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FRESHWATER ASSESSMENT

as part of the Section 24G NEMA process for the

UNAUTHORISED CLEARANCE OF VEGETATION AND CONSTRUCTION OF A DAM ON FARM ANGELIERSBOSCH RE/157, PRINCE ALBERT

PREPARED FOR:	Mr Johannes Jurie Klue Avondrust Boerdery PO Box 1 Klaarstroom 6932	**PREPARED BY:**	Sharples Environmental Services cc Author: Debbie Fordham Email: debbie@sescc.net
		DATE:	19/05/2021 (V2)

DECLARATION OF INDEPENDENCE

Independent Specialist Consultant

I, Debbie Fordham, declare that I:

- Act as an independent specialist consultant, in this application, in the field of wetland and riparian ecology;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the amended Environmental Impact Assessment Regulations, 2014;
- Have, and will have, no vested interest in the proposed activity proceeding;
- Have no, and will not engage in, conflicting interests in the undertaking of the activity;
- Undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the amended Environmental Impact Assessment Regulations, 2014; and
- Will provide the competent authority with access to all the information at my disposal regarding the application, whether such information is favourable to the applicant or not.

The following report has been prepared:

- As per the requirements of Section 32 (3) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Environmental Impact Assessment Regulations 2017 as per Government Notice No. 326 Government Gazette, 7 April 2017.
- In accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 - Environmental Impact Assessment 2014 Regulations and the National Environmental Management Act, 1998.
- With consideration to Cape Nature's standard requirements for biodiversity assessments.
- In accordance with DEA&DP's Guideline on Involving biodiversity specialists in the EIA process
- Independently of influence or prejudice by any parties.

Report citation:

Sharples Environmental Services cc. 2021. Aquatic assessment for the clearance of vegetation and construction of a dam on Farm Angeliersbosch RE/157, Prince Albert.

INDEMNITY AND COPYRIGHT

AUTHOR

The author of this report is in agreeance with the 'Declaration of Independence'.

SPECIALIST	QUALIFICATIONS / AFFILIATIONS	DETAILS
DEBBIE FORDHAM	❖ MSc - Environmental Science ❖ BAH (Hons) - Environmental Science ❖ BA – Environmental Science & Geography A member of the South African Wetland Society, Society for Wetland Scientists, the Southern African Association of Geomorphologists, and IAIA, amongst other organisations	Debbie is a qualified aquatic ecologist and environmental scientist. Debbie holds a BA (Environmental Science and Geography), BA (Hons) and M.Sc. in Environmental Science from Rhodes University. She was awarded her Master of Science degree, by thesis, in Wetland Ecology, entitled: The origin and evolution of the Tierkloof Wetland, a peatland dominated by Prionium serratum in the Western Cape. She has specialised in aquatic habitat assessment and has been consulting producing numerous aquatic habitat impact assessment reports. She is well established in her specialist field and has worked in various provinces within South Africa. She is familiar with the latest water resource related legislation and the processes that are required.

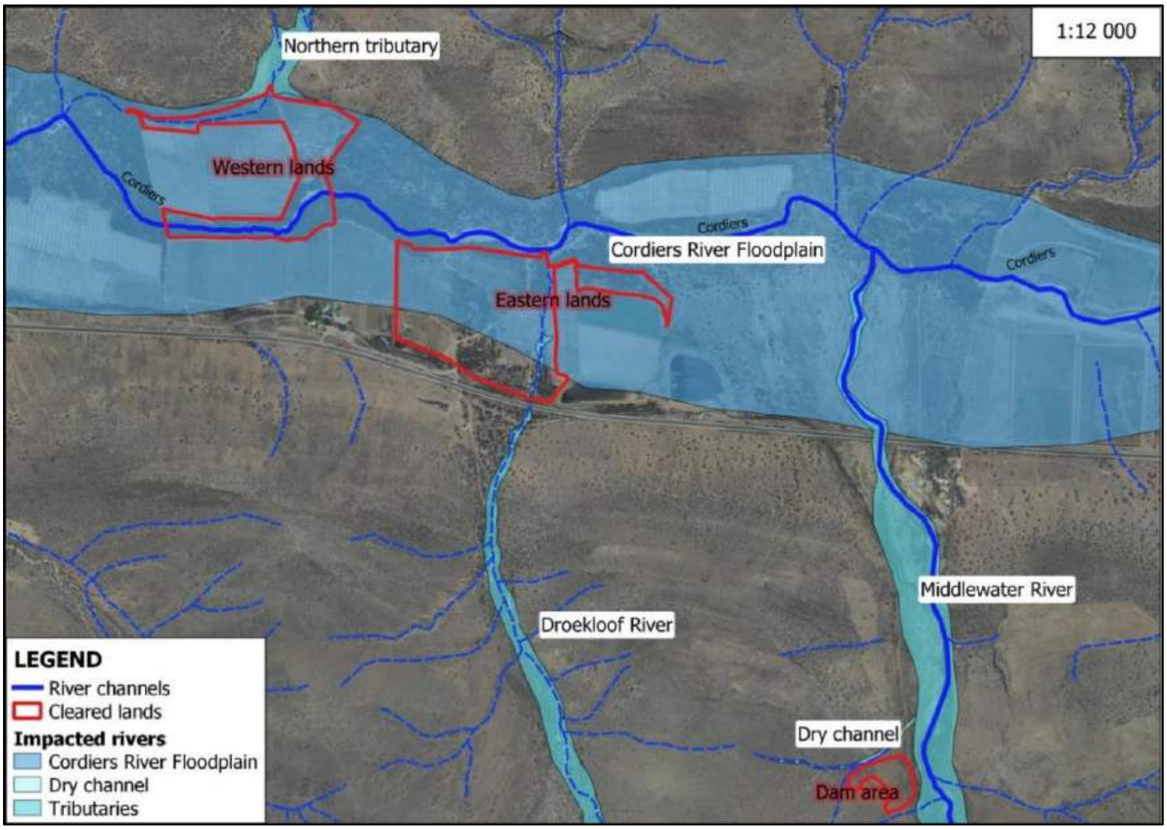
EXECUTIVE SUMMARY

Sharples Environmental Services cc has been appointed to undertake an aquatic habitat impact assessment as part of the requirements of a Section 24G application to be submitted as a result of the consequences of unauthorised commencement of listed activities in terms of the National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998). The need for this process relates to the clearance of the land, and alteration of watercourses, which commenced without environmental authorisation.

The study area falls within quaternary catchment J23E of the Gouritz Water Management Area. The largest river within the study area is the Cordiers River, a tributary of the Gamka River, which flows in a western direction towards Prince Albert. It is classified as a Southern Folded Mountains Ephemeral Upper Foothill River and identified as a NFEPA river. The reach under assessment is heavily utilised for agriculture. Large portions of the cleared land are mapped as CBA1 River.

An infield site assessment was conducted on the 24th of November 2020 to confirm the location and extent of the systems impacted by the commenced activities. It was determined that five watercourses have been impacted upon, namely:

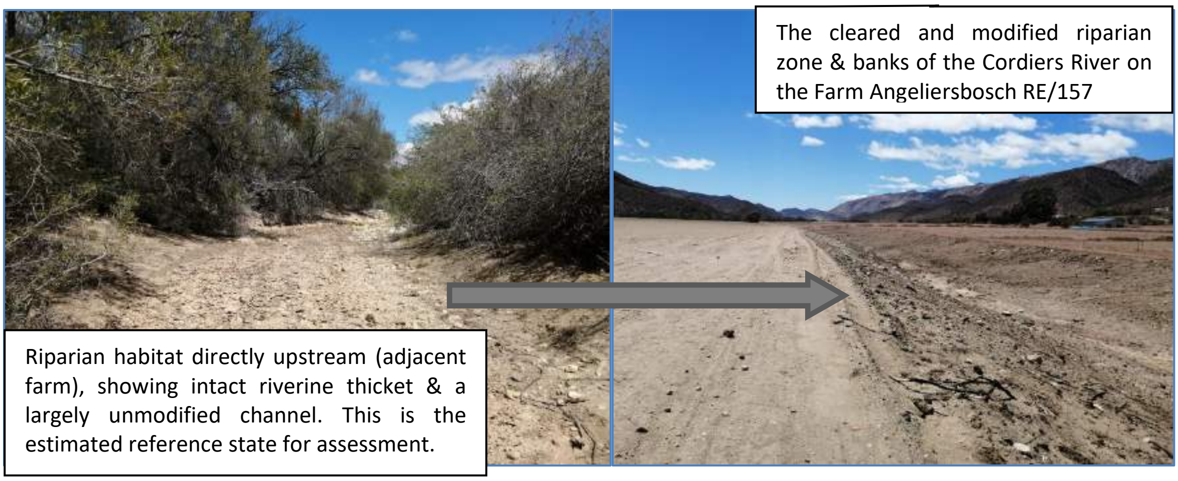
1. Cordiers River
2. Middlewater River
3. Northern tributary
4. Droekloof distributary channel
5. Dry channel



The reach of the Cordiers River that flows through the western and eastern lands has been severely altered by the unauthorised activities. Large sections of the river have been significantly modified due to the clearance of riparian vegetation, destruction of habitat, change of channel morphology, and subsequent flow diversion as a result of infilling and excavations. The present ecological state (PES) is currently ‘Seriously modified’ as the loss of natural habitat, biota and basic ecosystem functions is extensive. It should be the aim of rehabilitation to improve the ecological category to a minimum ‘C’ PES score.

PES Results	Pre-commencement		Post commencement		Rehabilitated*	
Ecological Category	**B**	**Pre-impact**	**E**	**Post-impact**	**C**	***Post rehab**

**assuming a good level of success in rehabilitating the entire reach impacted and riparian buffer zone*



The Cordiers River is an important ecological corridor and buffer and provides irreplaceable services to society. Severing this longitudinal link, as well as the lateral interaction within the landscape, is cumulatively causing loss of the water resources upon which agriculture relies. Without rehabilitation of the Cordiers River, the adoption of an aquatic buffer zone, and continued management, the cumulative impact upon aquatic habitat is High. The impact can be reduced to Medium if rehabilitation is successful. The clearance of the western lands has also impacted upon the small, ephemeral tributary that joins the Cordiers River floodplain from the north, as well as the lower reach of the ephemeral Droekloof River joining from the south. The construction of the dam has negatively impacted two watercourses: the Middlewater River and a dry drainage channel. It is an off-stream dam as it does not have significant runoff from its catchment entering it, but it is situated such that the wall is adjacent to the dry channel banks and upslope of the valley bottom system.

The impacts of the project were identified and grouped together as:

- Loss of riparian habitat and biota
- Sedimentation and erosion
- Flow pattern modifications

The impact assessment determined that the commencement impacts upon aquatic biodiversity are of High negative significance. During post-commencement the impacts were assessed under the 'Do nothing' scenario as well as the 'Rehabilitated' scenario. Currently (which is considered part of the Do-Nothing scenario), the activities have a High impact on the Cordiers River, largely as a result of sedimentation downstream and the erosion of the bare channel banks. Without rehabilitation, these impacts will continue to degrade the river. Under the post-commencement 'Rehabilitated' scenario, it is assumed that all mitigation measures and the recommendations of the rehabilitation plan are successfully implemented. As opposed to the High impacts of the 'Do nothing' scenario, the future impacts upon aquatic habitat can be reduced to Medium significance with rehabilitation. Rehabilitation may never achieve the pre-impacted ecological state, but it will partially mitigate the impacts to regain some ecosystem services and processes functioning.

The construction of the dam did not result in any High impacts as it is an off-channel dam. However, due to the lack of prior planning and mitigation, the construction resulted in Medium negative impacts upon aquatic biodiversity. The post-commencement impacts of the dam were assessed under the 'Do Nothing' scenario and with a mitigation alternative. It was determined that the continued existence of the dam has potential to cause impacts of Medium negative significance. However, if mitigation is implemented to reduce the risk of erosion of the disturbed soils, revegetate surrounding disturbed areas, and prevent alien plant encroachment, then Medium-Low impact significance can be achieved. The removal of the dam has the potential to cause further negative impacts upon nearby aquatic habitat (specifically the Middlewater River) due to the significant earthworks that will be required, and its removal is not deemed as mandatory. Authorisation for any unregistered water uses under the National Water Act (Act 36 of 1998) must be obtained.

Guidelines for rehabilitation of the Cordiers River reach affected by the commenced activities are provided. The objective of the rehabilitation is to regain, as near as possible, the pre-impacted ecological condition of the river prior to the unlawful activities. The overall recommended approach to the rehabilitation entails the reshaping of the channel cross sectional profile so that its banks are gently sloping, to facilitate the establishment of vegetation that will contribute to bank stabilization, and the establishment of a more spatially complex marginal and riparian habitat. The location and extent of the areas requiring rehabilitation are provided. The river rehabilitation plan of actions can be summarised as:

1.) Reshaping of banks
2.) Erosion protection and sediment trapping
3.) Revegetation of banks and buffer
4.) Monitoring rehabilitation
5.) Managing riparian buffer zone

The monitoring of the rehabilitation activities will provide necessary on-site guidance during implementation of the plan. Compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. It is imperative that an independent ECO monitor the site once before and then during rehabilitation every week (as a minimum), as well as when especially high risk activities are being undertaken. An environmental engineer must provide input to the rehabilitation plan prior to the commencement of any earthworks, to advise on site-specific measurements, in alignment with the objective of the rehabilitation, as well as approve the demarcated rehabilitation areas on site, prior to work commencing.

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1 INTRODUCTION

Sharples Environmental Services cc has been appointed to undertake an aquatic habitat impact assessment as part of the requirements of a Section 24G application to be submitted as a result of the consequences of unauthorised commencement of listed activities in terms of the National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998). The need for this process relates to the clearance of the land, and alteration of watercourses, which commenced on 17 July 2020, without environmental authorisation. The Environmental Law Enforcement Directorate of the Western Cape Government Department of Environmental Affairs and Development Planning has identified the following unlawfully commenced activities:

- *Approximately 10 ha of indigenous vegetation clearing (Swartberg Shale Renosterveld, Least Threatened) on the property;*
- *Alleged alterations to the riverine system (Cordiers River) where large-scale vegetation clearing conducted by mechanical machinery of rivierine thicket and channel widening, altering, shaping, infilling, excavations, etc.*
- *Removal of all vegetation within a watercourse and its banks up to existing agricultural lands, causing soil erosion to the riverine banks and system downstream; and*
- *Alleged expansion of agricultural fields.*

Also included in the S24G application, but not identified in the letter from the Department, is the newly constructed dam and the activities within tributary watercourses. Due to the activities largely being undertaken within or in close proximity to aquatic habitat an aquatic specialist assessment was required to inform the EIA process. Additionally, a rehabilitation plan with measures recommended to prevent further impacts, and mitigate against existing impacts, was compiled to guide rectification actions.

1.1 Location and Background

The study site is situated within the Cordiers River valley at the foot of the Groot Swartberg Mountains. The newly constructed dam is located in a north-south orientated side valley, while the cleared new land areas are located in a valley that connects Klaarstroom in the east with Prince Albert in the west. The dam is separated from the cleared areas of the valley by the R407 Road Figure 1).

Figures 2 below shows the characteristics of the Cordiers River site prior to the commencement of the unauthorised activities, while Figure 3 shows the changes to the same site following the land clearance and river modification.

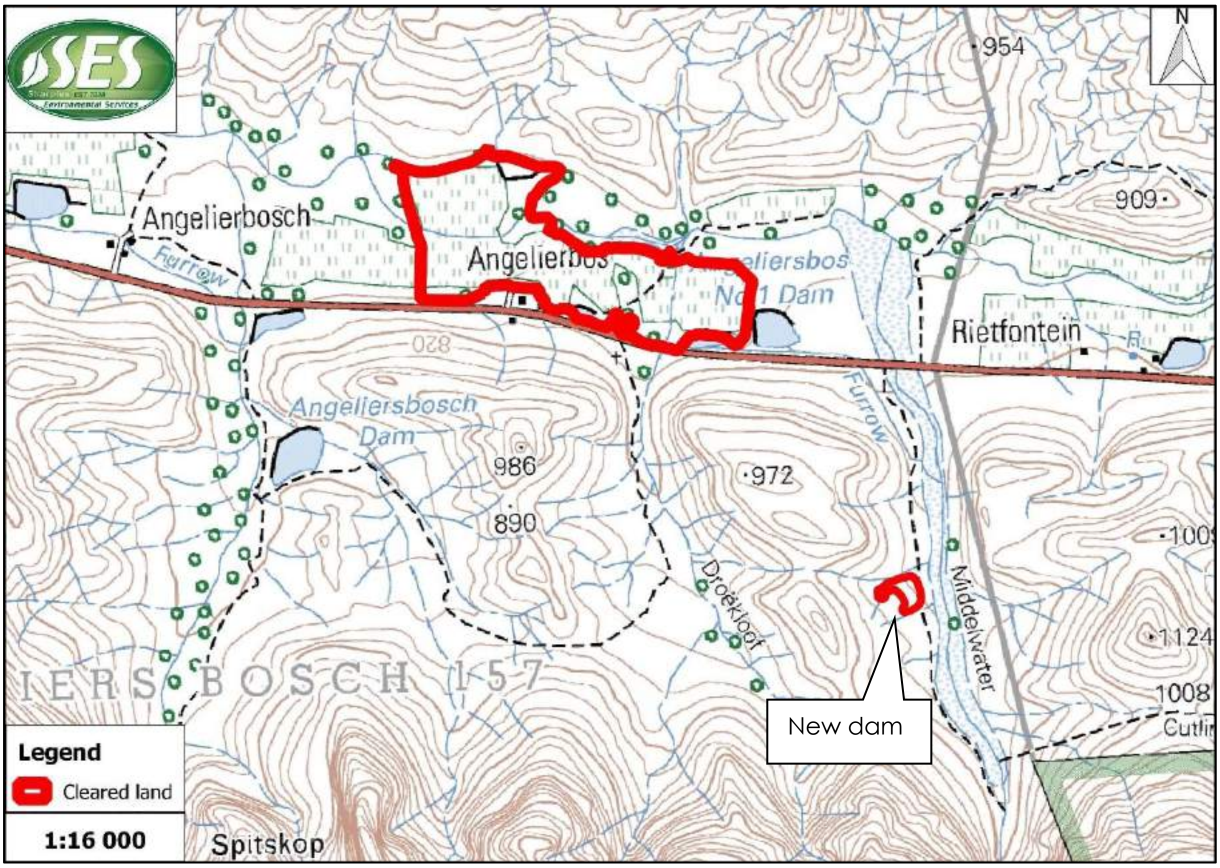

Figure 1: Cadastral map showing the location of the cleared areas in relation to the valley and road

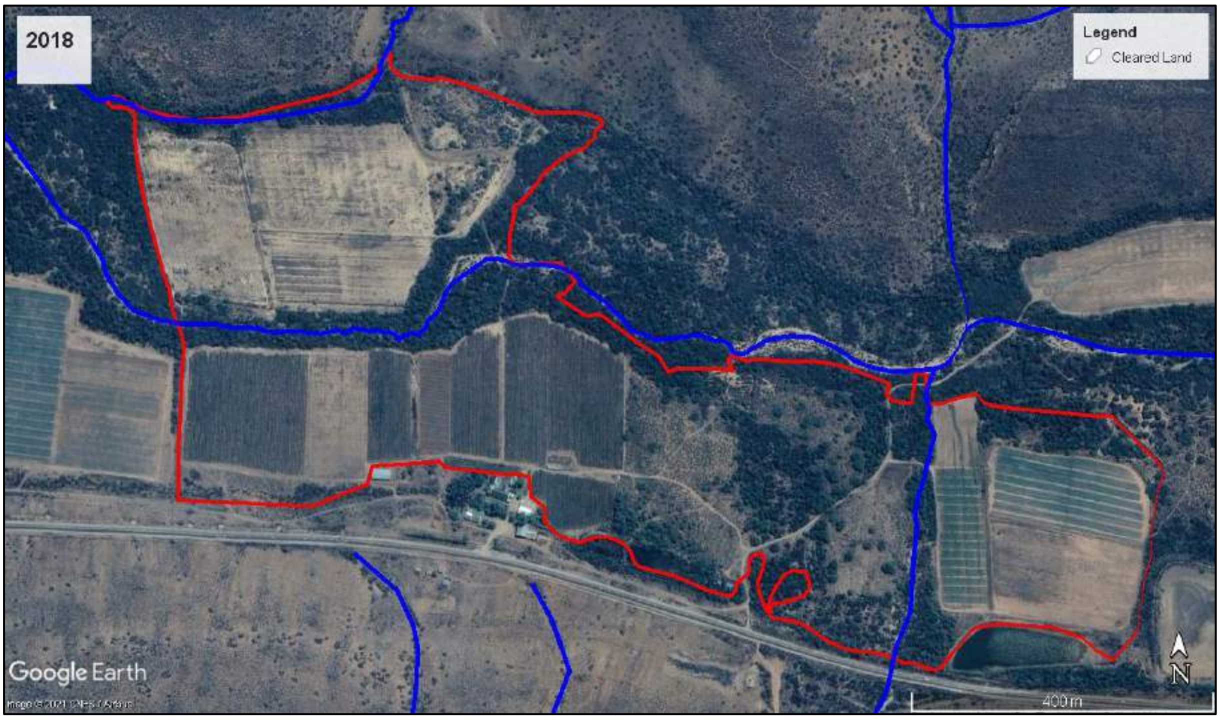

Figure 2: Google satellite image showing the study area in 2018 prior to the commencement of unauthorised activities in relation to the extent clearedin 2020 (shown within red line)

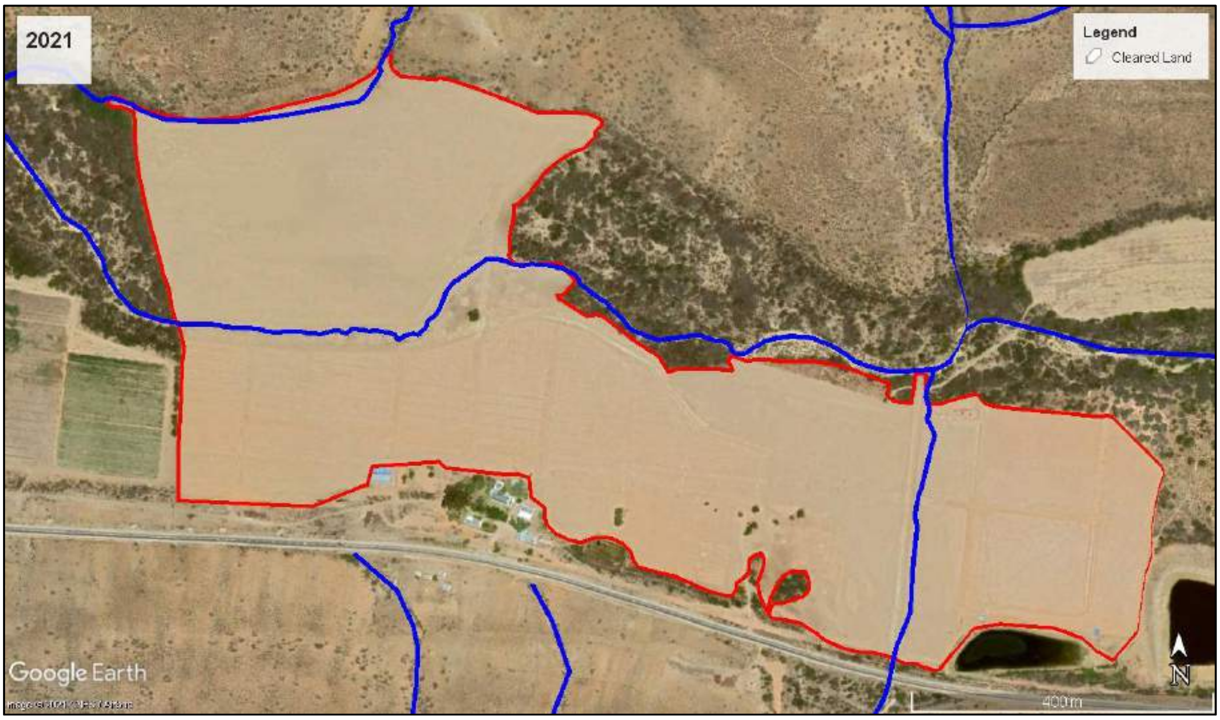

Figure 3: The latest Google satellite image from 2021 showing the changes to the study area from the commenced activities.

