PROJECT PROPONENT	**ANGLO AMERICAN GAIA PROJECT**
DATE	**FEBRUARY 2023**
DOCUMENT TITLE	**BIODIVERSITY SPECIALIST REPORT FOR A SOLAR PV PROJECT, UNKI MINE, SHURUGWI.**
EMA PROJECT NUMBER	**15177**

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EXECUTIVE SUMMARY

This biodiversity report is intended to form part of an overall environmental and social impact assessment for a 30-52 MWac solar PV installation within the Unki Mine claim area on the Great Dyke south of Shurugwi town. The objectives of the project are to reduce the mine's dependence on the currently unreliable grid power supply and to develop an alternative source of energy in keeping with Anglo American's aim to be carbon neutral by 2040.

After a preliminary screening exercise by Zutari with input from Black Crystal and in discussion with the proponent (Anglo American) a site on an open grassland and seasonally inundated wetland was selected. Two alternatives for transmission line routes were also proposed. Field surveys took place in August 2022 and incorporated the proposed site, the surrounding area in roughly a 2-5km zone and the two line routes. The biodiversity team worked fairly closely together and recorded vegetation and flora, birds, and mammals. After considering possible impacts on hydrology of the wetland, combined with pressure from local communities who use the wetland as a livestock grazing area the site was re-located to an area of woodland adjacent to and west of the original site. Fieldwork data were supplemented by eDNA collections made by NatureMetrics in 2022.

<u>Summary of abiotic factors that influence the biodiversity of the area</u>

The Great Dyke is the main topographic and geological feature of the area and was formed from an intrusion of mafic and ultramafic rocks from the Pre-Cambrian age. This part of the Great Dyke has a characteristic boat shape with a high ridge to the east, the Chironde Hills that rise to 1537masl, and a lower western ridge that reaches 1300masl. Between the two is an upland flat-bottomed valley and area of seasonal wetland (vlei) that was the original site. The wetland drains southwards and ultimately enters the Umtebekwa river which is one of two main rivers in the area that arise north of the study site and flow south in parallel to join the Runde river sub catchment drainage system. The Umtebekwana river follows the eastern side of the range, joining with the western Umtebekwa river south of the study area.

The soils follow a regular catenary pattern: on the higher well drained positions the soil is fersiallitic, with moderately deep dark reddish brown sandy or granular clay loams formed from the norite and pyroxenite rocks. Further down the slope and in the valleys the soils grade into dark brown to black clay vertisols in the poorly drained vleis.

The Koppen-Gieger classification for the area is "BSh" = semi-arid sub-tropical hot climate. The project falls largely within Agro Ecological Region III that is characterised by a rainfall of 650-800 mm per annum with fairly severe dry spells within the rainy season, making it only suitable for semi intensive fodder or cash crops and livestock production. In the past the claim area was a wildlife and cattle ranch. Below average rainfall occurred 18 times in the period from 1920 to 2000 and severe drought occurs every 15-20 years. Because of the hilly topography the area around Shurugwi is relatively cool, with a mean minimum temperature of 4.5 ºC in July and a mean maximum of 28.3 ºC in October.

The prevailing wind direction is from the east south east, reaching speeds of >28kpH in the hot dry months before the rains. The period of highest solar energy is late September to early December, prior to the rains, reaching a peak of 7.5 kWh in mid-October. The lowest solar energy of 4.9 kWh occurs mid-winter in June.

Vegetation and Flora

The vegetation was surveyed using a plotless sampling method and standard cover abundance estimates. Sample sites were selected so as to cover the most typical example of each type. Tree volume was measured in two woodland plots and the Acacia grassland.

Associated with the diverse geology and topography, Shurugwi is a meeting point for three main vegetation types: *Brachystegia spiciformis – Julbernardia globiflora* (miombo) woodland, *Acacia* tree savanna and *Terminalia sericea* tree savanna. In the study area these types are further subdivided into:

- *Brachystegia glaucescens* woodland on rocky hill tops, outcrops and hill slopes on norite and pyroxenite.
- *Brachystegia spiciformis – Julbernardia globiflora* woodland on the western side of the study area.
- Brachystegia spiciformis ecotonal woodland on the lower slopes of the Chironde range
- *Terminalia-Combretum-Acacia* shrubland on incipient drainage lines and bordering the edges of the valley
- *Acacia*[1] open grassland in the drier parts of the valley
- Wetland and seasonally inundated grassland in the centre of the valley.

A wetland is defined here as areas with waterlogged or saturated soils dominated by emergent vegetation i.e., plants with their roots in water but the rest of the plant is aerial e.g., sedges and grasses. Water may be static or flowing.

Common grass species are *Cynodon dactylon, Sporobolus pyramidalis, Bothriochloa inscuplta, Eragrostis heteromera* and *Melinis repens*. At the time of the site visit in August there was no visible water and the clay soils had dried out with deep cracks. The grassland has been severely over grazed and in the centre of the area there are deep erosion channels indicating recent high intensity fast water flows, caused by discharge from the upstream tailings and return water dams and episodes of heavy rainfall. In drier sections the grassland has been invaded by *Vachellia (Acacia) polyacantha*, *V. rehmanniana, V.nilotica* and *V.karroo* with occasional *Piliostigma thonningii*, *Flueggea virosa* and *Ziziphus mucronata* shrubs. The presence of distinct even sized (aged) cohorts of *V.polyacantha* indicates that the wetland is drying out in a series of episodic events.

The wetland meets the criteria of a Significant Biodiversity Feature (SBF) as it is part of the Umtebekwa drainage system. The wetlands within the study site have been heavily impacted by severe grazing pressure, physical disturbance and surface water discharge from the mine. Wetland functioning has been compromised in all of the wetland HGM units. Three of the wetland units have moderate ecological importance and sensitivity, while the other HGM units are of low EIS. This is a reflection of the poor potential of the wetland habitat to support wetland biodiversity due to the desiccating effect of the eroded gullies and the homogenization of the habitat due to heavy grazing.

Seven plants of conservation interest that are either listed as a Specially Protected Species under the Parks and Wildlife Act 20:14 and are on the IUCN Red Data list were found in the area.

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[1] *Acacia* is used as a general term to describe what have now been renamed as *Vachellia* and *Senegalia*

Specially Protected Indigenous Plants and IUCN Red List Species

E=English, N=Ndebele, S=Shona,

Species	Growth Form	Common English Name and local names	IUCN Threat status	Habitat / Comments
Aloe excelsa and *Aloe zebrina*	Succulent	Aloe (E), Gavakava (S)	Not listed	Specially protected plants (Parks Act). Miombo woodland
Orbea caudata subsp *rhodesiaca*	Stapeliad succulent	Stapeliad	Critically Endangered although taxonomy is very complex so probably LR	Small isolate populations, threatened by collectors and habitat loss. Not a specially protected species
Cyrtorchis praetermissa	epiphytic orchid	Tree orchid (E)	Not listed	Specially protected (Parks Act) Miombo woodland
Gloriosa superba	Geophyte	Flame Lily (E) Jongwe (S)	Not listed	Specially protected plants (Parks Act) Miombo woodland
Dalbergia melanoxylon	Shrub or tree	Blackwood dalbergia, Zebrawood (E)	Lower Risk near threatened	Mixed woodland, thickets, on rocky outcrops or termite mounds. Very occasional.
Pterocarpus angolensis	Tree	Bloodwood, Mukwa (E), Mubvamaropa, Umvagazi (N)	Lower Risk near threatened	Miombo woodland. Occasional. Most of the trees have been felled in the past.

The only EMA[2] listed invasive alien plant species was the woody shrub *Lantana camara.*

Carbon value

The woodland on the project site has an estimated value of 38,680 tonnes of CO_2 stored in the biomass. Assuming a project life span of 25 years, the amount of CO2 that would be sequestered by the woodlands is 91,071 tonnes, giving the woodlands a total value of approximately 129,751 tonnes of CO2. This value clearly needs to be taken into account when evaluating the cost/benefit analysis of the project.

[2] Environmental Management Act
Fifth Schedule (Sections 72 and 118) Part I

Wild Fauna

The diverse vegetation in the area provides a variety of habitats for wild fauna, ranging from closed canopy tall woodland trees on the hills to open grassland bordered with thorny species to a seasonally inundated wetland.

Birds were recorded using binoculars and identifying calls along walked transects and at a fixed point with supplementary observations as the team was travelling around the area.

The project and its immediate surrounding area is not classified as an Important Bird Area (IBA) but some of the avifauna have locally restricted habitat ranges. Using the IBA global criteria some of the bird species fall under Category A3: Biome-restricted assemblages[3] and within this, subdivision A10- Zambezian biome (Fishpool and Evans, 2001). Species which are listed in the Zambezian biome that have been recorded in and around the site are Rackettailed Roller, Kurrichane Thrush, Miombo Rock Thrush, Boulder Chat, Stierling's Wren Warbler, Eastern Miombo Sunbird and more A10 species are likely to occur there.

The August 2022 dry season survey recorded 105 species and combined with previous records a total of 168 species potentially occupy the study area and immediate surroundings. Of these, nine are Palaearctic migrants and 15 are Intra African migrants, 12 of which breed in Zimbabwe. The eDNA data collected by NatureMetrics did not add any species to the overall list, apart from Southern Boubou (*Laniarius ferrugineus*) which must be viewed as an incorrectly identified sample since this species does not occur in Zimbabwe, where it is replaced by the ecologically similar Tropical Boubou (*Laniarius major*).

Five species are classed as Specially Protected under Parks and Wildlife Act (20:14) and three are globally red listed. The area is also home to quite a number of water bird and migratory species.

Specially Protected and Red Data List Bird Species
E=English, N=Ndebele, S=Shona,

Species Name	Common English Name and local names	IUCN Threat status (Red List 2020)	Habitat / Comments
Terathopius ecaudatus	Bateleur (E) Chapungu (S)	Endangered	Specially protected (Parks Act); vulnerable to poisoning as it is one of the first birds to spot carcasses; numbers are declining throughout its range; Nests in large trees.
Polemaetus bellicosus	Martial Eagle (E) Chinyamudzura (S)	Endangered	Specially protected (Parks Act). Nests in large trees on hillsides. Recorded in wet and dry season surveys so clearly resident.
Circaetus pectoralis	Black chested Snake Eagle (E) Gondo (S)	Not listed	Specially protected (Parks Act). Grassland

[3] A group of species whose distributions are largely or wholly confined to one biome

Species Name	Common English Name and local names	IUCN Threat status (Red List 2020)	Habitat / Comments
Circaetus cinereus	Brown Snake Eagle (E) Gondo (S)	Not listed	Specially protected (Parks Act). Woodland
Aquila wahlbergii	Wahlberg's Eagle (E) Gondo (S)	Not listed	Specially protected (Parks Act). Migrant species. Woodland
Aquila (Hieraaetus) spilogaster	African Hawk Eagle (E) Gondo (S)	Not listed	Specially protected (Parks Act). Woodland
Scopus umbretta	Hamerkop (E), Tegwaan(N)	Not listed	Riparian species
Bucorvus leadbeateri	Southern ground hornbill (E) Dendera (S)	Vulnerable	Specially protected (Parks Act) Nests in large hollow trees.

Two invasive alien bird species were recorded, Common Myna and House Sparrow.

The mammals were surveyed by walking transects through the study area and recording spoor as well as systematic live trapping in the main habitats. A total of 86 mammal species (excluding bats) were identified as possibly occurring in the site. During the site visit 17 species were confirmed as present. An earlier study identified 18 species present. The total combined number of species confirmed in the area during the August 2022 field work was 24. eDNA data collected by NatureMetrics in 2022 added one further species to the list, namely Vervet Monkey (*Chlorocebus pygerythrus*).

Out of the 24 mammal species confirmed, two were identified as species of conservation concern on the IUCN Red Data list. Ground Pangolin is rare but has a widespread distribution and may occur in the area:

Specially Protected and Red Data List Mammal Species

E=English, N=Ndebele, S=Shona,

Species Name	Common English Name and local names	IUCN Threat status (Red List 2021)	Habitat / Comments
Smutsia (Manis) temminckii	Ground Pangolin (E) Haka (S) Inkakha (N)	Vulnerable	Rare. Threatened by habitat loss, poaching and illegal trade. Specially Protected Species (Parks Act). Used for ceremonial presentations to chiefs. They are also regularly electrocuted by lower strands of electric fences in areas where these occur.
Aonyx capensis	Cape Clawless Otter (E) Mbiti (S) Intini (N)	Near Threatened	Widespread in rivers dams. Threatened by pollution of water, loss of habitat, loss of food sources and conflict with humans
Panthera pardus	Leopard (E) Mbada (S)	Vulnerable	Solitary and elusive species. Threatened by habitat fragmentation,

	Ingwe (N)		reduced prey base, illegal skin trade, and retributive hunting for killing livestock.

The herpetofauna field survey has not yet taken place and will be a later addendum to this report. Desk top research has revealed that 44 reptiles and 10 frogs are recorded from the general area and are likely to occur on the site. eDNA data collected by NatureMetrics revealed the presence of one reptile, Serrated Hinged Terrapin (*Pelusios sinuatus*), and five amphibians, namely Guttural Toad (*Sclerophrys gutturalis*), Eastern Flat-backed Toad (*Sclerophrys pusilla*), Natal Puddle Frog (*Phrynobatrachus natalensis*), African Clawed Frog (*Xenopus laevis*) and Müller's Platanna (*Xenopus muelleri*).

Number of reptile and frog species from museum collections

Group	Number of species
Tortoises	2
Snakes	30
Lizards	11
Geckoes	1
Amphibians (frogs)	10

To date no endemic reptile or amphibian species have been recorded. All the currently known species are categorised as Least Concern on the IUCN Red Data list but this may change once the results of the wet season survey are known. The African Rock Python is the only Specially Protected species under the Parks Act. The eDNA data collected by NatureMetrics failed to detect any endemic or threatened reptiles.

Aquatic and Riparian Environment

The main drainage features are the Umtebekwa river flowing south from Lucilla Poort dam along the western edge of the claim area, and the parallel Umtebekwana river on east of the claim area. The Chironde Hills act as a watershed and several small ephemeral streams drain off east to the Umtebekwana river and west into an upland seasonal wetland (vlei) from the hills. Both rivers are outside the study area but part of the Umtebekwa is within the greater sphere of influence. The rivers and the wetlands feeding into them are an important resource for both wildlife, livestock and people and are therefore a Priority Ecosystem Service (PES).

As the solar PV site was re-located off the seasonal wetland the direct negative impact on the downstream aquatic environment has therefore been considerably reduced.

Water physio chemistry

Detailed baseline surveys of both rivers upstream and downstream of Unki mine were undertaken in 2019 and 2020 by Nhiwatiwa et al (2020) and the monitoring is continuing. Their results showed that total dissolved solids, chlorides, sulphates, nitrates, ammonia, fluoride, sodium, magnesium, manganese, copper, zinc and iron were lower than the WHO surface water guidelines. The widespread gold panning in both river catchments resulted in mercury, arsenic and free cyanide detected in the Umtebekwana river and free cyanide in the Umtebekwa river. The report compared the sampling results of 11 elements listed under the South African Target Water Quality Guidelines for Aquatic Ecosystems and found that cadmium, chromium, copper, free cyanide, mercury and zinc greatly exceeded the recommended limits. These metals are toxic and carcinogenic and can bioaccumulate, making them a serious threat to environmental and public health. It is recommended that Unki Mine undertake regular systematic monitoring of water quality in both rivers in order to detect and separate those changes that are due to the mine's activities and those that come from external influences.

Aquatic Invertebrate Diversity

The Umtebekwa river had higher habitat scores and generally high SASS average scores per taxon than the Umtebekwana river. The latter river is polluted by sediment from stream bank cultivation, acid mine drainage, chrome mining and gold panning. Both rivers contained *Planorbidae* snails that are the intermediate hosts for the bilharzia parasite. The Umtebekwa river was ecologically healthy just below Lucillia Poort dam but this decreased moving downstream with increasing human activities and the macro invertebrate fauna changed from being dominated by pollution sensitive taxa such as *Libellulidae, Coenagrionidae and Hydrocarina* to pollution tolerant taxa: *Planorbidae, Chironomidae, Oligochaeta, Notonectidae, Culicidae and Muscidae.*

Aquatic Vertebrate Diversity

The August 2022 field work recorded tadpoles of various ages from a species of *Xenopus laevis* (platanna) and a species of *Bufo* (toad) in shallow pools in the small stream south of the wetland. This coupled with the presence of adult dragonflies (*Aeshnidae*) and whirligig beetles (*Gyrinidae*) indicates that the ecological health of this stretch of the stream is good. eDNA collected by NatureMetrics in 2022 revealed the presence of numerous macroinvertebrates, which were identified to family level, namely Narrow-winged Damselflies (Coenagrionidae), Backswimmers (Notonectidae), Creeping Water Bugs (Naucoridae), Pygmy Water Boatmen (Micronectidae), Giant Water Bugs (Belostomatidae), Prong-gilled Mayflies (Leptophlebiidae), Small Mayflies (Baetidae), Black Flies (Simuliidae), Non-biting Midges (Chironomidae), Whirligig Beetles (Gyrinidae) and Predaceous Diving Beetles (Dytiscidae).

The Nhiwatiwa report (2020) recorded 12 species of fish in the two river systems, the most common being *Oreochromis mossambicus* (Mozambique tilapia), *Enteromius trimaculatus* (three spot barb), catfish (*Clarias gariepinus*) and *Serranochromis robustus* (yellow bellied bream). Two species of eel *Anguilla mossambicus* and *Anguilla bengalensis labiata* and the common invasive largemouth bass (*Micropterus salmoides*) were also found. The report noted that all fish species in both rivers were very small in size due to illegal netting with mosquito nets and that this is one of the major threats to the fish fauna. Nine fish taxa were identified through eDNA collections made by NatureMetrics in 2022, most of which were either identified to genus (e.g. *Enteromius, Labeo, Coptodon, Oreochromis, Serannochromis*) or family (Cyprinidae, Alestidae).

No fish species are regarded as Specially Protected in Zimbabwe but according to the IUCN Red List one species is vulnerable and several are near threatened. The remaining nine species that were recorded are of least concern.

IUCN Red List, Rare / Endangered and Specially Protected Indigenous Fish Species

E=English, S=Shona,

Species	Common Name/s	IUCN Threat status	Habitat / Comments
Serranochromis jallae	Yellow bellied bream (E) Nembwe (S)	Least Concern	Regionally threatened by overfishing

Anguilla bengalensis labiata, Anguilla mossambicus and possibly *A.mossambica and A.bicolor*	African mottled eel (E) Hunga (S)	Near threatened	Upstream migrations threatened by high weirs and dam walls.
Oreochromis mossambicus	Mozambique tilapia (E) Gwaya (S)	Vulnerable	Is thought to be able to survive in "dry" riverbeds through the flow of sub surface water. Threatened by destruction of habitat and hybridisation with Nile tilapia (*Oreochromis niloticus)*

Habitat Sensitivity, Level of Modification and Importance

Sensitive receptors are the wetland, riparian woodland and aquatic habitats and the miombo woodlands.

Main Habitat types and levels of modification

Habitat Type	IFC Classification	Level of Modification	Biodiversity Value
Aquatic and Wetland Habitats	Modified / Natural and Sensitive	Partially modified by construction of road, bridge and weir on the un named stream. Erosion channels in the wetland indicate recent changes in the hydrology with increased water flow and erosion. Siltation of stream bed. The open grassland / wetland habitat occurs in areas of black clay soils (hydric soils). The grassland is heavily grazed by cattle and grass species richness is low. Upper section of the wetland is highly modified by the presence of a tailings dam and a return water dam, mine housing, offices, construction camp and large quarry/borrow pit.	Fairly high although some sensitive species have probably been lost. The presence of fish, frogs and dragonflies indicate that aquatic ecosystems are still functional. High. The wetlands are hydrologically important acting as sponges, reducing the impact of heavy rains and flooding and acting as biofiltration systems. The PES is the provision of clean fresh water to wildlife and downstream communities. **This habitat meets the AA criteria for a Significant Biodiversity Feature (SBF)**[4]

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Natural habitat, of a pristine or degraded condition which supports biodiversity, ecological processes and/or ecosystem services.

Habitat Type	IFC Classification	Level of Modification	Biodiversity Value
a) Riparian Woodland on alluvial soils	Natural	Medium modification on the Umtebewana and Umtebekwa rivers, with some signs of past fires, trees have been felled, and invasion of *Lantana*. Stream bank cultivation in places and regular movement of livestock is destabilising the river banks.	Medium – High. The rivers are a very significant source of water for local communities, their livestock and to wild fauna
b) Miombo Woodland (Julbernardia-Brachystegia)	Natural	Medium modification. Outside the claim boundaries trees have been felled to make way for agricultural fields, cut for poles (housing) and firewood;	Medium. Type is widespread through project area but the patches of woodland provide spatial heterogeneity and niches for wild fauna. Large trees are important nesting sites for raptors (birds of prey). Woodlands also act as traps for rainfall, reducing run off and allowing slow drainage of underground water towards the central drainage line. The presence of epiphytic orchids, aloes and flame lilies increases the biodiversity value of these woodlands. The PES is the sequestration of significant volumes of carbon, nutrient re cycling and primary production.

IMPACT ANALYSIS

Construction activities will result in unavoidable, largely irreversible clearing of natural vegetation for panel installation, associated infrastructure (substation, battery storage, office) and the transmission line from the site to the mine. This will result in the direct physical effect of increased run off from rainfall, increased soil erosion that, without mitigation will lead to increased flooding, and a decreased recharge of wetlands. There will be a direct ecological effect with decreased biodiversity (floral and faunal habitats), decreased carbon storage and carbon sequestration and an indirect effect of increased spread of alien invasive species and weeds in disturbed areas. All of these impacts will negatively affect the services provided by the ecosystems. The significance of this direct, negative, long term impact is high and can only be partially mitigated.

The seasonal wetland and grasslands in the vicinity of the project site have already been negatively affected by severe overgrazing by livestock and erosion from surface water discharges are there are still some areas that are intact and functional, acting as water filters. This critical ecosystem service needs to be maintained and if possible enhanced. The woodlands bordering the wetland intercept the rainfall, slowing the surface runoff and allowing a slow infiltration of water to the sub surface ground water reservoir. This in turn is a source of water to the stream and ultimately the Umtebekwa river.

The proposed development will remove approximately 15ha of wetland habitat from the landscape. There is good potential to offset this loss through the rehabilitation of the degraded wetlands remaining in the study area. This will result in a no-net-loss, or even a net gain, of wetland functional area at the landscape level.

Additionally, the solar panels will generate a substantial volume of rainfall runoff. The discharge of runoff into the receiving environment will result in further soil erosion, channel scouring, sediment deposition and a decline in the quality of aquatic habitats extending several kilometers downstream. It is of utmost importance that stormwater be properly attenuated prior to discharge into the receiving environment. The vertic soils are extremely sensitive to soil erosion. Point source discharge into the wetland is, therefore, to be avoided.

The value in the degraded wetlands is not in their current state, but in their potential to be rehabilitated at a future date and the opportunity to restore lost wetland functioning and biodiversity to the landscape. HGM K should be buffered from the development. It is in good condition, and this should be maintained

As a consequence of the vegetation clearance there will be a loss of foraging and breeding habitat, increased habitat fragmentation, loss of habitat connectivity for birds, mammals, reptiles and amphibians. The direct negative impact is of medium significance and can be partially mitigated but is cumulative considering the increasing loss of woodlands in the surrounding area.

Actions that should be done in the pre-construction phase in order to mitigate the very significant impacts that will occur during construction phase are:

- Locate all specially protected plants within the site prior to any rescue and re-locations
- Identify suitable safe areas off site for the plants to be moved into
- A comprehensive check for active raptor nests and if any are found, the birds are left undisturbed until the chicks have fledged.

Large birds such as eagles, vultures, storks and cranes can be electrocuted if they fly too close to transmission lines or if they perch on the conductors. Birds may also collide with the lines when flying at night or on misty and rainy days. Some of these birds are regional migrants, so the while the loss may be local, the impact can be more widespread and is therefore significant. Mitigation measures should be implemented while the line is being constructed as retro-fitting is difficult.

The impacts to mammals and reptiles are of medium significance and can be mitigated by adjusting the height of the perimeter fence above ground allowing the smaller animals to move underneath and reducing artificial lighting at night.

Frogs have moist skins and are vulnerable to chemical pollution as well as a loss of breeding habitat. Mitigation measures include the protection of the wetland and prevention of run off from any fuel storage, batteries and other sources of chemicals

The aquatic environment in the stream immediately below the site is potentially vulnerable to changes in water flow, siltation, chemical run off but these impacts should be mitigated with appropriate management and the residual impact should not be significant.

The report concludes that the project is very commendable in that it aims reduce the reliance on grid power derived from a combination of hydroelectric and coal fired thermal sources. Some of the negative impacts of the project are unavoidable and the losses need to be weighed against the gain. It is recommended that the solar PV project environmental management programme closely aligns with that of Unki Mine to ensure there is a synergy of action and positive outcomes.

1 INTRODUCTION

1.1 THE PROJECT PROPONENT

Anglo American's (AA's) core business is the mining of copper, diamonds, platinum, iron ore, coal, polyhalite, nickel, manganese and the processing of these minerals into products demanded by the market. AA is a global market leader in mining and processing of these raw materials. AA has initiated a strategic objective to be carbon neutral by 2040. To achieve this, AA mines need to produce sufficient renewable energy to meet their energy demands. AA has already secured 100% renewable electricity supply for all its operations in South America, resulting in 56% of the AA global grid supply expected to be sourced from renewables by 2023. In Zimbabwe, while there is an abundance of renewable energy sources such as solar and to a lesser extent, wind, there is limited renewable infrastructure to harness it. As AA progresses towards its 2040 vision of carbon neutral operations, the AA Carbon Neutrality Group has made it its vision to supply a portion of AA mines in Southern Africa with renewable energy by 2030 through a combination of solar photovoltaic (PV), wind energy and energy storage known as the Southern African Regional Renewable Energy Programme (RREEP). SARERP consists of all the renewable energy facilities that AA will need to construct in close proximity to existing mines in order to achieve this objective. Approximately nineteen (19) projects have been identified, of which five (5) are being prioritised. One (1) of these priority projects is the Unki Solar PV Project (the Project) to be located at Unki Mine in Zimbabwe.

The Unki Mine is an underground platinum mine in the southern half of Zimbabwe's Great Dyke geological formation, widely recognised as the second-largest resource of platinum group metals (PGMs) in the world. The Mine is located approximately 23 km from Shurugwi of the Midlands Province in Zimbabwe. AA Platinum Limited (Anglo Platinum) wholly owns and operates the Unki Mine.

1.2 ENVIRONMENTAL CONSULTANTS

SLR Consulting (South Africa) (Pty) Limited (SLR), in collaboration with Black Crystal Consulting (Black Crystal), have been appointed by AA Integrated Permitting to undertake the Environmental and Social Impact Assessment (ESIA) for the Project. SLR is the lead consultant for the ESIA, while Black Crystal Consulting is the in-country partner. The ESIA is undertaken in line with Zimbabwean legislative requirements, specifically the Environmental Management Act (Chapter 20: 27) (Act No. 13 of 2002), and will further meet international lender standards, specifically the International Finance Corporation's (IFC's) Performance Standards (PS) and Equator Principles, in line with Good International Industry Practice (GIIP).

1.3 THIS REPORT

This specialist report is intended to feed into the main ESIA report for the proposed Unki Solar PV Project. It follows on from an earlier screening exercise by Zutari in which potential sites identified on satellite imagery were then ground truthed and assessed for their preliminary suitability by Black Crystal. The findings were later confirmed by a site visit by Zutari in mid-February 2022. The result of the screening exercise in discussion with the proponent identified a site south of the Unki tailings facility and return water dam in an area of seasonally wet open grassland (Site A) that drains southwards and via a stream ultimately into the Umtebekwa river.

A field survey of Site A, the surrounding area and the two options for powerlines was undertaken by the biodiversity team in August 2022. Following consultants' concerns about the impact of the project on wetland hydrology, the solar site was later moved into an area to the west of the wetland covering a patch of old growth miombo woodland and an extensive borrow pit. The pit is currently expanding providing material for the construction of dam walls on the mine's return water and tailings dam. The ultimate extent of the borrow pit is not known at this stage of report writing but according to the most recent project description (January 2023), it was agreed that material required to raise the TSF dam will be sourced on areas outside the Solar PV boundary.

This biodiversity report is therefore limited to a baseline description of the environment of the initial site (A) and surrounding area that fortunately included the new western site as that was only identified in late November after the August dry season field work.

As the proposed project is land based, the focus of this report is more on the terrestrial ecology than the aquatic ecology, although cognisance is paid to the functional importance of the wetland and downstream flow to other users.

The objective of the report is to provide an overview of key ecological and biodiversity aspects that will be impacted upon by the project and, conversely, those that may have an impact on the project itself.

The following specialists contributed to the study and compilation of this report:

Table 1-1: Specialist Team Members

NAME	QUALIFICATIONS	ORGANISATION and POSITION HELD	ROLE IN THIS PROJECT
S. L. Childes	BSc Hons Botany & Zoology, MSc Ecology	Senior Ecologist, Black Crystal Consulting	Co-ordinator and compiler of Biodiversity report, ecological and vegetation surveys, assist bird and mammal and herp surveys
M. Shadaya	BSc Hons Geography and Environmental Science	Junior Environmental Scientist, Black Crystal Consulting	Field Assistant: bird, plant and mammal surveys
A. Karimanzira	BSc Hons Environmental Science in Natural Resources Management, Post Graduate Diploma in Project Planning and Management	Project Officer, BirdLife Zimbabwe	Bird surveys and bird report
C. Mateke	BSc. Biology	Keeper of Mammalogy, Livingstone Museum, Zambia	Mammal survey & mammal specialist report

S. Broadley	BSc Hons Forestry and Wildlife	Herpetologist, Natural History Museum of Zimbabwe	Specialist Subconsultant: Reptiles and Amphibians
Doug McCulloch	MSc Conservation Biology	Associate Wetland Consultant	Specialist Wetland Consultant

1.4 ASSUMPTIONS AND LIMITATIONS

It is assumed that the project information provided by the client is accurate and that should the development proceed, it will not vary greatly from the original plan and description.

According to the project description, the activities associated with the Solar PV Project will not alter the approved mining and processing activities at the Unki Mine. Additionally, activities associated with the Project are separate to the existing operations.

The specialist reports were compiled using the material made available to Black Crystal Consulting by SLR, together with other readily available and publicly accessible material, including existing literature and studies. All efforts have been made to ensure that the information used as a basis for the assessment is accurate and up to date.

The specialists undertook a site visit and conducted surveys in the vicinity of the site and adjacent areas to provide more information for the assessment and to fill data gaps. This has resulted in a more accurate and up to date set of baseline data to use as the basis for the impact assessment. The specialists are of the opinion that the data used are relevant and valid at the time of reporting. However, field investigations have been restricted to a level of detail required to achieve the stated objectives of the work.

1.5 TERMS OF REFERENCE AND SCOPE OF WORK

The scope of work is restricted to the study area and the immediate area of influence (AoI) which varies according to the taxonomic group: 2km for flora and 5km for fauna.

The initial layout included two options for transmission lines (dark blue lines on **Figure 1-1**) and was the focus of the August 2023 dry season field work (Figure 1: PV panels are shown in bright blue and project boundary in light green). The site location was revised and moved westwards off the wetland into an area of miombo woodland see **Figure 1-2** below.

