of the SQRs.

Table 2: Fish species previously collected from or expected in the Ncandu River (V31J-02487).

Fish species	V31J-02487 (Ncandu River)
Amphilius uranoscopus	✓
Chiloglanis pretoriae	✓
Clarias gariepinus	✓
Enteromius motebensis	✓
Enteromius neefi	✓
Enteromius trimaculatus	✓
Enteromius unitaeniatus	✓
Labeo cylindricus	✓
Labeobarbus marequensis	✓
Pseudocrenilabrus philander	✓
Tilapia sparrmanii	✓

Table 3: Invertebrates previously collected from or expected at the SQR Ncandu River (V31J-02487).

- Aeshnidae
- Ancylidae
- Athericidae
- Atyidae
- Baetidae 2 Sp
- Belostomatidae
- Bulininae
- Caenidae
- Calopterygidae
- Ceratopogonidae
- Chironomidae
- Empididae
- Gerridae
- Gomphidae
- Gyrinidae
- Haliplidae
- Helodidae
- Heptageniidae
- Hirudinea
- Hydracarina
- Hydraenidae
- Hydrobiidae
- Nepidae
- Notonectidae
- Oligochaeta
- Oligoneuridae
- Perlidae
- Physidae
- Planorbinae
- Pleidae
- Polycentropodidae
- Potamonautidae
- Prosopistomatidae

- Chlorocyphidae
- Coelenterata
- Coenagrionidae \
- Corduliidae
- Corixidae
- Corydalidae
- Crambidae (Pyralidae)
- Culicidae
- Dytiscidae
- Ecnomidae
- Elmidae/Dryopidae
- Hydrometridae
- Hydrophilidae
- Hydropsychidae 2 Sp
- Hydroptilidae
- Leptoceridae
- Leptophlebiidae
- Lestidae
- Libellulidae
- Lymnaeidae
- Muscidae
- Naucoridae
- Psephenidae
- Simuliidae
- Sphaeriidae
- Chlorolestidae
- Tabanidae
- Tipulidae
- Tricorythidae
- Turbellaria
- Veliidae/Mesoveliidae

Table 4: Summary of the ecological status of the sub-quaternary catchment (SQ) reach associated with the freshwater ecosystems in proximity of the focus area based on the DWS RQS PES/EIS database.

Ecological status	V31J-02487 (Ncandu River)
Synopsis	
PES Category Median	Largely Natural (Class B)
Mean EI[5] class	High
Mean ES[6] class	Very High
Length	18.71
Stream order	1
Default EC[7]	Very High (Class A)
PES[8] Details	
Instream habitat continuity MOD[9]	Small
RIP/wetland zone continuity MOD	Small
Potential instream habitat MOD activities	Moderate
Riparian/wetland zone MOD	Small
Potential flow MOD activities	Moderate
Potential physico-chemical MOD activities	Small
EI Details	
Fish spp/SQ	7.00
Fish average confidence	4.71
Fish representivity per secondary class	Low
Fish rarity per secondary class	Moderate
Invertebrate taxa/SQ	51.00
Invertebrate average confidence	3.94
Invertebrate representivity per secondary class	Very High
Invertebrate rarity per secondary class	Very High
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating	High
Habitat diversity class	High
Habitat size (length) class	Low
Instream migration link class	Very High
Riparian-wetland zone migration link	Very High
Riparian-wetland zone habitat integrity class	Very High
Instream habitat integrity class	High
Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m	Very High
Riparian-wetland natural vegetation rating based on expert rating	Low
ES Details	
Fish physical-chemical sensitivity description	Very High
Fish no-flow sensitivity	Very High
Invertebrates physical-chemical sensitivity description	Very High

[5] EI = Ecological Importance
[6] ES = Ecological Sensitivity
[7] EC = Ecological Category; default based on median PES and highest of EI or ES means
[8] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors
[9] MOD = Modification

Ecological status	V31J-02487 (Ncandu River)
Invertebrates velocity sensitivity	Very High
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description	High
Stream size sensitivity to modified flow/water level changes description	Very High
Riparian-wetland vegetation intolerance to water level changes description	Low

3.3 Ecological Specifications

Proposed water resource classes and resource quality objectives (RQO) for Thukela catchments in the Pongola-Mtamvuna Water Management Area (WMA), Department of Water and Sanitation (DWS 2022). This publication provided updated classes and resource quality objectives of water resources for the Thukela catchment. The reserve for V31J applies (See Table 5). As all of the assessment points are located on tributaries of the Ncandu River, only the RQO for the Ncandu River is summarised in Table 6 overleaf.

Table 5: Summary of Water Resource Classes per Integrated Unit of Analysis and Ecological Categories – Thukela catchments (DWS, 2022)

Node Name	Quaternary Catchment	River Name	Ecological Category to Maintain	Mean Annual Runoff (MAR) (million m^3/annum)	EWR as % of natural MAR
THU_EWR19	**V31J**	**Ncandu**	**B/C**	**50.83**	**29.36%**

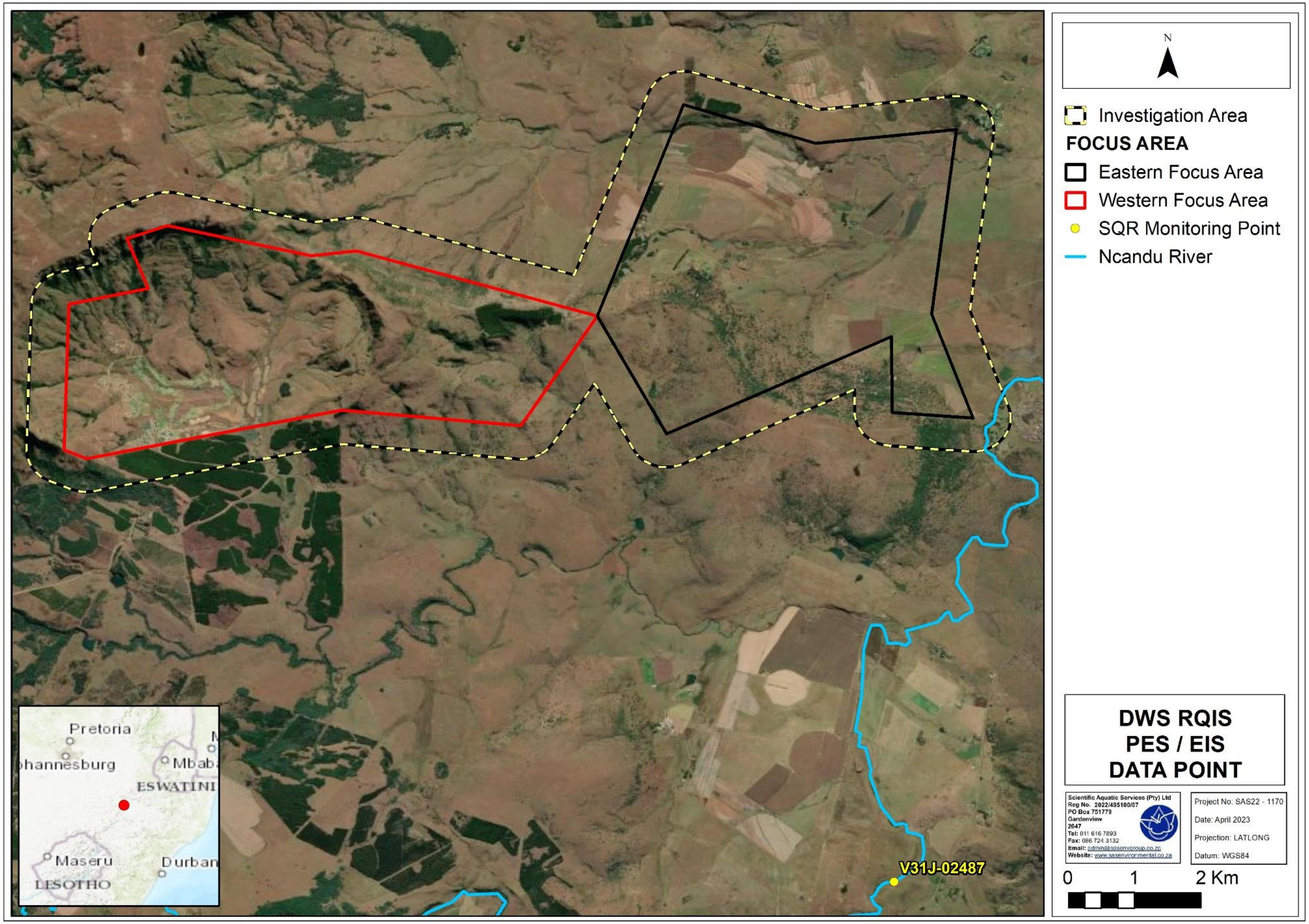


Figure 14: The DWS RQIS data points associated with the proposed Newcastle colliery.

Table 6: Summary of the relevant classes and resource quality objectives (DWS, 2022):

River	Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure		
Ncandu to confluence with Ngagane **V31H, V31J** **(EWR 19)**	**2.4**	Quantity	Low flows	EWR maintenance low and drought flows: Ncandu River at the EWR site THU_EWR19 (-27.8017, 29.8840) in V31J NMAR = 50.83 x10^6m^3 TEC=B/C category The maintenance low flows and drought flows must be attained to support the upstream and downstream aquatic ecosystem of the Ncandu River.	Maintenance and drought flows required for the Ncandu River		Maintenance Low flows (m^3/s)	Drought Low flows (m^3/s)
						Oct	0.151	0.023
						Nov	0.238	0.02
						Dec	0.327	0.02
						Jan	0.488	0.128
						Feb	0.651	0.170
						Mar	0.529	0.139
						Apr	0.373	0.099
						May	0.208	0.057
						Jun	0.120	0.034
						Jul	0.091	0.027
						Aug	0.087	0.026
						Sep	0.105	0.029
		Quality	Nutrients	Nutrient levels must be improved to sustain the aquatic ecosystem health and to meet the ecological state	Orthophosphate (PO_4^-) as Phosphorus	≤0.05 mg/L (50th percentile)		
					Total Inorganic Nitrogen (TIN$^-$) as Nitrogen	≤1 mg/L (50th percentile)		
			Salts	Instream salinity must be maintained or improved upon to support the aquatic ecosystem and the water quality requirements of the water users	Total Dissolved Solids	≤350 mg/L (95th percentile)		
				In-stream quality must be maintained	Sulphate	≤ 165mg/L (95th percentile)		
				In-stream quality must be maintained	Chloride	≤ 120mg/L (95th percentile)		
			System variables	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)		
			Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health.	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)		
					Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)		
					Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)		
					Cadmium (Cd)	≤ 0.0012 milligrams/litre (mg/l) (95th percentile)		
					Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)		
					Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)		

River	Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
					Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)
					Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)
					Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)
					Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)
					Atrazine	≤0.078 milligrams/litre (mg/l)
					Mancozeb	≤0.009 milligrams/litre (mg/l)
					Glyphosate	≤0.7 milligrams/litre (mg/l)
					Benzene	≤0.01 milligrams/litre (mg/l) (95th percentile)
					Toluene	≤0.7 milligrams/litre (mg/l) (95th percentile)
					Oil and grease	2.5 mg/l
			Pathogens	The presence of pathogens should not pose a risk to human health	*Escherichia coli*	≤130 Colony forming counts per 100 mL (95th percentile)
		Habitat	Instream	Natural flow pattern must be maintained in B Ecological Category. Alien invasive controls must be implemented, maintained and/ improved.	Index of Habitat Integrity (IHI and IHAS)	Instream Habitat Integrity (class B) Ecological Category (80 – 90%) Riparian Integrity - Class ≥B Ecological Category (80 – 90%) IHAS to be *good* habitat availability (>65%)
			Riparian habitat	The riparian vegetation must be maintained at VEGRAI ≥ C Ecological Category. Alien invasive controls must be implemented, maintained and/ improved.	Vegetation Response Assessment Index (VEGRAI)	VEGRAI survey every 5 years. VEGRAI ≥C Ecological Category (>60%)
		Biota	Fish	Flow and water quality sensitive Fish species to be maintained or improved to a PES B/C ecological category.	Fish Response Assessment Index (FRAI). *Amphilius natalensis* (ANAT) *Anguilla mossambica* (AMOS) *Labeo rubromaculatus* (LRUB) *Barbus (Enteromius) paludinosus* (BPAU) *Labeobarbus natalensis* (BNAT) *Barbus (Enteromius) viviparus* (BVIV)	During survey in all flow habitat classes all species present. BVIV, BNAT, BPAU – habitat indicators; and ANAT ≥ 5 individuals per species FRAI EC: B/C (70 - 89%)
			Aquatic invertebrates	Flow and water quality sensitive macroinvertebrate assemblages to be maintained.	Macroinvertebrate Response Assessment Index (MIRAI)	3 biotopes sampled; assemblages to be ≥ B abundances;

River	Resource Unit	Component	Sub-component	RQO	Indicator	Numerical Limit/ measure
				Macroinvertebrate assemblages must be maintained within a B/C ecological category or improved upon.	and South African Scoring System Version 5 (SASS5) Baetidae >2 spp Heptageniidae Leptophlebiidae Tricorythidae Leptoceridae Perlidae Hydropsychidae >1spp Elmidae Psephenidae Dixidae	SASS 5 scores: ≥190 ASPT score: ≥6.0 MIRAI EC: B/C (70 – 89%)
			Diatoms	Ecological water quality should be maintained as *good quality*	Specific Pollution Sensitivity Index (SPI) Percentage pollution tolerant values (%PTV)	SPI: 15 - 17 PTV: < 20%

4 RESULTS: FRESHWATER ECOSYSTEM ASSESSMENT

4.1 Freshwater Ecosystem Characterisation

In preparation for the field assessment, aerial photographs, digital satellite imagery and provincial and national wetland databases (as outlined in Section 2 of this report) were used to identify areas of interest at a desktop level. All possible measures were undertaken to ensure all freshwater ecosystems which may be affected by the proposed Newcastle colliery were identified, delineated and assessed.

During the assessment, the following freshwater ecosystems were identified to potentially be at risk from the proposed Newcastle colliery and therefore assessed further as part of this study. These were classified as follows:

Riverine Systems:

- The Inguduma River which flows in a south easterly direction was identified within the north-eastern corner of the focus area. The Inguduma River flows in a south-easterly direction and confluences with the Ncandu River approximately 8 km downstream;
- The Icawa River which flows in an easterly direction and confluences with the Inguduma River was identified north of the eastern focus area;
- Unnamed tributaries of the rivers in the focus area were identified and assessed as part of the field assessment; and
- The Ncandu River was also identified outside of the focus area but within the investigation area associated with the proposed Newcastle colliery.

Wetlands:

- Various wetlands were identified within the focus area of the proposed Newcastle colliery, these include: unchannelled valley bottom (UCVB), channelled valley bottom (CVB) and seep wetlands.

The freshwater ecosystems were classified according to the Classification System (Ollis *et al*., 2013) as Inland Systems, falling within the Natal Eastern Uplands Ecoregion. The dominant wetland vegetation group associated with the western portion of the focus area is the Sub-Eastern Escarpment Grassland Group 3, while the eastern portion is dominated by Sub-Eastern Escarpment Grassland Group 4, these wetland vegetation groups are considered Critical (CR) and Endangered (EN) respectively according to Mbona *et al.* (2015). At Levels 3 (Landscape Unit) and 4 (HGM Type) of the Classification System, the systems were classified as per the summary in Table 7.

Table 7: Characterisation of the freshwater ecosystems associated with proposed Newcastle colliery according to the Classification System (Ollis *et. al*., 2013).

Freshwater Ecosystem	Level 3: Landscape unit	Level 4: HGM Type
Inguduma River, Icawa River, unnamed tributaries thereof and Ncandu River.	**Valley floor:** The base of a valley, situated between two distinct valley side-slopes.	**River**: A linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit.
Seep Wetland	**Slope:** An inclined stretch of ground typically located on the side of a mountain, hill or valley, not forming part of a valley floor. Includes scarp slopes, mid-slopes and foot-slopes.	**Seep**: A wetland located on gently to steeply sloping land and dominated by colluvial (i.e gravity-driven), unidirectional movement of water and material down-slope.
Channelled valley bottom	**Valley floor:** The base of a valley, situated between two distinct valley side-slopes.	**Channelled valley bottom:** A valley bottom wetland with a river channel running through it.
Unchannelled Valley Bottom Wetland	**Valley floor:** The base of a valley, situated between two distinct valley side-slopes.	**Unchannelled valley bottom:** A valley bottom wetland without a river channel running through it.

4.2 Freshwater Ecosystem Delineation

As noted in Section 2.1, the freshwater ecosystems associated with investigation area were initially delineated using desktop methods (use of aerial photographs, digital satellite imagery and topographical maps), and refined in the field by ground-truthing the desktop delineation at certain pre-selected points. The delineations as presented in this report are thus regarded as a best estimate of the freshwater habitat boundaries based on the site conditions present at the time of assessment.

The following indicators were used to delineate the boundaries of the temporary zones associated with the identified rivers and wetlands:

- Terrain units were used as the primary indicator. Despite transformation of the landscape associated with the investigation area, the terrain provided an indication of low-lying areas where water is likely to collect and/or move through the landscape and areas in the landscape where freshwater ecosystems could potentially be expected to occur;
- Vegetation was utilised in conjunction with terrain as the secondary indicator, where feasible. Due to the transformation in some areas particularly around the cultivated/historically cultivated areas, the vegetation indicator was not always reliable;
- The soil wetness indicator, duration and frequency of saturation in the soil profile provides a diagnostic indicator since it influences the colour change in the soil. Low chroma (grey and muted colours) as well as mottles are more prominent in soil which is associated with fluctuating water table. Due to the current and historical activities

within the focus area, it is likely that the soil wetness indicator has been impacted due to presence of dewatering boreholes within the site which are used in order to increase available footprint areas for cultivation; and

- Similarly, the soil morphological characteristic indicator was also utilised especially in areas where no significant disturbance of soil has taken place. In unimpacted sites, the soil morphological characteristics typically associated with wetland conditions display gleying or mottling.

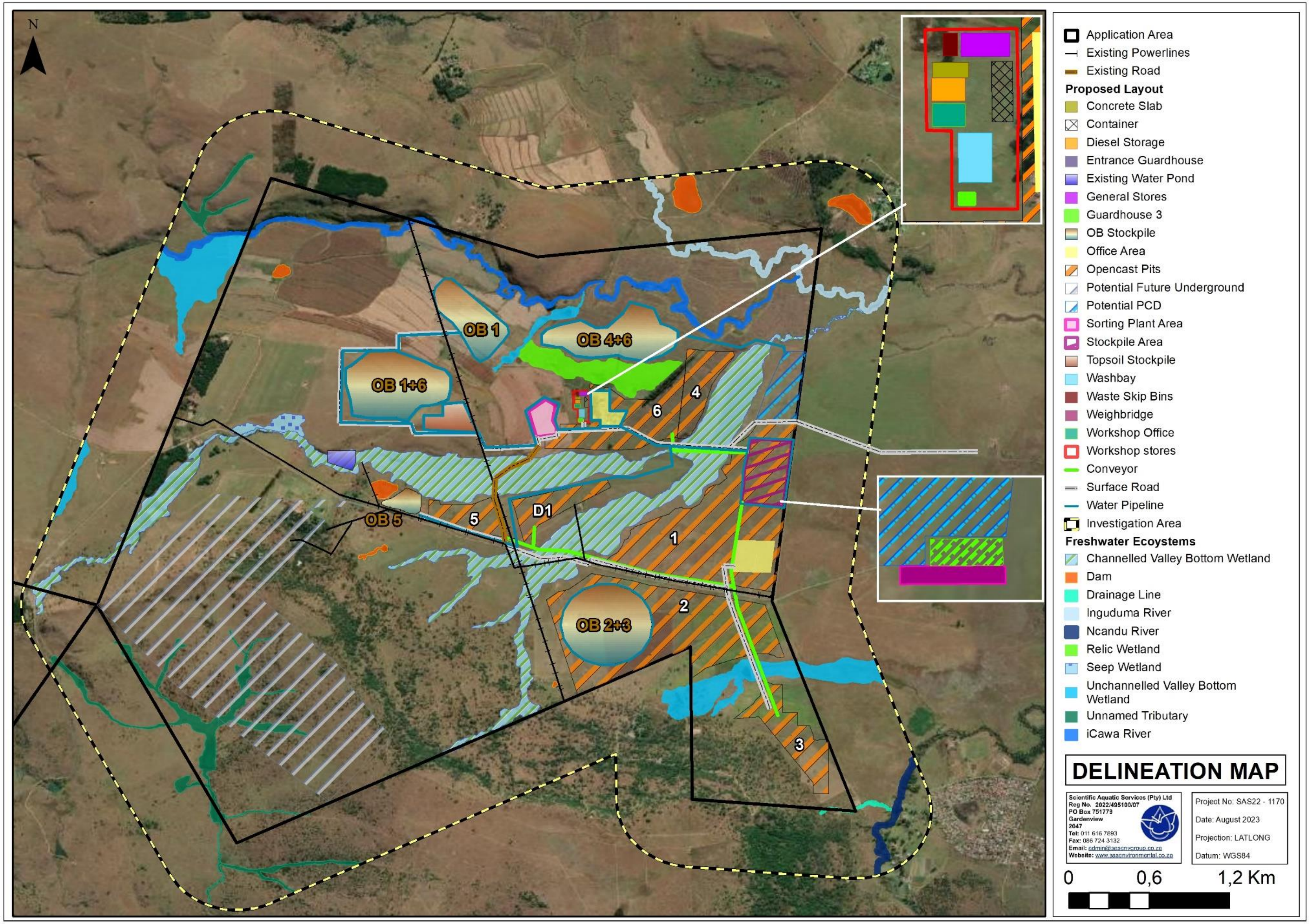


Figure 15: The location of the delineated freshwater ecosystems associated with proposed Newcastle colliery.

4.3 Analyses of Historical Aerial Imagery

Aerial photographs associated with the project were obtained from the Department of Rural Development and Land Reform's (DRDLR) National Geo-spatial Information database (http://cdngiportal.co.za/cdngiportal/) to further aid in the identification and delineation of the various features identified during the site assessment. In addition, historical aerial photography and digital satellite imagery are considered useful tools in showing how land has been transformed due to anthropogenic activities within a landscape.

The historical images overleaf indicate the broader landscape and general surroundings of freshwater systems associated with the project. The historical images indicate dominant land use within the landscape (dryland cultivation) which date back to 1935 (earliest image available). These activities have contributed to increase in loss of vegetation, changes in timing, flow and pattern of water in the landscape and increase in the sedimentation of the freshwater habitat in the area particularly during periods of rainfall.

Figure 16: Time-series historical images of the landscape associated with the proposed Newcastle Colliery (1935 – 2023) indicating presence of cultivation activities dating back as early as 1935 (earliest available historical image).

4.4 Field Verification Results

Following the site visit, various assessments were undertaken to determine the PES, EIS, and ecological service provision of the freshwater ecosystems as well as to assign an appropriate REC, RMO and BAS as described in Section 1.2 of this report. The findings are presented (Table 8 - 13) in the form of 'dashboard style' reports.

Due to the similar characteristics of the various HGM units (CVB/UCVB wetlands) and having been subjected to similar anthropogenic impacts (cultivation, cattle trampling and instream impoundments), the ecoservice provision, hydrological regime, geomorphological characteristics, water quality and habitat of these systems were assessed in a combined fashion.

Since the field assessment focused on the Eastern portion of the larger focus area and the Western portion was only assessed using desk based methods, the field verification results presented below are only from the eastern portion.

Relic wetlands are defined as wet agricultural lands which have been drained in the past for agricultural purposes and often currently found to be lacking any vegetation response that is typically associated with wetlands. Despite this, the relic systems are still found to be saturated at and near the surface and considered to be important in terms of hydropedological drivers (i.e., interflow soil) in the landscape supporting the functional wetland areas. Various drains and artificial channels were identified within the relic wetlands (Figure 17). Although the relic systems were assessed to lack any significant vegetation response that is typically associated with wetlands and therefore does not at present provide the ecological functions typically associated with wetlands, the driver of the wetlands (interflow soil) were still considered largely present.

Figure 17: Representative photograph of the relic wetland within the focus area associated with the Newcastle colliery.

Table 8: Summary of the assessment of the iCawa River which flows in an easterly direction of the eastern focus area.

Ecological & socio-cultural service provision graph:

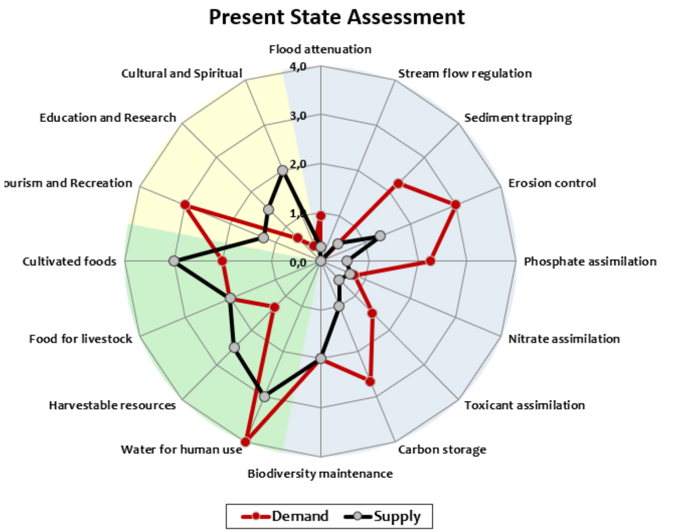


Figure A: Representative photographs of the iCawa River which flows in an easterly direction through the investigation area.

IHI Discussion	**PES Category: Instream IHI PES Category B/C** **Riparian IHI PES Category C** The assessed reach of the iCawa River remains in a largely unmodified ecological condition with only few modifiers present within the system. Observable impacts include adjacent cultivation activities which have potentially resulted in modification of the vegetation community, sedimentation of the river due to soil disturbances from adjacent areas and potential seepage of fertilizers from upgradient cultivated areas, although this is considered limited given the ideal water quality condition measured during the field assessment.	**Ecoservice provision**	**Ecoservices category: Moderate** Ecological services provided by the iCawa River include flood attenuation, streamflow regulation, assimilation of excess nutrients and toxicants, and sediment trapping. These functions are considered particularly important in the context of increased development within the river's catchment, especially downstream of the assessed reach. Such ecological services will provide indirect benefits to downstream users and as such, should be maintained as much as feasible.
EIS discussion	**EIS Category: High** The iCawa River is considered of high ecological importance due to the relative ecological intactness of the system and connectivity to surrounding natural areas, thus increasing the likelihood of the occurrence of threatened floral and faunal species. Additionally, the system provides important hydraulic functions, such as flood attenuation and sediment trapping.	**REC, RMO & BAS Category**	**Recommended Ecological condition: B** **Best Attainable State: B** **Recommended Management Objective: Maintain** The iCawa River, being relatively ecologically intact, of good ecological importance and sensitivity, should not be permitted to be further degraded as a result of the proposed mining activities. The placement of the mine pits, overburden stockpiles and the PCD balancing dam upgradient of the of the river as indicated by the preliminary layout by the proponent, will pose a significant risk to the river and to the recommended management objective.

<table>
<tr><th colspan="2">Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):</th></tr>
<tr><td colspan="2">The instream modifiers along the assessed reach of the iCawa River include river crossings upstream of the Inguduma River confluence and abstraction for cultivation activities dominant in the area potentially impact water flows. This has the potential to impact on flow patterns, particularly during low flow periods which would impact on taxa sensitive to changes in flow. Upstream of the assessed reach, very few impacts on the system were identified due to absence of significant development and therefore no changes in water inputs are anticipated at the time of the assessment.

A basic water quality assessment was undertaken at two assessment points on the iCawa River, upstream and downstream of the proposed infrastructure (mine pits, overburden stockpiles and the PCD balancing dam). The range of water quality results from this assessment were as follows: Temperature: 21.1 – 22 ˚C; pH: 8.53 – 8.55; EC: 10.1 – 11 mS/m and DO saturation: 85.1% - 109.8%. The water quality within the river is considered to be within the ideal ranges according to DWAF (1996) and indicates absence of significant impacts within the assessed reach at the time of the assessment.

The geomorphological processes of the iCawa River were assessed to be without significant modifiers. Little bank incision and erosion were observed during the time of the assessment; where erosion was present the intensity of the impact in relation to the larger reach was considered limited. Increased inputs of sediment are anticipated though, particularly from cultivation activities which are upgradient of the river and removal of vegetation for livestock grazing. The impact from this can be observed within areas where deeper flows are present, and sediment has deposited resulting in growth of instream vegetation.

The habitat and biota of the iCawa River is considered good and without significant modifiers. Due to sediment within the system, proliferation of Phragmitis australis was identified within the active channel of the river although not spread widely. Presence of this results in slower flows at parts of the river, deposition of the sediment due to loss of velocity and as such reduced sediment reaches the lower reaches of the river. As part of the assessment, assessment of the aquatic macro-invertebrate community integrity was conducted, results from the assessment indicate the presence of sensitive taxa such as Leptophlebiidae, Aeshnidae, Gomphidae (SAS 2023).</td></tr>
<tr><td>Extent of modification anticipated</td><td>High

The extent of modification of the iCawa River as a result of the proposed activities is considered to be high. Although no infrastructure will encroach directly on the river, the location of infrastructure such as the mine pits (Pit 4), overburden stockpiles (4 + 6) and the PCD/potential future PCD including balancing dam upgradient of the of the river as indicated by the preliminary layout by the proponent has the potential to result in potential migration of toxicants into the river if unmitigated during the construction and operation of the process water infrastructure through seepage or in the event of any infrastructure failure, and by wind during blasting if not appropriately mitigated. Reduction of hydrological flows is also considered a potential impact as well as the loss of hydropedologically important soils, particularly interflow soils will result in the modifications of the river. However, restricting the location of the infrastructure outside of the GN509/GN704 100m zone of regulation and/or the floodline has to potential to reduce impacts significantly.</td></tr>
<tr><th colspan="2">Consideration of Integrated Environmental Management and Sustainable Development principles:</th></tr>
<tr><td>High</td><td>The impact significance of the proposed activities is considered high due to the location of the proposed infrastructure upgradient of the of the river which will result in potential direct and indirect impacts on the river. Given the largely unmodified ecological state of the river as well as its importance for downstream processes in the greater Newcastle area, impacts on the system must be avoided. Therefore, it is recommended that no dirty water runoff be permitted to reach the river, in line with GN704 as it relates to the NWA and appropriate clean and dirty water separation and stormwater management controls must be developed during construction phase, all dirty water containment structures must be designed to contain a minimum storm event of a 24 hour 1 in 50 year flood event and pollution control facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs.

Furthermore, it is critical that, should mining proceed, the Environmental Management Programme (EMPr) cater for monitoring upstream and downstream points on the iCawa River and monitoring information used to allow for adaptive risk mitigation. Parameters and recommended monitoring frequency that must be considered for the monitoring programme include:
➢ Water chemistry based on a suite of water quality parameters appropriate to coal mining (monthly);
➢ Habitat suitability for aquatic macro-invertebrates using the Invertebrate Habitat Assessment System (IHAS) method (biannually);
➢ The integrity of the aquatic macro-invertebrate community using the South African Scoring System version 5 (SASS5) index, including the Macro-invertebrate Response Assessment Index (MIRAI)(biannually),
➢ Fish Community integrity and application of the FRAI Ecostatus tool (biannually);
➢ Diatom community assessment (biannually); and
➢ Whole Effluent Toxicity (WET) testing (biannually).</td></tr>
</table>

Table 9: Summary of the assessment of the Inguduma River which flows in an easterly direction of the eastern focus area.

Ecological & socio-cultural service provision graph:

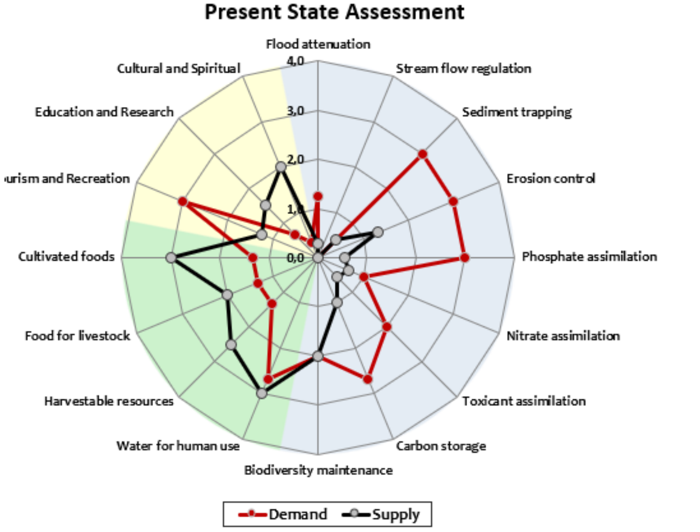


Figure B: Representative photographs of the Inguduma River which flows in an easterly direction through the focus area.

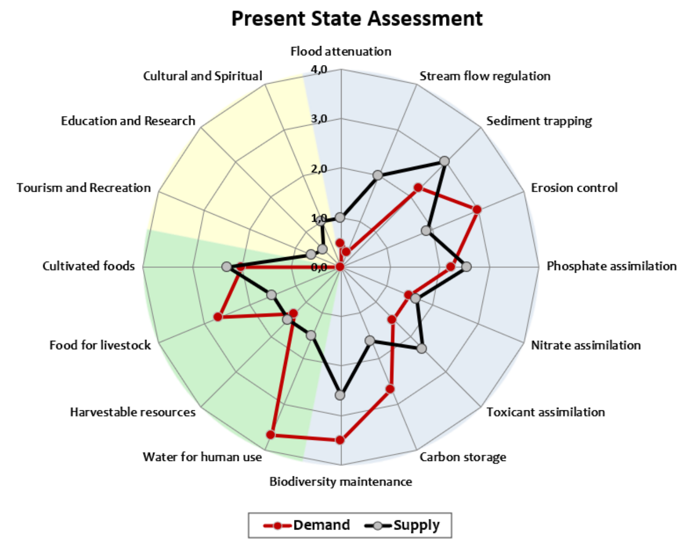
IHI Discussion	**PES Category: Instream IHI PES Category C** **Riparian IHI PES Category C** The assessed reach of the Inguduma river remains in a moderately unmodified ecological condition with only few modifiers present within the system. Commercial crop cultivation is also considered a dominant land use which likely drives changes in both the water quality and quantity within the river. In addition, road crossings impact the distribution and retention of water and sediment within the river. Some soil erosion was observed during the assessment resulting in increased water turbidity within the assessment and this is also due to sediment runoff from cultivated area into the river during recent rainfall in the area.	**Ecoservice provision**	**Ecoservices category: Low to Moderate** The Inguduma River was assessed to have a high demand for provision of services such as sediment control, and nitrate, phosphate and toxicant assimilation, and this is largely due to the surrounding catchment land use activities (highly industrial and residential) especially downstream within the Newcastle town. Within the assessed reach, important ecological services include provision of water for human use especially for farmers, biodiversity maintenance, food for livestock, phosphate assimilation and sediment trapping.
EIS discussion	**EIS Category: Moderate** The Inguduma river was assessed to be of "moderate" ecological importance and sensitivity (EIS) due to its hydro-functional importance to the ongoing ecological functioning of downstream river systems such as the Ncandu River. In addition, the Inguduma River has the potential to provide feeding and breeding habitat for avifauna, small mammals, reptiles and insects as well as aquatic biota such as fish and aquatic macro-invertebrates.	**REC, RMO & BAS Category**	**Recommended Ecological condition: C** **Best Attainable State: C** **Recommended Management Objective: Maintain** The Recommended Management Objective (RMO) for the Inguduma river based on the PES and EIS scores is to maintain the ecological integrity of the river to a Recommended Ecological Category (REC) of category C (Moderately Modified). Any planned activities for the proposed Newcastle colliery must be managed to mitigate impacts (in-line with the mitigation hierarchy) to ensure that at a minimum, the RMO is maintained.

Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):	
Limited impacts on the hydraulic regime of the Inguduma River were observed at the time of the assessment. Some impacts on the hydraulic processes include presence of some road crossings which alter the natural distribution and retention of flows and sediment within the river. At the time of the assessment, water quality sampling indicated good water quality conditions. Water quality was assessed at a single point on the river and the water quality findings were as follows: Electrical Conductivity (EC): 8.5 mS/m which is considered ideal; DO saturation: 82.5% and within the recommended saturation limit; pH: 8.3; and the temperature was 25.6 which is considered normal for the time of the day and season in which the assessment was conducted. Overall, the water quality within the site was considered fair/ideal at the time of the assessment and indicated no significant impacts on the system. The geomorphological regime of the river was moderately impacted due to observed erosion and incision of the riverbanks. The disturbances of the soil in the area due to cultivation activities has also increased the sediment laden runoff into the river particularly during periods of rainfall. However, although disturbances were observed, the extent and severity of these impacts is minimal and unlikely to have any severe effect on the ecological functioning of the system. The vegetation cover along the marginal and non-marginal zone of the Inguduma River was considered largely intact due to absence of significant disturbances as mentioned. The river provides good habitat to biota with vegetation cover comprised of riparian trees, shrubs and some grasses along the non-marginal zone of the river which included *Aristida junciformis, Sporobulus africanus, Helicrysum sp., and Verbena sp.* to name a few. The river is also considered to provide valuable roosting, breeding and feeding habitat for avifauna, small mammals, amphibians, reptiles and invertebrates.	
Impact anticipated	**Medium** The extent of modification of the Inguduma River is considered medium. Although no proposed infrastructure is located within the 100m regulated area of the river according to GN704 and GN509 as it relates to the National Water Act, the river is located downgradient of the proposed Newcastle colliery and as such it is at the receiving end of the potential impact pathway. This increases the risk of impaired runoff with toxicants and nutrients entering the system and having a significant impact on the aquatic ecology of the river if not adequately mitigated.
Consideration of Integrated Environmental Management and Sustainable Development principles:	
Medium	As mentioned above, the Inguduma River will not be directly impacted by the proposed Newcastle colliery project. However, increased biological availability of salts and other contaminants caused by mining related activities such as blasting has the potential to, over time, alter the species composition of the aquatic biota inhabiting the surrounding rivers especially downstream of the mining areas. As such cumulative increases in salts is still a cause for concern. It is recommended that no dirty water runoff be permitted to reach the river, in line with GN704 as it relates to the NWA and appropriate clean and dirty water separation and stormwater management controls must be developed during construction phase, all dirty water containment structures must be designed to contain a minimum storm event of a 24 hour 1 in 50 year flood event and pollution control facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs. The Environmental Management Programme (EMPr) must cater for monitoring upstream and downstream monitoring points on the Inguduma River and monitoring information used to allow for adaptive risk mitigation. Parameters and monitoring frequency that must be considered for the monitoring programme are as per those recommended for the monitoring of the iCawa River (refer to Table 8).

Table 10: Summary of the assessment of the central channelled valley bottom wetland system associated with the Machini River within the eastern focus area.

<table>
<tr>
<td colspan="2">

Ecological & socio-cultural service provision graph:



</td>
<td colspan="2">

Figure C: Representative photographs of the channelled valley bottom wetland within the eastern focus area.

</td>
</tr>
<tr>
<td>PES/ discussion</td>
<td>

PES Category: C (Moderately Modified)

The CVB wetland has been modified by catchment wide activities such as increased extent of impervious surfaces which have resulted in changes to water inputs. The wetland catchment is largely dominated by dryland cultivation which has resulted in disturbance of soil in the catchment and altered the natural distribution and retention of water in the landscape due to presence of various artificial drainage channels related to agricultural activities. Various upstream and downstream impoundments have also altered the natural hydraulic and geomorphological processes of the wetland, in turn leading to modifications to the vegetation within the wetland.

</td>
<td>Ecoservice provision</td>
<td>

Moderate to Moderately High

The ecological service provision by the CVB wetland was assessed to be moderate to moderately high. Ecoservices considered to be of highest importance include streamflow regulation, flood attenuation, erosion control, toxicant assimilation, assimilation of phosphates, sediment trapping. Given the dominance of agricultural activities in the area, the demand for ecological services such as food for livestock, cultivated foods and harvestable resources is considered high.

</td>
</tr>
<tr>
<td>EIS discussion</td>
<td>

EIS Category: Moderately High

Despite the moderately impacted ecological integrity of the wetland, the ecological importance and sensitivity of the system was considered moderate due to its ability to provide important ecological services. Such ecological services are considered important for the system given the degree of landscape transformations associated with development within its greater catchment. The CVB wetland system is also considered a FEPA wetland, and these wetlands are considered important on a national level in order to achieve biodiversity targets.

</td>
<td>REC, RMO & BAS Category</td>
<td>

Recommended Ecological Class Category: C
Best Attainable State: B/C (Improve/Maintain)
Recommended Management Objective: C (Maintain)

The Recommended Management Objective (RMO) based on the PES and the EIS of the wetland was to maintain the current ecological integrity of the system. The placement of the mine pits and overburden stockpiles within 32m of the wetland as indicated by the preliminary layout by the proponent, will pose a significant, potentially unacceptable risk to the wetland and to the recommended management objective.

</td>
</tr>
</table>

<table>
<tr><th colspan="2">Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):</th></tr>
<tr><td colspan="2">The presence of impoundments within the CVB wetland system has impacted on the hydraulic regime of the wetland since these impact on the water retention and distribution patterns within the wetland. The cultivation activities in the landscape have also likely impacted on the natural timing, flow and patterns of water which reports to the CVB wetland. Other impacts on the hydraulic regime of the wetland identified include presence of agricultural drains/channels and infilling as well as deposition of sediment within the wetland.

The water quality was measured during the field assessment conducted in November 2022, the pH, temperature, DO saturation and EC were measured as follows: 6.34, 28.3 ˚C, 84.3 and 5.7 mS/m. The dissolved salts are considered within the acceptable range limit (<30 mS/m) (DWA 2011) indicating absence of any significant impacts on the wetland. Similarly, the DO saturation was within the recommended saturation limit (80 – 120%) and considered ideal for aquatic biota. Parameters such as the pH and the temperature are considered within the normal range and not indicative of any significant impacts on the system.

Sediment laden runoff has likely increased over time within the wetland due to catchment wide activities (soil disturbances related to cultivation and vegetation clearing). The presence of instream dams within the CVB wetland has also resulted in the reduction of flow velocity within the channel, leading to deposition of sediment which forms ideal conditions for the growth of robust vegetation (e.g. Typha capensis) within the active channel of the wetland.

The wetland habitat was considered to be in a good state and only slightly impacted given the presence of encroacher and alien species indicative of disturbance which include but are not limited to, Bidens pilosa, Verbena brasiliensis, and Tagetes minuta. Despite this, the vegetation cover is considered important for providing refugia for fauna. As part of the assessment, assessment of the aquatic macro-invertebrate community integrity was conducted, results from the assessment indicate the presence of sensitive taxa such as Leptophlebiidae, Aeshnidae, Baetidae taxa indicating that the wetland is for providing habitat to aquatic biota as well as amphibians which were also observed during the assessment (SAS 2023).</td></tr>
<tr><td>Extent of modification anticipated</td><td>High

The extent of modification of the central CVB wetland as a result of the proposed activities is considered to be high. The layout provided by the proponent indicates that infrastructure overburden stockpiles will be located upgradient of the wetland and within 32m of the delineated boundary of the wetland. In addition, the layout indicates that Pit 5 and Pit D1 will be located within the delineated boundary of the wetland, resulting in significant impacts within the system if not mitigated. Loss of freshwater habitat and biota, impacts on the hydraulic regime (reduced baseflows and channelisation relating to potential diversion of flows) of the wetland and impacts on the sediment balance within the wetland are considered significant impacts associated with the proposed activities.

Given the importance of the wetland as a FEPA wetland and to downgradient freshwater systems such as the Inguduma River, impacts on the wetland must be avoided.</td></tr>
<tr><th colspan="2">Consideration of Integrated Environmental Management and Sustainable Development principles:</th></tr>
<tr><td>High</td><td>It is recommended that an alternative layout for the proposed Newcastle colliery is developed, which will be in-line with the mitigation hierarchy and with the requirements stipulated by GN704 as it relates to the National Water Act, 1998 (Act No 36 of 1998). This must include ensuring that no dirty water runoff be permitted to reach the wetland, in line with GN704 as it relates to the NWA and appropriate clean and dirty water separation and stormwater management controls must be developed during construction phase, all dirty water containment structures must be designed to contain a minimum storm event of a 24 hour 1 in 50 year flood event and pollution control facilities must be managed in such a way as to ensure that storage and surge capacity is available if a rainfall event occurs.

According to the layout provided by the proponent, infrastructure such as the mine pits (5, 1 and 2), Pit D1, overburden stockpile 5 and the access roads will encroach within the wetland and result in loss of freshwater habitat as well as the loss of hydropedologically important wetland recharge soil. It is recommended that avoidance of freshwater habitat be prioritised during the detailed planning phase of the mine, should this not be feasible, the impact must be minimised by means of mining the minimum opencast area in positions in the landscape that will pose the least risk to the receiving aquatic environment to make the mining project feasible. Should this approach to applying the mitigation hierarchy not be possible, the acceptability of an alternate approach and the quantum of a freshwater ecological offset that would most likely be required must be discussed with the relevant competent authorities to compensate for the residual impact on the receiving freshwater ecosystems.</td></tr>
</table>

Table 11: Summary of the assessment of the unnamed tributaries within the southern and northern portion of the eastern focus area.

Ecological & socio-cultural service provision graph:

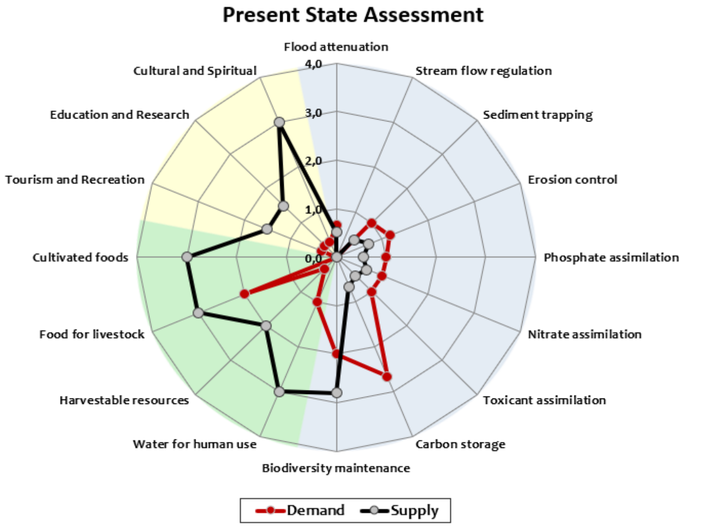


Figure D: Representative photographs of the unnamed tributaries located within the southern and northern portion of the eastern focus area. The photograph on the left indicates general landscape associated with unnamed tributaries.

IHI Discussion	**PES: Instream IHI - Category B (Largely Natural)** **Riparian IHI - Category B/C (Largely Natural/Moderately Modified)** The ecological integrity of the unnamed tributaries was assessed to be largely natural at the time of the assessment. Limited impacts were observed along the assessed reach, despite some erosion which has resulted in some alteration in the geomorphological processes. The hydraulic regime along the upper reaches of the systems has been impacted by presence of woody vegetation with a higher water use which has potentially reduced water inputs within the system. In addition, impoundments within the southern unnamed tributary have impacted on the natural distribution and retention of sediment and flows.	**Ecoservice provision**	**Ecoservices category: Moderate** The unnamed tributaries are considered of moderate ecological importance for the provision of hydro-functional services (specifically streamflow regulation and the assimilation of nutrients). The demand for water for human use and harvestable resources is considered significant due to the dependency of local farmers on the unnamed tributaries as a water source, particularly for cattle.
EIS discussion	**EIS Category: Moderate** The ecological importance and sensitivity (EIS) of the unnamed tributaries was ascertained to be moderate due to their hydro-functional importance to downstream river systems such as the iCawa River. In addition, the unnamed tributaries provide feeding and breeding habitat for avifauna, small mammals, reptiles and insects as well as aquatic biota such as fish (present within the dams) and aquatic macro-invertebrates.	**REC, RMO & BAS Category**	**Recommended Ecological Class Category: B** **Best Attainable State: B (Maintain)** **Recommended Management Objective: B (Maintain)** The RMO for the unnamed tributary based on the PES and EIS scores is to maintain/improve the ecological integrity of the unnamed tributaries. According to the layout provided by the proponent, the unnamed tributaries are located upgradient of the proposed Newcastle colliery and as such no impacts on the system are likely.

Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):	
The hydraulic regime of the unnamed tributaries remains largely unimpacted with limited modifiers identified which include presence of impoundments which have resulted in changes in the natural delivery of sediment and flows to downstream reaches of the system. At the time of the assessment, *in-situ* water quality was assessed on a single point on the southern unnamed tributary and the findings indicated generally good water quality conditions. Parameters measured were as follows: pH – 8.3; temperature – 27 ˚C; DO saturation – 101.8%; and EC – 8.3. The geomorphological regime of the unnamed tributaries was assessed to be largely unimpacted at the time of the assessment, sedimentation of these systems was largely limited due to absence of significant disturbances of the vegetation. Although some soil disturbances were observed, the extent and severity of these impacts is minimal and unlikely to have any significant effect on the ecological functioning of the system. The vegetation cover along the marginal and non-marginal zone of the unnamed tributary was considered largely intact due to absence of significant disturbances as mentioned. Given the very good water quality condition at the site, the site is considered ideal for providing habitat to taxa sensitive to changes in water quality.	
Extent of modification anticipated	**Low** The extent of modification anticipated due to the proposed Newcastle colliery on the unnamed tributaries is considered low given that the tributaries are located upgradient of the proposed activities and any risk to them is limited. The proposed future underground mining footprint is located beneath the southern unnamed tributary, should this proceed in future, then potential impacts associated with this activity must be assessed for the suitable environmental authorisations to be provided.
Consideration of Integrated Environmental Management and Sustainable Development principles:	
Low	No direct impacts to the unnamed tributaries are anticipated based on the preliminary information provided by the proponent. It is recommended that general ‘best practice’ mitigation measures to avoid edge effects be implemented throughout the Life of Mine. This includes specifically ensuring adequate dust management to minimise the volume of airborne sediment which may reach the unnamed tributaries.

Table 12: Summary of the assessment of the unchannelled valley bottom wetland located within the southern portion of the focus area.

Ecological & socio-cultural service provision graph:

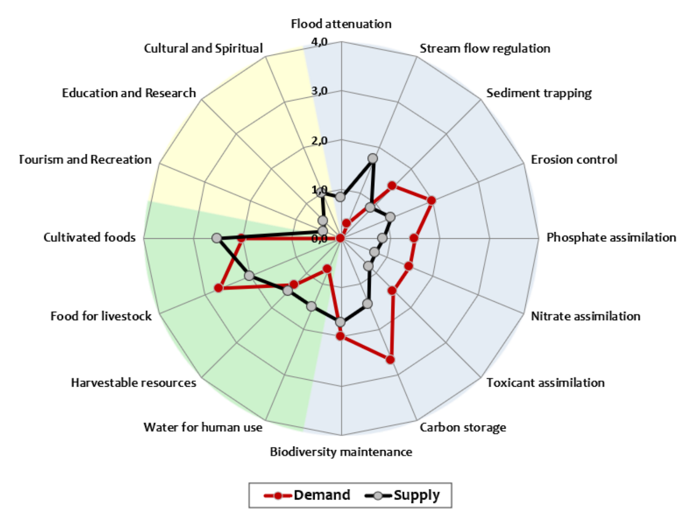


Figure E: Representative photographs of the unchannelled valley bottom wetland within the focus area.

PES/ discussion	**PES Category: C (Moderately Modified)** Similar to the CVB, the UCVB wetland was ascertained to be moderately modified due to presence of cultivation activities within the catchment and various instream impoundments which have altered the natural distribution and retention of flows within the wetland. Such modifications in the catchment have also resulted in modifications to the vegetation within the wetland since the deposition of sediment and increased availability of nutrients creates conditions conducive for growth of robust vegetation.	**Ecoservice provision**	**Moderate** The ecological service provision by the UCVB wetland was assessed to be low to moderate. The wetland is within an area utilised for various agricultural practices and as such it provides a water source for cattle and due to the good vegetation cover, the wetland also provides food for livestock. The wetland is also important for services such as assimilation of phosphates, sediment trapping and nitrate erosion control which are in demand considering dominance of agricultural activities in the area.
EIS discussion	**EIS Category: Moderate** Despite the moderately impacted ecological integrity of the wetland, the ecological importance and sensitivity of the system was considered moderate due to its ability to provide important ecological services. Such ecological services are considered important for the system given the degree of landscape transformations associated with development within its greater catchment.	**REC, RMO & BAS Category**	**Recommended Ecological Class Category: C** **Best Attainable State: B/C (Improve/Maintain)** **Recommended Management Objective: C (Maintain)** The Recommended Management Objective (RMO) based on the PES and the EIS of the wetland was to maintain the current ecological integrity of the system. The placement of the mine stockpiles (4 + 6), as indicated by the preliminary layout by the proponent, will pose a risk to the wetland and to the recommended management objective if not appropriately mitigated.

<table>
<tr><th colspan="2">Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):</th></tr>
<tr><td colspan="2">Various impoundments were identified within the UCVB wetlands, the presence of these features has impacted on the hydraulic regime of the wetland. The delivery of sediment and flows to downstream reaches is altered due to the presence of these instream dams, which has created various isolated ‘ponds’ which is not the natural flow pattern of the system. Although water quality was not assessed within the UCVB wetlands, it is considered most likely to be fair/good given the general water quality condition in the area has been good and the system has been subjected to similar impacts.

Sediment laden runoff has likely increased overtime within the wetland due to catchment wide activities (soil disturbances related to cultivation and vegetation clearing). The presence of instream dams within the UCVB wetland has also resulted in the reduction of flow velocity within the system, leading to deposition of sediment which forms ideal conditions for the growth of robust vegetation (e.g. Typha capensis) within the wetland.

The wetland habitat was considered good and only slightly impacted given the presence of encroacher and alien species indicative of disturbance which include but not limited to, Bidens pilosa, Verbena brasiliensis, and Tagetes minuta. Despite this, the vegetation cover is considered important for providing refugia for fauna</td></tr>
<tr><td>Extent of modification anticipated</td><td>Medium

The impact significant of the proposed activities is considered medium. According to the layout provided by the proponent, the proposed infrastructure will not encroach directly on the delineated UCVB wetland located along the northern portion of the investigation area. However, proposed infrastructure specifically the overburden stockpiles (4 + 6) is located approximately 18m upgradient of the wetland and as a result will most likely pose significant indirect impacts to the wetland if not appropriately mitigated. The location of the PCD also poses some impacts to the wetland given the potential runoff or seepage from the infrastructure, should leaks occur, which will alter the water quality regime of as well s biota within the wetland. It must be ensured that clean and dirty water runoff systems be constructed before construction of any other process water related infrastructure and that clear separation of operational and non-operational areas is conducted prior to commencement of construction activities.</td></tr>
<tr><th colspan="2">Consideration of Integrated Environmental Management and Sustainable Development principles:</th></tr>
<tr><td>Medium</td><td>It is recommended that an alternative layout for the proposed Newcastle colliery is developed, which will be in-line with the mitigation hierarchy and with the requirements stipulated by GN704 as it relates to the National Water Act, 1998 (Act No 36 of 1998). Given the potential loss of hydropedologically important wetland recharge soil, it is recommended that measures to compensate for loss of wetland recharge be considered. This includes ensuring that clean water from separation systems is returned back to the wetland in an attenuated manner that does not result in soil erosion or creation of anthropogenically derived saturated areas in the landscape.</td></tr>
</table>

Table 13: Summary of the assessment of the seep wetland associated with the proposed Newcastle colliery.

Ecological & socio-cultural service provision graph:

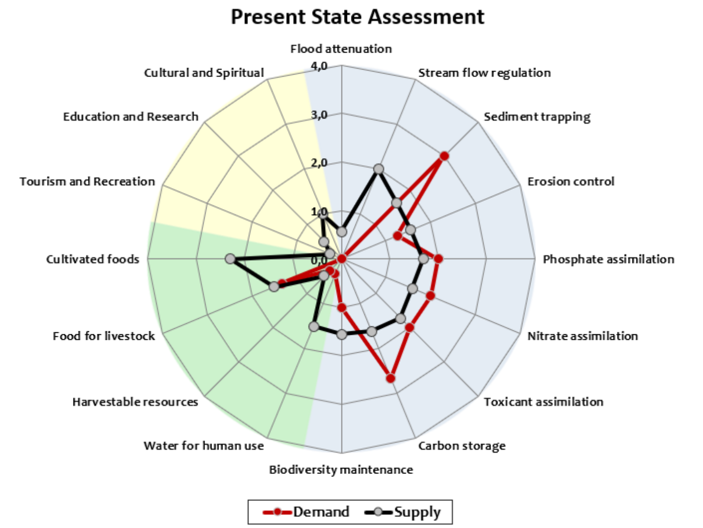


Figure F: Representative photographs of the seep wetland associated with the proposed Newcastle colliery.

PES Discussion	**PES Category: B (Largely Natural)** The seep wetland was ascertained to be largely natural and without major modifiers. The primary modifiers noted were impacts to the vegetation, primarily as a result of grazing and trampling by domestic livestock. The resulting reduction in natural vegetation cover has led to encroachment by floral species associated with disturbance, however this is not considered to be severe. Construction of farm fence lines upgradient of the seep wetland has also resulted in some disturbances in the soil although this is not considered significant.	**Ecoservice provision**	**Moderate** The ecological service provision by the seep wetland was assessed to be intermediate due to services such as sediment trapping, phosphate assimilation and erosion control. The seep covers a very small footprint and was not observed to have diversity of habitat available, as a result it was considered limited in terms of habitat provision for biodiversity support. Given that the wetland is within an area dominated by livestock husbandry, it also provides food for livestock.
EIS discussion	**EIS Category: Moderate** The ecological importance and sensitivity (EIS) of the wetland was assessed to be moderate. The seep wetland likely provides some habitat, foraging and migratory sites for various faunal species.	**REC, RMO & BAS Category**	**Recommended Ecological Class Category: B** **Best Attainable State: B (Improve/Maintain)** **Recommended Management Objective: B (Maintain)** The Recommended Management Objective (RMO) based on the PES and the EIS of the wetland was to maintain the current ecological integrity of the system. According to the layout provided, no infrastructure will encroach within the wetland or is located within 32m of the seep wetland and as a result, RMO of the wetland will be maintained.

<table>
<tr><td colspan="2">Freshwater ecosystem drivers and receptors discussion (hydraulic regime, geomorphological processes, water quality and habitat and biota):</td></tr>
<tr><td colspan="2">Very few impacts to the hydraulic regime and geomorphological processes were observed within the seep wetland during the site assessment, with the minimal topsoil disturbances caused by trampling of livestock. Other minor impacts identified relate to the construction and installation of farming fence lines upgradient of the seep wetland.

In-situ water quality parameters were not measured as there was no surface water present at the time of the assessment. Given the absence of activities which would significantly alter water quality the water quality within the wetland is considered to be fair when present.

The geomorphology within the wetland was considered largely unimpacted (apart from impacts associated with cattle trampling) and this was due to the good vegetation cover provided by the short grasses and sedges identified within the wetland. The seep wetland had a good vegetation cover which was dominated by various grasses and sedges. The grass layer was dominated by grasses commonly found in moisture rich/wet areas.</td></tr>
<tr><td>Extent of modification anticipated</td><td>Low
Given that no infrastructure is proposed to encroach the wetland or the associated 32m zone of regulation, the extent of modification anticipated is considered Low. General good construction principles must be held during the construction phase, ensuring no vehicles are allowed to indiscriminately drive through the wetland and that vehicles must remain on designated roadways throughout the construction and operation phase.</td></tr>
<tr><td colspan="2">Consideration of Integrated Environmental Management and Sustainable Development principles:</td></tr>
<tr><td>Low</td><td>No direct impacts to the seep wetland are anticipated based on the layout provided by the proponent. It is recommended that general ‘best practice’ mitigation measures to avoid edge effects be implemented throughout the Life of Mine. This includes specifically ensuring adequate dust management to minimise the volume of airborne sediment which may reach the seep wetland.</td></tr>
</table>

Relic wetlands are defined as wet agricultural lands which have been drained in the past for agricultural purposes and often currently found to be lacking any vegetation response that is typically associated with wetlands. Despite this, the relic systems are still found to be saturated at and near the surface and considered to be important in terms of hydropedological drivers (i.e., interflow soil) in the landscape supporting the functional wetland areas. Various drains and artificial channels were identified within the relic wetlands (shown in the figure 18 below).

Figure 18: Representative photograph of the relic wetland within the focus area associated with the Newcastle colliery.

5 RESULTS: AQUATIC ECOLOGICAL ASSESSMENT

Five aquatic sites located on the Icawa River, Machini River and unnamed tributaries of the Ncandu River were assessed as part of the ecological assessment. The geographical co-ordinates and description of the respective sites are provided below (Table 14):

Table 14: Geographic co-ordinates for the assessment points located on the unnamed tributaries of the Ncandu River.

Site	Description	GPS co-ordinates	
		Latitude	Longitude
NC1	Located north and upstream of the proposed PCD and OB Stockpiles 4+6 on the Icawa River.	27°44'3.87"S	29°51'5.12"E
NC2	Located downstream of the potential OB Stockpiles 4+6, Pit 6 and Pit 4 areas on the Icawa River.	27°44'28.10"S	29°52'59.42"E
NC3	Located in an area proposed for future underground mining in the eastern section.	27°46'16.54"S	29°50'51.01"E
NC4	Located in the centre of the eastern section, downstream of the OB Stockpiles 1+6, but adjacent to Pit 5 and Pit D1.	27°45'1.87"S	29°52'13.18"E
NC5	Located upstream of the Pit 5, Pit D1, OB Stockpile 3 and Pit 2.	27°45'39.46"S	29°52'7.72"E

The location of the assessment sites is indicated in Figure 19 overleaf.

5.1 Results and Interpretation

Results are presented as "dashboard style" reports (Table 15 to 19). These dashboard reports aim to present concise summaries of the data on as few pages as possible, to allow for integration of results by the reader to take place. Where required, further discussion and interpretation is provided.

As mentioned earlier, the future underground mining areas within the western focus areas were not assessed in-field during the assessment and were only considered at a desktop level. Therefore, the field assessment only focus on the eastern focus area and the results are presented in Tables 15 to 19 below.

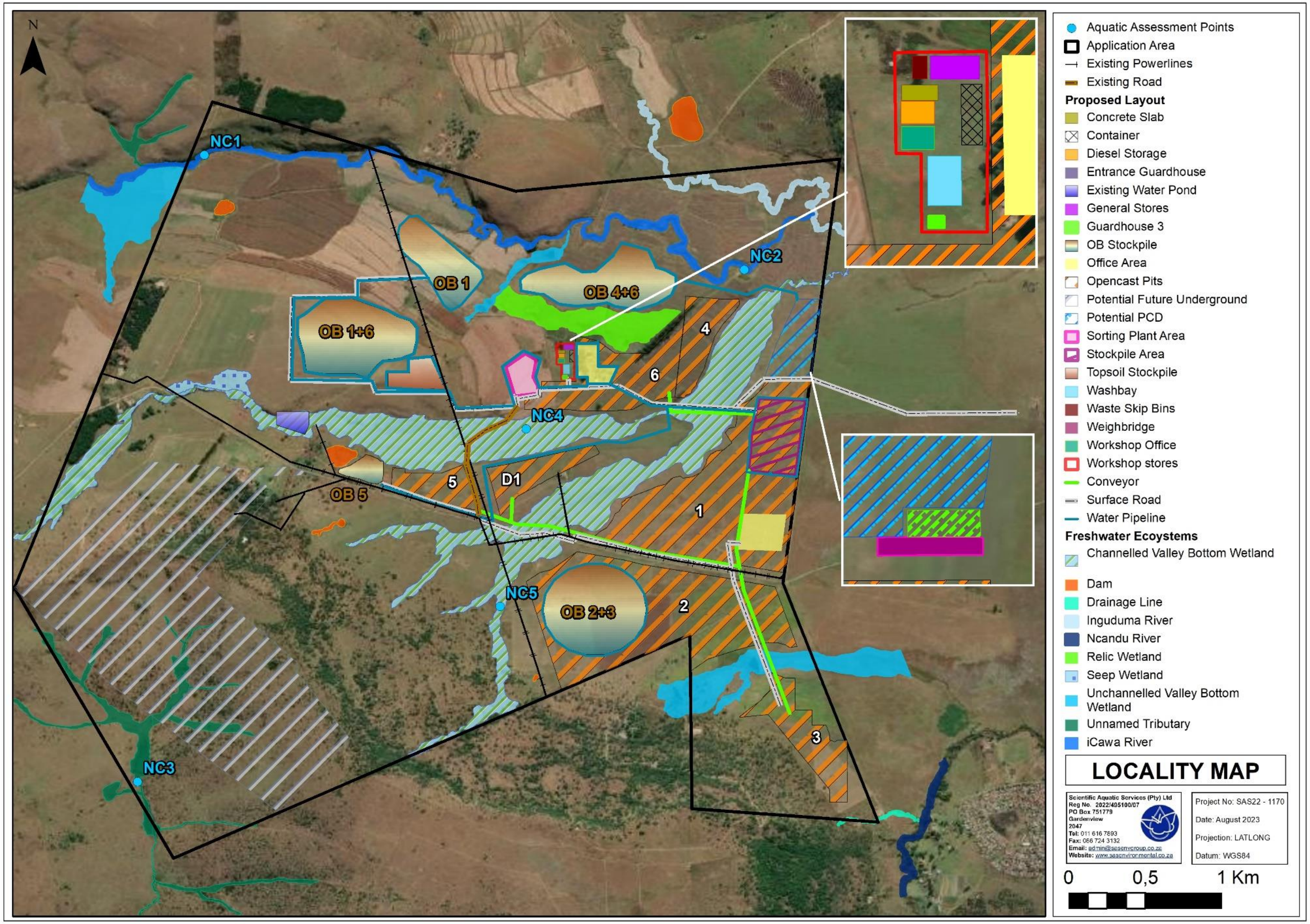


Figure 19: Location of the aquatic ecological assessment sites associated with the proposed Newcastle colliery.

Table 15: Results of the assessment at Site NC1

Site NC1

Figure 20: View of site NC1 at the time of the assessment.

Algal proliferation:	Slight proliferation on rocks.
Depth profiles:	Limited depth variation at the site under the current flow conditions. The site is dominated by shallow riffles and deeper pools.
Flow condition:	Moderately slow flow.
Riparian zone characteristics:	The riparian zone is considered relatively narrow due to the incised nature of the system. The site is dominated by trees, grasses and shrubs
Water clarity and odour:	Water was discoloured. No odours present.
Signs of pollution or impact.	None observed.

MIRAI	**Category C/D (Moderately to Largely Modified)**
Instream IHI	**Category B (Largely Natural)**
Riparian IHI	**Category C (Moderately Modified)**
VEGRAI	**Category B (Largely Natural)**
FRAI	**Category C/D (Moderately to Largely Modified)**
Diatoms	**Category B (Good Quality)**

Integrated Ecological Category: 71.0% (Category C: Moderately Modified)

Key Drivers of System Change:

- Cumulative impacts from surrounding agricultural activities.
- Significant areas of vegetation clearing, leading to increased erosion and sedimentation.

***In situ* physico-chemical water quality**

pH	8.53	**RWQO Ncandu River (DWS, 2022)**	
EC (mS/m)	11.0	**pH**	6.5 – 9.0
TDS (mg/l)	71.5	**TDS (mg/l)**	≤ 350
DO (mg/L)	6.2	**TWQR (DWAF, 1996)**	
DO (% sat)	85.1	**DO % Sat**	80 – 120%
Temp (℃)	21.1		

Water Quality Comments:

- The pH value measured during the assessment was largely natural and complied with the RWQO (DWS, 2022);
- The TDS concentrations complied with the guideline limits required by the RWQO (DWS, 2022);
- The DO saturation was considered adequate and complied with the target water quality requirements (DWAF, 1996);
- Temperature was considered largely natural considering diurnal variation and the time of day of the assessment; and
- Overall, the water quality of this section of the Icawa River was considered good.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

SASS5 score	94
ASPT score	5.2
IHAS score	73 (Good)
MIRAI score	59.6 (Category C/D)

Macro-Invertebrate Community Integrity Comments:

- The aquatic macro-invertebrate community integrity was classified as a Category C/D (Moderately to Largely Modified) condition according to the MIRAI EcoStatus tool;
- The aquatic community was considered largely tolerable with moderately sensitive taxa limited to Leptophlebiidae and Aeshnidae. The taxa observed on site had a diverse preference for stones, vegetation and Gravel, Sand and Mud (GSM) with various airbreathers (eight taxa) ranging from low to moderate water quality preferences;
- The habitat suitability was considered good at the time of the assessment, with adequate biotope diversity present.