As can be seen in the figures above, there were existing areas of land being actively farmed within the study site prior to the activities associated with this S24G application. These areas of existing lands have been mapped to differentiate between the lawfully cleared areas and the extent of indigenous vegetation which was cleared without authorisation. The unlawful clearance of indigenous vegetation relates to the areas within the red polygon in Figure 4 below which exceed the area occupied by pre-existing agricultural lands. For the purposes of assessment, the areas cleared without the requisite authorisations are shown as 'Eastern lands' and 'Western lands' in Figure 4. The new dam is also assessed as an area of vegetation clearance.

Figure 5 indicates the areas which have previously been disturbed for farming activities (such as land that has been fallow since 2006 and the site of an old dam) as opposed to the additional land area cleared of indigenous vegetation in 2021. Figure 6 is a similar map but uses imagery from 2014 to show the vegetation and landform characteristics prior to the commencement of the unauthorised activities. The maps differentiate between already cleared land/fallow land and the area cleared as a whole.

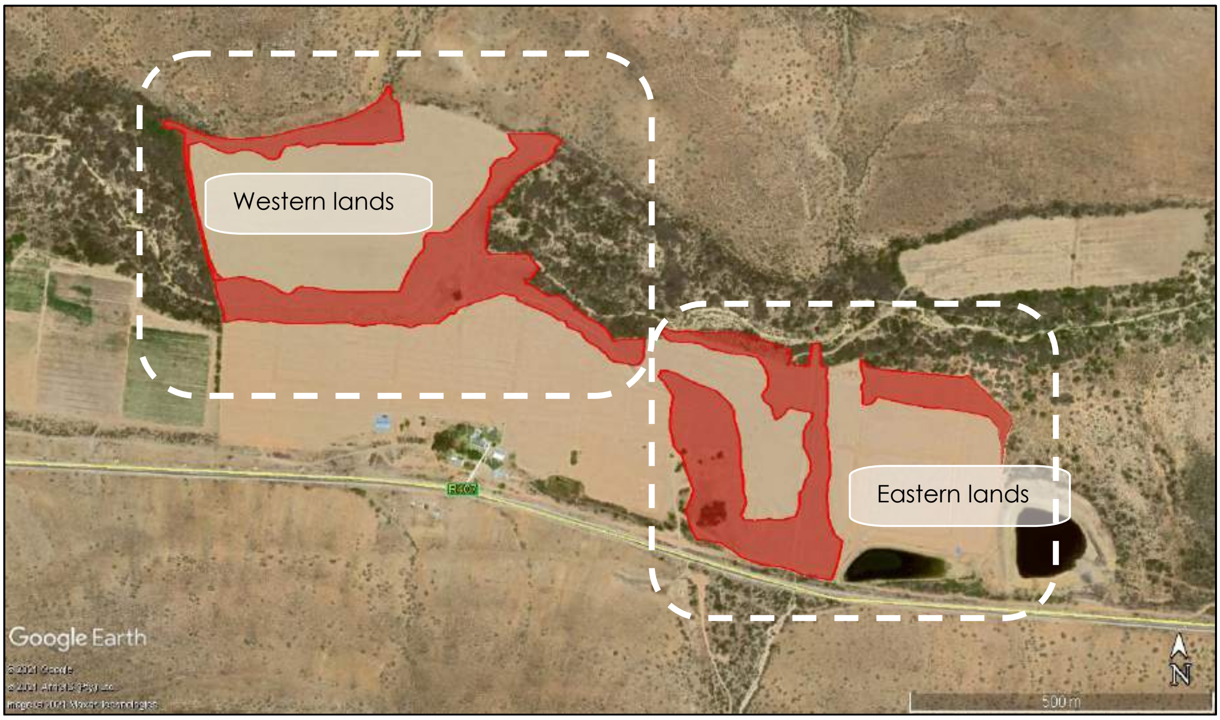

Figure 4: Google satellite image (2021) map indicating the extent of the cleared land (red polygons) and the areas named 'Eastern lands' and 'Western lands' for assessment purposes.

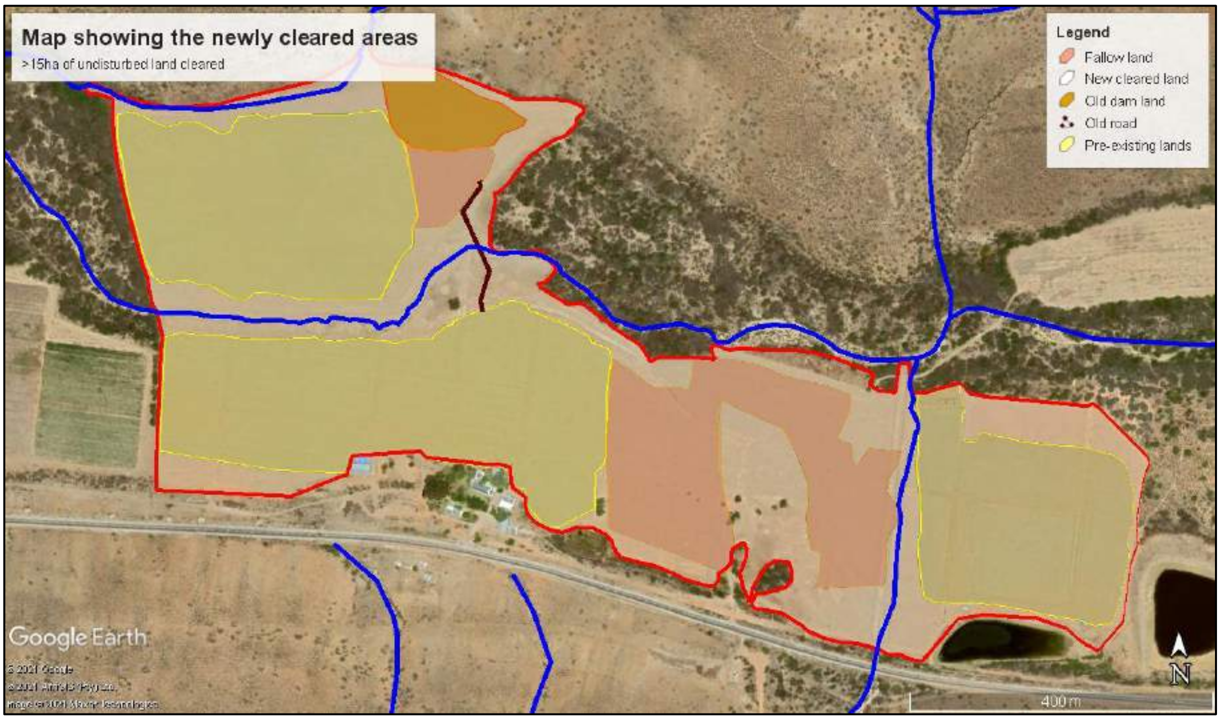

Figure 5: Google satellite image (2021) indicating the extent of the cleared land (red polygon) in relation to the existing lands (yellow polygon) and previously disturbed areas.

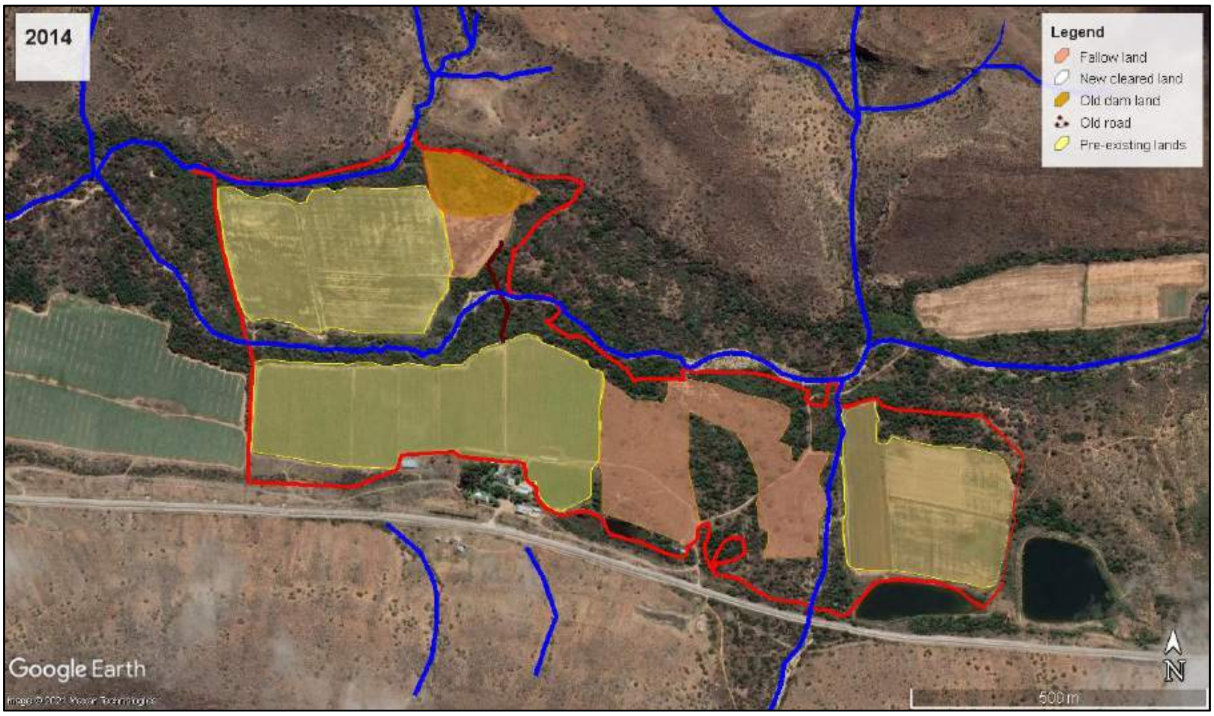

Figure 6: Google satellite imagery from 2014 showing the existing lands and disturbed lands in relation to the extent cleared in 2020

1.2 Commenced activities

A minimum of 15.5 ha has been cleared without environmental authorisation, this is excluding the old dam area and fallow lands. A new earth dam (1.26 ha) has been constructed on a mildly angled foot slope in a side valley south of the Klaarstroom road. The areas of land associated with aquatic habitat are assessed in this report, not the entire cleared area, as portions are purely terrestrial in nature and will not affect watercourses. The applicant seeks retroactive authorisation for these activities through this S24G of NEMA process.

The activities undertaken prior to authorisation have potentially impacted five watercourses, the largest system being the Cordiers River. Figures 7 and 8 below indicate the areas within the catchment, and the watercourses, which have been impacted upon by the commencement of activities.

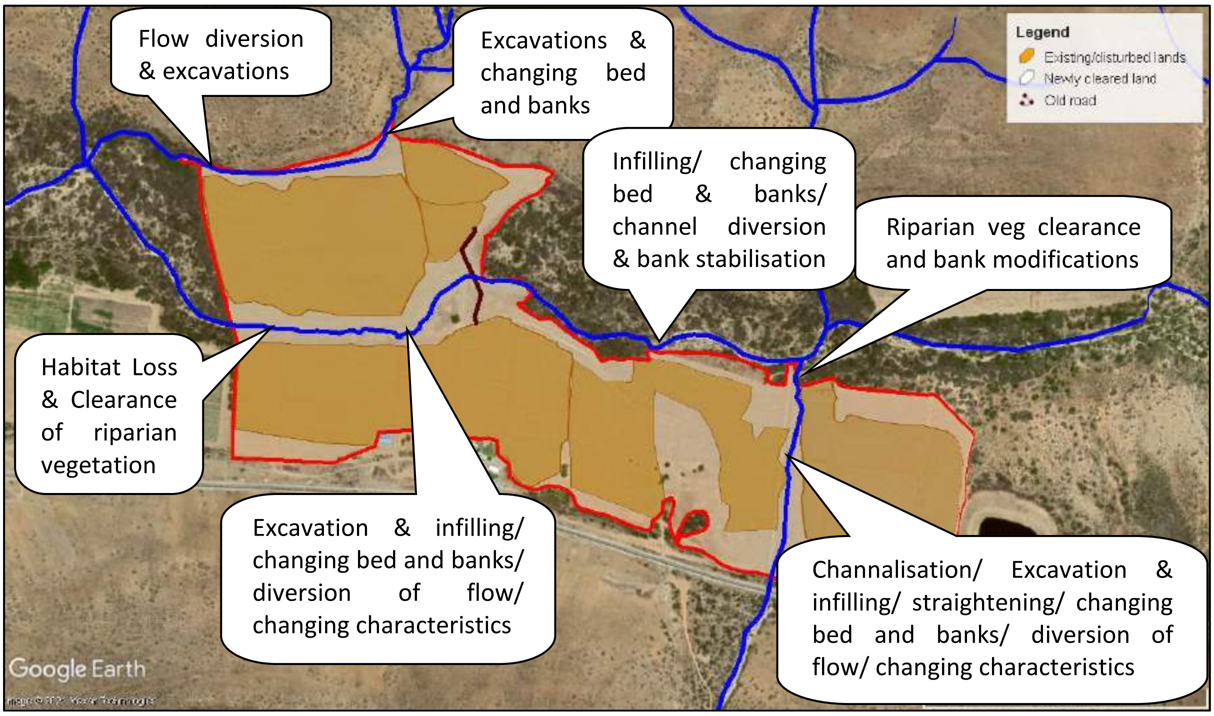

Figure 7: Map showing the general location of the type of unlawful activities impacting water resources

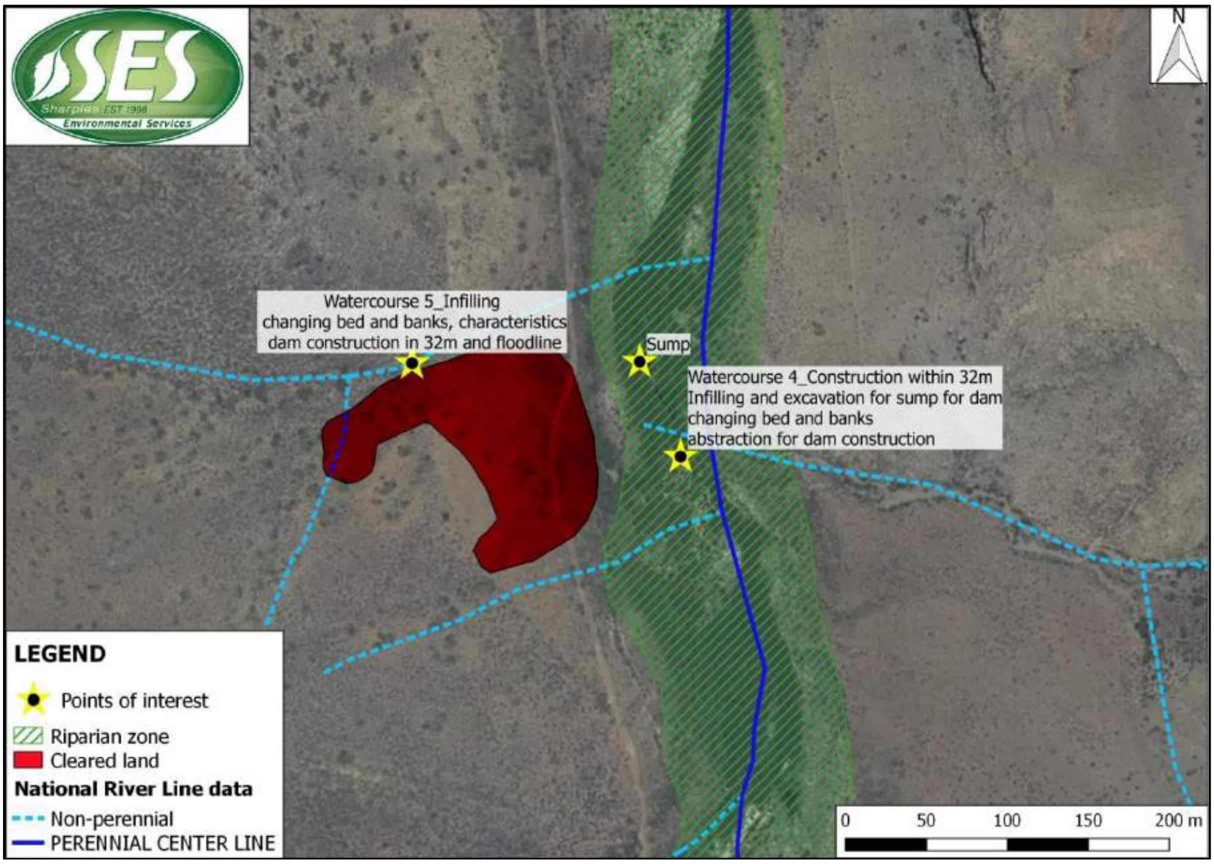

Figure 8: map of the unlawful activities related to the construction of the dam

1.3 Relevant Legislation

The protection of water resources is essential for sustainable development and therefore many policies and plans have been developed, and legislation promulgated, to protect these sensitive ecosystems. This project is related to Section 24G of NEMA and is a retroactive process. Table 1 below shows an outline of the environmental legislation relevant to the project.

Table 1: Relevant environmental legislation

Legislation	Relevance
South African Constitution 108 of 1996	The constitution includes the right to have the environment protected
National Environmental Management Act 107 of 1998	Outlines principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state.
Environmental Impact Assessment (EIA) Regulations	The 2014 regulations have been promulgated in terms of Chapter 5 of NEMA and were amended on 7 April 2017 in Government Notice No. R. 326. In addition, listing notices (GN 324-327) lists activities which are subject to an environmental assessment.
Section 24G of NEMA	Section 24(2) forbids the commencement of any listed activity from commencing without authorisation from the relevant authority. Continuance of the unauthorised activity or development constitutes a criminal offence. When section 24G is triggered, the unlawful activity must be halted, and the transgressor must apply for retroactive authorisation from the relevant authority. Once the application is submitted, the relevant authority may grant the necessary authorisation or direct the applicant to rehabilitate the environment wholly or partially (rectification of unlawful activities). However, the lawful and most efficient way for a landowner to approach any new activity on a property is to determine the legal requirements upfront, before starting any work that may impact the environment.
The National Water Act 36 of 1998	Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water. The water use activities associated with the property, that could potentially require a WULA or GA application under Section 21, unless they are already lawful, may include: - Abstraction of water from the river - Storage and irrigation of the water in off-stream dams - Excavations/ physical disturbances in the rivers (for the sump, channel, and rehabilitation) It is assumed that all of the existing water uses on the farm are registered and that any water uses triggered by the activities and rehabilitation actions will be applied for accordingly. As part of the rehabilitation, Section 21 (c) and (i) water uses as per the National Water Act (Act 36 of 1998) will be applicable. A water use license application (WULA) or General Authorisation (GA) registration application must be submitted to the Breede Gouritz Catchment Management Agency (BGCMA) which is the relevant Competent Authority.
General Authorisations (GAs)	Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a license which should be obtained from the Department of Water and Sanitation (DWS). The project will require a Water Use Authorisation or General Authorisation in terms of Section 21 (c) and (i) of the

	National Water Act (NWA), Act 36 of 1998, due to excavations associated with rehabilitation of the channel. Government Notice R509 of 2016 was issued as a revision of the General Authorisations (No. 1191 of 1999) for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA. Determining if a water use licence is required is associated with the risk of impacting on that watercourse. A low risk of impact could be authorised in terms of a General Authorisations (GA).
National Environmental Management: Biodiversity Act No. 10 of 2004	This is to provide for the management and conservation of South Africa's biodiversity through the protection of species and ecosystems; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; and the establishment of a South African National Biodiversity Institute.
Conservation of Agricultural Resources Act 43 of 1967	To provide for control over the utilization of the natural agricultural resources of the Republic in order to promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants; and for matters connected therewith.

1.4 Scope of Work

The Scope of Work in accordance with the specific Terms of Reference are described below:

Phase 1 (Contextualisation of study area)

- ✓ Contextualization of the study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information (including but not limited to vegetation, CBAs, Threatened ecosystems, any Red data book information, NFEPA data, broader catchment drainage and protected areas).
- ✓ Desktop delineation and illustration of all watercourses within and surrounding the site utilising available site-specific data such as aerial photography, contour data and water resource data.
- ✓ A risk/screening assessment of the identified aquatic ecosystems (as well as within the surrounding NWA regulated area) to determine which ones will be impacted upon by the proposed development and therefore require groundtruthing and detailed assessment.

Phase 2 (Delineation and classification)

- ✓ Ground truthing, infield identification, delineation, and mapping of any potentially affected aquatic ecosystems in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*.
- ✓ Field delineation must follow the accepted national protocol and should result in a map that includes the identified boundary and the field data collection points (which should include at least one point outside the wetland or riparian area), and a report that explains how and when the boundary was determined.

- ✓ Classification of the identified aquatic ecosystems in accordance with the, '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009).
- ✓ Description of the identified watercourses with photographic evidence.

Phase 3 (Aquatic Assessment)

- ✓ Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland habitat, utilising the latest tools, such as:
  - → Level 2 WET-Health Version 2 tool (Macfarlane *et al*., 2009) – PES
  - → WET-Ecoservices (Kotze *et al*., 2009) and/or the Wetland EIS assessment tool of Rountree and Kotze (2013). - Functional assessment
- ✓ Conduct a Present Ecological State (PES) and Present Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats, utilising:
  - → Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
  - → DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- ✓ Indicate the Recommended Ecological Category (REC) of the impacted aquatic ecosystems.

Phase 4 (Impact Assessment)

- ✓ Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project. Impacts are described in terms of their extent, intensity, and duration. The other aspects that must be included in the evaluation are probability, reversibility, irreplaceability, mitigation potential, and confidence.
- ✓ All direct, indirect, and cumulative impacts for each alternative must be rated with and without mitigation to determine the significance of the impacts.
- ✓ The potential significance of these impacts was assessed using the Risk Matrix which is specified in the Government Notice R509 of 2016 for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA (1998).

Phase 5 (Mitigation and monitoring)

- ✓ Recommend actions that should be taken to avoid impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas.
- ✓ Determination and mapping of any necessary buffer zones with consideration to the *Buffer zone guidelines for rivers, wetlands and estuaries* (Macfarlane & Bredin, 2016).
- ✓ Rehabilitation guidelines for disturbed areas and monitoring.

2 STUDY AREA

Geographic spatial data was utilised to contextualise the Cordiers River and its catchment in relation to the latest desktop biodiversity information relevant to aquatic habitats and the current conservation objectives. A summary of these findings is presented in Table 2 below. Historic aerial photography was also studied to obtain an understanding of the types of land use and cover changes which have influenced the characteristic of the specific area over time. The study of historic aerial photography in freshwater assessment is essential to establishing a 'benchmark' reference state for wetlands/rivers that is required for present ecological state determinations. Landuse changes within the catchment cause changes in hydrology as well as sediment yields (such as increased sediment runoff/erosion associated with the ploughed fields). Sediment supply relative to runoff is an important determinant of the watercourse morphology. Sediment supply has been increased by activities in the catchment that expose the soil surface, such as the vegetation clearing and farming activities.

The land use and cover changes since 1962 can be observed within Figure 9. The aerial photography of the farm taken in 1962 shows that the Cordier's Valley has been used for farming activities for decades and many of the agricultural lands still remain the same shape and extent. The road is clearly visible. There has been an increase in the number of dams and the extent of cleared land, but the floodplain was already used for cultivation and the Cordier's River has been subjected to habitat loss.