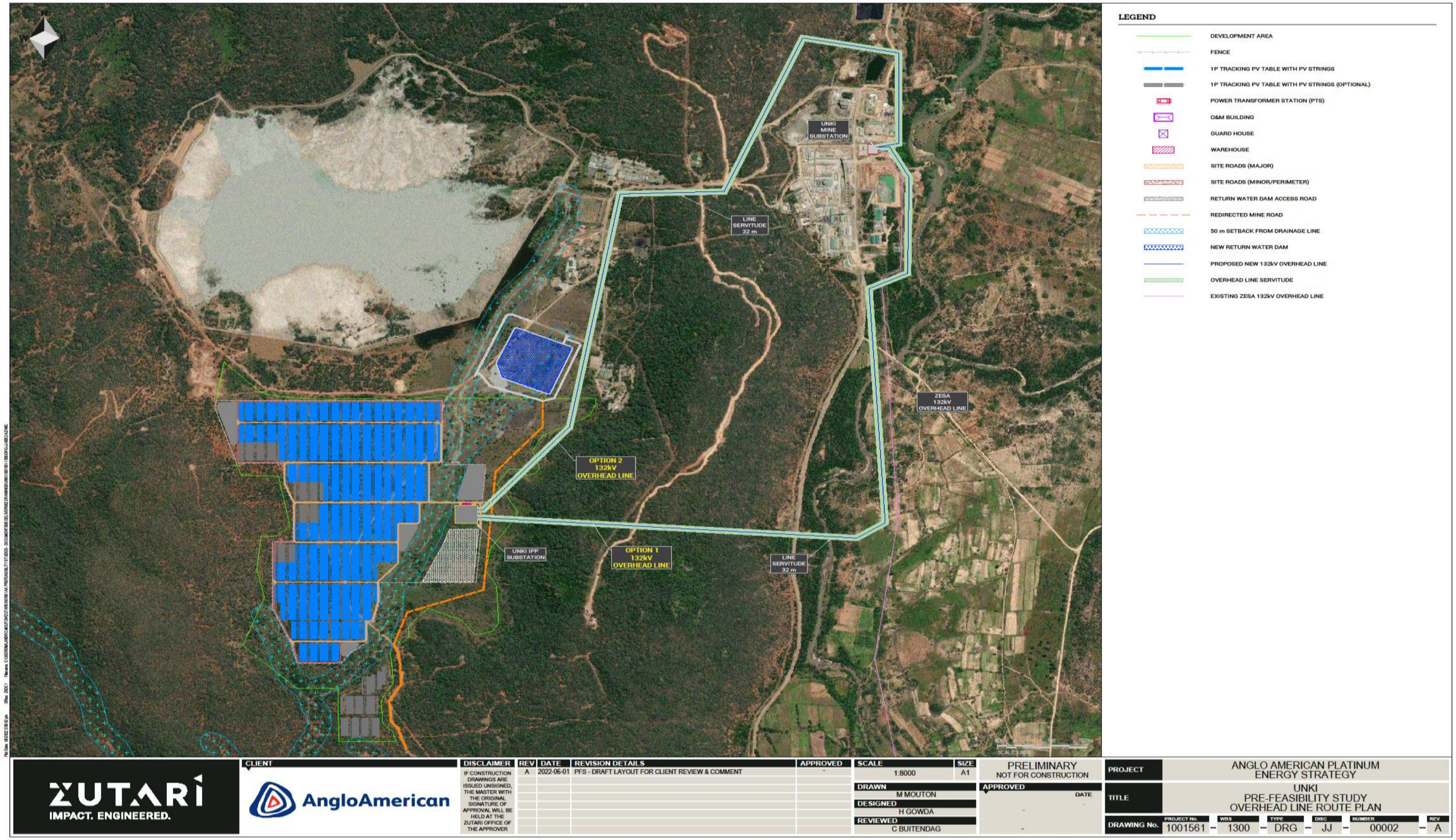


Figure 1-1: Originally proposed layout of panels, substation, battery storage and transmission line options. July 2022

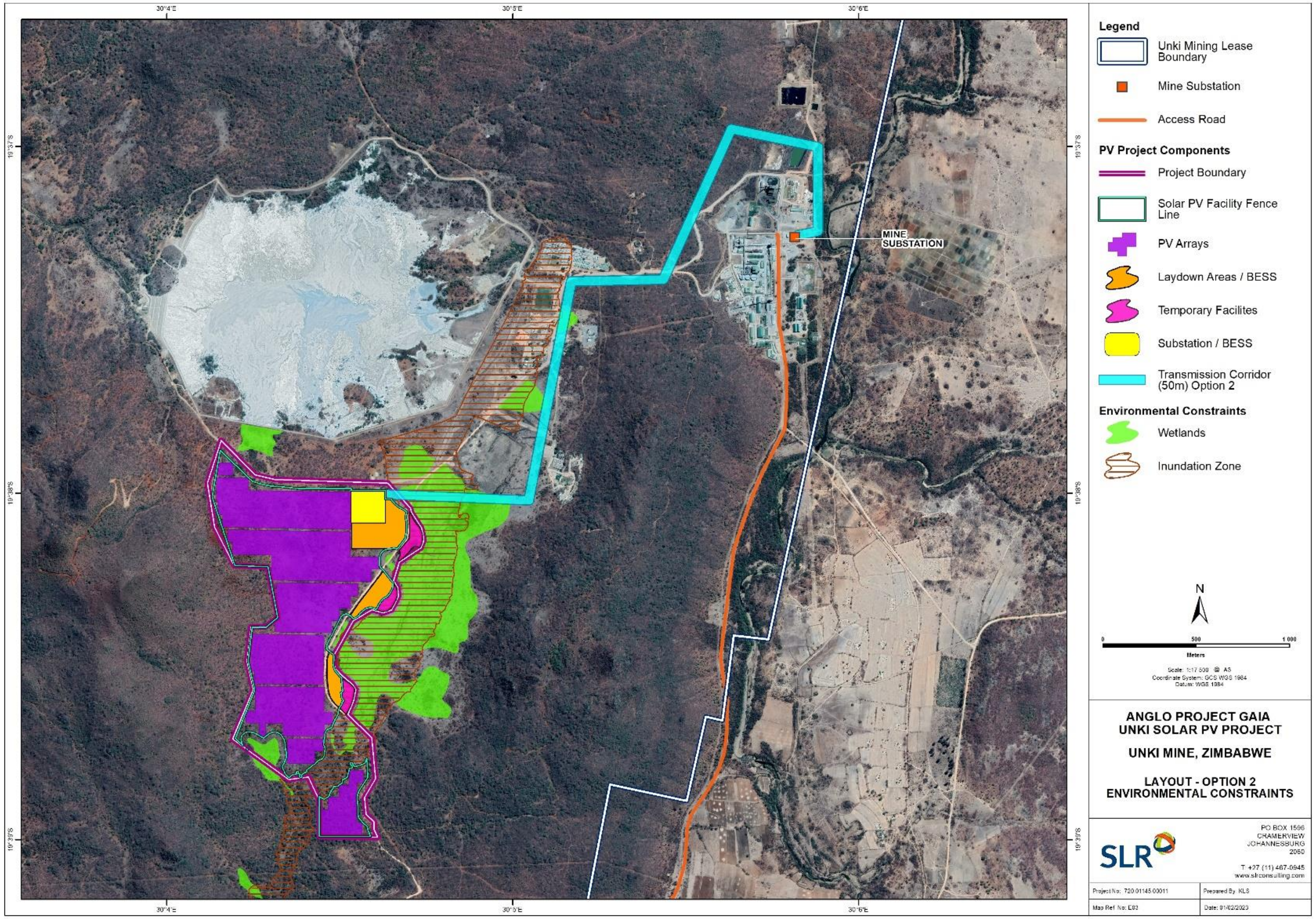


Figure 1-2: The revised site layout. January 2023

The detailed terms of reference for the specialist studies are given in **Appendix V** but in summary are:

- Compile a review and baseline description of terrestrial flora and fauna (birds, mammals and herpetofauna) including results of field surveys and an assessment of wetland and aquatic ecology.

- Focus on sensitive habitats and any rare, threatened or restricted range species.

- Assess the significance of all project-related impacts on flora and fauna and aquatic resources and recommend measures to mitigate any negative impacts, and the desirability and need for any biodiversity offsets.

1.6 ALTERNATIVES ASSESSMENT

The following alternatives were considered in the biodiversity part of the ESIA:

- Site layout alternatives:
  - Original layout (Layout Alternative 1)
  - Revised layout (Layout Alternative 2)
- Grid Infrastructure alternatives:
  - Transmission corridor Option 1 (southern line)
  - Transmission corridor Option 2 (northern line)

2 NATIONAL LEGISLATION, INTERNATIONAL STANDARDS AND GUIDELINES AND BEST PRACTICE

Details of relevant national legislation for the project are presented in a separate report and are not repeated here.

This biodiversity report forms part of the compliance with Zimbabwean Environmental Management Act and the International Finance Corporation (IFC) standards and guidelines. The objectives and scope below were summarised from the reference standard, Performance Standard 6.

2.1 PERFORMANCE STANDARD 6: BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES

The objectives for the standard are to:

- To protect and conserve biodiversity.
- To maintain the benefits from ecosystem services.
- To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

Scope of Application

Based on the risks and impacts identification and assessment process, the requirements of this Performance Standard are applied to projects:

- located in modified, natural, and critical habitats;
- that potentially impact on or are dependent on ecosystem services over which the client has direct management control or significant influence; or
- that include the production of living natural resources (e.g., agriculture, animal husbandry, fisheries, forestry).

The requirements of PS 6 are:

Biodiversity and Conservation

to identify areas of:

- Modified habitat that includes significant biodiversity value;
- Natural habitat composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified primary ecological functions and species composition;
- Critical habitat with high biodiversity value; or
- Legally protected and internationally recognised areas.

Address risks associated with invasive alien species, especially where deliberately introduced.

Management of Ecosystem Services

Identify priority services that are likely to be impacted by the project and likely to adversely affect communities, and on which the project is directly dependent for its operations.

Where avoidance of impacts is not possible develop and implement mitigation measures to maintain the value and functionality of priority ecosystem services.

2.2 AA ENVIRONMENTAL PERFORMANCE STANDARD: BIODIVERSITY 2022

The purpose of the Anglo American (AA) Biodiversity Standard is to "define the minimum requirements to maintain biodiversity in all phases of AA's operations to achieve a Net Positive Impact (NPI) and maximise contribution to biodiversity".

The objective of the standard is to "determine biodiversity and ecosystem service risks and implement a Mitigation Hierarchy through first avoid, minimising and then restoring potential adverse impacts. Where residual impacts on Significant Biodiversity Features (SBF) remain shall implement biodiversity offsets; where residual impacts remain to potential Priority Ecosystem Services (PES) shall engage affected stakeholders and implement programmes to maintain the benefits to the stakeholders".

Essentially the two performances standards, IFC PS6 and AA have the same objectives.

2.3 OTHER GUIDELINES AND BEST PRACTICES

The International Union for the Conservation of Nature (IUCN) 2021 guidelines for mitigating biodiversity impacts associated with solar and wind energy development are also referred to in this report (Bennun *et al.,* 2021).

3 PROJECT DESCRIPTION

The following information is summarised from information provided to Black Crystal by SLR in January 2023. The objectives of the Project are to:

- Achieve carbon neutrality at the Unki Mine in an effort to fully convert the AA Southern African operations to renewable energy;
- Achieve energy cost savings;
- Enhance security of electrical energy supply; and
- Enhance the livelihoods of local community members.

3.1 PROJECT LOCATION AND EXTENT

The Project is situated at Unki Mine, approximately 26 km south from Shurugwi town in the Midlands Province in Zimbabwe (see **Figure 3-1**). The area was previously commercial cattle and wildlife ranching land and is now part of the Tongogara Rural District Council land.

The proposed site is approximately 117 ha and has sufficient flat area available relative to other options considered in the earlier screening phases. The site is located within the Unki Mine Lease Area (UMLA) which is leased by the Mine from the Government of Zimbabwe. In addition, the site is strategically located in proximity to the existing Unki sub-station and has easy accessibility for transmission connections. Two transmission line routing options were considered and these transmission line alternatives form part of the Project extent. The preferred transmission line is the northern one, corridor 2.

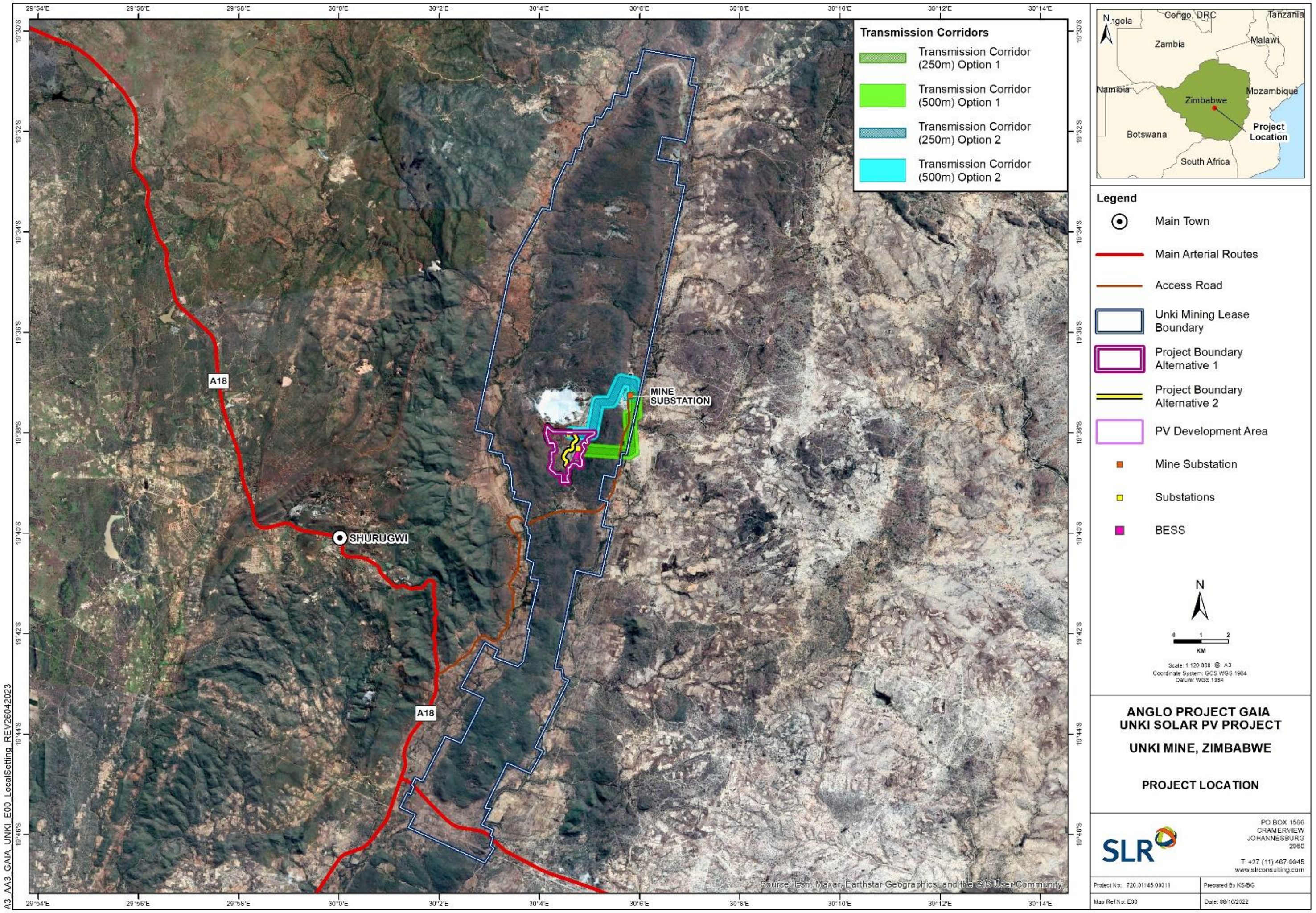


Figure 3-11: Site Locality and Transmission Corridor Options

3.2 OVERVIEW OF REQUIRED INFRASTRUCTURE

A detailed description of the project components and infrastructure is given in the main ESIA report and therefore not presented here. In summary the Project involves the construction of a 30- 52 MW alternating current solar PV facility Battery Electrical Storage System (BESS), transformer and substation. The key Project components are illustrated in **Figure 3-2** and the preferred layout shown in **Figure 3-3.**

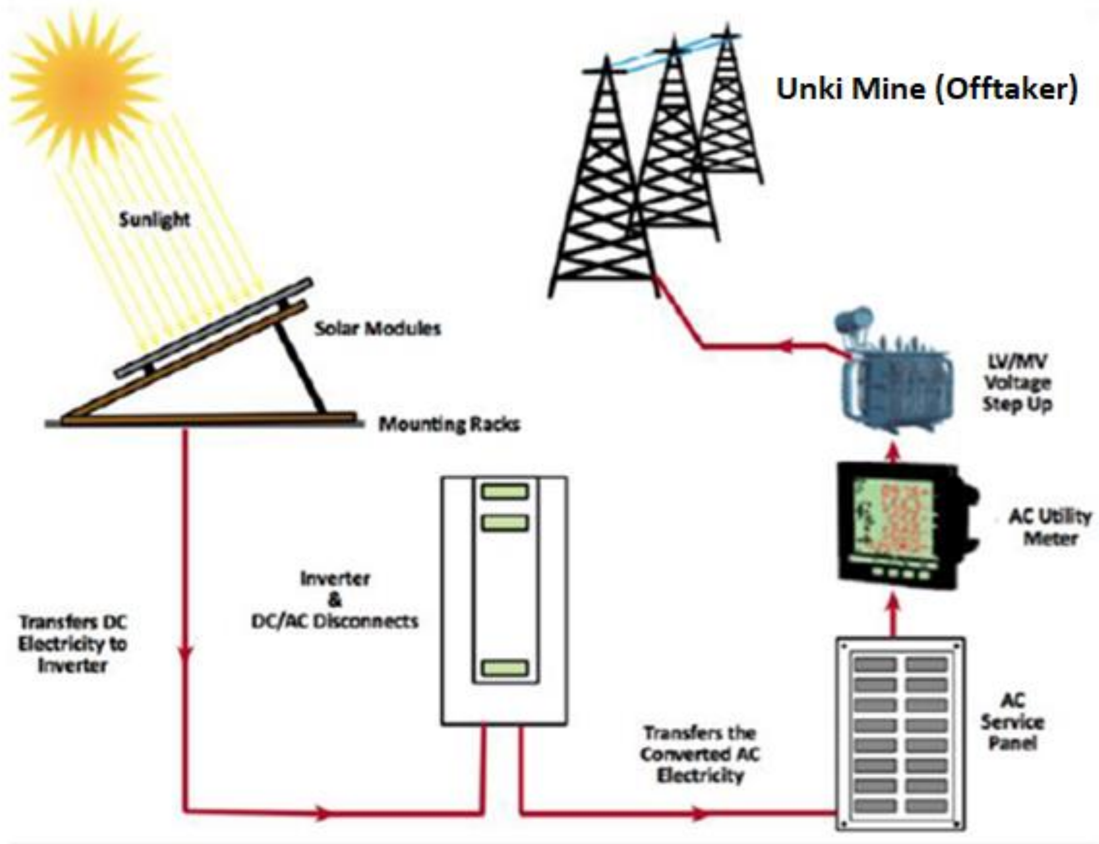


Figure 3-2: Generic Overview of a Solar PV Facility[5]

[5] *Source: International Finance Corporation. 2015. Utility-scale Solar Photovoltaic Power Plants. A Project Developer's Guide.*

Figure 3-3: Proposed Site Layout as per project description dated 20 January 2023

The Solar PV Facility will consist of the following components:

- PV cells, modules, arrays and mounting structures.
- Inverters, power transformer station, cabling, substation, transmission line and corridor.

Associated infrastructure will be:

- BESS, operation and maintenance buildings
- Construction camp, site offices and lay down areas
- Security structures (fencing, lighting)
- Roads - within the site and external access roads
- Stormwater infrastructure
- Water storage tanks

Services that will be required are:

- power supply
- water supply
- sewerage disposal system
- waste disposal systems
- transportation
- Labour: It is anticipated that about 130 people will be employed during construction phase.

3.3 PROJECT ACTIVITIES

The project description lists these activities for the construction of a PV facility

- Establishment of access roads
    - During the construction period, internal roads need to be established, however, these roads will only be temporary. Some permanent roads will need to be established for the construction, as well as for operation and will be gravel and/or tar-based. Existing roads will be used where possible.

- Site preparation
    - Vegetation would need to be cleared for the footprint of the infrastructure, as well as for the access roads to the site/internal roads and the laydown area, etc. Topsoil stripping from the construction of access roads and infrastructure would need to be stockpiled and used to rehabilitate areas of the construction footprint.

- Transportation of equipment and components to the site
    - The main components of the proposed facility would be transported by road to the site.
    - Excavators, graders, trucks, and compacting equipment would also need to be brought to the site.

- Establishment of workshops, temporary laydown areas and construction camps

  - Once all the equipment has been brought to the site a dedicated laydown and equipment camp will be established. Fuel for vehicles will most likely be stored on-site during construction; appropriate mitigation measures must be employed to ensure no pollution occurs as a result.
- Balance of System
  - The foundations for the PV panel array will either be excavated or by use of a ramming system for the support structure, which shall be dependent on the geotechnical condition of the ground. Concrete and aggregates would need to be brought to the site. Trenches would also need to be excavated for underground connection of the panels to the inverters and subsequently to the plant substation.
  - Site rehabilitation: Removal of all construction equipment from the site and rehabilitation of areas where reasonable and practical.
  - Several Heavy earth moving vehicles, mechanical equipment and light vehicles will be used during construction, reducing to two light vehicles during operation.

3.3.1 Hazardous Materials

Diesel and other fuels will be stored above ground in bunded bulk diesel tanks on site. 30 kl of diesel will be stored on site.

There will also be a hazardous materials area on site with the capacity of up to 2000 litres of a combination of greases, oils, fuels, chemicals and paint. This area will be ventilated and bunded.

The total volume of vanadyl sulphate electrolyte in this battery would be around 1200 m^3 with an equivalent of 1600 tonnes of Vanadium Pentoxide or 960 tonnes of pure Vanadium in the electrolyte.

3.3.2 Materials Management

The project requires a wide range of materials, namely:

- backfill materials or homogeneous materials of good mechanical quality (laterite, etc.);
- crushed gravel; sands, cement, bitumen.
- reinforcing steel for reinforced concrete structures or flat irons for formwork or mechanical fabrication; and
- wood, sheet metal for construction, mechanical fabrication and formwork.

3.4 EMISSIONS, DISCHARGES AND WASTES

Vehicular movement during construction will obviously result in considerable exhaust emissions.
During this phase, solid waste will mainly consist of vegetation material resulting from the clearing activity. Other types of solid waste will be wood from packaging, boxboards, expanded polystyrene and household waste.

During the operational phase (25 - 30 years), solid waste will mainly consist of general waste from the operational team. Other types of solid waste will come from the maintenance activity in case of failure of some components.

There will be a sewerage treatment system installed to serve the offices of the control building.

3.5 PROJECT TIMELINE

The Project will be carried out in the following phases:

- Development and Planning phase;
- Site preparation phase;
- Construction phase (12 – 18 months);
- Operational phase; and
- Decommissioning phase.

Activities to be undertaken during each of the phases will be described in detail in the ESIA**.**

3.6 SCHEDULE AND LIFE OF PROJECT

It is anticipated that after construction, the holder of the EC will own and operate the solar PV facility and associated infrastructure until decommissioning. The Project has an expected lifetime of 25 to 30 years. Should the Project need to be decommissioned at the end of this period, the owner of the facility would undertake the requisite applications for authorisation at that time.

4 METHODS

4.1 REVIEW OF EXISTING INFORMATION

The biodiversity assessment and ecological survey was based on interpretation of satellite imagery (Google Earth), reference to the Surveyor General of Zimbabwe topographical 1: 50,000 maps1921 C1, a recent soil report and maps compiled by F Mapanda (Black Crystal Consulting, 2022), coupled with ground truthing. The biodiversity reports by Childes (2008) prepared for the Impali Source Housing EIA and Unki Road Upgrade ESIA (Childes, 2010) and the Smelter EIA report (Ascon Africa, 2016) were also referred to. The Flora Zimbabwe website is a very useful source of botanical information but sadly only listed a few plants for the Shurugwi area, and the QDS plant list was for records made much further north of the site in the Kadoma and Gokwe region.

A comprehensive biodiversity baseline study was undertaken (Nhiwatiwa, Mhlanga, Dalu, Dondofema, 2020) in 2019 for Unki Mine that covered the claim area plus a 5 km buffer zone and included the wetland/grassland (Site A) and both the Umtebekwa and Umtebekwana rivers. The baseline report contains detailed checklists of flora, birds, mammals, some reptiles and aquatic vertebrates and invertebrates. A summary of results of the aquatic vertebrate, invertebrate and water quality analyses from five sites upstream and downstream of the mine and solar PV site is included in this report to supplement the findings of the terrestrial ecological survey.

Museum records of the herpetological collection in the Natural History Museum, Bulawayo were used for the basis of the reptile and amphibian checklists. Similarly, museum records provided background data for the mammal checklist.

4.2 STUDY RATIONALE

Biodiversity refers to the diversity of living organisms and the interactions between themselves and with the physical environment. Measuring and monitoring biodiversity gives an indication of the health of the environment and its resilience (ability to absorb impacts) and likelihood of recovery from disturbances.

The biodiversity of a particular environment can be extremely complex and detailed studies are time consuming. For this reason, ecologists select groups of organisms as indicators of biodiversity. These indicators are usually chosen for their ease of identification, their role in ecological processes (position in food chain) and their sensitivity to change. At a minimum, a biodiversity survey should include plants as the fundamental primary producers, a group of larger vertebrates as examples of the primary and secondary consumers. By surveying the producers and consumers, ecologists can establish the health of the ecosystems and the integrity of the ecological processes operating in the systems. In this biodiversity baseline study, the following taxa were selected: terrestrial flora and vegetation types which then describe the various habitat types, birds, mammals and herpetofauna as examples of higher vertebrates. In order to cover the seasonal range of biodiversity, both a wet season and dry season field visits are usually considered necessary in order to check on the rainy and dry season flora and the presence of migratory birds.

This report presents the results of the dry season field work undertaken on 18-22 August 2022 during which the main vegetation types, plant species and habitats were identified within the project area as originally defined. Mammal and bird surveys were undertaken simultaneously. Opportunistic records were made of other taxa as they were encountered. The presence of alien invasive species, and any endemic, rare or endangered species was noted.

The herpetofaunal survey and the wet season plant and bird surveys will be undertaken in late February 2023 and will be an addendum to the final ESIA report.

The field work focused on the wetland, the adjacent miombo woodland on the hills either side and the two options for transmission line routes. **Figure 4-1** below shows the tracks of the August 2022 surveys giving an idea of areas that were covered. The biodiversity team and cultural heritage expert generally worked fairly closely together in the field providing mutual assistance and discussing any interesting findings and observations.

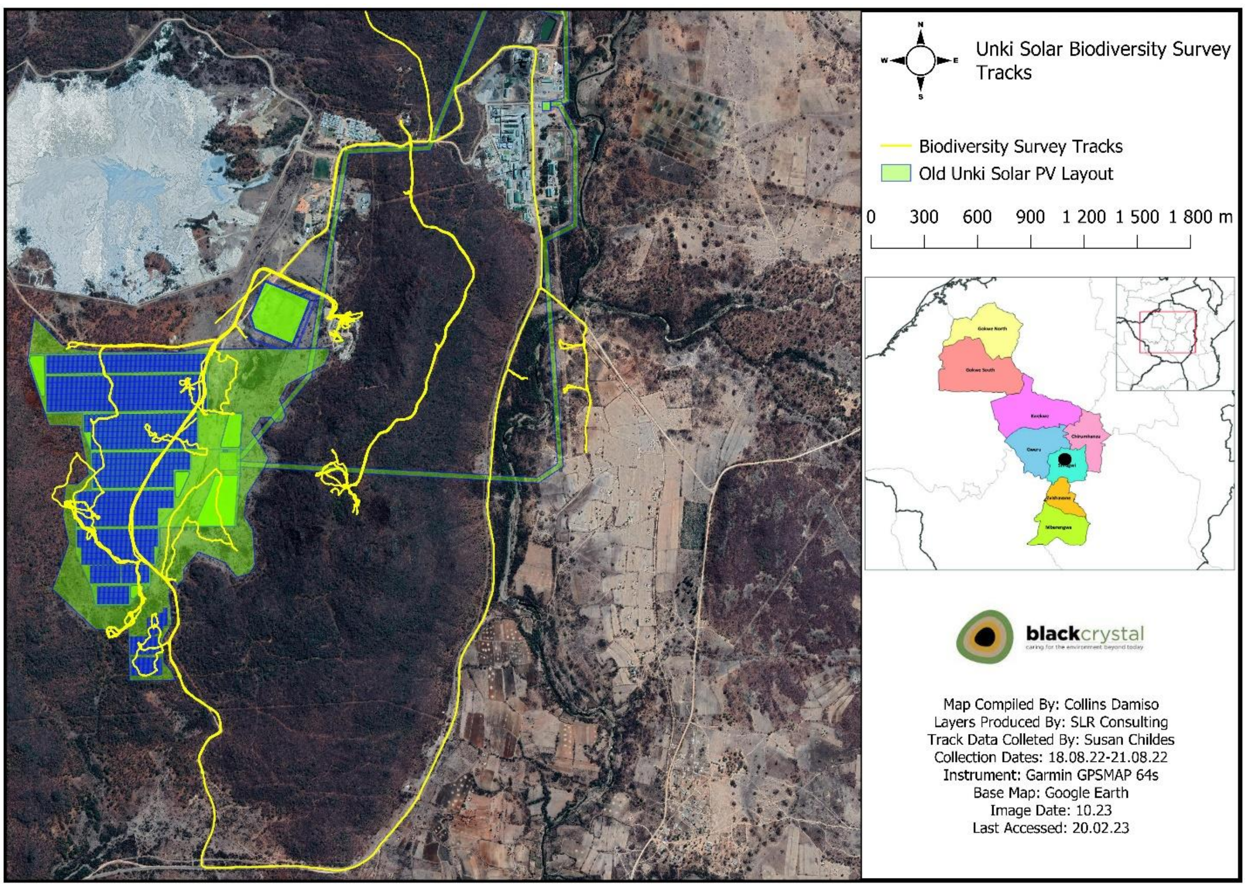


Figure 4-1 Survey tracks 18-21 August 2022 overlaid on original layout

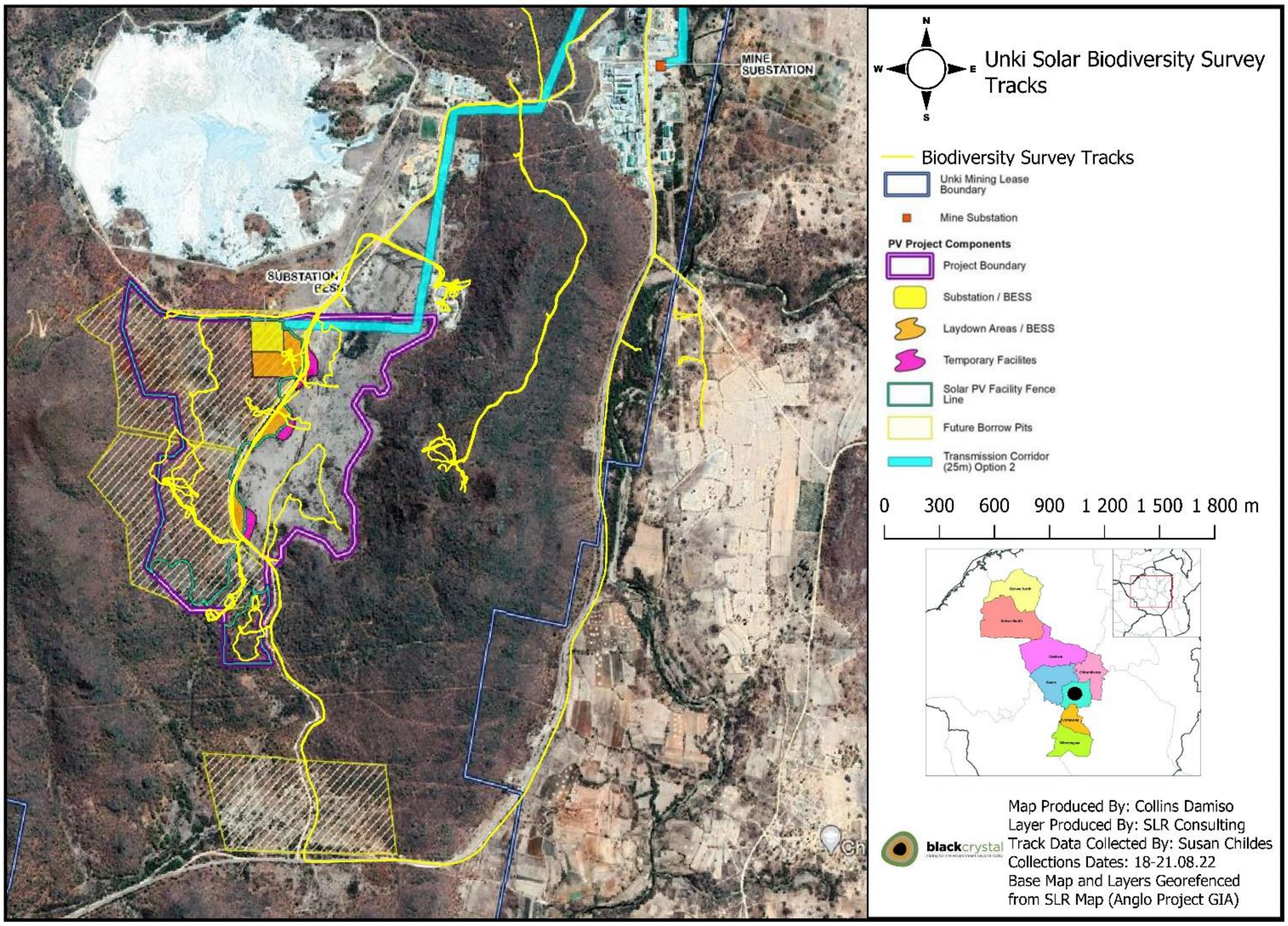


Figure 4-2: Survey tracks overlaid on location of new site.

