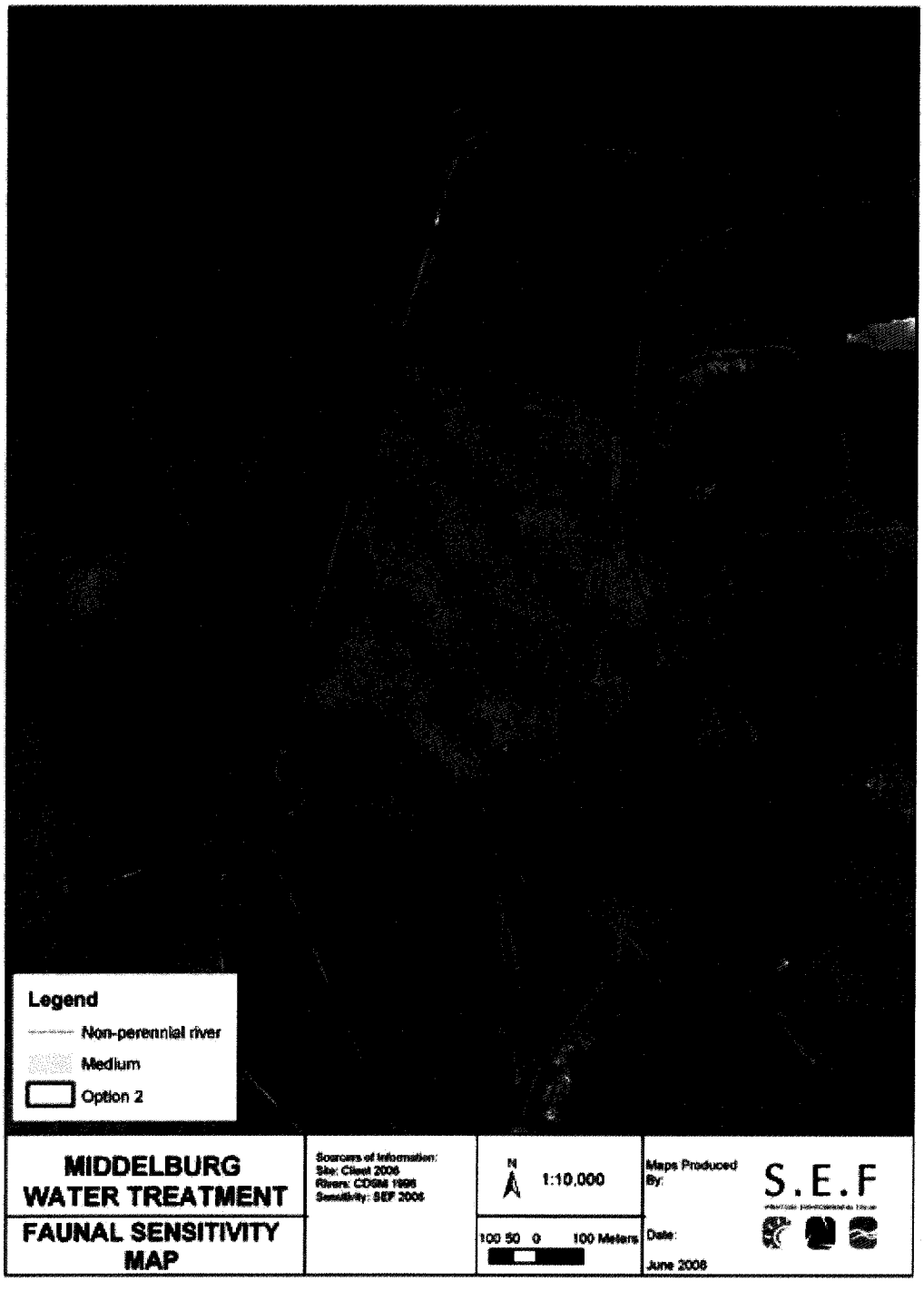

Figure 6. Sensitivity Map of Option 2

6.3 Discussion

The study highlighted the following sensitive features that warrant mitigation and/or protection.

6.3.1 Wetlands & Waterbodies

Freshwater systems like rivers, wetlands and pans are valuable resources that host a diverse and unique array of species, habitats and ecosystems, including some of the world's most threatened ecosystems and species (Allen & Flecker, 1993). Research indicates that as a result of developments, freshwater systems undergo physical alterations which affect water flows. The effect of flow changes on biodiversity is concerning for a number of reasons:

- Biotic composition is changed;
- Aquatic species have evolved life history strategies in direct response to the natural flow regimes;
- Maintenance of natural patterns for connectivity is essential to the viability of populations of many aquatic species; and
- The invasion and success of exotic species in rivers is facilitated by the alteration of flow regimes (Bunn & Arthington, 2002).

A number of wetland and river crossings are proposed along the pipeline route. Due to the sensitive nature of these systems it is advised that mitigation measures are undertaken.

6.3.2 Red Data/Protected Species

Option 1 was found to be highly sensitive as a result of Red Data individuals and Red Data habitat recorded on site.

The following Red Data individuals were recorded within the study area (Option 1):

- *Geronotus calvus* (Bald Ibis); and
- *Ourebia ourebi* (Oribi).

Habitat for the following Red Data individuals was recorded within the study area (Option 1):

- *Pyxicephalus adspersus* (Giant Bullfrog);
- *Dingana fraternal* (Stoffberg Widow Butterfly); and
- *Metisella meninx* (Marsh Sylph).

These species are all of Red Data status and therefore pose constraints to a development. Legislation also stipulates that areas supporting these species warrant conservation.

6.3.3 Sensitive Ridge

An undeveloped ridge system was identified along the proposed pipeline route. This occurs along the Spookspruit Perennial River where it crosses the R575 road (Figure 7). Ridges in a natural state are characterized by a particularly high biodiversity and their presence in a landscape warrants conservation (GDACEL, 2001). It is therefore advised that the pipeline route avoids the ridge system, and must instead be placed within the R575 road servitude at this point.

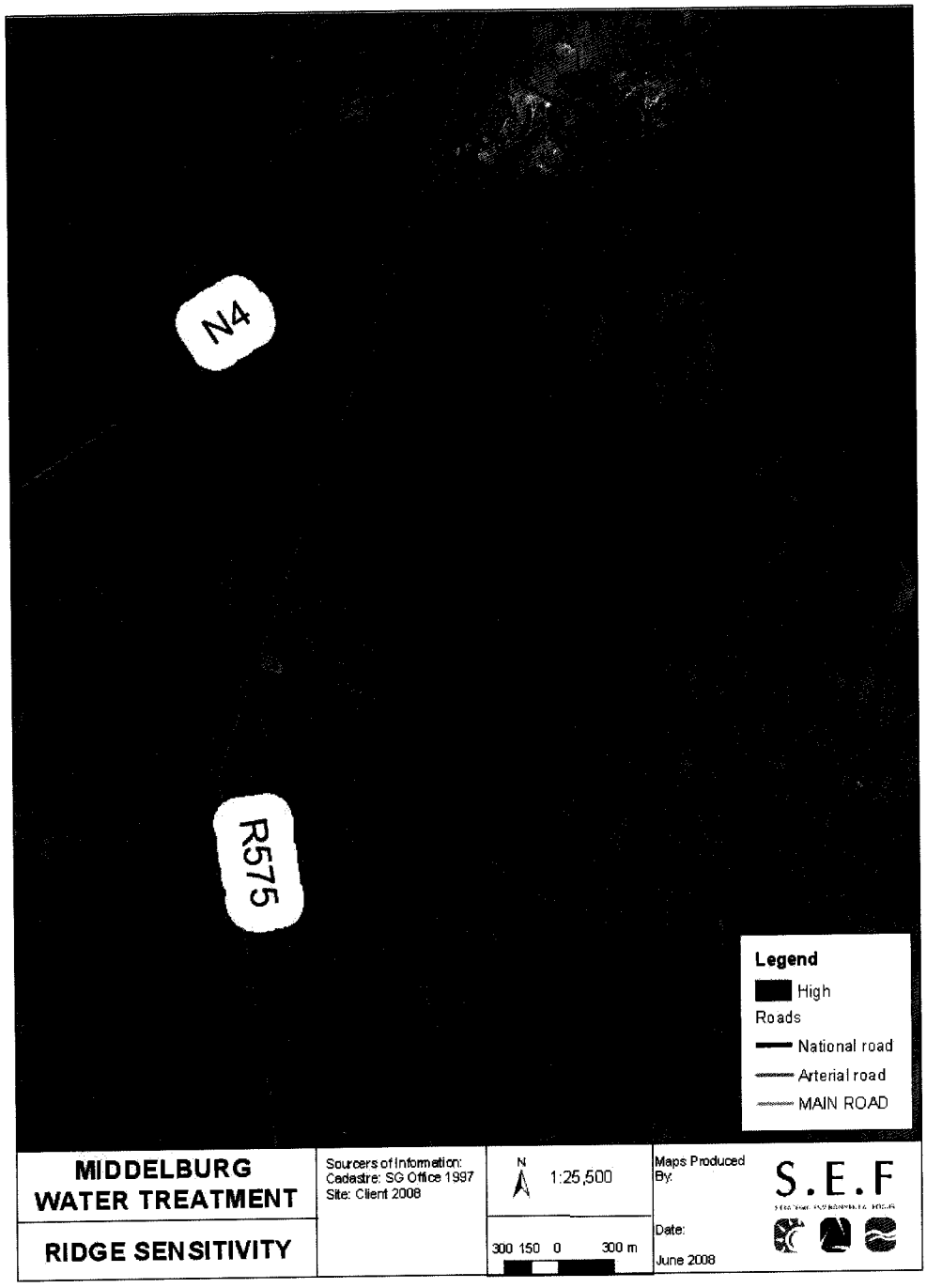

Figure 7. Sensitive Ridge System along pipeline route

7. IMPACT ASSESSMENT & MITIGATION

The assessment of the impacts has been conducted according to a synthesis of criteria. Each possible impact is analysed and discussed in detail in Section 7.2. The impacts are assessed with and without mitigation and the results presented in impact tables which summarise the assessment. Mitigation and management actions are also recommended, with the aim of enhancing positive impacts and minimising negative impacts.

7.1 Assessment Criteria

In order to assess these impacts; certain criteria are applied and these are discussed below.

7.1.1 Nature of Impact

This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how, and whether the impact is expected to be positive or negative.

7.1.2 Extent of Impact

A description of whether the impact will be local, (extending only as far as the servitude) limited to the study area and its immediate surroundings, regional or on a national scale.

7.1.3 Duration of Impact

This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

7.1.4 Intensity

This indicates the degree to which the impact would change the conditions or quality of the environment. This was qualified as low, medium or high.