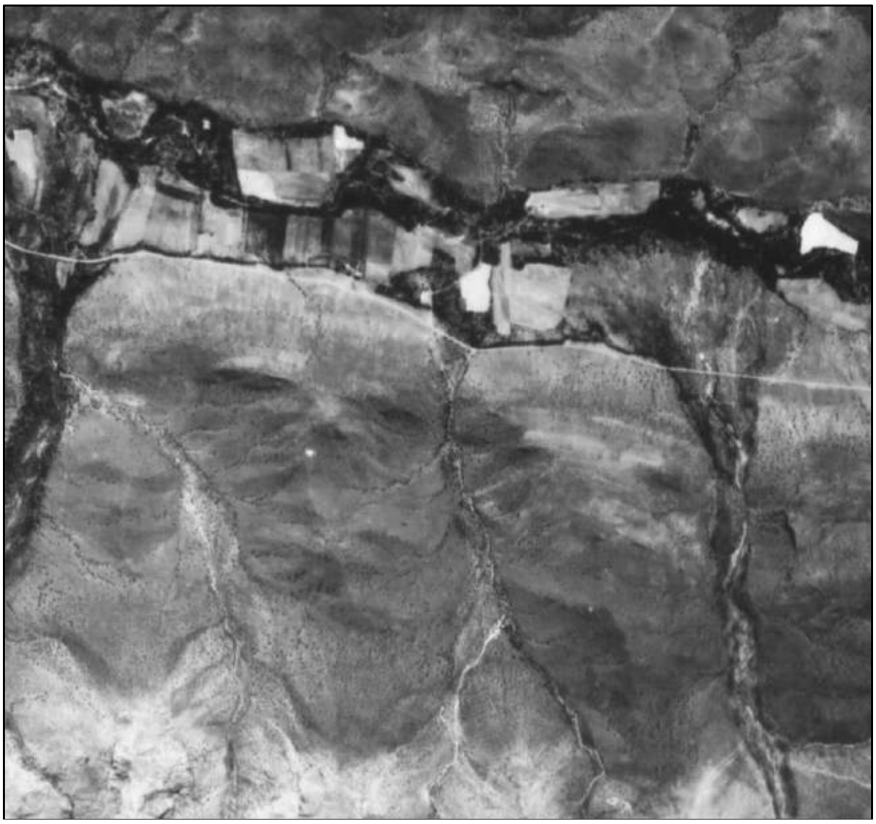

Figure 9: Historical aerial photography of the farm taken in 1962

Desktop investigations show that the study area falls within quaternary catchment J23E of the Gouritz Water Management Area. The largest river within the study area is the Cordiers River, a tributary of the Gamka River, which flows in a western direction towards Prince Albert. It is classified as a Southern Folded Mountains Ephemeral Upper Foothill River. The reach of the Cordiers River under assessment is heavily utilised for agricultural purposes. In 1999 the national rivers data described the Cordiers River as being in good- fair health with a present ecological state (PES) category of 'C'. However, the most recent National Biodiversity Assessment data for rivers (2019) has placed the river within the 'D' PES category indicating that the functioning has declined to result in poor river health levels (Table 2). There are a number of dams on the property but not in the Cordiers River itself. No wetlands have been mapped near the site (Figure 10). The national data also describes the river as having significant ecological importance and that the provision of water for agriculture is critical to the farmers and society. In alignment with this, it is also classified as a Critical Biodiversity Area, and National freshwater Ecosystem Priority Area, necessary to meet international biodiversity targets.

The study area lies within the arid Central Karoo region which experiences a mean annual rainfall of only 275 mm compared to the mean annual evaporation rate of 1231 mm. The mean annual runoff is approximately 30 mm. There are no strategic water resource areas, surface or groundwater, mapped near the study site. Analysis of the climate in this area for future water requirements and planning must consider the predicted impacts of climate change, such as decreased rainfall and increased temperatures.

The area falls within the Swartberg Shale Renosterveld vegetation unit of the Fynbos Biome (Figure 11). The riverine vegetation of the area usually consists of woody trees (*Acacia caffra, Acacia karoo, Rhus lancea, Tamarix usneoides,* etc.), reeds (*Phragmitis australis*) and bulrush (*Typha capensis*) that are resilient to brackish conditions (Vlok *et al.* 2005). Few rare or localized endemic plant species are known to occur in this riverine habitat. Refer to botanical specialist report for site detail.

Most of the riparian habitat in the region has been negatively affected by a number of activities. Most of the fresh water that used to run from the upper catchment areas into the river systems has been cut off and is now mostly used for agricultural purposes. The removal of this perennial supply of fresh water would have altered the composition of the natural vegetation in the riverine areas, such as along the Cordiers River floodplain. The karoo river floodplains have also in many cases been transformed to establish intensive agricultural crops, such as lucern. Irrigation of these lands results in the leaching of sodium from these old floodplain soils into the river system, thus causing an increased salinity of the water progressively down the river (Vlok *et al.* 2005).

Many karoo river systems are also heavily invaded by alien species such as *Arundo donax, Nerium oleander, Pennisetum clandestinum, Prosopis glandulosa, Shinus molle, Tamarix chinensis and Tamarix ramosissima*, while the floodplains occasionally have *Alhagi maurorum and Atriplex nummularia* present (Vlok *et al.* 2005). Apart from providing many unique habitats for bird and invertebrate species, the riparian corridor would have played an important role to provide suitable migration corridors for larger mammals in the past (presently Kudu are abundant).

The nearest Protected Area is the Groot Swartberg Nature Reserve to the south. Large portions of the cleared land areas are mapped as CBA's and ecological support areas (ESA's), including an aquatic CBA associated with the Cordiers River.

Table 2: Cordiers River and study area characteristics

Quaternary catchment	K10D
Mean annual precipitation	275 mm
Mean annual runoff	30 mm
Mean annual evaporation	1231 mm
Elevation	760 m.a.s.l.
Water Management Area	Gouritz
Biosphere reserve	Gouritz Cluster Biosphere Reserve
Main river in catchment (Figure 10)	Gamka River of which Cordiers River is a tributary
NBA 2019 Rivers assessment layer (Identifies Cordiers River only, and does not identify the other watercourses on site)	Cordiers River is a first order, Upper foothills zoned river with ephemeral flow.
	DWA PES 1999: C -Moderately Modified NFEPA condition: AB -Near Natural NBA PES 2018: D -Largely Modified
	ETS: Least threatened EPL: Moderately protected
National Wetland Map (NWM5 2018)	None within the NWA 500 m Regulated Area of the site
National freshwater Ecosystem Priority Area (NFEPA 2011)	Yes
Western Cape Biodiversity Spatial Plan (WCBSP) classification	CBA 1: Aquatic - Southern Folded Mountains Ephemeral Upper Foothill River and FEPA river corridor
Vegetation type (Figure 11)	Swartberg Shale Renosterveld
Geology	Weltevrede Subgroup and Witpoort Formation
Soils	Mainly alluvial valley deposits within the floodplain area. Surrounding area comprises of Reddish to white quartz arenite, red to brown thin-bedded sandstone, minor micaceous red or purple siltstone and shale, rhythmite. The soil has a High erodibility factor.

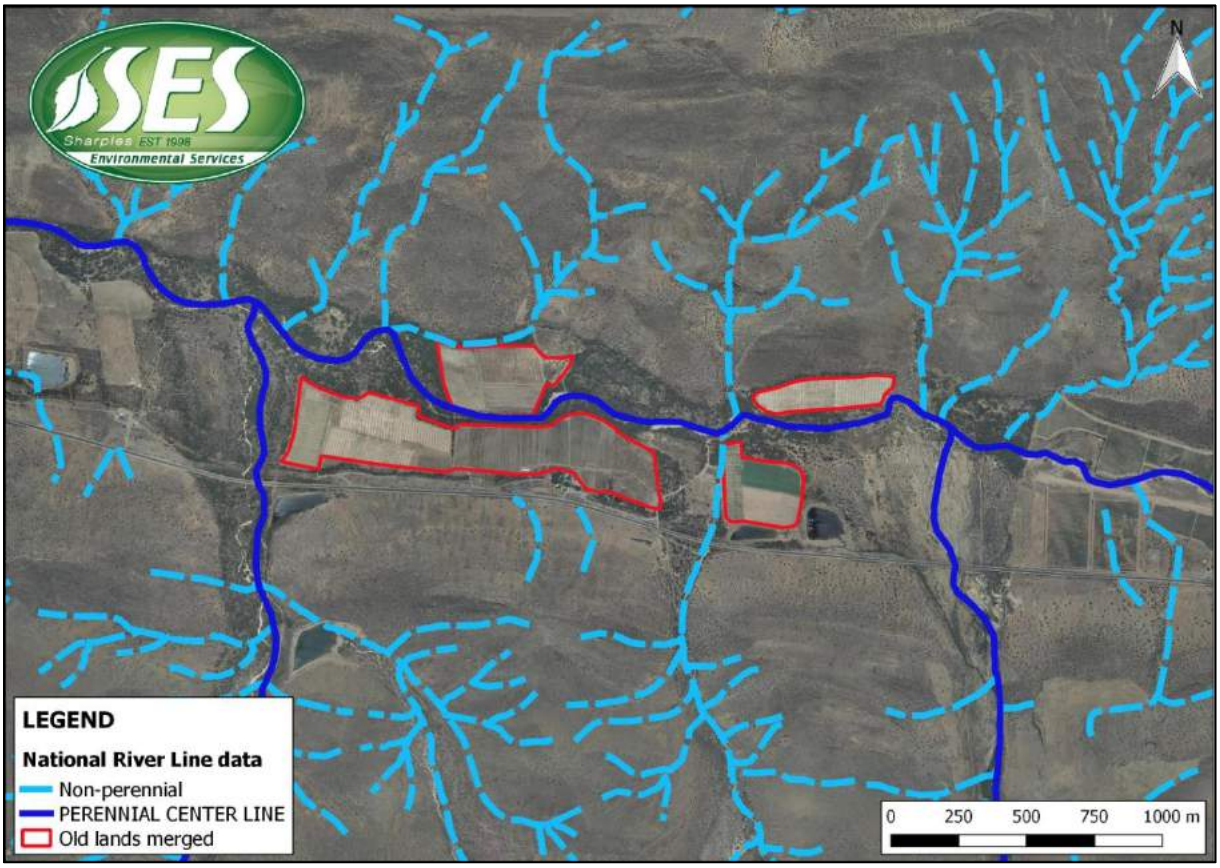

Figure 10: The catchment drainage pattern in relation to the study area

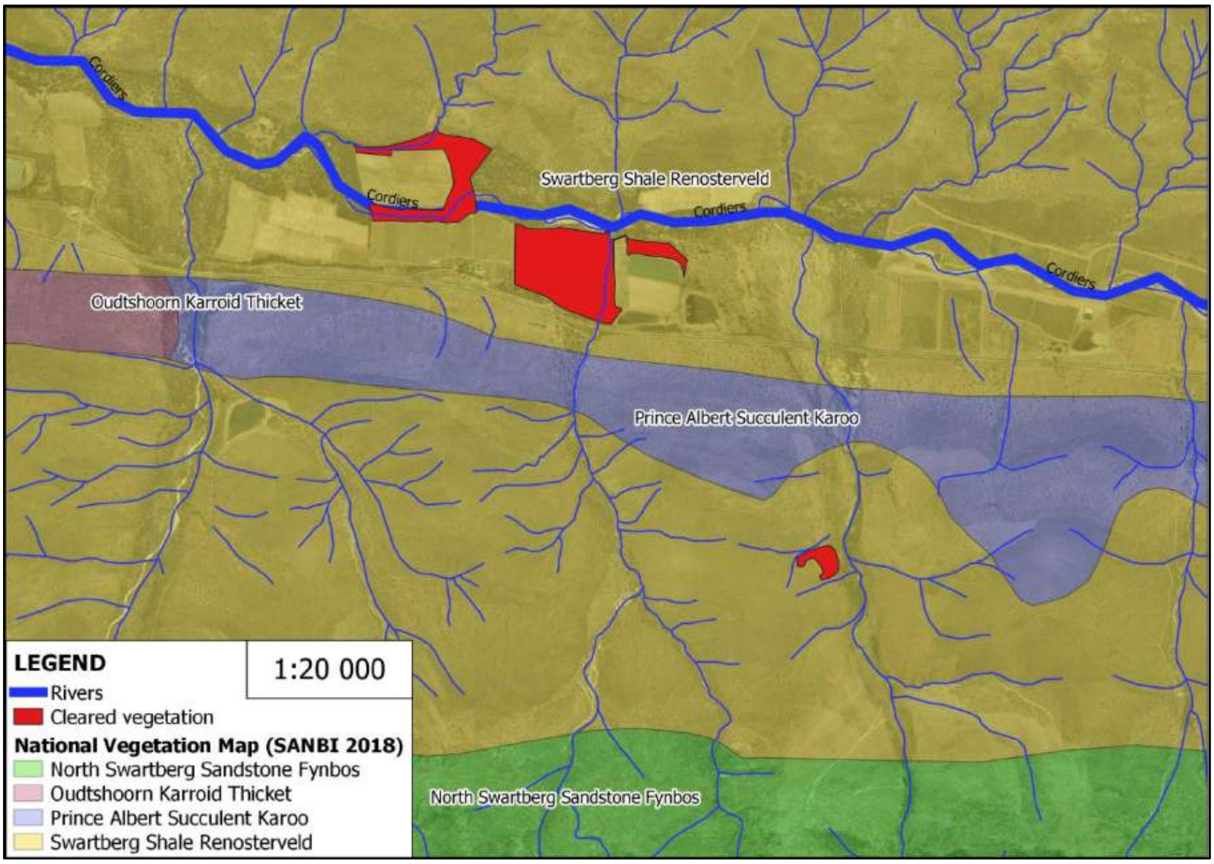

Figure 11: The sites in relation to the South African National Vegetation Map (SANBI 2018)

3 APPROACH AND METHODS

3.1 Desktop Assessment Methods

- The contextualization of each study area was undertaken in terms of important biophysical characteristics and the latest available aquatic conservation planning information in a Geographical Information System (GIS). It is imperative to develop an understanding of the regional drainage setting and longitudinal dynamics of the watercourse. The conservation planning information aids in the determination of importance and sensitivity, management objectives, and the significance of potential impacts.
- Following this, desktop delineation and illustration of all watercourses within the study area was undertaken utilising available site-specific data such as aerial photography, contour data and water resource data. Digitization and mapping were undertaken using QGIS 2.18 GIS software (Table 3).
- These results, as well as professional experience, allowed for the identification of specific watercourses that could potentially be impacted by the development and therefore required groundtruthing and detailed assessment. The following data sources listed within Table 3 assisted with the assessment.

Table 3: Utilised data and associated source relevant to the proposed project

Data	Source
Google Earth Pro™ Imagery	Google Earth Pro™
DWS Eco-regions (GIS data)	DWS (2005)
South African Vegetation Map (GIS Coverage)	SANBI (2018)
National Biodiversity Assessment Threatened Ecosystems (GIS Coverage)	SANBI (2016)
Geology	Council for Geoscience (2019)
Contours (elevation) - 5m intervals	Surveyor General
National Wetland Map 5	(CSIR 2018)
NFEPA river and wetland inventories (GIS Coverage)	CSIR (2011)
NEFPA river, wetland and estuarine FEPAs (GIS Coverage)	CSIR (2011)
Western Cape Biodiversity Spatial Plan 2017: Critical Biodiversity Areas of the Western Cape.	WC:DEA&DP 2017 WCBSP

3.2 Baseline Assessment Methods

- An infield site assessment was conducted in November 2020 to confirm the location and extent of the systems identified as likely to be impacted by the proposed project. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the project and position the system is located in the landscape. The identified aquatic ecosystems were classified in accordance with the '*National Wetland*

Classification System for Wetlands and other Aquatic Ecosystems in South Africa' (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009).

- Infield delineation was undertaken with a hand-held GPS, for mapping of any potentially affected aquatic ecosystems, in alignment with standard field-based procedures in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*. The delineation is based upon observations of the landscape setting, topography, vegetation and soil characteristics (using a hand-held soil auger for wetland soils).
- Determination of the Present Ecological State (PES), functional importance assessment and The Ecological Importance and Sensitivity (EIS) of freshwater habitats is an expression of the importance of the water resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).
- Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats was undertaken utilising:
    - Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
    - DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- The PES and EIS results then allowed for the determination of management objectives for the potentially impacted aquatic ecosystems. Refer to the Table below and Annexure 12 for a list and description of the tools utilised.

Table 4: Tools utilised for the assessment of water resources impacted upon by the proposed project.

METHOD/TOOL*	SOURCE	REFERENCE
Delineation of wetland and/or Riparian areas	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas.*	(DWAF 2005)
Classification of wetlands and/ or other aquatic ecosystems	*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa & WET-Ecoservices*	(Ollis *et al*., 2013), Kotze *et al*., 2009)
Present Ecological State (PES) Assessment (Wetland)	*WET-Health Assessment*	(McFarlane *et al.* 2009)
Functional Importance Assessment (Wetland)	*WET-Ecoservices Assessment*	(Kotze *et al*., 2009)
Ecological Importance & Sensitivity (EIS) Assessment (wetland)	*DWAF Wetland EIS Tool*	(Duthie 1999)
Present Ecological State (PES) Assessment (River)	*Rapid IHI (Index of Habitat Integrity) tool developed Kleynhans (1996), Modified by DWAF*	(Ecoquat)
Ecological Importance & Sensitivity (EIS) Assessment (River)	*DWAF EIS tool developed by Kleynhans (1999)*	(Kleynhans, 1999)

3.3 Impact Assessment Methods

- The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance for the three alternatives is determined.
- Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.
- The potential risk to the watercourses from project impacts was assessed using the Risk Matrix which is specified in the Government Notice R509 of 2016 for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA (1998).
- Actions are thereafter recommended to prevent and mitigate the identified impacts on aquatic habitat, in alignment with the mitigation hierarchy, as well as any measures necessary to restore disturbed areas or ecological processes.
- Any necessary buffer areas or No-Go areas are visually represented. The buffer zone was determined by a tool developed by Macfarlane and Bredin (2016) called *Buffer zone guidelines for rivers, wetlands and estuaries*, site-based information and professional opinion. The final buffer requirement includes the implementation of practical management considerations/ mitigation measures.

4 ASSUMPTIONS AND LIMITATIONS

- This report deals only with the impacts of the known activities taken place on this property up to the time of site assessment. It is assumed that any unauthorised activities ceased as per the DEA&DP Notice. Any activities which may have occurred since have not been assessed. For example, the dam is assessed as transformed habitat, not for its potential uses, as it was not storing any water on the 24th of November 2020.
- Aquatic ecosystems vary both temporally and spatially. Once-off surveys such as this are therefore likely to miss certain ecological information due to seasonality, thus limiting accuracy and confidence. However, regarding this assessment, the confidence level is considered good.
- Infield soil and vegetation sampling was only undertaken within a specific focal area, while the remaining watercourses were delineated at a desktop level with limited accuracy.
- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or

indicator wetland/riparian species and only provide a very general indication of the composition of the riverine vegetation communities. No detailed assessment of aquatic fauna/biota was undertaken. Refer to botanical assessment.

- This report is solely focused upon the rehabilitation of the reach of river modified as a result of the vegetation clearance and modification of the banks. A more comprehensive, catchment-wide planning process was not undertaken and thus reduces the level of certainty surrounding cumulative impacts.
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological concerns arising from the field survey and based on the assessor's working knowledge and experience with similar development projects.
- The study does not include environmental flow requirement determination, flood line determination or hydrogeological assessment.
- The study does not include the application for water use authorisation under Section 21 of the NWA for any uses, existing or proposed. The recommendations and mitigation measures in this plan do not exempt the landowner from complying with any relevant legislation.
- It is assumed that all the relevant mitigation measures and agreements specified in this report will be implemented in order to ensure minimal negative impacts and maximum environmental benefits. This is not a maintenance management plan, and the riparian habitat must not be modified again without authorisation. Maintenance plans may introduce some ad hoc regulatory relief to farming but will fall substantially short of contributing to the resolution of long-standing and complex environmental problems arising from a long history of human dependence on rivers and floodplains in the Western Cape (Day *et al.* 2016).

5 RESULTS

Following desktop and field analysis of the aquatic habitats, relevant to the project, the subsequent results were obtained.

5.1 Screening assessment

The aquatic habitats within the 500m regulated area of the activities were identified and mapped on a desktop level utilising available data, following which, the infield site assessment confirmed the location and extent of these systems (Figure 12). It was then determined that the Cordiers River, three tributaries, and a dry drainage channel have been impacted upon by the activities. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the activity and position of the system in the landscape. Factors considered for determining how a system was impacted included determining if the flow (surface or groundwater), water quality, biota or habitat have been negatively altered. Therefore, the following watercourses were assessed in detail:

- Cordiers River
- Middlewater River
- Northern tributary
- Droekloof distributary channel
- Dry channel

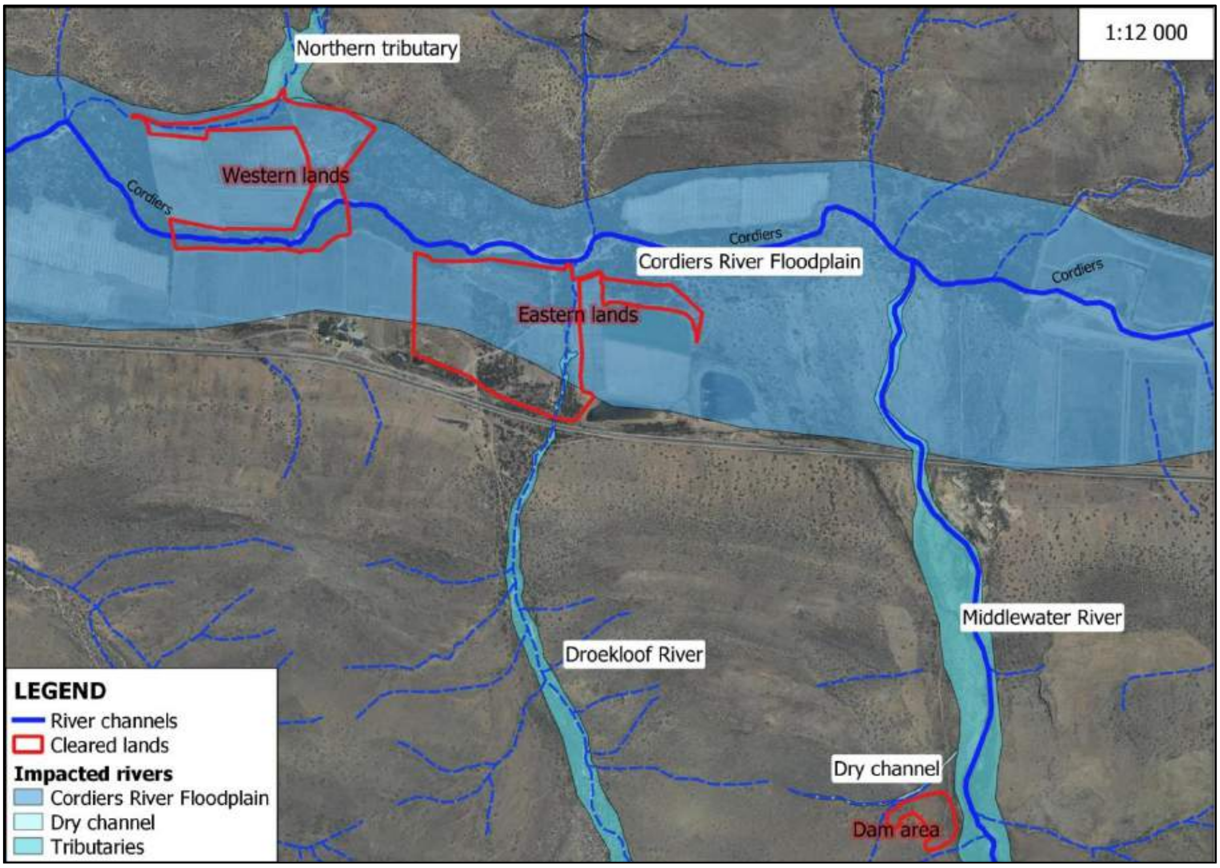

Figure 12: Map showing the identified and delineated freshwater habitats, impacted upon by the unlawful activities.