4.3 FLORA, VEGETATION TYPES AND HABITATS

A plotless sampling procedure was undertaken to assess the species and habitats in the immediate area. The main tree species encountered were identified and listed together with some components of the shrub and herbaceous layers, including grasses where possible. For each woody species, the cover abundance was visually assessed using a modified Braun-Blanquet scale, please see **Table 4-1** below.

A Garmin 64S was used to record GPS coordinates, from a central location within the sample site, set to UTM Arc 1950**.** Each sample site was given a sample number and a photo taken of the typical vegetation of the site.

Plants were regarded as woody if they were included in “A List of Trees, Shrubs and Climbers Indigenous or Naturalized in Rhodesia” (Drummond, 1975).

Table 4-1: The Modified Braun-Blanquet Scale

Species frequency & estimated aerial cover	Braun-Blanquet symbol
Few, with small cover	+
Numerous, but less than 5% cover, or scattered with up to 5% cover	1
Any number with 5-25% cover	2
Any number with 25-50% cover	3
Any number with 50-75% cover	4
Any number with more than 75% cover	5

4.3.1 Carbon Values

In order to give an approximate indication of the Carbon storage value of the main vegetation types a series of belt transects were marked out randomly in typical examples of the main types. Transects were 100m long (measured by tape measure) and 2.8m wide (measured at right angles on either side from central tape measure with handheld rod of 1.4m length). At a fixed height of 1.4m above the ground the circumference of each tree trunk or branch (if multiple stems) was recorded and the height estimated using the 1.4m rod as an index. Woody plants that were less than 5cm circumference and less than 1m high were excluded. Tree heights were checked and agreed by 3 observers using the 1.4m rod as a gauge.

Stem volume = height x stem area (calculated from the circumference). Using dry wood density values for the dominant woody species extracted from Goldsmith and Carter (1992) the above ground biomass can then be estimated. Applying a regional standard value for root: shoot biomass of 0.54 in miombo woodlands (Chidumayo, 2013) the below ground biomass is calculated and the sum of biomass converted to tonnes of Carbon per hectare (tC/ha).

4.4 FAUNA

4.4.1 Birds

The Southern African Bird Atlas Project (SABAP) has contributed vastly to gathering information on the distribution, abundance and trends of birdlife in southern Africa. The SABAP data provides substantial information on species including distribution and trends in most areas. However, Shurugwi has not received much attention in collecting data for both SABAP 1 and 2 therefore could not be used to provide information on the avifauna that could occur in the study area. Therefore, the assessment was based on data collected during onsite surveys and a checklist compiled by BirdLife Zimbabwe with assistance from other team members.

The avifaunal survey methodology took into account the best practice guidelines for avifaunal impact studies at solar developments, compiled by BirdLife South Africa (BLSA) in 2017 (Jenkins et al. 2017), adapted for the specific situation.

On-site surveys were conducted at the study area in the following manner:

Four walked transects were identified within the study area covering all the major habitat types. Surveys were undertaken at the same time and in the same areas as plant and mammal and heritage surveys.
The observer recorded all species on both sides of the walked transect. The observer stopped at regular intervals to scan the environment with binoculars.

The following data were recorded:
- Date;
- Start time and end time;
- Estimated distance from transect (m);
- Wind direction;
- Wind strength (estimated Beaufort scale 1 - 7);
- Weather (sunny; cloudy; partly cloudy; rain; mist);
- Temperature (cold; mild; warm; hot);
- Species;
- Number of birds;
- Behaviour (flushed; flying-display; perched; perched-calling; perched-hunting; flying foraging; flying-commute; foraging on the ground.

Photo 4-1: A.Karimanzira and M.Shadaya undertaking bird survey, Unki Solar study area. August 2022.

All incidental sightings of priority species in and around the proposed study areas were also recorded. A natural water hole downstream of the wetland was identified as a focal point within the study area, and counted once in the course of 5 days.

4.4.2 **Mammals**

Relevant literature, including previous biodiversity reports and existing project information were reviewed. A field survey of the site and surrounding environment, including supporting infrastructure was conducted from 18th to 21st August 2022, covering all represented habitats.

During the survey Sherman live rodent traps and snap traps were used to assess the small terrestrial mammal diversity in the different habitats. Traps were set before sunset and checked in the early morning. The location of each trap was marked and recorded on GPS. A total of 35 traps were set over a period of 3 nights.

Photo 4-2: C.Mateke, A.Karimanzira and M.Shadaya preparing small mammal traps. Unki Solar study area, August 2023.

Photo 4-3: Mammologist C.Mateke concealing a Sherman trap in leaf litter. Unki Solar study area, August 2022.

In addition to trapping, each of the habitats were surveyed for mammal spoor and scat, direct observation and any other evidence of the presence of mammals. This was done by driving and walking randomly through the project area, including while setting and checking traps. Furthermore, a night drive using spot-lights was conducted to look for evidence of nocturnal mammals.

The terms of reference specifically excluded bats. As such, they were excluded from the checklist and the field survey. However, these are an important group of mammals and this project is expected to have a significant impact on the bats occurring in the project area, so they have been included in the impact assessment.

4.4.3 **Reptiles and Amphibians**

No literature has been published specifically for the area of Shurugwi/Unki mine, only a few reptiles and amphibians have been collected in the past during 1958, 1960 and 1972. The area has not been well studied or surveyed. Only those specimens collected during very short visits lasting a day or two are in the national collection in the Natural History Museum of Zimbabwe. The museum records provided the basis for the reptile and amphibian checklist.

A field survey is planned for the wet season in February 2023. eDNA data collected by NatureMetrics revealed the presence of one reptile, Serrated Hinged Terrapin (*Pelusios sinuatus*), and five amphibians, namely Guttural Toad (*Sclerophrys gutturalis*), Eastern Flat-backed Toad (*Sclerophrys pusilla*), Natal Puddle

Frog (*Phrynobatrachus natalensis*), African Clawed Frog (*Xenopus laevis*) and Müller's Platanna (*Xenopus muelleri*).

4.5 WETLANDS

The following approach was used for the wetlands assessment:

4.5.1 Wetland and Riparian Habitat Delineation

Fieldwork was undertaken in August 2022, the height of the dry season. The wetland and riparian areas were delineated according *to A Practical Field Procedure for Identification and Delineation of Wetland and Riparian areas -Edition 1* (DWAF 2005). This method aligns with international best practices. The boundary of the wetlands, as determined by the edge of the temporary wetness zone, was determined and the relative proportion of the wetland composed of seasonal and permanently saturated zones was noted (Figure 4.3).

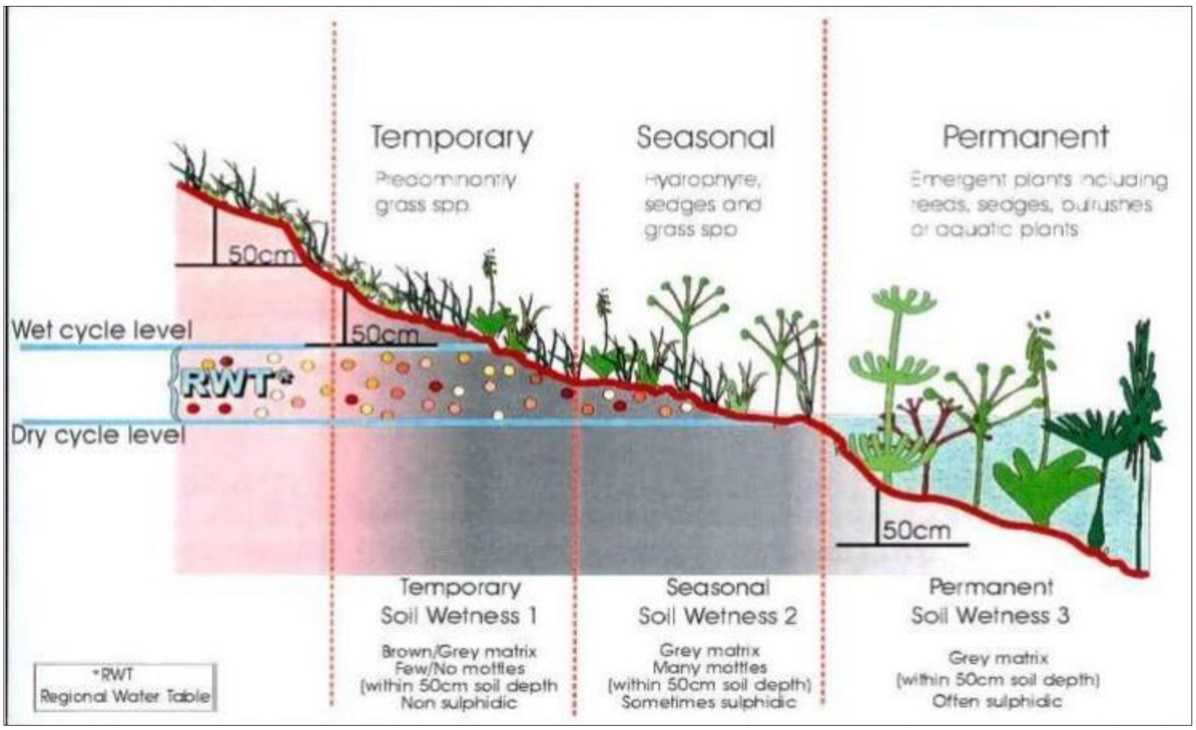


Figure 4-4-3. Cross section through a wetland showing soil, vegetation and topographical changes associated with wetland zones (from DWAF, 2005).

A perceived shortcoming of the above methodology is that it relies heavily on the identification of undisturbed soil hydromorphic characteristics. It also favours wetland systems located in the higher rainfall regions. To supplement, and add veracity to, the delineation data the methodology described in DWAF (2008) was also considered. This approach is more applicable to a wider range of environmental scenarios and makes use of several additional key indicators to classify wetland habitat, namely:

- *Soil hydromorphy*: the presence of grey and orange mottles indicating periods of alternating anaerobic and aerobic conditions. An important limit is the depth at which hydromorphic conditions occur. Wetlands are considered to be the result of an interaction between soil, water and vegetation, and the 50 cm depth limit represents the rooting zone of herbaceous wetland vegetation. Hydromorphic characteristics within the top 50 cm of the soil profile therefore indicate the presence of wetland habitat.
- *Vegetation*: Certain plant species or genera are obligate or facultative wetland species, and are good indicators of the temporary, seasonal and permanent wetland zones and terrestrial habitat.
- *Topography* is a good wetland indicator, particularly when delineating floodplain and channelled valley-bottom systems where the shape of the land indicates the likely extent of peak-flows.

The boundary of the wetland, as well as the seasonal and permanent wetness zones, was determined at appropriate intervals and the sample points recorded using a Global Positioning System (GPS). The subsequent information was assimilated to produce a Geographical Information System (GIS) spatial database of the wetland area.

Where appropriate the DWAF (2005) methodology was supplemented by the approach advocated by MacKenzie and Rountree (2007), which incorporates greater detail on riparian vegetation.

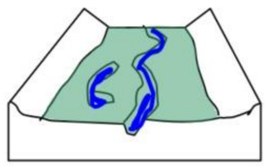
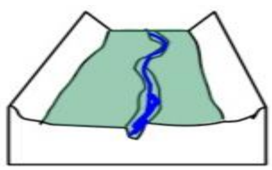
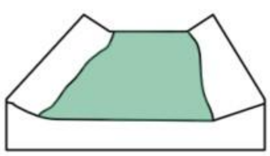
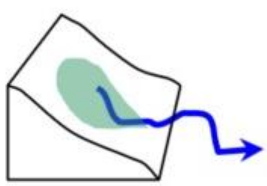
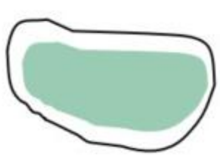
4.5.2 Wetland Hydrogeomorphic Classification

A classification system used for South African wetlands, referred to as the hydrogeomorphic (HGM) approach, recognises the three fundamental factors that influence how wetlands function, namely:

- Position in the landscape (geomorphic setting);
- Water source (hydrology); and
- The flow and fluctuation of the water once in the wetland (hydrodynamics).

The HGM approach classifies wetlands based on their differences in functioning, and importantly defines the functions that each class of wetland is likely to perform. The approach has been modified for use locally by Marneweck and Batchelor (2002) and is now the foundation of inland wetland classifications in South Africa (Ollis *et al*., 2013). This approach is valid across a wide geographical range since it considers the fundamentals of wetland formation. Each wetland identified within the study area was classified and described accordingly, which succeeded in highlighting the key hydrological drivers of the systems. Table 4-2 summarises the most common wetland HGM units and their primary hydrological drivers.

Table 4-2: Summary of HGM wetland classification system adopted for the study (from Kotze et al., 2009).

Hydro-geomorphic types	Description	Source of water maintaining the wetland[1]	
		Surface	Sub-surface
Floodplain 	Valley bottom areas with a well-defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley bottom with a channel 	Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/ ***
Valley bottom without a channel 	Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.	***	*/ ***
Hillslope Seepage Wetland 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow. Outflow is usually via a well-defined stream channel connecting the area directly to a stream channel or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.	*	***
Pan (depression) or Wetland Flat 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water, but overall its drainage is predominantly closed. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/ ***	*/ ***

1 Precipitation is an important water source and evapotranspiration an important output in all of the above settings

Water source:	*	Contribution usually small
	***	Contribution usually large
	*/ ***	Contribution may be small or important depending on the local circumstances

4.5.3 Wetland Functional Assessment

The ecological benefits and services associated with the wetlands were assessed using the functional assessment technique, WET-Ecoservices (Kotze *et al*, 2009). This assessment technique served to:

- Quantify the current level of functioning of the wetland systems, highlighting their relative importance at a landscape level; and
- Identify the important ecological services being provided by the wetland systems identified within the site.

For each wetland assessed a range of desktop and infield characteristics were observed and scored. These scores were ultimately weighted and integrated to deliver a single wetland score for each recognised ecological service. The resulting scores were evaluated against the guideline below to estimate the importance of that particular eco-service to the wetland.

0 - Low
1 – Moderately Low
2 - Intermediate
3 – Moderately High
4 – High

While this technique is qualitative it has proved to be a rapid, repeatable means of providing reliable, accurate information on wetland ecosystem services at a range of scales. The proviso is that it is a guideline, not a quantitative assessment, and the outcomes should always correspond with the field observations of the specialist. Table 4-3 presents the fifteen ecological services considered to be provided by wetlands to the surrounding landscape.

Table 4-3: Recognised wetland ecosystem services (Kotze et al., 2009).

Ecoservice	Category (as per Hanna *et al*, 2018)
Flood attenuation	Ecological regulation
Streamflow regulation	Ecological regulation
Sediment trapping	Ecological regulation
Phosphate trapping	Ecological regulation
Nitrate removal	Ecological regulation
Toxicant removal	Ecological regulation
Erosion control	Ecological support
Carbon storage	Ecological support
Maintenance of biodiversity	Ecological support
Water supply for human use	Provision of goods
Natural resources	Provision of goods
Cultivated foods	Provision of goods
Cultural significance	Cultural

Ecoservice	Category (as per Hanna *et al*, 2018)
Tourism and recreation	Provision of services
Education and research	Cultural

Wetland Present Ecological State (PES)

Wetlands are an expression of water moving through the landscape, and occur in the landscape where water accumulates at or near the soil surface for sufficient time for wetland conditions to develop. Activities that alter the movement or quality of water moving through the landscape will hence undoubtedly impact the wetlands. A rapid PES analysis was conducted on the wetland systems occurring within the study area. This establishes a baseline of the current state of the wetlands, an important requirement in estimating the potential extent of critical habitat for biodiversity, and the state of these water resources for wider society. The method described in the document "*Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems*" (DWAF, 1999) was applied to determine PES, with key wetland and catchment criteria scored as follows:

- Natural, unmodified (5),
- Largely Natural (4),
- Moderately Modified (3),
- Largely Modified (2),
- Seriously Modified (1), and
- Critically Modified (0).

The results were related to 4 in order to establish the PES Category for each wetland surveyed.

Table 4-4: Table showing the rating scale used for the PES assessment.

Mean*	Category	Explanation
Within generally acceptable range		
>4	**A**	Unmodified, or approximates natural condition
>3 and <=4	**B**	Largely natural with few modifications, but with some loss of natural habitats
>2.5 and <=3	**C**	Moderately modified, but with some loss of natural habitats
<=2.5 and >1.5	**D**	Largely modified. A large loss of natural habitat and basic ecosystem function has occurred.
Outside generally acceptable range		
>0 and <=1.5	**E**	Seriously modified. The losses of natural habitat and ecosystem functions are extensive
0	**F**	Critically modified. Modification has reached a critical level and the system has been modified completely with almost complete loss of natural habitat.

Riparian Ecological Integrity Assessment

The ecological integrity of a riparian system is defined as its ability to support and maintain a balanced, integrated composition of physico-chemical and habitat characteristics, as well as biotic components on a temporal and spatial scale that are comparable to the natural characteristics of ecosystems of that region. The ecological status of riparian habitat identified within the study area was assessed using a rapid technique developed by Kleynhans et al. (2007).

The Index of Habitat Integrity (IHI) involves the consideration of a range of key criteria (metrics) upon which to base estimates of riparian ecological integrity. These were:

- Indigenous vegetation removal,
- Exotic vegetation encroachment,
- Bank erosion,
- Channel modification,
- Water abstraction,
- Inundation,
- Flow modification, and
- Water quality

Each of these factors was assigned a score, or rating, in which the observed or deduced condition of each factor is compared to what it could have been under undisturbed conditions. The following scoring classes were used:

- None (0),
- Small (1 to 5),
- Moderate (6 to 10),
- Large (11 to 15),
- Serious (16 to 20), and
- Critical (21 to 25)

The metrics were ranked and weighted according to their relative importance in determining changes to habitat conditions. This rating and weighting process forms the basis of a Multi Criteria Decision Support Analysis approach. The criteria are able to be theoretically compared to a perceived benchmark (the reference condition) and rated according to their ecological removal from that benchmark. This enables a qualitative estimate of the current ecological integrity of the system as a whole to be made. Table 4-5, as taken from Kleynhans *et al*., (2007), indicates and describes the habitat integrity classes.

Table 4-5: Habitat Integrity Assessment (HIA) Classes

Class	Description	Score (% of total)
A	Unmodified	100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-99
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions are extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

Ecological Importance and Sensitivity (EIS)

An Ecological Importance and Sensitivity (EIS) analysis was also conducted for the wetland systems associated with the study site. This was done in order to establish a baseline of the current state of the wetlands, as is best practice in managing a water resource. The scoring system described in the document "*Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems*" (DWAF, 1999) was applied for the determination EIS, the ratings of which are shown in Table 4-6.

Table 4-6: Table showing the rating scale used for the EIS assessment

Ecological Importance and Sensitivity categories	Range of Median	Recommended Ecological Management Class
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetland is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate	>1 and <=2	C

Ecological Importance and Sensitivity categories	Range of Median	Recommended Ecological Management Class
Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.		
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

5 PROJECT LOCATION IN RELATION TO PROTECTED AREAS AND ECOLOGICAL AREAS OF INFLUENCE

According to IFC's Performance Standard 1, the Project Area of Influence (AoI) encompasses:

- The area likely to be affected by (i) the Project and the client's activities and facilities that are directly owned, operated or managed (including by contractors) and that are a component of the Project; (ii) impacts from unplanned but predictable developments caused by the Project that may occur later or at a different location; or (iii) indirect project impacts on biodiversity or on ecosystem services upon which affected communities' livelihoods are dependent;
- Associated facilities, which are facilities that are not funded as part of the Project, and that would not have been constructed or expanded if the project did not exist and without which the Project would not be viable; and
- Cumulative impacts that result from the incremental impact on areas or resources used or directly impacted by the project from which other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.

The study area is located in the southern portion of the Great Dyke in the Shurugwi District and approximately 26km south of Shurugwi town. It is accessed from the Shurugwi-Zvishavane road. The closest protected area is the small Sebakwe Dam Recreational Park that lies 70km to the north east on a separate catchment and drainage system (**Fig 5-1**) below.

The immediate area of ecological influence is the actual facility itself, the associated infrastructure including the proposed transmission lines, and the mine.

For terrestrial vegetation and flora, the wider sphere of influence is roughly a 2km strip around the outer edge of study site based on the pollination and seed dispersal mechanisms for the plants. For frogs and freshwater biodiversity the influence extends from the wetland/grassland to the southern stream and its confluence with the Umtebekwa river.

The area of influence of the project varies for different groups of mammals and reptiles. For most of these animals it is likely to be approximately 5 km from the development footprint of the project, determined by various factors such as home ranges of various species and the amount of disturbance in form of noise, water and air pollution and movement of vehicles and people outside the project site.

Birds are comparatively mobile so the area of ecological influence can be considerably larger, depending on the species and whether they are resident, migrant, breeding or non-breeding.

The wider sphere of influence includes the surrounding environment and communities that may depend on ecosystem services generated within the study area. This includes the provision of clean water draining from the seasonal wetland, sources of timber, livestock grazing and by no means the least, carbon sequestration by the woodlands.

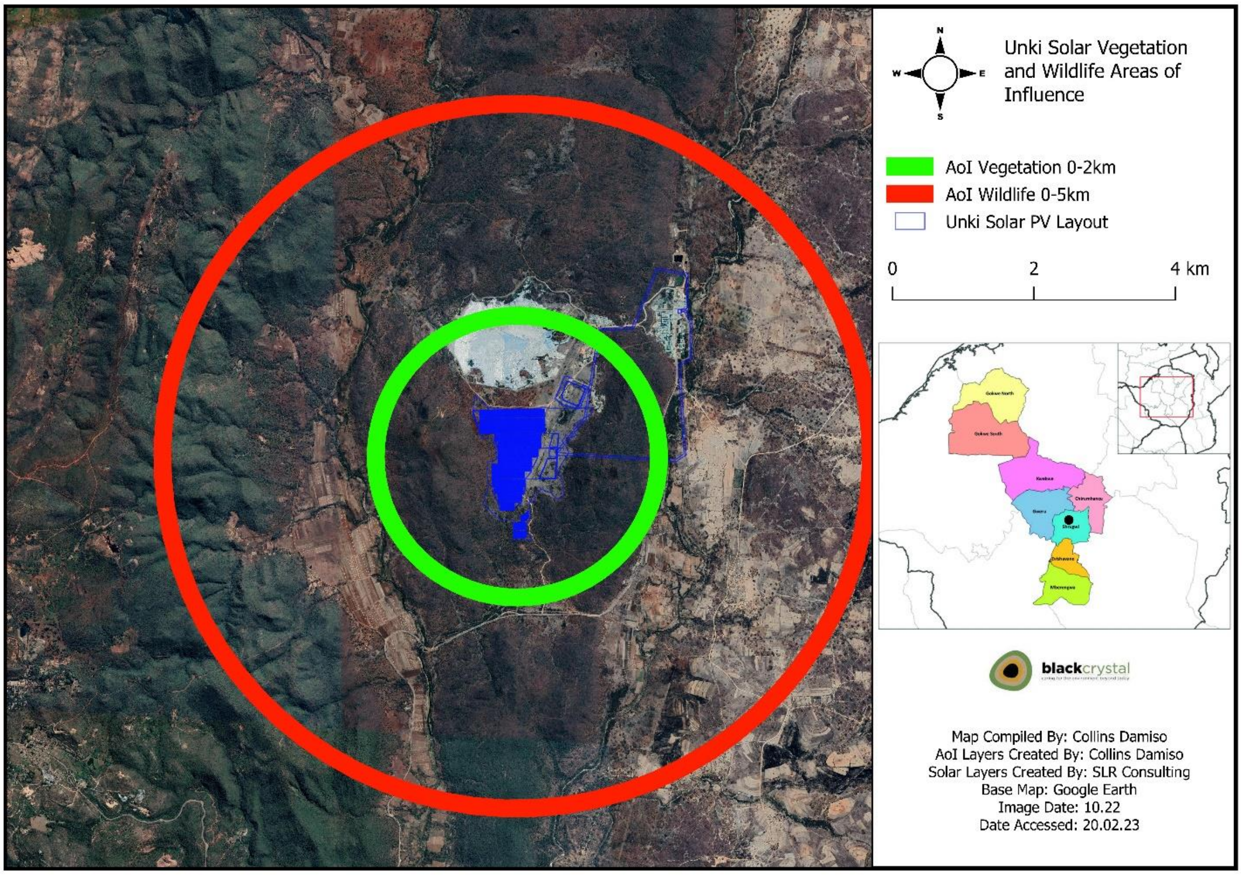
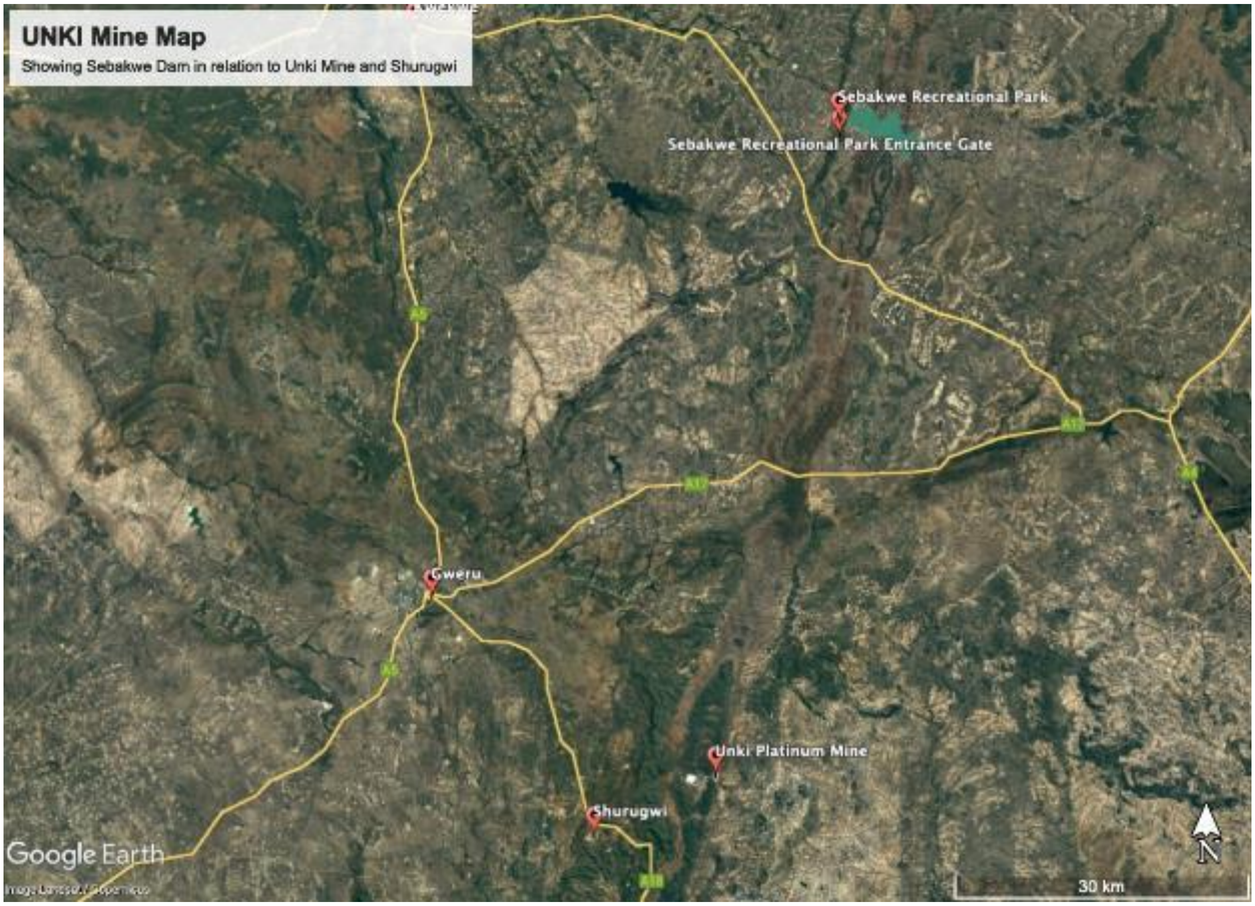


Figure 5-1; Approximate area of influence: flora and wildlife



Map 5-2: Map showing project site in relation to the closest protected area.

(Extracted from Google Maps)

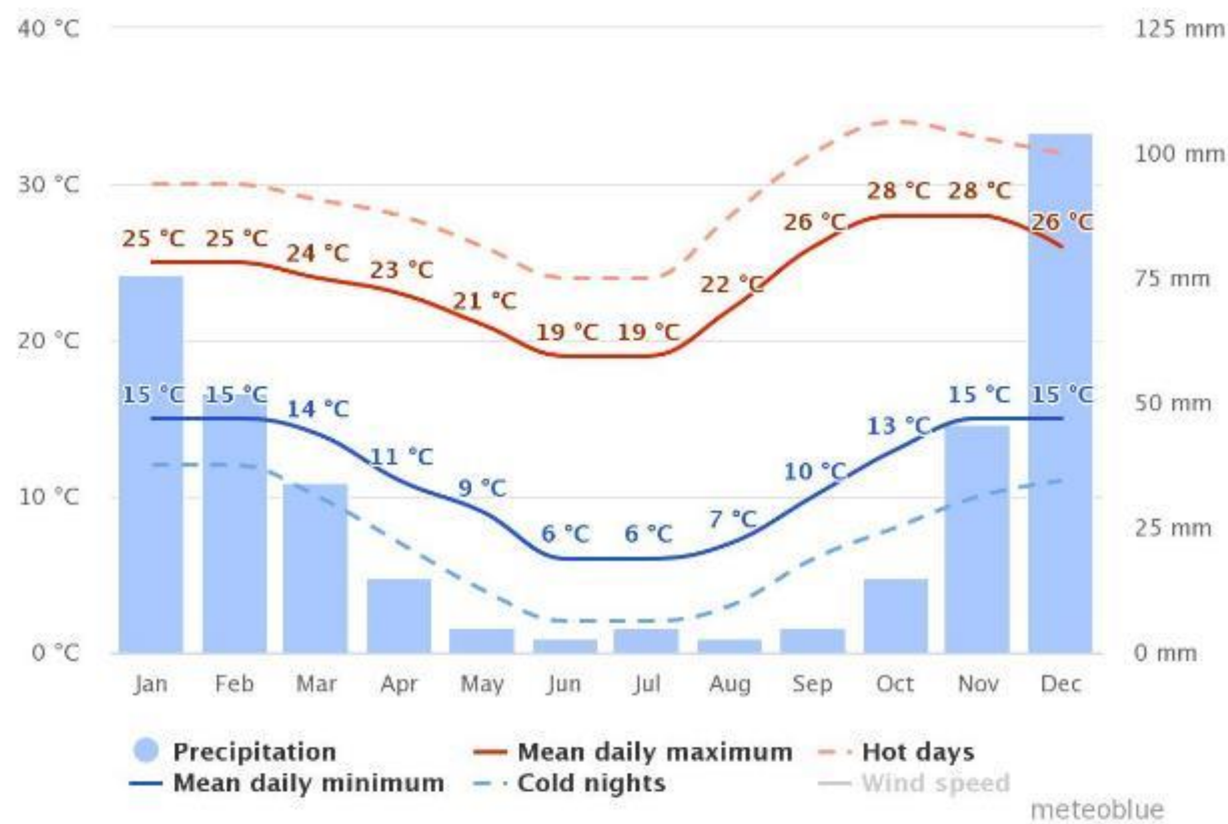
6 ABIOTIC FEATURES

Abiotic factors that influence the biota such as climate, geology, soils are detailed in other consultants' reports but the following summary is given in order to place the biotic descriptions in context.