Index of Habitat Integrity

Instream IHI – 86.2 (Category B)	**Riparian IHI** – 68.5 (Category C)

Some erosion evident at several points along the embankment. Alien vegetation encroachment is evident in the whole study area. Some sedimentation and algal proliferation observed on instream rocks.

Fish Community Assessment

FRAI Score	59.7 (Category C/D. Moderately to Largely Modified)

No fish were caught on site, however, the habitat is considered adequate in supporting the expected fish species listed in Section 3.1

Riparian Vegetation Response Assessment Index

VEGRAI score	Some alien vegetation encroachment present in the study area, along with significant areas of vegetation clearing due to agricultural activities. Alien vegetation species include: *Acacia mearnsii, Eucalyptus cinerea, Eucalyptus globulus, Jacaranda mimosifolia, Melia azedarach, Pinus* sp.*, Populus alba, Ricinus communis, Quercus robur, Salix babylonica, Solanum mauritianum*.
87.0 (Category B)	

Diatom Community Integrity

Specific Pollution sensitivity Index (SPI)	15.3
Generic Diatom Index (GDI)	15.9
Trophic Diatom Index (TDI)	10.1
Percentage Pollution Tolerant Valves (%PTV)	0
Trophic level	Oligo-Mesotrophic
Ecosystem Quality	Good Quality
Ecological Category	B

- The SPI and GDI scores are indicative of oligotrophic to mesotrophic conditions and classifies the site in a Good ecological condition (Category B);
- A low TDI is indicative of Oligotrophic conditions with no organic pollution present at the site supported by the calculated %PTV (0.0%) score;
- The ecology of both dominant diatom species identified (*Fragilaria Bicpes* and *Cymbella* spp.) are synonymous with a wide ranges of water quality ranging from oligotrophic to eutrophic nutrient enrichment, with *Cymbella* spp. an indicator of moderate electrolyte content. The presence of the dominant species together with the measured SPI index score (final score calculated based on the diatom community as a whole) are indicators of an oligo-mesotrophic ecosystem at the site at the time of the assessment with little to no organic pollution present based on the diatom community results; and
- Overall: Diatom results indicate a good ecosystem quality (Category B) for site NC1 with low to moderate nutrient enrichment and moderate electrolyte conditions present at the site.

Table 16: Results of the assessment at Site NC2

Site NC2

Figure 21: View of site NC2 at the time of the assessment.

Algal proliferation:	Slight proliferation on bedrock.
Depth profiles:	Limited depth variation at the site under the current flow conditions. The site is dominated by moderately shallow runs and deeper pools.
Flow condition:	Moderately slow flow.
Riparian zone characteristics:	The riparian zone is considered relatively narrow due to the incised nature of the system. The site is dominated by grasses and shrubs
Water clarity and odour:	Water was discoloured. No odours present.
Signs of pollution or impact.	None observed.

MIRAI	**Category C/D (Moderately to Largely Modified)**
Instream IHI	**Category B (Largely Natural)**
Riparian IHI	**Category C (Moderately Modified)**
VEGRAI	**Category B/C (Largely Natural to Moderately Modified)**
FRAI	**Category C/D (Moderately Modified)**
Diatoms	**Category B/C (Good Quality)**

Integrated Ecological Category: 68.1% (Category C: Moderately Modified)

Key Drivers of System Change:
- Cumulative impacts from surrounding agricultural activities.
- Significant areas of vegetation clearing, leading to increased erosion and sedimentation.

***In situ* physico-chemical water quality**

pH	8.53	**RWQO Ncandu River (DWS, 2022)**	
EC (mS/m)	10.1	**pH**	6.5 – 9.0
TDS (mg/l)	65.7	**TDS (mg/l)**	≤ 350
DO (mg/L)	8.4	**TWQR (DWAF, 1996)**	
DO (% sat)	109.8	**DO % Sat**	80 – 120%
Temp (℃)	22.0		

Water Quality Comments:
- The pH value measured during the assessment was largely natural and complied with the RWQO (DWS, 2022);
- The TDS concentrations complied with the guideline limits required by the RWQO (DWS, 2022);
- The DO saturation was considered adequate and complied with the target water quality requirements (DWAF, 1996);
- Temperature was considered largely natural considering diurnal variation and the time of day of the assessment; and
- Overall, the water quality of this section of the Icawa River was considered good.

Index of Habitat Integrity

Instream IHI – 86.2 (Category B)	**Riparian IHI –** 68.5 (Category C)

Some erosion evident at several points along the embankment. Alien vegetation encroachment is evident in the whole study area. Some sedimentation and algal proliferation observed on instream rocks.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

SASS5 score	87
ASPT score	4.83
IHAS score	69 (Good)
MIRAI score	58.4 (Category C/D)

Macro-Invertebrate Community Integrity Comments:
- The aquatic macro-invertebrate community integrity was classified as a Category C/D (Moderately to Largely Modified) condition according to the MIRAI EcoStatus tool;
- The aquatic community was considered largely tolerable with moderately sensitive taxa limited to Atyidae and Aeshnidae. The taxa observed on site had a diverse preference for stones, vegetation and GSM with various airbreathers (nine taxa) ranging from low to moderate water quality preferences;
- The habitat suitability was considered good at the time of the assessment, with adequate biotope diversity present.

Fish Community Assessment

FRAI Score	59.7 (Category C/D. Moderately to Largely Modified)

No fish were caught on site, however, the habitat is considered adequate in supporting the expected fish species listed in Section 3.1

Riparian Vegetation Response Assessment Index

VEGRAI score 81.1 (Category B/C)	Some alien vegetation encroachment present in the study area, along with significant areas of vegetation clearing due to agricultural activities. Alien vegetation species include: *Acacia mearnsii, Eucalyptus cinerea, Eucalyptus globulus, Jacaranda mimosifolia, Melia azedarach, Pinus sp., Populus alba, Ricinus communis, Quercus robur, Salix babylonica, Solanum mauritianum.*

Diatom Community Integrity

Specific Pollution sensitivity Index (SPI)	14.9
Generic Diatom Index (GDI)	15.1
Trophic Diatom Index (TDI)	11
Percentage Pollution Tolerant Valves (%PTV)	0
Trophic level	Mesotrophic
Ecosystem Quality	Good Quality
Ecological Category	B/C

- The SPI and GDI scores are indicative of mesotrophic conditions and classifies the site in a Good ecological condition (Category B/C);
- A low TDI score is indicative of Oligotrophic conditions with no pollution present at the site in the form of organic pollution as supported by the low %PTV (0.0%) score;
- The ecology of both dominant diatom species identified (*F. Bicpes* and *Cymbella* spp.) are synonymous with a wide ranges of water quality ranging from oligotrophic to eutrophic nutrient enrichment, with *Cymbella* spp. an indicator of moderate electrolyte content. The presence of the dominant species together with the measured SPI index score (final score calculated based on the diatom community as a whole) are indicators of a mesotrophic ecosystem at the site at the time of the assessment with little to no organic pollution present based on the diatom community results; and
- The diatom results indicate a slight downstream deterioration between sites NC1 and NC2. The diatom ecological category deteriorated from a Category B (oligo-mesotrophic) to a Category B/C (mesotrophic). However, both sites were still considered to be in a Good ecological quality.

Table 17: Results of the assessment at Site NC4

Site NC4

Figure 22: View of site NC4 at the time of the assessment.

Algal proliferation:	Isolated clumps observed.
Depth profiles:	Limited depth variation. The site is dominated by deeper pools.
Flow condition:	Slow flow.
Riparian zone characteristics:	The riparian zone is absent and considered a Channeled Valley Bottom (CVB) Wetland. The site is dominated by grasses and shrubs.
Water clarity and odour:	Water was clear. No odours present.
Signs of pollution or impact.	None observed.

MIRAI	**Category D (Largely Modified)**
Instream IHI	**Category B/C (Largely Natural to Moderately Modified)**
Riparian IHI	**Category C (Moderately Modified)**
Diatoms	**Category B/C (Good Quality)**

Key Drivers of System Change:

- ➢ Cumulative impacts from surrounding agricultural activities.
- ➢ Impacts on the hydraulic processes and geomorphological processes due to the effects of instream impoundments.

In situ **physico-chemical water quality**

pH	6.34	**RWQO Ncandu River (DWS, 2022)**	
EC (mS/m)	10.7	**pH**	6.5 – 9.0
TDS (mg/l)	69.6	**TDS (mg/l)**	≤ 350
DO (mg/L)	5.7	**TWQR (DWAF, 1996)**	
DO (% sat)	84.3	**DO % Sat**	80 – 120%
Temp (℃)	28.3		

Water Quality Comments:

- ➢ The pH value measured during the assessment did not comply with the RWQO (DWS, 2022), however at 6.34 no significant impact on the aquatic ecology is considered likely;
- ➢ The TDS concentrations complied with the guideline limits required by the RWQO (DWS, 2022);
- ➢ The DO saturation was considered adequate and complied with the target water quality requirements (DWAF, 1996);
- ➢ Temperature was considered largely natural considering diurnal variation and the time of day of the assessment; and
- ➢ Overall, the water quality of this section of the unnamed Machini River was considered fair.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

SASS5 score	47
ASPT score	4.27
IHAS score	44 (Poor)
MIRAI score	43.6 (Category D)

Macro-Invertebrate Community Integrity Comments:

- ➢ The aquatic macro-invertebrate community integrity was classified as a Category D (Largely Modified) condition according to the MIRAI EcoStatus tool;
- ➢ The aquatic community was considered largely tolerable with moderately sensitive taxa limited to Elmidae. The taxa observed on site had a diverse preference for vegetation and GSM with various airbreathers (six taxa) ranging from low to moderate water quality;
- ➢ The habitat suitability was considered poor at the time of the assessment, with limited biotope diversity present due to the nature of the impoundment;
- ➢ The SASS5 method is designed for low/moderate flow hydrology and is not ideally suited for wetlands, impoundments, estuaries and other lentic habitats. Therefor, low diversity and sensitivity was expected from this site.

Index of Habitat Integrity

Instream IHI – 81.4 (Category B/C)	**Riparian IHI** – 74.3 (Category C)

The system is moderately affected by instream impoundments and flow modification. Alien vegetation encroachment is evident in the whole study area. Some algal proliferation observed within the dam.

Fish Community Assessment

The FRAI was not applied to site NC4 due to the significant instream impoundments (which is expected to present a notable migration barrier to potential fish species). It is further suspected that the wetland nature of the associated section of the system was not likely to support large fish populations, if any. However, alien invasive *Micropterus salmoides* (Largemouth bass) were caught in one of the dams. Largemouth bass is not listed for dams (including for release in dams) within discrete catchment systems. However, *M. salmoides* is listed as a Category 3 in all rivers, wetlands, lakes and estuaries.

Diatom Community Integrity

Specific Pollution sensitivity Index (SPI)	14.3
Generic Diatom Index (GDI)	13.0
Trophic Diatom Index (TDI)	9.1
Percentage Pollution Tolerant Valves (%PTV)	13.8
Trophic level	Mesotrophic
Ecosystem Quality	Good Quality
Ecological Category	B/C

- ➢ Site NC4 has a high species diversity with an even species distribution;
- ➢ The SPI and GDI scores are indicative of Mesotrophic conditions and classifies the site in a Good ecological condition (Category B/C);
- ➢ A low TDI are indicative of Oligotrophic conditions with no pollution present at the site in the form of organic pollution as supported by the low %PTV (13.8%) score;
- ➢ The ecology of both dominant diatom species identified (*Sellaphora pupula* and *Navicula* spp.) are synonymous with nutrient enriched waters, with electrolyte-rich conditions. Both species are tolerant of strongly to critical levels of pollution. The presence of the dominant species together with the measured SPI index score (final score calculated based on the diatom community as a whole) are indicators of moderate nutrient enrichment (mesotrophic) at the site with elevated levels of pollution and electrolytes at the time of the assessment with little to no organic pollution present based on the diatom community results; and
- ➢ Diatom results indicate a good ecosystem quality for site NC4 with an ecological category B/C.

Table 18: Results of the assessment at Site NC5

Site NC5

Figure 23: View of site NC5 at the time of the assessment.

Algal proliferation:	Isolated clumps observed in between vegetation.
Depth profiles:	Limited depth variation. The site is dominated by deeper pools.
Flow condition:	Slow flow.
Riparian zone characteristics:	The riparian zone is absent and considered a Channeled Valley Bottom (CVB) Wetland. The site is dominated by grasses and sedges.
Water clarity and odour:	Water was clear. No odours present.
Signs of pollution or impact.	None observed.

MIRAI	**Category D (Moderately to Largely Modified)**
Instream IHI	**Category B/C (Largely Natural)**
Riparian IHI	**Category C (Moderately Modified)**

***In situ* physico-chemical water quality**

pH	8.44
EC (mS/m)	11.0
TDS (mg/l)	71.5
DO (mg/L)	5.6
DO (% sat)	68.1
Temp (℃)	25.3

RWQO Ncandu River (DWS, 2022)	
pH	6.5 – 9.0
TDS (mg/l)	≤ 350
TWQR (DWAF, 1996)	
DO % Sat	80 – 120%

Water Quality Comments:

- The pH value measured during the assessment was largely natural and complied with the RWQO (DWS, 2022);
- The TDS concentrations complied with the guideline limits required by the RWQO (DWS, 2022);
- The DO saturation was considered inadequate and did not comply with the target water quality requirements (DWAF, 1996). This was likely due to the stagnant condition of the site;
- Temperature was considered largely natural considering diurnal variation and the time of day of the assessment; and
- Overall, the water quality of this section of the unnamed tributary was considered fair.

Index of Habitat Integrity

Instream IHI – 81.4 (Category B/C)	**Riparian IHI –** 74.3 (Category C)

The system is moderately affected by instream impoundments and flow modification. Alien vegetation encroachment is evident in the whole study area. Some algal proliferation observed within the dam.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

SASS5 score	61
ASPT score	4.69
IHAS score	44 (Poor)
MIRAI score	43.8 (Category D)

Macro-Invertebrate Community Integrity Comments:

- The aquatic macro-invertebrate community integrity was classified as a Category D (Largely Modified) condition according to the MIRAI EcoStatus tool;
- The aquatic community was considered largely tolerable with moderately sensitive taxa limited to Hydraenidae. The taxa observed on site had a diverse preference for vegetation and GSM with various airbreathers (eight taxa) ranging from low to moderate water quality preferences;
- The habitat suitability was considered poor at the time of the assessment, with limited biotope diversity present due to the nature of the flow conditions being wetland in nature.

Fish Community Assessment

The FRAI was not applied to site NC5 due to the significant instream impoundments (which is expected to present a notable migration barrier to potential fish species). It is further suspected that the wetland nature of the associated section of the system was not likely to support large fish populations, if any. However, alien invasive *Micropterus salmoides* (Largemouth bass) was caught in one of the dams. Largemouth bass is not listed for dams (including for release in dams) within discrete catchment systems. However, *M. salmoides* is listed as a Category 3 in all rivers, wetlands, lakes and estuaries.

Key Drivers of System Change

- Cumulative impacts from surrounding agricultural activities.
- Slight vegetation clearing, leading to increased erosion and sedimentation.
- Impacts on the hydraulic processes and geomorphological processes due to the effects of instream impoundments.

Table 19: Results of the assessment at Site NC3

Site NC3

Figure 24: View of site NC3 at the time of the assessment.

Algal proliferation:	Isolated clumps observed in between vegetation.
Depth profiles:	Limited depth variation. The site is dominated by deeper pools.
Flow condition:	Slow flow.
Riparian zone characteristics:	The riparian zone is considered relatively narrow. The site is dominated by grasses and shrubs
Water clarity and odour:	Water was clear. No odours present.
Signs of pollution or impact.	None observed.

MIRAI	**Category D (Moderately to Largely Modified)**
Instream IHI	**Category B/C (Largely Natural)**
Riparian IHI	**Category B/C (Largely Natural to Moderately Modified)**
VEGRAI	**Category A/B (Unmodified to Largely Natural)**
FRAI	**Category C/D (Moderately to Largely Modified)**

Integrated Ecological Category: 67.2% (Category C: Moderately Modified)

***In situ* physico-chemical water quality**

pH	6.25
EC (mS/m)	8.3
TDS (mg/l)	54.0
DO (mg/L)	7.32
DO (% sat)	101.8
Temp (℃)	27.0

RWQO Ncandu River (DWS, 2022)	
pH	6.5 – 9.0
TDS (mg/l)	≤ 350
TWQR (DWAF, 1996)	
DO % Sat	80 – 120%

Water Quality Comments:

- The pH value measured during the assessment did not comply with the RWQO (DWS, 2022), however at 6.25 no significant impact on the aquatic ecology is considered likely;
- The TDS concentrations complied with the guideline limits required by the RWQO (DWS, 2022);
- The DO saturation was considered adequate and complied with the target water quality requirements (DWAF, 1996);
- Temperature was considered largely natural considering diurnal variation and the time of day of the assessment; and
- Overall, the water quality of this section of the unnamed tributary was considered fair.

Index of Habitat Integrity

Instream IHI – 78.7 (Category B/C)	**Riparian IHI –** 80.7 (Category B/C)

The system is moderately affected by instream impoundments and flow modification. Some erosion evident at several points along the embankment. Alien vegetation encroachment is evident in the whole study area. Some sedimentation and algal proliferation observed on instream rocks.

Aquatic macro-invertebrate community integrity

Invertebrate community assessment (SASS5 and IHAS)

SASS5 score	57
ASPT score	4.75
IHAS score	70 (Good)
MIRAI score	43.9 (Category D)

Macro-Invertebrate Community Integrity Comments:

- The aquatic macro-invertebrate community integrity was classified as a Category D (Largely Modified) condition according to the MIRAI EcoStatus tool;
- The aquatic community was considered largely tolerable with moderately sensitive taxa limited to Hydraenidae. The taxa observed on site had a diverse preference for vegetation and GSM with various airbreathers (eight taxa) ranging from low to moderate water quality preferences;
- The habitat suitability was considered poor at the time of the assessment, with limited biotope diversity present due to the nature of the impoundment.

Fish Community Assessment

FRAI Score	59.7 (Category C/D. Moderately to Largely Modified)

As with sites NC4 and NC5, site NC3 is located in a system modified by instream impoundments. Alien invasive species *M. salmoides* was caught on site, which is expected to limit the occurrence of indigenous species, as they are likely to be preyed upon or outcompeted. Largemouth bass is considered a Category 3 invasive species in all rivers according to NEMBA.

Riparian Vegetation Response Assessment Index

VEGRAI score	
91.4 (Category A/B)	Some alien vegetation encroachment present in the study area. Alien vegetation species include: *Acacia mearnsii, Eucalyptus cinerea, Eucalyptus globulus, Jacaranda mimosifolia, Melia azedarach, Pinus sp., Populus alba, Ricinus communis, Quercus robur, Salix babylonica, Solanum mauritianum.*

Key Drivers of System Change

- Impacts on the hydraulic processes and geomorphological processes due to the effects of instream impoundments.

5.2 Ecological Importance and Sensitivity Assessment

As with the derived aquatic ecological category, the Ecological Importance and Sensitivity (EIS) method (DWAF, 1999) was applied to the Icawa River, Machini River and unnamed tributaries of the Ncandu River to ascertain the sensitivity and importance of the system taking into account the instream component. The results of the assessment are presented in the table below:

Table 20: Results of the EIS assessment for the various tributaries within the study area.

Tributaries represented by sites:	NC1 – NC2 (Icawa River)	NC4 (Machini River)	NC5	NC3
Biotic Determinants	**Score**			
Rare and endangered biota	1	1	1	1
Unique biota	1	1	1	1
Intolerant biota	2	1	1	1
Species/taxon richness	2	2	2	2
Aquatic Habitat Determinants				
Diversity of aquatic habitat types or features	3	1	1	2
Refuge value of habitat type	2	2	2	2
Sensitivity of habitat to flow changes	2	2	2	2
Sensitivity of flow-related water quality changes	2	2	2	2
Migration route/corridor for instream and riparian biota	2	1	1	1
Nature Reserves, Natural Heritage sites, Natural areas, PNEs	4	4	4	4
RATINGS	**2**	**1.5**	**1.5**	**2**
EIS CATEGORY	**Moderate**	**Moderate**	**Moderate**	**Moderate**

The Ecological Importance and Sensitivity (EIS) assessment analysis of each tributary was considered of **moderate importance and sensitivity**. Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.

6 LEGISLATIVE REQUIREMENTS, NATIONAL AND PROVINCIAL GUIDELINES PERTAINING TO THE APPLICATION OF BUFFER ZONES

According to Macfarlane *et al.* (2015) the definition of a buffer zone is variable, depending on the purpose of the buffer zone. However, in summary, it is considered to be "a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another". Buffer zones are considered important to provide protection of basic ecosystem processes (in this case, the protection of aquatic and wetland ecological services), reduce impacts on water resources arising from upstream activities (e.g. by removing or filtering sediment and pollutants), provision of habitat for aquatic and wetland species as well as for certain terrestrial species, and a range of ancillary societal benefits (Macfarlane *et. al,* 2015). It should be noted, however, that buffer zones are not considered to be effective mitigation against impacts such as hydrological changes arising from stream flow reduction, impoundments or abstraction, nor are they considered to be effective in the management of point-source discharges or contamination of groundwater, both of which require site-specific mitigation measures (Macfarlane *et. al,* 2015).

The definition and motivation for a regulated zone of activity for the protection of the freshwater ecosystems can be summarised as follows:

Table 21: Articles of Legislation and the relevant zones of regulation applicable to each article.

Regulatory authorisation required	Zone of applicability
Water Use License Application in terms of the National Water Act, 1998 (Act No. 36 of 1998).	**Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the National Water Act, 1998 (Act No.36 of 1998)** In accordance with GN509 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998), a regulated area of a watercourse in terms of water uses as listed in Section 21(c) and 21(i) is defined as: • the outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; • in the absence of a determined 1 in 100-year flood line or riparian area the area within **100 m from the edge of a watercourse** where the edge of the watercourse is the first identifiable annual bank fill flood bench; or • a **500 m radius from the delineated boundary** (extent) of any wetland or pan in terms of this regulation. **Government Notice 704 Regulations as published in the Government Gazette 20119 of 1999 as it relates to the National Water Act, 1998 (Act 36 of 1998) regarding the use of water for mining and related activities aimed at the protection of water resources.** These Regulations were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining. It is recommended that

Regulatory authorisation required	Zone of applicability
	the proposed mining activities comply with Regulation GN 704 of the National Water Act, 1998 (Act No. 36 of 1998) which contains regulations on use of water for mining and related activities aimed at the protection of water resources. GN 704 states that: *No person in control of a mine or activity may:* *(a) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;* • According to the above, the activity footprint must fall outside of the 1:100 year floodline of the aquatic resource or 100m from the edge of the resource, whichever distance is the greatest.
Listed activities in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) EIA Regulations (2014), as amended must be taken into consideration if any activities (for example, access roads) are to take place within the applicable zone of regulation. This must be determined by the EAP in consultation with the relevant authorities.	**Activity 12** of Listing Notice 1 (GN 327) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) EIA regulations, 2014 (as amended) states that: *The development of:* *(xii) Infrastructure or structures with a physical footprint of <u>100 square meters</u> or more;* *Where such development occurs—* *a) Within a watercourse;* *b) In front of a development setback; or* *c) If no development setback has been adopted, within **32 meters of a watercourse**, measured from the edge of a watercourse.*
Biodiversity Impact Assessment Handbook for KwaZulu-Natal (Draft) (Ezemvelo KZN Wildlife, 2010)	The biodiversity assessment must comply with the minimum requirements as stipulated by Ezemvelo Biodiversity Guidelines (2010) and must contain the following information: ➢ Rules for buffer zone widths are as follows: ➢ 20 m from the 1: 100-year floodline for rivers/streams; ➢ **30 m from the edge of the riparian zone for rivers/streams; and** ➢ **30 m from the outer edge of the temporary zone of the wetland.**

These zones of regulation must be taken into consideration during any future planning processes, including planning for the necessary enviro-legal authorisation applications and development of the Environmental Management Programme, in line with the mitigation hierarchy as advocated by the Department of Environmental Affairs (DEA) *et. al*, 2013. It is however acknowledged that linear developments (such as powerlines, access roads, and conveyors) may need to traverse the delineated freshwater ecosystems and therefore cannot be entirely excluded from the applicable zones of regulation. The relevant authorisations will need to be obtained prior to the commencement of any activities. The freshwater ecosystems and their applicable zones of regulation in terms of NEMA and the NWA (GN704 and GN509) are conceptually depicted in Figure 25 and 26. The Figure 27 that follows indicates the NFEPA 1km recommended buffer applicable to all FEPA wetlands in the focus area.

The zones of regulations were also applied to the relic wetland systems given that these areas are still found to be saturated at and near the surface and considered to be important in terms of hydropedological drivers (i.e., interflow soil) in the landscape supporting the functional wetland areas (Zimpande Research Collaborative, 2023).

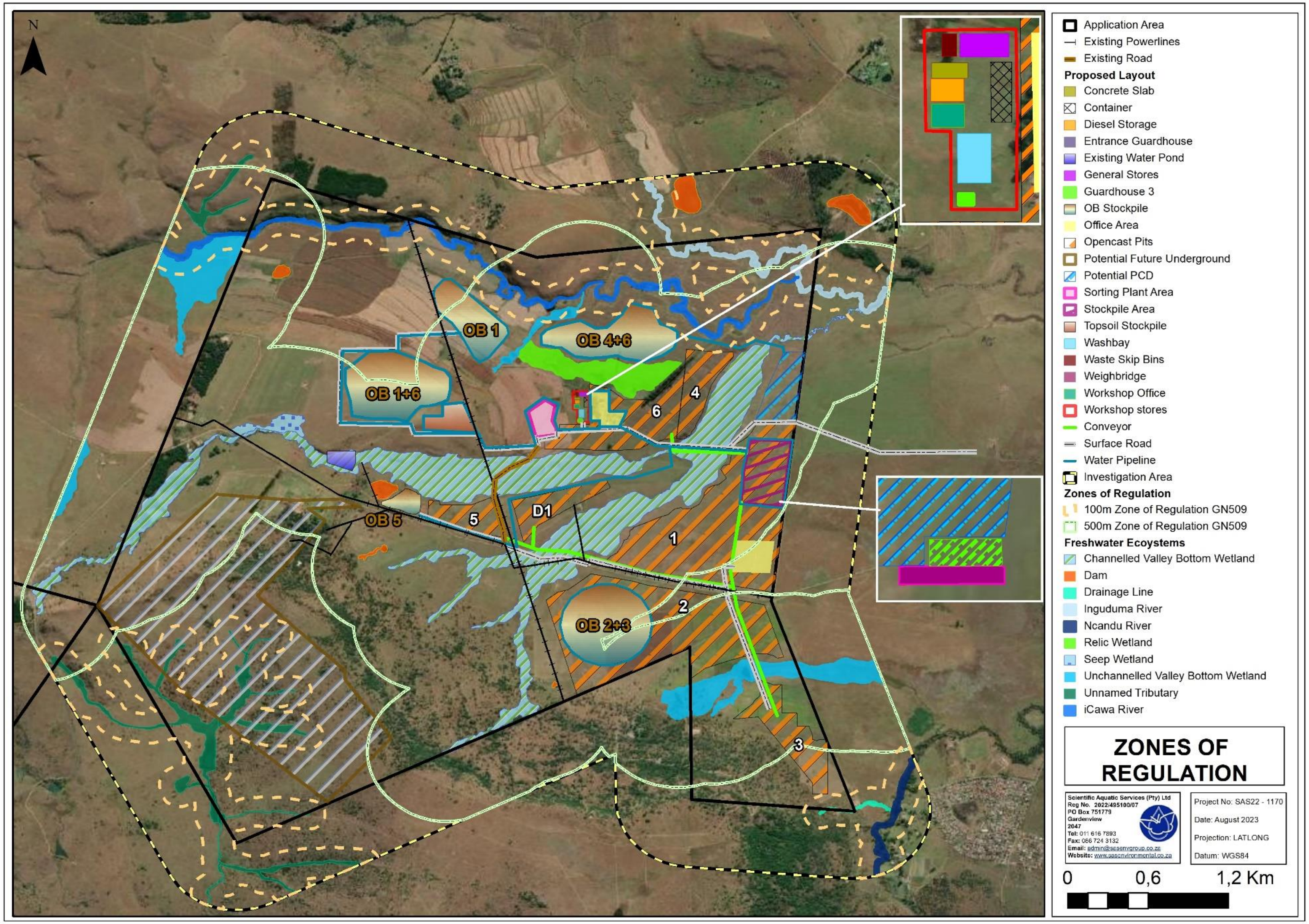


Figure 25: Conceptual presentation of the zones of regulations in terms of GN509 zones of regulation in relation to the proposed Newcastle colliery layout.

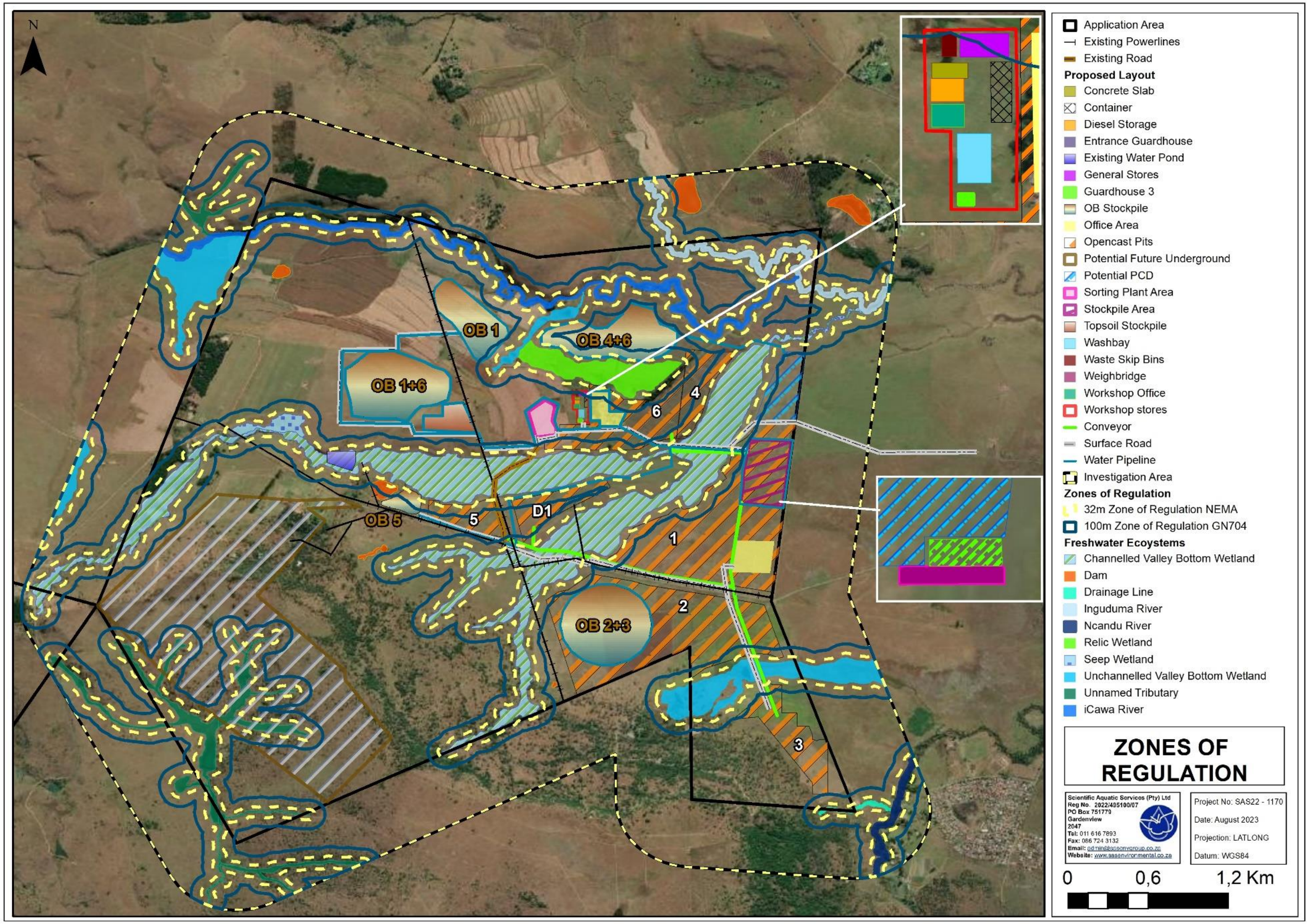


Figure 26: Conceptual presentation of the zones of regulation in terms of NEMA and GN704 of 2016 as it relates to the National Water Act. 1998 (Act No. 36 of 1998).