7.1.5 Probability of Occurrence

This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

7.1.6 Degree of Confidence

This describes the degree of confidence for the predicted impact based on the available information and level of knowledge and expertise. It has been divided in to low, medium or high.

7.2 Impact Assessment and Mitigation

7.2.1 Construction Phase

7.2.1.1 Loss of Faunal Habitat

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Loss of faunal habitat	Option 1	Local	Permanent	High	Definite	High	Medium	High

The loss of faunal habitat will arise at Option 1 where faunal species were recorded. A number of large and small burrows were observed within the rocky grassland and alien bush clumps on site. Furthermore, Rice Grass (*Leersia hexandra*), the breeding habitat for the Red Data Marsh Sylph Butterfly (*Metisella meninx*) was recorded within the wetland system on site. The natural pan provided habitat to a number of common and rare bird species as well as Red Data bullfrog species.

Displacement, limited migration potential, loss of food sources and even death are likely effects of this development on faunal inhabitants.

As this impact is envisaged to be high, the following measures are recommended;

- Refrain from development on site;
- Development, if permitted must be placed only in the low sensitivity or degraded areas;
- Apply an appropriate buffer, in line with wetland report recommendations, to the pan and wetland systems on site. Development is not permitted in these buffer zones;
- Access roads and temporary structures or associated developments are not permitted on sensitive sections of the site; and
- An education programme on animal awareness and protection, geared at employees accessing the site must be presented prior to construction (if development is permitted).

7.2.1.2 *Noise Disturbance*

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Displacement of fauna as a result of noise disturbance	Option 1 and Option 2	Local	Permanent	High	Definite	High	Medium	High

A development on site will create noise and visual disturbance during the construction phase, potentially affecting the distribution and behaviour of fauna. As the faunal inhabitants in the study area reside in a largely natural and undisturbed area, they are unaccustomed to anthropogenic disturbances and would therefore be intolerant to disturbance. Larger fauna that are able to migrate will likely move away from noise disturbances into adjacent areas of suitable habitat, however less mobile invertebrates and herpetofauna will likely be displaced by disturbances. It is therefore recommended that sensitive (habitat) features such as wetlands, pans, ridges and rocky outcrops are avoided during the development.

7.2.1.3 *Damage and loss of wetland systems*

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Damage and loss of wetland vegetation, services and hydrological functionality	Pans & Wetlands	Local and Regional	Long Term/ Permanent	High	Highly Probable	High	Medium	High

Rivers and wetlands are sensitive to disturbance. Disturbances from construction activities in the form of water and soil pollution, contamination and increases in hard surface structures affect the integrity and functionality of wetlands. As wetlands are protected by legislation, buffered areas are prescribed for the protection of wetlands and waterbodies (SEF, 2008b).

Wetland or riparian zones are the interface between land and a water body. They are significant in ecological systems due to their role in maintaining biodiversity, promoting aquatic health and soil conservation. Riparian areas appear in many forms including grassland, woodland, wetland or even non-vegetated areas (Haukos & Smith, 1994). They are important for fauna in the following ways:

- As the interface between aquatic and terrestrial environments, the highest biodiversity of plant, invertebrate, amphibian and small mammal taxa are located

here. They are therefore areas of high forage potential for fauna (Haukos & Smith, 1994); and

- They provide wildlife habitat as a result of the unique soil and microclimatic conditions, nesting sites and shaded areas.

As a number of wetland and river crossings are present along the proposed pipeline routes, the following is recommended:

- Already degraded areas or existing servitudes must be used for river and wetland crossings; and
- At river and wetland crossings, the pipeline must be placed on stilts or attached to road bridges and must remain out of the waterbody and buffer area. This minimises the disturbance and impact to the waterbody.

7.2.1.4 Faunal disturbance and destruction to rocky outcrops and rocky ridges

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Damage and loss of rocky outcrops and in turn floral and faunal species	Along pipeline	Local	Permanent	High	Probable	High	Medium	High

Rocky outcrops and rocky ridges are areas of high faunal biodiversity. Samways and Hatton (2000) consider hills and koppies to generally have more insects (both in terms of individuals and species) than the immediate surroundings. Samways (1994) has also found that invertebrates are reliant on hilltops as thermal refugia from cold winter drainage. Additionally Branch (1998) recorded rare reptile species utilizing rocky habitats such as those provided by ridges.

Damage or disturbance of rocky outcrops and ridges will occur where infrastructure is erected within these rocky areas or when maintenance tracks or construction camps span over or near to the rocky outcrops. Faunal species residing on or amongst rocky outcrops are sensitive to disturbance and are likely to be displaced. This impact is therefore of high significance. Fortunately these sensitivities occur sparsely within the landscape and can therefore be easily avoided.

The design should be positioned in a manner that avoids the rocky areas. Similarly, if the maintenance tracks do not traverse the rocky areas and construction camps are not built

directly next to rocky areas, there will be no impact. Some taxa such as reptiles would be able to escape this disturbance by moving into adjacent areas. For immobile and less mobile invertebrates, a disturbance of this nature would significantly threaten their existence.

7.2.2 Operation Phase

7.2.2.1 Noise Disturbance

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Noise Disturbance from maintenance trucks and vehicle movement at water treatment plant and along pipeline	Option 1	Local	Permanent	High	Definite	High	Medium	High

Noise disturbance will arise as a result of people and vehicle movement at the site of the water treatment plant as well as along the pipeline route. The impact is envisaged to be greater at the water treatment site as vehicle and human disturbances are likely to be more frequent (daily or weekly), whereas vehicle and human disturbances are only expected along the pipeline route during routine maintenance times.

This can be mitigated at Option 1 by placing the access road in low sensitivity areas and ensuring that high sensitivity areas are avoided during the operational phase. At Option 2, the surrounding land has sustained and continues to sustain noise disturbances from vehicle traffic passing along the adjacent road. The significance of this impact is therefore low. Along the pipeline route, noise disturbance is likely to be infrequent and will be confined to routine maintenance times. The significance of impact along the pipeline route is therefore also low.

8. CONCLUSION AND RECOMMENDATIONS

Option 1 is highly sensitive with two Red Data species recorded during sampling and suitable habitat for a further three Red Data species at this site. The Wetlands, Pans and Rocky grassland which provide habitat to these species were therefore also deemed to be highly sensitive. Highly sensitive areas perform important ecological functions offering burrowing habitat, migration corridors and forage areas to animals, and therefore warrant conservation.

The Alien Bush Clumps are also regarded as sensitive with sampling revealing three species of small mammal inhabiting this area. Ecological value is high as sampling effort revealed a greater abundance of burrows and colonies in the Alien Bush Clumps than other habitats at Option 1. However, as the Alien Bush Clumps are an exotic and invasive vegetation community; theoretically less conservational importance is assigned to this community. As opportunistic behaviour is employed by fauna to ensure survival, the faunal inhabitants at Option 1 are likely to have opportunistically exploited the Alien Bush Clumps for the moist soil conditions and shelter from predators offered by the tree cover. The Alien Bush Clumps now have functional value for fauna at Option 1. The importance of this habitat type for faunal diversity therefore cannot be dismissed and a high sensitivity rating is assigned to the Alien Bush Clumps.

Option 2 is comprised of two habitat types, Rocky Outcrop Grassland and Alien Bush Clumps. Sampling yielded no mammal taxa, and only common invertebrates and avifaunal taxa were recorded at Option 2. Option 2 was deemed to be of lower sensitivity than Option 1. A medium sensitivity characterised Option 2 as no conservational important species were recorded, although the habitat is intact and may support such species.

As a result of the sensitivities at Option 1, Option 2 is more preferred for the development of the Water Treatment Plant. Placing the development at Option 2 would confine the disturbance to a currently disturbed area of the mine. Furthermore sensitive aquatic habitats would not be affected and the displacement and disturbance of faunal taxa would be minimal.

Wetlands, Rivers, Rocky Outcrops and the Rocky Ridge are also sensitive areas along the pipeline route. Suitable mitigation measures have been prescribed in the current report which reduces the significance of impacts to these sensitive features.

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APPENDICES

Status (Conservation): **LC**: Least Concern
EN: Endangered
VU: Vulnerable
CR: Critically Endangered

Appendix 1: Observed and Expected Invertebrate Taxa (Adapted from MPTA, 2008 & Emery *et al.*2002)

Family Name	Scientific Name	Common Name	Occurrence On Site	Status
Family Coenagrionidae	*Ishnura senegalensis*	Marsh Bluetail	Recorded (Option 1)	LC
	Africallagma glaucum	Swamp Bluet	Recorded (Option 1)	LC
Family Rhinolermitidae	*Trinervitermes*	Snouted Harvester Hermites	Recorded (Option 1) and (Option 2)	LC
Family Tabanidae		Horse Flies	Recorded (Option 2)	LC
Family Clliphoridae		Bluebottles, Greenbottles, Blowflies	Recorded (Option 1) and (Option 2)	LC
	Chrysomya chloropyga	Copper Tailed Blowfly	Recorded (Option 2)	LC
	Lucilia sericata	European Green Blowfly	Recorded (Option 2)	LC
Family Ixodidae	*Amblyomma hebraeum*	Bont Ticks	Recorded (Option 2)	LC
Family Vespidae		Paper Wasps	Recorded (Option 1) and (Option 2)	LC
	Belonogaster dubia		Recorded (Option 1) and (Option 2)	LC
Family Halictidae		Sweat Bees/Flower Bees	Recorded (Option 1) and (Option 2)	LC
	Nomia amebilis	Flower Bees	Recorded (Option 1) and (Option 2)	LC
Family Apidae		Honey Bees	Recorded (Option 1) and (Option 2)	LC
	Apus mellifera		Recorded (Option 1) and (Option 2)	LC
	Meliponula sp.	Stingless bees/Mopane Bees	Recorded (Option 1) and (Option 2)	LC
Family Anthophoridae		Bees	Recorded (Option 2)	LC
	Amegella atrocincta	Bees	Recorded (Option 2)	LC