6.1 CLIMATE AND LAND USE

The Koppen-Gieger classification for the area is "BSh" = semi-arid sub-tropical hot climate. The project falls largely within Agro Ecological Region III (Surveyor General map, 2020) which is characterised by a rainfall of 650-800 mm per annum with fairly severe dry spells within the rainy season. It is classified as suitable for semi-intensive farming of cash and fodder crops and livestock production and these are the main agricultural activities in the area surrounding the claim.

Shurugwi experiences three main climatic seasons: hot and wet from November to March; cool and dry from April to July; hot and dry from August to October. As with most of Zimbabwe, the rainfall is strongly influenced by position of the Inter Tropical Convergence Zone, but an additional factor are the steep sided hills in the area. These rise about 200m above the flatter surrounding land and intercept the moist winds blowing up from the Indian Ocean, resulting in orographic rainfall. Mists and "guti" are common. Much of the rain falls in short, heavy showers which results in high runoff intensities and therefore high erosion potential (Scott Wilson report, 2001). For the period 1971-1992, Shurugwi received a mean annual rainfall of 995mm. Data from Gwenoro Dam which lies north east of the study area for the period 1959 to 1980 shows a 20 year mean annual rainfall of 846.6mm and mean annual evaporation of 1815.9mm (Water Dept report, 1980). Shurugwi is an important source of above and below ground water recharge for the Runde river Subcatchment area. Below average rainfall occurred 18 times in the period from 1920 to 2000 and severe drought occurs every 15-20 years.



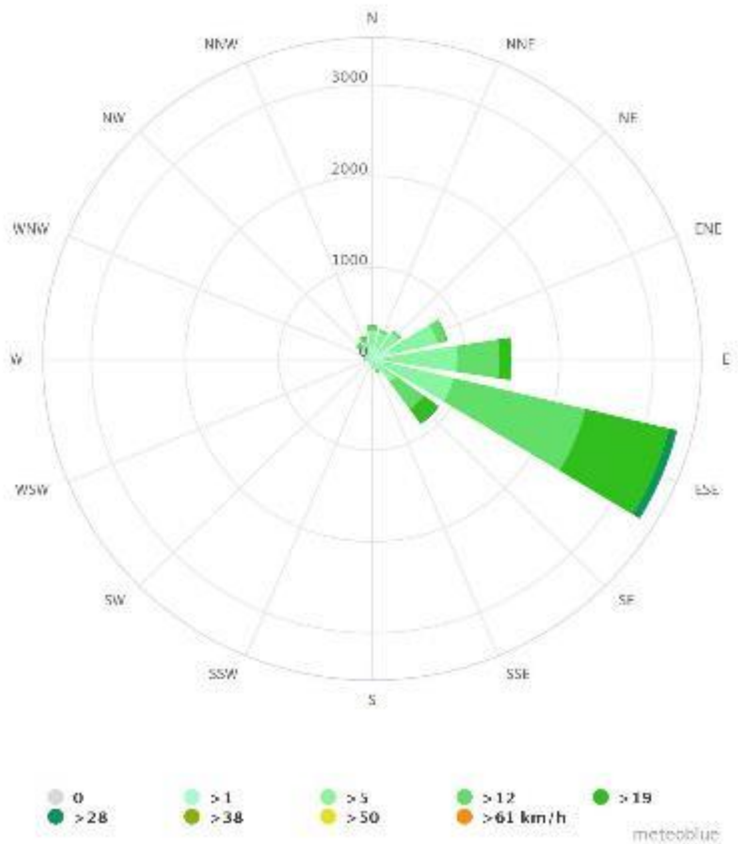
Graph 6-1: Seasonal changes in rainfall and temperature [6]

Because of the hilly topography the area around Shurugwi is relatively cool, with a mean minimum temperature of 4.5 ºC in July and a mean maximum of 28.3 ºC in October.

The prevailing wind direction is generally from the east south east, changing to north east for a short period just before the start of the rains (Graph 6-2). Average annual wind speed is 8.9 kpH, ranging from a monthly average of 6.9 kpH in June to 11.6kpH in October[7]. Speeds of >28 kpH can occur in the hot dry months prior to the rains.

[6] https://weatherspark.com/y/96331/Average-Weather-in-Shurugwi-Zimbabwe-Year-Round

[7] https://www.weatheronline.co.uk/weather/maps/city?FMM=1&FYY=2000&LMM=12&LYY=2021&WMO=67867&CONT=afri&REGION=0009&LAND=ZW&ART=WST&R=0&NOREGION=1&LEVEL=162&LANG=en&MOD=tab accessioned 8 October 2022.

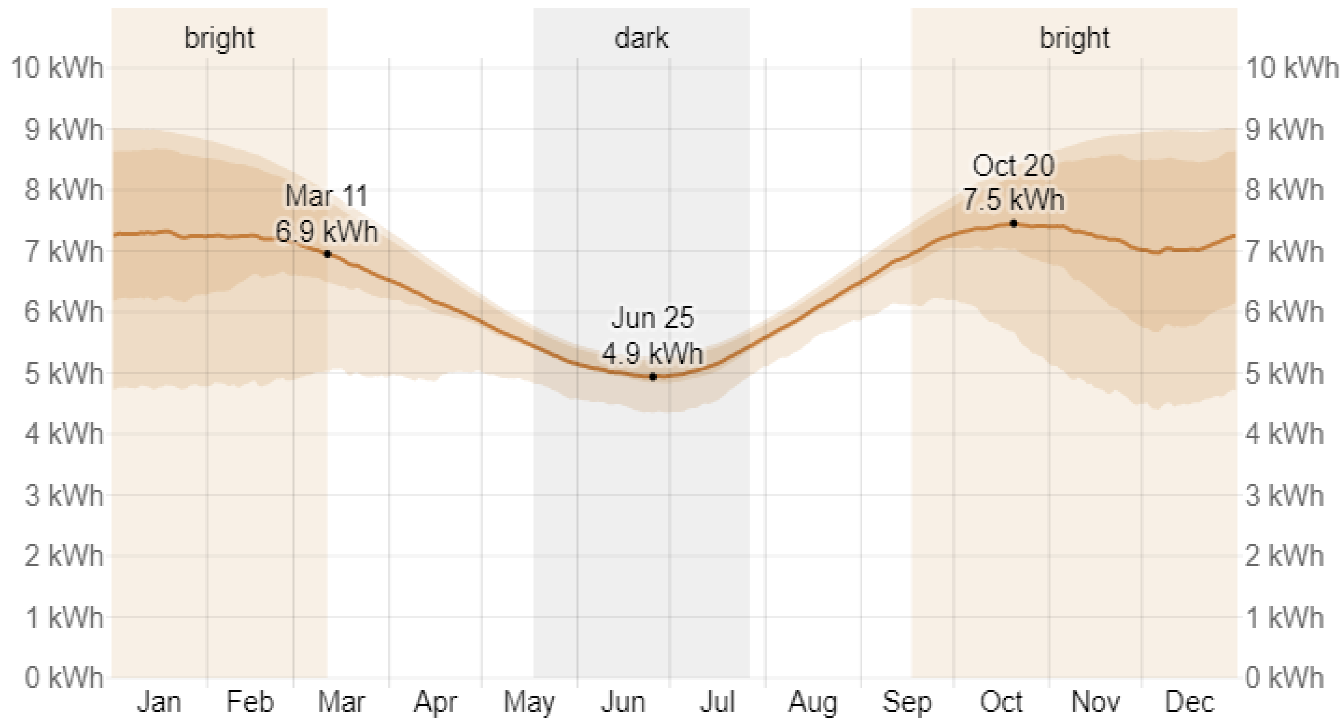


Graph 6-2: Wind direction

World Bank Climate model (CMIP5) predictions[8] for future temperature and precipitation in Zimbabwe for the period 2020-2039 indicate the following:

- Increased overall temperature: Annual temperature anomaly median value of +1.2 °C and a range of +1.1 to +1.5°C
- Decreased but variable precipitation: Annual precipitation anomaly median value of -3.3 mm with a range of -12.5 to +1.0 mm
- The evidence for increased temperatures and extreme ranges in precipitation is compelling and needs to be taken into account with mine developments.
- Solar radiation and daylength
- The predicted solar energy generation potential will be presented in detail in a separate specialist report but the seasonal trends in average daily incident shortwave energy are shown below.

[8] Climate Risk Profile: Zimbabwe (2021). The World Bank Group.



Graph 6-3: Average daily incident shortwave solar energy in Shurugwi[9]

The period of highest solar energy is late September to early December, prior to the rains, reaching a peak of 7.5 kWh in mid-October. The lowest solar energy of 4.9 kWh occurs mid-winter in June.

6.2 TOPOGRAPHY, GEOLOGY AND SOILS

The Great Dyke is the main topographic and geological feature of the area and is formed from an intrusion of mafic and ultramafic rocks from the Pre-Cambrian age. It is a younger geological feature than the surrounding rocks and separates the older western phyllitic schists, banded ironstones and greenstones, from the eastern granites. Artisanal gold mining is occurring on the greenstone belts and chrome mining on the serpentinites on the claim boundaries.

The soils follow a regular catenary pattern: on the higher well drained positions the soil is fersiallitic, with moderately deep dark reddish brown sandy or granular clay loams formed from the norite and pyroxenite rocks. Further down the slope and in the valleys the soils grade into dark brown to black clay vertisols in the poorly drained vleis. In the northern periphery of the claim area and beyond the study area there is a band of serpentinite that gives rise to shallow gravelly soils high in chrome and where the calcium: magnesium ratio maybe reversed. Further east of the mine and across the Umtebekwana river, the geology changes to dunite and then granite. The soils here are medium – fine grained greyish yellow sands.

[9] World Bank Climate Change Knowledge Portal.https://climateknowledgeportal.worldbank.org/country/zimbabwe Last Accessed: 31 August 2022

There are two rivers in the area which arise north of the study site and flow south in parallel along the pyroxenite / gabbro-norite interface to join the Runde river sub catchment drainage system. The Umtebekwana river follows the eastern side of the range, joining with the western Umtebekwa river south of the study area.

This part of the Great Dyke has a characteristic boat shape with a high ridge to the east, the Chironde Hills that rise to 1537masl, and a lower western ridge that reaches 1300masl. Between the two is an upland flat-bottomed valley and area of seasonal wetland (vlei) that in the north drains eastwards to the Umtebekwa river. The wetland also drains southwards and ultimately enters the Umtebekwa river at the Shurugwi-Unki Mine road bridge. The section of the valley that drains eastwards is now covered in the tailings dam and the south draining section is the proposed site for the project. Please see **Map 6-4** which shows the topography and drainage prior to mine development.

Map 6-4:Section of 1:50 000 scale map showing topography and drainage in study site.[10]

[10] Sebanga Poort 1829 C4 map, Surveyor General, Harare

The focal points of the Unki Mine are the underground operations, associated above ground processing infrastructure and smelter that lie on the eastern side the Chironde Hills. The tailings dam, return water dam and contractor housing are located west of the mine in the central part of the upland valley and just north of the study site.

The soil and drainage characteristics are similar across the entire catchment. The soils are red, well- drained coarse sandy loams. Rocks make up a large proportion of the soil profile, with individual rocks and boulders being separated by soil material. The hills making up the western catchment are underlain by ultramafic parent material. These are igneous rocks that are rich in magnesium and iron, and low in silicates. The subterranean rocks are smaller and comprise approximately 50% of the solum (Figure 6-5). The eastern catchment slopes have a different rock component with larger, granitic boulders being a part of the substrate.

Figure 6-5: Catchment soils from the western catchment (left), and eastern (centre) slopes. The rocks comprise a substantial proportion of the solum, and are separated by soil material. Note the rocks at the surface of the slope. Parts of the catchment also had deeper (50 cm) soil over weathered and hard rock (right). The soil is a well-drained, red, coarse-grained sandy loam.

The key characteristics of the catchment soils are:

- Overland runoff following intense rainfall events is broken up and dispersed by the rocks at the soil surface;

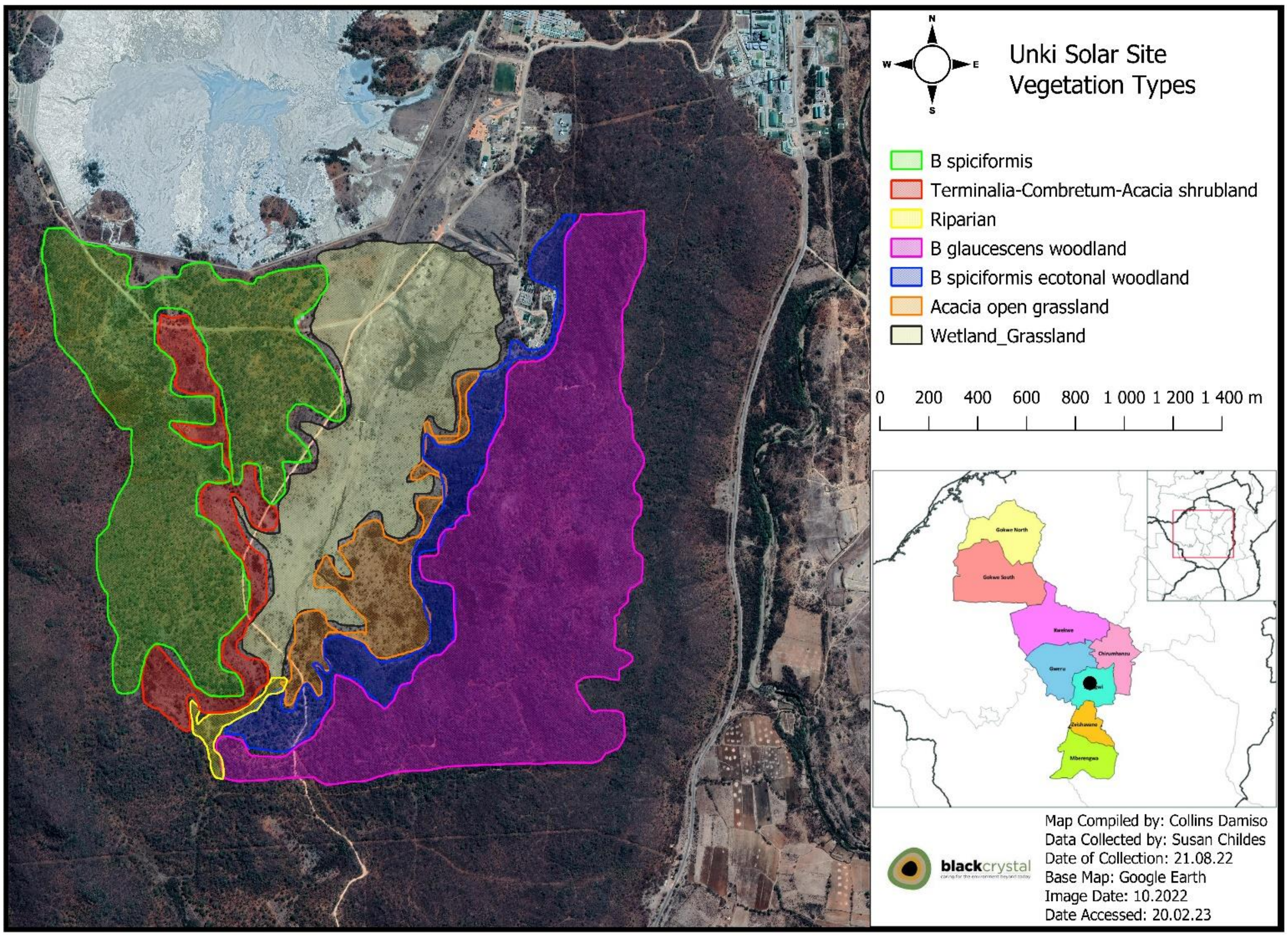
- Rainfall is able to infiltrate the soil profile via gaps at the interface between the rock and soil material, as well as via the space between tree roots and soil material.
- Although the slopes are steep, rainfall infiltration into the soil profile is high because surface flow is retarded by the high surface roughness (rocks and tree trunks).
- Soil storativity, the volume of water held in the catchment soil, will be low due to the high proportion of rock in the soil profile.

7 BASELINE DESCRIPTIONS OF BIODIVERSITY

7.1 VEGETATION AND FLORA

Associated with the diverse geology and topography, Shurugwi is a meeting point for three main vegetation types: *Brachystegia spiciformis* – *Julbernardia globiflora* (miombo) woodland, *Acacia* tree savanna and *Terminalia sericea* tree savanna (Wild and Fernandes, 1967). Much of the natural vegetation has been highly modified over a long time (past 100 years) through the initial gold rush in early Southern Rhodesia, followed by extensive clearing of land for commercial agriculture and forestry plantation from 1950's – 2000, and more recently by large scale mining and artisanal miners.

The main terrestrial vegetation types and habitats within the study site are shown below.



Map 7-1: Vegetation types and habitats in and around study area.

***Brachystegia glaucescens* woodland** on rocky hill tops, outcrops and hill slopes on norite and pyroxenite. Soils are well drained shallow red brown silty loams that accumulate in pockets at the base of the larger boulders.

Photo 7-1: *Brachystegia glaucescens* woodland on the rocky hill tops of the Chironde Hills

The *B.glaucescens* trees are tall (12+m), fairly uniform in size with a closed canopy and reduced shrub layer. Leaf fall had occurred creating a thin layer of humus that is vital for nutrient re-cycling and many trees were flushing. Other common trees are *B.spiciformis* and *Julbernardia globiflora*. The understorey small trees and shrubs include *Gardenia ternifolia* subsp *jovis-tonatis, Flacourtia indica, Pseudolachnostylis maprounefolia,* *Olea africana, Tarenna neurophylla* and where there has been past disturbance, *Dichrostachys cinerea*. The herbaceous layer was dry and it was not possible to identify any species.

***Brachystegia spiciformis – Julbernardia globiflora* woodland** on the lower slopes and on the western side of the study area. Soils are fersiallitic moderately deep red clay loams. Where there is a gravelly horizon, *Brachystegia boehmii* occurs as a co-dominant and on the rocky outcrops *B.glaucescens* re-appears with occasional *Ficus sur* and *Pittosporum viridiflorum*. Canopy is moderately closed and trees are 8-10m tall. The small tree / shrub layer is more mixed probably due to anthropogenic disturbances as there was evidence of tree cutting and frequent fires. *Combretum molle, Gardenia ternifolia, Pseudolachnostylis maprounefolia, Searsia tenuinervis, Lannea discolor* are common in the understorey. *Vachellia (Acacia) karoo* and *Dichrostachys cinerea* occur in areas of past disturbance.. Of conservation importance are the colonies of epiphytic orchid, *Cyrtorchis praetermissa* in the branches of the large old trees. This is an indication of a moist microclimate due to the mists that Shuruguwi is known for. Also important are the two aloe species: *Aloe excelsa* and *Aloe zebrina* that occur in this vegetation type. The 2020 biodiversity report also recorded *Gloriosa superba* (flame lily) and two species of terrestrial orchids, *Eulophia subsaprophytica* and *E.venulosa* but these were dormant and not visible in August or Feb. It is likely that there are several other species of terrestrial orchids present such as *E.cucullata, E. livingstoniana* and *E.streptopetala* since these are often found in miombo woodlands.

Photo 7-2: *Cyrtorchis praetermissa* epiphytic orchids in a *Brachstegia spiciformis* tree in proposed solar farm site

Photo 7-3: Young *Aloe excelsa* plants on a low outcrop in proposed solar farm site UTM 36K 192979 7825346

Photo 7-4: *Brachystegia spiciformis – Julbernardia globiflora* mixed woodland on lower slopes and deeper soils

Photo 7-5: Mixed *Brachystegia* ecotonal woodland on edges of the incipient drainage lines.

In areas of incipient drainage and disturbance from past tree felling the *Brachystegia* woodland gives way to a *Combretum – Terminalia – Acacia* open woodland and shrubland. An example of this is the western section of the site, south of the quarry.

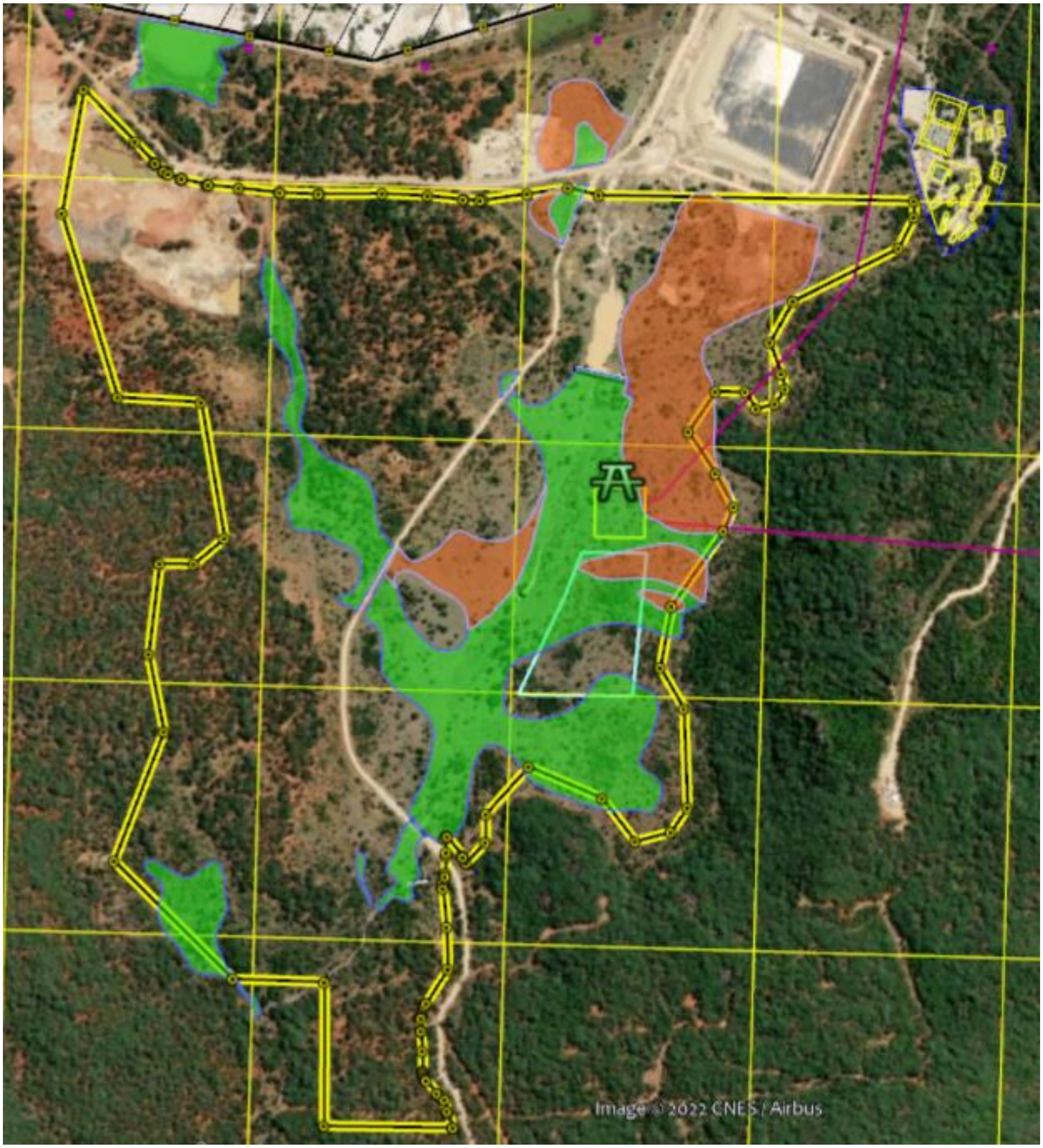
Mixed ecotonal woodland is also found at the junction of western slopes of the hills and the valley. Here the vegetation grades from *Brachystegia* dominated woodland into *Acacia (Vachellia)* open woodland on the drier areas and ultimately into seasonally wet perennial grassland on dark brown/black clays.

Wetland / Open Grassland on black clay soils. *A wetland is defined as areas with waterlogged or saturated soils dominated by emergent vegetation i.e., plants with their roots in water but the rest of the plant is aerial e.g., sedges and grasses.*

This vegetation type is found on a shallow valley in the middle of the study area and is clearly distinguished by the low tree cover and open short grassland. The Unki Mine EIA Addendum (2005) commented that "the grassland is unique to the vertisolic soils from the gabbronorite complex of the Great Dyke". At that time the report noted that the grassland was relatively well preserved but that heavy grazing pressure will cause deterioration of the system.

Common grass species are *Cynodon dactylon, Sporobolus pyramidalis, Bothriochloa inscuplta, Eragrostis heteromera* and *Melinis repens*. At the time of the site visit in August there was no visible water and the clay soils had dried out with deep cracks. The grassland has been severely over grazed and in the centre of the area there are deep erosion channels indicating recent high intensity fast water flows, caused by flooding from the upstream tailings and return water dams and episodes of heavy rainfall. In drier sections the grassland has been invaded by *Vachellia (Acacia) polyacantha*, *V. rehmanniana, V.nilotica* and *V.karroo* with occasional *Piliostigma thonningii*, *Flueggea virosa* and *Ziziphus mucronata* shrubs. The presence of distinct even sized (aged) cohorts of *V.polyacantha* indicates that the wetland is drying out in a series of episodic events. It is likely that the initial action that caused the wetland to change from a largely lentic system with standing or very slow-moving subsurface water to a lotic system where the water drains faster was the upgrading of the dirt access road and bridge crossing that interfered with the basal flow and effectively 'pulled the plug out 'of the wetland. This, coupled with overgrazing and frequent fires would have decreased grass cover exposing the soil to rainfall impaction, increasing surface runoff which in turn cut erosion channels back into the upper reaches of the wetland. It is clearly much more xeric than it used to be. It is strongly recommended that a well-considered environmental management plan is implemented for this area, restricting cattle grazing and wild fires being a priority.

For more details, please refer to Section 7.5 prepared by D McCulloch.



Map 7-2: Map showing wetland areas in more detail. Green are currently wet and brown are now dry. Courtesy of D.McCulloch, SLR

Photo 7-6: Open grassland on black clay soils. Seasonal wetland that is progressively drying out.

Photo 7-7: Aerial view of seasonal wetland showing erosion channels and invasion of *Vachellia (Acacia*) trees. Tailings and return water dams are in the background.

Photo 7-8: Erosion channels in seasonal wetland. *Cynodon dactylon* is the most common grass

Riparian fringing woodland on alluvium. This is a narrow strip of woodland and shrubs lining the southern stream and along the rivers. Dominant tree species are *Celtis africana, Searsia lancea, Combretum erythrophyllum* with occasional *Syzygium guineense*. Much of the riparian vegetation is highly disturbed and the invasive alien shrub, *Lantana camara* is common. This type is described further in the Aquatic Ecology section of this report.

7.1.1 ENDEMIC, RARE & SPECIALLY PROTECTED PLANTS & IUCN RED DATA LIST SPECIES

Since the study site is not on the serpentine soils as expected, no Great Dyke endemic plant species were found or are likely to occur. However, an interesting small succulent *Orbea caudata subsp rhodesiaca* was found in the miombo woodland west of the wetland. According to Mapaura and Timberlake (2002) Red Data List, this species is Critically Endangered, although Wursten in Flora Zimbabwe disputes the classification stating it is fairly widespread. Given the complex taxonomy of Asclepiads, the status of this species needs careful examination,

Photo 7-9: Dry season version of *Orbea caudata* subsp *rhodesiaca* that was found in miombo woodland in the project site. Photo: R Burrett

Photo 7-10: Wet season version of same plant that enabled identification of the species.

In addition to the succulent, species of epiphytic orchids and aloes were recorded.

Epiphytic orchids and aloes are "Specially Protected Indigenous Plant Species" under the Seventh Schedule of Parks and Wildlife Act Chapter 20:14, and so have been included in the table below with the two Red Data tree species recorded in the general claim area. Please refer to **Table 7-1**.

Table 7-1: Specially Protected Indigenous Plants and IUCN Red List Species

E=English, N=Ndebele, S=Shona, T=Tonga

Species	Growth Form	Common English Name and local names	IUCN Threat status	Habitat / Comments
Aloe excelsa and *Aloe zebrina*	Succulent	Aloe (E), Gavakava (S)	Not listed	Specially protected plants (Parks Act). Miombo woodland

Species	Growth Form	Common English Name and local names	IUCN Threat status	Habitat / Comments
Orbea caudata subsp *rhodesiaca*	Stapeliad succulent	Stapeliad	Critically Endangered	Small isolate populations, threatened by collectors and habitat loss. Not a specially protected species
Cyrtorchis praetermissa	epiphytic orchid	Tree orchid (E)	Not listed	Specially protected (Parks Act) Miombo woodland
Gloriosa superba	geophyte	Flame Lily (E) Jongwe (S)	Not listed	Specially protected plants (Parks Act) Miombo woodland
Dalbergia melanoxylon	Shrub or tree	Blackwood dalbergia, Zebrawood (E)	Lower Risk near threatened	Mixed woodland, thickets, on rocky outcrops or termite mounds. Very occasional.
Pterocarpus angolensis	Tree	Bloodwood, Mukwa (E), Mubvamaropa, Umvagazi (N)	Lower Risk near threatened	Miombo woodland. Occasional. Most of the trees have been felled in the past.

The 2020 Biodiversity report listed the terrestrial orchids *Eulophia subsaprophytica* and *E. venulosa* as protected plants and although all orchids are vulnerable to habitat destruction and plant collectors and therefore worthy of legal protection, terrestrial orchids are not on the Seventh Schedule.

7.1.1 Medicinal Plants

The terms of reference did not include an investigation into ethnobotany and with over ten different ethnic groups in the country it is often difficult to determine which group use which specific plants without a great deal of investigation. However, a literature search revealed that there some plants which are found in the site that may have medicinal value to some of the local communities in the area (Maroyi, 2013). All the plants are common and widespread.

Table 7-2: List of common medicinal plants found in the area

PLANT SPECIES	Growth Form	Number of Ailments it is used to treat
Albizia antunesiana	tree	6
Annona stenophylla	tree	4
Senna (Cassia) abbreviata	tree	5
Elephantorhiza goetzei	suffrutex	4
Flueggea virosa	shrub	4
Kirkia acuminata	tree	5
Peltophorum africanum	tree	4
Pterocarpus angolensis	tree	4
Strychnos cocculoides	tree	5
Ziziphus mucronata	tree	4
Sansevieria hyacinthoides	succulent	5

7.1.2 Invasive Alien Plants and Problem Weeds

The listed invasive alien woody shrub, *Lantana camara* is common throughout the whole area, particularly in places with deeper soils and a moist micro climate. Other common weeds that were found on the wetland in August were *Datura stramonium* and *Obetia tenax*.

7.2 ESTIMATED CARBON VALUES

7.2.1 Carbon Storage

In general terms the amount of carbon can be estimated using rainfall as an index of biomass using Frost's (1996) regression formula for miombo woodlands in Zimbabwe and Zambia:

Y = 0.14X - 56.21 where Y = above ground dry biomass (Mg/ha) and X = annual rainfall (mm)
Applying the average rainfall of 800 mm the predicted biomass is 55.8 Mg ha-1 and above ground carbon is 26.2 tC ha-1.

In this study, the carbon values were calculated from empirical measurements. The table below shows the stem volume, wood density and above ground woody biomass for trees and shrubs that were greater than 1.4m height with an over bark stem circumference greater than 5.0 cm. Dry wood density at 12% moisture content was corrected to total dryness i.e., 0% moisture to give above ground biomass values of 47.7 Mg ha-1 for *Brachystegia glaucescens* woodland, 51.6 Mg ha-1 for *Brachystegia spiciformis* woodland and 0.3 Mg ha-1 for *Vachellia polyacantha* open grassland. The above ground biomass figures for *Brachystegia* woodland in this study are very similar to those of Frost (loc. cit) for old growth, mixed age, dry miombo woodlands. Applying a factor of 47% to estimate the mass of Carbon in the biomass, the above ground Carbon values of the two types of miombo woodland are 22.4 and 24.3 tC ha-1. Ryan *et al* (2011) estimated a value of 21.2 tC ha-1 above ground for Mozambican miombo woodlands.