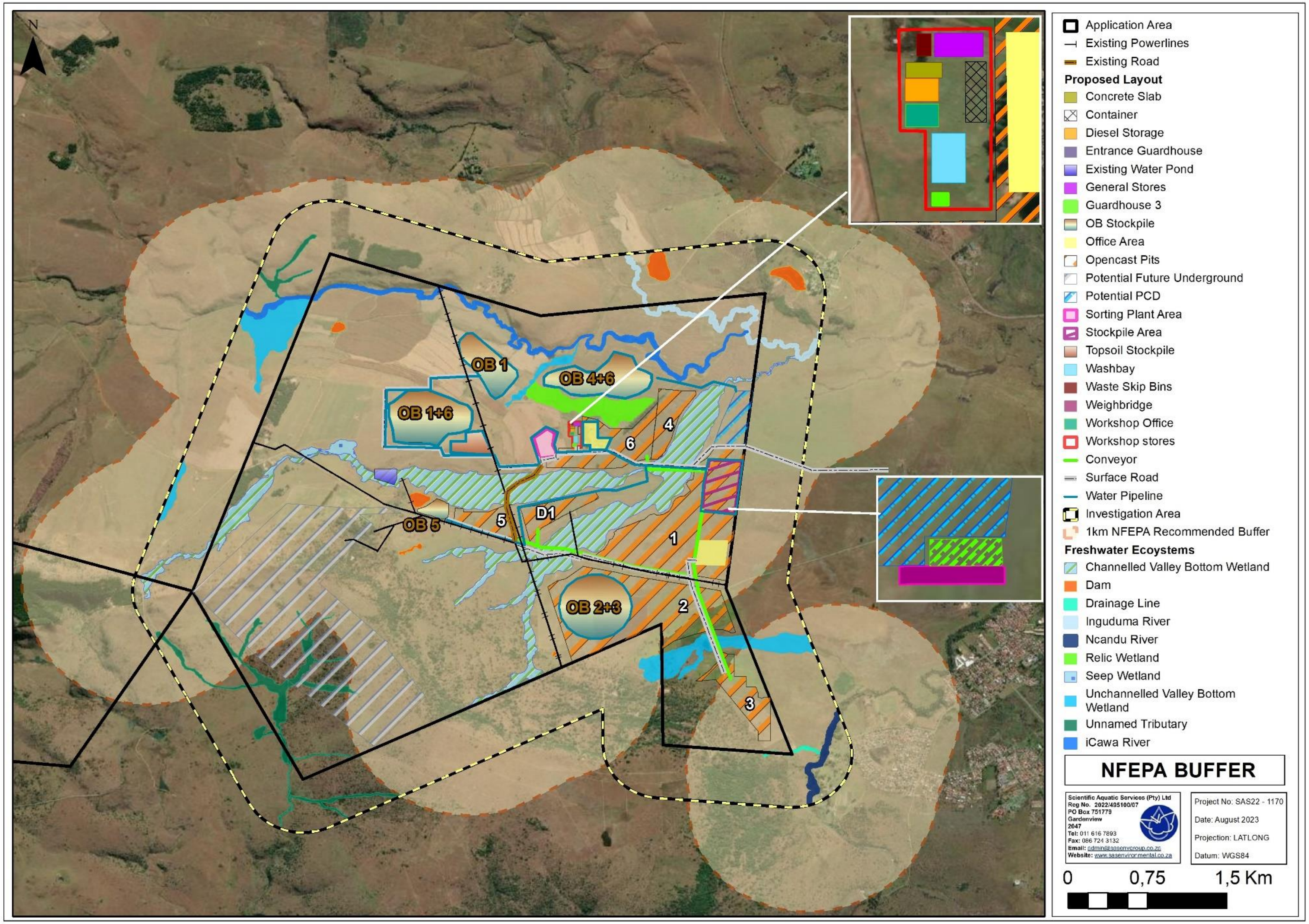


Figure 27: Conceptual presentation of the 1km NFEPA recommended buffer.

7 INTEGRATED FRESHWATER AND AQUATIC ECOLOGICAL IMPACT ASSESSMENT

This section presents the significance of potential impacts on the wetlands, and the riverine systems associated with the proposed Newcastle colliery. When evaluating the perceived impacts of the activities associated with the proposed project, the impact significance was ascertained based on the assumption that the recommended mitigation measures will be implemented, to reduce the risk significance. During the compilation of the impact assessment, no detailed information regarding the construction methods for the infrastructure associated with the mining activities was provided by the proponent. The proponent indicated that the method of mining would be rollover mining. Linked to this, the recommendations provided in the report were based on the available layout at the time.

In addition, the impact assessment also provides mitigatory measures pertaining to construction methods, construction sequencing as well housekeeping management and monitoring approaches. Should there be changes in the layout in future or should additional detailed information on construction methods become available, the impact assessment may need to be revised. The impact assessment is based on a revised conceptual layout which considered the findings of the freshwater ecological assessment and which has reduced encroachment of the freshwater systems to avoid and minimise overall impact significance on these systems.

The photographs below show the general landscape associated with the proposed Newcastle colliery (Figure 28).

Figure 28: Representative photographs of the landscape associated with the proposed Newcastle Colliery.

7.1 Impact Assessment Analysis

There are four key ecological impacts on the freshwater systems that are anticipated:

- Changes to the wetlands and riverine systems leading to the loss of habitat;
- Modification of hydrological function and water quality of the wetlands and riverine systems;
- Changes to the wetlands and riverine systems geomorphological processes and sedimentation; and
- Impacts on the wetlands and riverine systems leading to the loss of biota.

Various activities and development aspects may lead to these impacts, however, these impacts can be adequately minimized or avoided provided the mitigation measures provided in this report are implemented and adhered to.

The impact assessment was divided into broad categories of the various type of infrastructure/nature of activities associated with the proposed Newcastle colliery. These were categorised as follows:

- **Linear Infrastructure:**
  - Access roads (construction and upgrade of existing surface roads); Haul roads; conveyors; water pipelines.
- **Surface infrastructure:**
  - Diesel storage areas, general houses, workshop offices/stores, offices areas including ablution facilities and weigh bridge areas.
- **Process water infrastructure:**
  - Pollution Control Dam (PCD) balancing dam and potential process water related infrastructure.
- **Stormwater related infrastructure:**
  - Stormwater related infrastructure includes in-pit sumps, berms, culverts, trapezoidal channel and cut-off trench (The location of the infrastructure at the time of the compilation of the impact assessment was not confirmed, therefore it was assessed at a high level considering initial layouts).
- **Other infrastructure:**
  - Mining pits, overburden stockpiles and stockpile areas (in-pit RoM and sorting plant area).

It should be noted that the field assessment, data gathering and data analyses as well as reporting was based on the initial conceptual layout (November 2022) received by the EAP for the Newcastle Colliery project. However, the impact assessment provided in this section of the report is based on a more optimised conceptual layout received in August 2023 (Figure 29). Once the mine layout is finalized, it may be necessary that the impact assessment must be amended. The need for amendment will depend on the degree of amendment of the layout subsequent to this iteration of the concept layout.

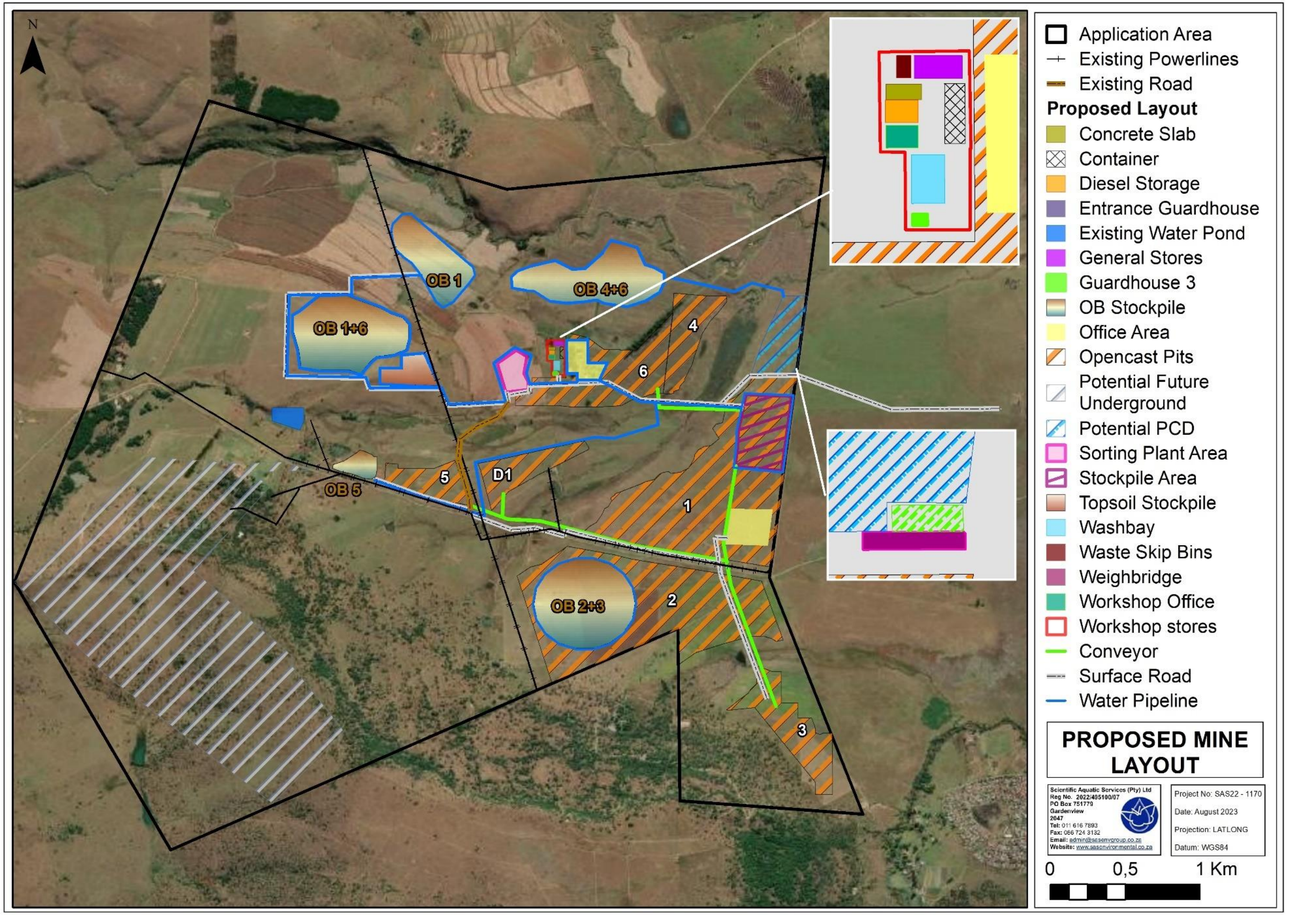


Figure 29: Conceptual mine layout (August 2023).

Table 22: Summary of the impact assessment conducted for the proposed Newcastle colliery activities for the Pre-construction Phase.

<table>
<tr><td colspan="8">ACTIVITY 1: Site preparation prior to commencement of construction activities associated with the proposed Newcastle colliery.</td></tr>
<tr><td colspan="8">Aspects include:
➢ Proposed mine layout (provided August 2023) footprint indicates that mine pits will avoid encroaching within the delineated wetlands. Some linear infrastructure however such as access roads, water pipelines and stormwater channels will encroach within some delineated wetlands (e.g., seep wetland and CVB wetland);
➢ No infrastructure will encroach on the delineated rivers within the focus area.

Potential impacts associated with site clearing prior to commencement of construction activities related to the proposed Newcastle colliery activities:
➢ Loss of catchment yield and surface water recharge due to separation of clean and dirty water areas, loss of biodiversity, sedimentation, impaired water quality.
➢ The wetland systems associated with the study area are largely supported by soils characterised by interflow processes and the predicted losses are anticipated to be of a high significance (a quantification of hydropedological losses will be confirmed upon completion of the hydropedological modelling process).</td></tr>
<tr><td></td><td>Probability</td><td>Sensitivity of the Aspect</td><td>Severity of the Impact</td><td>Duration</td><td>Scale / Extent</td><td colspan="2">Significance (without Mitigation)</td></tr>
<tr><td>Without mitigation</td><td>Definite
5</td><td>Very Sensitive
4</td><td>Moderate to High
4</td><td>Medium Term
3</td><td>Local
3</td><td>70</td><td>High</td></tr>
<tr><td colspan="8">Essential mitigation measures:
➢ The current mine layout has been optimised since the initial layout provided at the inception of the project (November 2022). The layout considers recommendations made in the initial freshwater and aquatic reports to avoid and minimise impacts. The final layout indicates that the mine pits will not encroach within the delineated wetlands and the impact on the wetlands is reduced in relation to the impact posed by the original layout.
➢ However, given the potential impacts associated with open cast mining in the landscape, it is the opinion of the specialist that mining underground identified resources and setting aside shallow resources to avoid open cast mining will significantly reduce potential impacts in the sensitive landscape and this is considered the most appropriate mining approach from a freshwater resource management point of view and the appropriateness of this strategy and setting aside of the shallower resources should be considered by the EAP, proponent and authorities in the decision making process;
➢ Recommendations in accordance with GN704 with regards to placement of infrastructure within regulated areas must be adhered to during the planning process for the proposed Newcastle Colliery;
➢ In terms of the underground or open cast mining, the regulations stipulate that no activities should be carried out within the 1:50-year floodline;
➢ Prior to site clearing and bulk earthworks, it is critical that stormwater management infrastructure development is conducted, and that clear separation of operational and non-operational areas (Clean and dirty water areas) takes place as the first part of development;
➢ Storage facilities and all other non-essential activities (e.g., contractor laydown area) must be located outside the extent of the riverine systems and wetlands and at a minimum outside of the 32m zone of regulation and in areas that are not deemed to be hydropedologically active;
➢ Construction personnel must be informed that all litter and waste must be disposed of immediately and only in closed dustbins and demarcated waste disposal facilities. Training on general good construction principles must be held with the construction personal. This training must elucidate important subjects such as litter, waste management, alien and invasive species and general environmentally friendly and water wise principles that need to be maintained throughout the construction phase of the project; and
➢ It is recommended that baseline hydro-chemical analysis of the surface and groundwater be conducted prior to construction. Proposed surface and groundwater monitoring sites including recommended monitoring frequency in the hydrological report must be used.</td></tr>
<tr><td>With mitigation</td><td>Highly Probable
4</td><td>Very Sensitive
4</td><td>Moderate to High
4</td><td>Medium Term
3</td><td>Local
3</td><td>56</td><td>Moderate</td></tr>
</table>

Table 23: Summary of the impact assessment conducted for the proposed Newcastle colliery activities associated with the Construction Phase for the linear infrastructure (Access roads, haul roads and conveyors).

ACTIVITY 2: Ground-breaking, excavations and other earthworks related to construction and installation of linear infrastructure (Access roads, haul roads, conveyors).

Aspects include:

- *Increased likelihood of dust generation;*
- *Excavation to facilitate preparation of the road base layers and for preparation of culverts within delineated wetlands;*
- *Movement of construction equipment/vehicles within the applicable freshwater ecosystems and 32 m thereof;*
- *Mixing and casting of concrete for construction purposes; and*
- *Removal of topsoil and creation of soil stockpiles.*

Potential impacts associated with the construction and installation of linear infrastructure related to the proposed Newcastle colliery activities:

- *Direct impacts on delineated wetlands;*
- *Increased likelihood of dust generation;*
- *Loss of wetland ecological integrity and ability to provide ecological services;*
- *Proliferation of alien and invasive plant species within the wetlands where construction of access roads are proposed;*
- *Loss of hydrological connectivity between the downgradient and upgradient portions of the wetland where construction of access roads is proposed;*
- *Altered runoff patterns within the local catchment of the watercourses, potentially leading to increased erosion and sedimentation of the watercourses;*
- *Incision and erosion of the wetland due to construction of wetland crossing; and*
- *Increased sedimentation of wetland habitat, leading to smothering of flora and benthic biota and potentially further altering surface water quality.*

	Probability	Sensitivity of the Aspect	Severity of the Impact	Duration	Scale / Extent	Significance (without Mitigation)	
Without mitigation	Definite	Very Sensitive	Moderate to High	Long Term	Local	75	High
	5	4	4	4	3		

Essential mitigation measures:

- All development footprint associated with the linear infrastructure within the wetlands must remain as small as possible and vegetation clearing to be limited to what is essential for the infrastructure;
- Storage facilities and other non-essential activities (e.g. contractor laydown area) must be located outside the freshwater environment and 32 m NEMA regulated zone to minimise surface contamination and impacts relating to sedimentation;
- Impacts associated with potential instream impeding and flow diversion due to construction activities will require the following mitigation:
  - Instream diversion should be done in a phased manner, in half width sections of the watercourse.
  - Ensure that any diversion of instream flow does not result in a significant water level difference upstream or downstream of the installation site.
- It must be ensured that sediment control devices are in place prior to the start of the excavation activities, and these must be maintained in order to minimise the risk of sedimentation to the freshwater habitat;
- All exposed soil must be protected for the duration of the construction phase with a suitable geotextile (e.g., Geojute or hessian sheeting) in order to prevent erosion and sedimentation of the freshwater habitat which may be located in close proximity to the stockpiles;
- It is highly recommended that a Soil Management Plan be developed by a suitably qualified soil scientist and implemented to aid in the conservation of soils. Excavated top-soil should not be contaminated, and it should be ensured that the minimum surface area is taken up with topsoil stockpiles not exceeding 2m in height. This material can later be used in conjunction with overburden material for purposes of backfilling;;
- During excavation activities, any topsoil as well as the vegetation (should any indigenous vegetation be present) that may need to be removed must be stockpiled outside of the delineated freshwater ecosystems and associated buffer zones;

- It must be ensured that adequate flow connectivity between the upstream and downstream portions of the wetlands to be crossed is maintained during the construction activities for the road crossings. The pioneering layer and/or number of low flow culverts installed (whichever is applicable) must ensure that water flows downgradient without any risk of back flooding and ensures that appropriate wetting of the full extent of the downgradient wetlands takes place; and
- For the conveyors, it must be ensured that support towers are spaced in such as a way that encroaching within the wetlands is avoided and at a minimum the applicable 32m zone of regulation;
- It is recommended that adequately sized culverts be used for the haul road in order to ensure that flow from the surrounding landscape is redirected to the downgradient reaches of the freshwater habitat in a diffused manner. The design of the culverts must also ensure that it allows for adequate space suitable for migration of faunal species; and
- It is recommended that baseline hydro-chemical analysis of the surface and groundwater be conducted prior to construction. During this period, water quality be measured every two weeks. The monitoring parameters including monitoring frequency are further discussed in detail in Section 8 (Freshwater Monitoring Programme) of the report.

Control measures specific to concrete works:

- Fresh concrete and cement mortar should not be mixed near the freshwater ecosystems. Mixing of cement may be done within the construction camp, however, may not be mixed on bare soil, and must be within a lined, bound or bunded portable mixer. Consideration must be given to the use of ready-mix concrete;
- No mixed concrete shall be deposited directly onto the ground within the freshwater ecosystems (outside of the designated area) or associated riparian habitat. A batter board or other suitable platform/mixing tray is to be provided onto which any mixed concrete can be deposited whilst it awaits placing;
- A washout area should be designated outside of the freshwater systems, and wash water should be treated on-site or discharged to a suitable sanitation system;
- Cement bags must be disposed of in the demarcated hazardous waste receptacles and the used bags must be disposed of through the hazardous substance waste stream; and
- Spilled or excess concrete must be disposed of at a suitable landfill site. Chain of custody documentation must be provided.

With mitigation	**Probable**	**Very Sensitive**	**Moderate to High**	**Medium Term**	**Local**	**42**	**Moderate**
	3	**4**	**4**	**3**	**3**		

Table 24: Summary of the impact assessment conducted for the proposed Newcastle colliery activities associated with the Construction Phase for the stormwater related infrastructure (PCD, in-pit sumps, culverts, trapezoidal channel, cut-off trenches, and berms).

ACTIVITY 3: Ground-breaking, excavations and other earthworks related to installation of the stormwater related infrastructure
Aspects include: ➢ *Construction activities upgradient of the delineated wetlands;* ➢ *Removal of topsoil and creation of soil stockpiles;* ➢ *Movement of construction equipment/vehicles within the applicable wetland and 32 m thereof;* ➢ *Movement of construction equipment/vehicles within the riparian zone and 32 m thereof;* ➢ *Mixing and casting of concrete for construction purposes; and* ➢ *Increased likelihood of dust generation due to exposed soil.* **Potential impacts associated with the installation of stormwater related infrastructure related to the proposed Newcastle colliery:** ➢ *Increased flood peaks as a result of formalisation and concentration of surface runoff in clean water diversion structures;* ➢ *Loss of catchment yield resulting from dirty water area stormwater containment, leading to reduced volume of water entering freshwater environment;* ➢ *The geohydrological data further indicates that the mean baseflow losses for the Newcastle Colliery will be 20% depending on the stage of the operational phase;* ➢ *The wetland systems associated with the study area are largely supported by soils characterised by interflow processes and the predicted losses are anticipated to be of a high significance (a quantification of hydropedological losses will be confirmed upon completion of the hydropedological modelling process);* ➢ *Reduction in volume of water entering the freshwater ecosystems, leading to loss of recharge;* ➢ *Compaction of soil as a result of movement of construction equipment leading to formation of preferential flow paths;*

<table>
<tr><td colspan="8">

- *Smothering of wetland and aquatic habitat and loss of biota due to increased sedimentation;*
- *Loss of wetland habitat and decreased ecoservices provision.*

</td></tr>
<tr><th></th><th>Probability</th><th>Sensitivity of the Aspect</th><th>Severity of the Impact</th><th>Duration</th><th>Scale / Extent</th><th colspan="2">Significance (without Mitigation)</th></tr>
<tr><td rowspan="2">Without mitigation</td><td>Definite</td><td>Very Sensitive</td><td>High</td><td>Long Term</td><td rowspan="2">Site
2</td><td rowspan="2">75</td><td rowspan="2">High</td></tr>
<tr><td>5</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td colspan="8">Essential mitigation measures:</td></tr>
<tr><td colspan="8">

- The current conceptual layout (August 2023) does not indicate the location of infrastructure such as culverts, trapezoidal channel, cut-off trenches, and berms since this was not finalised at the time of the assessment. Therefore, this was assessed based on previous mine layouts provided during the inception of the project. Once the location of the various infrastructure has been finalised, the impact assessment and scoring may need to be revised;
- Where stormwater outlets are planned, the stormwater outlet should be constructed making use of appropriate energy dissipating structures (such as inert rock, Armorflex or reno mattresses) to reduce the velocity of water outflow;
- Clear separation of operational and non-operational areas must take place prior to installation of stormwater management infrastructure. All development footprint areas to remain within the approved footprint and vegetation clearing is to be limited to what is essential for the proposed stormwater related infrastructure (i.e. infrastructure footprint and essential working areas around the footprint). For the linear infrastructure such as the trapezoidal channel and cut-off trenches, it is recommended that no more than 5 m on either side be disturbed to limit disturbance of the applicable wetland and riverine system;
- Sediment control devices must be in place prior to the start of the excavation activities. This must include dust suppression measures which must be applied to restrict the airborne dissemination of fine particles which may lead to impacts on wetland habitat and functionality. Trenching must be done in a phased manner to minimise the time where soil is left exposed and vulnerable to wind erosion;
- Excavations for the stormwater related infrastructure must only be conducted immediately before the infrastructure such as culverts, pipelines and channels are installed to limit duration of impacts;
- All topsoil stockpiles should not exceed 2 m in height and material excavated from the trench can be stockpiled temporarily directly next to the trench;
- Stockpiling of removed materials may only be temporary (may only be stockpiled during the period of construction at a particular site); and
- All culverts associated with the development must be maintained in operational order and it must be ensured that no back flooding or blockages occur, especially after a heavy rainfall event. In the event of blockages or failed infrastructure, a suitable waste removal plan must be put in place to attend to the removal of blockages efficiently and timeously.

In terms of the construction associated with the PCD, the following mitigation measures are recommended:

- Design of the process water related infrastructure must be environmentally and structurally sound and all possible precautions taken to prevent contamination of surface water;
- It must be ensured that the PCD balancing dam is located outside of the 1:100-year floodline and the applicable zones of regulation in line with regulatory requirements under GN704 and so as to ensure appropriate buffers from sensitive wetlands and rivers;
- The dirty water systems should be adequately sized as per the GN704 Regulatory Requirements, to prevent failure thereof and ultimately, discharge of contaminated water into the freshwater ecosystems. Sufficient operational surge capacity, in addition to anticipated flood volumes must be catered for to ensure that spills are prevented;
- The associated Pollution Control Dam (PCD) must have capacity to cater for a 1:50 year flood occurring over a 24-hour period and the PCD must be lined with an appropriate HDPE liner to be specified by an appropriately qualified engineer. All clean and dirty water management infrastructure (as required of GN704) must be implemented as the first structure components to be developed and prior to any further construction works.

Given that the land use activity in the area will be mining/industrial in nature it is recommended that the following mitigation measures be applied:

- Uncontaminated water must be confined to the clean water system and separated from dirty water; and
- Water associated with processes considered dirty water must be collected, kept within dirty water area or pollution control dam, and not discharged into the receiving freshwater environment.

</td></tr>
<tr><td rowspan="2">With mitigation</td><td>Highly Probable</td><td>Very Sensitive</td><td>Moderate</td><td>Medium Term</td><td rowspan="2">Site
2</td><td rowspan="2">48</td><td rowspan="2">Moderate</td></tr>
<tr><td>4</td><td>4</td><td>3</td><td>3</td></tr>
</table>

Table 25: Summary of the impact assessment conducted for the proposed Newcastle colliery activities associated with the Construction Phase for the surface infrastructure (wash bays, workshop stores, office areas, diesel storage areas and stockpile areas).

<table>
<tr><td colspan="8">ACTIVITY 4: Construction activities associated with the proposed surface infrastructure (crushing and screening plants, offices including ablution facilities and proposed workshops).</td></tr>
<tr><td colspan="8">Aspects include:
➢ Site clearing, removal of vegetation and associated disturbance to soil within the construction footprint;
➢ Disturbance/ compaction of soils from heavy construction vehicles; and
➢ Excavation of soil within and along the footprint of the infrastructure.

Potential impacts associated with excavation and concrete works for proposed surface infrastructure:
➢ Increased likelihood of dust generation;
➢ Changes to the timing and flood peaks of water moving through the landscape and within the freshwater ecosystems;
➢ Altered drainage patterns due to reduced vegetation cover and increased impermeable surfaces;
➢ Increased risk of loss of catchment yield due to presence of clean and dirty water separation systems;
➢ The wetland systems associated with the study area are largely supported by soils characterised by interflow processes and the predicted losses are anticipated to be of a high significance (a quantification of hydropedological losses will be confirmed upon completion of the hydropedological modelling process);
➢ Loss of foraging and breeding habitat and faunal migratory corridors; and
➢ Proliferation of alien and invasive vegetation species within the footprint areas associated with the proposed surface infrastructure.</td></tr>
<tr><th></th><th>Probability</th><th>Sensitivity of the Aspect</th><th>Severity of the Impact</th><th>Duration</th><th>Scale / Extent</th><th colspan="2">Significance (without Mitigation)</th></tr>
<tr><td rowspan="2">Without mitigation</td><td>Definite</td><td>Very sensitive</td><td>Moderate to High</td><td>Long term</td><td rowspan="2">Local
3</td><td rowspan="2">75</td><td rowspan="2">High</td></tr>
<tr><td>5</td><td>4</td><td>4</td><td>4</td></tr>
<tr><td colspan="8">Essential mitigation measures:</td></tr>
<tr><td colspan="8">➢ It must be ensured that sediment control devices are in place prior to the start of the excavation activities, and these must be maintained to minimise the risk of sedimentation to the freshwater habitat;
➢ All exposed soil must be protected for the duration of the construction phase with a suitable geotextile (e.g., Geojute or hessian sheeting) to prevent erosion and sedimentation of the freshwater habitat which may be located in close proximity to the stockpiles;
➢ Silt/sediment traps are to be used during the construction phase, to limit additional sediment associated with construction activities from reaching the freshwater habitat;
➢ All clean and dirty water management infrastructure (as required according to GN704) must be implemented as the first structures to be developed and prior to any further construction works;
➢ Design of infrastructure should be environmentally and structurally sound and all possible precautions taken to prevent contamination of surface and resources present;
➢ The stormwater management plan must have input from a suitably qualified freshwater specialist to ensure that no contaminants and pollutants that may runoff the hardened surface enter into the receiving freshwater environment;
➢ Adequate stormwater management must be incorporated into the design of the proposed mining project in order to prevent erosion and the associated sedimentation of the freshwater habitat. In this regard special mention is made of:
o Sheet runoff from cleared areas, paved surfaces and access roads needs to be curtailed;
o Water associated with processes considered dirty water must be collected, kept within dirty water area, and not discharged into the receiving freshwater environment.
➢ Where construction activities have taken place, footprint areas must be monitored for alien and invasive vegetation encroachment and all alien vegetation/weeds must be removed according to a suitable alien vegetation control plan.</td></tr>
<tr><td rowspan="2">With mitigation</td><td>Highly Probable</td><td>Sensitive</td><td>Moderate</td><td>Medium Term</td><td rowspan="2">Site
2</td><td rowspan="2">44</td><td rowspan="2">Moderate</td></tr>
<tr><td>4</td><td>3</td><td>3</td><td>3</td></tr>
</table>

Table 26: Summary of the impact assessment conducted for the operation of stormwater infrastructure, surface infrastructure (offices, ablution facilities) including process water related infrastructure (PCD balancing dam and associated process water infrastructure).

ACTIVITY 5: Operation of the process water related infrastructure (PCD balancing dam and associated process water infrastructure).

Aspects include:

- *Potential spills/seepage from process water related infrastructure;*
- *Containment/diversion of all stormwater (clean water) runoff into the clean water system and clean water being released within the downgradient reach of the freshwater habitat;*
- *Increased velocity of water and flood peaks into downstream reaches of freshwater ecosystems as a result of formalisation and concentration of surface runoff.*

Potential impacts associated with operation of process water related infrastructure:

- *Reduction in volume of water entering the freshwater habitat due to the loss of catchment yield created by the formation and management of the dirty water containment areas, leading to loss of recharge and potential desiccation of reaches;*
- *Changes in the vegetation community and structure due to unattended seepage from infrastructure;*
- *Erosion and sedimentation of the riverine habitat beyond the outlet of the clean water trench;*
- *Reduced water quality with specific mention of reduced pH, increased turbidity, increased dissolved salts and potentially introducing toxins, such as heavy metals as well as hydrocarbons into the system due to discharges in large storm events, accidental spills and potential seepage; and*
- *Loss of freshwater biodiversity and taxa including negative changes to aquatic biota community diversity and integrity.*

	Probability	*Sensitivity of the Aspect*	*Severity of the Impact*	*Duration*	*Scale / Extent*	*Significance (without Mitigation)*	
Without mitigation	**Definite** **5**	**Very sensitive** **4**	**Moderate** **3**	**Medium term** **3**	**Local** **3**	**65**	**High**

Essential mitigation measures:

- The associated Pollution Control Dam (PCD) must have capacity to cater for a 1:50 year flood occurring over a 24-hour period in addition to diurnal surge capacity that may be required due to daily mining process cycles;
- It must be ensured that the PCD is managed in a manner that it remains as empty as possible, especially in the wet months of the year to ensure that stormwater retention capacity is maintained and to ensure that no discharge takes place;
- The PCD must be lined with an appropriate HDPE liner to be specified by an appropriately qualified civil engineer. All clean and dirty water management infrastructure (as required of GN704) must be implemented as the first structures to be developed and prior to any further construction works;
- It must be ensured that weekly inspections of all stormwater infrastructure are conducted by an on-site environmental officer. During the inspection data must be recorded including photographic evidence and kept for the purposes of tracking and reporting. A detailed monitoring plan is provided in Section 8 of the report;
- Any spills to be immediately cleaned up and treated accordingly. An emergency spill kit must be available at the plant and must take cognisance that there are freshwater ecosystems in the vicinity of the of the PCD balancing dam and associated process water infrastructure;
- Clean water captured in the clean water system should be discharged into the surrounding freshwater habitat. However, protection against erosion arising from the discharge of clean water must be ensured. Energy dissipating structures should be installed to prevent erosion. Water should also be distributed in a diffuse manner mimicking natural conditions as far as possible to prevent erosion incision and sedimentation;
- Ongoing aquatic biomonitoring should take place. Should any indication appear in the data that the system is suffering harm, appropriate adaptive management should take place to ensure that the impacts to receiving environment are adequately reduced to meet the Resource Quality Objectives for the system;
- Water quality, with special mention of pH, dissolved salts and specific problematic chemical constituents of concern need to monitored on a monthly basis and results used to highlight points and aspects of concern that require adaptive management;
- Management of water quality must be done by monitoring water quality in the rivers in support of Resource Quality Objectives of the region. The development of the infrastructure should not result in cumulative impacts on water quality in the area; and

➢ The toxicological risk to the receiving environment should be determined by using acute toxicity assessment principles. If screening assessments indicate that there is a significant risk to biota, this should be further refined with tests run according to the Direct Estimate of Ecological Effect Potential (DEEEP) Method.							
With mitigation	**Highly Probable** **4**	**Sensitive** **3**	**Moderate** **3**	**Medium Term** **3**	**Site** **2**	**44**	**Moderate**

Table 27: Summary of the impact assessment conducted for the operation of opencast, underground mining and stockpile areas associated with the proposed Newcastle colliery.

ACTIVITY 6: Operation of opencast, underground mining and stockpile areas.							
Aspects include: ➢ *Increasing indirect impacts from surrounding open cast mining activities on wetland habitats and associated terrestrial habitats supporting adjacent wetland and riverine habitats and associated processes;* ➢ *Potential creation and increasing impact due to the formation of a cone of depression in groundwater and hydropedological processes which int turn will impact on wetland structure, function and goods services provision.* ➢ *Seepage of nitrates associated with mine blasting residue;* ➢ *Increased risk of sediment transport in surface runoff from the overburden stockpiles; and* ➢ *Formation of areas of preferential flow in the landscape due to disturbances.* Potential impacts associated with operation of process water related infrastructure: ➢ *Loss of catchment yield resulting from stormwater containment, leading to reduced volume of water entering freshwater environment;* ➢ *The geohydrological data further indicates that the mean baseflow losses during the operation phase of the Newcastle Colliery will be 20% depending on the stage of the operational phase;* ➢ *The wetland systems associated with the study area are largely supported by soils characterised by interflow processes and the predicted losses are anticipated to be of a high significance (a quantification of hydropedological losses will be confirmed upon completion of the hydropedological modelling process);* ➢ *Potential impact of desiccation of freshwater habitats due to impacts on groundwater and hydropedological processes, as a result of loss of recharge due to containment of process water;* ➢ *Increased risk of pollution of surface water and groundwater, potentially affecting the downgradient freshwater ecosystems;* ➢ *Altered water quality, smothering of biota and altered vegetation community composition due to sediment transport;* ➢ *Increased risk of erosion, leading to further altered topography/geomorphology, in turn resulting in altered runoff patterns and formation of preferential flow paths;* ➢ *Potential eutrophication of the receiving environment and resulting in impairment of water quality within the catchment; and* ➢ *Alteration of the hydraulic processes.*							
	Probability	***Sensitivity of the Aspect***	***Severity of the Impact***	***Duration***	***Scale / Extent***	***Significance (without Mitigation)***	
Without mitigation	**Definite** **5**	**Very Sensitive** **4**	**High** **5**	**Long term** **4**	**Local** **3**	**80**	**Significant**
Essential mitigation measures: ➢ The current mine layout has been optimised since the initial layout provided at the inception of the project (November 2022). The layout considers recommendations made in the initial freshwater and aquatic reports to avoid and minimize impacts. ➢ The final layout indicates that the mine pits will not encroach within the delineated wetlands and the impact on the wetlands is reduced in relation to the impact posed by the original layout. ➢ However, given the potential impacts associated with open cast mining in the landscape, it is the opinion of the specialist that mining underground identified resources and setting aside shallow resources to avoid open cast mining will significantly reduce potential impacts in the sensitive landscape and this is considered the most appropriate mining approach from a freshwater resource management point of view and the appropriateness of this strategy and setting aside of the shallower resources should be considered by the EAP, proponent and authorities in the decision making process ;							

- Pollution prevention through infrastructure design, to prevent, eliminate and/or control potential pollution of soils, groundwater and surface water should be implemented; - Implement a monitoring programme to detect and through active management prevent the pollution of soils, surface water and groundwater; - If possible, the overburden stockpiles should be located in areas where it would not impact on any of the local hydrological drivers of the freshwater ecosystems; - Reduce airborne dust during blasting activities through damping dust generation areas with water (although not in sufficient quantities to generate runoff) and use of hessian or brush barrier fences; - A monitoring programme to detect, manage and prevent the pollution of soils, surface water and groundwater, as well as monitoring of the freshwater ecosystems, must be implemented; - Management of water quality must be done by monitoring water quality in the rivers in support of Resource Quality Objectives of the region; - The geohydrological data indicates that decant due to the proposed mine layout will occur and indicates various decant nodes located within and adjacent to the delineated freshwater ecosystems. It is recommended that mitigatory measures as determined by such specialist must be adhered to. The decant zones in relation to the delineated freshwater ecosystems is indicated in the figure below (Figure 30); - Measures to contain and reuse as much water as possible within the mine process water system must be sought, and very strict control of water consumption must take place. Detailed monitoring must be implemented and maintained to ensure that all water usage is continuously optimised; and - Overburden stockpiles should be located in an area where they will not impact on any hydrological features of increased importance within the study area. As such, further refinement of the layout should be considered in order to ensure that significance of potential impacts is reduced.							
With mitigation	**Highly Probable** **4**	**Very Sensitive** **4**	**Moderate to High** **4**	**Long term** **4**	**Local** **3**	**60**	**High**

Table 28: Summary of the impact assessment conducted for the decommissioning phase associated with the proposed Newcastle colliery.