Family Formicidae		Ants	Recorded (Option 1) and (Option 2)	LC
	Chroplolepis custodiens	Pugnacious Ant	Recorded (Option 1) and (Option 2)	LC
	Camponotus maculatus	Spotted Sugar Ant	Recorded (Option 1) and (Option 2)	LC
	Linepithema humile	Aregentine Ant	Recorded (Option 1) and (Option 2)	LC
	Carebara vidua	Arfrican Thief Ant	Recorded (Option 1) and (Option 2)	LC
	Solenopsis punctaticeps	Fire Ant	Recorded (Option 1) and (Option 2)	LC
	Messos capensis	Harvester Ant	Recorded (Option 1) and (Option 2)	LC
	Tetraponera	Slender Ants	Recorded (Option 1) and (Option 2)	LC
	Dorylus helvolus	Red Driver Ant	Recorded (Option 1) and (Option 2))	LC
	Pachycondyla tarsata	African Stink Ant	Recorded (Option 1) and (Option 2)	LC
Family Carabidae		Ground Beetles	Recorded (Option 1) and (Option 2)	LC
	Bradybaenus opulentus	Marsh Ground Beetle	Recorded (Option 1)	LC
	Craspedophorus bronvouloiri	Yellow Spotted Ground Beetle	Recorded (Option 1) and (Option 2)	LC
	Thermophilum fornasinii	Ground Beetle	Recorded (Option 1) and (Option 2)	LC
	Caminora	Starred Ground Beetle	Recorded (Option 1) and (Option 2)	LC
	Tefflus	Peaceful Giant Ground Beetle	Recorded (Option 1) and (Option 2)	LC
	Manticora	Monster Tiger Beetles	Recorded (Option 1) and (Option 2)	LC
Family Histeridae		Steel Beetles/Hister Beetles	Recorded (Option 1) and (Option 2)	LC
Family Staphylinidae		Rove Beetles	Recorded (Option 1) and (Option 2)	LC
Family Bolboceratidae		Scarab Beetles	Recorded (Option 1) and (Option 2)	LC
Family Scarabaeidae	Numerous Species	Scarab Beetles/Dung	Recorded (Option 1) and	LC

		Beetles	(Option 2)	
	Sisyphus	Spider Dung Beetles		LC
	Scarabaeus rusticus	Dung Beetle	Recorded (Option 1)	LC
	Anomalipus planus	Darkling Beetle		LC
	Aphodius mesontoplatys zulu	Dung Chafers		LC
	Aphodius pharaphodius impurus	Dung Chafers		LC
	Aphodius nobius inoratus	Dung Chafers		LC
	Aphodius pharaphodius posticus	Dung Chafers		LC
	Aphodius pharaphodius teter	Dung Chafers		LC
	Aphodius trichaphodius lanuginosus	Dung Chafers		LC
	Aphodius trichaphodius pseudohumilis	Dung Chafers		LC
Family Cleridae		Chequered Beetles	Recorded (Option 1) and (Option 2)	LC
Family Melyridae		Soft-Winged Flower Beetles	Recorded (Option 1) and (Option 2)	LC
Family Coccinellidae		Ladybugs/Ladybirds	Recorded (Option 1) and (Option 2)	LC
Family Tenebrionidae	Various Species	Darkling Beetles	Recorded (Option 1) and (Option 2)	LC
Family Anthicidae		Ant Beetles	Recorded (Option 1) and (Option 2)	LC
Family Mordellidae		Tumbling Flower Beetles	Recorded (Option 1) and (Option 2)	LC
Family Cerambycidae		Longhorn Beetles/Timber Beetles	Recorded (Option 1) and (Option 2)	LC
Family Chrysomelidae		Leaf Beetles	Recorded (Option 1) and (Option 2)	LC
Family Bruchidae		Pea/Bean/Seed Weevils	Recorded (Option 1) and (Option 2)	LC
Family Anthribidae		Fungus Weevils	Recorded (Option 1)	LC
Family Brentidae		Primitive Weevils	Recorded (Option 1) and (Option 2)	LC
Family Curculionidae		Weevils/Snout Weevils	Recorded (Option 1) and (Option 2)	LC
Red Data Species (Adapted Emery *et al*. 2002)				

Family Lycaenidae	*Aloeides rossouwi*			EN
	Aloeides barbarae			EN
	Aloeides nubilis			VU
Family Lycaenidae	*Lepidochrysops swanepoeli*	Swanepoel's Blue		EN
	Lepidochrysops jefferyi	Jeffrey's Blue		EN
Family Nymphalidae	*Dingana fraterna*	Stoffberg Widow	Habitat Recorded (Option 1)	EN
Family Hesperiidae	*Metisella meninx*	Marsh Sylph	Habitat Recorded (Option 1)	VU
Family Coenagrionidae	*Pseudagrion coeleste.*	Damselfly		CR
	Pseudagrion inopinatum	Damselfly		VU
	Pseudagrion newtoni	Damselfly		VU
	Pseudagrion sjoestedti pseudosjoestedti	Damselfly		CR

Recorded (Option 1):Option 1,
Recorded (Option 2):Option 2,
Recorded (Option 1) and (Option 2):Both Sites
Blank(No information):Not Recorded

Appendix 2: Herpetofauna recorded within quarter degree grids 2529CD, 2529DC and 2629AB) (Adapted from MPTA, 2008 & Branch, 1998)

Scientific Name	Common Name	Habitat	Status
Reptiles			
Atractaspis bibronii	Bibrons stiletto snake		
Pachydactylus bibronii	Bibron's thicktoed gecko		
Dendroaspis polylepis	Black mamba		
Aparallactus capensis	Black-headed centipede eater		
Gerrhosaurus nigrolineatus	Black-lined plated lizard		
Lamprophis fuliginosus	Brown House Snake	Common in highveld grassland and arid karoo regions, also tolerant of urban sprawl.	
Lycodonomorphus rufulus	Brown water snake		
Leptotyphlops conjunctus conjunctus	Cape and Eastern Thread Snakes	Varied:Grassland, coastal bush, mesic and arid savannah	
Aparallactus capensis	Cape Cnetipede eater	Varied including highveld and montan grassland, sabannah and coastal bush	Not Endemic
Mehelya capensis	Cape file snake		
Lycophidion capense	Cape wolf snake		
Python sebae	Common african python		
Lycodonomorphus rufulus	Common BrownWater Snake	Small streams, pans and vleis	
Lygodactylus capensis	Common dwarf gecko		
Dasypeltis scabra	Common egg-eater		
Bitis arietans	Common puffadder		
Mabuya striata	Common striped skink		
Mabuya varia	Common variable skink		
Dasypeltis scabra	Common/Rhombic Egg Eater	All habitats except true desert and canopy forest	
Agama aculeata	Distant's spiny agama		
Telescopus semiannulatus semiannulatus	Eastern Tiger Snake	Savannah and sandveld	

Telescopus semiannulatus	Eastern tiger snake		
Typhlops schlegelii	Giant blind snake		
Acontias plumbeus	Giant legless skink		
Gerrhosaurus validus	Giant plated lizard		
Platysaurus intermedius wilhelmi	Greater flat lizard		
Agama aculeata distanti	Ground Agama	Semi deset and sandveld savannah	
Crotaphopeltis hotamboeia	Herald/Red Lipped Snake	Savannah and Open woodland	
Cordylus tropidosternum	Jones' girdled lizard		
Aspidelaps scutatus	Lebombo shield snake		
Psammophis brevirostris brevirostris	Leopard and Short snouted grass snakes	Rocky area, highveld and montane grassland	
Geochelone pardalis	Leopard Tortoise	Varied	Not Endemic
Leoptotyphlops conjunctus	Lesser worm snake		
Leptotyphlops longicaudus	Long-tailed worm snake		
Dipsadoboa aulica	Marbled tree snake		
Naja mossambica	Mfesi		
Hemirhagerrhis nototaenia	Mopane snake		
Amblyodipsas concolor	Natal purple-glossed snake		
Varanus niloticus	Nile monitor		
Mehelya nyassae	Nyasa file snake		
Psammophis phillipsii	Olive grass snake		
Nucras ornata	Ornate scrub lizard		
Amblyodipsas polylepis	Purple-glossed snake		
Mabuya quinquetaeniata	Rainbow rock skink		
Crotaphopeltis hotamboeia	Red-lipped snake		
Hemachatus haemachatus	Rinkhals	Grassland from the coast upto 2500m	
Varanus albigularis	Rock leguan		
Ichnotropis squamulosa	Rough-scaled sand lizard		
Scelotes mossambicus	Short footed burrowing skink		

Naja annulifera annulifera	Snouted cobra	Svannah particularly in bushveld and lowveld	
Causus defilippii	Snouted night adder		
Naja annulifera	South-eastern egyptian (snouted) cobra		
Philothamnus hoplogaster	Southeastern green snake		
Agama atra	Southern Rock and Knobel's Agama	Semi desert to fynbos from sea level to mountain tops	
Thelotornis capensis	Southern vine snake		
Atractaspis bibronii	Southern's Burrowing Asp	Varied, ranging from highveld grassland, semi desert to montane bush	Not Endemic
Kinixys spekii	Speke's hinged-back tortoise		
Lygodactylus ocellatus	Spotted Dwarf Gecko	Well wooded Granite hills	
Prosymna ambigua	Spotted shovel-snout		
Pachydactylus punctatus	Spotted thicktoed gecko		
Psammophylax rhombeatus rhombeatus	Spotted/Rhombic Skapstekaar	Highveld grasslands,mesic thicket and fynbos enetering karroid areas	
Psammophylax tritaeniatus	Striped skaapsteker	Floodplain grassland	
Pachydactylus capensis	Striped Skink	Mangrove Swamp to arid savannah	
Lygosoma sundevallii	Sundevall's writhing skink		
Psammophylax tritaeniatus	Three-lined grass snake		
Cordylus vittifer	Transvaal Girdled Lizard	Mesic Thicket	
Pachydactylus affinis	Transvaal Thick Toed Gecko	Rocky outcrops and dead termite nests in highveld grasslands	
Leptotyphlops distanti	Transvaal worm snake		
Agama atricollis	Tree agama		
Dispholidus typus	Tree-snake		
Hemidactylus mabouia	Tropical house gecko		
Prosymna bivittata	Twinstriped shovel-snout		
Mabuya sp. nov	typical skink	Varied	
Pachydactylus vansoni	Van Son's thicktoed gecko		
Philothamnus semivariegatus	Variegated bush snake		
Zygaspis violacea	Violet round-headed worm lizard		

Panaspis wahlbergii	Wahlberg's snake-eyed skink		
Homopholis wahlbergii	Wahlberg's velvety gecko		
Psammophis subtaeniatus	Western stripe-bellied sand snake		
Gerrhosaurus flavigularis	Yellow throated plated lizard	Varied; montane grassland, savannah, bushveld and low open coastal forest	
Amphibians			
Strongylopus wageri	Plain Stream Frog	Rivers systems, foothills and high slopes	VU
Pyxicephalus adspersus	Giant Bullfrog	Pans and wetlands in savanna grassland	VU
Hyperolius semidiscus	Yellow -striped Reed Frog	River systems	VU
Breviceps species	Whistling Rain Frog	Aquatic systems	VU
Bufo gariepensis nubicolus	Karoo Toad	Aquatic systems	VU
Afrixalis fornasinii	Greater-Leaf Folding Frog	Aquatic systems	VU
Heleophryne natalensis	Natal Ghost Frog	River systems	VU