Table 7-3: Carbon values of main vegetation types in the study area

Vegetation Type and dominant species	Stem Volume m^3 ha^{-1}	Dry Wood Density kg m^{-3} @12% moisture for main tree species	Above Ground Biomass Mg ha^{-1}	Above Ground Carbon Value (47% of Biomass) tC ha^{-1}	Total Carbon Value of above and below ground biomass (assuming root: shoot ratio of 0.54) tC ha^{-1}
B glaucescens woodland	120.23	960	47.7	22.4	**73.5**
B. spiciformis woodland	169.66	735	51.6	24.3	**79.4**
Vachellia polycantha open grassland	39.59	705	0.3	0.14	**0.4**

When a biomass expansion factor / root: shoot ratio of 0.54 (Chidumayo, 2013) is applied to take into account the below ground biomass, the total carbon value of the *B.glaucescens* woodland is 73.5 tC ha-1 and of the *B.spiciformis* woodland is 79.4 tC ha-1. Unsurprisingly, the carbon value of woody plants in the *Vachellia polyacantha* open grassland is very low (0.4 tC ha-1). However, the value of carbon in the roots of grasses, sedges and the humic layer is not known and therefore should not be dismissed as insignificant.

7.2.2 Carbon Sequestration Rate

The net ecosystem productivity or carbon sequestration rate of miombo woodlands varies considerably according to the rainfall, soil type, fire history, stem density and age of the vegetation. Williams *et.al* (2008) indicate the range can be as low as 0.14 tC ha-1 year-1 to as high as 0.39 GtC ha-1 year-1. The global average for tropical savannas is 7.2 tC ha-1 year-1.

7.2.3 Total Carbon Dioxide (CO_2) Value

Applying a stoichiometric ratio of 3.6663 carbon to carbon dioxide, the 138ha of woodland on the project site has an estimated value of 38,680 tonnes of CO_2 stored in the biomass. Assuming a project life span of 25 years, the amount of CO2 that would be sequestered by the woodlands is 91,071 tonnes, giving the woodlands a total value of 129,751 tonnes of CO2.

This value clearly needs to be taken into account when evaluating the cost/benefit analysis of the project which ideally should include the carbon cost of manufacturing the panels, the construction and associated transport costs, the cost of providing water to clean the panels etc. Scope 1, Scope 2 and Scope 3 emissions should be calculated.

7.3 FAUNA

7.1.2 BIRDS

Description of affected environment – Avifauna

Vegetation structure rather than the actual plant species greatly influences species distribution and abundance (Harrison et al, 1997). The vegetation description below largely follows the extensive work of Harrison et al, 1997. The criteria used to amalgamate botanically defined vegetation units, or to keep them separate were (1) the existence of clear differences in vegetation structure, likely to be relevant to birds, and (2) the results of published community studies on bird/vegetation associations.

The general project area falls within a very broad habitat classification, the Miombo Eco region that is further divided into biomes largely based on the main vegetation types. The savvana biome dominates with grassland stretches occupying parts of the area. Using the Important Bird Area (IBA) global criteria some of the bird species fall under Category A3: Biome-restricted assemblages and within this, subdivision A10-Zambezian biome (Fishpool and Evans, 2001). Species which are listed in the Zambezian biome that have been recorded in and around the site are Rackettailed Roller, Kurrichane Thrush, Miombo Rock Thrush, Boulder Chat, Stierling's Wren Warbler, Eastern Miombo Sunbird and more A10 species are likely to occur there. As Irwin (1981) points out "many species which can be quite common within a restricted habitat may occupy an extensive range, yet may have small and often vulnerable populations". While the general vegetation is broadly classified as miombo woodlands, these are rapidly disappearing through agricultural expansion, mining, annual wild fires, firewood collection, often leaving only small isolated pockets of well-developed mature woodland. This has implications for the long term survival of many of the species associated with the woodlands

The savanna biome is known to hold significant numbers of large raptors, and forms the stronghold of Red Data species. The adjacent mountain ranges (Chironde, Boterekwa and Sifunduka) which consists of miombo vegetation clusters are key habitats and breeding grounds of large raptors that are considered as power line sensitive species. African Hawk Eagle, Martial Eagle, Walhberg's Eagle, Steppe Buzzard and Bateleur are known to occur in the mountain ranges.

A number of drainage lines within the study area forms an extensive riparian vegetation and a number of small bird species congregates within that area. During the dry season the rivers sustain birds from small pools along the course. The Unki Mine tailing dams which are adjacent to the project area are an important source of surface water and habitat to many waterbird species including White-faced Whistling Duck, Red Billed Teal and Black Winged Stilt.

The grassland patch within the study area is important for many habitat restricted species and provides hunting grounds for raptors such as Black Chested Snake Eagle. Communities around the area utilize the grasslands for cattle grazing which then modifies the habitat to be perfect for the migratory Abdim's Stork. Habitat restricted species which occupies the grasslands include African Pipit and Rufous Naped Lark

7.1.3 Endemic, rare and specially protected birds and IUCN Red Data species

Zimbabwe has no endemic birds but it has numerous species with restricted habitat ranges, some of which are found in old growth, well developed miombo woodlands such as Boulder Chat, Miombo Rock Thrush, Cinnamon breasted Tit, Spotted Creeper, Southern Hyliota.

The August 2022 dry season survey recorded 105 species and combined with previous records a total of 168 species potentially occupy the study area and immediate surroundings, see Appendix II for the full checklist. Of these, 9 are Palaearctic migrants and 15 are Intra African migrants, 12 of which breed in Zimbabwe. The eDNA data collected by NatureMetrics did not add any species to the overall list, apart from Southern Boubou (*Laniarius ferrugineus*) which must be viewed as an incorrectly identified sample since this species does not occur in Zimbabwe, where it is replaced by the ecologically similar Tropical Boubou (*Laniarius major*).

Five species are classed as Specially Protected under Parks and Wildlife Act (20:14) and three are globally red listed (**Table 7-4**). The area is also home to quite a number of water bird and migratory species.

Table 7-4. Specially Protected and Red Data List Bird Species

E=English, N=Ndebele, S=Shona,

Species Name	Common English Name and local names	IUCN Threat status (Red List 2020)	Habitat / Comments
Terathopius ecaudatus	Bateleur (E) Chapungu (S)	Endangered	Specially protected (Parks Act); vulnerable to poisoning as it is one of the first birds to spot carcasses; numbers are declining throughout its range; Nests in large trees.
Polemaetus bellicosus	Martial Eagle (E) Chinyamudzura (S)	Endangered	Specially protected (Parks Act). Nests in large trees on hillsides. Recorded in wet and dry season surveys so clearly resident.
Circaetus pectoralis	Black chested Snake Eagle (E) Gondo (S)		Specially protected (Parks Act). Grassland
Circaetus cinereus	Brown Snake Eagle (E) Gondo (S)		Specially protected (Parks Act). Woodland

Aquila wahlbergii	Wahlberg's Eagle (E) Gondo (S)		Specially protected (Parks Act). Migrant species. Woodland
Aquila (Hieraaetus) spilogaster	African Hawk Eagle (E) Gondo (S)		Specially protected (Parks Act). Woodland
Scopus umbretta	Hamerkop (E), Tegwaan(N)		Riparian species
Bucorvus leadbeateri	Southern ground hornbill (E) Dendera (S)	Vulnerable	Specially protected (Parks Act) Nests in large hollow trees.

7.1.4 Invasive Alien Species

Common Myna (*Acridotheres tristis*) is a highly invasive alien species that out competes indigenous species such as Starlings. The birds compete aggressively for nesting hollows, displacing, outcompeting and excluding many native species, especially hollow-dependant birds such as parrots. They are known to eat the eggs and attack the fledglings of other birds.

House Sparrow (*Passer domesticus*) outcompetes native cavity-nesting birds, and are known to destroy nests and eggs, and kill nestlings and adults while taking over an occupied nest site.

7.2 WILD MAMMALS

The main mammal habitats identified in or near the site were:

1. Miombo woodland dominated by *Brachystegia spicif*ormis, *Julbernardia globiflora* and *Brachystegia boehmii* on lower slopes and flat areas
2. Miombo woodland dominated by *Brachystegia tamarinoides (synoymn glaucescens)* on rocky hill tops and steep slopes
3. Open grassland with scattered *Acacia* trees.
4. Riparian vegetation

A total of 86 mammal species (excluding bats) were identified as possibly occurring in the site. During the site visit 17 species were confirmed as present. A study done in 2020 (Nhiwatiwa et al, unpublished) identified 18 species present. The total combined number of species confirmed in the area during the August 2022 field work was 24 (See Appendix III). eDNA data collected by NatureMetrics in 2022 added one further species to the list, namely Vervet Monkey (*Chlorocebus pygerythrus*).

LARGE MAMMALS	COMMON NAME OF GROUP	NUMBER OF SPECIES
>25 kg	Baboon	1
>0.5m shoulder height	Hyaena	1
	Leopard	1
	Aardvark/Antbear	1
	Pigs	2
	Large Antelope	7
MEDIUM-SIZED MAMMALS	Medium-sized Primates	3
2-25 kg	Pangolin	1
<0.5m shoulder height	Hares and Rabbits	2
	Large Rodents	4
	Jackals	2
	Otters, badgers & polecats	3
	Mongooses	6
	Genets and Civets	3
	Aardwolf	1
	Medium-sized cats	3
	Dassies/Hyraxes	2
	Medium-sized Antelope	5
SMALL MAMMALS	Sengis	2
< 2kg	Hedgehog	1
	Shrews	9
	Squirrel	1
	Mice and Rats	25

Table 7-5 : Summary of wild mammals possibly occurring on the site

A. Leopard scat (Miombo woodland on rocky hills)

B. Cape Clawless Otter scat (riverine habitat)

C & D. Signs of dragging of carcass and chewing on bones by hyaena (grassland)

E. Greater Kudu spoor (Miombo woodland)

F. Bushbuck scat (Miombo woodland)

G. Greater Kudu scat (riverine habitat)

H. Sharpe's Grysbok scat (riverine habitat

I. Bushbuck spoor (riverine vegetation)

J. Common Duiker spoor (grassland near settlements)

K & L. Common Duiker scat (grassland near settlements)

M. Savanna Hare scat (grassland) N. Jameson's Red Rock Rabbit scat (Miombo woodland on rocky hills)

O. Rodent burrow (Miombo woodland) P. Multimammate Mouse (grassland)

Photo 7- 1: Photos showing evidence of mammals found in the general study area

Q. Multimammate Mouse R. Red Veld Rat S. Namaqua Rock Mouse
(Q, R & S - Miombo woodland in rocky hills)

Out of the 24 mammal species confirmed, two were identified as species of conservation concern on the IUCN Red Data list (**Table 7-6).** Ground Pangolin is rare but has a widespread distribution and may occur in the area:

Table 7-6: Specially Protected and Red Data List Mammal Species

E=English, N=Ndebele, S=Shona,

Species Name	Common English Name and local names	IUCN Threat status (Red List 2021)	Habitat / Comments

Smutsia (Manis) temminckii	Ground Pangolin (E) Haka (S) Inkakha (N)	Vulnerable	Rare. Threatened by habitat loss, poaching and illegal trade. Specially Protected Species (Parks Act). Used for ceremonial presentations to chiefs. They are also regularly electrocuted by lower strands of electric fences in areas where these occur.
Aonyx capensis	Cape Clawless Otter (E) Mbiti (S) Intini (N)	Near Threatened	Widespread in rivers dams. Threatened by pollution of water, loss of habitat, loss of food sources and conflict with humans
Panthera pardus	Leopard (E) Mbada (S) Ingwe (N)	Vulnerable	Solitary and elusive species. Threatened by habitat fragmentation, reduced prey base, illegal skin trade, and retributive hunting for killing livestock.

7.3 REPTILES AND AMPHIBIANS

The museum herpetological records are given in Appendix IV. In summary, 44 reptiles and 10 frogs are recorded from the general area and are likely to occur on the site (**Table 7-7).**

Table 7-7: Number of reptile and frog species from museum collections

Group	Number of species
Tortoises	2
Snakes	30
Lizards	11
Geckoes	1
Amphibians (frogs)	10

7.3.1 Endemic, rare and specially protected and IUCN Red Data species

To date no endemic species have been recorded. All the currently known species are categorised as Least Concern on the IUCN Red Data list. This may change once the results of the wet season survey are known.

The African Rock Python is the only Specially Protected species under the Parks Act.

Photo 7-11: Blue tailed Skink (left) and Agama lizard (right). Photos: C. Mateke, August 2022.

7.4 AQUATIC AND RIPARIAN ENVIRONMENT

The main drainage features are the Umtebekwa river flowing south from Lucilla Poort dam along the western edge of the claim area, and the parallel Umtebekwana river on east of the claim area. The Chironde Hills act as a watershed and several small ephemeral streams drain off east to the Umtebekwana river and west into an upland seasonal wetland (vlei) from the hills. Both rivers are outside the study area but the Umtebekwa is within the greater sphere of influence. The rivers and the wetlands feeding into them are an important resource for both wildlife, livestock and people and are therefore a Priority Ecosystem Service (PES).

The project was re-located off the seasonal wetland and therefore the potential impact on the aquatic environment has been considerably reduced. The intention of this section of the biodiversity report is therefore to provide a general background description of the aquatic environment, highlighting any Significant Biodiversity Features (SBF) and ecosystem services. The information is derived from the Unki Mine Biodiversity Baseline and Ecosystem Services Assessment Report (Nhiwatiwa et al, 2020) coupled with the author's own observations during the field work.

7.4.1 Vegetation

The riparian vegetation varies according to the substrate, in rocky places there is little vegetation except for a narrow strip of shrubs such *Searsia (Rhus) lancea* and *Flueggea virosa*. In areas where there is silt and sand deposited *Phragmites* reeds occur. The old river terraces support *Syzygium guineense, Celtis africana, Combretum erythrophyllum, Pterocarpus rotundifolius* and occasional *Piliostigma thonningii* and *Faurea saligna* trees with an understorey of *Lantana camara, Combretum zeyheri, S.lancea. Vachellia (Acacia) karoo and V.niloticus* occur in areas of previous disturbance. The riparian vegetation is highly disturbed in places where artisanal miners have dug into the banks.

The banks of the small stream draining south from the wetland have been eroded and several pools along the stream are silted with sedges (*Schoenoplectus* sp.) and interestingly, a horsetail *Equisetum ramosissimum* and a xerophytic fern *Pellea sp*. was found on the streambank. *Syzygium guineense, Combretum erythrophyllum* trees and *Diospyros lycioides* shrubs occur in places along the edges of the stream. *Cynodon dactylon* is the common grass species.

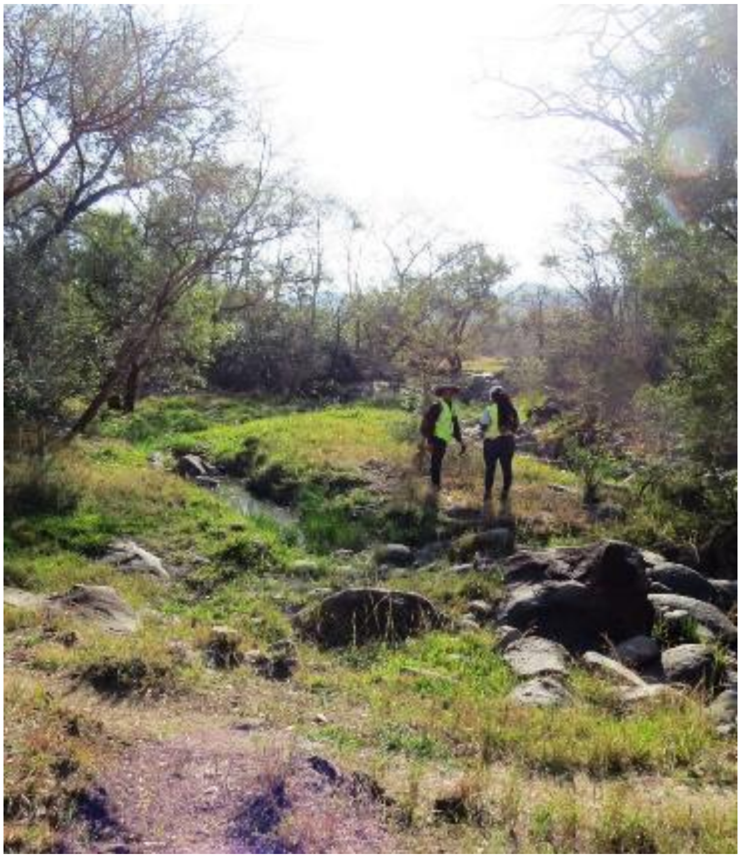


Photo 7-12: Small un-named stream that drains the wetland and ultimately into the Umtebekwa river. August 2022

Photo 7-13: *Equisetum ramosissimum* subsp *ramosissimum* (Horsetail) found growing on the edge of the stream. August 2022

7.4.2 Water Physio Chemistry

The baseline report found that physio-chemical characteristics sampled in December 2019 and February 2020 of both rivers were similar, with differences attributed to the type of land use within the two catchments: chrome mining, gold panning, agriculture and geology. The waters of both rivers were very turbid especially after the rains when there is runoff from ground exposed by mining and agriculture. The pH was alkaline and oxygen levels were high but nitrates, total nitrogen, reactive phosphate (P) and total phosphates were low possibly because there is little inorganic fertilizer used in the agricultural fields. Water colour, total dissolved solids, chlorides, sulphates, nitrates, ammonia, fluoride, sodium, magnesium, manganese, copper, zinc and iron were lower than the WHO surface water guidelines. The report noted with concern that the widespread gold panning in both river catchments resulted in mercury, arsenic and free cyanide detected in the Umtebekwana river on both sampling occasions and while, mercury and arsenic was not detected in the Umtebekwa river, free cyanide was found in February 2020. The report compared the sampling results of 11 elements listed under the South African Target Water Quality Guidelines for Aquatic Ecosystems and found that cadmium, chromium, copper, free cyanide, mercury and zinc greatly exceeded the recommended limits. These metals are toxic and carcinogenic and can bioaccumulate, making them a serious threat to environmental and public health. It is recommended that Unki Mine undertake regular systematic monitoring of water quality in both rivers in order to detect and separate those changes that are due to the mine's activities and those that come from external influences.

7.3.1 Macro Invertebrates

The Nhiwatiwa et al (2020) report noted that the overall condition of the biological state of the rivers were derived from passive monitoring of the benthic macro invertebrates used the South African System version 5 (SASS 5) method together with the scoring of aquatic habitats using the Habitat Assessment Index (HAI). The Umtebekwa river had higher habitat scores and generally high SASS average scores per taxon than the Umtebekwana river. The latter river is polluted by sediment from stream bank cultivation, acid mine drainage, chrome mining and gold panning. Both rivers contained *Planorbidae* snails that are the intermediate hosts for the bilharzia parasite. The Umtebekwa river was ecologically healthy just below Lucillia Poort dam but this decreased moving downstream with increasing human activities and the macro invertebrate fauna changed from being dominated by pollution sensitive taxa such as *Libellulidae, Coenagrionidae and Hydrocarina* to pollution tolerant taxa: *Planorbidae, Chironomidae, Oligochaeta, Notonectidae, Culicidae and Muscidae.* eDNA collected by NatureMetrics in 2022 revealed the presence of numerous macroinvertebrates, which were identified to family level, namely Narrow-winged Damselflies (Coenagrionidae), Backswimmers (Notonectidae), Creeping Water Bugs (Naucoridae), Pygmy Water Boatmen (Micronectidae), Giant Water Bugs (Belostomatidae), Prong-gilled Mayflies (Leptophlebiidae), Small Mayflies (Baetidae), Black Flies (Simuliidae), Non-biting Midges (Chironomidae), Whirligig Beetles (Gyrinidae) and Predaceous Diving Beetles (Dytiscidae).

7.3.2 Aquatic Vertebrate Diversity

The August 2022 field work recorded tadpoles of various ages from a species of *Xenopus laevis* (platanna) and a species of *Bufo* (toad) in shallow pools in the small stream south of the wetland. This coupled with the presence of adult dragonflies (*Aeshnidae*) and whirligig beetles (*Gyrinidae*) indicates that the ecological health of this stretch of the stream is good.

Photo 7-14*: Xenopus* tadpoles in the stream below the wetland. August 2022. Photo: C.Mateke

The Nhiwatiwa report (2020) recorded 12 species of fish in the two river systems, the most common being *Oreochromis mossambicus* (Mozambique tilapia), *Enteromius trimaculatus* (three spot barb), catfish (*Clarias gariepinus*) and *Serranochromis jallae* (yellow bellied bream). Two species of eel *Anguilla mossambicus* and *Anguilla bengalensis labiata* and the common invasive largemouth bass (*Micropterus salmoides*) were also found. The report noted that all fish species in both rivers were very small in size due to illegal netting with mosquito nets and that this is one of the major threats to the fish fauna. Nine fish taxa were identified through eDNA collections made by NatureMetrics in 2022, most of which were either identified to genus (e.g. *Enteromius, Labeo, Coptodon, Oreochromis, Serannochromis*) or family (Cyprinidae, Alestidae).

No fish species are regarded as Specially Protected in Zimbabwe but according to the IUCN Red List one species is vulnerable and several are near threatened (**Table7-6** below). The remaining 9 species that were recorded are of least concern.

Table 7-6. IUCN Red List, Rare / Endangered and Specially Protected Indigenous Fish Species

E=English, S=Shona,

Species	Common Name/s	IUCN Threat status	Habitat / Comments
Serranochromis jallae	Yellow bellied bream (E) Nembwe (S)	Least Concern	Regionally threatened by overfishing
Anguilla bengalensis labiata, Anguilla mossambicus	African mottled eel (E) Hunga (S)	Near threatened	Upstream migrations threatened by high weirs and dam walls

Oreochromis mossambicus	Mozambique tilapia (E) Gwaya (S)	Vulnerable	Is thought to be able to survive in "dry" riverbeds through the flow of sub surface water. Threatened by destruction of habitat and hybridisation with Nile tilapia (*Oreochromis niloticus*)[11]

7.5 WETLANDS

7.5.1 Wetland Delineation

Fourteen wetland and one riparian system (collectively referred to as aquatic systems) were identified within the study area (Figure 7-15). The area of aquatic habitats was aproximately 129 ha. The landscape is dominated by a large central unchanneled valley bottom wetland (HGM N) draining into a seasonally flowing stream, with lateral hillslope seepage wetlands seeps emerging at the base of the side slopes. According to the (South African) National Water Act, Act 36 of 1998, wetlands are defined as follows:

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

The presence of wetlands in the landscape can be linked to the presence of both surface water and perched groundwater. Wetland types are differentiated based on their hydro-geomorphic (HGM) characteristics; i.e. on the position of the wetland in the landscape, as well as the way in which water moves into, through and out of the wetland. The wetland habitat within the site consists of the following hydrogeomorphic (HGM) units:

- Two unchannelled valley bottom (UVB) wetlands fed by a combination of subsurface seepage, groundwater discharge from springs, surface rainfall runoff from adjacent slopes and direct rainfall. HGM N is the largest wetland with an area of approximately 49,5 ha and is the dominant central HGM unit. The northern half of the HGM unit has been covered in mine infrastructure, substantially reducing the size if the original wetland unit. HGM O is a smaller UVB draining into HGM N from the north and west.

- Twelve lateral hillslope seep wetlands (HS) were identified. Four of these drain directly into HGM N (HGMs E, F, G and H). Three seep wetlands historically drained into the greater valley bottom wetland system but have since become isolated by the construction of the mine infrastructure (HGMs A, B, and D). HGM C drains northwards away from the project area, and has become isolated by the establishment of the tailings dam. HGMs I, J, K and L are lateral seeps that drain into the riparian system below the unchanneled valley bottom complex. The northern seeps (HGMs A, B, C and D) have been severely affected by disturbance. The remaining seepage are intact, have been minimally disturbed and share a similar disturbance regime, namely heavy grazing and frequent trampling by cattle, and periodic fire.

[11] Marshall, B. (2011).The Fishes of Zimbabwe and their Biology. *Smithiana* Monograph 3,1. SAIAB, South Africa.

- One seasonally flowing riparian B-channel reach that is associated with confined flow through the hard igneous rock between two hilly regions.

Figure 7-15 showing the distribution of wetland and riparian habitats within the study area.

Of the 15 HGM units identified, HGMs A, B, D and L are considered to be irrelevant to this study since they are not likely to be impacted by, or have an influence on, the development. These will hence be excluded from further consideration, and the focus will be on the remaining HGM units.

Figure 7-16 shows the distribution of the zones of wetness throughout the wetland habitat within the site, as well as the various impacts sustained by the wetland. The following features are important to note:

- There is no permanently wet habitat within the study area. The areas of wetland habitat showing signs of seasonal inundation are confined to an impoundment above the road, and parts of HGM F.
- Most of the wetland habitat within the area is temporary, with saturated conditions occurring irregularly.
- Large areas within the wetland complex have dried out, mostly due to the erosion of channels and a consequent drop in water table, but in some cases also by the diversion of water inputs by roads and drains.
- There are several borrow pits within the study area. These are having a substantial influence on the hydrology of the unchanneled valley bottom wetlands.
- A holding dam has been constructed in the upper reaches of HGM N.
- A soil stockpile has also been established in the northern part of HGM N.
- A broad channel has been excavated below the holding dam to manage water outflows from this.

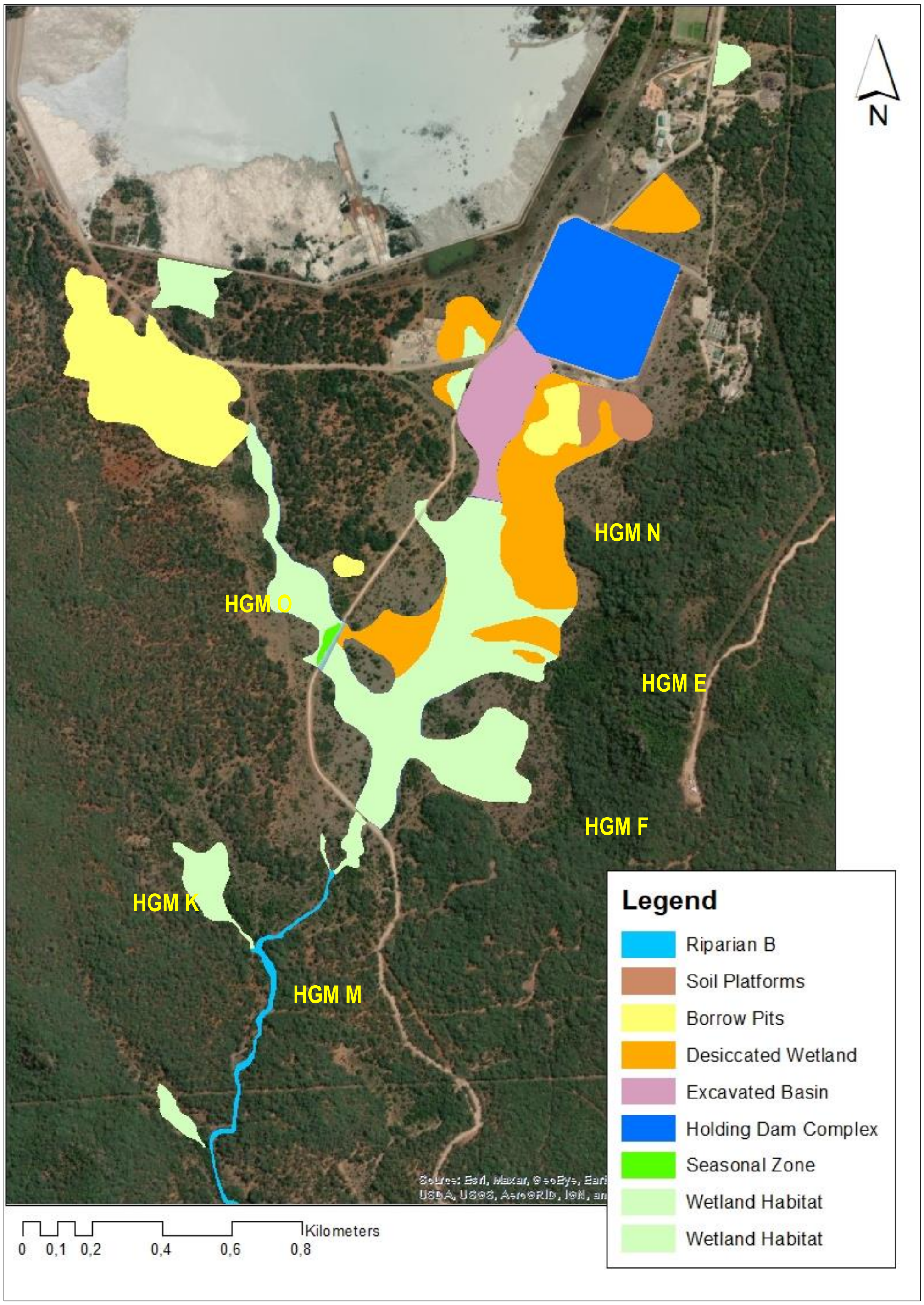


Figure 7-16. map showing the distribution of the wetland zones of saturation, as well as relevant disturbance features.

7.5.2 Wetland Hydrogeomorphic Classification The key characteristics of these units are
ıtatives of each aquatic type occurring within the study area.

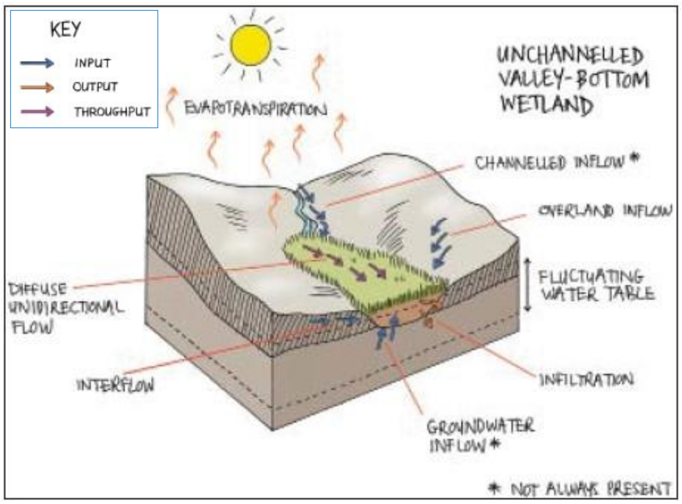
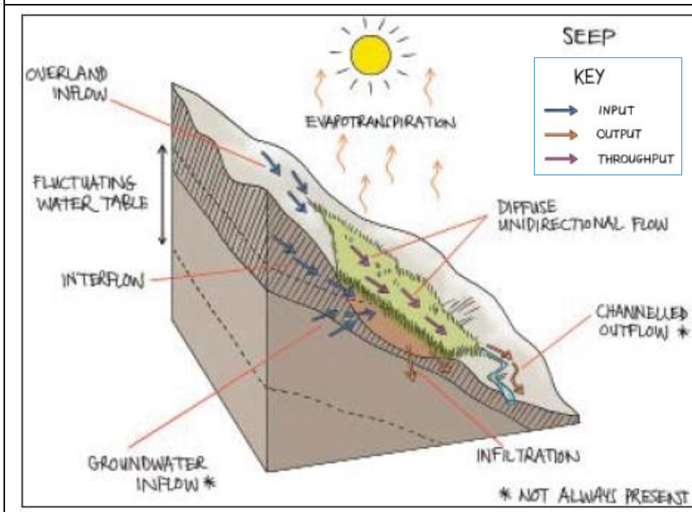
Table 7-7. Description of the Hydrogeomorphic units associated with the site.

Table 7-7 indicates the types of wetland HGM units identified within the study area, and highlights the key site-specific characteristics of each wetland type. The HGM units were:

- Two Unchannelled Valley Bottom Wetlands – HGMs O and N;
- Seven Hillslope Seepage Wetlands – HGMs D, E, F, H, I, J, and K.
- One Riparian B-Channel- HGM M.

The key characteristics of these units are described below, along with typical representatives of each aquatic type occurring within the study area.

Table 7-7. Description of the Hydrogeomorphic units associated with the site.

HGM Type	Comments
	• Low energy systems. • Site of long-term fine sediment and mineral accumulation. The substrate is dark vertic clay soil. • Flow velocity and volume are insufficient to mobilise sediment. • Diffuse subsurface water influx is the primary wetland driver. Lateral surface runoff influx following rainfall is also important. • Typical 'dambo' wetland setting with broad herbaceous valley bottom with broadleafed woodland in the catchments. • Stable when intact, but highly sensitive if channel erosion has begun.
	• Stable, well vegetated systems due to the gentle slopes. Sensitive to confined surface flow. • Support hygrophilous grass species and *Senegalia polyacantha*. • Subsurface seepage is the main hydrological driver.