5.2 Impacted watercourses

The reach of the Cordiers River that flows through the western and eastern lands has been severely altered. Large sections of the river have been significantly modified due to the clearance of riparian vegetation, destruction of habitat, change of channel morphology, and subsequent flow diversion as a result of infilling and excavations. The land clearance in the western site has had the largest impact upon this reach of the Cordiers River (Figure 13); with the eastern land clearance activities resulting in localised, indirect impacts to the river channel and riparian zone. However, all of the activities are within the Cordiers River catchment and impacted the already modified floodplain.

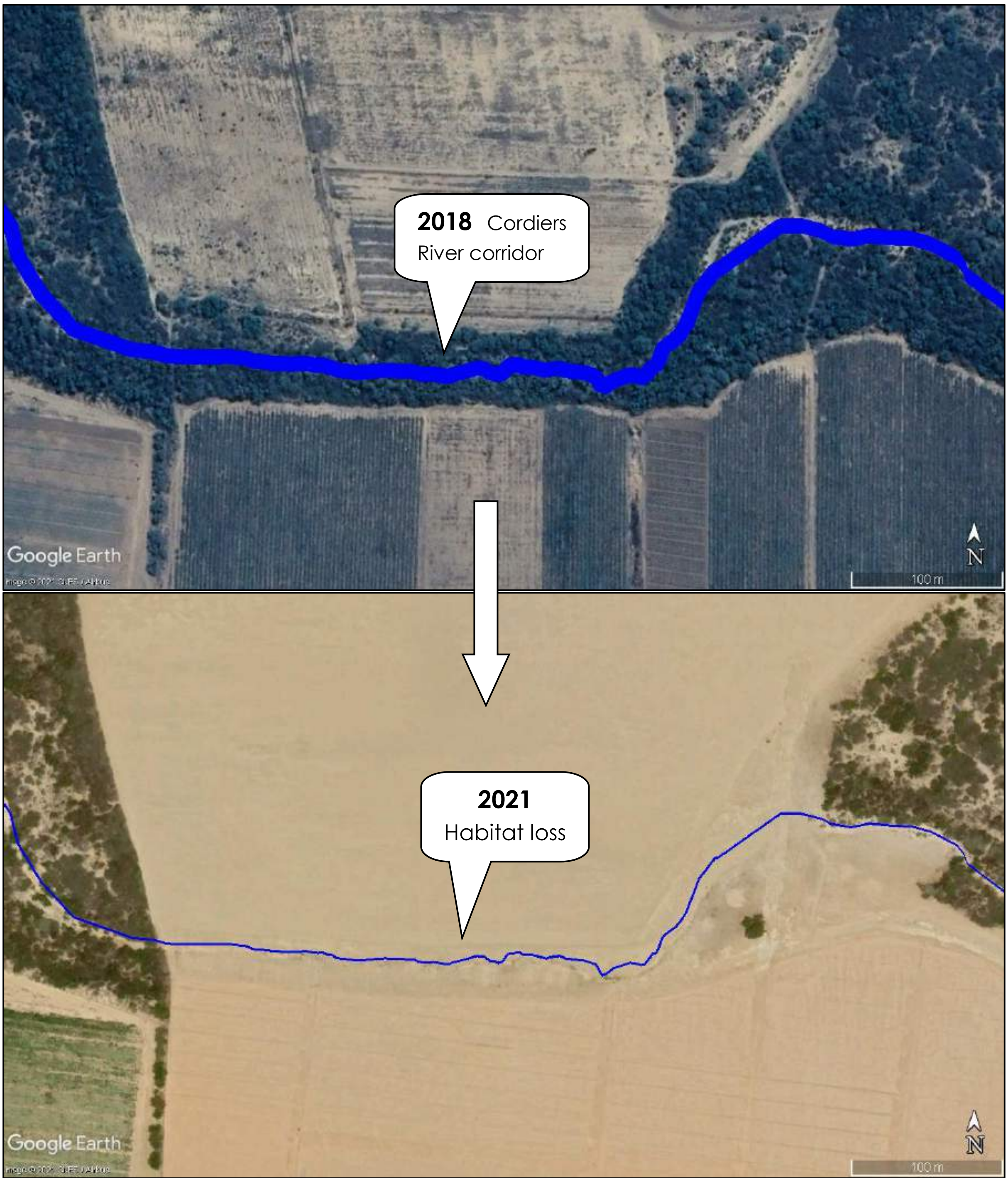

Figure 13: Google satellite imagery showing the change to the reach of the Cordiers River on site pre- and post-clearance and excavations

The western lands have also impacted upon the small, ephemeral tributary that joins the Cordiers River floodplain from the north. The watercourse has been named 'Northern Tributary' for assessment purposes. The clearance of land and disturbance of soil has extended into this drainage line and altered the channel. A large cut-off berm has been constructed at the foot of the valley to direct any flows away from the floodplain to the west (Figure 14). According to the landowner, there were past measures placed in this location before, but the current excavations are far larger and exceed and possible past footprint.

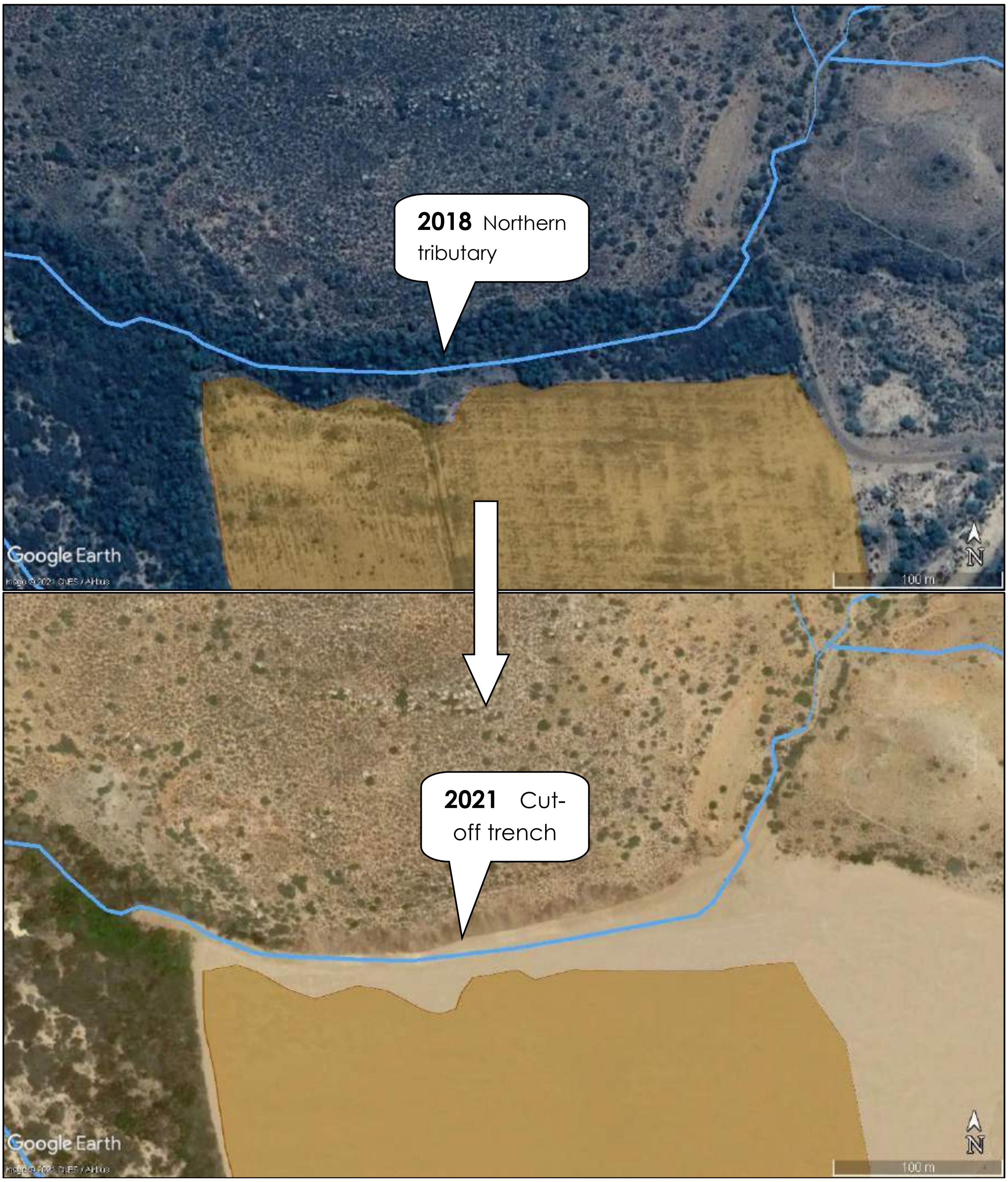

Figure 14: Google satellite imagery showing the change to the Northern tributary

The clearance and levelling of the eastern lands has negatively impacted the left bank of the Cordiers River channel. In this reach (eastern lands), localised areas of riparian thicket have been destroyed. Additionally, channel infilling for bank protection has occurred to halt lateral channel movement.

The eastern land transformation has also impacted upon the alluvial fan of an ephemeral tributary. The river system, named Droekloof River, enters the Cordiers River floodplain from the south, flowing through a road culvert onto the alluvial fan. An alluvial fan is a sediment deposit which formed at the river apex due to the transition from the confined tributary valley to the unconfined

Cordiers River floodplain. There is evidence to suggest that a distributary channel on the alluvial fan once joined the Cordiers River channel but was since abandoned. The alluvial fan and channel no longer exist as a result of the historic infrastructure (such as the R407 Road) and the unlawful land clearance, which involved the levelling of the sediments and channelisation of the channel directly into the Cordiers River (Figure 15). Therefore, the lower reach of the Droeikloof River, although already modified, has been significantly modified by the activities associated with the eastern lands.

Figure 15: Google satellite imagery showing the change to the Droekloof tributary

The construction of the dam has negatively impacted two watercourses: the Middlewater River and a dry drainage channel. It is technically an off-stream dam as it does not have significant runoff from its catchment entering it, but it is situated such that the wall is adjacent to the dry channel banks. The siting of the dam on the hillslope is intended to avoid the valley bottom tributary (Middlewater River) downslope. However, by constructing it upslope, it is located alongside the dry drainage channel which directs surface flows (episodically) towards the tributary river. The construction has modified the bank of the channel, named 'Dry channel' in this report for hydrogeomorphic (HGM) unit assessment purposes. The characteristics of the identified watercourses are described in detail in the subsections to follow.

Although the dam is located outside of the riparian area of the Middlewater River, the construction activities have had indirect impacts (i.e. sedimentation) from vegetation clearance/soil disturbance on the valley slope and along the access road within the catchment. It is assumed that the dam is highly unlikely to fail in operation and wash material into the river and scour the bank. A sump has been excavated within the river channel to temporarily abstract subsurface flow for use in dam construction (and in doing so, disturbed the left bank in this locality). The volume abstracted for this construction dust suppression was probably minimal and the footprint easy to restore.

5.2.1 Cordiers River

The Cordiers River is a non-perennial upper foothills zoned system (Figure 16). Low-gradient (slope of 1%) alluvial sand-bed channel, and regime reach type. Confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is an increase in silt content in bed or banks. It is an important corridor for fauna in the arid landscape which results in a Moderate ecological importance and sensitivity (EIS) rating. Figure 9 below shows an upstream reach of the river, beyond the western property boundary, which has not been affected by the unlawful activities. It is highly likely that the impacted reach was similar and so this habitat can be considered as the reference condition for this study.

Prior to the commencement of the unauthorised activities the river was not in a pristine ecological state. It had already been subjected to indirect impacts from agriculture within this reach. However, there was previously a buffer area of riverine thicket to protect the river characteristics from impacts, as well as less disturbance within the floodplain, which allowed for continued ecological functioning in only a slightly modified state (B PES score). The reference state (in the context of this study) is therefore of a river Largely Natural river reach with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions were essentially unchanged (Table 5). However, the unlawful activities of riparian vegetation clearance, infilling and excavations, have severely degraded the ecological condition of this specific reach and will negatively impact downstream areas.

The present ecological state (PES) is currently 'Seriously modified' as the loss of natural habitat, biota and basic ecosystem functions is extensive. It should be the aim of rehabilitation to improve the ecological category to a 'C' PES score which is indicative of a river in fair health and the basic ecosystem functions are still predominantly unchanged from the reference condition. It would be ideal to restore the system to good ecological condition but potentially unrealistic.

Table 5: The present ecological state assessment of the impacted reach of river

PES Results	**Pre-commencement**		**Post commencement**		**Rehabilitated***	
Determinand	Score (0-5)	% intact	Score (0-5)	% intact	Score (0-5)	% intact
Bed modification	1.5	80	3.5	40	2	70
Flow modification	1.5	80	4	30	2	70
Inundation	0.5	90	1.5	80	0.5	90
Bank condition	2	70	5	10	3	50
Riparian condition	1.5	80	5	10	2.5	60
Water quality modification	0.5	90	2.5	60	2	70
Average Score	**1.3**	81.7	**3.6**	38.3	**2.0**	68.3
Ecological Category	**B**	**Pre-impact**	**E**	**Post-impact**	**C**	***Post rehab**

**assuming a good level of success in rehabilitating the entire reach impacted and riparian buffer zone*

Figures 16 to 29 below show the severely degraded present state of the river reach and depict some of the causes.

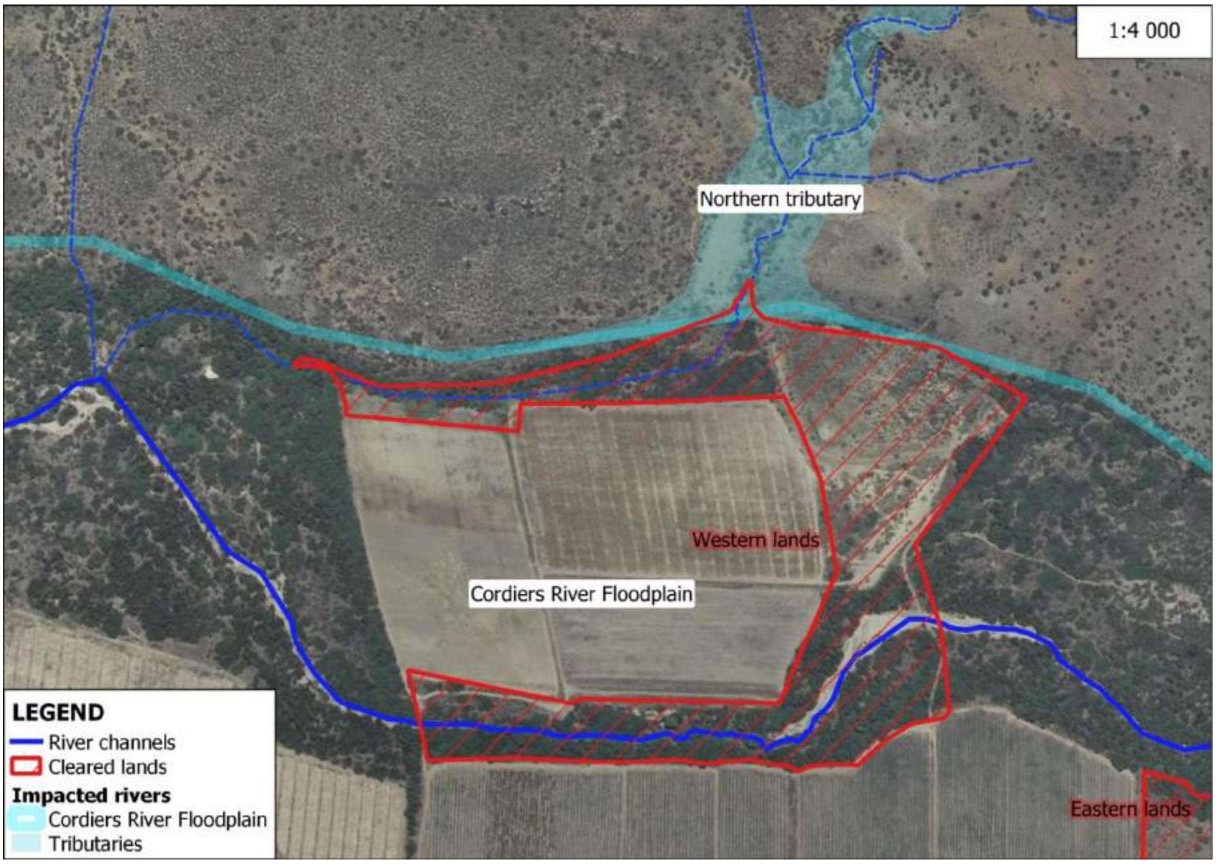

Figure 16: Map showing the area of riparian habitat in the Cordiers River which has been entirely cleared of thicket and instream vegetation and the banks have been modified though infilling and excavation

Figure 17: Riparian thicket vegetation upstream of the cleared reach indicating the natural characteristics of the Cordiers River

Figure 18: The farm boundary fence separating the cleared river reach from the undisturbed upstream area

Figure 19: The channel of the Cordiers River downstream of the eastern cleared lands, indicating the pre-impacted condition of the reach cleared.

Figure 20: Photograph of the cleared western lands showing the river channel

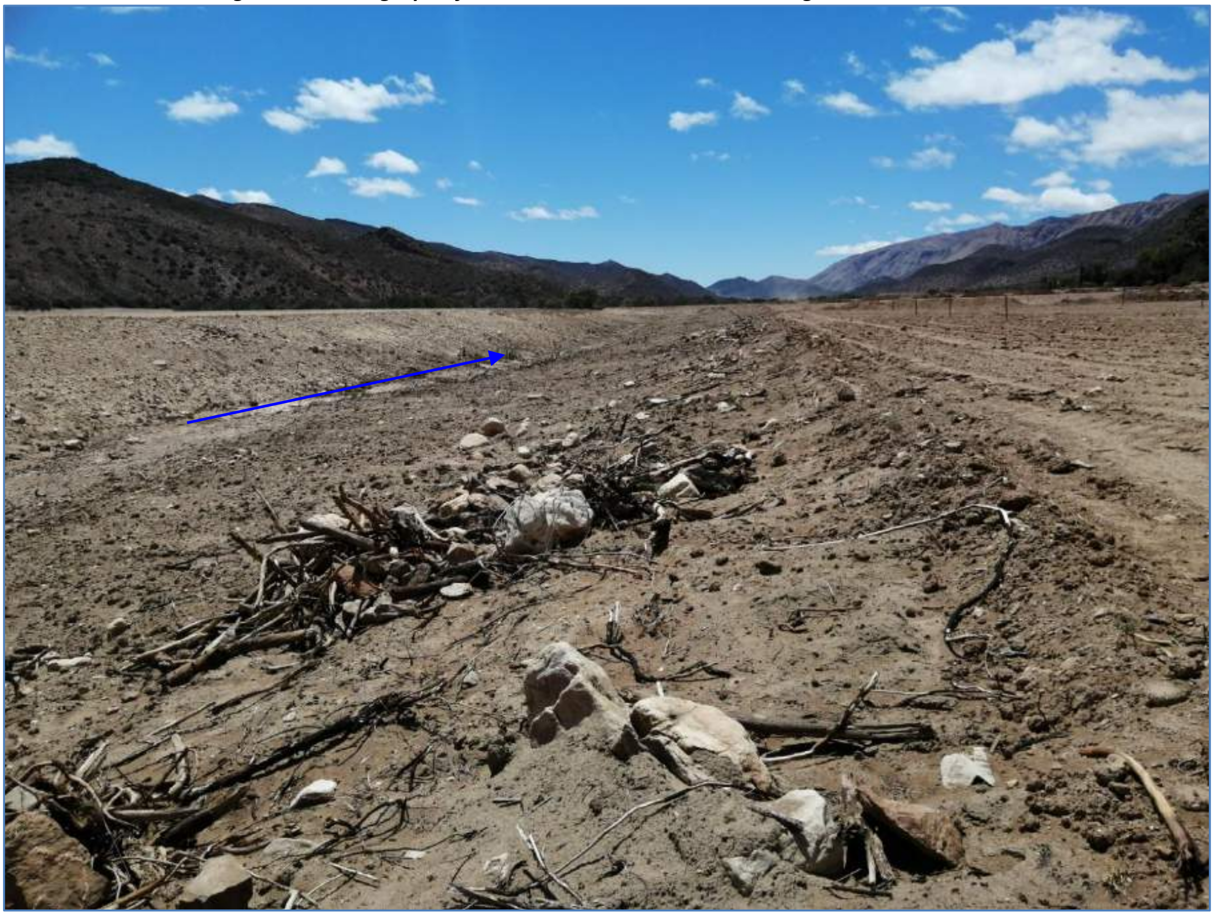

Figure 21: Photograph looking east down the excavated channel of the river

Figure 22: Photograph showing severe bank erosion where the reach has been cleared and modified on the western lands

Figure 23: Photograph of the clear bed and banks of the Cordiers River. Insert: Evidence of the drainage line still being used as a corridor by fauna despite the clearance

Figure 24: Riverine plant species resprouting in the channel bed

Figure 25: Photographs showing the western land clearance of riparian thicket through the property

Figure 26: Photograph of dead material from riparian vegetation clearance

Figure 27: Infilling of the channel with rubble in order to divert flow from the lands

Figure 28: Infilling along the bank of the Cordiers River to protect lands from natural channel migration

Figure 29: Infilling of riparian habitat from lands

5.2.2 Middlewater River

The Middlewater River is a mountain stream which enters the Cordiers River from the south (Figure 30). The tributary is approximately 6 Km in length and has a moderate average longitudinal slope of 5%. The broad and flat channel is composed largely of boulders and cobbles. Surface flow is seasonal in nature, but shallow subsurface water is permanently available. The sub-surface flow towards the lower reach of the system, across the wide flat channel, may in phases support valley bottom wetland habitat in low-flow conditions. It is a mixed bedrock-alluvial system. The sediment free water surfaces at intermittent intervals along its length. This habitat is highly sensitive to the abstraction of groundwater, as altered water availability results in the rapid demise of the wetland and seasonal river habitat.

The vegetation is different to that of the trunk river as it is short and dominated by restioid and graminoid vegetation interspersed between boulders and on the banks. These types of habitat are often important for flora and fauna, as it is possible for localised endemic plant species to occur in the upper reaches. The provision of clean water results in these watercourses being incredibly important but sensitive systems.

Once this vegetation is disturbed it results in erosion (reduction in water quality), invasion by alien species and loss of biodiversity (biota restricted to this habitat) (Vlok *et al.* 2005). It is presently in a near pristine condition and is resilient to invasion by alien plant species, but the construction of the dam and sump have caused localised disturbance. Therefore, the construction of the dam has not significantly reduced the PES category of this upper reach from AB but the activities have negatively affected the Middlewater River. Figures 31 to 32 show the present river characteristics.