Appendix 3: Avifauna recorded within quarter degree grids, 2529CD, 2529DC and 2629AB (Adapted from MPTA, 2008)

Scientific Name	Common Name	Habitat	Distribution/Protection Status	Occurrence
Anas sparsa	African Black Duck	Fast flowing water	Resident	
Upupa africana	African Hoopoe	Thornveld, open woodland, parks, gardens	Common Resident	
Porphyrio madagascariensis	African Purple Swamphen	Reedbeds, sedge marshes, flooded grassland	Common Resident	
Lagonosticta ribricata	African Quail Finch	Thickets, riverine scrub, suburbia	Common Resident	
Theskiornis aethopicus	African Sacred Ibis	Grassland, Vlei areas	Common Resident	
Threskiornus aethiopicus	African Sacred Ibis	Grassland, vleis	Common Resident	**Sighted**
Vanellus senegallus	African Wattled Lapwing Plover	Damp Grass, wetland fringes	Common Resident	
Myrmecocichla formicivora	Anteating Chat	Grasslands with termite mounds, open sony areas	Common Resident (SA endemic)	
Nycticorax nycticorax	Black Crowned Night Heron	Reedbeds, Shaded Areas	Common Resident	
Ardea melanocephala	Black Headed Heron	Grassy areas near water	Common Resident	
Himantopus himantopus	Black Winged Stilt	Marshed & pans	Common Resident	
Vanellus armatus	Blacksmith Lapwing Plover	Damp Areas & Wetland Margins	Common Resident	
Telophorus zeylonus	Bokmakierie	Fynbos, scrub woodland, suburbia	Common Resident (endemic)	
Lonchura cucullata	Bronze Mannikin	Diverse, grassy areas, woodland, edges of water	Common Resident	
Phedina borbonica	Brown Throated Martin	Freshwater lakes, rivers, streams	Common Resident	
Serinus canicollis	Cape Canary	Grassland, suburbia	Common Resident	
Macronyx capensis	Cape Longclaw	Grassland adjoining freshwater areas	Common Resident	
Cossyphra caffra	Cape Robin Chat	Diverse	Common Resident	
Streptopelia capicola	Cape Turtle Dove	Diverse	Abundant Resident	
Motacilla capensis	Cape Wagtail	Usually near freash water	Common Resident	
Ploceus capensis	Cape Weaver	Grassland along river courses, reedbeds, trees	Common Resident (SA endemic)	
Passer melanurus	Cape White Eye	Grassland, grain fields	Common Resident (SA near endemic)	
Bubulcus ibis	Cattle Egret	Associated with cattle & game	Common Resident	

Cisticola textrix	Cloud (Tink Tink) Cisticola	Grassland	Common Resident	**Sighted**
Lanius collaris	Common Fiscal Shrike	Diverse	Common Resident	**Sighted**
Gallinula chloropus	Common Moorhen	Any water with reeds & tall grass	Common Resident	
Trachyphonus vaillantii	Crested Barbet	Woodland, savanna, gardens	Common Resident	
Vanellus coronatus	Crowned lapwing plover	Short grass/golf courses	Common Resident	
Pycnonotus tricolor	Dark Capped (Black Eyed) Bulbul	Variety of habitats	Abundant Resident	
Cisticola aridulus	Desert Cisticola	Arid grassland/old fields	Common Resident	
Chrysococcyx caprius	Dideric Cuckoo	Diverse	Common Visitor	
Alopochen aegyptiaca	Egyptian Goose	Freshwater	Common Resident	
Euplectes axillaris	Fan-tailed Widowbird	Reedbeds, damp grassInd, sugarcane fields	Common Resident	
Silegus silens	Fiscal Flycatcher	Diverse	Common Resident (SA endemic)	
Plegadis falcinellus	Glossy Ibis	Associated with water	Common Resident	
Podiceps cristatus	Great CrestedGrebe	Large stretches of freshwater	Common Resident	
Cinnyric afer	Greater Double Collared Sunbird	Diverse	Common Resident (endemic)	
Hirundo cucullata	Greater Stripped Swallow	Grassland, vleis	Summer Visitor	
Ardea cinerea	Grey Heron	Pans, aquatic environments	Common Resident	**Sighted**
Bostrychia hagedash	Hadeda Ibis	Widespread	Common Resident	
Numida meleagris	Helmeted Guineafowl	Diverse	Common Resident	
Apus Horus	Horus Swift	Diverse (mainly aerial)	Summer Visitor	
Anas hottentota	Hottentot Teal	Small waterbodies lines with vegetation	Locally Common Resident	
Passer domesticus	House Sparrow	Suburbia, gardens	Abundant Resident	
Charadrius pecuarius	Kittlitz Plover	Areas near water	Common Resident	
Streptopelia senegalensis	Laughing Dove	Widespread	Abundant Resident	
Hirundo abyssinica	Lesser Stripped Swallow	Near Water	Common Resident	
Cisticola tinniens	LeVaillant's Cisticola	Redbeds, long grassesclose to water	Common Resident	**Sighted**
Egretta garzetta	Little Egret	Freshwater	Common Resident	
Tachybaptus ruficollis	Little Grebe	Open stretch of freshwater	Common Resident	**Sighted**
Vidua paradisaea	Longtailed Paradise Wydah	Mixed woodland	Common Resident	
Euplectes progne	Longtailed Widowbird	Open graasland, especially in valleys & damp areas	Common Resident	**Sighted**

Oxyura maccoa	Maccoa Duck	Quiet Water	Common Resident (SA endemic)	**Sighted**
Cisticola fulvicapilla	Neddicky (piping) Cisticola	Grassy understroy, woodland	Common Resident	
Turdus olivaceus	Olive Thrush	Diverse	Common Resident	
Amandava subflava	Orange Breasted Waxbill	Grassland & weedy areas near water	Common Resident	
Spreo bicolor	Pied Starling	Grassland, scrub woodland, around farm houses	Common Resident (SA endemic)	
Vidua macroura	Pin Tailed Wydah	Savanna, grassland, scrub	Common Resident	**Sighted**
Ardea purpurea	Purple Heron	Aquatic sedges, reeds	Common Resident	
Quelea quelea	Red Billed Quelea	Savanna, thornveld, cropland	Common Visitor (nomadic)	
Anas erythrorhyncha	Red Billed Teal	Freshwater	Common Resident	
Streptopelia semitorquata	Red Eye Dove	Diverse	Common Resident	
Fulica cristata	Red Knobbed Coot	Dams, pans, lakes	Common Resident	
Phalacrocorax africanus	Reed Comorant	Freshwater dams, lakes & rivers	Common Resident	
Hirundo fuligula	Rock Martin	Cliffs, quarried, rocky terrain	Common Resident	
Geronticus calvus	Southern Bald Ibis	Short grazed or burnt upland grasslnd	Vulnerable (protected)	**Sighted**
Passer diffusus	Southern Grey Headed Sparrow	Mixed woodland, suburbia	Common Resident	
Ploceus velatus	Southern Masked Weaver	Savanna & grassland, close to water	Common Resident	
Euplectes orix	Southern Red Bishop	Grasslands, savanna near water. Breeds in reedbeds	Common Resident	
Colius striatus	Specled Mousebird	Thick tangled bush, fruiting trees, gardens, parks	Common Resident	
Columba guinea	Specled Rock Pigeon	Rocky terrain	Common Resident	
Burhinus capensis	Spotted Dikkop	Grassland & savanna	Common Resident	
Plectropterus gambensis	Spur Winged Goose	Grassland, agricultural fields	Common Resident	
Ardeola ralloides	Squacco Heron	Vegetated margins of freshwaterlakes, pans, slow moving rivers	Common Resident	
Pternistes swainsonii	Swainson's Francolin	Dry thornveld, agricultural fields	Common (SA Near-Endemic)	
Charadrius tricollaris	Three Banded Plover	Waterbodies with sandy/pebble layer	Common Resident	
Ploceuscocollatus	Village Weaver	Savanna, overhanging trees	Common Resident	
Phalacrocorax lucidus	White Breasted Comorant	Freshwater	Common Resident	

Apus cafer	White Rumped Swift	Diverse (mainly aerial)	Summer Visitor	**Sighted**
Hirundo albigularis	White Throated Swallow	Closely associated with water	Summer Visitor	
Cisticola ayresii	Wing Snapping (Ayre's) Cisticola	Upland grassland	Common Resident	
Anas undulata	Yellow Billed Duck	Open Water	Common Resident	
Egretta intermedia	Yellow Billed Egret	Damp, grassy areas	Common Resident	
Euplectes afer	Yellow Crowned Bishop	Grassland & vleis	Common Resident	
Cisticola juncidis	Zitting (fantailed) Cisticola	Areas of thick grass in damp situations	Common Resident	

Sighted- At Natural Pan (Option 1)

Appendix 4: Observed and Expected Mammal Taxa (Adapted from MPTA, 2008)

Scientific Name	Common Name	Protection Status	Location on site	Occurrence
Cryptomys hottentotus	African Molerats	LC	Rocky Grassland	Recorded (Option 1)
Otomys angoniensis	Angoni Vlei Rat	LC	Grassland/Pan Interface	Recorded (Option 1)
Parahyaena brunnea	Brown Hyaena	NT		
Tragelaphus scriptus	Bushbuck	LC		
Potamochoerus porcus	Bushpig			
Tatera brantsii	Highveld Gerbil	DD		
Tatera leucogaster	Bushveld Gerbil	LC	Alien Invasive Bush clumps	Recorded (Option 1)
Vulpes chama	Cape Fox	LC		
Hystrix africaeaustralis	Cape Porcuine	LC (Protected)	Rocky Grassland	Recorded (Option 1)
Sylvicapra grimmia	Grey Duiker			Recorded (Option 1)
Genetta tigrina	Large Spotted Genet			
Aethomys namaquensis	Namaqua Rock Rat	LC	Alien Invasive Bushclumps	Recorded (Option 1)
Ourebia ourebi	Oribi	EN	Rocky Grassland	Recorded (Option 1)
Lepus saxatilis	Scrub Hare	LC	Rocky Grassland	Recorded (Option 1)
Lemniscomys roscilia	Single Striped Grass Mouse	LC	Alien Invasive Bush clumps	Recorded (Option 1)
Galerella sanguinea	Slender Mongoose	LC	Pipeline Route	Recorded (Route)
Raptucerus campestris	Steenbok	LC	Rocky Grassland	Recorded (Option 1)
Cynictus penicillata	Yellow Mongoose	LC	Pipeline Route	Recorded (Route)
Recorded (Option 1)-Sighting at Option 1, Recorded (Route)-Sighting along pipeline route				

Appendix J

MIDDELBURG MINE WATER TREATMENT PLANT: ECOLOGICAL ASSESSMENT FOR NEW SITE

(Strategic Environmental Focus, 2009)

MIDDELBURG MINE WATER TREATMENT PLANT: ECOLOGICAL ASSESSMENT FOR NEW SITE

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S.E.F
STRATEGIC ENVIRONMENTAL FOCUS

May 2009

EXECUTIVE SUMMARY

BHP Billiton Energy Coal South Africa (BECSA) is in the process of conducting a feasibility study into the construction and operation of a 25Ml/d mine water treatment facility which will be located on the Middleburg Mine, North Section. Excess water from the Middleburg Mine Services and Douglas Colliery, as well as mine water supplied from the Bank/Goedehoop Colliery (Anglo Coal) will be treated by the facility. In 2008, environmental studies were done for the area considered for development and based on these findings an additional site was added for consideration of the proposed development. Strategic Environmental Focus (Pty) Ltd (SEF), as independent environmental practitioners, were therefore appointed by Jones and Wagner (Pty) Ltd to undertake the ecological assessments associated with the additional section of land considered for the Middleburg Mine Water Treatment Plant Facility.