Unchannelled Valley Bottom Wetlands

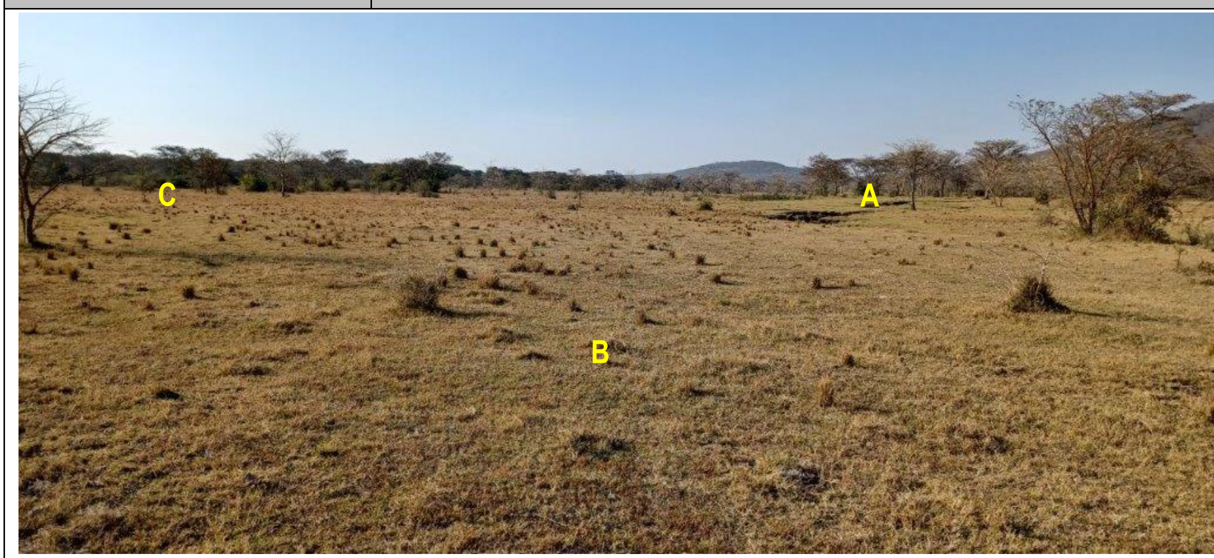
Unchannelled valley bottom wetlands are valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. They reflect conditions where surface flow velocities are such that they do not, under existing flow conditions, have sufficient energy to transport sediment to the extent that a channel is formed. With wetlands based on vertic soils there are two dominant hydrological processes:

1. Lateral and longitudinal subsurface seepage along an impermeable or slightly permeable layer of broken weathered rock and clastic material (aquitard). Rainfall enters this layer via infiltration of the soil profile at the interface between rock and soil material. The interflow water daylights at the base of the slope to form the seep. Where the volume of water is sufficient to saturate the soil from the lower aquitard to within 50cm of the soil surface a wetland is formed.
2. Lateral and longitudinal surface flow. Vertic soils shrink during the dry winter months, forming prominent cracks at the surface. During the wet season they saturate and swell, sealing the surface against infiltration by water. Diffuse surface runoff from the adjacent slopes enters the valley bottom and flows across the surface of the soil before entering and settling in the wetland.

The UVB wetlands associated with the study area are described in detail in Table 7-8 and Table 7-9.

Table 7-8. Unchannelled Valley Bottom Wetland- HGM N

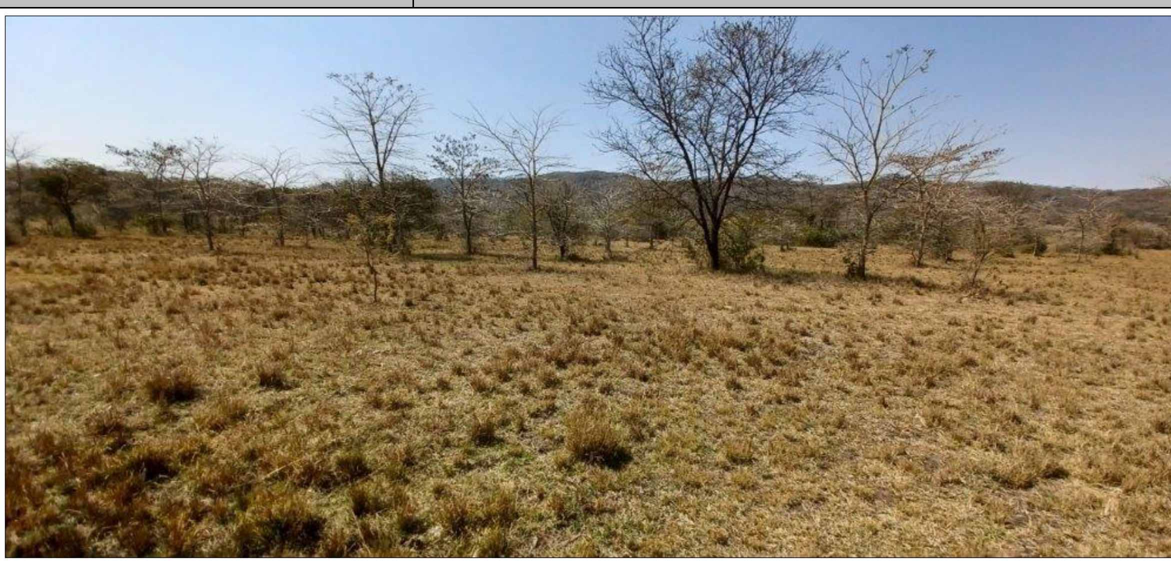
HGM N	



View of the unchanneled valley bottom wetland looking upstream. Key features are: heavy grazing by cattle; eroded channel at A; desiccated grassland in the foreground with terrestrial grass species (B); intact wet seepages further away from the influence of the channel showing hygrophilous grass species and *Senegalia polyacantha* (C).

 Vertic soil samples, the rich black topsoil ped against the greyer, lower chroma ped from further down the profile indicative of periodically saturated conditions.	 Severe gully erosion through the centre of the wetland caused by uncontrolled confined surface discharge from the mining infrastructure at the head of the system. This has resulted in the drop in water table and desiccation of the wetland.
Hydrogeomorphic Setting	Unchannelled Valley Bottom Wetland. There is a geological keypoint at the base of the system, below which it discharges into the riparian stream.
Wetland Characteristics	Broad, historically unchanneled system. Dense, dark vertic clays. Heavily grazed by cattle. Severely eroded by a combination of destabilisation further down the wetland and high volume discharges and confined flow form upstream. Has largely dried out due to the effect of multiple eroded gullies.
Dominant Drivers	Lateral and longitudinal diffuse subsurface seepage; diffuse lateral surface flow from the adjacent slopes and seeps; rainfall.
Catchment Characteristics	Steep, intact well-wooded hills with rocky land surfaces.
Present Ecological State	Critically modified.
Key Ecosystem Services	Grazing, some streamflow augmentation.

Table 7-9. Unchannelled Valley Bottom Wetland- HGM O

HGM O	
	

Unchanneled valley bottom wetland looking upstream. Key features are: heavy grazing by cattle; intact wet seepages showing hygrophilous grass species and *Senegalia polyacantha*.	
Hydrogeomorphic Setting	Unchannelled Valley Bottom Wetland. Drains a small valley and discharges into the larger UVB HGM N.
Wetland Characteristics	Small, narrow unchanneled system. Dense, dark vertic clays. Heavily grazed by cattle. Supports hygrophilous grass species and *S. polyacantha*, which are indicators of wet conditions. Catchment is relatively small, and wet conditions occur during most season, although this is erratic. Longitudinal influx of water from the head of the catchment has been removed by a large borrow pit.
Dominant Drivers	Lateral and longitudinal diffuse subsurface seepage; diffuse lateral surface flow from the adjacent slopes and seeps.
Catchment Characteristics	Intact well-wooded low hills, rocky land surface, gentle gradient.
Present Ecological State	Largely intact.
Key Ecosystem Services	Grazing, streamflow augmentation, erosion control, sediment trapping.

Hillslope Seep Wetlands

Hillslope seepage wetlands are generally associated with shallow to deep, well-drained catchment soils associated with an impeding horizon that limits deep infiltration. They typically reflect the presence of seasonal, shallow interflow. The dominant hydrological driver is lateral subsurface seepage across a semi-impermeable aquitard such as dense clay, soft or hard plinthite or parent material. Most of the catchment soils are well-drained sandy loams. These soils facilitate the infiltration of rainfall into the soil profile. The rainfall filters down the profile until it makes contact with the aquitard, whereupon vertical infiltration becomes lateral seepage along the interface between the soil and the impervious layer. There is also likely to be further infiltration through cracks in the aquitard into a deeper layer of weathered and broken rock. Subsurface flow is also lateral through this layer. Lower down in the landscape, where the aquitard comes into contact with the surface of the soil, water is expressed to the landscape as a wetland. The interflow in the upper layer of the profile is event-driven, and water is delivered to the seep wetland relatively quickly flowing rainfall events. The deeper interflow is driven by the pooling and subsequent gradual seepage. The flow is more constant, and the volume and rate delivered is more a function of the current seasonal rainfall pattern. Table 7-10 summarises the characteristics of an intact seepage wetland (HGM F), while Table 7-11 describes a degraded seep (HGM E).

Table 7-10. Hillslope Seep- HGM F

HGM F	
 Hillslope seep wetland at the base of the steep, wooded catchment. Key features are: heavy grazing by cattle; intact seepage showing taller, more dense (and unpalatable) hygrophilous grass species and *Senegalia polyacantha*.	
Hydrogeomorphic Setting	Hillslope seepage wetland, situated at the footslope of a steep, rocky slope. Tall closed canopy woodland is effective at capturing rainfall and funnelling it down to the soil surface, facilitating the dispersing runoff.
Wetland Characteristics	Intact seep. Dense, dark vertic clays. Greater than 60% composed of seasonally inundated habitat, although this is arranged in a mosaic. Heavily grazed by cattle. Supports hygrophilous grass species and *S. polyacantha*, which are indicators of wet conditions. Catchment is intact. Is drier than it would have been prior to the introduction of the eroded gully in HGM N. The drop in water table and increase in pressure differential ensures a more rapid passage of water through the wetland.
Dominant Drivers	Lateral diffuse subsurface seepage; lateral diffuse surface flow from the adjacent slopes.
Catchment Characteristics	Intact well-wooded hills, steep rocky slopes.
Present Ecological State	Largely natural.
Key Ecosystem Services	Grazing, streamflow augmentation, erosion control, sediment trapping.

Table 7-11. Hillslope Seep- HGM E

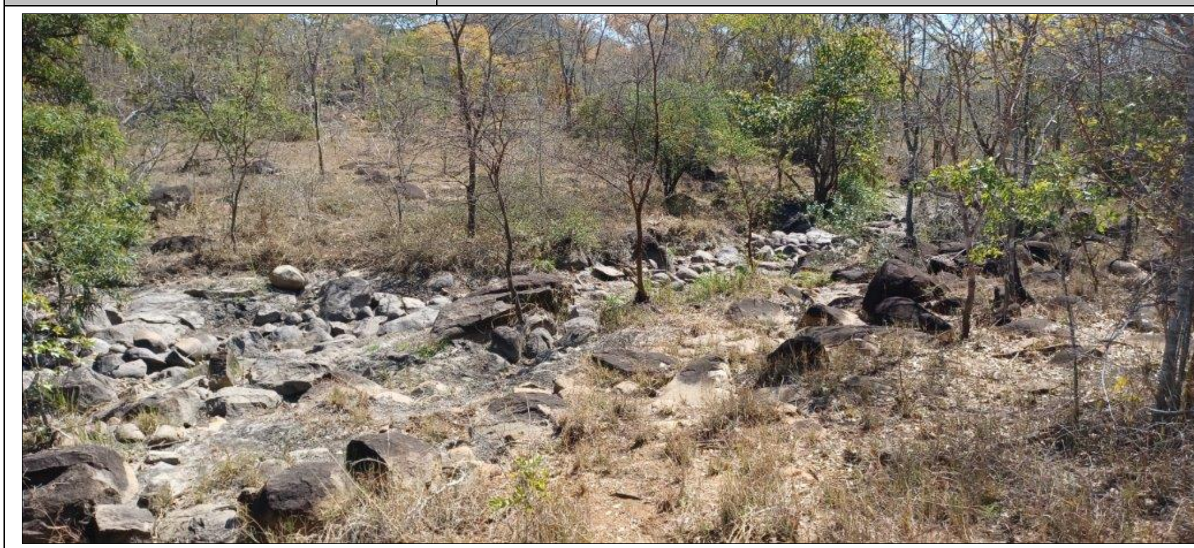
HGM E	
 Desiccated hillslope seep wetland (HGM E). Key features are: heavy grazing by cattle; large cracks in the soil surface; dominance of terrestrial grass species (*Cynodon dactylon*); and encroachment by terrestrial tree species (*Vachellia karoo*).	
 HGM E showing gulley erosion eating laterally from the main central gully in HGM N. Note drop in base level (and hence drop in water table); and slumping of soil on the right hand edge. Surface flow splashes onto the base of the slope and erodes soil from beneath, undercutting the upper horizon which then collapses.	
Hydrogeomorphic Setting	Hillslope seepage wetland, situated at the footslope of a steep, rocky slope. Tall closed canopy woodland is effective at capturing rainfall and funnelling it down to the soil surface, facilitating the dispersing runoff.
Wetland Characteristics	Critically impacted. Heavy grazing pressure. Dark, heavy vertic clays with shrink/ swell properties. Severe lateral erosion has caused a drop in water table. Water that would have remained in the soil profile now drains away. Much of the HGM unit is no longer wetland. Dry soil conditions cause cracking at the surface as the clays shrink. The wetland vegetation has been replaced by terrestrial grass species. There is encroachment by terrestrial tree species.
Dominant Drivers	Lateral diffuse subsurface seepage; lateral diffuse surface flow from the adjacent slopes.

Catchment Characteristics	Intact well-wooded hills, steep rocky slopes.
Present Ecological State	Critically modified.
Key Ecosystem Services	Grazing, slight streamflow augmentation.

Riparian B-Channels

Riparian B-channels are watercourses characterised by seasonal contact with base-flow. The primary driver is longitudinal surface flow, although lateral surface runoff and periodic contact with ground water are also likely to be important hydrological contributors. The riparian channel within the study area has the fundamental defining characteristics of distinct topography, alluvial soil deposition and vegetation that is distinct from the surrounding terrestrial matrix. HGM M is a typical mountain stream, the specific characteristics of which are summarised in Table 7-12. The adjacent igneous rocky slopes weather slowly, and the channel is confined. Under natural conditions flows prevent the sequential accumulation of sediment. Lateral subsurface seepage from several adjacent seepage wetlands is also an important hydrological driver. The system is largely intact, although the excessive surface flows from the mining operation upstream have resulted in considerable bank scouring and localised black clay sediment deposition.

Table 7-12. Riparian B-Channel (HGM M)

HGM M	
 Upper reaches of the seasonally flowing riparian B-channel, showing distinct topography, rocky substrate, and localised black clay sediment deposition.	
Hydrogeomorphic Setting	Riparian B-channel in seasonal contact with baseflow. Directly below the rocky keypoint of the large unchanneled valley bottom wetland (HGM N). Rocky substrate with poorly defined riparian vegetation. Channel contains aquatic plant species.
Riparian Characteristics	Well defined channel morphology; distinct vegetation community; evidence of sediment deposition; serious channel scouring in the lower reaches; poorly developed riparian gallery forest.
Dominant Drivers	Longitudinal surface flow; longitudinal baseflow during the wet season; localised lateral subsurface seepage from hillslope seeps; some lateral surface runoff.

Catchment Characteristics	Intact well-wooded hills, steep rocky slopes.
Present Ecological State	Moderately modified.
Key Ecosystem Services	Conveying water through the landscape, erosion control, sediment trapping, biodiversity support, nutrient cycling.

7.5.3 **Wetland Ecosystem Services**

The importance of wetland ecosystem services was assessed by considering:

- The effectiveness of a wetland in performing a function, and
- The opportunity for the wetland to provide a service.

Undisturbed wetlands with natural catchments may be effective at performing a suite of functions (usually regulatory) because the wetland is intact. However, because there are few people living in proximity to the wetland and there are few disturbances, the opportunity for the wetland to provide certain services (eg. water quality enhancement, crop cultivation, provision of natural resources) is reduced because there is nobody around to use these services. For this reason the importance of certain ecosystem systems ironically increases with increasing disturbance and modification. However, should the level of disturbance and modification reach a point where the effectiveness of the wetland to perform a function is permanently compromised, then the value of that service declines irrespective of the inherent opportunity.

The wetland HGM types share similar biophysical characteristics, and have been subjected to the same impacts. For the purposes of assessment the UVB wetlands were assessed individually because they are the most important systems in the landscape, and are likely to be the most impacted by the development. The remaining HGM units were divided into intact seeps and degraded seeps, and assessed collectively to reduce repetition.

At each wetland sampled a range of wetland and catchment characteristics were rapidly evaluated. The resulting scores were integrated to deliver a single wetland score for each recognised ecological service. The resulting scores were assigned the following categories to express the importance of the ecosystem service to wetlands with similar characteristics:

- 0 - Low
- 1 – Moderately Low
- 2 - Intermediate
- 3 – Moderately High
- 4 – High

A detailed summary of the ecosystem services provided by each HGM unit is provided in Table 7-13.

Table 7-13. Wetland Ecosystem Services for the Unki Wetlands

Ecoservice	HGM N	HGM O	Hillslope Seeps (Intact)	Hillslope Seeps (Degraded
Flood attenuation	1,8	2,0	2,1	2,1
Streamflow regulation	2,2	2,5	2,5	2,3
Sediment trapping	1,8	1,8	2,0	2,0
Phosphate trapping	2,2	2,2	2,2	1,4
Nitrate removal	2,4	2,4	2,6	1,7
Toxicant removal	2,0	2,1	2,0	1,3
Erosion control	1,9	2,9	**3,0**	1,9
Carbon storage	0,0	1,7	1,7	0,3
Maintenance of biodiversity	1,9	2,6	**3,0**	1,8
Water supply for human use	0,4	0,6	0,6	0,4
Natural resources	2,2	2,2	2,2	2,2
Cultivated foods	1,6	1,6	1,6	1,6
Cultural significance	1,0	1,0	1,0	1,0
Tourism and recreation	0,9	0,4	0,7	0,0

Unchannelled Valley Bottom Wetlands

The ability of UVB wetlands to contribute to catchment *flood attenuation* is at best moderate because once the wetland soil is saturated water moves straight across the surface, with slight attenuation provided by the vegetation. Under moderate to serious levels of disturbance this is reduced further by the removal of native vegetation (eg.by grazing) and the associated surface roughness. The extensive channel incision that has occurred within HGM N has confined longitudinal flow to the extent that peak flows are rarely spread across the width of the wetland, and the wetland's potential to provide this regulatory service is reduced further.

Streamflow augmentation is an important ecosystem regulatory service performed by UVB wetlands. The value is in the gradual, diffuse nature of subsurface multi-dimensional water flow through the wetland and catchment soil profile. This ecoservice remains intact in more modified systems, even with the loss of wetland and terrestrial vegetation. Once the level of disturbance reaches the serious or critical stage, the wetland becomes canalised and drained as the water influx into the wetland is altered from diffuse to concentrated at point-source. In this case HGM N has sustained pulses of longitudinal surface flow at unnaturally high volume and velocity from the dewatering of the underground mining operations. The confined surface flows have resulted in severe channel incision, and a subsequent drop in water table. The resulting increase in pressure differential has increased the rate of transit of water through the wetland, reducing the capability of the wetland to provide sustained perennial stream flow to downstream river systems.

The UVB wetlands play a role in *sediment trapping* and *erosion control*, and these are relatively important ecological services. This is, however, a binary outcome because vertic soils are highly stable if the soil surface and covering vegetation remain intact, but highly unstable if preferential flow-paths for surface flow are established. HGM O provides these regulatory services, but HGM N has lost capacity for these due to the introduction of multiple actively eroding gulley networks due to external disturbances.

Phosphate trapping, nitrate removal, and *toxicant removal* are recognised as being among the more important ecosystem services provided by UVB wetlands due to the interactions between diffuse water flow, soil and vegetation. For the two UVB wetlands on site, the value of these regulatory services to the landscape is at an ***intermediate*** level. HGM O is intact and is able to perform this function effectively, but it lacks the opportunity because there are few sources of pollutants in the catchment. The effectiveness of HGM N to perform this function has been compromised by the extensive canalisation that has occurred, together with the reduction in vegetation biomass resulting from heavy grazing. The mining tailings and infrastructure upstream, however, provide the opportunity to perform these functions because effluent periodically discharged into the wetland. Evidence for this is seen in the white salt precipitates that coat the channel surfaces.

Neither of the UVB wetlands play an important role in *supporting biodiversity*. The wetland habitats available have been severely impacted heavy grazing, desiccation and the general prevailing disturbance regime. The score is boosted by the comparative rarity of wetland habitats in the area.

The wetlands are mostly clastic (fine material is clay-based rather than organic), and carbon sequestration through anaerobic organic matter accumulation is limited by fluctuating water tables. Carbon storage is therefore of low importance in the UVB wetlands associated with the study area.

The UVB wetlands are important source of forage for cattle belonging to local communities, which is why the *provision of natural resources* yields ***intermediate*** scores. The remaining ecological services are not considered to be important since they return ***low*** and ***moderately low*** scores.

Seepage Wetlands (Hillslope Seeps)

The most important ecological services provided by seepage wetlands are:

- Streamflow augmentation: water seeps gradually out of the catchment soils and into the drainage networks even during periods without rainfall,
- Erosion control: seeps tend to be situated on slopes, and the dense vegetation is important in controlling sediment mobilisation,
- The supply of clean water to people and the landscape in general,
- Sediment trapping, and
- The maintenance of biodiversity.

The intact seeps are able to provide these services at an ***intermediate*** to ***moderately high*** level. The functioning of the degraded seeps has been compromised, and the wetlands are less effective at providing these services in spite of the increased opportunity provided by the landuse in the catchment.

7.5.4 **Present Ecological State (PES) and Riparian Ecological Integrity**

Wetlands are an expression of water moving through the landscape, and occur in the landscape where water is slowed down and appears close enough to, or on the surface of, the land for a sufficiently long time for wetland conditions to develop. Activities that alter the movement or quality of water moving through the landscape will thus have significant impacts on the wetlands. The results of the PES assessments for the wetland HGM units associated with the site are summarised in Table 7-14.

Table 7-14. PES of the wetlands associated with the study area.

Criteria and attributes	**STUDY SITE**									
HYDROLOGIC	**HGM N**	**HGM O**	**HGM F**	**HGM E**	**HGM D**	**HGM G**	**HGM I**	**HGM J**	**HGM K**	**HGM H**
Flow modification	0	0	5	0	0	4	0	5	5	0
WATER QUALITY										
Water quality modification	1	4	5	4	0	4	0	5	5	5
Sediment load modification	0	4	5	0	2	4	0	5	5	4
HYDRAULIC / GEOMORPHIC/PHYSICAL										
Canalisation	0	5	5	0	3	3	2	5	5	3
Impounding	1	5	5	4	0	2	0	5	5	1
Topographic alteration	1	5	5	1	0	5	5	5	5	4
Modification of key driver or keypoint	0	0	5	0	0	4	3	5	5	0
BIOTA										
Change in species composition and richness	1	2	3	0	0	3	3	4	4	3
Invasive plant encroachment	3	3	4	3	4	4	3	4	2	4
Over utilization of biota (including over-grazing)	0	0	0	0	0	0	0	0	0	0
Land-use modification (including conversion to pasture or crops)	1	4	5	0	0	4	1	2	4	0
TOTAL	8	32	47	12	9	37	17	45	45	24
MEAN	**0,7**	**2,9**	**4,3**	**1,1**	**0,8**	**3,4**	**1,5**	**4,1**	**4,1**	**2,2**

PES	E	C	A	E	E	B	D	A	A	D

The catchment surrounding the wetlands in the study area is almost intact, and many of the wetlands have sustained minimal disturbance or impact. These are almost intact and are considered to be unmodified and ***natural*** or ***largely natural***. HGM O has been affected by the large borrow-pit in its upper reaches, which has essentially removed the water inputs from this part of the catchment. It is ***moderately modified*** (category C).

The large UVB wetland (HGM N) is has been severely impacted by:

- The discharge of large quantities of water into its upper reaches, which has eroded a series of large gullies through the centre of the wetland;
- The discharge of poor quality water into the wetland;
- Poorly designed impoundments which serve to concentrate surface flow and exacerbate soils erosion;
- The road across the bottom of the wetland, which has both confined flow (exacerbating erosion upstream) and trapped sediment, causing an impediment to surface flow.
- The excavation of a borrow pit and a broad flow-path within the wetland. This has introduced eroding faces to the wetland, resulting in severe lateral gully erosion;
- The establishment of a soil stockpile in the upper reaches of the wetland.

The wetland has an E category PES score, meaning that it is ***severely modified***. The potential reversibility of these impacts prevents the wetland from being considered critically modified. Similar impacts are affecting HGMs H, I, D and E and these are considered to be ***largely*** to ***seriously modified***, with extensive loss of ecosystem processes and functions.

The riparian B-channel into which the wetlands drain (HGM M) is ***moderately modified*** (Table 7-15). Several severe impacts were observed, namely:

- Channel scouring and erosion;
- Poor water quality (salt stains on the rocks);
- Flow modification, with unnaturally large pulses of longitudinal surface flow from upstream; and
- Sediment deposition within the channel.

Table 7-15. Riparian Habitat Integrity score for HGM M

Riparian Zone	
Criterion	**Score**
Water Abstraction	0
Flow Modification	20
Channel modification	15
Water Quality Modification	20
Inundation	5
Vegetation Removal	0
Exotic Vegetation Encroachment	4
Bank Erosion	16
Total	**59,7**
Category	**C**

7.5.5 Ecological Importance and Sensitivity (EIS)

The self-evident results of the Ecological Importance and Sensitivity (EIS) assessments for the respective wetlands is provided in Tables 7-16. Units O, F and K are considered to be of ***Moderate*** ecological importance and sensitivity, where they are ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications, and they play a small role in moderating the quantity and quality of water of major rivers.

The remaining wetlands are of ***Low or Marginal*** ecological importance. These wetlands are not considered to be ecologically important and sensitive at any scale *in their current state*. The biodiversity of these wetlands is common and widespread, and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers. The main reason for these low sensitivity grades is that the wetlands do not support any significant biodiversity asset. This is mainly due to:

- Their small size;
- The desiccation of much of the wetland habitat; and
- The heavy, sustained grazing that has homogenised the habitats and removed cover for fauna.

Table 7-16. EIS scores for the wetland HGM units

	HGM									
	N	**O**	**F**	**E**	**D**	**G**	**I**	**J**	**K**	**H**
1. Rare and endangered species	0	0	0	0	0	0	0	0	2	0
2. Populations of unique species	0	0	1	0	0	0	0	0	2	0
3. Species / taxon richness	1	1	2	0	0	1	0	0	3	0
4. Diversity of habitat types or features	1	1	2	1	0	1	0	1	3	0
5. Migration/breeding and feeding site for wetland species	0	0	0	0	0	0	0	0	2	0

	HGM									
	N	O	F	E	D	G	I	J	K	H
6. Sensitivity to changes in natural hydrological regime	4	3	4	3	1	1	1	2	4	2
7. Sensitivity to water quality changes	2	2	3	3	1	1	1	1	3	2
8. Flood storage, energy dissipation and particulate/element removal	1	2	2	2	1	1	1	1	2	1
MODIFYING DETERMINANTS										
9. Protected status	2	2	2	2	2	2	2	2	2	2
10. Ecological integrity	1	3	4	1	1	3	3	4	1	1
TOTAL	12	14	20	12	6	10	8	11	24	8
MEDIAN	1	2	2	1	1	1	1	1	2	1
EISC	D"	C	C	D"	D"	D"	D"	D"	C	D"

The sensitivity of each HGM units is illustrated in Figure 7-18.

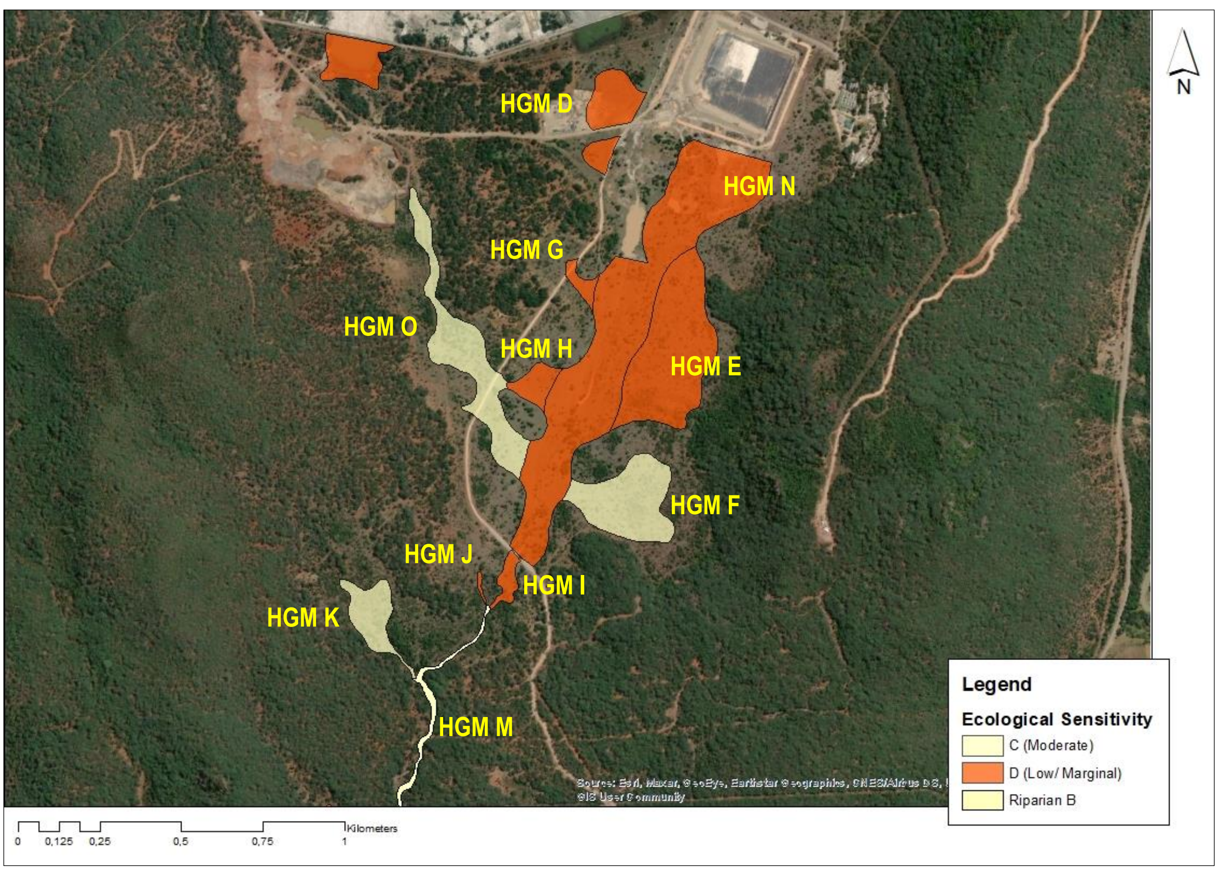


Figure 7-18. Sensitivity map for the aquatic habitat associated with the study area.

8 LEVELS OF MODIFICATION OF HABITATS AND ECOSYSTEM SERVICES

This section evaluates the level of disturbance to the main habitats and the natural functioning of the ecosystems, and the services they provide

8.1 ECOSYSTEM SERVICES (IFC PERFORMANCE STANDARD 6)

Ecosystem services are the benefits that humans and other creatures, derive from ecosystems. Ecosystem services are divided into four types:

(i) *provisioning services*, which are the products people obtain from ecosystems; **Examples in this project are freshwater, food (wild fruits, honey), wood (firewood and poles for huts), thatching grass, medicinal plants, grazing for livestock.**

(ii) *regulating services*, which are the benefits people obtain from the regulation of ecosystem processes; **Examples are surface water purification by wetlands, amelioration of flooding by wetlands, carbon sequestration and storage by woodlands and grasslands, regulation of climate.**

(iii) *cultural services*, which are the nonmaterial benefits people obtain from ecosystems. E**xamples are aesthetic enjoyment of scenery, sacred sites**

(iv) *supporting services*, which are the natural processes that maintain the other services. **Examples are nutrient cycling, soil formation, primary production (trapping of the sun's energy through photosynthesis)**

Biodiversity is the underlying basis for these services that ecosystems provide and thus by conserving biodiversity we are helping to protect these services. The objective of the Performance Standard is to assist in the sustainable management of the project's impacts and to mitigate these impacts on biodiversity and ecosystem services throughout the project's lifecycle.