ACTIVITY 7: Decommissioning including the removal of surface infrastructure.							
Aspects include: *Potential further site clearing, removal of vegetation and associated disturbance to soil;* *Movement of equipment/vehicles within the applicable wetland and 32 m thereof;* *Movement of equipment/vehicles within the riparian zone and 32 m thereof;* *Increased likelihood of dust generation due to exposed soil; and* *Compacted soils, latent impacts of vegetation losses.* Potential impacts associated with decommission and removal of surface infrastructure: *Increased likelihood of dust generation;* *Loss of wetland ecological integrity and ability to provide ecological services;* *Proliferation of alien and invasive plant species within the wetlands;* *Increased runoff volumes and formation of preferential surface flow paths as a result of compacted soils and unvegetated areas, leading to increased sedimentation, erosion, and increased water inputs to downgradient wetland and riverine systems;* *Altered runoff patterns within the local catchment of the watercourses, potentially leading to increased erosion and sedimentation of the watercourses; and* *Increased sedimentation of wetland habitat, leading to smothering of flora and benthic biota and potentially further altering surface water quality.*							
	Probability	***Sensitivity of the Aspect***	***Severity of the Impact***	***Duration***	***Scale / Extent***	***Significance (without Mitigation)***	
Without mitigation	**Definite** **5**	**Sensitive** **3**	**Moderate** **3**	**Short to Medium Term** **2**	**Site** **2**	**50**	**Moderate**
Essential mitigation measures:							

➢ Impacts associated with the removal of infrastructure are considered similar to those arising during the construction phase although impacts will be reduced due to the already impacted landscape, as such, mitigatory measures as outlined in the construction phases above must be implemented; ➢ Demolition footprint must be clearly demarcated and no related activities, including the movement of vehicles, must be permitted to occur outside of the already impacted footprint area; ➢ All related waste and rubble must be removed from site and disposed of according to relevant SABS standards. No waste must be permitted to enter freshwater ecosystems; ➢ All areas affected by stockpiling during the operational phase of the mine must be rehabilitated and stabilised to prevent sedimentation of the freshwater ecosystems in the area; ➢ Ensure that soils are replaced in the correct layers, ripped and re-reprofiled post-closure, and that indigenous vegetation is restored to a point where succession will lead to the same conditions as the pre-mining state as a minimum; and ➢ Rehabilitation measures must be implemented. Implementation must be overseen by a suitably qualified Environmental Site Officer (ESO) with freshwater experience and the ESO must sign off the rehabilitation before the relevant contractors leave site.							
With mitigation	**Probable** **3**	**Sensitive** **3**	**Slight to Moderate** **2**	**Short to Medium Term** **2**	**Isolated** **1**	**24**	**Low**
ACTIVITY 8: Aspects and Impacts Associated with Mine Closure.							
Aspects include: ➢ *Decant from mine pit post closure. The geohydrological data indicates that decant due to the proposed mine layout will occur and indicates multiple decant nodes located within and adjacent to the delineated freshwater ecosystems which may make management difficult;* ➢ *Increased risk of pollution of groundwater, potentially leading to the formation of a contaminated groundwater plume, thus possibly affecting the freshwater systems in the vicinity; and* ➢ *Increased risk of sediment transport in surface runoff from the mine areas to freshwater ecosystems, leading to altered water quality and sedimentation.* Potential impacts associated with mine closure: ➢ *Increased risk of pollution of surface water as a result of decant;* ➢ *Increased risk of pollution of groundwater, potentially leading to the formation of a contaminated groundwater plume, which may migrate downgradient of the surface infrastructure, thus possibly affecting the downgradient freshwater ecosystems; and* ➢ *Percolation and mobilisation of contaminants from mine waste areas which are toxic to the receiving aquatic environment.*							
	Probability	***Sensitivity of the Aspect***	***Severity of the Impact***	***Duration***	***Scale / Extent***	***Significance (without Mitigation)***	
Without mitigation	**Definite** **5**	**Sensitive** **3**	**Moderate** **3**	**Medium Term** **3**	**Local** **3**	**60**	**High**
Essential mitigation measures:							
The below mitigation measures are to be assessed by the project engineers, and adapted as required: ➢ Management of water quality must be done by monitoring water quality in the rivers in support of Resource Quality Objectives of the region. ➢ Upon closure, the mine pits are to be backfilled (using material that is geochemically inert). The backfilled areas must be free-draining and ensure that no preferential flow areas are created in order to avoid formation of anthropogenically derived saturation areas in the landscape; ➢ Strict monitoring throughout LOM and post-closure is required in order to ensure the health and functioning of the watercourses is retained and monitoring data must be proactively utilised to identify any emerging issues; ➢ The geohydrological data indicates that decant due to the proposed mine layout will occur and indicates various decant nodes located within and adjacent to the delineated freshwater ecosystems. It is recommended that mitigation measures as determined by such specialist must be adhered to; and ➢ Decant must be treated to the quality as stipulated by the Water Use licence and released to the environment in a controlled manner, mimicking natural conditions. Sufficient budget must be made available to ensure that decant can be treated to the required values until such time as decanting water reaches values that can support the Resource Quality Objectives of the receiving environment.							
With mitigation	**Probable** **3**	**Sensitive** **3**	**Moderate** **3**	**Medium Term** **3**	**Site** **2**	**33**	**Low**

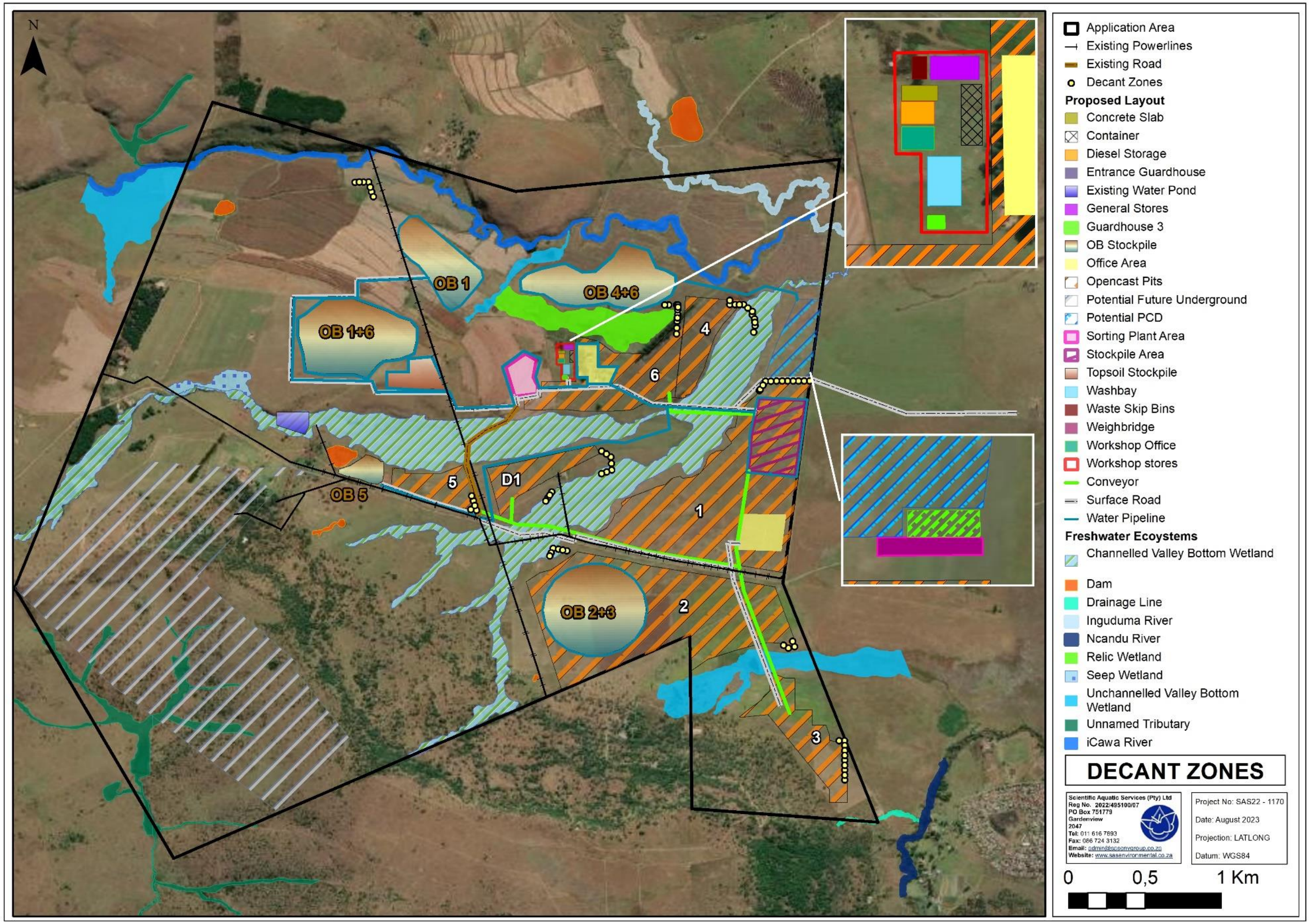


Figure 30: High risk decant zones in relation to the conceptual mine layout and freshwater ecosystems.

7.2 Cumulative Impacts

Cumulative impacts are activities and their associated impacts on the past, present and foreseeable future, both spatially and temporally, considered together with the impacts identified in Section 7.1 above. Freshwater ecosystems within the region are under continued threat due to historical and current agriculture, growing urbanisation and mining activities in the surrounding landscape.

Direct and indirect impacts on freshwater ecosystems within the greater Newcastle areas include agricultural activities, expansive urbanisation, growing mining activities and the development of infrastructure required to support the services. These activities have the resulted in loss of catchment yield, removal of indigenous vegetation, increase sediment runoff into freshwater ecosystems. Impacts on water quality due to the effects of stormwater runoff from build-up areas as well as the impacts from mining and industrial activities and associated loss of sensitive biota is evident. Aquatic and alien invasive species proliferation is also of significant concern. The freshwater ecosystems in the focus area have historically been impacted by cultivation activities and proposed mining activities will further result in direct loss of freshwater habitat, alteration of the natural movement of water in the landscape, changes in water quality and ability to support sensitive biota and increase in AIPs associated with the disturbed area. The impact significance of this is considered high as the focus area forms part of the headwater catchment for larger river systems such as the Ncandu River which are of significant ecological importance for the greater Newcastle area and are hydraulically linked to systems considered strategic water source areas.

In addition to the direct loss of freshwater habitat, the proposed mining activities have the potential to result in the cumulative increase in salt concentration in rivers including toxicants and heavy metals. The biological availability of salts as a result of activities such as blasting has the potential to, over time, alter the species composition of the aquatic biota inhabiting the surrounding rivers particularly especially downstream of the mining areas. Through continued rehabilitation efforts such as long-term alien vegetation management and reinstatement of indigenous vegetation, these cumulative impacts on the freshwater ecosystems can be reduced and the ecological functioning of the systems can be maintained.

8 FRESHWATER MONITORING PROGRAMME

Prudent monitoring of the areas impacted by the proposed mining activities especially in areas where mining infrastructure will result in direct impact on the freshwater ecosystems is required. This will ensure a continual flow of data, enabling all parties involved to accurately assess and manage the progress of the mitigation measures and rehabilitation interventions and any arising issues particularly for the monitoring of water quality on aquatic resources in the vicinity of the mining activities, monitoring of alien and invasive species, water retention and distribution patterns in the landscape. To ensure the accurate gathering of data, the following techniques and guidelines should be followed (Table 29):

Table 29: Proposed Newcastle colliery monitoring and audit programme.

Monitoring method	Roles and Responsibilities	Data collection requirements	Timing and monitoring schedules	Data analyses Procedures	Quality Assurance	Reporting
Aquatic biomonitoring	Appointed River Health Programme (RHP) accredited aquatic ecologist and must also be a SACNASP registered practitioner.	The assessment sites described in Section 5 (Aquatic results) of the report should be used for temporal and spatial comparison.	Monitoring must take place on a biannual basis (once during the wet season and once during dry season).	➢ Habitat Assessments using IHAS and IHIA indices ➢ Aquatic macro-invertebrate community integrity (SASS5 and MIRAI). ➢ Diatom community integrity (SPI).	Accredited aquatic ecologist SACNASP practitioner to compile and sign off report.	For first year prior to construction quarterly assessments to be done. During operation six-monthly monitoring report compiled after every assessment. Surveys should be compared to baseline data in order to determine if any impacts on the aquatic ecosystems are occurring on the subject property. Report must be compiled biannually for all data collected and include mitigation and management actions that are recommended and that are undertaken.
Wetland Monitoring	Appointed freshwater ecologist. Must also a SACNASP registered practitioner.	Wetlands described in Section 4 (freshwater results) of the report.	Monitoring must take place on a biannual basis (once during the wet season and once during dry season).	➢ WET-Health	Accredited freshwater ecologist SACNASP practitioner to compile and sign off report.	Six-monthly monitoring report compiled after every assessment. Surveys should be compared to baseline data in order to determine if any impacts on the freshwater resources are occurring on the subject property. Report must be compiled biannually for all data collected and include mitigation and management actions that are recommended and that are undertaken.
Toxicity monitoring	Appointed suitably qualified specialist.	Once the proposed Newcastle colliery is operational, WET testing must include the process water system at points which contain water which has the potential to come into contact with the receiving environment. Any potential sources of decant or discharge should also be tested. The collection of water samples for toxicological screening on three trophic levels: -*Vibrio fischeri* (representing bacteria), -*Daphnia pulex* (representing aquatic macro-invertebrates), -*Poecilia reticulata* (representing fish)	Testing to take place on a 6-monthly basis in conjunction with the biomonitoring.	SANAS accredited toxicity testing laboratory.	GPS point must be taken at monitoring sites to ensure consistency at the same point. Analysis to be conducted at a SANAS accredited laboratory.	Six-monthly monitoring report compiled after every assessment. Surveys should be compared to baseline data to determine if any impacts on the aquatic ecosystems are occurring on the subject property. Toxicological testing on three trophic levels to be reported on: -Bacteria, -Macro-invertebrates, and -Fish. Once operational, implement the calculation of discharge dilution factors by means of the Direct Estimation of Ecological Effect Potential (DEEEP)

Monitoring method	Roles and Responsibilities	Data collection requirements	Timing and monitoring schedules	Data analyses Procedures	Quality Assurance	Reporting
						protocol if it becomes evident that discharge will take place.
Surface Water quality	Appointed suitably qualified specialist / ECO	Surface water quality monitoring should as a minimum be tested at the upstream and downstream monitoring points associated with the proposed infrastructure. Proposed surface water monitoring sites recommended in the hydrological report must be used. Parameters to be considered have been outlined below: ***In-situ* parameters:** ➢ pH, EC (mS/m), DO (%Sat), DO (mg/l); and TSS (mg/l). **Chemical Parameters:** ➢ Sulphate (mg/l), Nitrate (mg/l), Phosphate(mg/l), Ammonia (mg/l), BTEX, TPH and Faecal Coliforms, Turbidity (NTU) and metals using an ICP scan.	Surface water must be tested monthly.	Laboratory analyses according to the parameters recommended must be undertaken by a SANAS accredited facility. Parameters to be compared to the limits specified by the WUL (once in place) and applicable Resource Water Quality Objectives (RWQOs).	A GPS device must be taken at monitoring sites to ensure consistency at the same point. The samples must be kept cold and delivered to the laboratory within 24 hours. All chain of custody forms must be filed.	Surveys should be compared to baseline data to determine if any impacts on the aquatic ecosystems are occurring on the subject property. Both spatial and temporal data analyses must take place with the percentage of deviation and significance of deviation as well as trends noted. Short memoranda to be submitted after each monthly assessment. Six (6) monthly comprehensive surface water reports to be submitted to the relevant authorities.
Groundwater Quality	Appointed suitably qualified specialist / ECO	Groundwater quality monitoring should be conducted as recommended in the monitoring program specified in the Geohydrology Report. Parameters to be considered have been outlined below: ***In-situ* parameters:** ➢ pH, EC (mS/m), DO (%Sat), DO (mg/l); and TSS (mg/l). **Chemical Parameters:** Sulphate (mg/l), Nitrate (mg/l), and Faecal Coliforms, Turbidity (NTU) and metals using an ICP scan.	Groundwater must be tested quarterly.	Laboratory analyses according to the parameters recommended must be undertaken by a SANAS accredited facility. Parameters to be compared to the limits specified by the WUL (once in place) and applicable Resource Water Quality Objectives (RWQOs).	A GPS device must be taken at monitoring sites to ensure consistency at the same point. The samples must be kept cold and delivered to the laboratory within 24 hours. All chain of custody forms must be filed.	Surveys should be compared to baseline data to determine if any impacts on the aquatic ecosystems are occurring on the subject property. Both spatial and temporal data analyses must take place with the percentage of deviation and significance of deviation as well as trends noted. Short memoranda to be submitted after each assessment. Six (6) monthly comprehensive groundwater reports to be submitted to the relevant authorities.
Alien vegetation monitoring	Removal of the alien and weed species encountered in the application area must take place in order to comply with existing legislation (amendments to the regulations under the CARA, 1983 and Section 28 of the NEMA, 1998). Removal of AIP and weed species should take place throughout the construction and operation, phases in line with an approved AIP Management Plan (STS 2023).					

9 CONCLUSION

Scientific Aquatic Services (SAS) was appointed to conduct a freshwater ecosystem assessment as part the Environmental Impact Assessment (EIA) process for the proposed colliery in Newcastle, in the KwaZulu-Natal Province, hereafter referred to as the "proposed Newcastle colliery". The proposed Newcastle colliery includes the development of mining areas and infrastructure such as: open cast mining pits, stockpile areas, sorting plant area, wash bays, Pollution Control Dam (PCD), linear infrastructure (water pipelines, access roads and conveyors), surface infrastructure (workshop stores/offices, office area, general stores and guardhouse), stormwater management infrastructure (berms, culverts, in-pit sums and cut-off trenches) and proposed future underground mining.

FRESHWATER ECOSYSTEM ASSESSMENT CONCLUSION:

During the assessment, the following freshwater ecosystems were identified within the focus area and potentially at risk from the proposed Newcastle colliery and therefore assessed further as part of this study. These were classified as follows:

Riverine Systems:

- The Inguduma River which flows in a south easterly direction was identified within the north-eastern corner of the focus area. The Inguduma River flows in a south-easterly direction and confluences with the Ncandu River approximately 8 km downstream;
- The Icawa River which flows in an easterly direction and confluences with the Inguduma River was identified north of the eastern focus area;
- Tributaries of the rivers in the focus area were identified and assessed as part of the field assessment; and
- The Ncandu River was also identified outside of the focus area but within the investigation area associated with the proposed Newcastle colliery.

Wetlands:

- Various wetlands were identified within the focus area of the proposed Newcastle colliery, these include: unchannelled valley bottom (UCVB), channelled valley bottom (CVB) and seep wetlands.

The result of the ecological assessment is summarised in Table 30 below.

Table 30: Summary of results of the field assessment as discussed in Section 4.

Freshwater Ecosystem	Present Ecological State (PES) / Ecostatus	Ecoservices	Ecological Importance and Sensitivity (EIS)	Recommended Ecological Category / Recommended Management Objective / Best Attainable State
Inguduma River	Category C (Moderately Modified)	Moderate	High	REC Category: C BAS Category: C RMO: Maintain
iCawa River	Category C (Moderately Modified)	Low to Moderate	Moderate	REC Category: C BAS Category: C RMO: Maintain
Channelled valley bottom (CVB) wetlands	Category C (Moderately Modified)	Moderate to Moderately High	High	REC Category: C BAS Category: C RMO: Maintain
Unnamed tributaries	Category A/B (Unmodified Modified/Largely Natura)	Moderate	Moderately High	REC Category: B BAS Category: B RMO: Maintain/Improve
Unchannelled valley bottom (UCVB) wetlands	Category C (Moderately Modified)	Low to Moderately Low	Moderate	REC Category: C BAS Category: C RMO: Maintain
Seep Wetlands	Category B (Largely natural)	Low to Moderately Low	Low/Marginal	REC Category: B BAS Category: B RMO: Maintain/Improve

AQUATIC ECOLOGICAL ASSESSMENT CONCLUSION:

The aquatic ecological assessment included five sites (NC1 – NC5) located on four different tributaries of the Ncandu River. These sites were chosen to best represent the Present Ecological State (PES) of the aquatic resources located in the eastern portion of the proposed open pit mining component as well as associated proposed infrastructure.

Water quality of all five selected sites was considered good, with largely natural Electrical Conductivity (EC), pH and Dissolved Oxygen (DO) concentrations observed during the site assessment, with only pH falling slightly below the Resource Quality Objectives (RQO) of the Ncandu River (DWS, 2022) at sites NC3 and NC4, and DO saturation falling below the 80 – 120% saturation recommended by the Target Water Quality Recommendations (TWQR) for Aquatic Ecosystems (DWAF, 1996) at site NC5.

Considering the Ecostatus Categories for both sites NC1 and NC2 on the Icawa River, the Instream and Riparian Index of Habitat Integrity (IHI) as well as the Diatom community integrity complied with the RQO of the Ncandu River (DWS, 2022) while the macro-invertebrate community integrity and fish community integrity borderline complied with the Category B/C recommendations. Similarly, the Instream and Riparian IHI and Diatom community integrity Ecostatus Categories at site NC4 complied with the RQO, while the MIRAI Ecostatus did not. At both sites NC5 and NC3, the Instream and Riparian IHI Ecostatus complied with the RQO, while the MIRAI Ecostatus did not.

Overall, the Integrated Ecological Category at sites NC1 and NC2 on the Icawa River as well as site NC3 on an unnamed tributary was classified as a Category C at each site, complying with the Ecological Category to be maintained (Category B/C) for the Ncandu River (DWS, 2022).

OVERALL INTEGRATED FRESHWATER AND AQUATIC ASSESSMENT CONCLUSION:

The current mine layout has been optimised since the initial layout provided at the inception of the project (November 2022). The layout considers recommendations made in the initial freshwater and aquatic reports to avoid and minimize impacts. The final layout indicates that the mine pits will not encroach within the delineated wetlands and the impact on the wetlands is reduced in relation to the impact posed by the original layout. However, given the potential impacts associated with open cast mining in the landscape, it is the opinion of the specialist that mining underground identified resources and setting aside shallow resources to avoid open cast mining will significantly reduce potential impacts in the sensitive landscape and this is considered the most appropriate mining approach from a freshwater resource management point of view and the appropriateness of this strategy and setting aside of the shallower resources should be considered by the EAP, proponent and authorities in the decision making process.

Mining using open cast approach has a high potential to lead to changes to the quality and quantity of flows within the catchment, changing of pattern flow and timing of water in the landscape as well as alteration of the geomorphological regime and water quality supporting the freshwater resources associated with the site due to disturbances in the landscape. In addition, an open cast approach will likely lead to potential significant loss of aquatic biodiversity, freshwater functionality as well as goods and services provision. The significance of the freshwater ecosystems in the area, which form part of an important headwater catchment for larger river systems in the greater Newcastle area and are hydraulically linked to systems which are considered strategic water source areas. this fact must be considered in the planning and application process.

Therefore, as stated above, most appropriate method of freshwater ecological impact mitigation for this project would be that of setting aside the shallower coal and only planning for underground mining where the coal resources are deeper. Where avoidance is not deemed viable given the financial requirements / viability of the project and the need to ensure that mineral resources are extracted optimally and not sterilised, minimisation and mitigation of impacts is considered essential. As such, it is recommended that as far as possible, the current mine layout be minimised to an extent where the operations are still considered financially viable but in such a way to limit impacts to the receiving environment and to limit locations in the landscape to those that will not pose a long-term detrimental risk to the receiving freshwater resources of the region.

REFERENCES

CEMAGREF.1982. Etude des méthodes biologiques quantitatives d'appréciation de la qualité des eaux. Rapport Division Qualité des Eaux Lyon - Agence Financiére de Bassin Rhône-Méditerranée- Corse. Pierre-Benite

Chutter, F. M. (1998). Research on the rapid biological assessment of water quality impacts in streams and rivers. Report to the water research commission by Environmentek, CSIR, WRC report No 422/1/98. Pretoria: Government printer.

Coste M. and Ayphassorho H. 1991. Etude de la qualité des eaux du bassin Artois Picardie à l'aide des communautés de diatomées benthiques (Application des indices diatomiques). Rapport Cemagref Bordeaux – Agence de l'Eau Artois Picardie. 227 pp. [in French]

Dallas, H. F. (2007). River Health Programme: South African Scoring System (Sass) Data Interpretation

Department of Water Affairs and Forestry (1996). *South African Water Quality Guidelines vol. 7, Aquatic ecosystems*

Department of Water Affairs and Forestry (DWAF). (1999). Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems Version 1.0. Resource Directed Measures for Protection of Water Resources, Pretoria, South Africa.

Department of Water and Sanitation (DWS) Resource Quality Services (RQS) PES, EI and ES database for desktop assessment. https://www.dwaf.gov.za/iwqs/rhp/eco/peseismodel.aspx.

Department of Water and Sanitation (DWS). (2022). Proposed water resource classes and resource quality objectives for Thukela catchments in the Pongola-Mtamvuna water management area. Government Gazette No. 46032. March 2022.

Department of Water Affairs and Forestry (DWAF). 2008. *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas,* prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Report no. X. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF). 2005. *Final draft: A practical field procedure for identification and delineation of wetlands and Riparian areas.*

Department of Water and Sanitation (DWS). 2014. *A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Secondary: C2 Compiled by RQIS-RDM: Online available: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx*

Dickens, C. W. S. and Graham, P. M. (2002). *The South African Scoring System (SASS) Version 5 Rapid bio assessment method for rivers.* African Journal of Aquatic Science; 27: 1-10.

Kelly. M.G. and Whitton. B.A. 1995. The Trophic Diatom Index: a new index for monitoring eutrophication in rivers. J. Appl. Phycol. 7(4):433–444.

Kleynhans C.J., Thirion C. and Moolman J. 2005. *A Level 1 Ecoregion Classification System for South Africa, Lesotho and Swaziland.* Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria

Kleynhans C.J., Thirion C., Moolman J, Gaulana L. 2007. *A Level II River Ecoregion Classification System for South Africa, Lesotho and Swaziland.* Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria.

Kleynhans CJ, Louw MD, Graham M. (2008). Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08

Kleynhans CJ, Louw MD, Moolman J. (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kleynhans CJ, MacKenzie J, Louw MD. (2007b). *Module F: Riparian Vegetation Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2).* Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 333/08.

Kleynhans CJ. (2007). Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT330/08.

Kotze D.C., Marneweck G.C., Batchelor, A.L., Lindley D.S. and Collins N.B. 2009*. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands.* WRC Report No TT 339/08, Water Research Commission, Pretoria.

Lecointe, C., Coste, M. and Prygiel, J.1., 1993. “Omnidia”: software for taxonomy, calculation of diatom indices and inventories management. Hydrobiologia, 269(1), pp.509-513.

National Environmental Management Act (NEMA) 107 of 1998

National Water Act (NWA) 36 of 1998.

Macfarlane D.M., Kotze D.C., Ellery W.N., Walters D., Koopman V., Goodman P. and Goge C. 2008. *WET-Health: A technique for rapidly assessing wetland health.* WRC Report No. TT 340/08. Water Research Commission, Pretoria.

Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C. and Dickens, C.W.S., (2015). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Water Research Commission.

McMillan, P. H. (1998): *An Integrated Habitat Assessment System (IHAS v2) for the Rapid Biological Assessment of Rivers and Streams.* A CSIR research project. Number ENV-P-I 98132 for the water resources management programme. CSIR. ii +44 pp.

Nel, JL, Driver, A., Strydom W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J, Nienaber, S., Van Deventer, H., Swartz, E. & Smith-Adao, L.B. 2011. *Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources.* Water Research Commission Report No. TT 500/11, Water Research Commission, Pretoria.

NFEPA: Driver, A., Nel, J.L., Snaddon, K., Murruy, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. and Funke, N. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. Water Research Commission. Report No. 1801/1/11. Online available: http://bgis.sanbi.org/nfepa/project.asp

Ollis, D.J., Boucher, C., Dallas, H.F. and Esler, K. (2006). Preliminary testing of the integrated habitat assessment system (IHAS) for aquatic macroinvertebrates. Southern Africa Journal of Aquatic Science 31 (1) 1-14.

Ollis, D.J., Snaddon, C.D., Job, N.M. & Mbona, N. 2013. *Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems.* SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria.

Rossouw, L., Avenant, M. F., Seaman, M. T., King, J. m., Barker, C. H., du Preez, P. J., Pelser, A. J., Roos, J. C., van Staden, J. J., van Tonder, G. J., and Watson, M. 2005. *Environmental Water Requirements in Non-Perennial Systems.* WRC Report 1414/1/05. Water Research Commission. Pretoria.

Rountree, M.W. and Kotze, D.C. 2013. Appendix A3: Ecological Importance and Sensitivity Assessment. In: Rountree, M. W., Malan, H.L., and Weston, B.C. Eds. *Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0)*. WRC Report No. 1788/1/12. Pretoria. STS 210042.

Scientific Terrestrial Services (STS). 2023. Terrestrial Biodiversity Assessment as Part of the Environmental Application and Planning Process for the Proposed Newcastle Colliery. STS 22-2083.

Taylor. J.C., Harding. W.R. and Archibald. C.G.M. 2007. A methods manual for the collection. preparation and analysis of diatom samples. WRC Project No. K5/1588. Water Research Commission. Pretoria.l

Thirion, C. (2007). *Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2).* Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No.

Van Deventer, H.; Smith-Adao, L.; Mbona, N.; Petersen, C.; Skowno, A.; Collins, N.B.; Grenfell, M.; Job, N.; Lötter, M.; Ollis, D.; Scherman, P.; Sieben, E.; Snaddon, K. 2018. *South African Inventory of Inland Aquatic Ecosystems. South African National Biodiversity Institute, Pretoria. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.*

Van Deventer, H., Smith-Adao, L., Collins, N.B., Grenfell, M., Grundling, A., Grundling, P-L., Impson, D., Job, N., Lötter, M., Ollis, D., Petersen, C., Scherman, P., Sieben, E., Snaddon, K., Tererai, F. & Van der Colff, D. 2019. *South African National Biodiversity Assessment 2018: Technical Report. Volume 2b: Inland Aquatic (Freshwater) Realm. CSIR report number*

CSIR/NRE/ECOS/IR/2019/0004/A. South African National Biodiversity Institute, Pretoria. http://hdl.handle.net/20.500.12143/6230.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. *2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 November 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.*

Zimpande Research Collaborative, *2023***.** *Soil, Land Use And Land Capability Assessment For The Proposed Colliery Near Newcastle In The KwaZulu – Natal Province*. Report Reference: ZRC 22-4040.

APPENDIX A – Terms of Use and Indemnity

INDEMNITY AND TERMS OF USE OF THIS REPORT

The findings, results, observations, conclusions, and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and SAS and its staff reserve the right to, at their sole discretion, modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

Although SAS (Pty) Ltd exercises due care and diligence in rendering services and preparing documents, SAS (Pty) Ltd accepts no liability and the client, by receiving this document, indemnifies SAS (Pty) Ltd and its directors, managers, agents and employees against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by SAS (Pty) Ltd and by the use of the information contained in this document.

This report must not be altered or added to or used for any other purpose other than that for which it was produced without the prior written consent of the author(s). This also refers to electronic copies of this report which are supplied for the purposes of inclusion as part of other reports, including main reports. Similarly, any recommendations, statements or conclusions drawn from or based on this report must make reference to this report. If these form part of a main report relating to this investigation or report, this report must be included in its entirety as an appendix or separate section to the main report.
.