The site visit was conducted on 26 and 27 March 2009 and identified four vegetation types namely, grassland vegetation, disturbed grassland vegetation, hydrophilic vegetation and exotic bush clumps. The hydrophilic vegetation unit included two wetlands, a valley bottom and a seepage wetland. The wetlands were considered to have a high ecological function and were therefore considered to be of high sensitivity. The grassland vegetation, although disturbed, did contain protected plant species as well as the structural diversity to support a number of faunal species and was therefore considered to be of medium sensitivity. The disturbed grassland and alien invasive bush clumps were considered to be of low ecological sensitivity.

It is recommended for the sensitive areas (wetlands and grassland holding protected plant species) to remain intact and be used to form part of an open space system incorporating areas from the adjacent sites previously assessed. The low sensitivity areas are recommended for development purposes should the mitigation measures be implemented and managed accordingly. However, all areas should be minimally disturbed if not used for the development of the wastewater treatment plant as they do contribute to the ecosystem ecology.

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1. INTRODUCTION

BHP Billiton Energy Coal South Africa (BECSA) is in the process of conducting a feasibility study into the construction and operation of a 25Ml/d water treatment facility to be located on Middelburg Mine North Section. This water treatment facility will treat all excess mine water produced by both Middelburg Mine Services (MMS) and Douglas Colliery (known as the Douglas Middelburg Optimization (DMO) project - BESCA) as well as mine water supplied from Bank /Goedehoop Colliery (Anglo Coal). The water will be treated to catchment standards for release into the catchment and/or to drinking water standard to supply to local users (Steve Tswete Municipality and neighboring mines).

In 2008 Middelburg Mine Services proposed two possible sites (Preffered – and Alternative Site) for the Water Treatment Plant (WTP) for which ecological studies were conducted (Strategic Environmental Focus, 2008 a, b and c). As a result of some ecological sensitivity on these sites, a new site was proposed adjacent to the disturbed area of the Preferred Site. For the purpose of this report, this proposed site is referred to as the New Site.

2. BACKGROUND AND TERMS OF REFERENCE

As part of the study, it was necessary to determine the environmental impacts associated with the implementation of this project to ultimately determine the feasibility thereof. Strategic Environmental Focus (Pty) Ltd was tasked by Jones and Wagner (Pty) Ltd to undertake the ecological assessment of the New Site. This report combines the findings of a wetland study, floral and faunal assessment done on 26 and 27 March 2009.

The purpose of the wetland assessment was:

- Delineation of the wetlands found within the study areas; and
- Recommendation of suitable mitigation measures where applicable.

The purpose of this floral study was to assess the floral sensitivity of the New Site to inform the design of the planned project accordingly. This entailed the following:

- Identification of the regional vegetation expected to occur on the sites;
- Identification of the vegetation found on the sites;
- Assessment of the status of the vegetation found on the site;
- Classification of the vegetation sensitivity of the sites and pipeline routes; and
- Determine possible impacts associated with the proposed development; and
- Identify mitigation measures to limit impacts on the aquatic resources.

The purpose of this faunal study was to assess the faunal assemblages which could possibly occur on site to inform the design of the planned project accordingly. This entailed the following:

- Identification of the broad-based vegetation units on site pertaining to faunal habitats;
- Lists of faunal species recorded and expected to occur on site;
- Classification of the faunal sensitivity of the site;
- Determine possible impacts associated with the proposed development; and
- Identify mitigation measures to limit impacts on the aquatic resources.

3. BACKGROUND INFORMATION

3.1 Location

Middelburg Mine is situated adjacent to the R 575 in the Mpumalanga Province in close proximity (± 20km) of the towns of Witbank (Emalahleni) and Middelburg. The mine falls within the 2529CD, 2529DC and 2629AB quarter degree squares and the proposed project involves the following farms: Goedehoop 315 JS, Hartbeesfontein 339 JS, Klipfontein and Bankfontein.

The New Site is located adjacent to the Preffered Site and east of the R 575 to Van Dyksdrif (Figure 1).

3.2 Land Use

The land use is classified as vacant, cultivated, quarries and mining with wetlands and exotic plantations scattered throughout the region (DEAT, 2001). The study area is used for livestock grazing and a borrow pit can be found within the boundaries.

3.3 Biophysical Description

3.3.1 Climate

Mpumalanga Province experiences summer rainfall and very dry winters with frost. Temperature ranges between an average high of 34 ℃ and a low of 8℃. Rainfall is on average 710 mm per year (South Africa Weather Service, 2008).

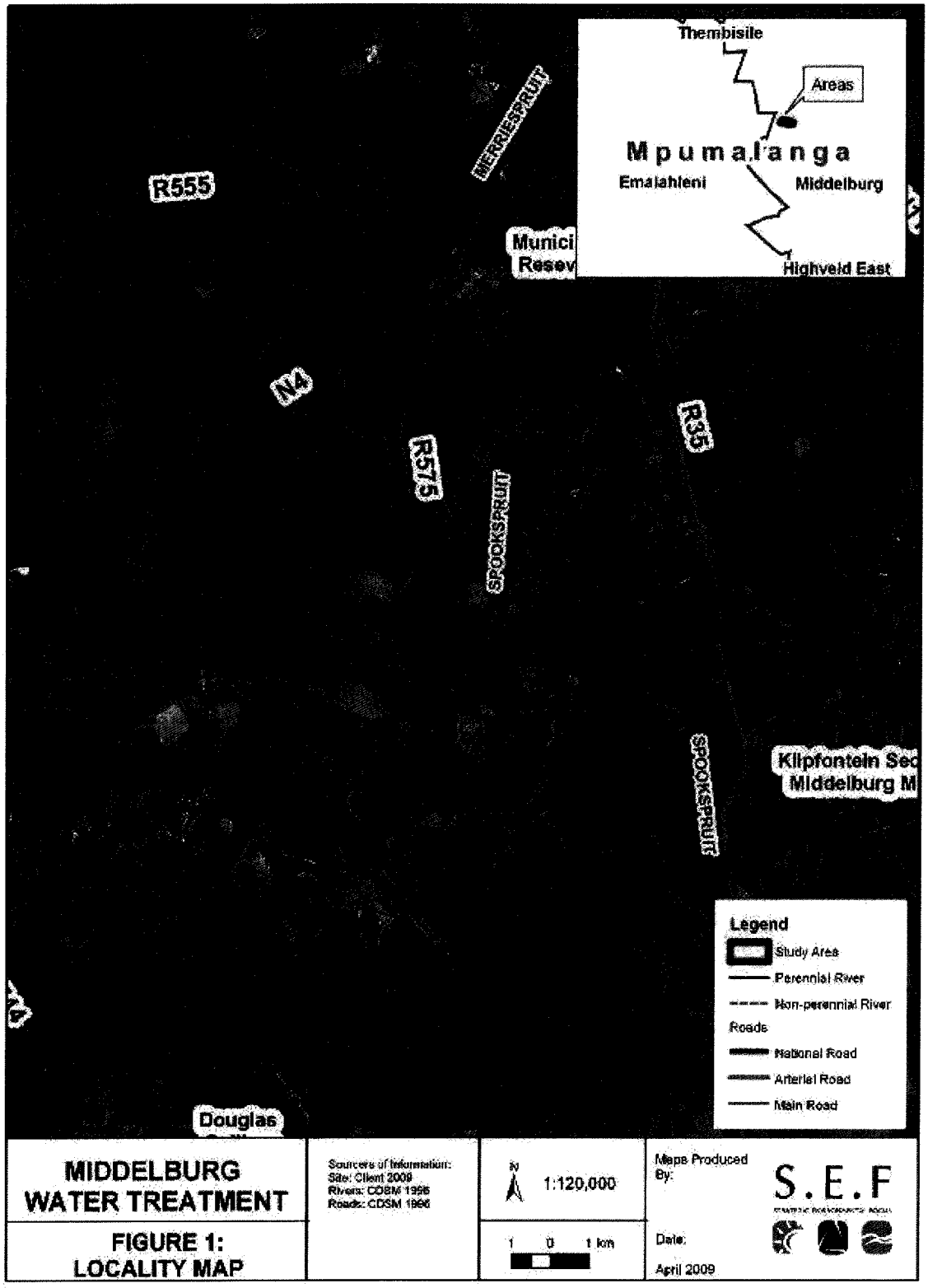


Figure 1: Site locality

3.3.2 Landscape features and soil

The landscape of the area is characterised by moderately undulating plains, with some low hills, rocky areas and pan depressions. There are several perennial and non-perennial rivers around the site including the endangered Spookspruit and Olifants River.

The site includes plinthic and red soils (DEAT, 2001). Plinthic soils contain high-chroma mottles and concretions (often with black centres). Mottling takes place in zones periodically saturated with water (Soil Classification Working Group, 1991). Plinthic soils are thus associated with wetland conditions (Soil Classification Working Group, 1991).

3.3.3 Regional vegetation

The study site falls within the Grassland Biome (Rutherford & Westfall, 1994). High summer rainfall characteristic of the Grassland Biome combined with dry winters with night frost and marked diurnal temperature variations are unfavourable to tree growth. The Grassland Biome therefore comprises mainly of grasses and plants with perennial underground storage organs, for example bulbs and tubers and less trees.

The Grassland Biome comprises various vegetation units of which the Rand Highveld Grassland and Eastern Highveld Grassland (Mucina & Rutherford, 2006). The wetland systems that occur in this region are classified as the Eastern Temperate Freshwater Wetlands (Mucina & Rutherford, 2006).