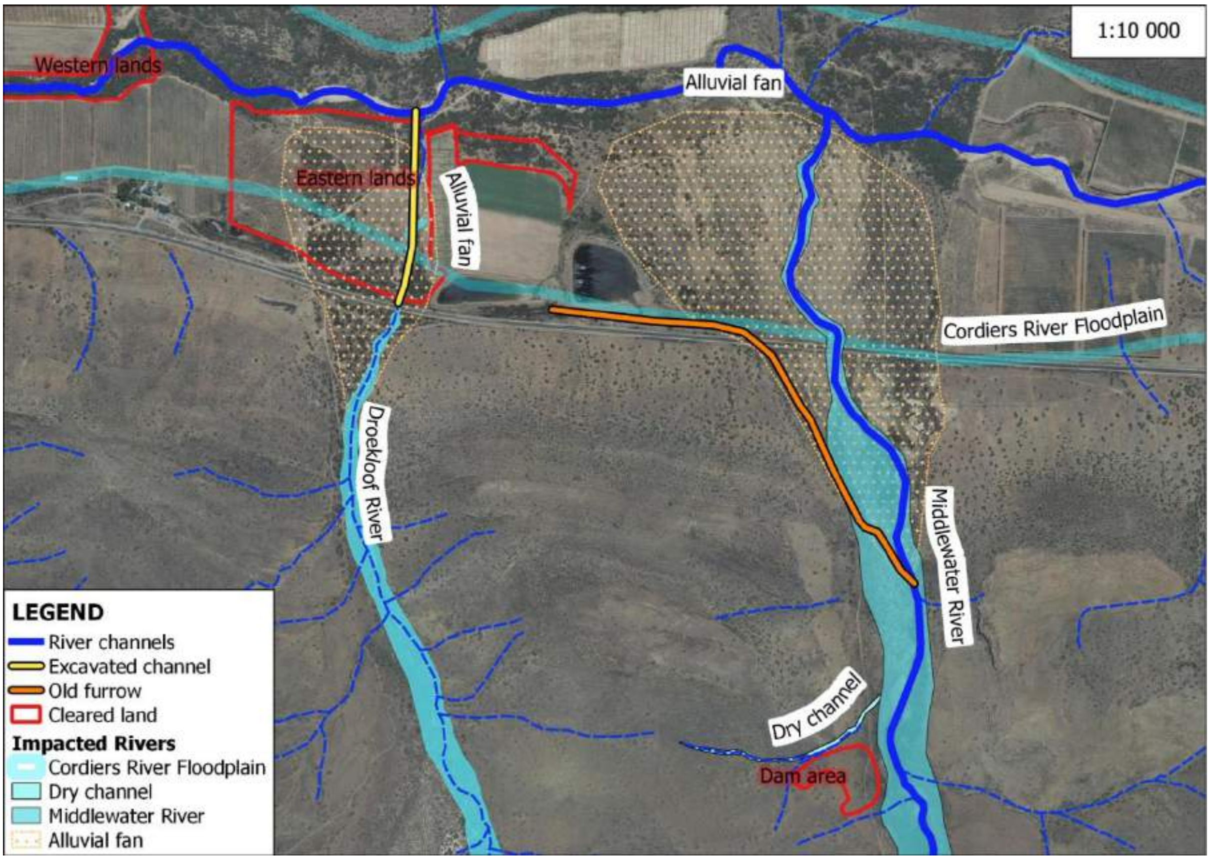

Figure 30: Map of the impacted watercourses showing the dam in relation to the Middlewater River

Figure 31: Photograph of the mountain stream bed

Figure 32: Subsurface flow surfacing in the mountain stream channel near the dam site

5.2.3 Northern tributary

A small and ephemeral tributary to the Cordiers River which is largely undisturbed (Figure 33). It is an important corridor for mammals between the river floodplain and mountainous areas. There was historically a shallow dam southeast of the tributary fan which has been since been cleared. According to the landowner there was an old channel directing any flows towards the dam, but it was no longer functional. The old channel is however not clearly visible in historic imagery but will have altered the river characteristics during flow. Figures 34 and 35 show the excavations which have been undertaken at the foot of the drainage line to divert surface flows during rainfall events away from the cropland floodplain.

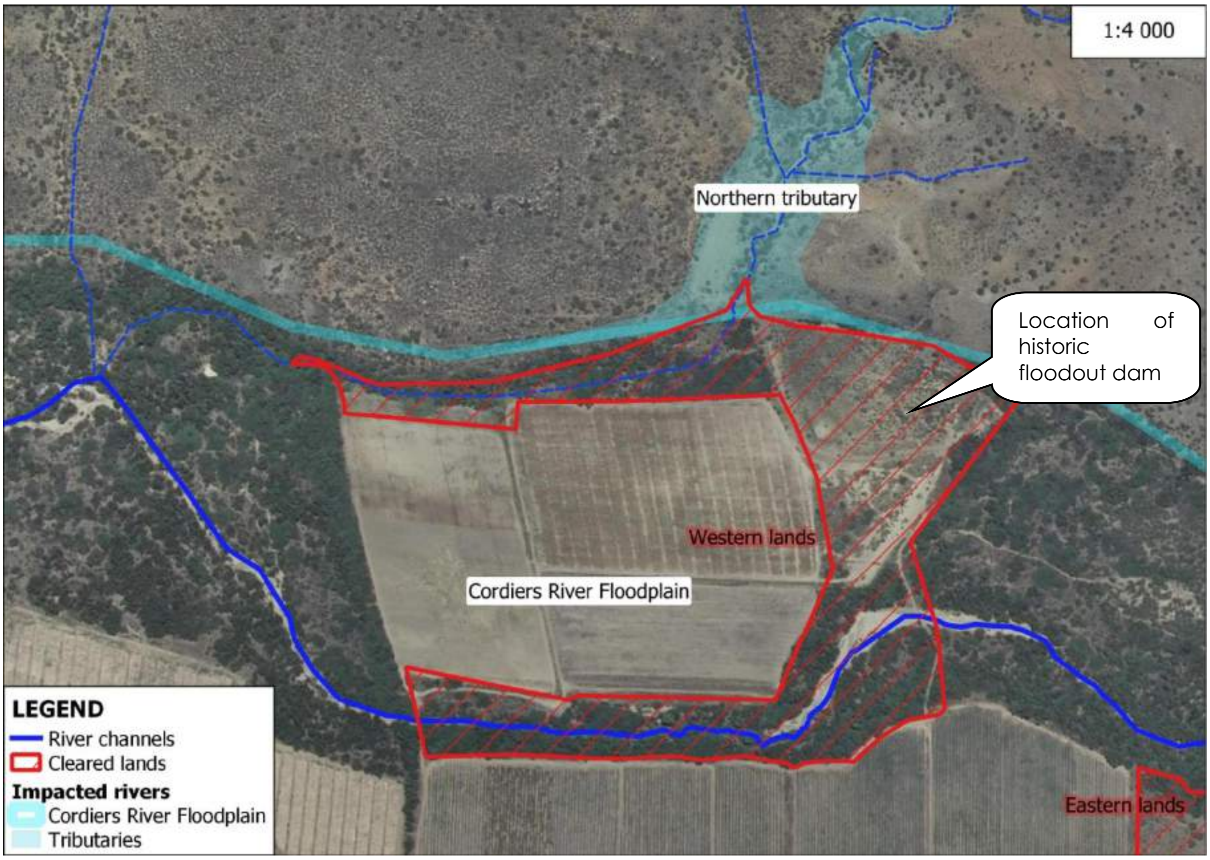

Figure 33: Map showing the cleared area (western lands) in relation to the northern tributary stream

Figure 34: The ephemeral stream which joins the Cordiers River from the north, that has been subjected to vegetation clearance and morphology changes in the lowest reach.

Figure 35: The lower reach of the stream channel has been modified and a cut-off berm diverts the flow around the northern edge of the lands

5.2.4 Droekloof distributary channel

The Droekloof River is an ephemeral tributary to the Cordiers River (Figure 36). The lower section on the alluvial fan has historically been modified for agriculture and now it has been further transformed by farming activities (Figures 37 to 40). The natural movement of sediment onto the alluvial fan was long ago disconnected by the construction of the R407 Road. Additionally, the road culvert resulted in confined flows towards the trunk river. This has now been formally channelised by the farmer. The many changes make determining the reference state of this system challenging. It is estimated that prior to the commencement of activities the ecological functioning was already largely compromised.

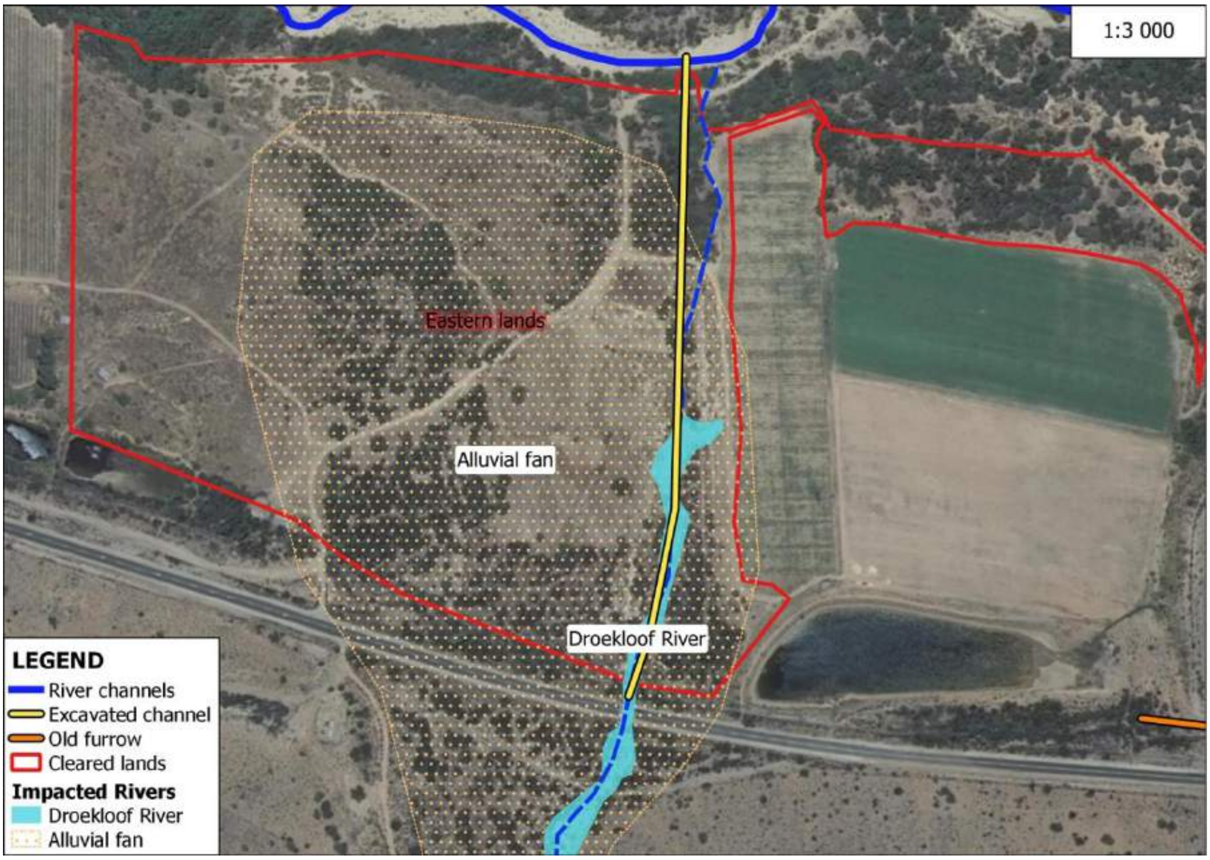

Figure 36: Map showing the location of the road and excavated channel on the eastern lands which have been cleared of vegetation, in relation to the natural characteristics of the DroeKloof River

Figure 37: Photograph of the channelised drainage line from a southern tributary to the Cordiers River

Figure 38: The excavated channel directing any surface flow directly into the channel of the Cordiers River

Figure 39: The excavated channel directing any surface flow directly into the channel of the Cordiers River from the road

Figure 40: The excavated channel directing surface flow and sediment into the channel of the Cordiers River

5.2.5 Dry channel

The dry channel is narrow (less than 5m in width), less than 500m in length, and has an average longitudinal slope of 20%. The channel bed is approximately 1m in depth with rectangular shape and flat 2m wide floor (Figure 41). The channel collects surface runoff during rainfall events and directs flow into the Middlewater River in the valley bottom. It loses definition towards the valley bottom and join subsurface flow. It is an important sediment source but otherwise has limited ecological services and low sensitivity compared to the larger river.

The drainage channel has been impacted by wildfire which may have caused minor erosion and increased sediment inputs. However, prior to the disturbance from the construction of the dam, the channel was in a largely natural state. The dam construction has resulted in stockpile material, and boulders which were removed from the excavation area, entering the channel. Additionally, stormwater runoff from the side of the dam is likely to cut this channel and incise the bed downstream. The dam should not have been constructed near the bank of the channel and erosion protection measures must be installed to compensate for this impact.

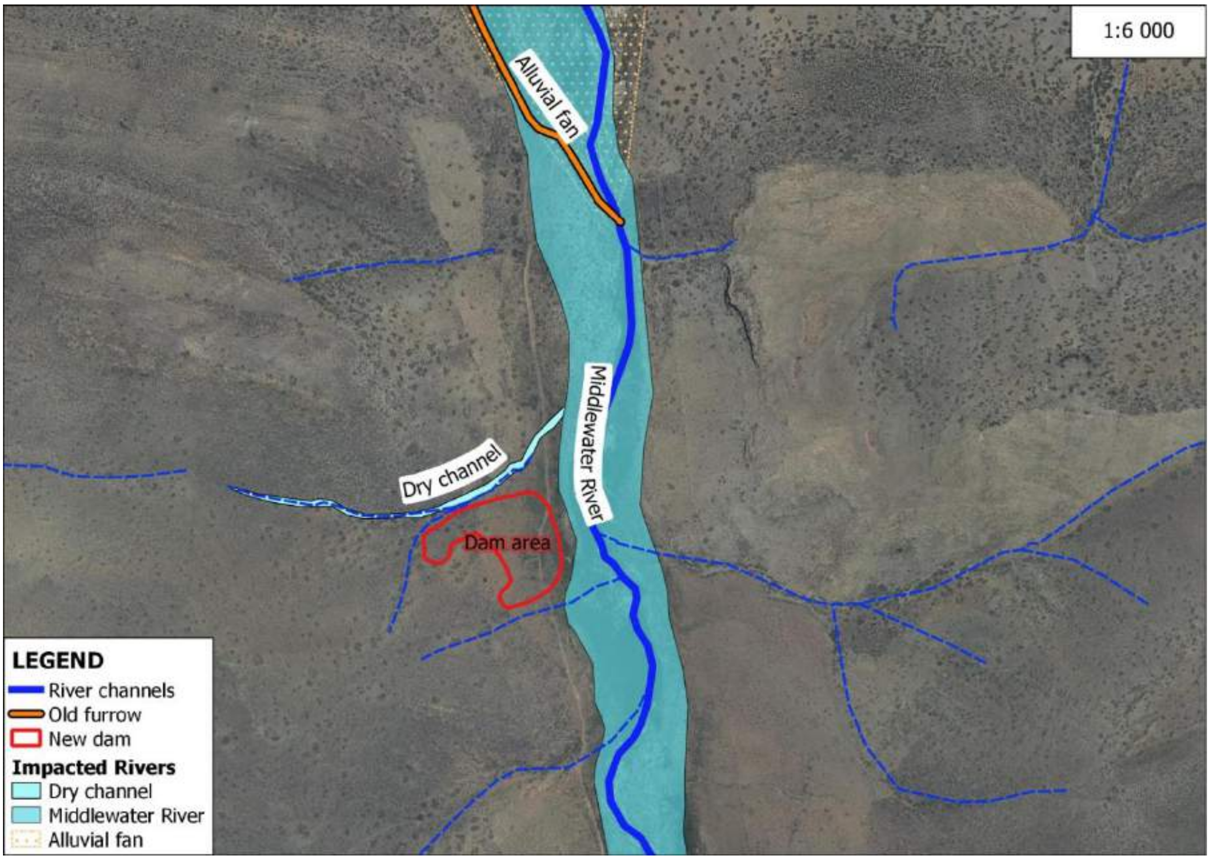

Figure 41: Map showing the location of the new dam in relation to the dry drainage channel and Middel River

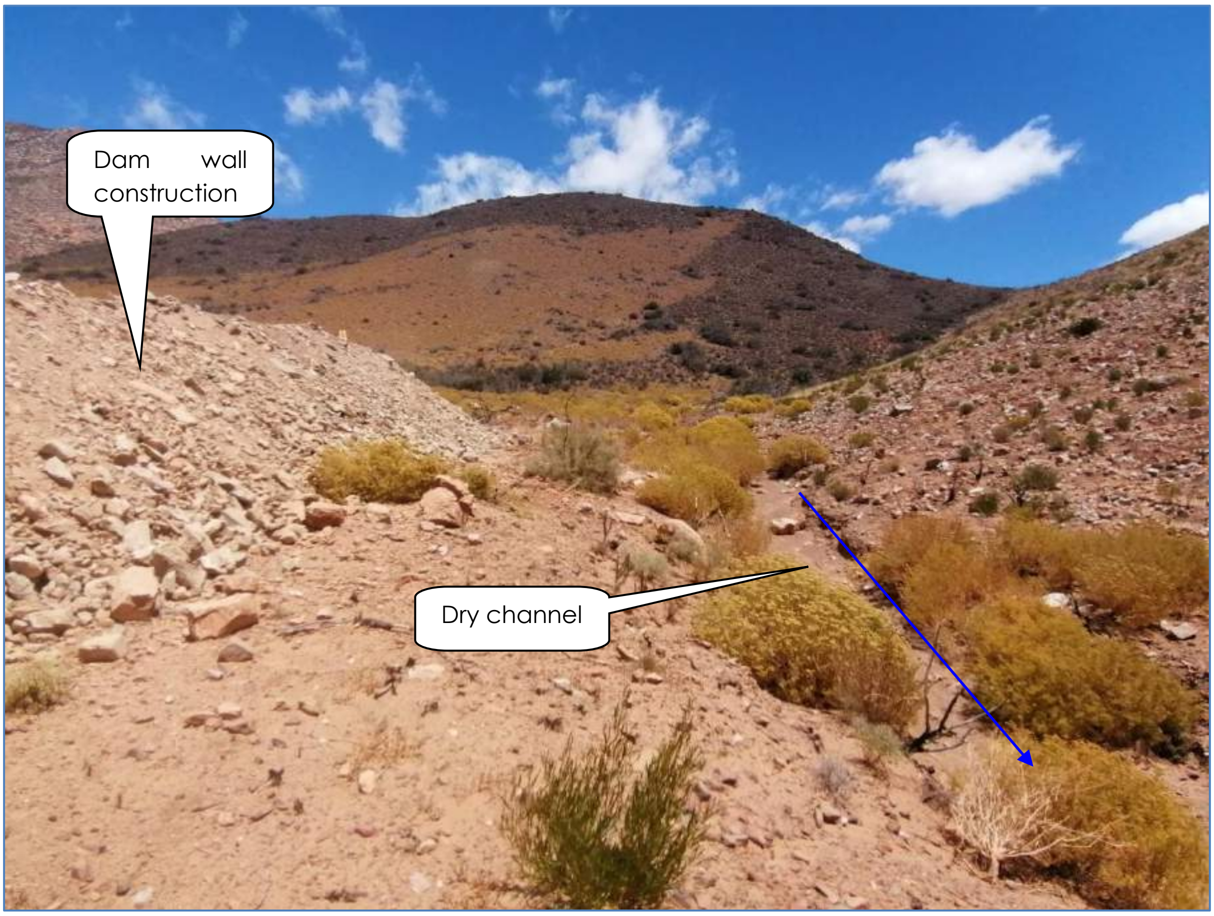

Figure 42: The dry channel located on the hillside where the dam has been constructed

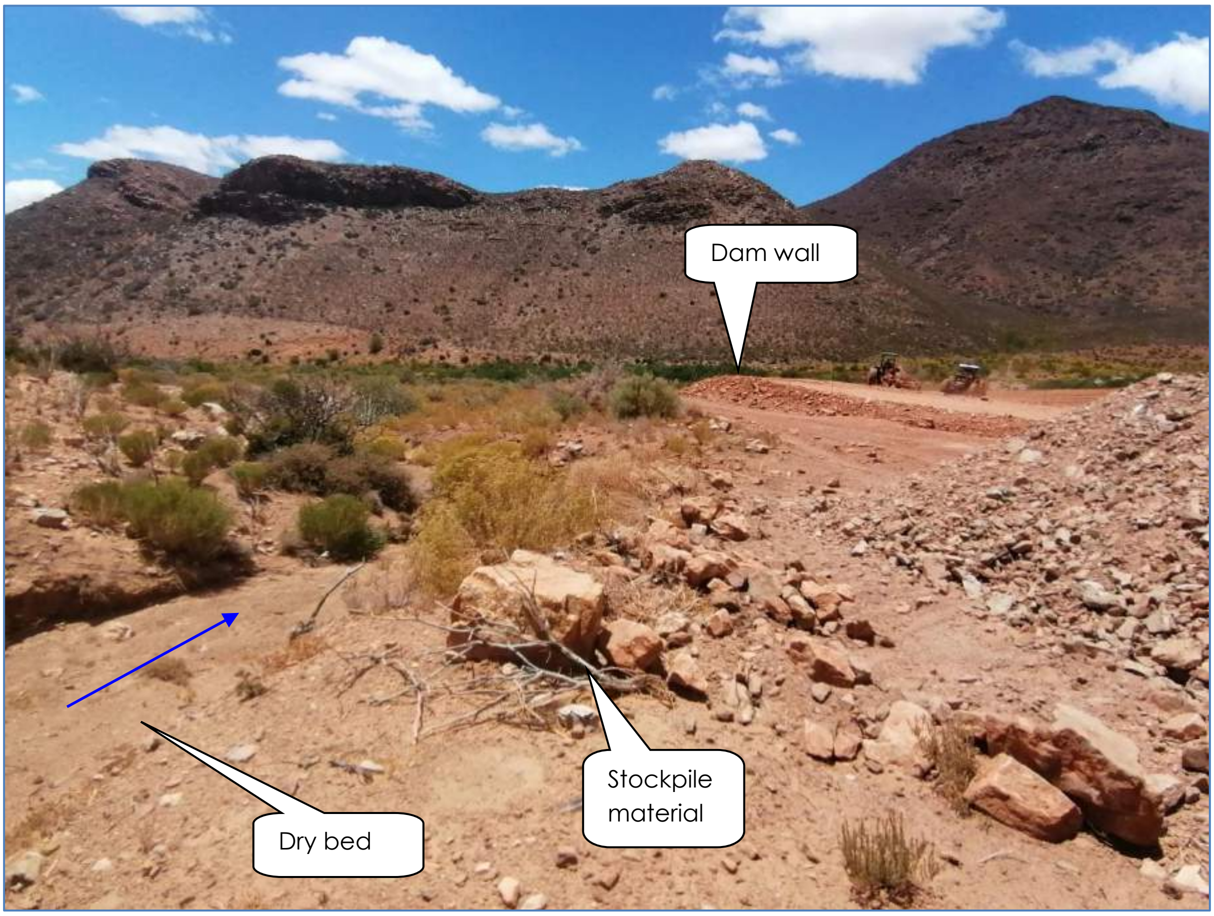

Figure 43: The channel bed in relation to the construction activities

Figure 44: Photograph showing the narrow and uniform sand and gravel bed of the channel which is sparsely vegetated

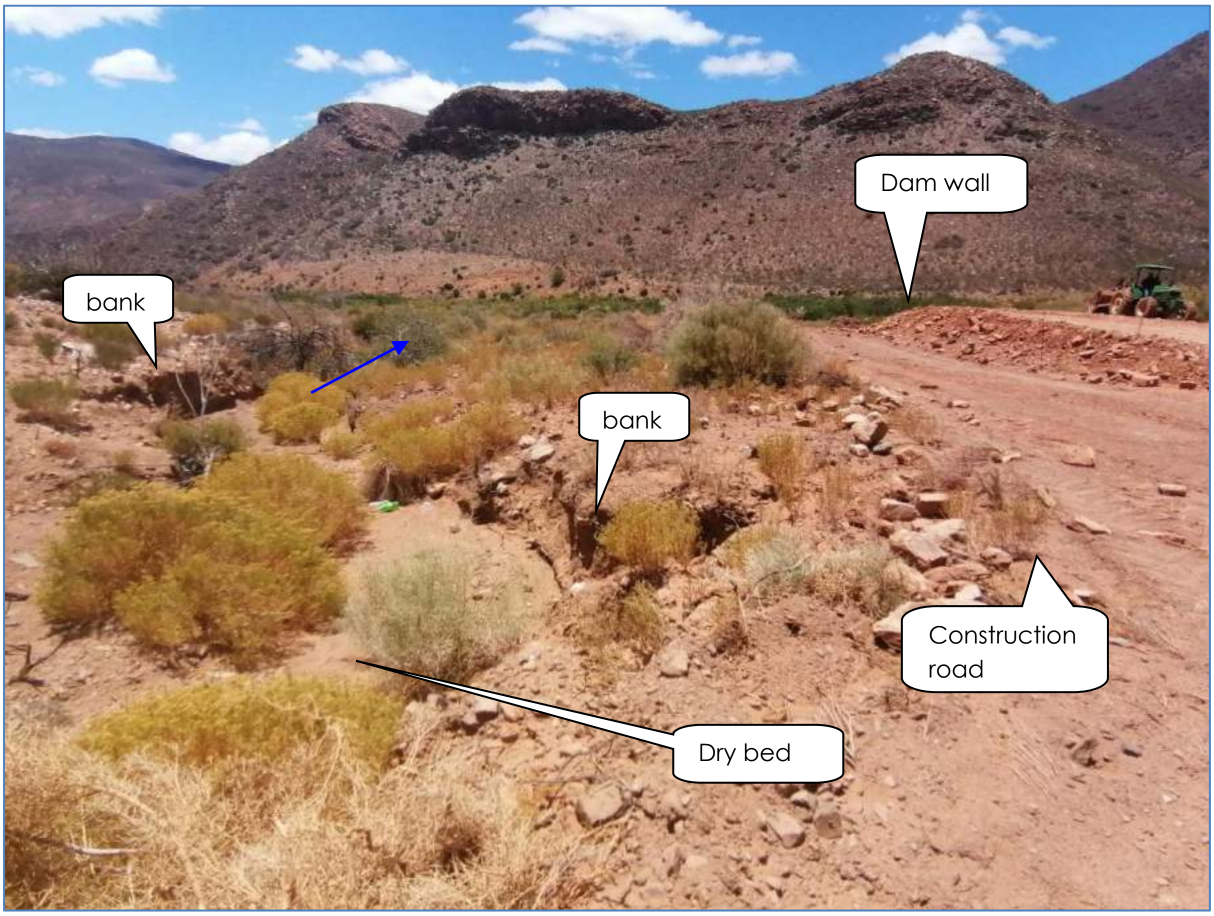

Figure 45: The impact of the dam construction on the small dry channel banks

6 IDENTIFIED IMPACTS

Aquatic ecosystems are particularly vulnerable to human activities and these activities can often result in irreversible damage or longer term, cumulative changes. The physical form of a watercourse is the result of the interaction between flow, sediment, and vegetation. The three are intricately linked: artificial manipulations of the river's bed, banks and floodplain will affect flow and sediment movement through the system. The significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed.