APPENDIX B – Legislation

LEGISLATIVE REQUIREMENTS

The Constitution of the Republic of South Africa, 1996	The environment and the health and well-being of people are safeguarded under the Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996) by way of section 24. Section 24(a) guarantees a right to an environment that is not harmful to human health or well-being and to environmental protection for the benefit of present and future generations. Section 24(b) directs the state to take reasonable legislative and other measures to prevent pollution, promote conservation, and secure the ecologically sustainable development and use of natural resources (including water and mineral resources) while promoting justifiable economic and social development. Section 27 guarantees every person the right of access to sufficient water, and the state is obliged to take reasonable legislative and other measures within its available resources to achieve the progressive realisation of this right. Section 27 is defined as a socio-economic right and not an environmental right. However, read with section 24 it requires of the state to ensure that water is conserved and protected and that sufficient access to the resource is provided. Water regulation in South Africa places a great emphasis on protecting the resource and on providing access to water for everyone.
National Environmental Management Act (NEMA) (Act No. 107 of 1998)	The National Environmental Management Act (NEMA) (Act 107 of 1998) and the associated Regulations as amended in 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact. Provincial regulations must also be considered.
The National Water Act (NWA) (Act No. 36 of 1998)	The National Water Act (NWA) (Act 36 of 1998) 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. No activity may therefore take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DWS in terms of Section 21 (c) & (i).
Government Notice 704 Regulations as published in the Government Gazette 20119 of 1999 as it relates to the National Water Act, 1998 (Act No. 36 of 1998)	These Regulations were put in place in order to prevent the pollution of water resources and protect water resources in areas where mining activity is taking place from impacts generally associated with mining. It is recommended that the proposed project complies with Regulation GN 704 of the NWA which contains regulations on the use of water for mining and related activities aimed at the protection of water resources. GN 704 states that: *No person in control of a mine or activity may:* *(b) locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year floodline or within a horizontal distance of 100 metres from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on waterlogged ground, or on ground likely to become waterlogged, undermined, unstable or cracked;* According to the above, the activity footprint must fall outside of the 1:100 year floodline of the aquatic resource or 100m from the edge of the resource, whichever distance is the greatest.
Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA)	The obtaining of a New Order Mining Right (NOMR) is governed by the MPRDA. The MPRDA requires the applicant to apply to the DMRE for a NOMR which triggers a process of compliance with the various applicable sections of the MPRDA. The NOMR process requires environmental authorisation in terms of the MPRDA Regulations and specifically requires the preparation of a Scoping Report, an EIA, an Environmental Management Programme (EMP), and a Public Participation Process (PPP).
National Environmental Management: Biodiversity Act (2004) (Act 10 of 2004) (NEMBA)	**Ecosystems that are threatened or in need of protection** (1) (a) The Minister may, by notice in the Gazette, publish a national list of ecosystems that are threatened and in need of protection. *(b)* An MEC for environmental affairs in a province may, by notice in *the Gazette,* publish a provincial list of ecosystems in the province that are threatened and in need of protection. (2) The following categories of ecosystems may be listed in terms of subsection (1):

	(a) critically endangered ecosystems, being ecosystems that have undergone severe degradation of ecological structure, function or composition as a result of human intervention and are subject to an extremely high risk of irreversible transformation; *(b)* endangered ecosystems, being ecosystems that have undergone degradation of ecological structure, function or composition as a result of human intervention, although they are not critically endangered ecosystems; (c) vulnerable ecosystems, being ecosystems that have a high risk of undergoing significant degradation of ecological structure, function or composition as a result of human intervention, although they are not critically endangered ecosystems or endangered ecosystems; and *(d)* protected ecosystems, being ecosystems that are of high conservation value or of high national or provincial importance, although they are not listed in terms of paragraphs *(a), (b)* or (c).
Government Notice 598 Alien and Invasive Species Regulations (2014), including the Government Notice 864 Alien Invasive Species List as published in the Government Gazette 40166 of 2016, as it relates to the National Environmental Management Biodiversity Act, 2004 (Act No 10 of 2004)	NEMBA is administered by the Department of Environmental Affairs and aims to provide for the management and conservation of South Africa's biodiversity within the framework of the NEMA. This act in terms of alien and invasive species aims to: ➢ Prevent the unauthorized introduction and spread of alien and invasive species to ecosystems and habitats where they do not naturally occur, ➢ Manage and control alien and invasive species, to prevent or minimize harm to the environment and biodiversity; and ➢ Eradicate alien species and invasive species from ecosystems and habitats where they may harm such ecosystems or habitats. Alien species are defined, in terms of the NEMBA as: (a) A species that is not an indigenous species; or (b) An indigenous species translocated or intended to be translocated to a place outside its natural distribution range in nature, but not an indigenous species that has extended its natural distribution range by natural means of migration or dispersal without human intervention. Categories according to NEMBA (Alien and Invasive Species Regulations, 2017): ➢ **Category 1a:** Invasive species that require compulsory control; ➢ **Category 1b:** Invasive species that require control by means of an invasive species management programme; ➢ **Category 2:** Commercially used plants that may be grown in demarcated areas, provided that there is a permit and that steps are taken to prevent their spread; and ➢ **Category 3:** Ornamentally used plants that may no longer be planted.

Government Notice 509 as published in the Government Gazette 40229 of 2016 as it relates to the NWA (Act 36 of 1998)	In accordance with Regulation GN509 of 2016, a regulated area of a watercourse for section 21c and 21i of the NWA, 1998 is defined as: a) The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; b) In the absence of a determined 1 in 100-year flood line or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench; or c) A 500 m radius from the delineated boundary (extent) of any wetland or pan. This notice **replaces GN1199** and may be exercised as follows: i) Exercise the water use activities in terms of Section 21(c) and (i) of the Act as set out in the table below, subject to the conditions of this authorisation; ii) Use water in terms of section 21(c) or (i) of the Act if it has a low risk class as determines through the Risk Matrix; iii) Do maintenance with their existing lawful water use in terms of section 21(c) or (i) of the Act that has a LOW risk class as determined through the Risk Matrix; iv) Conduct river and stormwater management activities as contained in a river management plan; v) Conduct rehabilitation of wetlands or rivers where such rehabilitation activities has a LOW risk class as determined through the Risk Matrix; and vi) Conduct emergency work arising from an emergency situation or incident associated with the persons' existing lawful water use, provided that all work is executed and reported in the manner prescribed in the Emergency protocol. A General Authorisation (GA) issued as per this notice will require the proponent to adhere with specific conditions, rehabilitation criteria and monitoring and reporting programme. Furthermore, the water user must ensure that there is a sufficient budget to complete, rehabilitate and maintain the water use as set out in this GA. Upon completion of the registration, the responsible authority will provide a certificate of registration to the water user within 30 working days of the submission. On written receipt of a registration certificate from the Department, the person will be regarded as a registered water user and can commence within the water use as contemplated in the GA.
National Environmental Management: Waste Act, No 59 of 2008 (NEMWA)	NEMWA, which reforms the law regulating waste management in order to protect the health and the environment by providing reasonable measures for the prevention of pollution; provides for national norms and standards for regulating the management of waste by all spheres of government, and provides for the licensing and control of waste management activities.

APPENDIX C – Method of Assessment

1. Desktop Study

Prior to the commencement of the field assessment, a background study, including a literature review, was conducted in order to determine the ecoregion and ecostatus of the larger aquatic system within which the watercourses present or in close proximity of the focus area are located. Aspects considered as part of the literature review are discussed in the sections that follow.

1.1 National Freshwater Ecosystem Priority Areas (NFEPA, 2011)

The NFEPA project is a multi-partner project between the Council of Scientific and Industrial Research (CSIR), Water Research Commission (WRC), South African National Biodiversity Institute (SANBI), DWA, South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The project responds to the reported degradation of freshwater ecosystem condition and associated biodiversity, both globally and in South Africa. It uses systematic conservation planning to provide strategic spatial priorities of conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development.

The NFEPA project aims to identify a national network of freshwater conservation areas and to explore institutional mechanisms for their implementation. Freshwater ecosystems provide a valuable, natural resource with economic, aesthetic, spiritual, cultural and recreational value. However, the integrity of freshwater ecosystems in South Africa is declining at an alarming rate, largely as a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (competition between stakeholders for utilisation) and institutional (building appropriate governance and co-management mechanisms).

The NFEPA database was searched for information in terms of conservation status of rivers, wetland habitat and wetland features present in the vicinity of or within the focus area.

2. Classification System for Wetlands and other Aquatic Ecosystems in South Africa

The watercourses encountered within the focus area were assessed using the Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*., 2013), hereafter referred to as the "Classification System". A summary of Levels 1 to 4 of the classification system are presented in Table C1 and C2, below.

Table C1: Proposed classification structure for Inland Systems, up to Level 3.

WETLAND / AQUATIC ECOSYSTEM CONTEXT		
LEVEL 1: SYSTEM	LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT
Inland Systems	DWA Level 1 Ecoregions OR NFEPA WetVeg Groups OR Other special framework	Valley Floor
		Slope
		Plain
		Bench (Hilltop / Saddle / Shelf)

Table C2: Hydrogeomorphic (HGM) Unit for the Inland System, showing the primary HGM Types at Level 4A and the subcategories at Level 4B to 4C.

FUNCTIONAL UNIT		
LEVEL 4: HYDROGEOMORPHIC (HGM) UNIT		
HGM type	Longitudinal zonation/ Landform / Outflow drainage	Landform / Inflow drainage
A	**B**	**C**
River	Mountain headwater stream	Active channel
		Riparian zone
	Mountain stream	Active channel
		Riparian zone
	Transitional	Active channel
		Riparian zone
	Upper foothills	Active channel
		Riparian zone
	Lower foothills	Active channel
		Riparian zone
	Lowland river	Active channel
		Riparian zone
	Rejuvenated bedrock fall	Active channel
		Riparian zone
	Rejuvenated foothills	Active channel
		Riparian zone
	Upland floodplain	Active channel
		Riparian zone
Channelled valley-bottom wetland	(not applicable)	(not applicable)
Unchannelled valley-bottom wetland	(not applicable)	(not applicable)
Floodplain wetland	Floodplain depression	(not applicable)
	Floodplain flat	(not applicable)
Depression	Exorheic	With channelled inflow
		Without channelled inflow
	Endorheic	With channelled inflow
		Without channelled inflow
	Dammed	With channelled inflow
		Without channelled inflow
Seep	With channelled outflow	(not applicable)
	Without channelled outflow	(not applicable)
Wetland flat	(not applicable)	(not applicable)

Level 1: Inland systems

From the Classification System, Inland Systems are defined as aquatic ecosystems that have no existing connection to the ocean[10] (i.e. characterised by the complete absence of marine exchange and/or tidal influence) but which are inundated or saturated with water, either permanently or periodically. It is important to bear in mind, however, that certain Inland Systems may have had a historical connection to the ocean, which in some cases may have been relatively recent.

[10] Most rivers are indirectly connected to the ocean via an estuary at the downstream end, but where marine exchange (i.e. the presence of seawater) or tidal fluctuations are detectable in a river channel that is permanently or periodically connected to the ocean, it is defined as part of the estuary.

Level 2: Ecoregions & NFEPA Wetland Vegetation Groups

For Inland Systems, the regional spatial framework that has been included at Level 2 of the classification system is that of DWA's Level 1 Ecoregions for aquatic ecosystems (Kleynhans *et al.,* 2005). There is a total of 31 Ecoregions across South Africa, including Lesotho and Swaziland. DWA Ecoregions have most commonly been used to categorise the regional setting for national and regional water resource management applications, especially in relation to rivers.

The Vegetation Map of South Africa, Swaziland and Lesotho (Mucina & Rutherford, 2006) group's vegetation types across the country according to Biomes, which are then divided into Bioregions. To categorise the regional setting for the wetland component of the National Freshwater Ecosystem Priority Areas (NFEPA) project, wetland vegetation groups (referred to as WetVeg Groups) were derived by further splitting bioregions into smaller groups through expert input (Nel *et al*., 2011). There are currently 133 NFEPA WetVeg Groups. It is envisaged that these groups could be used as a special framework for the classification of wetlands in national- and regional-scale conservation planning and wetland management initiatives.

Level 3: Landscape Setting

At Level 3 of the Classification System, for Inland Systems, a distinction is made between four Landscape Units (Table C1) on the basis of the landscape setting (i.e. topographical position) within which an HGM Unit is situated, as follows (Ollis *et al.,* 2013):

- **Slope:** an included stretch of ground that is not part of a valley floor, which is typically located on the side of a mountain, hill or valley;
- **Valley floor:** The base of a valley, situated between two distinct valley side-slopes;
- **Plain:** an extensive area of low relief characterised by relatively level, gently undulating or uniformly sloping land; and
- **Bench (hilltop/saddle/shelf):** an area of mostly level or nearly level high ground (relative to the broad surroundings), including hilltops/crests (areas at the top of a mountain or hill flanked by down-slopes in all directions), saddles (relatively high-lying areas flanked by down-slopes on two sides in one direction and up-slopes on two sides in an approximately perpendicular direction), and shelves/terraces/ledges (relatively high-lying, localised flat areas along a slope, representing a break in slope with an up-slope one side and a down-slope on the other side in the same direction).

Level 4: Hydrogeomorphic Units

Seven primary HGM Types are recognised for Inland Systems at Level 4A of the Classification System (Table C2), on the basis of hydrology and geomorphology (Ollis *et al*., 2013), namely:

- **River:** a linear landform with clearly discernible bed and banks, which permanently or periodically carries a concentrated flow of water;
- **Channelled valley-bottom wetland:** a valley-bottom wetland with a river channel running through it;
- **Unchannelled valley-bottom wetland:** a valley-bottom wetland without a river channel running through it;
- **Floodplain wetland:** the mostly flat or gently sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank;
- **Depression:** a landform with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates.
- **Wetland Flat:** a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat; and
- **Seep:** a wetland area located on (gently to steeply) sloping land, which is dominated by the colluvial (i.e. gravity-driven), unidirectional movement of material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend into a valley floor.

The above terms have been used for the primary HGM Units in the classification system to try and ensure consistency with the wetland classification terms currently in common usage in South Africa. Similar terminology (but excluding categories for "channel", "flat" and "valleyhead seep") is used, for example, in the recently developed tools produced as part of the Wetland Management Series including WET-Health (Macfarlane *et al*., 2008), WET-IHI (DWAF, 2007) and WET-EcoServices (Kotze *et al*., 2009).

3. Watercourse Function Assessment

"The importance of a water resource, in ecological social or economic terms, acts as a modifying or motivating determinant in the selection of the management class".[11] The assessment of the ecosystem services supplied by the identified watercourses was conducted according to the guidelines as described by Kotze *et al.* (2009). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the service is provided:

- Flood attenuation;
- Stream flow regulation;
- Sediment trapping;
- Phosphate trapping;
- Nitrate removal;
- Toxicant removal;
- Erosion control;
- Carbon storage;
- Maintenance of biodiversity;
- Water supply for human use;
- Natural resources;
- Cultivated foods;
- Cultural significance;
- Tourism and recreation; and
- Education and research.

The characteristics were used to quantitatively determine the value, and by extension sensitivity, of the watercourses. Each characteristic was scored to give the likelihood that the service is being provided. The scores for each service were then averaged to give an overall score to the watercourses.

Table C5: Classes for determining the likely extent to which a benefit is being supplied.

Score	Rating of the likely extent to which the benefit is being supplied
<0.5	Low
0.6-1.2	Moderately low
1.3-2	Intermediate
2.1-3	Moderately high
>3	High

4. Ecological Importance and Sensitivity (EIS) (Rountree & Kotze, 2013)

The purposed of assessing importance and sensitivity of water resources is to be able to identify those systems that provide higher than average ecosystem services, biodiversity support functions or are especially sensitive to impacts. Water resources with higher ecological importance may require

[11] Department of Water Affairs and Forestry, South Africa Version 1.0 of Resource Directed Measures for Protection of Water Resources, 1999

managing such water resources in a better condition than the present to ensure the continued provision of ecosystem benefits in the long term (Rountree & Kotze, 2013).
In order to align the outputs of the Ecoservices assessment (i.e. ecological and socio-cultural service provision) with methods used by the DWA (now the DWS) used to assess the EIS of other watercourse types, a tool was developed using criteria from both WET-Ecoservices (Kotze, *et, al,* 2009) and earlier DWA EIA assessment tools. Thus, three proposed suites of important criteria for assessing the Importance and Sensitivity for wetlands were proposed, namely:

- Ecological Importance and Sensitivity, incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWA and thus enabling consistent assessment approaches across water resource types;
- Hydro-functional importance, taking into consideration water quality, flood attenuation and sediment trapping ecosystem services that the wetland may provide; and
- Importance in terms of socio-cultural benefits, including the subsistence and cultural benefits provided by the wetland system.

The highest of these three suites of scores is then used to determine the overall Importance and Sensitivity category (Table C6) of the wetland system being assessed.

Table C6: Ecological Importance and Sensitivity Categories and the interpretation of median scores for biota and habitat determinants (adapted from Kleynhans, 1999).

EIS Category	Range of Mean	Recommended Ecological Management Class
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications.	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications.	>2 and <=3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications.	>1 and <=2	C
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications.	>0 and <=1	D

5. Recommended Management Objective (RMO) and Recommended Ecological Category (REC) Determination

"A high management class relates to the flow that will ensure a high degree of sustainability and a low risk of ecosystem failure. A low management class will ensure marginal maintenance of sustainability but carries a higher risk of ecosystem failure" (DWA, 1999).

The RMO (table below) was determined based on the results obtained from the PES, reference conditions and EIS of the watercourse (sections above), with the objective of either maintaining, or improving the ecological integrity of the watercourse in order to ensure continued ecological functionality.

Table C7: Recommended management objectives (RMO) for water resources based on PES & EIS scores.

			Ecological and Importance Sensitivity (EIS)			
			Very High	High	Moderate	Low
PES	A	Pristine	A Maintain	A Maintain	A Maintain	A Maintain
	B	Natural	A Improve	A/B Improve	B Maintain	B Maintain
	C	Good	A Improve	B/C Improve	C Maintain	C Maintain
	D	Fair	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	Poor	D* Improve	E/F* Improve	E/F* Maintain	E/F* Maintain

***PES Categories E and F are considered ecologically unacceptable (Malan and Day, 2012) and therefore, should a watercourse fall into one of these PES categories, an REC class D is allocated by default, as the minimum acceptable PES category.**

A watercourse may receive the same class for the REC as the PES if the watercourse is deemed in good condition, and therefore must stay in good condition. Otherwise, an appropriate REC should be assigned in order to prevent any further degradation as well as enhance the PES of the watercourse.

Table C8: Description of Recommended Ecological Category (REC) classes.

Class	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified
D	Largely modified

6. General Habitat Integrity

The general habitat integrity of each site was discussed based on the application of the Index of Habitat Integrity (Kleynhans *et al.* 2008). It is important to assess the habitat at each site in order to aid in the interpretation of the results of the community integrity assessments, by taking habitat conditions and impacts into consideration. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitat at each site. The method classifies habitat integrity into one of six classes, ranging from unmodified/natural (Class A) to critically modified (Class F), as indicated in Table C9 below.

Table C9: Classification of Present State Classes in terms of Habitat Integrity [Kleynhans *et al.* 2008]

Class	Description	Score (% of total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60 - 79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40 – 59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20 – 39

F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 - 19

7. The Riparian Vegetation Response Assessment Index (VEGRAI)

VEGRAI is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results (Kleynhans *et al.*, 2007a). Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

Riparian vegetation is described in the National Water Act (NWA; Act 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soil, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

Table C10: Descriptions of the A-F ecological categories.

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

8. Freshwater ecosystem delineation

The freshwater ecosystem delineation took place according to the method presented in the "Updated manual for the identification and delineation of wetland and riparian resources" published by DWAF in 2008. The foundation of the method is based on the fact that wetlands and riparian zones have several distinguishing factors including the following:

- The presence of water at or near the ground surface;
- Distinctive hydromorphic soils;
- Vegetation adapted to saturated soils; and
- The presence of alluvial soils in stream systems.

According to the DWA (2005) like wetlands, riparian areas have their own unique set of indicators. It is possible to delineate riparian areas by checking for the presence of these indicators. Some areas may display both wetland and riparian indicators and can accordingly be classified as both. If you are adjacent to a watercourse, it is important to check for the presence of the riparian indicators described below, in addition to checking for wetland indicators, to detect riparian areas that do not qualify as wetlands. The delineation process requires that the following be taken into account:

- topography associated with the watercourse;
- vegetation; and
- alluvial soils and deposited material.

By observing the evidence of these features in the form of indicators, wetlands and riparian zones can be delineated and identified. If the use of these indicators and the interpretation of the findings are applied correctly, then the resulting delineation can be considered accurate (DWA, 2005).

9. AQUATIC ECOLOGICAL METHOD OF ASSESSMENT

The sections below describe the methodology used to assess the aquatic ecological integrity of the sites selected based on water quality, instream and riparian habitat condition and biological impacts and integrity.

Visual Assessment
Each site was investigated in order to identify visible impacts on the site, with specific reference to impacts from surrounding activities. Both natural constraints placed on ecosystem structure and function, as well as anthropogenic alterations to the system, were identified by observing conditions and relating them to professional experience. Photographs of each site were taken to provide visual indications of the conditions at the time of assessment. Factors which were noted in the site specific visual assessments included the following:

- Stream morphology;
- Instream and riparian habitat diversity;
- Stream continuity;
- Erosion potential;
- Depth flow and substrate characteristics;
- Signs of physical disturbance of the area; and
- Other life forms reliant on aquatic ecosystems.

Physico Chemical Water Quality Data
On-site testing of biota specific water quality parameters including pH, Electrical Conductivity (EC), dissolved oxygen concentration (DO) and temperature. The results aid in the interpretation of the data obtained by the biomonitoring. Results are discussed against the guideline water quality values for aquatic ecosystems (DWAF 1996 vol. 7) as well as the Resource Water Quality Objectives (RWQO) of the Ncandu River (DWS, 2022). Although the guideline water quality values pertain to temporal comparisons, it will also be applied to spatial comparisons for the purpose of this report, as no suitable alternative is currently available.

General Habitat Integrity
The general habitat integrity of each site was discussed based on the application of the Index of Habitat Integrity (Kleynhans *et al.* 2008). It is important to assess the habitat at each site in order to aid in the interpretation of the results of the community integrity assessments, by taking habitat conditions and impacts into consideration. This method describes the Present Ecological State (PES) of both the in-stream and riparian habitat at each site. The method classifies habitat integrity into one of six classes, ranging from unmodified/natural (Class A) to critically modified (Class F), as indicated in Table C1 below.

Table C11: Classification of Present State Classes in terms of Habitat Integrity [Kleynhans *et al.* 2008]

Class	Description	Score (% of total)
A	Unmodified, natural.	90 - 100
B	Largely natural with few modifications. The flow regime has been only slightly modified and pollution is limited to sediment. A small change in natural habitats may have taken place. However, the ecosystem functions are essentially unchanged.	80 - 89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60 - 79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40 – 59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20 – 39

F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0 - 19

Habitat for aquatic macro-invertebrates

The Integrated Habitat Assessment System (IHAS), according to the protocol of McMillan (1998), is used to determine specific habitat suitability for aquatic macro-invertebrates as well as to aid in the interpretation of the results of the South African Scoring System version 5 (SASS5) scores. However, according to a study conducted within the Mpumalanga and Western Cape regions, the IHAS method does not produce reliable scores with regard to the suitability of habitat at sampling sites for aquatic macroinvertebrates (Ollis *et al*., 2006). Furthermore, the performance of the IHAS seems to vary between geomorphologic zones and between biotope groups (Ollis *et al*., 2006). It has, however; become clear that IHAS requires further validation and testing, although the basic data remains of value (Thirion, 2007).

Table C12: IHAS Scores and their corresponding description of overall condition (quality and quantity) of available aquatic macroinvertebrate habitat (McMillan, 1998)

IHAS Score (%)	Description
>75	Excellent
65 – 74	Good
55 – 64	Adequate / Fair
<55	Poor

Aquatic Macro-Invertebrates: South African Scoring System version 5 (SASS5)

Sampling was performed using the qualitative kick sampling method called SASS5 (South African Scoring System version 5) (Dickens and Graham, 2002). The SASS5 method has been specifically designed to comply with international accreditation protocols. This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (1998).

The SASS5 method was designed to incorporate all available biotypes at a given site and to provide an indication of the integrity of the of the aquatic macro-invertebrate community through recording the presence of various macro-invertebrate families at each site, as well as consideration of abundance of various populations, community diversity and community sensitivity. Each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas 2007).

Aquatic Macro-Invertebrate Integrity: The Macro-Invertebrate Response Assessment Index (MIRAI)

The four major components of a stream system that determine productivity, with reference to aquatic organisms, are flow regime, physical habitat structure, water quality and energy inputs. An interplay between these factors (particularly habitat and availability of food sources) result in the discontinuous, patchy distribution pattern of aquatic macro-invertebrate populations. As such, aquatic invertebrates shall respond to habitat changes (i.e. changes in driver conditions).

To relate drivers to such changes in habitat and aquatic invertebrate condition, two key elements are required. Firstly, habitat preferences and requirements for each taxa present should be obtained. As such, reference conditions can be established against which any response to drivers can be measured. Secondly, habitat features should be evaluated in terms of suitability and the requirements mentioned in the first point. As a result, expected and actual patterns can be evaluated to achieve an Ecostatus Category rating.

Based on the three key requirements, the MIRAI provides an approach to deriving and interpreting aquatic invertebrate response to driver changes. The index has been applied to the sites following methodology described by Thirion (2007).

Aquatic macro-invertebrates expected at each point were derived both from previous studies of rivers near the area, as well as from the DWS RQIS database.

Fish biota: Fish Response Assessment Index (FRAI)
The FRAI (Kleynhans, 2007) is based on the premise that "drivers" (environmental conditions) may cause fish stress which shall then manifest as changes in fish species assemblage. The index employs preferences and intolerances of the reference fish assemblage, as well as the response of the actual (present) fish assemblage to particular drivers to indicate a change from reference conditions. Intolerances and preferences are divided into metric groups relating to preferences and requirements of individual species. This allows cause-effect relationships to be understood, i.e. between drivers and responses of the fish assemblage to changes in drivers. These metric groups are subsequently ranked, rated and finally integrated as a fish Ecological Category.

The fish community could not be sampled using an electro-shock method due to rain at the time of assessment. However, fish species expected to occur were derived from the Department of Water and Sanitation (DWS) Resource Quality Information Services (RQIS) PES/EIS database.

The Riparian Vegetation Response Assessment Index (VEGRAI)
VEGRAI is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results (Kleynhans *et al.*, 2007b). Results are defensible because their generation can be traced through an outlined process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

Riparian vegetation is described in the National Water Act (NWA; Act 36 of 1998) as follows: 'riparian habitat' includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

Table C13: Descriptions of the A-F ecological categories.

Ecological category	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitat and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat have occurred, but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

Diatom Community Assessment
Diatom slides were prepared through use of the hot Hydrochloric Acid (HCl) and Potassium Permanganate ($KMnO_4$) method as this is the preferred method of use for South African samples, as it usually contains higher levels of organic content (Taylor *et al.,* 2007). The clean samples were mounted onto microscope slides using pleurax as it has a high refraction index (1.73) ideal for diatom frustule identification. Diatom taxa were identified to the lowest possible level of identification and diatom valves counted (400 counts) for ecological conclusions to be drawn. Dominant species ecology was inferred from Taylor *et al*. (2007) and Omnidia software (Lecointe *et al.,* 1993) were used to calculate diatom index scores with score interpretation presented in Tables C4 to C7. The following indices were calculated for the present report:

- Specific Pollution sensitivity Index (SPI) (CEMAGREF, 1982) (Tables C4 & C5): This index is the most comprehensive as it includes >1400 species to calculate its final score and provides a measure of organic pollution.
- Generic Diatom Index (GDI) (Coste and Ayphassorho, 1991) (Table C5): Final score is based on genus level and is a measure of organic pollution.

- Trophic Diatom Index (TDI) (Kelly and Whitton, 1995) (Table C6): The index's final score is quantified based on the degree of organic and inorganic pollution.
- Percentage Pollution Tolerant Valves (%PTV) (Kelly and Whitton, 1995) (Table C7): Indicates the diatoms in the sampled community that are tolerant to pollution, thus indicating the degree of eutrophication vs organic pollution. The %PTV score indicates whether nutrients or organic pollution contributed to the TDI final score.

Values for the SPI and GDI were transformed to a score out of 20 where a score of 0 indicates eutrophication and very heavy pollution and a score of 20 indicates no pollution and oligotrophic conditions (Tables C4 & C5). The TDI score is worked off a maximum of 100, where a score of <20% infers that the site is oligotrophic and free from pollution and a score >60% infers that the site is eutrophic with pollution present (Table C6). The %PTV is worked off a maximum score of 100%, where a score of <20% infers that the site is free from organic pollution and a score >60% infers that the site is heavily contaminated with organic pollution (Table C7). For the diatom frustule abnormality assessment, if the percentage of deformed frustules is greater than 2% of the population it is considered that there is significant impact from either pesticides or metals and further assessment is recommended, especially where mining is a related concern.

Table C14: Interpretation of Ecological Categories from the SPI index scores.

Index Score (up to 20)	Ecosystem quality	Ecological Category
18 – 20	High quality	A
17 – 18		A/B
15 – 17	Good quality	B
14 – 15		B/C
12 – 14	Moderate quality	C
10 – 12		C/D
8 – 10	Poor quality	D
6 – 8		D/E
5 – 6	Bad quality	E
4 – 5		E/F
< 4		F

Table C15: Interpretation of both the SPI and GDI scores to determine the Ecosystem Quality and Trophic level of the sampled site.

Index Score (up to 20)	Trophic Level
>17	Oligotrophic (No Pollution)
15 - 17	Oligo-mesotrophic
12 - 15	Mesotrophic
9 - 12	Meso-eutrophic
< 9	Eutrophic

Table C16: Interpretation of the TDI score to determine the Trophic level of the sampled site.

Index Score	Trophic Level
0 – 20	Oligotrophic (No Pollution)
21 – 40	Oligo-mesotrophic
41 – 60	Mesotrophic
61 – 80	Meso-eutrophic
>80	Eutrophic

Table C17: Interpretation of the %PTV score to determine the Ecological Status of the site.

Index Score (up to 20)	Ecological Status
< 20	Site free from organic pollution
21 – 40	Some evidence of organic pollution
41 – 60	Organic pollution likely to contribute to eutrophication
>60	Heavily contaminated with organic pollution

Ecological Importance and Sensitivity (EIS) Method of assessment

The EIS method considers a number of biotic and habitat determinants surmised to indicate either importance or sensitivity. The determinants are rated according to a four-point scale (Table C8). The median of the resultant score is calculated to derive the EIS category (Table C9).

Table C18: Definition of the four-point scale used to assess biotic and habitat determinants presumed to indicate either importance or sensitivity

Four point scale	Definition
1	One species/taxon judged as rare or endangered at a local scale.
2	More than one species/taxon judged to be rare or endangered on a local scale.
3	One or more species/taxon judged to be rare or endangered on a Provincial/regional scale.
4	One or more species/taxon judged as rare or endangered on a National scale (i.e. SA Red Data Books)

Table C19: Ecological importance and sensitivity categories (DWAF, 1999)

EISC	General Description	Range of median
Very high	Quaternaries/delineations that are considered to be unique on a national and international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3-4
High	Quaternaries/delineations that are considered to be unique on a national scale based on their biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases may have substantial capacity for use.	>2-≤3
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are not usually very sensitive to flow modifications and often have substantial capacity for use.	>1-≤2
Low/ marginal	Quaternaries/delineations that are not unique on any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have substantial capacity for use.	≤1

APPENDIX D – Impact Assessment Methodology

In order for the Environmental Assessment Practitioner (EAP) to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the Applicant to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The below impact assessment methodology is provided by Cabanga Environmental and was used in the evaluation of possible impacts and risk of the proposed development on the focus area. The assessment was used to investigate the possible impacts during the construction, operational and decommission phases of the proposed development and is applied to freshwater ecosystems. Based on the perceived impact possible mitigation measures are suggested to mitigate or improve risk on the freshwater ecosystems.

Impact significance = Consequence x Likelihood

Likelihood refers to the probability that an impact will occur at some time during the project.
The Matrix which is proposed to determine Likelihood is as follows:

Table A1: Matrix used to determine likelihood

Likelihood	Unlikely: Impact Could occur in extreme events. Less than 15% chance of the impact ever occurring.	1
	Possible: possibility of impact occurring is very low. 16% - 30% chance of the impact occurring.	2
	Probable There is a distinct possibility of the impact occurring. 31% to 60% chance.	3
	Highly Probable: The impact is expected to occur. Between 61% and 85 % chance.	4
	Definite: There are sound scientific reasons to expect that the impact will occur	5

Consequence is calculated by considering the duration, spatial scale and intensity of an impact.

Duration relates to the time-frame that an aspect will be impacted upon. For example, any impact to a heritage resource is considered permanent, while the impact of increased traffic related to a construction activity will only last as long as the construction phase. Duration is rated according to the following criteria:

Table A2: Matrix used to rate duration

Duration	Short term: Less tan 1 year and is reversable	1
	Short to medium term: 2-3 years	2
	Medium term: 3 – 10 years	3
	Long terms: 11-20 years	4
	Permanent: in excess of 20 years	5

Spatial **Scale** relates to the physical extent of the zone of influence of an impact. Where groundwater or air quality impacts, for example, can extend far beyond the footprint of the activity, it is not expected that the impact of vegetation removal should extend beyond the footprint of the activity. Scale is rated according to **Table A3**:

Table A3: Matrix used to rate scale.

Scale / Extent	Isolated: Limited footprint within the site will be affected (less than 50% of the site)	1
	Site Specific: The entire Site will be affected	2
	Local: Will affect the site and surrounding areas	3
	Regional: Will affect the entire region / catchment / province	4
	National: Will affect the country, and possibly beyond the borders of the country	5

The **Intensity** of an impact is calculated by considering the **severity of the impact** (how it will change the aspect, will it be destroyed completely, or altered slightly?) and the **sensitivity of the aspect** (is the aspect sensitive to change, and is the aspect important to ecosystem processes or social dynamics?).

For example, if the impact is anticipated to completely destroy a local plant population, but the plant population is commonly found and protected in nearby surroundings, the over-all intensity is lowered. If, however, the plant population in question is unique or protected, the intensity increases proportionately.

The Matrix which was used to determine Intensity is as follows:

Table A4: Matrix used to rate Intensity.

Magnitude	Slight: Little effect, negligible disturbance / benefit.	1
	Slight to Moderate: Effects are observable but natural process continue.	2
	Moderate: ecosystem processes / social dynamics are permanently altered, but functioning.	3
	Moderate - High: natural / social processes are altered to the point where function is limited.	4
	High: The aspect is affected so that its functioning is compromised, and this effect is irreversible.	5
Sensitivity	The aspect is not sensitive to change (No irreplaceable loss of resource).	1
	The aspect is of not of significant value but is sensitive to change.	2
	The affected aspect is of moderate value and is slightly resilient to change.	3
	The affected aspect is of significant value and only slightly resilient to change.	4
	The affected aspect is valued, irreplaceable and sensitive to change. Irreplaceable loss of significant resource.	5

Therefore, considering the formula:

Significance = Consequence x Likelihood

Where **Consequence = Duration + Scale + Severity of the Impact + Sensitivity of the Aspect**

The over-all Significance rating can be calculated as a value between 4 and 100. The score is then categorised as follows:

- 4 to 19 = Insignificant Impact, no mitigation is required beyond standard best practice;
- From 20 to 39 = Low Impact, specific mitigation should be included in the EMP and monitoring should be undertaken;
- From 40 to 59 = Moderate Impact, specific mitigation with strict monitoring is required;
- From 60 to 79 = High Impact, mitigation should consider alteration of the design or process to reduce the impact significance;
- >Higher than 80 (100 max) = The Impact is so Significant that the project design must be reconsidered to avoid the impact.