8.2 IFC DEFINITIONS

The IFC Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources classified habitats under the following three main categories.

8.2.1 Modified Habitat

Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Examples of this habitat are the agricultural fields adjacent to the claim boundaries and the farm homesteads and villages.

8.2.2 Natural Habitat

Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition. Examples of these habitats are the patches of well-developed miombo woodlands, the wetland (vlei) and the riparian woodlands.

8.2.3 Critical Habitat

Critical habitats are areas with high biodiversity value, including:

(i) habitat of significant importance to Critically Endangered and/or Endangered species;
(ii) habitat of significant importance to endemic and/or restricted-range species;
(iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species;
(iv) highly threatened and/or unique ecosystems; and/or
(v) areas associated with key evolutionary processes.

No critical habitats were identified in the immediate project area but the serpentinite soils in the north of the claim support 9 species of endemic plants. These are unlikely to be affected by this development so are not considered here.

Habitats that are considered sensitive receptors are the riparian and aquatic habitats in the rivers and the miombo woodlands. **Table 8-1** below lists the main habitats and their current level of modification.

Table 8-1: Main Habitat types and levels of modification

Habitat Type	IFC Classification	Level of Modification	Biodiversity Value
Aquatic and Wetland Habitats	Modified / Natural and Sensitive	Partially modified by construction of road, bridge and weir on the un named stream. Erosion channels in the wetland indicate recent changes in the hydrology with increased water flow and erosion. Siltation of stream bed. The open grassland / wetland habitat occurs in areas of black clay soils (hydric soils). The grassland is heavily grazed by cattle and grass species richness is low. Upper section of the wetland is highly modified by the presence of a	Fairly high although some sensitive species have probably been lost. The presence of fish, frogs and dragonflies indicate that aquatic ecosystems are still functional. High. The wetlands are hydrologically important acting as sponges, reducing the impact of heavy rains and flooding and acting as biofiltration systems. The PES is the provision of clean fresh

Habitat Type	IFC Classification	Level of Modification	Biodiversity Value
		tailings dam and a return water dam, mine housing, offices, construction camp and large quarry/borrow pit.	water to wildlife and downstream communities. **This habitat meets the AA criteria for a Significant Biodiversity Feature (SBF)**[12]
a) Riparian Woodland on alluvial soils	Natural	Medium modification on the Umtebewana and Umtebekwa rivers, with some signs of past fires, trees have been felled, and invasion of *Lantana*. Stream bank cultivation in places and regular movement of livestock is destabilising the river banks.	Medium – High. The rivers are a very significant source of water for local communities, their livestock and to wild fauna
b) Miombo Woodland (Julbernardia-Brachystegia)	Natural	Medium modification. Outside the claim boundaries trees have been felled to make way for agricultural fields, cut for poles (housing) and firewood;	Medium. Type is widespread through project area but the patches of woodland provide spatial heterogeneity and niches for wild fauna. Large trees are important nesting sites for raptors (birds of prey). Woodlands also act as traps for rainfall, reducing run off and allowing slow drainage of underground water towards the central drainage line. The presence of epiphytic orchids, aloes and flame lilies increases the biodiversity value of these woodlands. The PES is the sequestration of significant volumes of carbon, nutrient re cycling and primary production.

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Natural habitat, of a pristine or degraded condition which supports biodiversity, ecological processes and/or ecosystem services.

Habitat Type	IFC Classification	Level of Modification	Biodiversity Value
b) Acacia woodland on heavy soils or disturbed soils	Natural – some Modified	Medium- High. Localised modification where land has been cultivated or over grazed	Low. The habitat type is very widespread
Cultivation	Modified	High. Where the cultivation has been intense and long term, the level of modification is high, although some ecological processes still continue, albeit at a reduced rate: e.g., nutrient re-cycling. Invasive and weedy species are common e.g., *Tagetes, Bidens, Lantana*	Low. Wildlife and indigenous plant species absent or in low numbers; habitats highly modified.
Settlement	Highly modified	High. Many ecological processes have been compromised, except in vegetable gardens and fields. Weedy species common.	Low. There may be some introduced trees and ornamental plants in gardens.

8.3 HABITAT SENSITIVITY

The wetland and stream that runs through the project area are the most sensitive habitats. Removal of trees and other woody plants along the rivers will lead to instability of the river banks, increasing erosion and exacerbating the effect of flooding. In addition, the aquatic environment is vulnerable and sensitive to pollution from chemicals, fuels etc that may run off from the BESS, laydown and construction areas. The map below shows the infrastructure lay out and the environmental constraints of the wetland.

Habitats that are moderately sensitive and vulnerable are the miombo woodlands. Loss of woodland will lead to reduced penetration of rainfall and therefore increased run off and soil erosion. Maintaining a patchwork of undisturbed woodlands is also important for spatial diversity of birds and other animals that find refuge and breed in these habitats. Miombo woodlands have an intrinsic resilience and if not too damaged are capable of recovery, although with slow growing hardwood species this can take many years.

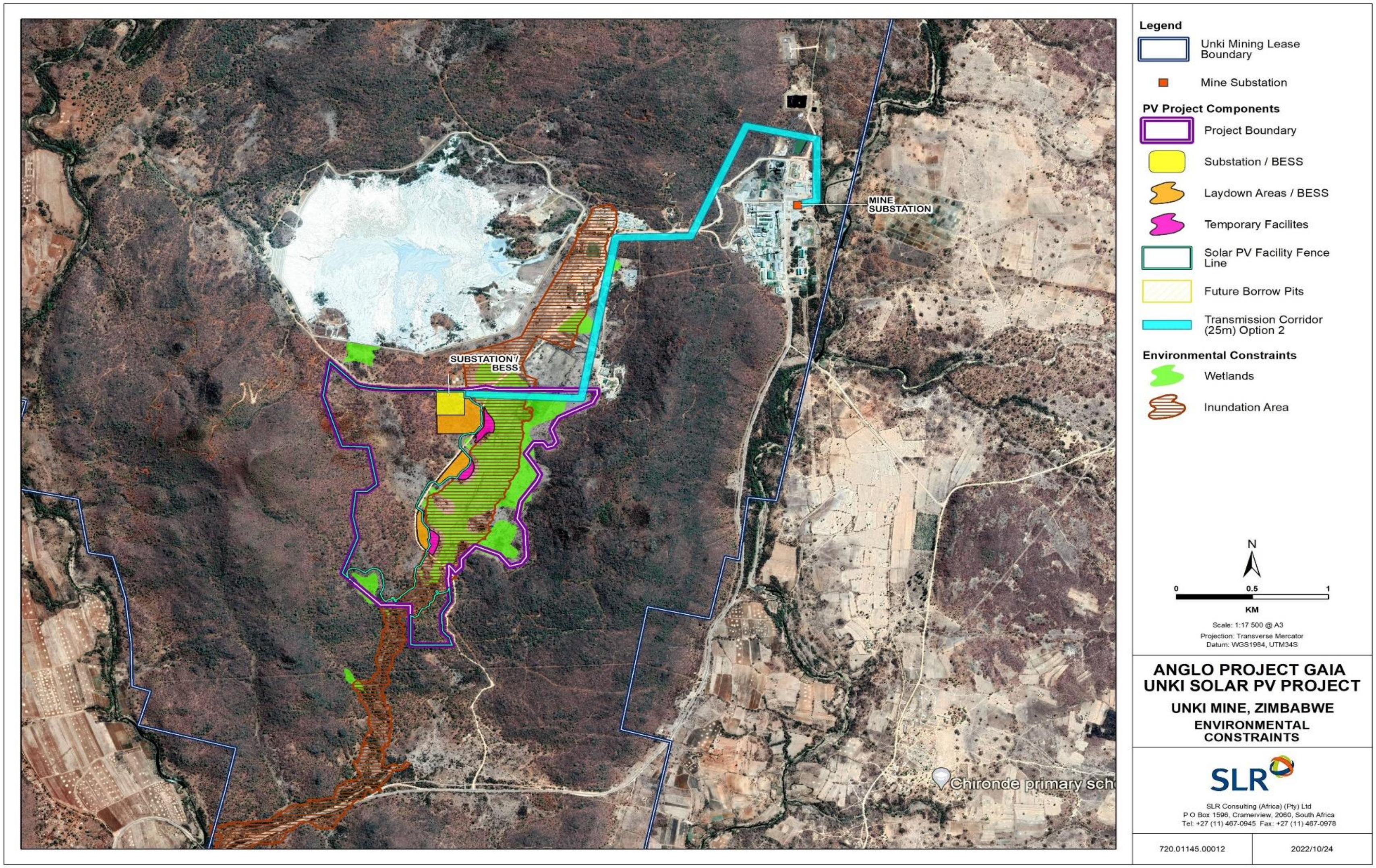

Figure 8-1: Infrastructure lay out and wetland constraints

9 IMPACT ANALYSES

9.1 General Discussion

The project, although commendable in its intention, will result in very significant irreversible changes to an area of indigenous miombo woodland habitat and associated biodiversity. There will be changes to soils, topography, hydrology, wild flora and fauna, and to local communities. In the planning phase of the project it should be axiomatic that a decision-making hierarchy is applied in order to reduce the negative impacts and enhance any positive ones and ensure compliance with AA environmental policies, national legislation and commitments to international best practice.

Through the implementation of a mitigation hierarchy, projects can also minimize the costs of implementing mitigation measures as well as reduce the long-term costs associated with progressive rehabilitation, and with post-closure rehabilitation. Implementing mitigation measures that prioritize avoidance and minimization of impacts over restoration and offsets ultimately makes economic and ecological sense.

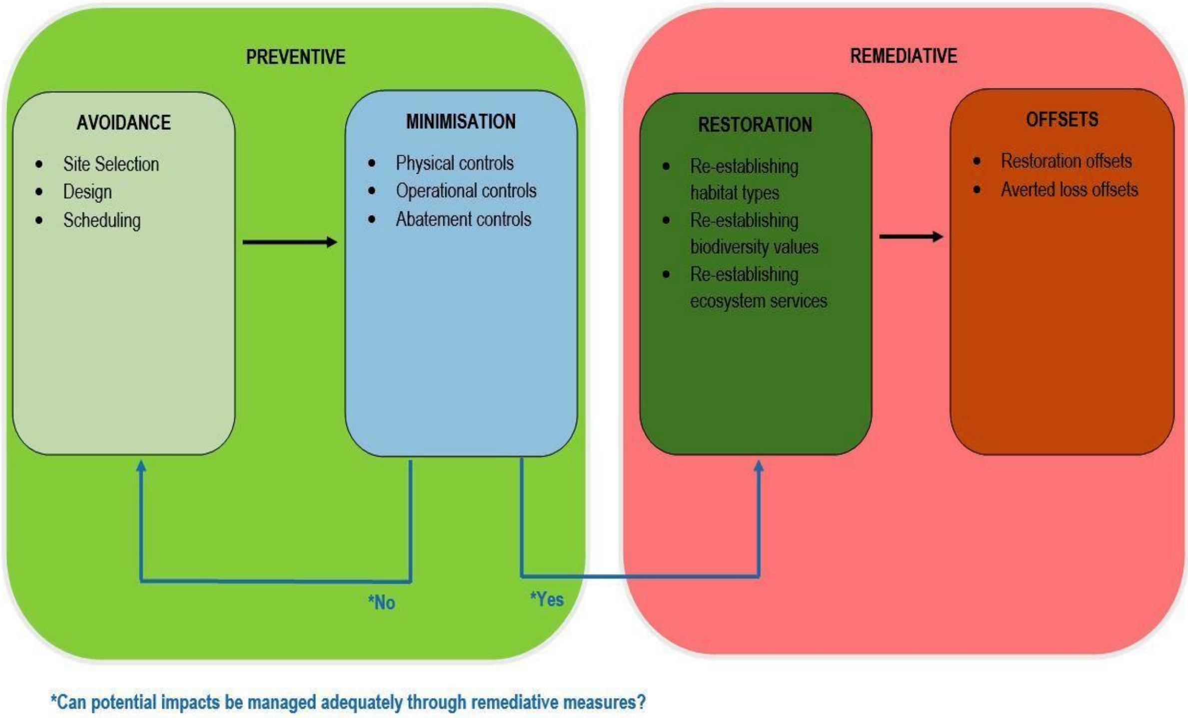

Figure 9-1 : Diagram illustrating the hierarchy of mitigation measures (redrawn from the Biodiversity Consultancy, CSBI 2015)

1. Avoid or minimise at the source so that the factor inducing the impact is eliminated through improved design and management. Avoiding or minimising at the source is the highest priority action. The project site was originally on a wetland but was then re-located to an adjacent area of miombo woodland.

2. Minimise or abate on site (front of pipe), which entails modifying or improving the basic design of the project activities and elements that impact biodiversity to abate or decrease these impacts before they reach the natural environment. For example, re-cycle water to reduce abstraction from the environment, appropriate design of storm water drainage systems to prevent soil erosion and run off from potentially polluted areas such as the battery storage facility and substation.

3. Minimise or Abate at receptor (end of pipe), which includes implementing mitigation measures at the receptor if an impact cannot be abated on site (e.g. fencing to prevent large animals straying onto the site).

4. Restoration or repair applies when there are unavoidable impacts to a resource. Mitigation measures are employed in an attempt to restore the original habitat and species distribution. For example, areas that are degraded/disturbed should be replanted with indigenous plants. Local tree nurseries established so that species that are already adapted to the soils and climate of the site are used.

5. Compensation or Offsets should only be used when other mitigation measures are not sufficient or possible or when there are significant residual negative impacts that cannot be avoided. It should be the last resort for mitigation. The process of identifying suitable areas for offset, and the appropriate type of offset action will require quite detailed investigation to ensure that the intervention is in fact effective. It is also important to take into account potential conflicts (land use, compensation, finding suitable areas for relocation of households) and the accumulative impacts that may jeopardize the natural and social environment of the general area. This is particularly true of mining activities adjacent to the project area where the negative impacts of one operation may complicate effective environmental management of the other.

While the biodiversity baseline study covered the whole project area including the two options for transmission lines, this impact analysis focused on the new site, i.e. the woodland to the west of the original wetland site, as at the time of writing this was the final selected location.

SLR provided the format and evaluation methods used in this analysis that considered impacts relating to biodiversity and the functioning of the natural environment. Only the three phases, pre-construction, construction and operation were examined since the project is long term.

9.1.1 Pre-construction phase

Activities prior to construction on the PV site and transmission line route should include a detailed topographical, soil and hydrology mapping to inform the final layout of the infrastructure. It is unlikely that any of these activities will cause a significant impact.

Other actions that should be done in the pre-construction phase in order to mitigate the very significant impacts that will occur during construction are:

- Locate all specially protected plants within the site prior to any rescue and re-locations
- Identify suitable safe areas off site for the plants to be moved into

- A comprehensive check for active raptor nests and if any are found, the birds are left undisturbed until the chicks have fledged.

Further details of these actions are given in the report.

9.1.2 Construction phase

a) Transmission lines

Two options for the transmission line routes were checked during the August field work. A comparison of the two options indicates that Option 2 (the northern line) is the better route.

- Option 1 (southern route): is longer, it will result in the clearing of large tract of woodland on the Chironde Hills and most importantly will cut across the known flight paths of Martial Eagles and African Hawk Eagles that frequent the hills, raising the threat of bird collisions with the line.
- Option 2 (northern route): is the shorter route and will traverse areas around the TSF, return water dam and staff camps that are already very disturbed so the impact is considerably less than Option1.

Prior to constructing the transmission line the route will need to be cleared of vegetation for the width of the wayleave about 15-20m and foundations for the towers dug. During the construction of the transmission line will erected but only become live in the operational phase.

b) Solar PV Site, Substation and BESS

Construction activities will result in a great deal of physical change to the structure, ecology and environmental services on the site. The close proximity of the wetland means that it will be affected by the construction activities, particularly the clearance of laydown areas and vehicle parking.

9.1.3 Operational phase

Once the PV farm has been constructed and the contractor's camps and lay down areas rehabilitated, the daily operations will only require a small number of personnel. Noise and traffic levels should diminish considerably. The substation and transmission line will be active making the line live. There will need to be routine maintenance of the facility and clearance along the line. Water usage will decrease from construction levels and a supply will only be needed for the office and substation sewerage system and for cleaning the panels. The rainfall run off from the panels will need to be controlled in such a way as to reduce any erosion of the wetland and if possible enhance the water table of that area.

9.2 VEGETATION CLEARING OF SOLAR SITE, ASSOCIATED INFRASTRUCTURE AND TRANSMISSION LINE

Miombo woodland trees are adapted to a savanna climate and have extensive, robust rooting systems and are capable of regenerating through coppice shoots from their roots, even when the main tree trunk and branches has been removed. There are two options to prevent this re-shooting:

either physically remove the roots or treat the cut stumps with herbicide. It is not known which method will be used.

Construction activities will result in unavoidable, largely irreversible clearing of natural vegetation for panel installation, associated infrastructure (substation, battery storage, office) and the transmission line from the site to the mine. This will result in the direct physical effect of increased run off from rainfall, increased soil erosion that, without mitigation will lead to increased flooding, and a decreased recharge of wetlands. There will be a direct ecological effect with decreased biodiversity (floral and faunal habitats), decreased carbon storage and carbon sequestration and an indirect effect of increased spread of alien invasive species and weeds in disturbed areas. All of these impacts will negatively affect the services provided by the ecosystems.

9.2.1 Impact: Vegetation Clearance

Description of Impact: Clearance of mature miombo woodland		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Prominent change (High)
Duration	Permanent (Very Long)	Long-term (High)
Extent	Whole site (Low)	Whole site (Low)
Consequence	High	Medium
Probability	Definite / Continuous	Probable
Significance	**High -**	**Medium -**
Degree to which impact can be reversed	*The loss of woodland and biodiversity on the site is irreversible*	
Degree to which impact may cause irreplaceable loss of resources	*High: Miombo trees are slow growing and long lived so recovery after project closure is very slow*	
Degree to which impact can be avoided	*None: the site is in a woodland*	
Degree to which impact can be mitigated	*Medium: some of the impact can be offset with careful protection, rehabilitation and management of existing woodlands outside the site. Re-forestation and wood lots are additional mitigation measures but need be implemented judiciously so they do not create more problems than they solve.*	
Cumulative impact		
Nature of cumulative impacts		
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	High -	**Medium -**
Cumulative impact		

Nature of cumulative impacts	*Removal of yet another patch of woodland in an area that is already under threat from mining, tree felling, bush fires will have a cumulative negative impact on the local environment and biodiversity.*

Mitigation Measures:

A contractor's code of conduct should be drawn up by the proponent and regular compliance checks made.

Laydown areas, access roads to the site and contractors' camps need to be clearly demarcated during the pre-construction and so that destruction of vegetative cover outside the actual site is minimized. Once the construction has been completed, these areas should be rehabilitated by encouraging the regeneration of natural species, preventing the invasion of alien weedy species and replanting indigenous species if necessary.

Top soil that may have been removed during construction should be stored in covered heaps and spread out under the panels to encourage re-establishment of indigenous grasses and small shrubs.

Branches and leaves should be composted on site and used in the rehabilitation of the disturbed areas.

The area is already subjected to regular hot burns and this may increase with the presence of construction camps and workers. Mitigation: ensure that the construction contractors abide by the mine policy of no uncontrolled fires. Have a fire warning and reaction team in place to manage wild fires.

9.2.2 Impact on seasonal wetland and grassland adjacent to the site

Impact 1: Loss of wetland habitat and biodiversity

The solar panels will remove HGMs O, H, G and part of HGM D from the landscape. Although the habitat and biodiversity value of these wetland is low, these could potentially be improved through management and rehabilitation activities. The development will forego the opportunity to return wetland habitat and biodiversity to this landscape.

The direct impact is severe, although it is superimposed on an existing impact which mitigates the magnitude of the risk to *medium*. Rehabilitation and management of intact wetland in the study area will have a positive impact on the quality of habitat available for aquatic biodiversity, compensating for the loss of habitat through the development.

The catchment has undergone a substantial reduction in wetland area, and further removal of wetlands will have a *high* cumulative impact on the local landscape. This cumulative risk may be reduced by strategically restoring degraded wetlands.

Mitigation measures

According to the mitigation hierarchy, avoiding or minimising this impact is not feasible.

Rehabilitating and managing the wetlands that remain outside the planned development, and improving the quality of the wetland habitat available for aquatic flora and fauna, is a viable way to replace the lost potential biodiversity asset. Implementing a biodiversity-friendly grazing and burning strategy would be an important component of a future management plan.

Loss of Wetland Habitat and Biodiversity		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Moderate change (Medium)
Duration	Permanent (Very Long)	Long-term (High)
Extent	Part of site (Very Low)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Probable
Significance	**Medium -**	**Medium -**
Degree to which impact can be reversed	*Unlikely to be reversible.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: foregoing the potential to regain lost wetland habitats.*	
Degree to which impact can be avoided	*None: Not avoidable*	
Degree to which impact can be mitigated	*High: impact can be successfully offset by the improvement in wetland habitats in the rest of the study area.*	
Cumulative impact		
Nature of cumulative impacts	*Negative*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	High -	**Low -**
Cumulative impact		
Nature of cumulative impacts	*There has been a substantial loss of wetland habitat from the local area.*	

Impact 2: Loss of wetland functioning from the landscape

The solar panels will remove wetland functional habitat from the landscape. Key ecological services lost are streamflow augmentation, water quality enhancement, erosion control and sediment trapping. Although the level of wetland ecoservice delivery is currently low, this could potentially be improved through management and wetland rehabilitation activities. The development will forego the future opportunity to return wetland functional habitat to this landscape.

The direct impacts of the development will unavoidably be *high* and negative as wetlands are removed from the landscape. However, opportunity exists to make substantial gains by rehabilitating degraded wetlands in the area to offset the loss of wetland functional area. The potential gains will have a *high* positive impact.

Mitigation measures

According to the mitigation hierarchy, avoiding or minimising this impact is not feasible. Rehabilitating and managing the degraded wetlands that remain outside the planned development is a viable way to replace the lost wetland functioning. It is possible to quantify the current level of ecosystem functioning of all of the wetlands in their current state, as well as that under a conceptual rehabilitated scenario, and compare the two state using hectare-equivalents as a currency. It is then possible to show that the improvement in wetland functioning caused by rehabilitation measures in certain wetlands is able to compensate for the wetland functioning lost through the development. This would ensure a no net loss of wetland functioning at the landscape level, a development objective that is regarded as international best practice.

Loss of Wetland Functioning		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Prominent change (High)
Duration	Permanent (Very Long)	Long-term (High)
Extent	Beyond site (Medium)	Beyond site (Medium)
Consequence	High	High
Probability	Probable	Probable
Significance	High -	High -
Degree to which impact can be reversed	*Unlikely to be reversible.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: foregoing the potential to regain lost wetland functioning.*	
Degree to which impact can be avoided	*None: Not avoidable*	
Degree to which impact can be mitigated	*High: impact can be successfully offset by the rehabilitation of degraded wetland habitats in the rest of the study area.*	
Cumulative impact		
Nature of cumulative impacts	*Negative*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	High -	Medium -
Cumulative impact		
Nature of cumulative impacts	*There has been a substantial loss of wetland habitat from the local area.*	

Impact 3: An increase in the volume and velocity of water entering the receiving environment

Under natural conditions rainfall would either enter the catchment soils and filter through into the wetlands as seeping interflow, or flow along the surface as runoff. However, the rocky catchment surfaces offer resistance to flow, dissipating it prior to gradual, diffuse discharge into the wetland. The solar panels will have two effects:

1. They will intercept rainfall that would have entered and been stored in the soil, and discharge this directly into the receiving environment; and
2. The surface roughness is removed, and runoff could enter the receiving environment at a greater rate than under current conditions.

The consequences of a greater volume of water entering the receiving environment at a greater rate are likely to be soil erosion and sediment deposition downstream, leading to further environmental degradation.

The risk of this occurring is v*ery high*, but with appropriate mitigation the risk can be reduced to *medium*, or even *low*.

Mitigation measures

This impact can be reduced to acceptable levels, and the risks minimised, by the design and construction of appropriate runoff storage features and stormwater attenuation facilities to properly manage stormwater prior to its discharge into the receiving environment.

Increase in Volume and Velocity of Surface Inputs		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Minor change (Low)
Duration	Long-term (High)	Long-term (High)
Extent	Far beyond site (High)	Beyond site (Medium)
Consequence	Very high	Medium
Probability	Definite / Continuous	Probable
Significance	**Very high -**	**Medium -**
Degree to which impact can be reversed	*Mostly reversible.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: soil erosion, sediment deposition in downstream water resources, further loss of wetland habitat.*	
Degree to which impact can be avoided	*High: Avoidable*	
Degree to which impact can be mitigated	*High: rainfall runoff storage and attenuation in a stormwater management plan.*	
Cumulative impact		
Nature of cumulative impacts	*Negative*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	High -	**Low -**
Cumulative impact		
Nature of cumulative impacts	*The runoff associated with an increase in hardened surfaces has had an impact on aquatic systems in the vicinity of the mine.*	

Impact 4: Erosion and sediment mobilisation

Construction activities such as vegetation clearance and earthworks increase the potential for soil erosion and sediment deposition into the adjacent wetlands. High sediment loads in watercourses can be transported for some distance downstream and reduce dissolved oxygen, smother natural gravel bed materials, and settle out changing flow dynamics in channel morphology. There is a medium risk of this impact occurring without mitigation. The risk is reduced to low if mitigation measures are adopted.

Mitigation measures

Install cut-off drains parallel to work/cleared areas to control run-off from adjacent areas; and
Implement sediment control measures such as bunds, berms, and silt fencing where watercourses may be affected.
The temporary storage areas and earth platforms should have a formal stormwater management plan included in the Biodiversity Management Plan (BMP).

Earthworks should commence in the dry season, with vegetation clearance during the wet season avoided.

Soil Erosion and Sediment Mobilisation		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Pre-construction	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Prominent change (High)	Minor change (Low)
Duration	Short-term (Low)	Short-term (Low)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Low
Probability	Probable	Probable
Significance	**Medium -**	**Low -**
Degree to which impact can be reversed	*Reversible*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: soil erosion, sediment deposition in downstream water resources, damage to aquatic habitat downstream.*	
Degree to which impact can be avoided	*High: Avoidable*	
Degree to which impact can be mitigated	*High: sediment traps, cut-off berms, sequential excavation so that only part of the site is bare of vegetation at any one time, time of year for excavations.*	
Cumulative impact		
Nature of cumulative impacts	*Negative*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	High -	**Low -**
Cumulative impact		
Nature of cumulative impacts	*The deposition of soil into aquatic systems at a catchment level has negative impacts on major water resources downstream.*	

Impact 5: Point-source discharge of rainfall runoff into the receiving environment

The wetlands in this landscape are driven by diffuse subsurface and surface water flow. The vertic soils are stable as long as the soil surface and its vegetation cover remain intact. They become highly unstable should confined surface flow breach the soil surface. The resulting confined longitudinal flow invariable results in an incised channel that extends along the length of the wetland, resulting in a drop in water table, drying of the system and destruction of the wetland. The significance of this impact is *high* without mitigation, and *very low* with suitable mitigation.

Mitigation measures

Ensure that runoff is appropriately attenuated;

Runoff should be discharged into the receiving environment across a wide surface to encourage diffuse flow, or through multiple small discharge points rather than a few large ones.

Point source discharge of rainfall runoff		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Severe change (Very high)	Minor change (Low)
Duration	Long-term (High)	Short-term (Low)
Extent	Beyond site (Medium)	Part of site (Very Low)
Consequence	High	Very low
Probability	Probable	Probable
Significance	**High -**	**Very low -**
Degree to which impact can be reversed	*Reversible*	
Degree to which impact may cause irreplaceable loss of resources	*High: confined flow may result in severe soil erosion, gully formation and sediment deposition downstream.*	
Degree to which impact can be avoided	*High: Avoidable*	
Degree to which impact can be mitigated	*High: careful planning of introduction into the receiving environment, multiple small points or diffuse spreader canal.*	
Cumulative impact		
Nature of cumulative impacts	*Negative*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	High -	**Very low -**
Cumulative impact		
Nature of cumulative impacts	*Direct, all of the roads and hardened surfaces in the catchment tend to discharge via point source leading to considerable sediment deposition downstream.*	

9.2.3 Impact: Loss of Rare or Specially Protected Plant Species

The miombo woodlands support several colonies of aloes and some of the old growth trees carry clusters of epiphytic orchids. Flame Lily (*Gloriosa superba*), *Orbea caudata* subsp *rhodesiaca* and several species of terrestrial orchids have been recorded in and around the site. These plants occur elsewhere in the area and country. Construction activities will cause destruction of these plants and their habitats but the impact can be relatively easily mitigated through a careful transplanting programme.

Description of Impact: loss of specially protected and rare plants	
Type of Impact	Direct
Nature of Impact	Negative
Phases	Construction

Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Minor change (Low)
Duration	Medium-term (Medium)	Short-term (Low)
Extent	Beyond site (Medium)	Beyond site (Medium)
Consequence	Medium	Low
Probability	Definite / Continuous	Probable
Significance	Medium -	Low -
Degree to which impact can be reversed	*Partially reversible: The potential loss of aloes, orchids and other protected plants can be mitigated*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: Unless there is a comprehensive check on the location of epiphytic orchids, aloes and Orbea caudata plants prior to construction there will be an irreplaceable loss.*	
Degree to which impact can be avoided	*Low: the removal of all trees and vegetative cover cannot be avoided*	
Degree to which impact can be mitigated	*High: Most of these plants are easy to transplant, except the Flame Lily and terrestrial orchids. These can only be located when they are in their above ground stage flowering stage and unless carefully transplanted, are unlikely to survive.*	
Cumulative impact		
Nature of cumulative impacts		
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Low -	Very low -
Cumulative impact		
Nature of cumulative impacts	*Fragmentation of the habitats will have a localised impact on food sources for birds (feeding on aloe nectar) and pollinators (feeding on orchid nectar).*	

Mitigation Measures:

Develop and implement a plant rescue plan in liaison with the National Herbarium and with Parks and Wildlife Management Authority and the Aloe Society of Zimbabwe to ensure that an appropriate rescue operation is done before any clearing of land, construction starts. Carefully remove the aloes and transplant them to suitable safe areas of similar habitat elsewhere in the Unki claim area. When transplanting any trees or tall aloes, mark the north on the trunk and replant the aloe facing the same direction as its original position. When rescuing epiphytic orchids, the plants should preferably be removed in situ on the branches and re-located to the same position on a similar sized tree of the same species in the safe area. Rescuing flame lilies and terrestrial orchids can be done through carefully digging up the rhizomes and replanting in safe patches of miombo woodland. Terrestrial orchids do not generally transplant well into gardens as they have specific mycorrhizae fungi.

9.2.4 Impact: Loss of Carbon Storage and Sequestration

The removal of trees and other vegetation on the site will result in the release of stored carbon and the loss of future carbon sequestration potential. Although this impact is localised it should be considered in the overall evaluation of the project.