The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance is determined. Impact significance is defined broadly as a measure of the desirability, importance, and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent, and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.

The impacts of the project were identified and grouped together as:

- Loss of riparian habitat and biota
- Sedimentation and erosion
- Flow pattern modifications

The water quality impacts associated with the dam construction would have only occurred for a short period of time and been limited to the dam site. The significance of this impact is thus seen to be negligible and was not assessed further.

6.1 Loss of riparian vegetation, biota and habitat

The disturbance or loss of aquatic vegetation and habitat refers to the direct physical destruction or disturbance of aquatic habitat caused by vegetation clearing, disturbance of riparian habitat, encroachment, and colonisation of habitat by invasive alien plants. The reduction or removal of riparian vegetation cover, within rivers which reduces the resistance to flow and thus increases flow velocities, directly reduces the protection of the river bed and banks which was afforded through the vegetation cover. The disconnection from the floodplain, loss of biodiversity, and loss of natural habitat diversity can result in over-topping of the banks and flooding of the lands.

The stripping of indigenous vegetation and the promotion of un-natural and unstable river geometries will have the most harmful effect on the river. The activities have disturbed the composition of the bed and banks which increases the risk of erosion. The clearance may cause a widespread erosion of sediments and vegetation from the river during a flood event. Thereafter, the disturbance is also highly likely to result in the establishment of alien invasive plant species. The outcome is that of habitat simplification, or loss of diversity. Such losses may relate to losing structural complexity.

Modified banks may also limit lateral connectivity, preventing some riverine fauna from moving up the bank and onto the floodplain. If the structures do this then the quality of longitudinal ecological corridors along the bank and riparian zone will be reduced. The promotion of a straight, single channel river such as the channellisation of the Droekloof distributary channel, reduces habitat diversity, associated ecosystem services are reduced or lost.

6.2 Sedimentation and erosion

Sedimentation and erosion refers to the alteration in the physical characteristics of the river as a result of increased turbidity and sediment deposition, caused by soil erosion and earthworks that are associated with infilling and excavation activities, as well as instability and collapse of unstable soils during operation. These impacts can result in the deterioration of aquatic ecosystem integrity and a reduction/loss of habitat for aquatic dependent flora & fauna. Erodibility can be increased by desiccation, rainsplash and rill formation, trampling by people or animals, destruction of riparian vegetation, and by wind against the bank.

The excavations and infilling activities have created a deeper, narrower channel with banks of erodible sediments which will result in the reach being permanently destabilised through lateral and vertical erosion. The change in channel geometry and removal of vegetation (reduced roughness) will also increase the capacity for sediment transport and will lead to erosion of the bare unstable soils.

6.3 Flow Modification

The changes in the quantity, timing and distribution of water inputs and flows within the watercourse. Possible ecological consequences associated with this impact may include deterioration in freshwater ecosystem integrity, reduction/loss of habitat for aquatic dependent flora & fauna, and a reduction in the supply of ecosystem goods & services.

The bank modification has resulted in the straightening and deepening of the channel which will increase the flood conveyance. The channel is now artificially deep and narrow channel, with an associated unnatural increase in flow velocity and sediment transport capacity. The modification to the channel geometry will cause faster flow velocities, reduce natural flood attenuation, increase sediment transportation, and consequently impact downstream reaches. This is also especially relevant to the completely channellised Droekloof tributary.

The impacts of any water abstraction from MiddelWater could be highly negative if undertaken without specialist assessment and the relevant authorisations. If such activities are proposed they must be assessed accordingly and must not commence prior to obtaining water use authorisation.

6.4 Cumulative Impacts

Cumulative impacts on the environment can result from broader, long term changes and not only as a result of a single activity. They are rather from the combined effects of many activities overtime. Rivers are longitudinal systems where different reaches interact in a continuum along the length of the river. This is vitally important to understand in the context of cumulative impacts from agriculture. Activities in the upper reaches influence the processes of the lower reaches and it must therefore be viewed as a whole. Watercourses are set apart from many other ecosystem types by the degree to which they integrate with and are influenced by the surrounding landscape, or catchment. The physical, chemical and biological characteristics of any river are determined almost entirely by the nature of its catchment and the activities, human and natural, that take place in it

(Davies and Day 1998). Widespread land use conversion at a catchment scale can dramatically alter the flow rates, water quality and sediment regimes of watercourses. Erosion and deposition are natural processes within watercourses, but the extent, severity and frequency of these impacts can increase in response to site-specific as well as catchment-wide land use activities.

6.4.1 Poor catchment management

The Cordiers River catchment has been impacted by human activities for a long period of time (refer to 1962 aerial photograph above). The river has been subjected to modification as a result of the surrounding agricultural activities, and those within the watercourse itself. The cumulative impact of activities in the catchment such as the clearance of riparian vegetation, infilling and diversions, agricultural encroachment into the floodplain, water over-abstraction, and an altered sediment regime, has resulted in wide-spread habitat degradation. The assessment of the impacts of the activities specific to this short reach of river will not be representative of the cumulative impact of continued poor agricultural practices and bad land management within this catchment as a whole. The river is an important ecological corridor and buffer and provides irreplaceable services to society. Severing this longitudinal link, as well as the lateral interaction within the landscape, is cumulatively causing loss of the water resource upon which the agriculture relies.

An intensely utilised river floodplain, such as that of the Cordiers River, although no longer in a natural condition, should be viewed as critically important to water resource protection due to the significance of the remaining habitat and the increasing threats from poor land use. The significance of the impacts increases in the context of the amount of riparian habitat already lost within the catchment. Each activity resulting in habitat loss (such as within this reach of river) is impacting a smaller remaining area of riparian habitat and thus would have a larger negative effect, cumulatively.

6.4.2 Biodiversity conservation targets

The riparian areas impacted are classified as Critical Biodiversity Areas (CBA 1: Aquatic and CBA 2: River) and fragments as Ecological Support Areas (ESA 2: River) according to the Western Cape Biodiversity Spatial Plan (WCBSP, 2017). CBAs are the areas required to meet biodiversity targets and they need to be maintained in a natural or near-natural state. The Cordiers River is also a Freshwater Ecosystem Priority Area (FEPA) river corridor and as a result plays an important role in allowing biota movement within the landscape. These FEPAs rivers are important in achieving biodiversity targets for riverine ecosystems. FEPAs are strategic spatial priorities for conserving freshwater ecosystems and associated biodiversity. The unauthorised activities have severed landscape connectivity in the ecological corridor and have caused habitat fragmentation. Therefore, without rehabilitation of the Cordiers River, adoption of an aquatic buffer zone, and continued management thereof, the biodiversity conservation targets will not be reached and the cumulative impact upon aquatic habitat is negative and High. The impact can be reduced to cumulatively Medium if rehabilitation is successful and most of the ecological connectivity and functioning is regained.

6.4.3 Dams

Agriculture is a very climate-sensitive sector. Recent prolonged drought conditions have significantly impacted farmers of the Prince Albert area. In the context of climate change, and increased pressure from market demand, water security is increasingly at risk and farmers are naturally seeking ways to protect their future livelihoods. This is resulting in an increase in the construction of dams.

The increasing number of dams within the catchments and rivers assessed will have cumulatively significant impacts. However, this study does not include the assessment of any potential water use associated with the construction of the dam, as it was outside the scope of works and not occurring at the time of the site visit. Abstraction from rivers without sustainable yield determinations and aquatic specialist input would have cumulative impacts upon aquatic biodiversity from the activities.

7 IMPACT SIGNIFICANCE

The impact significance of the unauthorised activities was determined for each direct and indirect impact. The construction/commencement impacts upon aquatic biodiversity are of High negative significance (Table 6). No assessment of mitigation is applicable as none was undertaken. If nothing is immediately done to remedy these impacts, there will be a permanent loss of aquatic habitat.

During post-commencement (such as an operational phase) the impacts were assessed under the 'Do nothing' scenario as well as the 'Rehabilitated' scenario. Currently, the activities are continuing to have a High impact on the Cordiers River, largely as a result of sedimentation downstream and the erosion of the bare channel banks (Table 7). These modifications, as well as the channelled flow, pose an incredibly significant risk to the river should a flood occur. Without rehabilitation, these impacts will continue to degrade the river. Post-commencement vegetation impacts are of Medium significance, if the status quo remains, as there is negligible vegetation remaining. However, alien invasive plants are highly likely to establish without mitigation and rehabilitation actions undertaken.

Under the post-commencement 'Rehabilitated' scenario, it is assumed that all mitigation measures and the recommendations of the rehabilitation plan are successfully implemented. As opposed to the High impacts of the 'Do nothing' scenario, the future impacts upon aquatic habitat can be reduced to Medium significance with rehabilitation (Table 7) of the present river state (at the time of site assessment). In this scenario, the current state of the Cordiers River would be improved to a 'C' PES category and managed in perpetuity with an aquatic buffer zone adopted. This is not rehabilitation of the High commencement/construction phase impacts, as this phase has passed; it is a mitigation measure for the ongoing rehabilitation of the aquatic habitat from the current degraded state, following the direct activities.

Rehabilitation may never achieve the pre-impacted ecological state, but it will have positive outcomes to regain some ecosystem services and processes functioning. However, the physical actions taken to rehabilitate the river can result in negative impacts. These construction (not operational) impacts were assessed with and without the adoption of mitigation (Table 8). Mitigation must be implemented during the rehabilitation to ensure only Low impact significance (such as the prevention of erosion and sedimentation during the recontouring/excavations of the banks). The rehabilitation activities recommended in this report, if conducted in a sensitive and precautionary manner (with mitigation), they will not result in any significant impacts to remaining habitat.

Table 9-11 is an evaluation of the direct and indirect impacts associated with construction of the off-channel dam, excavation of the sump in the Middlewater River for construction purposes, as well as the future impacts of the dam existing in its current state (with and without mitigation applied). The construction of the dam did not result in any High impacts as it is an off-channel dam. However, due to the lack of prior planning and adoption of any mitigation, the construction resulted in Medium negative impacts upon aquatic biodiversity. The excavation of the sump was not highly significant either, due to the small disturbance footprint and reversibility, but the location and use of the access route into the river has caused bank erosion and disturbed vegetation in this site, resulting in Medium impact significance (Table 9). It is recommended that the sump be filled, and the area rehabilitated.

The post-commencement impacts of the dam were assessed under the 'Do Nothing' scenario and with mitigation alternative (Table 10). It was determined that the continued existence of the dam has potential to cause impacts of Medium negative significance. However, if mitigation is implemented to reduce the risk of erosion of the disturbed soils, revegetate surrounding disturbed areas, and prevent alien plant encroachment, then Low impact significance can be achieved. This post-commencement phase assessed should not be confused with the typical operational phase scenario for dams. It assumes that the activities and resultant structures observed during the site visit continue in that same state, or in a mitigated state, such that only the physical dam structure and access road footprint are assessed, and not a scenario consisting of any water storage or use impacts, which may be planned but were not occurring at time of site assessment.

The removal of the dam (which would be a rectification approach and require rehabilitation) has the potential to cause further negative impacts upon nearby aquatic habitat (including the Middlewater River) due to significant earthworks and soil movement that will be required. The removal of the dam was therefore not assessed as an alternative under post-commencement and mitigation of the present state was deemed as acceptable. It is an off-channel dam, and while it would have resulted in fewer impacts if aquatic input were obtained prior to design, its removal will not significantly benefit aquatic habitat and thus is not deemed as requisite. However, authorisation for the dam under the National Water Act (Act 36 of 1998) must be obtained prior to water use. As part of mitigation, maintenance works at the dam should be in accordance with an approved Maintenance Management Plan (MMP).

Table 6: Evaluation of impacts of the commenced activities upon aquatic biodiversity

IMPACTS FROM COMMENCEMENT							
IMPACT	**EXTENT**	**DURATION**	**MAGNITUDE**	**PROBABILITY**	**SIGNIFICANCE**	**REVERSIBILITY**	**IRREPLACEABLE RESOURCE LOSS**
Loss of riparian vegetation & habitat	Local (2)	Long term (4)	High (8)	Definite (5)	**High (70)**	Partly	Yes
Erosion & sedimentation	Regional (3)	Long term (4)	High (8)	Definite (5)	**High (75)**	Barely	Yes
Flow modification	Regional (3)	Long term (4)	Moderate (6)	Definite (5)	**High (65)**	Partly	Yes

Table 7: Evaluation of impacts upon aquatic biodiversity under the 'Do Nothing' scenario, and the assessment of potential impacts in operation with mitigation applied (this assumes that the implementation of recommended mitigation measures and the rehabilitation plan is effective (including effective on-going management of buffer)

IMPACTS POST COMMENCEMENT - WITHOUT ('DO-NOTHING') AND WITH REHABILITATION									
IMPACT	**MITIGATION**	**EXTENT**	**DURATION**	**MAGNITUDE**	**PROBABILITY**	**SIGNIFICANCE**	**REVERSIBILITY**	**MITIGATION POTENTIAL**	**IRREPLACEABLE RESOURCE LOSS**
Loss and disturbance of aquatic vegetation & habitat	Do nothing	Regional (3)	Permanent (5)	Moderate (6)	Highly Likely (4)	**Medium (56)**	Barely	High	No
	Rehabilitated	Local (2)	Medium (3)	Moderate (6)	Highly Likely (4)	**Medium (44)**	Partly	Low	No
Erosion & sedimentation	Do nothing	Regional (3)	Permanent (5)	High (8)	Highly Likely (4)	**High (64)**	Barely	Medium	Yes
	Rehabilitated	Local (2)	Long term (4)	Moderate (6)	Probable (3)	**Medium (36)**	Partly	Low	No
Flow modification	Do nothing	Regional (3)	Permanent (5)	Moderate (6)	Definite (5)	**High (70)**	Barely	Medium	Yes
	Rehabilitated	Local (2)	Medium (3)	Moderate (6)	Probable (3)	**Medium (33)**	Barely	Low	No

Table 8: The assessment of possible impacts associated with the physical rehabilitation actions recommended for the watercourses, with mitigation and without

IMPACTS DURING REHABILITATION CONSTRUCTION									
IMPACT	**MITIGATION**	**EXTENT**	**DURATION**	**MAGNITUDE**	**PROBABILITY**	**SIGNIFICANCE**	**REVERSIBILITY**	**MITIGATION POTENTIAL**	**IRREPLACEABLE RESOURCE LOSS**
Erosion & sedimentation	Without mitigation	Regional (3)	Long term (4)	Moderate (6)	Highly Likely (4)	**Medium (52)**	Partly	Medium	Yes
	With mitigation	Local (2)	Long term (4)	Minor (2)	Probable (3)	**Low (24)**	Barely	Low	No
Flow modification	Without mitigation	Local (2)	Long term (4)	Moderate (6)	Probable (3)	**Medium (36)**	Partly	High	No
	With mitigation	Site only (1)	Very short (1)	Low (4)	Improbable (2)	**Low (12)**	Reversible	Low	No

Table 9: Impacts upon aquatic habitat from the construction of the dam and sump, and the potential impacts of the dam structure if not removed

IMPACTS FROM DAM AND RIVER SUMP CONSTRUCTION							
IMPACT	**EXTENT**	**DURATION**	**MAGNITUDE**	**PROBABILITY**	**SIGNIFICANCE**	**REVERSIBILITY**	**IRREPLACEABLE RESOURCE LOSS**
Loss of riparian vegetation & habitat	Site (1)	Medium (3)	Low (4)	Definite (5)	**Medium (40)**	Mostly	No
Erosion & sedimentation	Site (1)	Long term (4)	Moderate (6)	Definite (5)	**Medium (55)**	Barely	No
Flow modification	Local (2)	Long term (4)	Low (4)	Definite (5)	**Medium (50)**	Barely	No

Table 10: An assessment of the post-construction impacts upon aquatic habitat from the dam structure (if not removed), with mitigation and without mitigation

IMPACTS POST CONSTRUCTION OF DAM - WITHOUT ('DO-NOTHING') AND WITH MITIGATION (only the physical dam structure and access road footprint but not including any water storage or use impacts which may be planned but were not occurring at time of site assessment)									
IMPACT	**MITIGATION**	**EXTENT**	**DURATION**	**MAGNITUDE**	**PROBABILITY**	**SIGNIFICANCE**	**REVERSIBILITY**	**MITIGATION POTENTIAL**	**IRREPLACEABLE RESOURCE LOSS**
Loss and disturbance of aquatic vegetation & habitat	Do nothing	Local (2)	Permanent (5)	Low (4)	Probable (3)	**Medium (33)**	Partly	Low	No
	After mitigation	Site (1)	Permanent (5)	Minor (2)	Improbable (2)	**Low (16)**	Barely	Low	No
Erosion & sedimentation	Do nothing	Regional (3)	Permanent (5)	Moderate (6)	Highly Likely (4)	**Medium (56)**	Barely	Medium	Partial
	After mitigation	Local (2)	Permanent (5)	Minor (2)	Improbable (2)	**Low (18)**	Barely	Low	No
Flow modification	Do nothing	Local (2)	Permanent (5)	Low (4)	Highly Likely (4)	**Medium (44)**	Partly	Medium	Partial
	After mitigation	Local (2)	Permanent (5)	Low (4)	Improbable (2)	**Low (22)**	Barely	Low	No

8 REHABILITATION

8.1 Introduction

The riparian area destroyed/disturbed as a result of the unauthorized activities must be rehabilitated in an attempt to prevent irreplaceable resource loss. The high degree of modification to aquatic habitat will unfortunately require a proportionate amount of rehabilitation work and resources. It is necessary to avoid permanent habitat loss.

Rehabilitation is defined as "promoting the recovery of ecosystem functions and values in a degraded system in order to regain some of the value the system previously had to society" (Dunster and Dunster 1996, Grenfell *et al*. 2007). Rehabilitation is not the same as restoration, which is the manipulation of a site in order to revert the watercourse back to its full range of natural (historic) processes and functions. In the South African context, restoration would mean restoring rivers back to an A (Reference State) Ecological Category. Rehabilitation, by comparison, only aims to improve aspects of the degraded state (such as some of the identified assets and processes of a system), and although this should be a reversion back towards the natural state, it does not purport to achieve the Reference or natural historical state, but rather improve watercourse condition and functions for the benefit to society and the environment.

The rehabilitation recommendations in this report are specifically to rehabilitate the reach of river/s affected by the recent land clearance and river channel changes. It is not within the scope of this study to develop a complete river rehabilitation plan nor restoration. To improve the ecological condition of the entire river, the past and present catchment scale activities which result in significant river degradation over the whole catchment length (such as alien tree invasion, channel straightening, riparian thicket removal, pollution, abstraction, infrastructure, etc. by various landowners) would need to be addressed in a larger study. The following guidelines are based upon:

- Russel WB, 2009. *WET-RehabMethods: National guidelines and methods for wetland rehabilitation*. WRC Report No. 341/09. Water Research Commission, Pretoria.
- Day, L., Rowntree, M., & King, H. 2016. The Development of a Comprehensive Manual for River Rehabilitation. WRC Report No TT 646/15. Water Research Commission, Pretoria.
- Cowden, C. & Kotze, D.C. 2009. WETRehabEvaluate: Guidelines for monitoring and evaluating wetland rehabilitation projects. WRC Report No TT 342/09, Water Research Commission, Pretoria.

It should be noted that all designs and recommendations in this document are conceptual in nature and need to be verified at the time of construction by a suitably qualified environmental engineer in order to ensure that each intervention appropriately meets the initial objectives of the rehabilitation plan as site conditions are likely to change between the time of planning and implementation. The recommendations detailed below must be viewed as a guideline for rehabilitation of the site which may require adaptive management.

8.2 Objective

The objective of the rehabilitation is to regain, as near as possible, the pre-impacted ecological condition of the aquatic habitat prior to the impacts of the unlawful activities.

8.3 Location

The areas which require rehabilitation with regards to aquatic biodiversity are shown in Figure 46 below (orange). From an aquatic perspective only, the areas which (at a minimum) must be rehabilitated consist of the areas of land which have been cleared within the remaining riparian habitat. Once rehabilitated, those areas, as well as the remaining riparian habitat, must be treated as No-Go area and maintained for ecological integrity. Figure 46 indicates the extent of cleared riparian habitat which is required to be rehabilitated. For planning purposes these can be described as areas A, B, and C (which are the Northern tributary area, Cordiers River area, and Droekloof channel area, respectively). The rehabilitation plan focuses on improving and conserving the damaged riparian areas which form part of the Cordiers River (Area B). However, the objective for Area A and Area C is to prevent any further degradation of the tributaries to avoid impacts upon the trunk river.