Impacts were rated as per the abovementioned methodology without consideration of mitigation measures first, however there may be some mitigation already inherent in the design of the Project (i.e. by avoiding identified wetland areas in the layout of the project, by using existing roads instead of constructing a new access road, etc.).

Those impacts that are rated as having a moderate impact or above will be investigated further and management measures identified to attempt to reduce the Consequence or Likelihood of the impact. These impacts will then be rated again, while considering the mitigation measures that have been imposed.

Likelihood	5	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
	4	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
	3	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
	2	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	1	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Consequence																

As shown in the Table below, impacts that are insignificant do not justify the effort and expense that most types of mitigation measures would be associated with. As impact significance increases, increased efforts (and associated costs) of mitigation become relevant.

Range		Significance	Management
From	To		
4	19	Insignificant	None required
20	39	Low	Continue to Monitor
40	59	Moderate	Implement mitigation and monitoring.
60	79	High	High negative impacts must be justified by positive value of project, potential offsets or altered design required.
80	100	Significant	Alter design to address impact cause If still significant after mitigation = fatal flaw to the Project.

Mitigation measure development

According to the DEA *et al.,* (2013) "Rich biodiversity underpins the diverse ecosystems that deliver ecosystem services that are of benefit to people, including the provision of basic services and goods such as clean air, water, food, medicine, and fibre; as well as more complex services that regulate and mitigate our climate, protect people and other life forms from natural disaster and provide people with a rich heritage of nature-based cultural traditions. Intact ecological infrastructure contributes significant savings through, for example, the regulation of natural hazards such as storm surges and flooding which is attenuated by wetlands".

According to the DEA *et al.,* (2013) ecosystem services can be divided into 4 main categories:

- ➢ Provisioning services are the harvestable goods or products obtained from ecosystems such as food, timber, fibre, medicine, and fresh water;
- ➢ Cultural services are the non-material benefits such as heritage landscapes and seascapes, recreation, ecotourism, spiritual values and aesthetic enjoyment;
- ➢ Regulating services are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards; and
- ➢ Supporting services are the natural processes such as nutrient cycling, soil formation and primary production that maintain the other services.

Loss of biodiversity puts aspects of the economy, wellbeing, and quality of life at risk, and reduces socio-economic options for future generations. This is of particular concern for the poor in rural areas who have limited assets and are more dependent on common property resources for their livelihoods. The importance of maintaining biodiversity and intact ecosystems for ensuring on-going provision of ecosystem services, and the consequences of ecosystem change for human well-being, were detailed in a global assessment entitled the Millennium Ecosystem Assessment (MEA, 2005), which established a scientific basis for the need for action to enhance management and conservation of biodiversity.

Sustainable development is enshrined in South Africa's Constitution and laws. The need to sustain biodiversity is directly or indirectly referred to in a number of Acts, not least the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (hereafter referred to as the Biodiversity Act) and is fundamental to the notion of sustainable development. In addition, International guidelines and commitments as well as national policies and strategies are important in creating a shared vision for sustainable development in South Africa (DEA *et al.,* 2013).

The primary environmental objective of the Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) is to give effect to the environmental right contained in the South African Constitution. Furthermore, Section 37(2) of the MPRDA states that "any prospecting or mining operation must be conducted in accordance with generally accepted principles of sustainable development by integrating social, economic and environmental factors into the planning and implementation of prospecting and mining projects in order to ensure that exploitation of mineral resources serves present and future generations".

Pressures on biodiversity are numerous and increasing. According to the DEA *et al.,* (2013) Loss of natural habitat is the single biggest cause of biodiversity loss in South Africa and much of the world. The most severe transformation of habitat arises from the direct conversion of natural habitat for human requirements, including[12]:

- Cultivation and grazing activities;
- Rural and urban development;
- Industrial and mining activities, and
- Infrastructure development.

Impacts on biodiversity can largely take place in four ways (DEA *et al.,* 2013):

- **Direct impacts:** are impacts directly related to the project including project aspects such as site clearing, water abstraction and discharge of water from riverine resources;
- **Indirect impacts:** are impacts associated with a project that may occur within the zone of influence in a project such as surrounding terrestrial areas and downstream areas on water courses;
- **Induced impacts:** are impacts directly attributable to the project but are expected to occur due to the activities of the project. Factors included here are urban sprawl and the development of associated industries; and
- **Cumulative impacts:** can be defined as the sum of the impact of a project as well as the impacts from past, existing, and reasonably foreseeable future projects that would affect the same biodiversity resources. Examples include numerous mining operations within the same drainage catchment or numerous residential developments within the same habitat for faunal or floral species.

Given the limited resources available for biodiversity management and conservation, as well as the need for development, efforts to conserve biodiversity need to be strategic, focused, and supportive of sustainable development. This is a fundamental principle underpinning South Africa's approach to the management and conservation of its biodiversity and has resulted the definition of a clear mitigation strategy for biodiversity impacts.

'Mitigation' is a broad term that covers all components of the 'mitigation hierarchy' defined hereunder. It involves selecting and implementing measures – amongst others – to conserve biodiversity and to protect the users of biodiversity and other affected stakeholders from potentially adverse impacts as a result of mining or any other land use. The aim is to prevent adverse impacts from occurring or, where this is unavoidable, to limit their significance to an acceptable level. Offsetting of impacts is considered to be the last option in the mitigation hierarchy for any project.

The mitigation hierarchy in general consists of the following in order of which impacts should be mitigated (DEA *et al.,* 2013):

- **Avoid/prevent impact:** can be done through utilising alternative sites, technology, and scale of projects to prevent impacts. In some cases, if impacts are expected to be too high the "no

[12] Limpopo Province Environment Outlook. A Report on the State of the Environment, 2002. Chapter 4.

project" option should also be considered, especially where it is expected that the lower levels of mitigation will not be adequate to limit environmental damage and eco-service provision to suitable levels;

- **Minimise impact:** can be done through utilisation of alternatives that will ensure that impacts on biodiversity and ecoservices provision are reduced. Impact minimisation is considered an essential part of any development project;
- **Rehabilitate impact:** is applicable to areas where impact avoidance and minimisation are unavoidable where an attempt to re-instate impacted areas and return them to conditions which are ecologically similar to the pre-project condition or an agreed post project land use, for example arable land. Rehabilitation can however not be considered as the primary mitigation tool as even with significant resources and effort rehabilitation usually does not lead to adequate replication of the diversity and complexity of the natural system. Rehabilitation often only restores ecological function to some degree to avoid ongoing negative impacts and to minimise aesthetic damage to the setting of a project. Practical rehabilitation should consist of the following phases in best practice:
  - **Structural rehabilitation** which includes physical rehabilitation of areas by means of earthworks, potential stabilisation of areas as well as any other activities required to develop a long terms sustainable ecological structure;
  - **Functional rehabilitation** which focuses on ensuring that the ecological functionality of the ecological resources on the focus area supports the intended post closure land use. In this regard special mention is made of the need to ensure the continued functioning and integrity of wetland and riverine areas throughout and after the rehabilitation phase;
  - **Biodiversity reinstatement** which focuses on ensuring that a reasonable level of biodiversity is re-instated to a level that supports the local post closure land uses. In this regard special mention is made of re-instating vegetation to levels which will allow the natural climax vegetation community or community suitable for supporting the intended post closure land use; and
  - **Species reinstatement** which focuses on the re-introduction of any ecologically important species which may be important for socio-cultural reasons, ecosystem functioning reasons and for conservation reasons. Species re-instatement need only occur if deemed necessary.
- **Offset impact:** refers to compensating for residual or unavoidable negative impacts on biodiversity. Offsetting should take place to address any impacts deemed to be unacceptable which cannot be mitigated through the other mechanisms in the mitigation hierarchy. The objective of biodiversity is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity[13].

The significance of residual impacts should be identified on a regional as well as national scale when considering biodiversity conservation initiatives. If the residual impacts lead to irreversible loss or irreplaceable biodiversity the residual impacts should be considered to be of *very high significance* and when residual impacts are considered to be of *very high significance*, offset initiatives are not considered an appropriate way to deal with the magnitude and/or significance of the biodiversity loss. In the case of residual impacts determined to have *medium to high significance*, an offset initiative may be investigated. If the residual biodiversity impacts are considered of low significance no biodiversity offset is required.[14]

In light of the above discussion the following points present the key concepts considered in the development of mitigation measures for the proposed project:

- Mitigation and performance improvement measures and actions that address the risks and impacts[15] are identified and described in as much detail as possible;
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation, or compensation where possible; and
- Desired outcomes are defined and have been developed in such a way as to be measurable events with performance indicators, targets and acceptable criteria that can be tracked over

13 Ezemvelo KwaZulu-Natal Wildlife: Concise Guideline: Biodiversity offsets in KwaZulu – Natal, 2013.

14 Provincial Guideline on Biodiversity Offsets, Western Cape, 2007.

15 Mitigation measures should address both positive and negative impacts.

defined periods, with estimates of the resources (including human resource and training requirements) and responsibilities for implementation wherever possible.

Recommendations

Recommendations were developed to address and mitigate impacts associated with the proposed development. These recommendations also include general management measures which apply to the proposed development as a whole. Mitigation measures have been developed to address issues in all phases throughout the life of the operation from planning, through to construction and operational and decommissioning phase of the development.

APPENDIX E – Results of Field Investigation

PRESENT ECOLOGICAL STATE (PES) AND ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS) RESULTS

Table E1: Presentation of the results of the WET-Health assessment applied to UCVB wetland.

HGM Unit	Ha	Extent (%)	Hydrology		Geomorphology		Vegetation		
			Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score	
1	4	4	4,0	-1	1,9	0	1,9	-1	2.8 (C)
Area weighted impact scores*			0,2	0,0	0,1	0,0	0,1	0,0	
PES Category (See Table 5.29)			A	→	A	→	A	→	

Table E2: Presentation of the results of the WET-Health assessment applied to CVB and seep wetlands.

HGM Unit	Ha	Extent (%)	Hydrology		Geomorphology		Vegetation		
			Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score	
1	144	98	4,0	-2	1,8	0	2,9	-1	3.01 (C)
02	3	2	2,0	-2	1,0	0	2,2	-1	1.77 (B)
Area weighted impact scores*			4,0	-2,0	1,8	0,0	2,8	-1,0	
PES Category (See Table 5.29)			C	↓↓	B	→	C	↓	

Table E3: Presentation of the results of the IHI for the iCawa River.

INSTREAM IHI	MRU
Base Flows	-2,0
Zero Flows	0,0
Floods	3,5
HYDROLOGY RATING	**1,3**
pH	1,0
Salts	0,0
Nutrients	1,0
Water Temperature	0,0
Water clarity	1,0
Oxygen	-0,5
Toxics	1,0
PC RATING	**0,6**
Sediment	1,0
Benthic Growth	0,5
BED RATING	**0,8**
Marginal	-2,0
Non-marginal	-2,0
BANK RATING	**2,0**
Longitudinal Connectivity	1,0
Lateral Connectivity	1,0
CONNECTIVITY RATING	**1,0**
INSTREAM IHI %	**78,7**
INSTREAM IHI EC	**B/C**
INSTREAM CONFIDENCE	**3,0**

RIPARIAN IHI	MRU
Base Flows	-2,5
Zero Flows	0,0
Moderate Floods	2,5
Large Floods	2,5
HYDROLOGY RATING	**1,7**
Substrate Exposure (marginal)	1,0
Substrate Exposure (non-marginal)	1,0
Invasive Alien Vegetation (marginal)	0,5
Invasive Alien Vegetation (non-marginal)	1,0
Erosion (marginal)	1,0
Erosion (non-marginal)	1,5
Physico-Chemical (marginal)	0,5
Physico-Chemical (non-marginal)	1,0
Marginal	1,0
Non-marginal	1,5
BANK STRUCTURE RATING	**1,1**
Longitudinal Connectivity	2,5
Lateral Connectivity	2,5
CONNECTIVITY RATING	**2,5**
RIPARIAN IHI %	**68,0**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**2,0**

Table E4: Presentation of the results of the IHI for the Inguduma River.

INSTREAM IHI	MRU
Base Flows	-2,0
Zero Flows	0,0
Floods	3,5
HYDROLOGY RATING	**1,3**
pH	1,0
Salts	0,0
Nutrients	1,0
Water Temperature	0,0
Water clarity	2,0
Oxygen	-0,5
Toxics	2,0
PC RATING	**1,0**
Sediment	-1,0
Benthic Growth	0,0
BED RATING	**0,6**
Marginal	-2,0
Non-marginal	-2,0
BANK RATING	**2,0**
Longitudinal Connectivity	-3,0
Lateral Connectivity	-2,0
CONNECTIVITY RATING	**2,9**
INSTREAM IHI %	**71,1**
INSTREAM IHI EC	**C**
INSTREAM CONFIDENCE	**#DIV/0!**

RIPARIAN IHI	MRU
Base Flows	-2,5
Zero Flows	0,0
Moderate Floods	2,5
Large Floods	2,5
HYDROLOGY RATING	**1,7**
Substrate Exposure (marginal)	1,0
Substrate Exposure (non-marginal)	1,0
Invasive Alien Vegetation (marginal)	0,5
Invasive Alien Vegetation (non-marginal)	1,0
Erosion (marginal)	1,0
Erosion (non-marginal)	1,5
Physico-Chemical (marginal)	0,5
Physico-Chemical (non-marginal)	1,0
Marginal	1,0
Non-marginal	1,5
BANK STRUCTURE RATING	**1,1**
Longitudinal Connectivity	2,0
Lateral Connectivity	1,5
CONNECTIVITY RATING	**1,8**
RIPARIAN IHI %	**70,9**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**1,7**

Table E5: Presentation of the results of the IHI for the tributaries.

	MRU
INSTREAM IHI	
Base Flows	-2,0
Zero Flows	0,0
Floods	3,5
HYDROLOGY RATING	**1,3**
pH	0,0
Salts	1,5
Nutrients	1,0
Water Temperature	0,0
Water clarity	0,0
Oxygen	0,5
Toxics	0,0
PC RATING	**0,6**
Sediment	0,0
Benthic Growth	0,0
BED RATING	**0,0**
Marginal	1,0
Non-marginal	0,0
BANK RATING	**0,6**
Longitudinal Connectivity	-1,0
Lateral Connectivity	-0,5
CONNECTIVITY RATING	**1,0**
INSTREAM IHI %	**85,6**
INSTREAM IHI EC	**B**
INSTREAM CONFIDENCE	**3,0**

	MRU
RIPARIAN IHI	
Base Flows	-2,5
Zero Flows	0,0
Moderate Floods	2,0
Large Floods	0,0
HYDROLOGY RATING	**1,2**
Substrate Exposure (marginal)	1,0
Substrate Exposure (non-marginal)	1,0
Invasive Alien Vegetation (marginal)	0,5
Invasive Alien Vegetation (non-marginal)	1,0
Erosion (marginal)	1,0
Erosion (non-marginal)	1,0
Physico-Chemical (marginal)	0,5
Physico-Chemical (non-marginal)	0,0
Marginal	1,0
Non-marginal	1,0
BANK STRUCTURE RATING	**1,0**
Longitudinal Connectivity	0,5
Lateral Connectivity	1,0
CONNECTIVITY RATING	**0,7**
RIPARIAN IHI %	**80,4**
RIPARIAN IHI EC	**B/C**
RIPARIAN CONFIDENCE	**2,2**

Table E6: Presentation of the results of the Ecoservices assessment applied to iCawa River.

		Present State			
ECOSYSTEM SERVICE		**Supply**	**Demand**	**Importance Score**	**Importance**
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0,3	0,9	0,0	Very Low
	Stream flow regulation	-	-	#VALUE!	#VALUE!
	Sediment trapping	0,5	2,3	0,1	Very Low
	Erosion control	1,3	3,0	1,3	Moderately Low
	Phosphate assimilation	0,5	2,3	0,2	Very Low
	Nitrate assimilation	0,7	0,8	0,0	Very Low
	Toxicant assimilation	0,5	1,5	0,0	Very Low
	Carbon storage	1,0	2,7	0,8	Low
	Biodiversity maintenance	2,0	2,0	1,5	Moderately Low
PROVISIONING SERVICES	Water for human use	3,0	4,0	3,5	Very High
	Harvestable resources	2,5	1,3	1,7	Moderately Low
	Food for livestock	2,0	2,0	1,5	Moderately Low
	Cultivated foods	3,0	2,0	2,5	Moderately High
CULTURAL SERVICES	Tourism and Recreation	1,3	3,0	1,3	Low
	Education and Research	1,5	0,7	0,3	Very Low
	Cultural and Spiritual	2,0	0,3	0,7	Very Low

Table E7: Presentation of the results of the Ecoservices assessment applied to the Inguduma River.

ECOSYSTEM SERVICE		Present State Supply	Present State Demand	Present State Importance Score	Present State Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0,3	1,3	0,0	Very Low
	Stream flow regulation	-	-	#VALUE!	#VALUE!
	Sediment trapping	0,5	3,0	0,5	Very Low
	Erosion control	1,3	3,0	1,3	Moderately Low
	Phosphate assimilation	0,5	3,0	0,5	Very Low
	Nitrate assimilation	0,7	1,0	0,0	Very Low
	Toxicant assimilation	0,5	2,0	0,0	Very Low
	Carbon storage	1,0	2,7	0,8	Low
	Biodiversity maintenance	2,0	2,0	1,5	Moderately Low
PROVISIONING SERVICES	Water for human use	3,0	2,7	2,8	High
	Harvestable resources	2,5	1,3	1,7	Moderately Low
	Food for livestock	2,0	1,3	1,2	Low
	Cultivated foods	3,0	1,3	2,2	Moderate
CULTURAL SERVICES	Tourism and Recreation	1,3	3,0	1,3	Low
	Education and Research	1,5	0,7	0,3	Very Low
	Cultural and Spiritual	2,0	0,3	0,7	Very Low

Table E8: Presentation of the results of the Ecoservices assessment applied to unnamed tributaries.

ECOSYSTEM SERVICE		Present State Supply	Present State Demand	Present State Importance Score	Present State Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0,5	0,7	0,0	Very Low
	Stream flow regulation	-	-	#VALUE!	#VALUE!
	Sediment trapping	0,5	1,0	0,0	Very Low
	Erosion control	0,7	1,2	0,0	Very Low
	Phosphate assimilation	0,5	1,0	0,0	Very Low
	Nitrate assimilation	0,7	1,0	0,0	Very Low
	Toxicant assimilation	0,5	1,0	0,0	Very Low
	Carbon storage	0,7	2,7	0,5	Very Low
	Biodiversity maintenance	2,8	2,0	2,3	Moderately High
PROVISIONING SERVICES	Water for human use	3,0	1,0	2,0	Moderate
	Harvestable resources	2,0	0,3	0,7	Very Low
	Food for livestock	3,0	2,0	2,5	Moderately High
	Cultivated foods	3,0	0,0	1,5	Moderately Low
CULTURAL SERVICES	Tourism and Recreation	1,5	0,3	0,2	Very Low
	Education and Research	1,5	0,3	0,2	Very Low
	Cultural and Spiritual	3,0	0,3	1,7	Moderately Low

Table E9: Presentation of the results of the Ecoservices assessment applied to the UCVB wetland.

	ECOSYSTEM SERVICE	Present State: Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0,8	0,0	0,0	Very Low
	Stream flow regulation	1,8	0,3	0,4	Very Low
	Sediment trapping	0,9	1,5	0,1	Very Low
	Erosion control	1,1	2,0	0,6	Very Low
	Phosphate assimilation	0,9	1,5	0,1	Very Low
	Nitrate assimilation	0,8	1,5	0,0	Very Low
	Toxicant assimilation	0,8	1,5	0,1	Very Low
	Carbon storage	1,4	2,7	1,3	Low
	Biodiversity maintenance	1,7	2,0	1,2	Low
PROVISIONING SERVICES	Water for human use	1,5	0,7	0,3	Very Low
	Harvestable resources	1,5	1,3	0,7	Very Low
	Food for livestock	2,0	2,7	1,8	Moderate
	Cultivated foods	2,5	2,0	2,0	Moderate
CULTURAL SERVICES	Tourism and Recreation	0,4	0,0	0,0	Very Low
	Education and Research	0,5	0,0	0,0	Very Low
	Cultural and Spiritual	1,0	0,0	0,0	Very Low

Table E10: Presentation of the results of the Ecoservices assessment applied to the CVB wetland.

	ECOSYSTEM SERVICE	Present State: Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	1,0	0,5	0,0	Very Low
	Stream flow regulation	2,0	0,3	0,7	Very Low
	Sediment trapping	3,0	2,3	2,6	Moderately High
	Erosion control	1,9	3,0	1,9	Moderate
	Phosphate assimilation	2,6	2,3	2,2	Moderate
	Nitrate assimilation	1,7	1,5	0,9	Low
	Toxicant assimilation	2,3	1,5	1,6	Moderately Low
	Carbon storage	1,6	2,7	1,4	Moderately Low
	Biodiversity maintenance	2,6	3,5	2,9	High
PROVISIONING SERVICES	Water for human use	1,5	3,7	1,8	Moderate
	Harvestable resources	1,5	1,3	0,7	Very Low
	Food for livestock	1,5	2,7	1,3	Moderately Low
	Cultivated foods	2,3	2,0	1,8	Moderate
CULTURAL SERVICES	Tourism and Recreation	0,6	0,0	0,0	Very Low
	Education and Research	0,5	0,0	0,0	Very Low
	Cultural and Spiritual	1,0	0,0	0,0	Very Low

Table E11: Presentation of the results of the Ecoservices assessment applied to the seep wetland.

		Present State			
ECOSYSTEM SERVICE		Supply	Demand	Importance Score	Importance
REGULATING AND SUPPORTING SERVICES	Flood attenuation	0,6	0,0	0,0	Very Low
	Stream flow regulation	2,0	0,0	0,5	Very Low
	Sediment trapping	1,6	3,0	1,6	Moderately Low
	Erosion control	1,5	1,3	0,7	Very Low
	Phosphate assimilation	1,7	2,0	1,2	Low
	Nitrate assimilation	1,6	2,0	1,1	Low
	Toxicant assimilation	1,7	2,0	1,2	Low
	Carbon storage	1,6	2,7	1,4	Moderately Low
	Biodiversity maintenance	1,6	1,0	0,6	Very Low
PROVISIONING SERVICES	Water for human use	1,5	0,3	0,2	Very Low
	Harvestable resources	0,5	0,3	0,0	Very Low
	Food for livestock	1,5	1,3	0,7	Very Low
	Cultivated foods	2,3	0,0	0,8	Very Low
CULTURAL SERVICES	Tourism and Recreation	0,3	0,0	0,0	Very Low
	Education and Research	0,5	0,0	0,0	Very Low
	Cultural and Spiritual	1,0	0,0	0,0	Very Low

Table E12: Presentation of the EIS results of the Channelled Valley Bottom (CVB) and seep wetland.

FRESHWATER FEATURE:	Channelled Valley Bottom	Seep Wetland	Confidence
Ecological Importance and Sensitivity	Score (0-4)	Score (0-4)	Confidence (1-5)
Biodiversity support	Average	Average	Average
	1.67	1.67	4.00
Presence of Red Data species	0	0	4
Populations of unique species	2	2	4
Migration/breeding/feeding sites	3	3	4
Landscape scale	**B (Average)**	**B (Average)**	**B (Average)**
	2.20	2.00	4.00
Protection status of the wetland	4	4	4
Protection status of the vegetation type	2	3	4
Regional context of the ecological integrity	2	1	4
Size and rarity of the wetland type/s present	2	1	4
Diversity of habitat types	1	1	4
Sensitivity of the wetland	**C (Average)**	**C (Average)**	**B (Average)**
	1.67	1.00	4.00
Sensitivity to changes in floods	2	1	4
Sensitivity to changes in low flows/dry season	2	1	4
Sensitivity to changes in water quality	1	1	4
ECOLOGICAL IMPORTANCE & SENSITIVITY	**Max of (A, B or C)**	**Max of (A, B or C)**	
Fill in highest score	**C (2.20)**	**C (2.00)**	
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.			
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.			

Hydro-Functional Importance			Score (0-4)	Score (0-4)	Score (0-4)
Regulating & supporting benefits	Flood attenuation		2	2	4
	Streamflow regulation		2	2	4
	Water Quality Enhanceme	*Sediment trapping*	2	2	4
		Phosphate assimilation	2	2	4
		Nitrate assimilation	1	1	4
		Toxicant assimilation	2	1	4
		Erosion control	2	1	4
	Carbon storage		3	2	4
HYDRO-FUNCTIONAL IMPORTANCE (average score)			2.00	1.63	4.00
Direct Human Benefits			Score (0 – 4)	Score (0 – 4)	Score (0-4)
Subsistence benefits	*Water for human use*		2	1	4
	Harvestable resources		2	0	4
	Cultivated foods		0	0	4
Cultural benefits	*Cultural heritage*		0	0	4
	Tourism and recreation		1	1	4
	Education and research		0	0	4
DIRECT HUMAN BENEFITS (average score)			0.83	0.33	4.00

Table E13: Presentation of the EIS results of the iCawa River and Inguduma River.

FRESHWATER FEATURE:	iCawa River	Inguduma River	Confidence
Ecological Importance and Sensitivity	Score (0-4)	Score (0-4)	Confidence (1-5)
Biodiversity support	Average	Average	Average
	1,00	0,67	4.00
Presence of Red Data species	0	0	4
Populations of unique species	1	1	4
Migration/breeding/feeding sites	2	1	4
Landscape scale	B (Average)	B (Average)	
	2,20	2,00	
Protection status of the wetland	3	3	4
Protection status of the vegetation type	2	2	4
Regional context of the ecological integrity	2	1	4
Size and rarity of the wetland type/s present	2	2	4
Diversity of habitat types	2	2	4
Sensitivity of the wetland	C (Average)	C (Average)	C (Average)
	2,00	1,00	4
Sensitivity to changes in floods	2	2	4
Sensitivity to changes in low flows/dry season	2	0	4
Sensitivity to changes in water quality	2	1	4
ECOLOGICAL IMPORTANCE & SENSITIVITY	Max of (A, B or C)	Max of (A, B or C)	
Fill in highest score	B (2.20)	B (2.0)	
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.			
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.			

Hydro-Functional Importance			Score (0-4)	Score (0-4)	
Regulating & supporting benefits	Flood attenuation		0	0	4
	Streamflow regulation		1	1	4
	Water Qualit y	*Sediment trapping*	2	2	4
		Phosphate assimilation	2	2	4
		Nitrate assimilation	1	1	4

	Toxicant assimilation	2	2	4
	Erosion control	2	2	4
	Carbon storage	2	2	4
HYDRO-FUNCTIONAL IMPORTANCE (average score)		1.38	1.0	
Direct Human Benefits		**Score (0 – 4)**	**Score (0 – 4)**	
Subsistence benefits	*Water for human use*	3	2	4
	Harvestable resources	2	2	4
	Cultivated foods	2	1	4
Cultural benefits	*Cultural heritage*	1	1	4
	Tourism and recreation	2	2	4
	Education and research	0	0	4
DIRECT HUMAN BENEFITS (average score)		1.67	1.33	

Table E14: Presentation of the EIS results of the unnamed tributaries.

FRESHWATER FEATURE:		**the unnamed tributaries**	**Confidence**
Ecological Importance and Sensitivity		Score (0-4)	Confidence (1-5)
Biodiversity support		Average 1.67	Average 4.00
Presence of Red Data species		0	4
Populations of unique species		2	4
Migration/breeding/feeding sites		3	4
Landscape scale		**B (Average)** 2.20	**B (Average)** 4.00
Protection status of the wetland		4	4
Protection status of the vegetation type		2	4
Regional context of the ecological integrity		2	4
Size and rarity of the wetland type/s present		2	4
Diversity of habitat types		1	4
Sensitivity of the wetland		**C (Average)** 1.67	**B (Average)** 4.00
Sensitivity to changes in floods		2	4
Sensitivity to changes in low flows/dry season		2	4
Sensitivity to changes in water quality		1	4
ECOLOGICAL IMPORTANCE & SENSITIVITY		**Max of (A, B or C)**	
Fill in highest score		**C (2.20)**	
Hydro-Functional Importance		**Score (0-4)**	**Score (0-4)**
Regulating & supporting benefits	Flood attenuation	2	4
	Streamflow regulation	2	4
	Water Quality Enhancement *Sediment trapping*	2	4
	Phosphate assimilation	2	4
	Nitrate assimilation	1	4
	Toxicant assimilation	2	4
	Erosion control	2	4
	Carbon storage	3	4
HYDRO-FUNCTIONAL IMPORTANCE (average score)		2.00	4.00
Direct Human Benefits		**Score (0 – 4)**	**Score (0-4)**
Subsistence benefits	*Water for human use*	2	4
	Harvestable resources	2	4
	Cultivated foods	0	4
Cultural benefits	*Cultural heritage*	0	4
	Tourism and recreation	1	4
	Education and research	0	4
DIRECT HUMAN BENEFITS (average score)		0.83	4.00

AQUATIC ECOLOGICAL ASSESSMENT

Integrated Habitat Integrity (IHI)

Site NC1

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	1.0
HYDROLOGY RATING	0.5
pH	0.0
Salts	0.0
Nutrients	0.0
Water Temperature	0.0
Water clarity	-1.0
Oxygen	0.0
Toxics	0.0
PC RATING	0.5
Sediment	-1.0
Benthic Growth	-0.5
BED RATING	0.7
Marginal	-1.0
Non-marginal	-1.0
BANK RATING	1.0
Longitudinal Connectivity	-1.0
Lateral Connectivity	-1.0
CONNECTIVITY RATING	1.0
INSTREAM IHI %	86.2
INSTREAM IHI EC	B
INSTREAM CONFIDENCE	3.0

RIPARIAN IHI	
Base Flows	-2.5
Zero Flows	0.0
Moderate Floods	2.5
Large Floods	2.5
HYDROLOGY RATING	1.9
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	2.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	0.0
Physico-Chemical (non-marginal)	0.0
Marginal	2.0
Non-marginal	1.0
BANK STRUCTURE RATING	1.6
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	1.0
RIPARIAN IHI %	68.5
RIPARIAN IHI EC	C
RIPARIAN CONFIDENCE	3.0

Site NC2

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	1.0
HYDROLOGY RATING	0.5
pH	0.0
Salts	0.0
Nutrients	0.0
Water Temperature	0.0
Water clarity	-1.0
Oxygen	0.0
Toxics	0.0
PC RATING	0.5
Sediment	-1.0
Benthic Growth	-0.5
BED RATING	0.7
Marginal	-1.0
Non-marginal	-1.0
BANK RATING	1.0
Longitudinal Connectivity	-1.0
Lateral Connectivity	-1.0
CONNECTIVITY RATING	1.0
INSTREAM IHI %	86.2
INSTREAM IHI EC	B
INSTREAM CONFIDENCE	3.0

RIPARIAN IHI	
Base Flows	-2.5
Zero Flows	0.0
Moderate Floods	2.5
Large Floods	2.5
HYDROLOGY RATING	1.9
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	2.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	0.0
Physico-Chemical (non-marginal)	0.0
Marginal	2.0
Non-marginal	1.0
BANK STRUCTURE RATING	1.6
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	1.0
RIPARIAN IHI %	68.5
RIPARIAN IHI EC	C
RIPARIAN CONFIDENCE	3.0

Site NC3

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	1.0
HYDROLOGY RATING	**0.5**
pH	-0.5
Salts	0.0
Nutrients	0.0
Water Temperature	0.0
Water clarity	0.0
Oxygen	0.0
Toxics	0.0
PC RATING	**0.5**
Sediment	-2.0
Benthic Growth	-0.5
BED RATING	**1.0**
Marginal	-2.0
Non-marginal	-1.0
BANK RATING	**1.6**
Longitudinal Connectivity	-3.0
Lateral Connectivity	-1.0
CONNECTIVITY RATING	**2.4**
INSTREAM IHI %	**78.7**
INSTREAM IHI EC	**B/C**
INSTREAM CONFIDENCE	**3.0**

RIPARIAN IHI	
Base Flows	-1.0
Zero Flows	0.0
Moderate Floods	1.5
Large Floods	1.0
HYDROLOGY RATING	**0.9**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	1.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	0.0
Physico-Chemical (non-marginal)	0.0
Marginal	1.0
Non-marginal	1.0
BANK STRUCTURE RATING	**1.0**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
RIPARIAN IHI %	**80.7**
RIPARIAN IHI EC	**B/C**
RIPARIAN CONFIDENCE	**3.0**

Site NC4

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	1.0
HYDROLOGY RATING	**0.5**
pH	-0.5
Salts	0.0
Nutrients	0.0
Water Temperature	0.0
Water clarity	0.0
Oxygen	0.0
Toxics	0.0
PC RATING	**0.5**
Sediment	-1.0
Benthic Growth	-0.5
BED RATING	**0.7**
Marginal	-1.0
Non-marginal	-1.0
BANK RATING	**1.0**
Longitudinal Connectivity	-3.0
Lateral Connectivity	-1.0
CONNECTIVITY RATING	**2.4**
INSTREAM IHI %	**81.4**
INSTREAM IHI EC	**B/C**
INSTREAM CONFIDENCE	**3.0**

RIPARIAN IHI	
Base Flows	-1.0
Zero Flows	0.0
Moderate Floods	1.5
Large Floods	1.5
HYDROLOGY RATING	**1.1**
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	2.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	0.0
Physico-Chemical (non-marginal)	0.0
Marginal	2.0
Non-marginal	1.0
BANK STRUCTURE RATING	**1.6**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
RIPARIAN IHI %	**74.3**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.0**

Site NC5

INSTREAM IHI	
Base Flows	-1.0
Zero Flows	0.0
Floods	1.0
HYDROLOGY RATING	**0.5**
pH	0.0
Salts	0.0
Nutrients	0.0
Water Temperature	0.0
Water clarity	0.0
Oxygen	-2.0
Toxics	0.0
PC RATING	**0.5**
Sediment	-1.0
Benthic Growth	-0.5
BED RATING	**0.7**
Marginal	-1.0
Non-marginal	-1.0
BANK RATING	**1.0**
Longitudinal Connectivity	-3.0
Lateral Connectivity	-1.0
CONNECTIVITY RATING	**2.4**
INSTREAM IHI %	**81.4**
INSTREAM IHI EC	**B/C**
INSTREAM CONFIDENCE	**3.0**

RIPARIAN IHI	
Base Flows	-1.0
Zero Flows	0.0
Moderate Floods	1.5
Large Floods	1.5
HYDROLOGY RATING	**1.1**
Substrate Exposure (marginal)	2.0
Substrate Exposure (non-marginal)	1.0
Invasive Alien Vegetation (marginal)	1.0
Invasive Alien Vegetation (non-marginal)	1.0
Erosion (marginal)	2.0
Erosion (non-marginal)	1.0
Physico-Chemical (marginal)	0.0
Physico-Chemical (non-marginal)	0.0
Marginal	2.0
Non-marginal	1.0
BANK STRUCTURE RATING	**1.6**
Longitudinal Connectivity	1.0
Lateral Connectivity	1.0
CONNECTIVITY RATING	**1.0**
RIPARIAN IHI %	**74.3**
RIPARIAN IHI EC	**C**
RIPARIAN CONFIDENCE	**3.0**

Macro-Invertebrate Response Assessment Index (MIRAI)

Site NC1

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	**FM**	44.6	*0.385*	17.1598	1	100
HABITAT	**H**	70.0	*0.192*	13.4615	3	50
WATER QUALITY	**WQ**	56.7	*0.308*	17.4359	2	80
CONNECTIVITY & SEASONALITY	**CS**	100.0	*0.115*	11.5385	4	30
						260
INVERTEBRATE EC				59.5957		
INVERTEBRATE EC CATEGORY				**C/D**		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Site NC2

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	44.6	*0.385*	17.1598	1	100
HABITAT	H	60.8	*0.192*	11.6864	3	50
WATER QUALITY	WQ	58.7	*0.308*	18.0513	2	80
CONNECTIVITY & SEASONALITY	CS	100.0	*0.115*	11.5385	4	30
						260
INVERTEBRATE EC				58.4359		
INVERTEBRATE EC CATEGORY				C/D		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Site NC3

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	35.4	*0.308*	10.8876	2	80
HABITAT	H	42.3	*0.192*	8.13609	3	50
WATER QUALITY	WQ	34.7	*0.385*	13.3333	1	100
CONNECTIVITY & SEASONALITY	CS	100.0	*0.115*	11.5385	4	30
						260
INVERTEBRATE EC				43.8955		
INVERTEBRATE EC CATEGORY				D		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Site NC4

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	40.0	*0.308*	12.3077	2	80
HABITAT	H	40.0	*0.192*	7.69231	3	50
WATER QUALITY	WQ	31.3	*0.385*	12.0513	1	100
CONNECTIVITY & SEASONALITY	CS	100.0	*0.115*	11.5385	4	30
						260
INVERTEBRATE EC				43.5897		
INVERTEBRATE EC CATEGORY				D		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Site NC5

INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	%WEIGHT FOR METRIC GROUP
FLOW MODIFICATION	FM	32.3	*0.385*	12.426	1	100
HABITAT	H	47.7	*0.192*	9.1716	3	50
WATER QUALITY	WQ	34.7	*0.308*	10.6667	2	80
CONNECTIVITY & SEASONALITY	CS	100.0	*0.115*	11.5385	4	30
						260
INVERTEBRATE EC				43.8028		
INVERTEBRATE EC CATEGORY				D		
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F						

Fish Response Assessment Index (FRAI)

AUTOMATED	
FRAI (%)	8.9
EC: FRAI	F
ADJUSTED	
FRAI (%)	59.7
EC: FRAI	C/D

WEIGHT OF METRIC GROUPS	
METRIC GROUP	WEIGHT (%)
VELOCITY-DEPTH	90.91
COVER	100.00
FLOW MODIFICATION	96.97
PHYSICO-CHEMICAL	66.67
MIGRATION	57.58
IMPACT OF INTRODUCED	54.55

ABBREVIATIONS: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	REFERENCE FREQUENCY OF OCCURRENCE	EC:OBSERVED & HABITAT DERIVED FREQUENCY OF OCCURRENCE
Anat	AMPHILIUS NATALENSIS BOULENGER, 1917	1.00	0.00
Amos	ANGUILLA MOSSAMBICA PETERS 1852	1.00	0.00
Cgar	CLARIAS GARIEPINUS (BURCHELL, 1822)	1.00	0.00
Bano	BARBUS ANOPLUS WEBER, 1897	1.00	0.00
Bnat	BARBUS NATALENSIS CASTELNAU, 1861	1.00	0.00
Bpal	BARBUS PALLIDUS SMITH, 1841	1.00	0.00
Bpau	BARBUS PALUDINOSUS PETERS, 1852	1.00	0.00
Bviv	BARBUS VIVIPARUS WEBER, 1897	1.00	0.00
Lrub	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913	1.00	0.00
Omos	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	3.00	0.00

Diatom species list and abundances for site NC1.