Description of Impact: Release of stored carbon dioxide and loss of sequestration potential		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Moderate change (Medium)
Duration	Long-term (High)	Long-term (High)
Extent	Whole site (Low)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Conceivable
Significance	Medium -	Low -
Degree to which impact can be reversed	*Partially reversible: The loss of carbon storage and sequestration can be offset*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: Carbon storage and sequestration on site will be lost*	
Degree to which impact can be avoided	*None: the site will be cleared of trees*	
Degree to which impact can be mitigated	*Medium: The loss can be mitigated through offsets (see main text for more details)*	
Cumulative impact		
Nature of cumulative impacts		
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -
Cumulative impact		
Nature of cumulative impacts	*It is very likely that the loss of woodlands around the project area and in the region will continue*	

Mitigation Measures:

The impact can be mitigated through a carefully planned and implemented compensation/ offset programme that should take into account the following aspects:

a) Ensure the relatively undisturbed woodland and grassland habitats around the site are protected and thus provide refuges for fauna that have been displaced by the project. This protection needs to be a collaborative effort between the proponent and Unki Mine.

b) Restoration of laydown and workers' camp areas that are damaged and disturbed. Mitigation measures should include replanting of indigenous grasses, forbs and woody species and control of alien invasive plant species such as *Lantana*. The control of invasive plants should be a joint programme with Unki Mine (see below)

c) Protection and rehabilitation of natural vegetation elsewhere in the claim area as compensation. Suitable sites should be chosen in collaboration with Unki Mine as part of the AA net positive impact plan.

d) Establishment of plantations and woodlots should only be considered as a last resort. Alien trees such as Eucalyptus have a negative impact on water tables and are not always appropriate although they are quick growing and robust. It is important to take into account potential conflicts (land use, compensation, finding suitable areas for relocation of households) and the accumulative impacts that may jeopardize the natural and social environment of the general area. This is particularly true of mining activities adjacent to the project area where the negative impacts of one operation may complicate effective environmental management of the other.

9.2.5 Impact: Spread of alien invasive plant species

Construction of the plant infrastructure and excavations will result in disturbances to the soil surface that encourages the proliferation of weeds and pioneer plants. There may be a loss of natural vegetation species due to competition from alien invasive plants. This is a long-term impact but reversible and if mitigated, the level of the impact will be reduced.

Description of Impact: Spread of invasive plant species		
Type of Impact	Indirect	
Nature of Impact	Negative	
Phases	All	
Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Negligible change (Very Low)
Duration	Long-term (High)	Long-term (High)
Extent	Whole site (Low)	Whole site (Low)
Consequence	Medium	Low
Probability	Probable	Probable
Significance	Medium -	**Low -**
Degree to which impact can be reversed	*Partially reversible: alien invasive plant control programme is needed*	
Degree to which impact may cause irreplaceable loss of resources	*Low: If controlled the impact on indigenous flora will be low*	
Degree to which impact can be avoided	*Low: construction activities will cause loss of flora and create conditions for the spread of weedy and invasive plants*	
Degree to which impact can be mitigated	*High: Implement invasive plant control programme in operational phase*	
Cumulative impact		
Nature of cumulative impacts		

Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Medium -
Cumulative impact		
Nature of cumulative impacts	*Invasive plants are generally robust and easily dispersed, establishing themselves rapidly in disturbed soil. As more and more natural vegetation is disturbed by roads, clearing, overgrazing, extensive fire, the indigenous plants will be out competed in these places.*	

Mitigation Measures:

Develop a programme for the removal of *Lantana* and any other invasive or weedy plants from the solar plant area, paying particular attention to the riparian fringes downstream of the site.

Specific Actions:

- Assess distribution of *Lantana* in relation to sensitive habitats, e.g. riparian woodland on stream banks
- Prioritise sites for controlling the plants, starting at the top of the wetland and working downstream; start controls in areas least affected first and move to the dense infestations later
- Investigate the most cost effective methods of control e.g. herbicide vs physical removal
- Maintain regular follow up plan, checking treated sites for re-invasion
- Use indigenous plants for the rehabilitation of disturbed ground.

9.3 DISTURBANCE / LOSS OF WILD FAUNA AND HABITATS

The construction activities, infrastructure and roads will cause noise and disturbance to the wild fauna in the immediate area, including the adjacent areas. The loss of habitat through clearing of vegetation and increased activity near the rivers will have a further direct negative impact on the wildlife. This impact is long term and irreversible and cumulative. Although the immediate impact will be localised to the solar site area, the fragmentation of habitats and increased disturbance will also affect the wild faunal population in the surrounding areas. The impact on small mammals, reptiles and amphibians will be similar, whilst birds and larger animals are more mobile and capable of escaping to alternative refuges.

Increased numbers of construction workers on the site increases the likelihood of snaring of wildlife and destruction of bee hives and raiding of bird nests in adjacent areas.

Mitigation Measures:

Code of conduct for contractors to prevent snaring of wild animals including birds; destruction of bee hives; prevention of bush fires (as per the Parks and Wildlife Act).

The proponent should have an animal rescue plan in liaison with PWMA and Veterinarians for Animal Welfare Zimbabwe (VAWZ) to ensure any capture and translocation of animals is done in a humane manner.

The Code of conduct for contractors must include the proviso that if an active raptor nest is discovered it should be left undisturbed i.e. the trees not felled until the breeding cycle is complete and the chicks have fledged and left the nest. Contact Bird Life Zimbabwe for assistance and advice.

9.3.1 Impacts on Birds

Habitat loss and degradation for resident bird species from construction and operational activities		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Moderate change (Medium)
Duration	Long-term (High)	Long-term (High)
Extent	Whole site (Low)	Part of site (Very Low)
Consequence	Medium	Low
Probability	Definite / Continuous	Probable
Significance	Medium -	Low -
Degree to which impact can be reversed	*Partially reversible: Regrowth of native vegetation might occur after the completion of the project. However, due to plant succession the area might be occupied by other plant and invasive species leading to permanent habitat loss.*	
Degree to which impact may cause irreplaceable loss of resources	*Low: Habitat destruction will partially or permanently displace, destroy foraging and nesting sites of resident birds from the site area as well as causing habitat fragmentation.*	
Degree to which impact can be avoided	*Low: The project will definitely involve vegetation clearance to enable construction of the plant. Clearance should be restricted to the footprint to minimize the impact*	
Degree to which impact can be mitigated	*Medium: Vegetation clearance should be restricted to the project foot print to minimize extent of impact*	
Cumulative impact		
Nature of cumulative impacts	*Vegetation clearance and presence of solar infrastructure amounts to habitat transformation for resident species*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	High -	Medium -
Cumulative impact		

Displacement and loss of species with a restricted range in miombo habitat; loss of hunting area for raptors		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	All	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Prominent change (High)
Duration	Permanent (Very Long)	Long-term (High)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Possible / frequent
Significance	Medium -	Low -
Degree to which impact can be reversed	*Partially reversible: Resident species might occupy the area again if habitat status is restored to normal after project completion*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: The site might be occupied by invasive species after decommissioning which might permanently displace bird species*	
Degree to which impact can be avoided	*Low: Habitat restricted species are sensitive to habitat change. Such bird species are likely to move due to disturbances.*	
Degree to which impact can be mitigated	*None: Once land is cleared, birds species will have to utilize other suitable areas*	
Cumulative impact		
Nature of cumulative impacts	*Displacement due to habitat loss and fragmentation from construction activities. Displacement due to habitat transformation and disturbance from construction and operational activities. Loss of hunting grounds for large raptors.*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

<u>Bird Electrocution and Collisions with Transmission Lines and electrical infrastructure</u>

Large birds such as eagles, vultures, storks and cranes can be electrocuted if they fly too close to transmission lines. Birds may also collide with the lines when flying at night or on misty and rainy days. Some of these birds are regional migrants, so while the loss may be local, the impact can be more widespread.

Electrocution and collision caused when perching on, or flying into, the power line infrastructure.	
Type of Impact	Direct

Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Minor change (Low)
Duration	Long-term (High)	Long-term (High)
Extent	Beyond site (Medium)	Beyond site (Medium)
Consequence	High	Medium
Probability	Definite / Continuous	Definite / Continuous
Significance	**High -**	**Medium -**
Degree to which impact can be reversed	*Reversible: Collision could occur during construction and operation. Electrocution of birds is only during the operational phase of the project.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: Although chances of electrocution are low, it will lead to death of rare and endangered species. Southern Ground Hornbills and Owls will be at high risk from electrocution and collision*	
Degree to which impact can be avoided	*Low: Site is located far from the existing substation hence new lines will be constructed.*	
Degree to which impact can be mitigated	*Medium: Collisions can be avoided by using anti-collision marking devices, constructed with bird friendly designs. Electrocution can be avoided by providing alternative perches on towers.*	
Cumulative impact		
Nature of cumulative impacts	*If mitigation measures are not implemented electrocution and collision of priority species will be ongoing through the duration of the operational phase*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	High -	Low -

<u>Mitigation Measures</u>:

The following mitigation measures should be implemented during construction so that the potential impacts are reduced once the PV plant is operational. The information below is extracted from Eskom transmission bird collision prevention guidelines.

Attaching anti-collision devices (typically flappers, balls or spirals) to transmission grounding wires to increase their visibility. There are several types of devices.

1. Static devices

Particularly known as the bird flight diverters, they are mechanically more durable because they lack the aspect of wear and tear as compared to dynamic devices. However, static devices has had limited success because they are less visible especially the small ones. A better option would be to use larger devices.

Figure 9-2: Example of a static device

2. Dynamic devices

Dynamic devices are very effective in reducing collisions as the birds seem to see them very well probably because of the movement that attracts attention. The disadvantage of dynamic devices is that they are subject to extensive wear and tear, inevitably limiting the lifespan of the device. Wear could result on the device itself as well as on the cable to which it is attached.

Figure 9-3. Reflective devices

A new product that shows great potential is the Inotec BFD88, a reflective stainless steel sphere of 70mm diameter. Experiments have shown the visibility of this device to be superior to coloured (red, yellow, white, black) objects especially during the low light conditions at dawn and dusk when birds may be flying from roosting areas to feeding areas and back. Due to the spherical shape, the device reflects any available light in all directions and is therefore visible from all directions including above or below the diverter.

Figure 9-4: Another example of anti collision device

Spacing intervals

Research in the Netherlands has shown that spacing intervals have a major influence on the effectiveness of anti-collision devices. In South Africa, the same has been found. A 5 meter interval is suggested with Bird Flappers. In the case of the Inotec BFD88 diverters, a similar 5 meter interval is suggested. It is important to alternate the colours (yellow-white) in order for maximum contrast and only the middle 60% of each span (that is from tower to tower) needs to be marked as this is where most of the collisions occur.

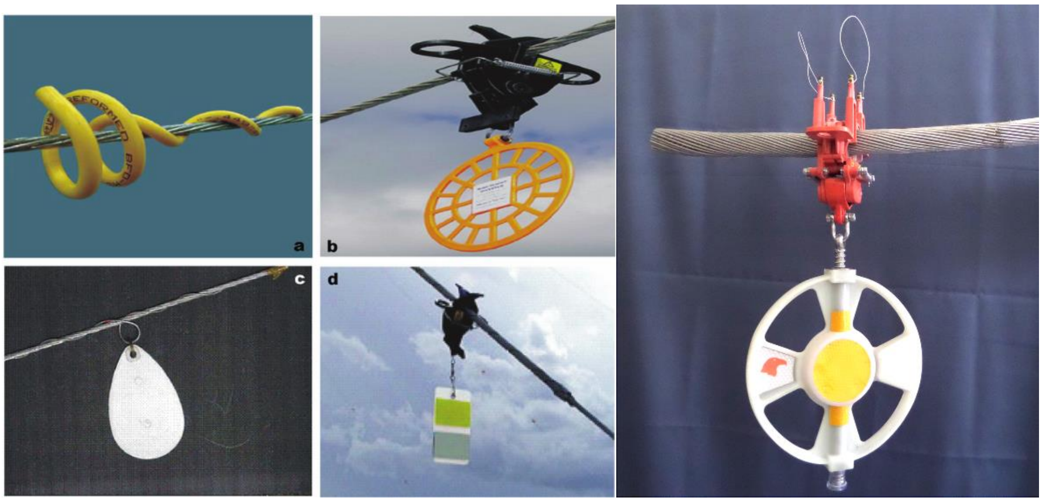

Figure 9-5: Examples of bird flappers

Figure 9-6: Large eagle using transmission line pole as a perch (L) and an electrocuted falcon (R).

Entrapment of birds in perimeter fences		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Minor change (Low)
Duration	Long-term (High)	Long-term (High)
Extent	Whole site (Low)	Whole site (Low)
Consequence	Medium	Medium
Probability	Possible / frequent	Possible / frequent
Significance	Low -	Low -
Degree to which impact can be reversed	*Fully reversible: The presence of a double perimeter fence could lead to entrapment of large terrestrial birds such as Abdim's storks and Southern Ground Hornbills. The use of a single perimeter fence is advisable.*	

Degree to which impact may cause irreplaceable loss of resources	*Low: Birds entrapped in perimeter fences may suffer from depression which might lead to death*	
Degree to which impact can be avoided	*Medium: The use of a single perimeter fence is advised*	
Degree to which impact can be mitigated	*High: A single perimeter fence is likely to reduce species being entrapped in the fences*	
Cumulative impact		
Nature of cumulative impacts	*Entrapment of priority species during the operational phase of the project. Death of species entrapped within the fences.*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

Impact: Collision with solar panels		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Minor change (Low)	Negligible change (Very low)
Duration	Long-term (High)	Long-term (High)
Extent	Whole site (Low)	Whole site (Low)
Consequence	Medium	Low
Probability	Possible / frequent	Conceivable
Significance	Low -	Very low -
Degree to which impact can be reversed	*Fully reversible: Collision will end with decommissioning of the project*	
Degree to which impact may cause irreplaceable loss of resources	*Low: The impact has a very low expected magnitude*	
Degree to which impact can be avoided	*Low: Collisions are inevitable*	
Degree to which impact can be mitigated	*Medium: Adjusting tilting angles of solar panels will reduce solar PV arrays that leads to collision*	
Cumulative impact		
Nature of cumulative impacts	*The presence of the PV solar arrays will lead to collisions with the reflective solar panels in the PV footprint*	
Rating of cumulative impacts	*Without Mitigation*	*With Mitigation*
	Low -	*Very low -*

Mitigation Measures:

By reducing the impact of the solar panels on insects, the localized impact on insectivorous birds and other fauna will be reduced.

Non-polarising white tape can be used around and/or across panels to minimise reflection which can attract aquatic insects as it mimics reflective surfaces of waterbodies. In a field experiment conducted in Hungary, aquatic insects, including mayflies, stoneflies, long-legged flies and tabanid flies, avoided solar panels with white tape on the border of and/or in a grid-like pattern across panels (Horváth et al. 2010).

9.3.2 Impact on Mammals

CONSTRUCTION PHASE

ACTIVITY: Vegetation clearing, topsoil stripping and compacting, movement of heavy machinery, road constructio

MAMMAL GROUP: Small mammals <1kg

Description of Impact: Loss of populations; destruction of habitat, foraging and breeding areas		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Prominent change (High)
Duration	Medium-term (Medium)	Short-term (Low)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Definite / Continuous
Significance	Medium -	Medium -
Degree to which impact can be reversed	*Partially reversible: The loss of habitat can be reversed to some extent by replanting indigenous grass and shrubs.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: Some aspects of the habitat, such as trees, will not be replaced, resulting in permanent loss of mammal species associated with this resource within the project area*	
Degree to which impact can be avoided	*Low: Impact cannot be avoided*	
Degree to which impact can be mitigated	*High: Existing small animals will be exterminated, but if indigenous grass and shrubs are replanted and human and vehicular footprint is kept to a minimum, some small mammals are likely to return to the project area*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area are already disturbed by either mining activities, cattle herding, subsistence hunting and artisanal mining, this activity will add to the number of impacts*	

	negatively affecting the existence of small mammals in the area	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

CONSTRUCTION PHASE

ACTIVITY: Vegetation clearing, topsoil stripping and compacting, movement of heavy machinery, road construction

MAMMAL GROUP: Medium and Large-sized mammals

Description of Impact: loss of habitat		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction	
Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Moderate change (Medium)
Duration	Permanent (Very Long)	Short-term (Low)
Extent	Whole site (Low)	Part of site (Very Low)
Consequence	Medium	Medium
Probability	Probable	Probable
Significance	Medium -	Medium -
Degree to which impact can be reversed	*Partially reversible: The loss of habitat can be reversed to some extent by replanting native grass and shrubs in the project site*	
Degree to which impact may cause irreplaceable loss of resources	*High: Some aspects of the habitat, such as trees, will not be replaced, resulting in permanent loss of mammal species associated with this resource within the project area*	
Degree to which impact can be avoided	*Low: Impact cannot be avoided*	
Degree to which impact can be mitigated	*Medium: If indigenous grass and shrubs are replanted and human and vehicular footprint is kept to a minimum some species are likely to return to the project area*	
Cumulative impact		

Nature of cumulative impacts	*Considering that many areas around the project area are already disturbed by either mining activities, cattle herding, subsistence hunting and artisanal mining, this activity will add to the number of impacts negatively affecting the existence of medium and large-sized mammals in the area*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

OPERATIONAL PHASE
ACTIVITY: Fencing project area
MAMMAL GROUP: Small terrestrial mammals (<1kg)

Loss of habitat connectivity between populations and breeding and foraging sites		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Minor change (Low)
Duration	Permanent (Very Long)	Permanent (Very Long)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Possible / frequent
Significance	Medium -	Low -
Degree to which impact can be reversed	*Only reversible at the end of the project lifespan*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: If fences do not allow free movement of small mammals, then they will have lost access to an area formerly used for foraging or as refuge or connecting to other areas.*	
Degree to which impact can be avoided	*Medium: It could only be completely avoided by not installing fences, although this may lead to a security risk for equipment.*	
Degree to which impact can be mitigated	*High: The impact can be mitigated by leaving gaps under all the fences to allow free movement of small mammals through the project site*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area already have restricted access by small mammals, this is yet another area of habitat that will be inaccessible, leading to a fragmented habitat and even less areas available for wildlife use.*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

OPERATIONAL PHASE
ACTIVITY: Fencing project area

MAMMAL GROUP: Larger mammals

Loss of habitat connectivity ; loss of available habitat		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Minor change (Low)
Duration	Permanent (Very Long)	Permanent (Very Long)
Extent	Beyond site (Medium)	Part of site (Very Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Possible / frequent
Significance	Medium -	Low -
Degree to which impact can be reversed	*Only reversible at the end of the project lifespan*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: If fences do not allow free movement of the larger mammals, then they will have lost access to an area formerly used for foraging or as refuge or connecting to other areas.*	
Degree to which impact can be avoided	*Medium: It could only be completely avoided by not installing fences, although this may lead to a security risk for equipment.*	
Degree to which impact can be mitigated	*Medium: The impact can be mitigated by leaving gaps (0.5m) under all the fences to allow free movement of some of the smaller sized mammals through the project site, although the larger ones will be excluded.*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area already have restricted access by medium-sized mammals, this is yet another area of habitat that will be innaccessible, leading to a fragmented habitat and even less areas available for wildlilfe use.*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

OPERATIONAL PHASE

ACTIVITY: Movement of people, vehicles, installation of lights

MAMMAL GROUP: All mammals

Noise, light and water pollution		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Moderate change (Medium)	Minor change (Low)
Duration	Permanent (Very Long)	Permanent (Very Long)
Extent	Beyond site (Medium)	Whole site (Low)

Consequence	Medium	Medium
Probability	Probable	Possible / frequent
Significance	Medium -	Low -
Degree to which impact can be reversed	*Only reversible at the end of the project lifespan*	
Degree to which impact may cause irreplaceable loss of resources	*Low: It will mainly cause disturbance of wildlife*	
Degree to which impact can be avoided	*Medium: control vehicle movements and speed to avoid running over small animals and colliding with larger ones*	
Degree to which impact can be mitigated	*High: The impacts can be mitigated by restricting movement of people and vehicles to the minimum necessary to maintain the equipment and by implementing strict codes of behaviour while in the project site. Light pollution can be minimised by constructing shelters and using appropriate lights. Water pollution can be avoided by strictly controlling run-off and drainage systems.*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area are already disturbed by either mining activities, cattle herding, subsistence hunting and artisanal mining, this activity will add to the number of impacts negatively affecting the existence of mammals in the area*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

OPERATIONAL PHASE

ACTIVITY: Installation of lights

MAMMAL GROUP: Bats

Habitat disturbance, noise, light and water pollution		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Operational	
Criteria	**Without Mitigation**	**With Mitigation**
Intensity	Moderate change (Medium)	Moderate change (Medium)
Duration	Permanent (Very Long)	Permanent (Very Long)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Medium
Probability	Probable	Possible / frequent
Significance	**Medium -**	**Low -**

Degree to which impact can be reversed	*Only reversible at the end of the project lifespan*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: If disturbance is high, bats may be discouraged from foraging, roosting or breeding in the area in and around the project site*	
Degree to which impact can be avoided	*Low:There will definitely be disturbance in the area, although it can be reduced slightly by mitigation*	
Degree to which impact can be mitigated	*Medium: The impacts can be mitigated by restricting movement of people and vehicles to the minimum necessary to maintain the equipment and by implementing strict codes of behaviour while in the project site. Light pollution can be minimised by constructing shelters and using appropriate types of lights. Water pollution can be avoided by strictly controlling run-off and drainage systems.*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area are already disturbed by either mining activities, cattle herding, subsistence hunting and artisanal mining, this activity will add to the number of impacts negatively affecting the diversity of bats in the area*	
Rating of cumulative impacts	**Without Mitigation**	**With Mitigation**
	Medium -	**Low -**

9.3.3 Impacts on Reptiles and Amphibians

CONSTRUCTION and OPERATIONAL PHASE

ACTIVITY: Vegetation clearing, topsoil stripping and compacting, movement of heavy machinery, road construction; vehicle traffic; noise

The removal of the topsoil and vegetation will impact mostly fossorial (ground dwelling and burrowing) reptiles, as there will be a loss of habitat and microhabitat.

The use of heavy construction vehicles compacts the soils that affect fossorial species.
With the construction phase there is going to be traffic motion, pollution, disturbance, noise and human presence. All this will affect the herpetofauna, which is likely to move to safer areas or be persecuted. Once operational, there will less traffic, noise and human presence and some reptiles and frogs may be able to return and re-colonise the area.

The infrastructure of the power lines, fencing, gates and access control are not likely to significantly impact landscape connectivity, but the roads might create barriers to those reptiles and amphibians that are unable to cross the roads due to noise, lights and traffic motion. Some species of snakes make use of the warmth of the road for thermoregulation making them vulnerable to being run over by passing vehicles. The same applies to those frogs that are actively seeking mates and suitable breeding areas (wetland, streams, puddles) during the rainy season.

The PV site will be fenced for security but details of the type of fencing is not known. Before erecting the fence, the area needs to be searched for reptiles (tortoises) that can be removed before the fence is erected. Tortoises can get caught or end up falling upside down trying to climb the fence. Once they fall on their back they may die if they fail to right themselves up. Leaving a gap at the bottom of the fence will allow tortoises and other small animals to move through.

IMPACT: Loss of habitat, death of individuals, destruction of animal roosts and refuges		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Prominent change (High)
Duration	Medium-term (Medium)	Short-term (Low)
Extent	Beyond site (Medium)	Whole site (Low)
Consequence	Medium	Medium
Probability	Definite / Continuous	Definite / Continuous
Significance	Medium -	Medium -

Degree to which impact can be reversed	*Partially reversible: The loss of habitat can be reversed to some extent by replanting indigenous grass and shrubs after construction is completed.*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: Some aspects of the habitat, such as trees, will not be replaced, resulting in permanent loss of reptile and frog species associated with this resource within the project area*	
Degree to which impact can be avoided	*Low: Impact cannot be avoided*	
Degree to which impact can be mitigated	*High: Existing small reptiles and frogs will be exterminated, but if indigenous grass and shrubs are replanted and human and vehicular footprint is kept to a minimum, some small animals are likely to return to the project area*	
Cumulative impact		
Nature of cumulative impacts	*Considering that many areas around the project area are already disturbed by either mining activities, cattle herding, subsistence hunting and artisanal mining, this activity will add to the number of impacts negatively affecting the existence of reptiles and frogs in the area*	
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

List of amphibians and reptiles likely to be affected by habitat loss, following the habitat preferences according to Du Preez & Carruthers (2017), Channing & Rodel (2019) and Lambiris, A.J.L. (1989) for amphibians and Broadley, & Blaylock for snakes (2013).

Species	English Name/Shona/Ndebele	Habitat
Schismaderma carens	Red Toad	savanna, woodland
Sclerophrys garmani	Eastern Olive Toad	occurs in bushveld savanna
Kassina senegalensis	Senegal Running Frog	Vegetation at margins of aquatic sites in savanna and grassland
Philothamnus hoplogaster	Southeastern Green Snake	wetland, permanent water
Philothamnus angolensis	Angolan Green Snake	Wetland
Psammophis phillipsii	Olive Whip-Snake	grassland, wetland, in reedbeds
Lycodonomorphus rufulus	Brown Water Snake	wetland, common around streams
Natriciteres olivacea	Olive Marsh Snake	wetlands, found also along rivers

- The project should plant compatible grasses under the solar panels to encourage species that inhabit grassy habitats to recolonize after construction has ended.
- Plant low shrubs that do not interfere with the sunlight round the area provide arboreal species with their usual habitat.
- The water that is released into the wetland must go through pollutant purification processes, since pollutants affect amphibians.
- Artificial ponds can be provided for amphibians to find breeding places since they need water during the breeding season.

CONSTRUCTION and OPERATIONAL PHASES
ACTIVITY: Use of herbicides, spillage of hazardous substances including fuels, chemical pollution from battery leakages.

Pollution of water bodies and frog breeding habitats		
Type of Impact	Direct	
Nature of Impact	Negative	
Phases	Construction and Operational	
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change (High)	Minor change (Low)
Duration	Long-term (High)	Long-term (High)
Extent	Beyond site (Medium)	Beyond site (Medium)
Consequence	High	Medium
Probability	Possible / frequent	Possible / frequent
Significance	Medium -	Low -
Degree to which impact can be reversed	*Partially reversible*	
Degree to which impact may cause irreplaceable loss of resources	*Medium: pollution of water bodies and frog breeding areas could cause localised loss of the animals*	
Degree to which impact can be avoided	*High: Control of chemicals, hazardous substances and waste*	
Degree to which impact can be mitigated	*High: Carefully supervise use of any chemicals likely to have an adverse effect on frogs*	
Cumulative impact		
Nature of cumulative impacts		
Rating of cumulative impacts	Without Mitigation	With Mitigation
	Medium -	Low -

Cumulative impact	
Nature of cumulative impacts	*Frogs are important insectivores and sources of food for other animals e.g. snakes, birds and therefore loss of this group of animals has an impact on other vertebrates and invertebrates.*

Amphibians exchange gases with their immediate water environment which makes them very sensitive to chemical pollutants and therefore good indicators of pollutants in water (du Preez, & Carruthers, 2017). Studies have shown that vanadium affects amphibians at the metamorphosis stage. The limb development gets affected and the ability to store lipids that are essential in the growth of amphibians (Hopkins, et al.)

Mitigation: ensure all hazardous substances and chemicals are stored correctly and that there is an effective management plan in place in the event of any spillages. Control grass and weeds around the panels by physical digging and weeding and not use herbicides such as glyphosate (Round Up) as this is also known to affect tadpoles and metamorphosis.

9.3.4 **Potential Impacts of Artificial Lighting at night on all Fauna.**

The project area is rural and ambient lighting at night in currently low with the exception of the staff camps along the edge of the Chironde Hills. With the development of the solar infrastructure, artificial lighting will be installed for security of the premises. This will have a direct impact upon both invertebrates, particularly insects, reptiles such as geckoes and upon bats and night-flying birds.

Increased lighting has been shown to have an adverse effect on wildlife, particularly on those species that have evolved to be active during the hours of darkness. Consequently, development needs to carefully consider what lighting is necessary and reduce any unnecessary lighting, both temporally and spatially.

Overview of impacts

Artificial light significantly disrupts natural patterns of light and dark, disturbing invertebrate feeding, breeding and movement, which may reduce and fragment populations. Many invertebrates' natural rhythms depend upon day-night and seasonal and lunar changes that can be adversely affected by artificial lighting levels.

External lighting is often one of the most significant factors affecting terrestrial invertebrates in the vicinity of large-scale industrial developments. Large numbers of insects may be attracted to lights, which interfere with their normal navigation systems. Once trapped by a light source, they may keep flying around the light until dying from exhaustion and lack of food, or may be eaten by predators such as bats or geckos that learn to use lights as highly productive foraging locations. It is known that UV and green and blue light, which have short wavelengths and high frequencies, are seen by most insects and are highly attractive to them.

Birds

Many species of bird migrate at night and there are well-documented cases of the mortality of nocturnal migrating birds as they collide with infrastructure. Artificial light can also affect bird breeding and nesting behaviours.

Bats

The following section is extracted from guidance notes from the Bat Conservation Trust.[13] The detrimental effect of artificial lighting is most clearly seen in bats. Light falling on a bat roost exit point, regardless of species, will at least delay bats from emerging, which shortens the amount of time available to them for foraging. As the main peak of nocturnal insect abundance occurs at and soon after dusk, a delay in emergence means this vital time for feeding is missed. At worst, the bats may feel compelled to abandon the roost. Bats are faithful to their roosts over many years and disturbance of this sort can have a significant effect on the future of the colony. In addition to causing disturbance to bats at the roost, artificial lighting can also affect the feeding behaviour of bats and their use of commuting routes. There are two aspects to this: one is the attraction that short wave length light (UV and blue light) has to a range of insects; the other is the presence of lit conditions.

Studies have shown that, although some vesper bats, take advantage of the concentration of insects around white street lights as a source of prey, this behaviour is not true for all bat species. Some slower flying, broad-winged species generally avoid external lights.

Lighting can be particularly harmful if it illuminates important foraging habitats such as river corridors and woodland edges used by bats. Studies have shown that continuous lighting along roads creates barriers which some bat species cannot cross. It is also known that insects are attracted to lit areas from further afield. This could result in adjacent habitats supporting reduced numbers of insects, causing a further impact on the ability of light-avoiding bats to feed.

Mitigation Measures:

Principles and design considerations

Do not

- provide excessive lighting. Use only the minimum amount of light needed for the task.
- directly illuminate bat roosts or important areas for nesting birds.

Avoid

- installing lighting in ecologically sensitive areas such as: near ponds, rivers
- using reflective surfaces under lights i.e. position the lights away from the panels to reduce reflections.

Do Use

- narrow spectrum light sources to lower the range of species affected by lighting.
- light sources that emit minimal ultra-violet light

[13] https://www.google.com/search?channel=nrow5&client=firefox-b-d&q=bat+conservation+trust accessed 24.09.2021

- lights with a wavelength peak higher than 550 nm e.g. low pressure sodium lamps
- Motion detectors to minimise use of lights, allowing for periods of darkness
- Use light shades to minimise incident light and upward lighting.
- Position the lights so that only the necessary area is illuminated

10 CONCLUSION

Zimbabwe's power is supplied from hydroelectric and coal fired thermal sources. With the increasing and very justified worldwide concern about global warming, reducing any partial reliance on coal fed thermal power is commendable. The country's sub tropical climate and comparatively high levels of solar irradiation provides an ideal opportunity to use solar energy as an alternative source of power. However this solar PV project will result in an unavoidable loss of biodiversity and carbon storage on 138ha area of miombo woodland. This loss can be mitigated to some extent but the residual and cumulative impacts do need to be weighed against the gain of 'clean' energy.

From a wetland perspective, the wetlands within the study site have been heavily impacted by severe grazing pressure, physical disturbance and surface water discharge from the mine. Wetland functioning has been compromised in all of the wetland HGM units. Three of the wetland units have moderate ecological importance and sensitivity, while the other HGM units are of low EIS. This is a reflection of the poor potential of the wetland habitat to support wetland biodiversity due to the desiccating effect of the eroded gullies and the homogenization of the habitat due to heavy grazing.

The proposed development will remove approximately 15ha of wetland habitat from the landscape. There is good potential to offset this loss through the rehabilitation of the degraded wetlands remaining in the study area. This will result in a no-net-loss, or even a net gain, of wetland functional area at the landscape level.

Additionally, the solar panels will generate a substantial volume of rainfall runoff. The discharge of runoff into the receiving environment will result in further soil erosion, channel scouring, sediment deposition and a decline in the quality of aquatic habitats extending several kilometers downstream. It is of utmost importance that stormwater be properly attenuated prior to discharge into the receiving environment. The vertic soils are extremely sensitive to soil erosion. Point source discharge into the wetland is, therefore, to be avoided.

The value in the degraded wetlands is not in their current state, but in their potential to be rehabilitated at a future date and the opportunity to restore lost wetland functioning and biodiversity to the landscape. HGM K should be buffered from the development. It is in good condition, and this should be maintained.

It is strongly recommended that the solar PV environmental management plan aligns closely with that of Unki Mine as the actions of one will have consequences for both.

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12 APPENDICES

I Plant Data Sheets
II Bird checklist
III Mammal checklist
IV Reptile and Frog checklist

V Terms of Reference -