The majority of the site comprises Eastern Highveld Grassland, while Rand Highveld Grassland occurs on the north western portion of the site. Both vegetation units are poorly conserved with much of their area transformed by cultivation, grazing, and mining. Where disturbances occur, the invasive exotic tree *Acacia mearnsii* (Black Wattle) can become dominant and displace the natural vegetation. Due to the extensive usage of the areas covered by the endangered Rand Highveld Grassland and Eastern Highveld Grassland vegetation types, the remaining portions are of high conservation value and sensitivity and are thus classified as endangered vegetation communities (Mucina & Rutherford, 2006).

The Eastern Temperate Freshwater Wetlands occur in flat landscapes or shallow depressions filled with water. The water bodies contain aquatic zones and outer parts with hygrophilous vegetation of temporary flooded grasslands (Mucina & Rutherford, 2006).

Although mines and quarries are one of the smallest physical transformers of the vegetation communities and contributed just more than two percent to transformation in the Bankenveld, they do however have a much larger and less obvious effect on the surrounding communities through air, soil, water and noise pollution (Macdonald, 1991).

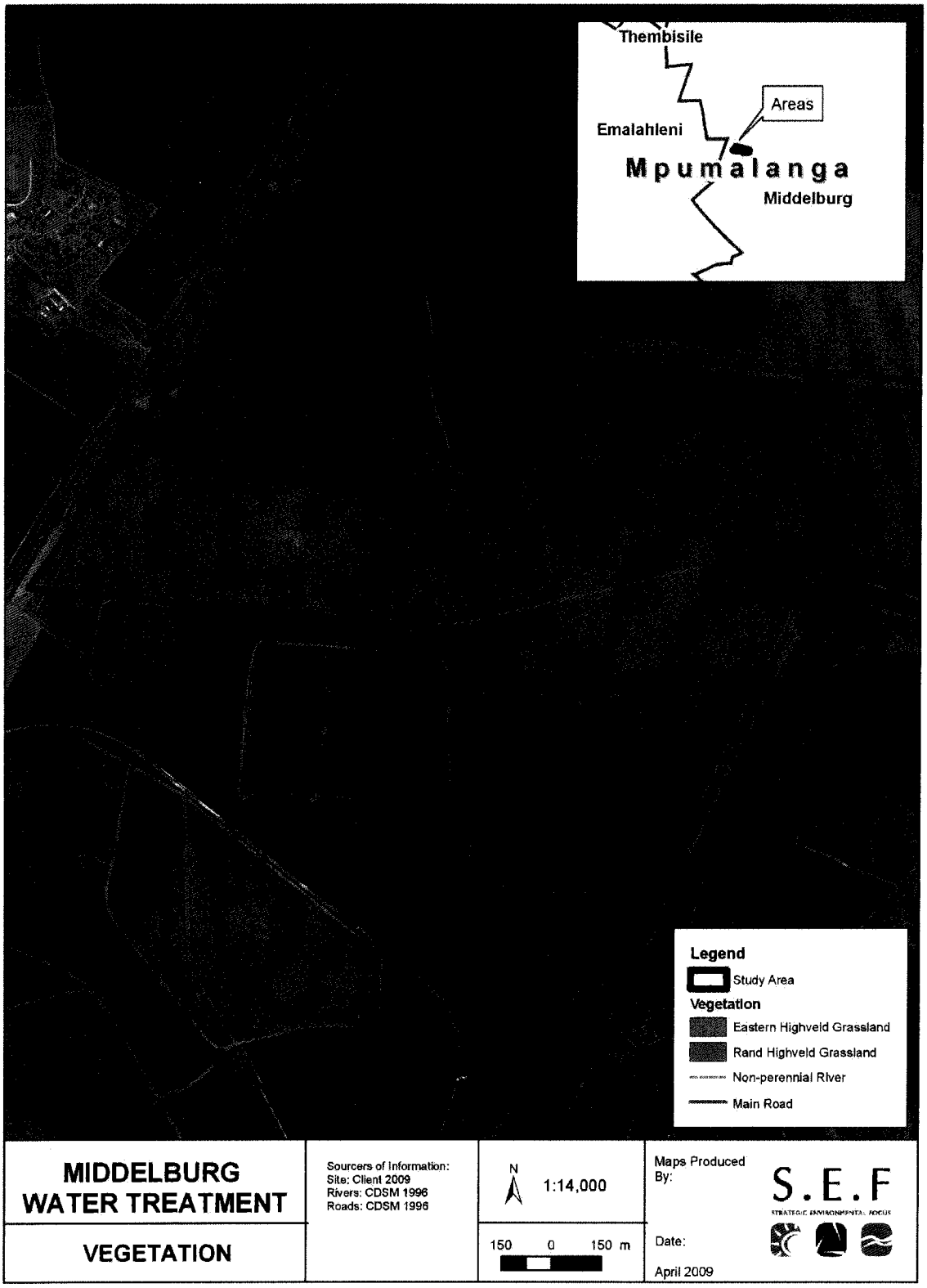


Figure 2: Regional vegetation

4. STUDY APPROACH

The methodology utilised during this study is discussed in Appendix A, D and F as well as the definitions used in the description of the ecological sensitivity of the site.

4.1 Limitations

The following limitations were applicable to the study area:

- The study was undertaken on 26 and 27 March 2009. In order to obtain a comprehensive understanding of the dynamics of communities and the status of endemic, rare or threatened species in an area, ecological studies should ideally be replicated over several seasons and over a number of years. However, due to project time constraints such long-term studies are not feasible;

- Rare and endangered plant species in grasslands are mostly small, very localised and visible for only a few weeks in the year when they flower (Ferrar & Lötter, 2007). The site visit was conducted during March 2009, when the flowering period for many plant species had ended. The probabilities of occurrence for these plants were based on distribution data and information gathered with regards to the area; and

- The large study area did not allow for the finer level of assessment that can be obtained in smaller study areas. Therefore, data collection in this study relied heavily on data from representative sections (transect walks), as well as general observations, a desktop analysis and work previously done within the area.

4.2 Assumptions

It was assumed that no Red Data species would occur on areas currently disturbed by open cast mining activities or rehabilitated land.

5. RESULTS: VEGETATION

The vegetation and ecological features found on the New Site (newly proposed site adjacent to the Preferred Site) were compared to the desktop analysis of the regional vegetation and weighed according to the sensitivity ratings (Appendix A).

The New Site comprises grassland, a wetland system (See wetland section) and alien bush clumps (Bluegum and Wattle trees). During the site visit, Braun-Blanquet sample plots were undertaken in visually homogenous vegetation communities. The different communities were similar with regards to species composition, ecological features or evidence of disturbance (e.g. overgrazing).

During the site visit, a total of 25 plots were sampled within the above mentioned vegetation communities (Figure 3). Sample plot 26 indicates the presence of the grass *Leersia heandra* (Rice Grass); host plant to the endangered *Metissila menix* (Marsh Sylph).

A correspondence analysis resulted in the cluster diagram depicted in Figure 4. The sample plots that appear close to each other on Axis 1 are more similar with respect to species composition, while Axis 2 indicates the variance within the similar groups (e.g. species that are not in common or discriminant species). The majority of the plots, even though they were visually different from each other, thus have a number of species in common. Plots 1, 2, 5, 8 and 17 display clear differences in species composition from the majority of the sample plots (outliers).

Sample plot 5 and 17 were dominated by the exotic Wattle species, while sample plot 1, 2 and 8 were greatly disturbed. These sampled plots were subjected to various disturbances: sample plot 1 and 2 were dominated by the weedy *Conyza albida* (Tall Fleabane), while sample plot 8 included moist soils with numerous Wattle saplings.

To further analyse the similarities within the majority of the sample plots, the outliers were removed from the data which resulted in the cluster diagram depicted in Figure 5. This figure gives a clearer indication of the similarities and variations within the remainder of the grassland sample plots.

The remainder of the samples comprised grassland. The majority of the sample plots are grouped around the same point on Axis 1, although a lot of variation occurs on Axis 2. These plots thus have similar species composition although discirminant species, or species that distinguish plots from each other, are responsible for the variation on Axis 2.