Species	Counts	Abundances
Fragilaria biceps (Kützing) Lange-Bertalot	178	44,50
CYMBELLA C.Agardh	86	21,50
Cymbella aspera(Ehrenberg) H.Peragallo	51	12,75
Gomphonema affine Kützing	27	6,75
NAVICULA J.B.M. Bory de St. Vincent	17	4,25
Pinnularia viridiformis Krammer var. minor Krammer	13	3,25
Surirella angusta Kützing	12	3,00
Encyonopsis leei Krammer var. leei	10	2,50
GOMPHONEMA C.G. Ehrenberg	6	1,50
Total	400	

Diatom species list and abundances for site NC2.

Species	Counts	Abundances
Fragilaria biceps (Kützing) Lange-Bertalot	217	54,25
Cymbella spp. C.Agardh	71	17,75
Gomphonema insigne Gregory	19	4,75
Gomphonema spp. C.G. Ehrenberg	18	4,50
Pinnularia gibba Ehrenberg	18	4,50
Cymatopleura solea (Brebisson in Breb. & Godey) W.Smith var.solea	14	3,50
Encyonopsis leei Krammer var. leei	12	3,00
Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot	11	2,75
Cocconeis placentula Ehrenberg var. placentula	10	2,50
Gyrosigma attenuatum (Kützing) Rabenhorst	10	2,50
Total	400	

Diatom species list and abundances for site NC4.

Species	Counts	Abundances
Sellaphora pupula (Kützing) Mereschkowksy	69	17,25
Navicula spp. J.B.M. Bory de St. Vincent	57	14,25
Navicula ranomafanensis (Manguin) Metzeltin & Lange-Bertalot	50	12,50
Gomphonema parvulum (Kützing) Kützing var. parvulum f. parvulum	41	10,25
Frustulia vulgaris (Thwaites) De Toni	33	8,25
Gomphonema affine Kützing	25	6,25
Fragilaria parasitica (W.Sm.) Grun. var. parasitica	19	4,75
Rhopalodia gibba (Ehr.) O.Muller var.gibba	16	4,00
Eunotia pectinalis (Dyllwyn) Rabenhorst var.pectinalis	15	3,75
Nitzschia sinuata (Thwaites) Grunow var.sinuata	14	3,50
Nitzschia etoshensis Cholnoky	12	3,00
Fragilaria biceps (Kützing) Lange-Bertalot	10	2,50
Placoneis spp. C. Mereschkowsky	10	2,50
Pinnularia joculata (Manguin) Krammer	8	2,00
Encyonopsis leei Krammer var. leei	7	1,75
Pinnularia subbrevistriata Krammer	6	1,50
Amphora spp. C.G. Ehrenberg ex F.T. Kützing	5	1,25
Surirella angusta Kützing	3	0,75
Total	400	

IHAS Scoresheets

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: NC1	**Date: 17/11/2022**					
SAMPLING HABITAT	**0**	**1**	**2**	**3**	**4**	**5**
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(* NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			**21**		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				**11**	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				**13**	
	HABITAT TOTAL (MAX 55):				**45**	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX 4!			**28**		
	TOTAL IHAS SCORE (%):				**73**	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: NC2	Date: 17/11/2022					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(*NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			21		
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				11	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				14	
	HABITAT TOTAL (MAX 55):				46	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					23
	TOTAL IHAS SCORE (%):				69	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:

Site Name: **NC3**

Date: **17 November 2022**

SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(*NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			17		
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				13	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				11	
	HABITAT TOTAL (MAX 55):				41	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					29
	TOTAL IHAS SCORE (%):				70	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)						
River Name:						
Site Name: NC 4	Date: 17 November 2022					
SAMPLING HABITAT	0	1	2	3	4	5
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	**none**	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	**none**	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	**0**	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	**none**	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	**n/a**	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	**0**	<1	>1-2	2	>2-3	>3
(*NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			0		
VEGETATION	0	1	2	3	4	5
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	**>2**
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	**0-½**	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		**run**	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	**26-50**	51-75	>75
	Vegetation Score (max 15):				11	
OTHER HABITAT/GENERAL	0	1	2	3	4	5
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	**none**	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	**under**	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	**½**	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	**0-½**	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	**none**	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	**isol**	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		**corr**		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				12	
	HABITAT TOTAL (MAX 55):				23	
STREAM CONDITION	0	1	2	3	4	5
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	**pool**		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	**1-2**	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	**<½-¼**	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	**slow**	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		**disc**		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	**fire**	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	**shrubs**	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	**other**		open
Left bank cover: (rocks and vegetation) (in %)	0-50	**51-80**	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	**50-80**	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					21
	TOTAL IHAS SCORE (%):				44	

INVERTEBRATE HABITAT ASSESSMENT SYSTEM (IHAS)

River Name:						
Site Name: NC 5	**Date** : 17th November 2022					
SAMPLING HABITAT	**0**	**1**	**2**	**3**	**4**	**5**
STONES IN CURRENT (SIC)						
Total length of white water rapids (i.e.: bubbling water) (in meters)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in meters)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC area's kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cm's) (gravel is <2, bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment, etc) (in %)*	n/a	0-25	26-50	51-75	>75	
PROTOCOL: time spent actually kicking stones (in minutes) (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
(*NOTE: up to 25% of stone is usually embedded in the stream bottom)						
	SIC Score (max 20):			0		
VEGETATION	**0**	**1**	**2**	**3**	**4**	**5**
Length of fringing vegetation sampled (river banks) (PROTOCOL - in meters)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation sampled (underwater) (in square meters)	none	0-½	>½-1	>1		
Fringing vegetation sampled in: ('still' = pool/still water only; 'run' = run only)	none		run	pool		mix
Type of vegetation (% leafy veg. As opposed to stems/shoots) (aq. Veg. Only = 49%)	none		1-25	26-50	51-75	>75
	Vegetation Score (max 15):				11	
OTHER HABITAT/GENERAL	**0**	**1**	**2**	**3**	**4**	**5**
Stones out of current (SOOC) sampled: (PROTOCOL - in square meters)	none	0-½	>½-1	1	>1	
Sand sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	>½-1	1	>1
Mud sampled: (PROTOCOL - in minutes) ('under' = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (PROTOCOL - in minutes) (if all gravel, SIC stone size = <2)**	none	0-½	½	>½**		
Bedrock sampled: ('all' = no SIC, sand, or gravel then SIC stone size = >20)**	none	some			all**	
Algae present: ('1-2m² = algal bed; 'rocks' = on rocks; 'isol' = isolated clumps)***	>2m²	rocks	1-2m²	<1m²	isol	none
Tray identification: (PROTOCOL - using time: 'coor' = correct time)		under		corr		over
(** NOTE: you must still fill in the SIC section)						
	Other Habitat Score (max 20):				12	
	HABITAT TOTAL (MAX 55):				23	
STREAM CONDITION	**0**	**1**	**2**	**3**	**4**	**5**
PHYSICAL						
River make up: ('pool' = pool/still/dam only; 'run' only; etc)	pool		run	rapid	2mix	3mix
Average width of stream: (in meters)		>10	>5-10	<1	1-2	>2-5
Average depth of stream: (in meters)	>1	1	>½-1	½	<½-¼	<¼
Approximate velocity of stream: ('slow' = <½m/s; 'fast' = >1m/s) (use twig to test)	still	slow	fast	med		mix
Water colour: ('disc' = discoloured with visible colour but still transparent)	silty	opaque		disc		clear
Recent disturbance due to: ('const.' = construction; 'fl/dr' = flood or drought)***	fl/dr	fire	constr	other		none
Bank/riparian vegetation is: ('grass' = includes reeds; 'shrubs' = include trees)	none		grass	shrubs	mix	
Surrounding impacts: ('erosn' = erosion/shear bank; 'farm' = farmland/settlement)***	erosn	farm	trees	other		open
Left bank cover: (rocks and vegetation) (in %)	0-50	51-80	81-95	>95		
Right bank cover: (rocks and vegetation) (in %)	0-50	50-80	81-95	>95		
(*** NOTE: if more than one option, choose the lowest)						
	STREAM CONDITIONS TOTAL (MAX					21
	TOTAL IHAS SCORE (%):				44	

SASS5 scoresheets

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 17 November 2022	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S:°	COELENTERATA	1					Belostomatidae*	3			A	A	Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3	A	A		B	Blepharoceridae	15				
SITE CODE: NC1	ANNELIDA:						Gerridae*	5					Ceratopogonidae	5	A	A		A
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2			A	A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7		A		A	Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3					Dixidae*	10				
TEMP:	Amphipoda	13					Notonectidae*	3		A		A	Empididae	6				
Ph:	Potamonautidae*	3	A			A	Pleidae*	4					Ephydridae	3				
DO:	Atyidae	8					Veliidae/M..veliidae*	5			A	A	Muscidae	1				
Cond:	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5	A	A		B
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6	B	A			Hydropsychidae 2 sp	6		A	A	A	Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12				B	Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3	A	A		A
FLOW:	Leptophlebiidae	9	B			B	CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		43	66	35	94
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		9	13	7	18
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		4.78	5.08	5.00	5.22
	Chlorolestidae	8					Pisuliidae	10					IHAS:	73%				
	Coenagrionidae	4	A	A		B	Sericostomatidae SWC	13					OTHER BIOTA: CHILOGLANIS					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		A	A	B	COMMENTS: HEAVY RAIN PRIOR TO ASS					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5	A	B		B	SWC = South Western Cape					
	Aeshnidae	8		A	A	B	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6		A	A	B	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 17 November 2022	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT	TAXON		S	VG	GSM	TOT
GRID REFERENCE:	PORIFERA	5					HEMIPTERA:						DIPTERA:					
S:°	COELENTERATA	1					Belostomatidae*	3	A			A	Athericidae	10				
E: °	TURBELLARIA	3					Corixidae*	3		B		B	Blepharoceridae	15				
SITE CODE: NC2	ANNELIDA:						Gerridae*	5		B		B	Ceratopogonidae	5	A	A		B
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2	A			A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7					Culicidae*	1				
WEATHER CONDITION:	CRUSTACEA:						Nepidae*	3		A		A	Dixidae*	10				
TEMP:	Amphipoda	13					Notonectidae*	3		A		A	Empididae	6				
Ph:	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO: 4	Atyidae	8		A		A	Veliidae/M..veliidae*	5					Muscidae	1				
Cond:	Palaemonidae	10					MEGALOPTERA:						Psychodidae	1				
BIOTOPES SAMPLED:	HYDRACARINA	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	PLECOPTERA:						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					TRICHOPTERA						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	EPHEMEROPTERA						Ecnomidae	8					GASTROPODA					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4		A		A	Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6		A	A	A	Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3		A		A
FLOW:	Leptophlebiidae	9		A		A	CASED CADDIS:						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					PELECYPODA					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					SASS SCORE:		18	68	20	87
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					NO OF TAXA:		4	14	3	18
	Chlorocyphidae	10					Petrothrincidae SWC	11					ASPT:		4.50	4.86	6.67	4.83
	Chlorolestidae	8					Pisuliidae	10					IHAS:	69%				
	Coenagrionidae	4		A		A	Sericostomatidae SWC	13					OTHER BIOTA: CHILOGLANIS					
	Lestidae	8					COLEOPTERA:											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		A		A	COMMENTS: HEAVY RAIN PRIOR TO ASS					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		B		B	SWC = South Western Cape					
	Aeshnidae	8	A		A	A	Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6			A	A	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5		A		A	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 17 November 2022	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3			A	A	Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3	A		A	B	Blepharoceridae	15				
SITE CODE: NC3	**ANNELIDA:**						Gerridae*	5		A		A	Ceratopogonidae	5	A			A
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7		A	A	B	Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP:	Amphipoda	13					Notonectidae*	3	A			A	Empididae	6				
Ph:	Potamonautidae*	3	1			1	Pleidae*	4					Ephydridae	3				
DO:	Atyidae	8		A		A	Veliidae/M..veliidae*	5					Muscidae	1				
Cond:	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4					Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		18	26	29	57
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		5	4	6	12
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		3.60	6.50	4.83	4.75
	Chlorolestidae	8					Pisuliidae	10					**IHAS:**	70%				
	Coenagrionidae	4	A			A	Sericostomatidae SWC	13					**OTHER BIOTA:**					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5			A	A	**COMMENTS:**					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5			A	A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6		A	A	A	Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET

DATE: 17 November 2022	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3		A	A	B	Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: NC 4	**ANNELIDA:**						Gerridae*	5			A	A	Ceratopogonidae	5				
RIVER:	Oligochaeta	1		A		A	Hydrometridae*	6					Chironomidae	2			A	A
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7			A	A	Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP:	Amphipoda	13					Notonectidae*	3					Empididae	6				
Ph:	Potamonautidae*	3					Pleidae*	4					Ephydridae	3				
DO:	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond:	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5		A	A	A
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4			A	A	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3		A	1	A
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3				
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	16	46	47
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	5	10	11
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0.00	3.20	4.60	4.27
	Chlorolestidae	8					Pisuliidae	10					**IHAS:**	44%				
	Coenagrionidae	4		A	A	A	Sericostomatidae SWC	13					**OTHER BIOTA:**					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5			A	A	**COMMENTS:**					
	Protoneuridae	8					Elmidae/Dryopidae*	8			A	A	* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5					SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6					Hydraenidae*	8					S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5					VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

RIVER HEALTH PROGRAMME - SASS 5 SCORE SHEET																		
DATE: 17 November 2022	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**	**TAXON**		**S**	**VG**	**GSM**	**TOT**
GRID REFERENCE:	**PORIFERA**	5					**HEMIPTERA:**						**DIPTERA:**					
S:°	**COELENTERATA**	1					Belostomatidae*	3			A	A	Athericidae	10				
E: °	**TURBELLARIA**	3					Corixidae*	3					Blepharoceridae	15				
SITE CODE: NC 5	**ANNELIDA:**						Gerridae*	5					Ceratopogonidae	5		A		A
RIVER:	Oligochaeta	1					Hydrometridae*	6					Chironomidae	2				
SITE DESCRIPTION:	Leeches	3					Naucoridae*	7		A		A	Culicidae*	1				
WEATHER CONDITION:	**CRUSTACEA:**						Nepidae*	3					Dixidae*	10				
TEMP:	Amphipoda	13					Notonectidae*	3		A	A	B	Empididae	6				
Ph:	Potamonautidae*	3		A		A	Pleidae*	4					Ephydridae	3				
DO:	Atyidae	8					Veliidae/M..veliidae*	5					Muscidae	1				
Cond:	Palaemonidae	10					**MEGALOPTERA:**						Psychodidae	1				
BIOTOPES SAMPLED:	**HYDRACARINA**	8					Cordalidae	8					Simuliidae	5				
SIC: TIME: minutes	**PLECOPTERA:**						Sialidae	6					Syrphidae*	1				
SOOC:	Notonemouridae	14					**TRICHOPTERA**						Tabanidae	5				
BEDROCK:	Perlidae	12					Dipseudopsidae	10					Tipulidae	5				
AQUATIC VEG: DOM SP:	**EPHEMEROPTERA**						Ecnomidae	8					**GASTROPODA**					
M VEG IC: DOM SP:	Baetidae 1sp	4		A		A	Hydropsychidae 1sp	4					Ancylidae	6				
M VEG OOC: DOM SP:	Baetidae 2 sp	6					Hydropsychidae 2 sp	6					Bulininae*	3				
GRAVEL:	Baetidae >2 sp	12					Hydropsychidae >2 sp	12					Hydrobiidae*	3				
SAND:	Caenidae	6					Philopotamidae	10					Lymnaeidae*	3				
MUD:	Ephemeridae	15					Polycentropodidae	12					Physidae*	3		A	A	A
HAND PICKING/VISUAL OBS:	Heptageniidae	13					Psychomyiidae/Xiphocen.	8					Planorbidae*	3				
FLOW:	Leptophlebiidae	9					**CASED CADDIS:**						Thiaridae*	3				
TURBIDITY:	Oligoneuridae	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
RIPARIAN LAND USE:	Polymitarcyidae	10					Calamoceratidae ST	11					**PELECYPODA**					
	Prosopistomatidae	15					Glossosomatidae SWC	11					Corbiculidae	5				
	Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae	3				
	Tricorythidae	9					Hydrosalpingidae SWC	15					Unionidae	6				
	ODONATA:						Lepidostomatidae	10					**SASS SCORE:**		0	58	24	61
DISTURBANCE IN RIVER:	Calopterygidae ST,T	10					Leptoceridae	6					**NO OF TAXA:**		0	12	6	13
	Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT:**		0.00	4.83	0.00	4.69
	Chlorolestidae	8					Pisuliidae	10					**IHAS:**		44%			
	Coenagrionidae	4		A	A	B	Sericostomatidae SWC	13					**OTHER BIOTA:**					
	Lestidae	8					**COLEOPTERA:**											
SIGNS OF POLLUTION:	Platycnemidae	10					Dytiscidae*	5		B	A	B	**COMMENTS:**					
	Protoneuridae	8					Elmidae/Dryopidae*	8					* = airbreathers					
	Zygoptera juvs.	6					Gyrinidae*	5		A		A	SWC = South Western Cape					
	Aeshnidae	8					Halipidae*	5					T = Tropical					
	Corduliidae	8					Helodidae	12					ST = Sub-tropical					
OTHER OBSERVATIONS:	Gomphidae	6		A	A	A	Hydraenidae*	8		A		A	S = Stone & rock					
	Libellulidae	4					Hydrophilidae*	5		A		A	VG = all vegetation					
	LEPIDOPTERA:						Limnichidae	10					GSM = gravel, sand & mud					
	Pyralidae	12					Psephenidae	10					1=1, A=2-10, B=10-100, C=100-1000, D=>1000					

APPENDIX F – Impact Analysis and Mitigation Measures

General construction management and good housekeeping practices

Latent and general impacts which may affect the freshwater ecosystem ecology and biodiversity, will include any activities which take place in close proximity to the project activities may impact on the receiving environment. Mitigation measures for these impacts are highlighted below and are relevant to the freshwater ecosystem identified in this report:

Development footprint

- All development footprint areas should remain as small as possible and should only encroach into the freshwater ecosystem where appropriate authorisation has been obtained;
- The boundaries of footprint areas, including contractor laydown areas, are to be clearly defined and it should be ensured that all activities remain within defined footprint areas. Edge effects will need to be extremely carefully controlled;
- Appropriate sanitary facilities must be provided for the life of the mine and all waste removed to an appropriate waste facility;
- All hazardous chemicals as well as stockpiles should be stored on bunded surfaces and have facilities constructed to control runoff from these areas;
- It must be ensured that all hazardous storage containers and storage areas comply with the relevant SABS standards to prevent leakage;
- No fires should be permitted in or near the construction area; and
- Ensuring that an adequate number of waste and “spill” bins are provided will also prevent litter and ensure the proper disposal of waste and spills.

Vehicle access

- All vehicles must be regularly inspected for leaks. Re-fuelling must take place on a sealed surface area to prevent ingress of hydrocarbons into the topsoil;
- In the event of a vehicle breakdown, maintenance of vehicles must take place with care and the recollection of spillage should be practiced near the surface area to prevent ingress of hydrocarbons into topsoil and subsequent habitat loss; and
- All spills should they occur, should be immediately cleaned up and treated accordingly.

Vegetation

- Proliferation of alien and invasive species is expected within any disturbed areas. Whilst not considered severe at this time, the vegetation component within the freshwater ecosystem environment is already transformed. However, alien invasive species are opportunistic, and where disturbances do occur, they will promulgate; therefore, these species should be eradicated and controlled to prevent their spread beyond the project footprint. Alien plant seed dispersal within the top layers of the soil within footprint areas, that will have an impact on future rehabilitation, has to be controlled;
- Removal of the alien and weed species encountered within the freshwater ecosystem must take place in order to comply with existing provincial guidelines (Biodiversity Impact Assessment in KwaZulu-Natal ((EKZN, 201)) including legislation (amendments to the regulations under the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) and Section 28 of the National Environmental Management Act, 1998 (Act No. 107 of 1998);
- Species specific and area specific eradication recommendations:
  - Footprint areas should be kept as small as possible when removing alien plant species*;* and
  - No vehicles should be allowed to drive through designated sensitive freshwater ecosystems areas during the eradication of alien and weed species.

Soils

- As much vegetation growth as possible (of indigenous floral species) must be established to protect soils and minimise runoff into the riparian freshwater systems; and
- Regular monitoring should be undertaken to assess the footprint area and to measure the degree of sedimentation and soil disturbance in order to allow for adaptive management.

APPENDIX G – Specialist information

DETAILS, EXPERTISE AND CURRICULUM VITAE OF SPECIALISTS

1. (a) (i) Details of the specialist who prepared the report

Stephen van Staden	MSc (Environmental Management) (University of Johannesburg)
Amanda Mileson	Postgraduate Diploma: Nature Conservation (UNISA)
Leandra Jonker	MSc (Aquatic Health) (University of Johannesburg)
Nqobile Lushozi	MSc (Geoinformatics) (Stellenbosch University)

1. (a). (ii) The expertise of that specialist to compile a specialist report including a curriculum vitae

Company of Specialist:	Scientific Aquatic Services		
Name / Contact person:	Stephen van Staden		
Physical address:	29 Arterial Road West, Oriel		
Postal code:	2007	Cell:	083 415 2356
Telephone:	011 616 7893	Fax:	086 724 3132
E-mail:	Stephen@sasenvgroup.co.za		
Qualifications	MSc (Environmental Management) (University of Johannesburg) BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg) BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)		
Registration / Associations	Registered Professional Natural Scientist at South African Council for Natural Scientific Professions (SACNASP) Accredited River Health Practitioner by the South African River Health Program (RHP) Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum		

1. **(b) a declaration that the specialist is independent in a form as may be specified by the competent authority**

I, Stephen van Staden, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

Signature of the Specialist

I, Amanda Mileson, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

----

Signature of the Specialist

I, Nqobile Lushozi, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

----

Signature of the Specialist

I, Leandra Jonker, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct

----

Signature of the Specialist

SAS ENVIRONMENTAL GROUP OF COMPANIES –

SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF STEPHEN VAN STADEN

PERSONAL DETAILS

Position in Company	Group CEO, Water Resource discipline lead, Managing member, Ecologist, Aquatic Ecologist
Joined SAS Environmental Group of Companies	2003 (year of establishment)

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)
Accredited River Health practitioner by the South African River Health Program (RHP)
Member of the South African Soil Surveyors Association (SASSO) Member of the Gauteng Wetland Forum
Member of the Gauteng Wetland Forum;
Member of International Association of Impact Assessors (IAIA) South Africa;
Member of the Land Rehabilitation Society of South Africa (LaRSSA)

EDUCATION

Qualifications

MSc Environmental Management (University of Johannesburg)	2003
BSc (Hons) Zoology (Aquatic Ecology) (University of Johannesburg)	2001
BSc (Zoology, Geography and Environmental Management) (University of Johannesburg)	2000
Tools for wetland assessment short course Rhodes University	2016
Legal liability training course (Legricon Pty Ltd)	2018
Hazard identification and risk assessment training course (Legricon Pty Ltd)	2013
Short Courses	
Certificate – Department of Environmental Science in Legal context of Environmental Management, Compliance and Enforcement (UNISA)	2009
Introduction to Project Management - Online course by the University of Adelaide	2016
Integrated Water Resource Management, the National Water Act, and Water Use Authorisations, focusing on WULAs and IWWMPs	2017

AREAS OF WORK EXPERIENCE

South Africa – All Provinces
Southern Africa – Lesotho, Botswana, Mozambique, Zimbabwe Zambia
Eastern Africa – Tanzania Mauritius
West Africa – Ghana, Liberia, Angola, Guinea Bissau, Nigeria, Sierra Leona
Central Africa – Democratic Republic of the Congo

KEY SPECIALIST DISCIPLINES

Biodiversity Assessments

- Floral Assessments
- Biodiversity Actions Plan (BAP)
- Biodiversity Management Plan (BMP)
- Alien and Invasive Control Plan (AICP)
- Ecological Scan
- Terrestrial Monitoring
- Protected Tree and Floral Marking and Reporting
- Biodiversity Offset Plan

Freshwater Assessments

- Desktop Freshwater Delineation
- Freshwater Verification Assessment
- Freshwater (wetland / riparian) Delineation and Assessment
- Freshwater Eco Service and Status Determination
- Rehabilitation Assessment / Planning
- Maintenance and Management Plans
- Plant species and Landscape Plan
- Freshwater Offset Plan
- Hydropedological Assessment
- Pit Closure Analysis

Aquatic Ecological Assessment and Water Quality Studies

- Habitat Assessment Indices (IHAS, HRC, IHIA & RHAM)
- Aquatic Macro-Invertebrates (SASS5 & MIRAI)
- Fish Assemblage Integrity Index (FRAI)
- Fish Health Assessments
- Riparian Vegetation Integrity (VEGRAI)
- Toxicological Analysis
- Water quality Monitoring
- Screening Test
- Riverine Rehabilitation Plans

Soil and Land Capability Assessment

- Soil and Land Capability Assessment
- Soil Monitoring
- Soil Mapping

Visual Impact Assessment

- Visual Baseline and Impact Assessments
- Visual Impact Peer Review Assessments
- View Shed Analyses
- Visual Modelling

Legislative Requirements, Processes and Assessments

- Water Use Applications (Water Use Licence Applications / General Authorisations)
- Environmental and Water Use Audits
- Freshwater Resource Management and Monitoring as part of EMPR and WUL conditions

SAS ENVIRONMENTAL GROUP OF COMPANIES –

SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF AMANDA MILESON

PERSONAL DETAILS

Position in Company	Ecologist: Wetland Ecology
Joined SAS Environmental Group of Companies	2013

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Member of the South African Wetland Society (SAWS)
Member of the International Society for Wetland Scientists
Member of the Gauteng and Northern Cape Wetland Forums (GWF and NCWF)

EDUCATION

Qualifications

N. Dip Nature Conservation (UNISA)	2017
Advanced Diploma: Nature Conservation (UNISA)	2020
Postgraduate Diploma: Nature Conservation	2023

Short Courses

Wetland Management: Introduction and Delineation (University of the Free State)	2018
Tools for Wetland Assessment (Rhodes University)	2017
Wetland Rehabilitation (University of the Free State)	2015

AREAS OF WORK EXPERIENCE

South Africa – Gauteng, Mpumalanga, Free State, North West, Limpopo, Northern Cape, Eastern Cape
Africa – Zimbabwe, Zambia

KEY SPECIALIST DISCIPLINES

Freshwater Assessments

- Desktop Freshwater Delineation
- Freshwater Verification Assessment
- Freshwater (wetland / riparian) Delineation and Assessment
- Freshwater EcoService and Status Determination
- Rehabilitation Assessment / Planning
- Maintenance and Management Plans
- Plant Species Plan
- Freshwater Offset Plan

Biodiversity Assessments

- Ecological Scan
- Biodiversity Offset Plan

SAS ENVIRONMENTAL GROUP OF COMPANIES –
SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF NQOBILE LUSHOZI

PERSONAL DETAILS

Position in Company	Junior Freshwater Ecologist Wetland and Aquatic Ecology
Joined SAS Environmental Group of Companies	April 2019

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Member of the International Affiliation for Impact Assessments (IAIAsa) South Africa
Member of the South African Wetland Society (SAWS)

EDUCATION

Qualifications

MSc Geoinformatics (Cum laude) (Stellenbosch University)	2019
BSc (Hons) Environmental Sciences (University of KwaZulu-Natal)	2015
BSc Environmental Sciences (University of KwaZulu-Natal)	2014

Short courses

Tools for Wetland Assessment (Rhodes University)	2020
Grass Identification Course (Africa Land-Use Training)	2021

AREAS OF WORK EXPERIENCE

South Africa – Gauteng, Mpumalanga, North West, Limpopo, KwaZulu-Natal, Northern Cape, Free State

KEY SPECIALIST DISCIPLINES

Freshwater Assessments

- Desktop Freshwater Delineation
- Freshwater Verification Assessment
- Freshwater (wetland / riparian) Delineation and Assessment
- Freshwater Eco Service and Status Determination
- Rehabilitation Assessment / Planning
- Maintenance and Management Plans

Aquatic Ecological Assessment and Water Quality Studies

- Toxicological Analysis
- Surface and groundwater quality Monitoring
- Screening Test
- Mass and salt balance determination

SAS ENVIRONMENTAL GROUP OF COMPANIES –
SPECIALIST CONSULTANT INFORMATION

CURRICULUM VITAE OF LEANDRA JONKER

PERSONAL DETAILS

Position in Company	Aquatic Ecologist
Joined SAS Environmental Group of Companies	2012

MEMBERSHIP IN PROFESSIONAL SOCIETIES

Registered Professional Scientist at South African Council for Natural Scientific Professions (SACNASP)
Accredited River Health practitioner by the South African River Health Program (RHP)
Southern African Society of Aquatic Scientists

EDUCATION

Qualifications

MSc Aquatic Health (University of Johannesburg)	2015
BSc Environmental Management (Hons) (University of South Africa)	2011
BSc Botany and Zoology (North-West University)	2009

AREAS OF WORK EXPERIENCE

South Africa – Gauteng, Mpumalanga, North West, Limpopo, KwaZulu-Natal, Free State

KEY SPECIALIST DISCIPLINES

Aquatic Ecological Assessment and Water Quality Studies
- Habitat Assessment Indices (IHAS, HRC, IHIA, IHI & RHAM)
- Aquatic Macro-Invertebrate Community Integrity Assessments (SASS5 & MIRAI)
- Fish Community Integrity Assessments (FRAI)
- Fish Health Assessments
- Diatom Community Assessments
- Riparian Vegetation Integrity Assessments (VEGRAI)
- Toxicological Analysis
- Water quality Monitoring
- Sediment Chemical Analysis
- Riverine Rehabilitation Plans

Legislative Requirements, Processes and Assessments
- Water Use Applications (Water Use Licence Applications / General Authorisations)
- Freshwater Resource Management and Monitoring as part of EMPR and WUL conditions