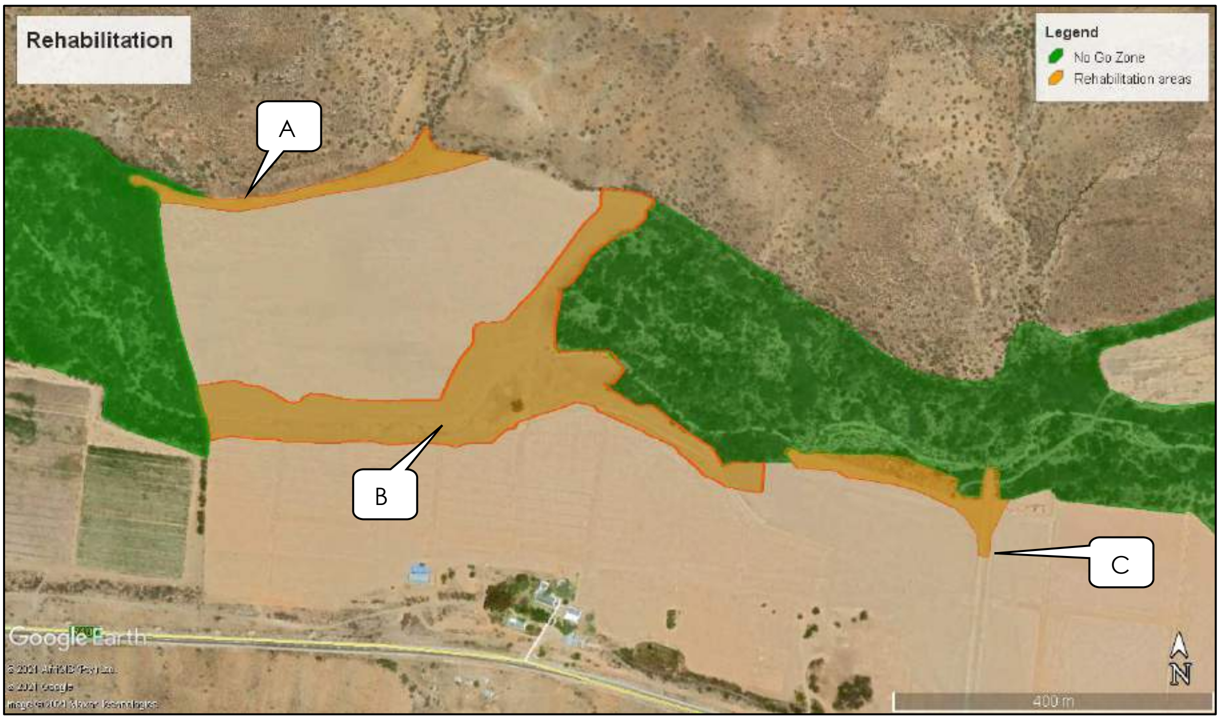

Figure 46: Map showing the areas required to be rehabilitated (orange polygons) and the No Go zone which is remaining habitat that must be avoided (green polygon)

8.4 Interventions

Methods of river rehabilitation may include hard engineering interventions such as concrete or gabion structures, or soft engineering interventions which also offer successful rehabilitation methods. Examples include the re-vegetation of stabilised areas with appropriate riparian plant species, the fencing off of sensitive areas to allow for the re-establishment of vegetation, and/ or the use of biodegradable or natural soil retention systems such as eco-logs, plant plugs, grass or hay bales, and brush-packing techniques. Structures should never be viewed as a substitute for good riparian and upland management. Reshaping and planting of banks provides opportunities for improving longitudinal connectivity along the river, as well as lateral connectivity with the floodplain and/ or riparian and terrestrial areas. A larger riparian corridor is created in the process.

It is usually desirable to keep all constructed river rehabilitation interventions (earthworks, soft structures, hard structures) to a minimum, not only for reasons of economy, but for avoiding interfering with natural processes as far as possible. The converse is also true, that one does not want half-hearted interventions that fail unnecessarily during floods and the river has to be disturbed by construction once more when the intervention is reconstructed. An important factor for consideration in this project is the highly dynamic nature of the sediment processes and flow regime which define the Cordiers River. For long-term and sustainable rehabilitation efforts the natural processes of erosion and aggradation must inform interventions.

It is important to prepare an accurate estimate of the financial costs of rehabilitation and ensure that sufficient funds are allocated to achieve a successful outcome. Failure to implement appropriate rehabilitation activities timeously can also have tremendous costs, often orders of magnitude greater than the costs of early intervention, and resulting at best in stabilising the degradation process, with no chance of returning the system to its original condition.

8.5 Approach

8.5.1 Area A & Area C

Area A (northern rehabilitation area) requires stabilising the channel and preventing erosion while allowing for vegetation to establish. There should be measures in place to trap sediments that could be washed down the trench from the bare banks during rainfall. The end of the trench must be recontoured into a gentle cross section to introduce any flow into the floodplain in a diffuse pattern to slow velocities from the confined trench and prevent erosion downslope. Small stone berms within the trench and at the toe could be used. Haybales may provide a temporary solution while the earth settles. This area does not require any large structures but must be monitored for erosion regularly.

Area C (the toe of the Droekloof channel system routed through the lands to the Cordiers River channel) requires stabilisation to reduce sediment inputs to the main river due to soil disturbance and open ground. This may be achieved with the establishment of indigenous vegetation, geotextile fibre mats of nets, or harder structures provided they prevent the disturbed soils from being transported downslope. Sediment traps should be installed (and maintained) at intervals along the channel length at least temporarily while the channel surface stabilises. The bed and banks at the bottom of the channel, from the trunk river to approx. 60m upslope, must be levelled to a gentle topography (a wide fan). This area must then be revegetated with riverine thicket species (Figure 47). Any erosion in this channel or on the bank must be halted before impacted the trunk river.

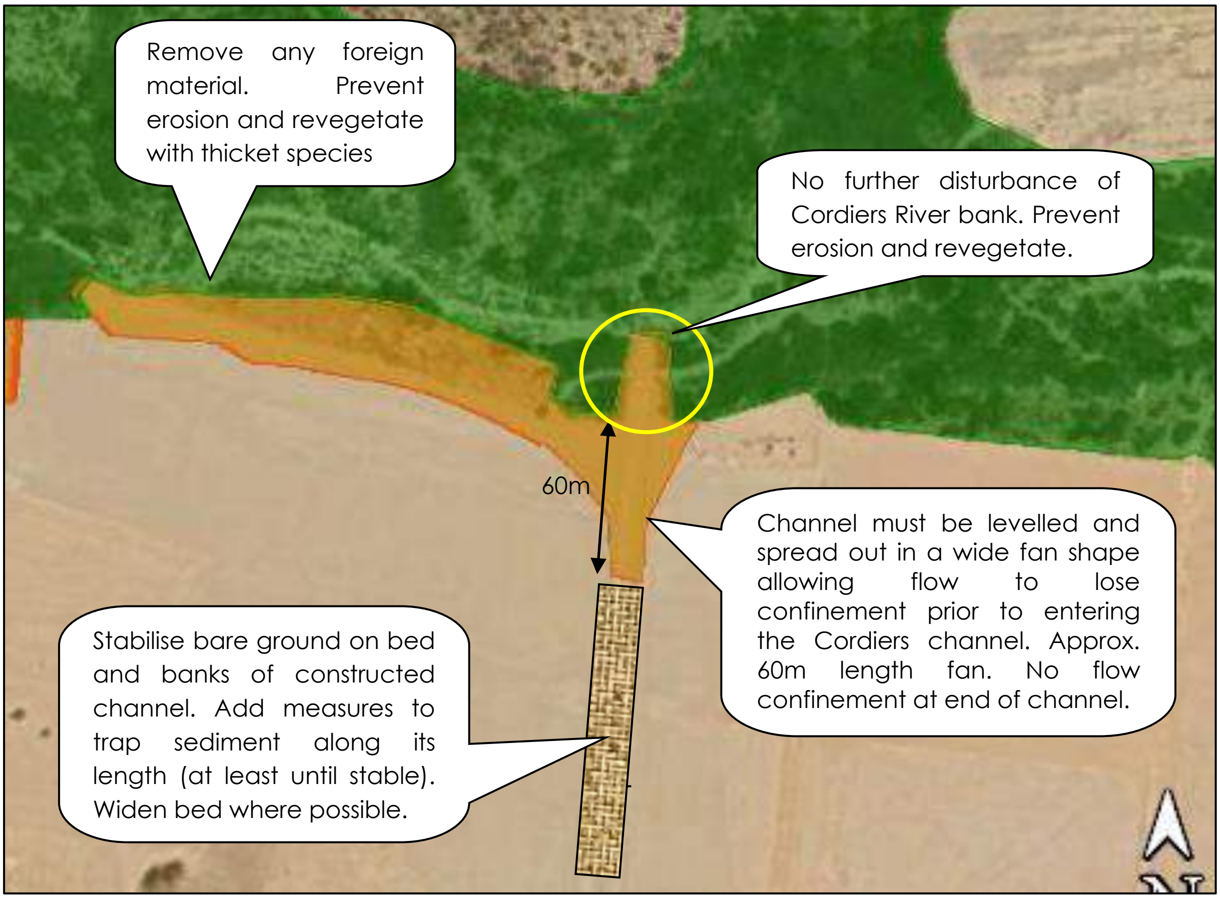

Figure 47: Drawing to illustrate the objectives of rehabilitation on Area C

8.5.2 Cordiers River Rehabilitation - Area B

The rehabilitation will require and integrated approach and maintenance to be successful. It is recommended that the initial step to rehabilitation be reshaping the banks to restore channel geometry and create gentler sloping banks. During this disturbance it is advised that sediment traps be installed (and maintained) at intervals along the channel length. It is imperative that bank reshaping be immediately followed by soil stabilisation to prevent further erosion and sedimentation (i.e., no bare soil surfaces/banks should be left without measures to prevent erosion for longer than a day). Should surface runoff result in erosion or bank collapse then the rehabilitation will be undermined, and reshaping will need to begin again. Once stabilised, the banks and entire rehabilitation zone (cleared buffer area) must be revegetated with locally occurring vegetation. It is not deemed necessary at this point to revegetate the channel bed as species should establish naturally if sedimentation and alien infestation is prevented.

Efforts must continue through monitoring the rehabilitated area to ensure success and managing the riparian buffer zone indefinitely. In general, this approach entails reshaping of the channel cross sectional profile so that its banks are gently sloping, to facilitate the establishment of vegetation that will contribute to bank stabilization, and the establishment of a more spatially complex marginal and riparian habitat. The river rehabilitation plan of actions can be summarised as:

6.) Reshaping of banks
7.) Erosion protection and sediment trapping
8.) Revegetation of banks and buffer
9.) Monitoring rehabilitation
10.) Managing riparian buffer zone

8.6 Rehabilitation measures

8.6.1 Re-sloping and stabilising banks

The river banks should be reshaped to provide an increased flow width and gentler slopes. Gentler slopes allow for more effective revegetation and generally simulate natural bank structure. The banks should be pulled back to gradients no steeper than 1:4 and preferably much gentler, taking care to vary the position of the toe of the slope very slightly with distance along the bank, so as to create a meandering effect, and to pull the bank back coarsely, so that the final product has a natural, rough appearance, with vertical and longitudinal heterogeneity. Banks can be terraced rather than entirely graded, with a step comprising a relatively flat shelf (approx. 1 m wide and at least 1m above the toe of the bank). The environmental engineer must approve the dimension on site prior to work commencing and all distances must be clearly marked.

Upstream and downstream extents of shaped banks should be moulded in to remaining, unshaped banks, so that neither protrudes into the channel, where it might trigger erosion. Prior to commencement, the relevant distances and boundaries for work and No-Go areas must be clearly demarcated and approved by an environmental engineer, to ensure that by using the marked measurements and gradients, the rehabilitation objectives will be achieved. Machinery should operate from the top of bank, rather than in-channel, to minimise disturbance and downstream sedimentation. Areas of bank which has since revegetated naturally with indigenous vegetation should be excluded from excavation area, provided the exclusion of the area will not compromise rehabilitation as a whole. The reshaped banks must then be stabilised with a combination of vegetation, coir rolls, and or geofabric.

8.6.2 Erosion control and sediment trapping

Measures to aid soil stability and revegetation include geotextile fibre mats or nets which may be placed on the soil surface on the re-sloped banks (Figure 48). These are any permeable textile material that is used to holding seed, fertilizers and/or topsoil in place, or holding disturbed soil on graded sites, in order to prevent erosion. The advantages of erosion control mats are that plants can take root and , although not indigenous, they are natural fibres which decompose. In the arid climate these mats are very useful for re-vegetating slopes where a micro-climate needs to be created until small plants appear with leaves shading the soil, creating a habitat where other plants can thrive. By the time these mats have decomposed the vegetation would generally have established to provide erosion control. Another applicable use for geotextile is to trap sediment in the channel itself and prevent bed erosion by making sand bags with the material. These bags filled with locally available sand (there are limited rocks) can be laid across the channel to trap sediment.

Surface preparation is important, as the soil should be relatively smooth and without humps. The mat should extend beyond the edge of the area to be covered, with the top end buried in a trench at least 10 cm deep by 20 cm wide (Figure 49). The mat will need to be further secured with stakes. There must be maximum soil contact to prevent erosion underneath. Ideally, vegetation is the best form of erosion control, with geotextiles only used for temporary stabilisation purposes until vegetation cover is established.

The area of the new dam does not necessarily require rehabilitation, but measures must be implemented during operation to ensure that no erosion is initiated in the dry channel and sediment from the disturbed slope does not become transported into the Middlewater River. The general objective for the management of this area should be to prevent any activities from indirectly impacting the river, and from direct encroachment into the riparian area.

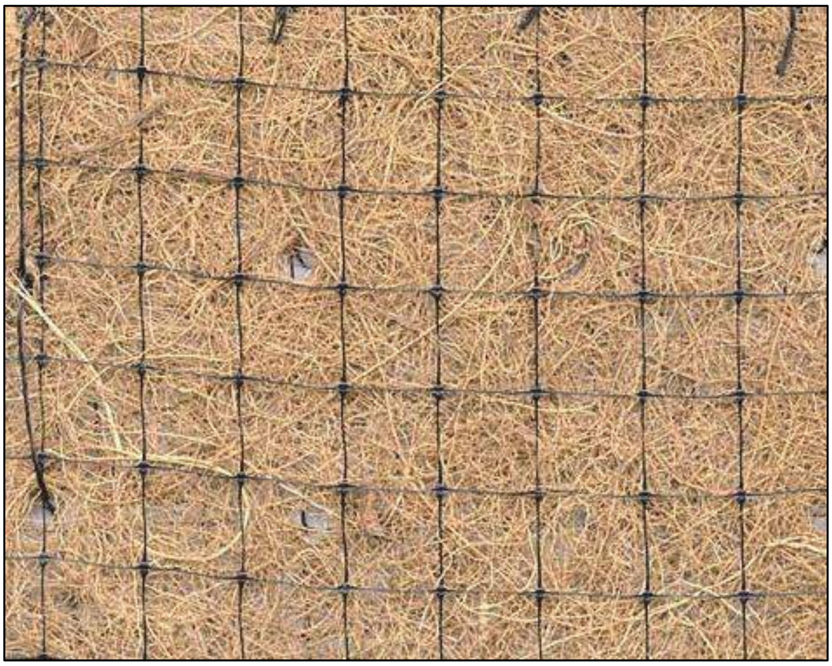

Figure 48: Example of a non-woven geotexile mat (Source: Day et al. 2016)

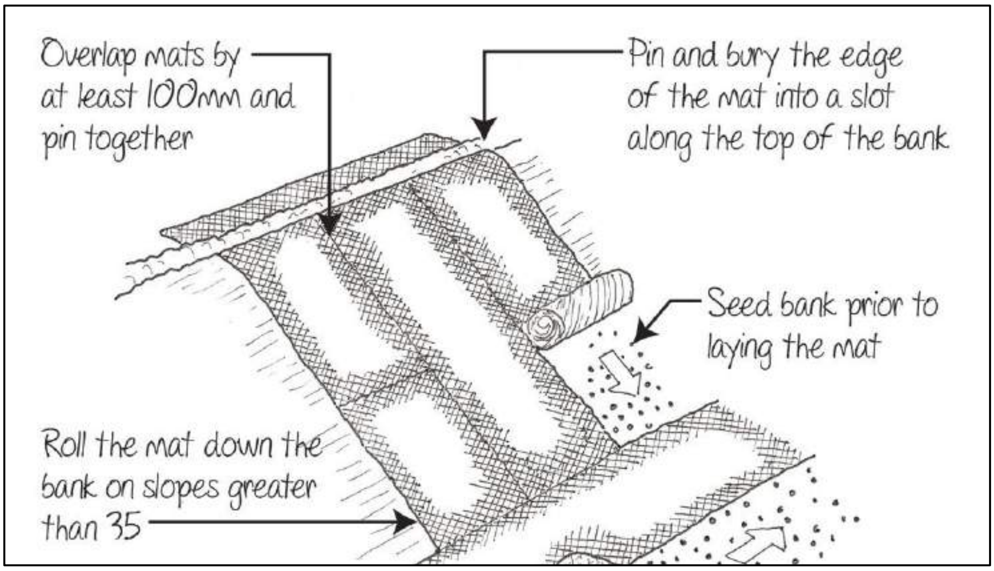

Figure 49: Rough example of the suggested fibrer mat use in conjunction with bank reshaping to stabilise the banks, limit erosion and promote faster vegetation re-establishment (Torre, 2001)

8.6.3 Re-vegetating riparian area

Vegetation is able to stabilise bank soil through various processes. Vegetation reduces bank erosion above ground as shoots bend and cover the surface and reduce the velocity at the soil/water interface, whilst below ground, roots mechanically restrain or hold soil particles in place preventing surface erosion.

The planting of vegetation must occur as soon as the re-shaped banks have been stabilised to prevent surface runoff from removing bank material. The banks are a priority area and rehabilitation must start closest to the river channel and move outwards until complete. Input from a botanist regarding revegetation of the banks would help to achieve an appropriate mix of locally indigenous riparian thicket species. Consideration should be given to reseeding with hardy pioneer and understorey species. Failure of the vegetation could result in exposure of the unprotected banks to conditions and undermine rehabilitation efforts. Due to the dry climate irrigation may be required to accelerate vegetation establishment. Depending on the plant species, the propagation period will vary. It will be a minimum of 12 months before plants propagated from seeds or cuttings will be ready to plant out on site, in some cases longer. An establishment maintenance period is necessary to monitor the growth of the plants (a minimum of 12 months is usually required).

Plants should be planted randomly or staggered with gaps; they should not be planted in straight lines. As a general rule, plants should be planted into a hole which is double its size. There are products available which act as water retention substances as well as fertilisers, or in some cases just water retainers.

8.6.4 Monitoring of vegetation

Maintenance of the plants will be required, such as watering, weeding, disease and insect pest control, and replacement of dead material in all planted areas. Alien invasive plant species often establish in disturbed areas and outcompete the natural vegetation. It will be necessary to manage the rehabilitated area constantly and indefinitely for alien invasive plants. Under CARA legislation (Conservation of Agricultural Resources Act No. 43 of 1983) the landowner is required to remove the alien invasive trees on the entire property. The neighbouring landowners and those upstream are also required to manage alien invasive trees on their properties.

8.6.5 Managing riparian buffer zone

Aquatic buffer zones which are designed to act as barriers between human activities and sensitive water resources in order to protect them from adverse negative impacts. Buffer zones associated with water resources have been shown to perform a wide range of functions and have therefore been adopted as a standard measure to protect water resources and associated biodiversity. An aquatic impact buffer zone is defined as a zone of vegetated land designed and managed so that sediment and pollutant transport carried from source areas via diffuse surface runoff is reduced to acceptable levels (Macfarlane and Bredin 2016). Rehabilitation is aimed at facilitating the long-term sustainability of riverine environments by allowing for ecological buffer areas / corridors and implementing various land-use controls.

A buffer must be implemented to achieve the greatest scope for enhancement of habitat quality, diversity or function in degraded transformed environments. River habitat quality depends on the design and management of ecological buffer areas to protect the longitudinal ecological corridors and the interface between the river environment and the adjacent land uses. It is recommended that a buffer zone be adopted and maintained for the Cordiers River (Figure 50). The width of which will need to correlate with remaining habitat and must include the rehabilitation areas.

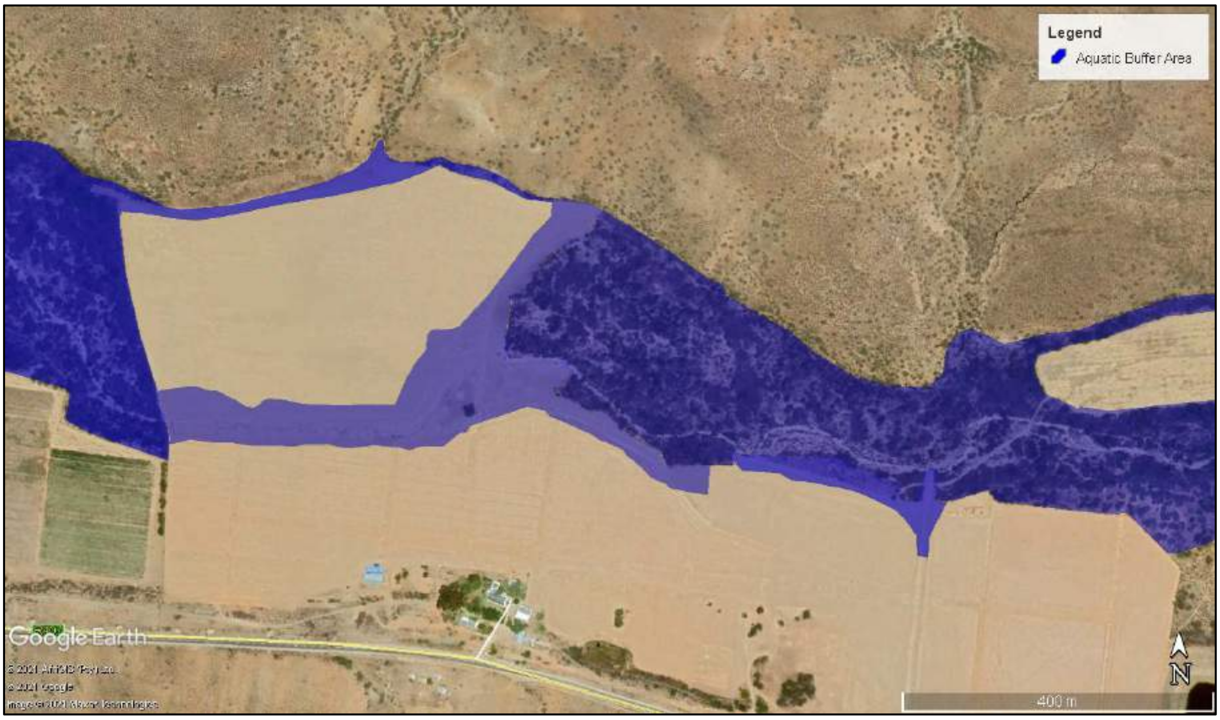

Figure 50: Map showing the aquatic buffer area which must be rehabilitated and maintained in a good ecological state.

It is recommended that no fences within the riparian areas (including tributaries) are constructed. Faunal movement within the trunk river and its tributaries should not be restricted. No draining of buffer areas by means of channels and subsurface drains can take place, as this directly affects buffer function. Foreign materials must be removed from the buffer area.