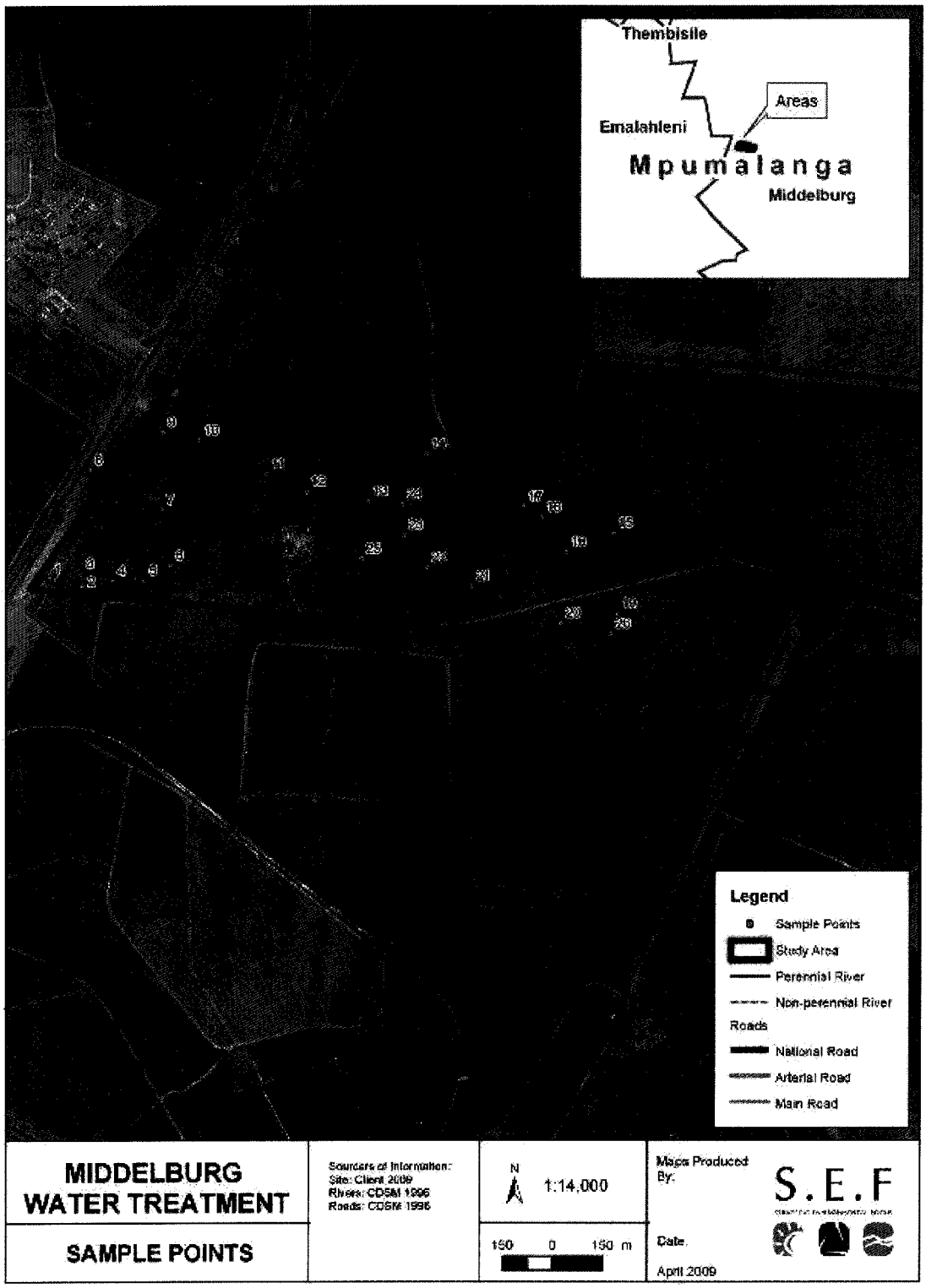


Figure 3: Sample points

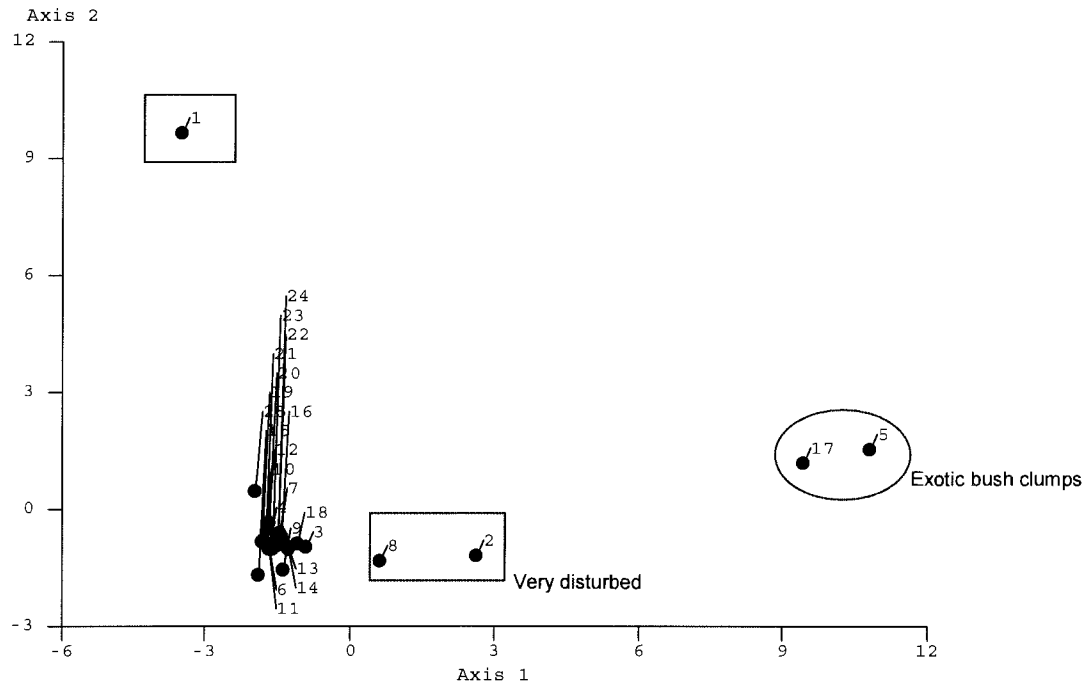


Figure 4: Cluster diagram of data obtained from the site

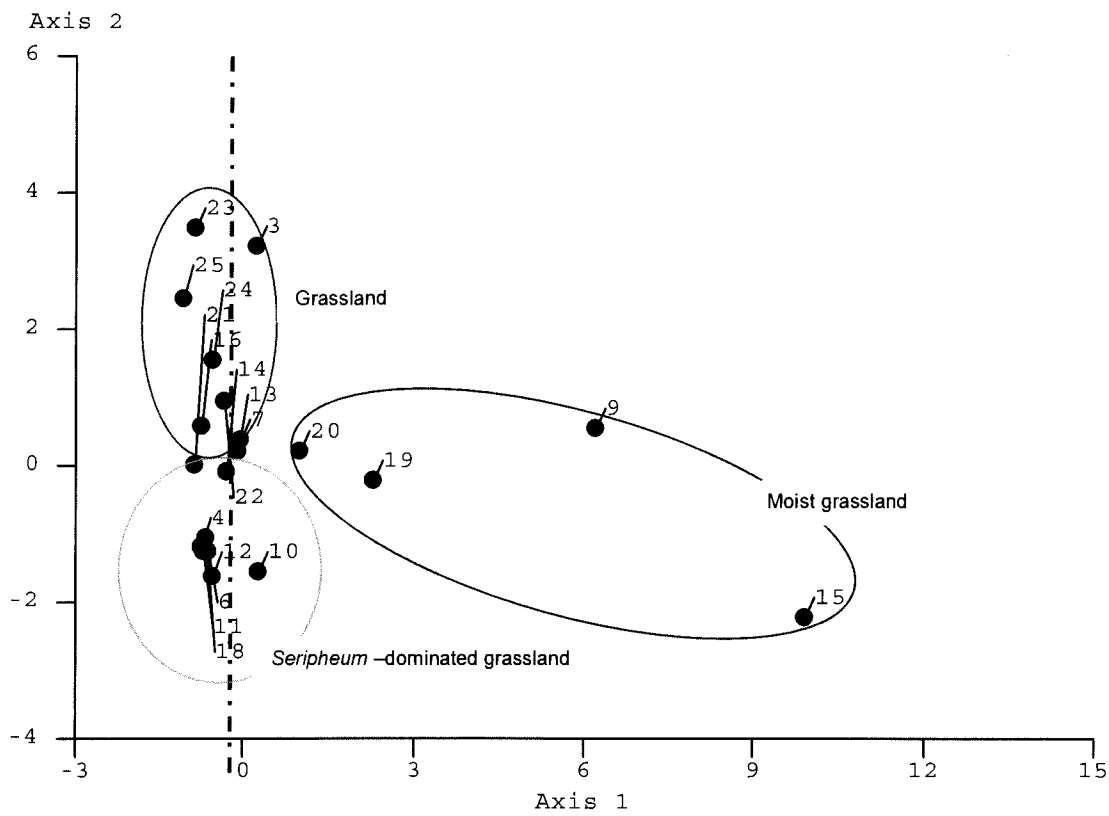


Figure 5: Cluster diagram of data without outliers

When Figure 5 is compared to the field notes, the following can be deduced:

- Sample plot 9, 15, 19 and 20 were situated in moist areas and correspond to the wetland delineation as set out in this report (Section 6) (Moist grassland);
- Plots that comprised largely of *Seripheum plumosum* (Bankrupt Bush) can be grouped (*Seripheum*-dominated grassland);
- Similarly, grassland with less or no *Seripheum plumosum* (Bankrupt Bush) is grouped closer to each other on Figure 5 (Grassland).

The vegetation communities on the site are therefore classified as:

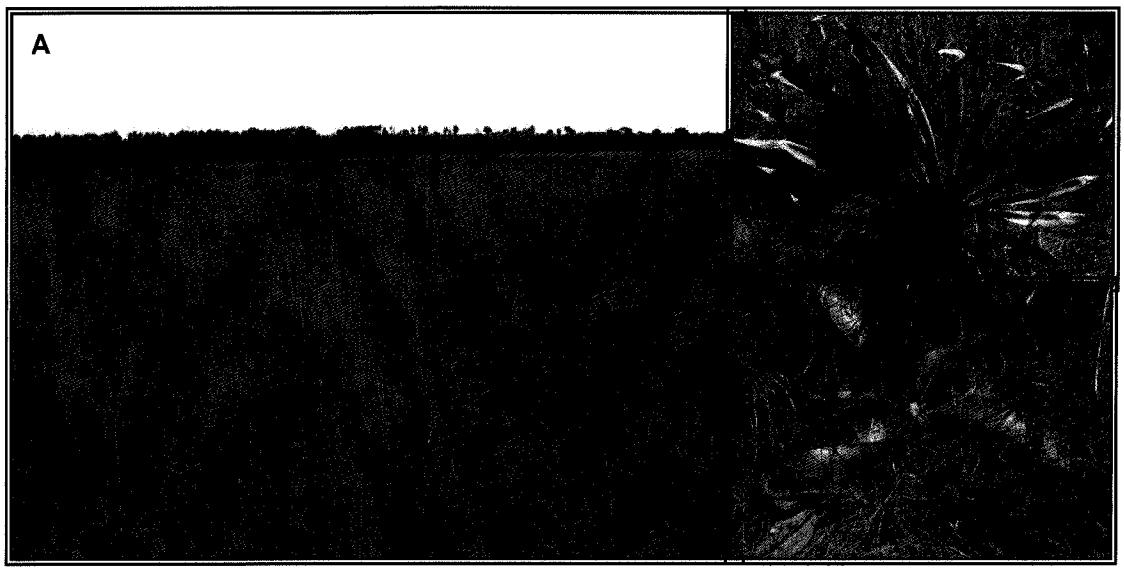
- Grassland;
- *Seripheum*-dominated grassland (disturbed);
- Moist Grassland; and
- Exotic Bush Clumps (Figure 4).

5.1 Grassland Vegetation Community

The majority of the site comprises grassland. Although this grassland has been subjected to disturbances such as grazing and a quarry in the past, some pockets of intact grassland still remain on the site. The grassland pockets were centred around the middle of the site on either side of the dirt road that pass in between sample plot 13, 14 and 24. Another small portion was located around sample plot 7, however disturbance was evident here. The grassland varied in species composition and included *Themeda triandra* (Red Grass), *Schizachyrium sanguineum* (Red Autumn Grass) and *Enneapogon cenchroides* (Nine-awned Grass). The grassland did not contain a high number of herbaceous plants; however, protected *Gladiolus* species, *Boophane distichia* (Poison Bulb) and a *Crinum* species grew here. The *Gladiolus* was in seed and could not be positively identified to species level, although studies on the adjacent property noted the presence of *Gladiolus crassifolius* (SEF, 2008a). The *Crinum* species was also not in flower (Photograph 1C). The grassland comprised at least ten (10) grass species, noticeably less than the species count on the adjacent property during the 2008 study (SEF, 2008a). *Enneapogon cenchroides* (Nine-awned Grass) is a pioneer grass that helps restore disturbed areas. The abundance of this grass within the grassland portions, indicate that some disturbances took place.