9 MONITORING

Monitoring is required to guide the work planned on the river, evaluate progress, and gauge success in achieving the objectives. Any areas that are not progressing satisfactorily must be identified and action must be taken. Monitoring of rehabilitation activities is essential, not only because of uncertainty in terms of understanding the cause-effect relationships in river ecosystems, in underlying dynamic conditions of rivers themselves, and in the ability of selected rehabilitation options to successfully achieve the stated outcomes, but also from an adaptive management perspective, that relies on "learning by doing" development and refinement of rehabilitation practices (Day et al. 2016). Monitoring should be undertaken before and during rehabilitation and afterwards for a sufficient timescale to detect both rapid and longer term changes. Prior to any soil movement it is recommended that the environmental engineer visit the site and, with the objectives of the rehabilitation plan, approve the planned approach and dimensions.

The monitoring of the activities is essential to ensure the rehabilitation measures are implemented in a sensitive manner. Therefore, compliance with the mitigation recommendations must be audited by a suitably qualified independent Environmental Control Officer with an appropriately timed audit report. It is imperative that an independent ECO monitor the site once before and then during rehabilitation every week, as well as when especially high risk activities are being undertaken. It is recommended that the BGCMA or an independent aquatic specialist visit the site, after construction but prior to the contractor leaving site, to ensure the rehabilitation fulfils the requirements. The Department of Water regional office and/ or DEA&DP should be notified, as soon as possible, of any accidental disturbance.

Monitoring for non-compliance must be done on a daily basis by the contractors. Photographic records of all incidents and non-compliances must be retained. Monitoring should especially focus on preventing erosion and sedimentation. Monitoring should primarily be focused towards demonstrating that the rehabilitation objectives have been achieved. Regular evaluation of your monitoring results will enable you to react to unanticipated effects of the rehabilitation. Also consult WET-RehabEvaluate (Cowden and Kotze, 2009) and the river rehabilitation manual developed by Day *et al.* 2016 for further information. The following mitigation measures must be implemented to ensure that the rehabilitation activities do not impact the river further:

- The landowner or ECO must educate all staff undertaking the work on the best practice methods and environmentally sensitive areas (general do's and don'ts).
- The specific boundaries of areas to be excavated and recontoured etc. must be clearly demarcated.
- Use the smallest possible working corridor. Outside the working corridor, all watercourses are to be considered no go areas. Any unnecessary intrusion into these areas is prohibited. Where intrusion is required, the working corridor must be kept to a minimum and identified and demarcated clearly before any construction commences to minimise the impact. The edges of the construction / rehabilitation zone within the vicinity of the freshwater habitat must be clearly staked-out and demarcated using highly visible material (e.g. fencing poles 5m apart) prior to construction commencing.
- The longitudinal gradient must not be altered in a way that results in erosion downstream or impoundment of flows upstream. The cross sectional profile of the bed and banks must be restored as far as possible.

- Sedimentation must be minimised with appropriate measures.
- Bare areas must be covered with geotextiles or revegetated to prevent sediments eroding into the watercourses.
- Remove any alien plant species. Where large gaps in the riparian areas have resulted (i.e. where indigenous vegetation has been replaced by dense alien plant infestations), it is recommended that cover components be reinstated appropriately. Only indigenous species are to be considered.
- Where possible, soil movement activities should be conducted during the drier months of the year to minimise the possibility of erosion, sedimentation and transport of suspended solids associated with disturbed areas and rainfall events. Planning for such a situation must be undertaken.
- The riparian area must be maintained through alien invasive plant species removal and the establishment of indigenous vegetation cover to filter run-off before it enters the freshwater habitat.
- Erosion features that have developed within the aquatic habitat due to the project are required to be stabilised. This may also include the need to deactivate any erosion headcuts/rills/gullies that may have developed.
- Any use of herbicides in removing alien plant species is required to be investigated by the ECO before use, for the necessity, type proposed to be used, effectiveness and impacts of the product on aquatic biota.
- The pre-construction gradient of the river must be reinstated as accurately as possible, without humping or hollowing over the construction right of way so as to limit erosion.
- A monitoring programme shall be in place, not only to ensure compliance with the EMPr throughout the rehabilitation phase, but also to monitor any post-rehabilitation environmental issues and impacts such as increased and concentrated surface runoff causing erosion. It is recommended that monitoring be undertaken at least once a week during any significant work in the rivers.

10 WATER LICENSING IMPLICATIONS

The National Water Act (NWA), 1998 (Act 36 of 1998), aims to manage national water resources in order to achieve sustainable use of water for the benefit of all water users. This requires that the quality of water resources is protected, and integrated management of water resources takes place. Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water.

As part of the rehabilitation process, Section 21 (c) and (i) water uses as per the National Water Act (Act 36 of 1998) will be applicable. A water use license application (WULA) or General Authorisation (GA) registration application must be submitted to the Breede Gouritz Catchment Management Agency (BGCMA) which is the relevant Competent Authority.

The water use activities associated with the property, that could potentially require a WULA or GA application under Section 21, unless they are already lawful, may include:

- Abstraction of water from the river
- Storage and irrigation of the water in off-stream dams
- Excavations/ physical disturbances in the rivers (for the sump, channel, and rehabilitation)

11 CONCLUSION

The commencement of activities on Angeliersbosch Farm, such as the clearing of indigenous vegetation and construction of a dam, without authorisation has resulted in High negative impacts upon aquatic habitat and biodiversity. The large-scale transformation of land has caused the degradation of the Cordiers River and impacted its tributaries to a degree in which some habitat functions will be permanently lost. There are no obvious mitigating factors regarding these actions and rehabilitation may not be successful.

The newly constructed dam and area of vegetation cleared outside of the Cordiers River riparian buffer zone can be mitigated to Medium-Low impact upon aquatic habitat and therefore could be considered by the competent authority for Environmental Authorisation and approval. The other activities impacting water resources should undergo a rectification process and no continuation should be approved. The entire extent of damaged riparian habitat must be rehabilitated with no further loss.

The activities have resulted in the physical disturbance of the Cordiers River have resulted in high negative impacts upon aquatic biodiversity. Significant efforts will be required to rehabilitate the reach of the river located on the property and to regain some of the natural floodplain processes. Most importantly, this riparian habitat must be rehabilitated to again function as an important ecological corridor and prevent largescale erosion and sedimentation. The continuation of farming within this aquatic habitat and buffer zone should not be authorised and the impacts should be rectified. Rehabilitation of all riparian habitat must be strictly implemented in order to regain ecological state and prevent further degradation. Immediate intervention should be implemented to stabilise the bare ground in riverine areas in order to avoid devastating impacts in the event of a flood.

It is recommended that rehabilitation include soft engineering measures such as the re-sloping of the banks, erosion protection to stabilise soils, sediment trapping within the channel, revegetation of the impacted riparian area with the local thicket species, and the maintenance of an aquatic buffer area and ecological corridors. It was determined that the rehabilitation activities will have a low, temporary negative impact upon the habitat but to do nothing will have permanent negative consequences for aquatic biodiversity. The monitoring of the recommended activities will provide valuable on-site guidance and determine the level of success of rehabilitation.

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13 Annexure (Methodologies):

13.1 Wetland delineation and HGM type identification

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005a). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

Four specific wetland indicators were used in the detailed field delineation of wetlands, which include:

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

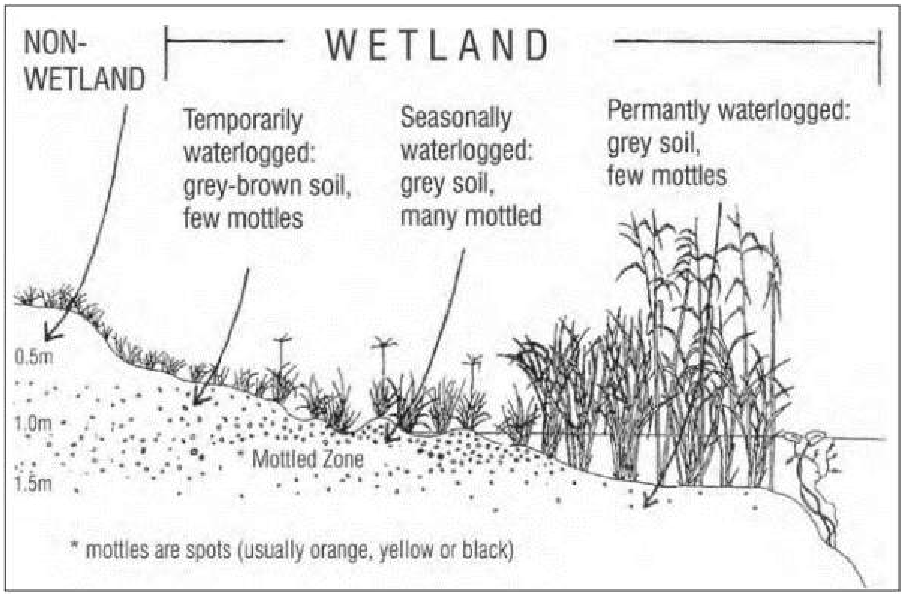

Figure12.1 : Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

The permanent, seasonal, and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table below)

Table12.1: Soil Wetness Indicators in the various wetland zones

Temporary Zone	Seasonal Zone	Permanent Zone
Minimal grey matrix (<10%)	Grey matrix (<10%)	Prominent grey matrix
Few high chroma mottles	Many low chroma mottles present	Few to no high chroma mottles
Short periods of saturation (less than three months per annum)	Significant periods of wetness (at least three months per annum)	Wetness all year round (possible sulphuric odour)

Table 12.2: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands

Vegetation	Temporary Wetness Zone	Seasonal Wetness Zone	Permanent Wetness Zone
Herbaceous	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants.
Woody	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).
Symbol	**Hydric Status**	**Description/Occurrence**	
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)	
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas	
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas	
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)	
D	Dryland species	Almost always grow in drylands	

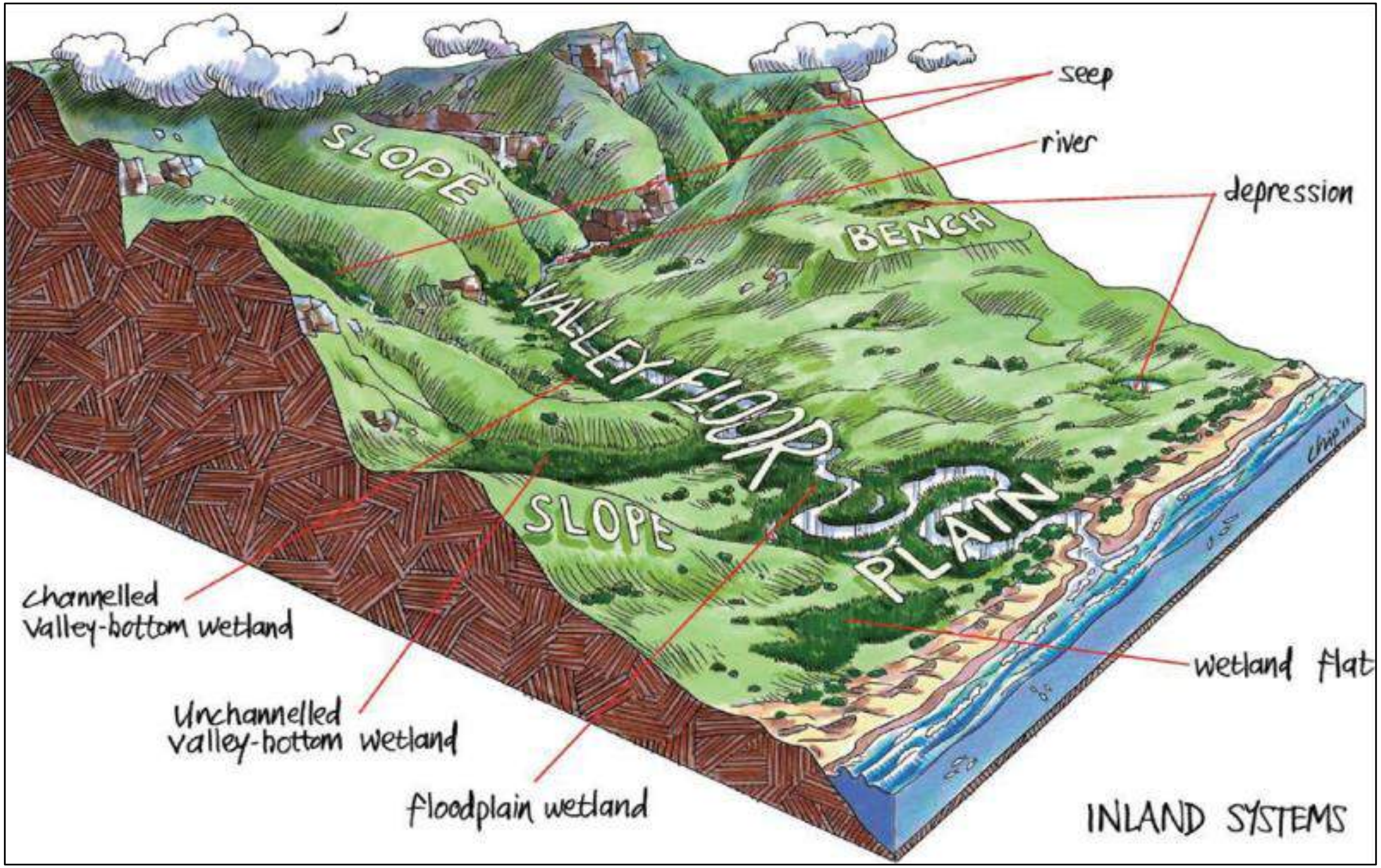

Figure 12.2: Illustration of wetland types and their typical landscape setting (From Ollis <u>et al.</u> 2013)

13.2 Delineation of Riparian Areas

Riparian zones are described as “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 areas” i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or channel, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas. Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or channel channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units), namely the: - Crest (hilltop); - Scarp (cliff); - Midslope (often a convex slope); - Footslope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or channel channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

Topography and recently deposited material associated with riparian areas The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised “macro-channels” which are typical of many of southern Africa’s eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

As with the delineation approach for wetlands, the field delineation method for riparian areas focuses on two main indicators of riparian zones: - **Vegetation Indicators**, and - **Topography** of the banks of the river or channel. Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or channel channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of "restrictive floodplain" within which one or more active channels flow. Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

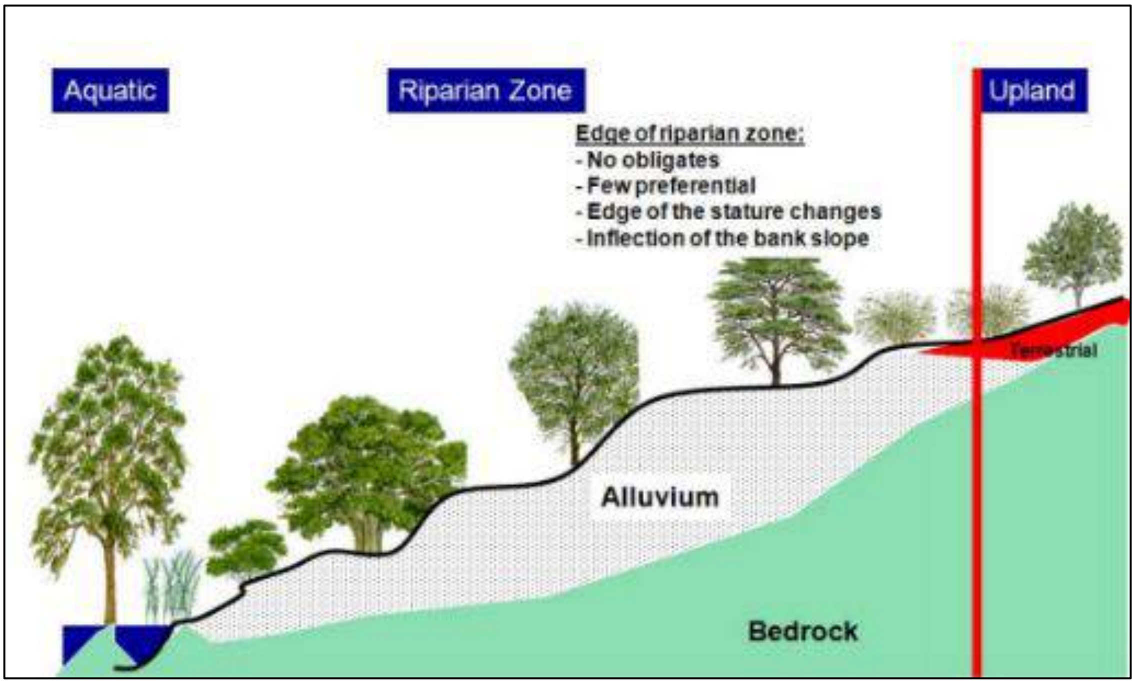

Figure 12.3: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river (DWAF 2008).

13.3 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively. Level 1 was utilised for the assessment.

WET-Health is a tool designed to assess the health or integrity of a wetland. Wetland health is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health in three separate modules.

Hydrology is defined in this context as the distribution and movement of water through a wetland and its soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the wetland.

Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact.

Table 12.4: Guideline for interpreting the magnitude of impacts on integrity (Macfarlane et al., 2008).

Impact Category	Description	Score
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 –
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable, but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from "unmodified/natural" (Category A) to "severe/complete deviation from natural" (Category F) as depicted in Table below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table 12.5. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

Impact Category	Description	Range	Pes Category
None	Unmodified, natural.	0 – 0.9	**A**
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 – 1.9	**B**
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	**C**
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	**D**
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9	**E**

Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 – 10	**F**

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

13.4 Wetland Functional Importance (Goods and Services)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table below) - that is, the benefits provided to people by the ecosystem.

Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits		Flood attenuation	The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
				Streamflow regulation	Sustaining streamflow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
				Carbon storage	The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance**[2]			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits		Provision of water for human use	The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
				Provision of harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
				Provision of cultivated foods	The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits		Cultural heritage	Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants
				Tourism and recreation	Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
				Education and research	Sites of value in the wetland for education or research

Table 12.6: Ecosystem services assessed by WET-Ecoservices

The steps involved in applying WET-EcoServices can be summarised as follows.

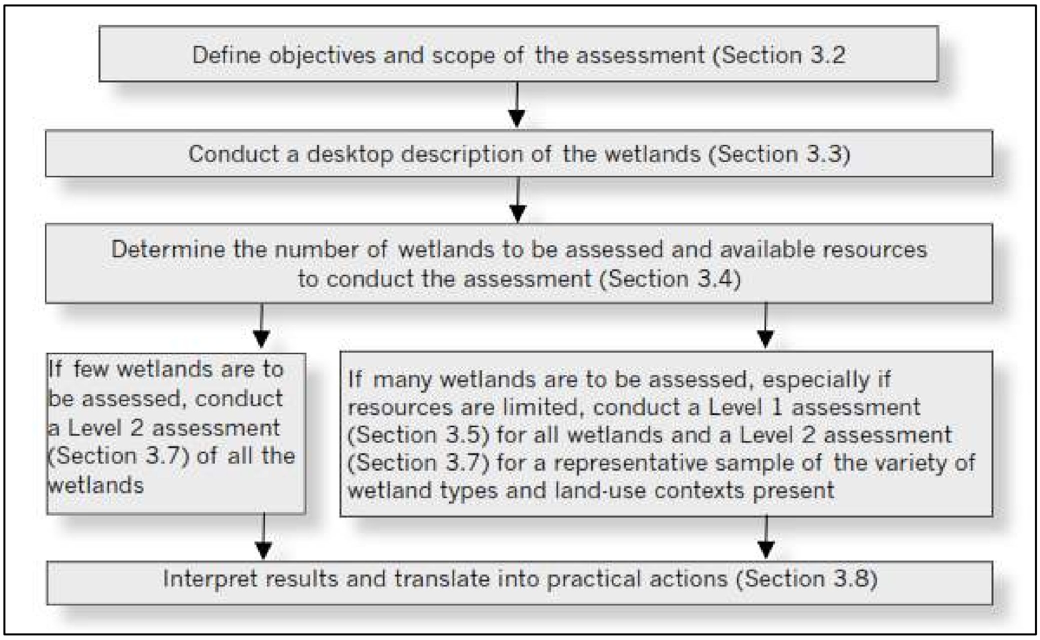

Figure 12.5: Steps required for Wet-EcoServices. The sections referred to within this figure relate back to the Wetland Management Series: Wet-Ecoservices. WRC Report TT 339/08

13.5 Ecological Importance & Sensitivity (EIS) - Wetlands

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table below. The scores are then placed into a category of very low, low, moderate, high and very high as shown in below.

Table 12.7: Example of scoring sheet for Ecological Importance and sensitivity

Ecological Importance And Sensitivity:			
Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation for site**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			
HYDROLOGICAL/FUNCTIONAL IMPORTANCE			
IMPORTANCE OF DIRECT HUMAN BENEFITS			
OVERALL IMPORTANCE			

Table 12.8: Category of score for the Ecological Importance and Sensitivity

Rating	Explanation
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

13.6 Present Ecological State (PES) – Riparian

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (in-stream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physic-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table below) according to the following metrics:

- Bed modification
- Flow modification
- Inundation
- Bank condition
- Riparian zone condition
- Water quality modification

This assessment was informed by (i) a site visit where potential impacts to each metric were assessed and evaluated and (ii) an understanding of the catchment feeding the river and landuses / activities that could have a detrimental impact on river ecosystems.

Table 12.9: The rating scale for each of the various metrics in the assessment

Rating Score	Impact Class	Description
0	**None**	*No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.*
0.5 - 1.0	**Low**	*The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.*
1.5 - 2.0	**Moderate**	*The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.*
2.5 - 3.0	**Large**	*The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.*
3.5 - 4.0	**Serious**	*The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.*
4.5 - 5.0	**Critical**	*The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.*

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table below).

Table 12.10: The habitat integrity PES categories

Habitat Integrity PES Category	Description
A: Natural	Unmodified, natural.
B: Good	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C: Fair	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D: Poor	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E: Seriously modified	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F: Critically modified	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.

13.7 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh et al., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table below).

Table 12.11: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided.

Ecological Importance and Sensitivity assessment (Rivers)		
Determinants		**Score (0-4)**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0,5
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0,0
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	0,5
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1,5
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1,0
	Refugia (4=Very high - 1=marginal/low)	1,5
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1,0
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	1,0
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2
MEDIAN OF DETERMINANTS		1,00
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**LOW, EC=D**

The scores assigned to the criteria in Table above were used to rate the overall EIS of each mapped unit according to Table below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane et al., 2008).

Table 12.12: The ratings associated with the assessment of the EIA for riparian areas

Rating	**Explanation**
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

13.8 Direct, Indirect and Cumulative Impacts Methodology

Direct, indirect and cumulative impacts should be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration**, wherein it will be indicated whether:
    - The lifetime of the impact will be of a very short duration (0-1 years) –a score of 1.
    - The lifetime of the impact will be of short duration (2-5 years) –a score of 2;
    - Medium term (5-15 years) – assigned a score of 3;
    - Long-term (> 15 years) – assigned a score of 4; or
    - Permanent – assigned a score of 5.
- The **magnitude**, quantified on a scale of 0-10, where:
    - 0 is small and will have no effect on the environment,
    - 2 is minor and will not result in an impact on processes,
    - 4 is low and will cause a slight impact on processes,
    - 6 is moderate and will result in processes continuing but in a modified way,
    - 8 is high (processes are altered to the extent that they temporarily cease), and
    - 10 is very high and results in complete destruction of patterns and processes.
- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1-5, where:
    - 1 is very improbable (probably will not happen),
    - 2 is improbable (some possibility, but low likelihood),
    - 3 is probable (distinct possibility),
    - 4 is highly likely (most likely) and;
    - 5 is definite (impact will occur regardless of any prevention measures).
- The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high;
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources; and
- The degree to which the impact can be mitigated.
- The significance is calculated by combining the criteria in the following formula, **S = (E+D+M) P**:
    - S = significance weighting
    - E = extent

- D = duration
- M = magnitude
- P = probability

- The significance weightings for each potential impact are as follows:
  - <30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop the area),
  - 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
  - >60 points: High (i.e. where the impact must have an influence on the decision process to develop the area).