The forb species that were found within this grassland area are indicative of the presence of Rand Highveld Grassland and Eastern Highveld Grassland. Other forb species identified included *Erica drakensbergensis* (Drakensberg Heath), *Strigea elegans* (Large Witchweed), *Pollichia campestris* (Waxberry) and *Hypoxis rigidula* (Kaffirtulp). This grassland portion is small and not in a primary state. The basel cover is reasonably low and overgrazing evident; however, protected plants occurred here. Due to the varying degrees of disturbance, it was no possible to delineate this portion of grassland from disturbed grassland. This report thus estimated the extent of relatively

intact grassland (Photograph 1) which is ecologically functional. The function of this grassland is important around the moist grassland / wetland areas as well as where it includes protected plants and it is classified as *medium* sensitivity.



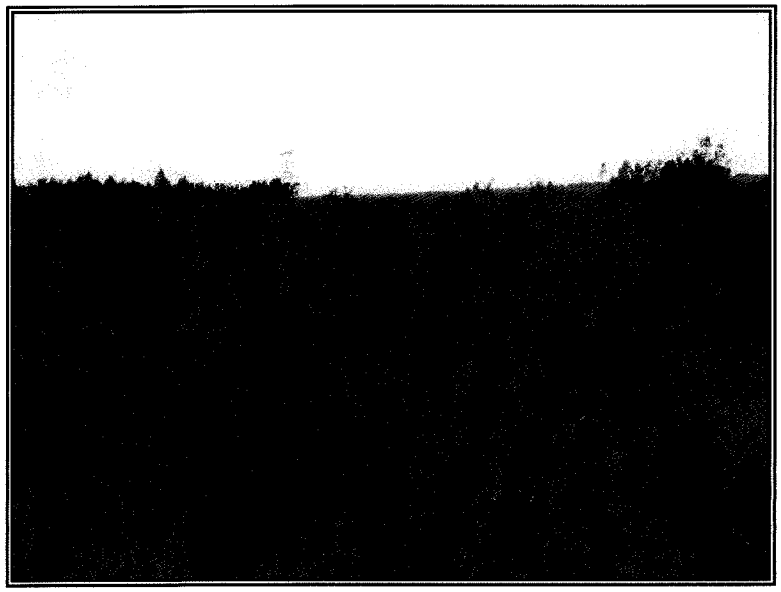
Photograph 1: Grassland (A) with protected species *Boophane distichia* (B) and *Crinum* sp (C)

5.2 Disturbed Grassland Vegetation Community

The majority of the grasslands displayed signs of severe overgrazing. The pioneer shrub, *Seripheum plumosum* (Bankrupt Bush) grew abundantly with very few forbs and grass species present. In a sample plot here, *Seripheum plumosum* (Bankrupt Bush) typically covered up to 70% of the sample plot while grasses such as *Monocymbium ceresiliforme* (Boat Grass), *Perotis patens* (Cat's Tail) and *Aristida congesta* (Tassel Three-awn) completed the cover.

All the perceived disturbed areas plotted are grouped in the cluster diagram in Figure 5. Some plots were not completely dominated by *Seripheum plumosum* and are closer to the grassland plots.

Seripheum plumosum (Bankrupt Bush) is known to proliferate in overgrazed areas (Van Wyk & Malan, 1997). The abundance of the shrub on most of the site thus indicates that overgrazing was and is still taking place on the site. The Bankrupt Bush formed dense stands, which inevitably will smother the forb species. No threatened or protected plant species were encountered within this vegetation community and none were expected to grow here. Due to the disturbances, this vegetation community is regarded as being of *low* sensitivity and low conservation concern.



Photograph 2: Dominance of *Seripheum plumosum* (Bankrupt Bush) within the disturbed grassland

5.3 Hydrophilic Vegetation Community

The eastern portion of the site displayed hydrophilic vegetation such as *Miscanthus junceus* (Sedge-leaved Broom Grass), *Mariscus congestus, Cyperus* species, *Leersia hexandra* (Rice Grass) and *Centella asiatica* (Marsh Pennywort). The north western portion of the site also contained grasses known to grow in moist soils such as *Paspalum dilatum* (Dallis Grass), *Mariscus congestus* and *Cyperus* species. Historically, this wetland was disturbed as apparent by the small dam in this area (See section 7: Wetland delineation).

The hydrophilic vegetation is presented by sample plot 9, 15, 19 and 20. The eastern portion and the western portion of the site thus contains moist elements and are classified as wetlands (Section 7). Point 26 on Figure 3 indicates a population of *Leersia hexandra* (Rice Grass), the host plant for the endangered *Metissela menix* (Marsh Sylph) (See section: Faunal assessment).

Due to its ecological functionality, this report describes the hydrophilic vegetation associated to be of *high* sensitivity. Furthermore, the Mpumalnga Biobase (Linström & Emery in Emery *et al*, 2002) described wetlands as one of the most valuable ecosystems in the world and that all activities that impact on the functionality of wetlands in this area are prohibited to take place within a 30 meter buffer from the wetlands.

5.4 Alien Bush Clump Vegetation Community

The remainder of the eastern portion of the site comprises of alien invasive bush clumps dominated by *Acacia mearsnii* (Black Wattle). Although an eradication plan seemingly

fell and burned some of the Wattle trees, most of the trees have re-sprouted and are growing profusely (Photograph 3). The sample plots that contained the alien bush clumps (Sample plot 5 and 17) had a cover abundance of 80% Wattle trees or more. The sample plots also contained grasses that are evident of the disturbed nature of this community and included *Cynodon dactylon* (Couch Grass) and *Eragrostis gummiflua* (Gum Grass). Declared weeds and invaders have the tendency to dominate or replace the herbaceous layer of natural ecosystems, thereby transforming the structure, composition and function of natural ecosystems. This reduces the ecological importance of this vegetation community and it is thus regarded as being of low sensitivity.

Photograph 3: Alien bush clumps

These species invade riparian and seep zones with disastrous impacts on water resources, especially within catchments regions. These species should be controlled to prevent further infestation and it is recommended that all individuals of the invader species be removed and eradicated.

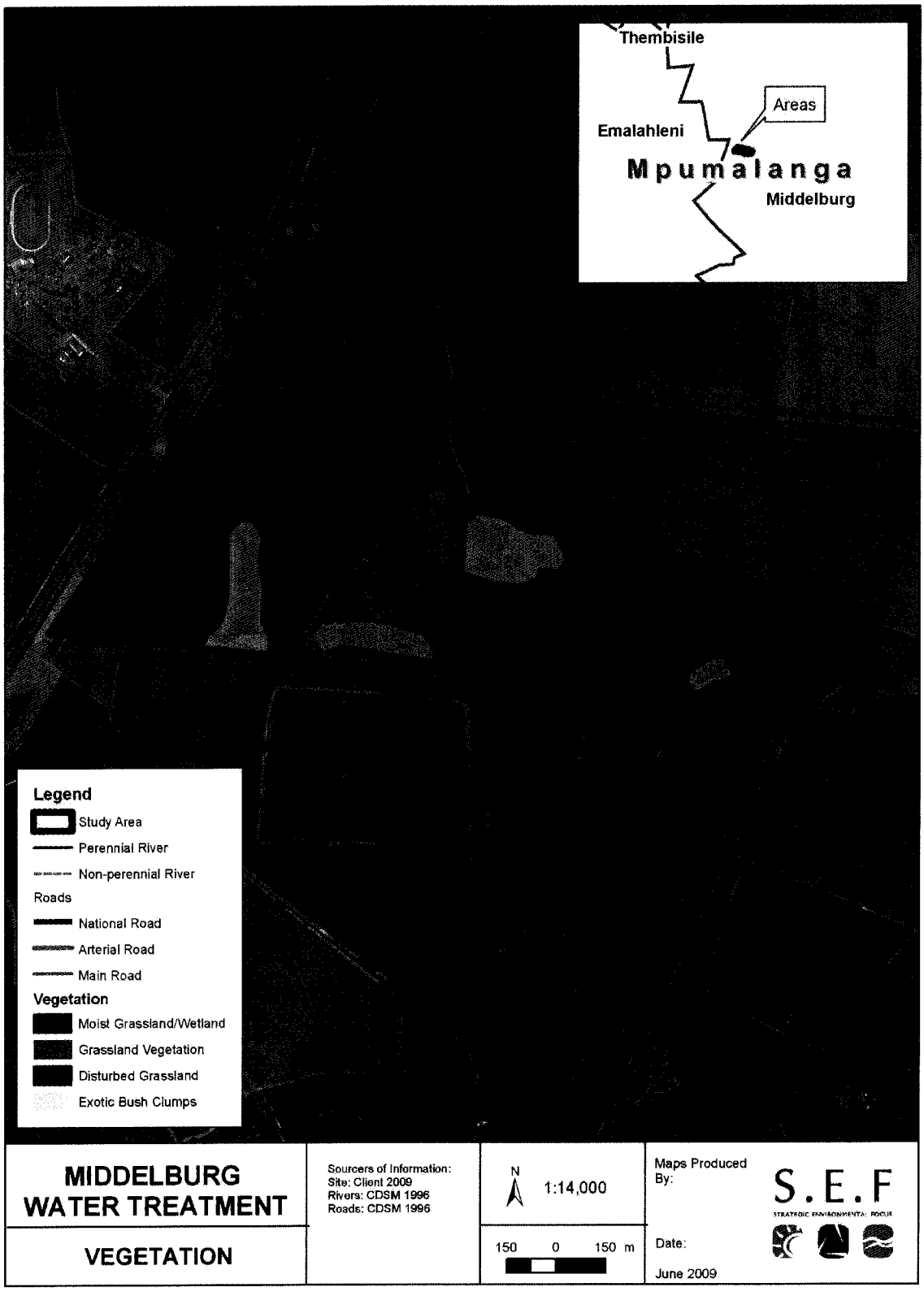


Figure 6: Vegetation Map

5.5 Red Data and Threatened Plants

No Red Data or Threatened floral species were encountered during the site visit, although suitable habitat does exists for some Red Data floral species (Emery *et al*, 2002). Appendix C lists the threatened floral species of Mpumalanga and provides an indication of their probability of occurrence on the site.

5.6 Protected Plants

Protected plants are listed in the Mpumalanga Nature Conservation Act, 1998 (Act No. 10 of 1998). A number of these plants were identified on the study sites, including *Boophane distichia* (Poison Bulb). *Boophane disticha* is a bulbous plant that occurs in grasslands and rocky areas. The plants were found growing within the grassland portion, currently not dominated by *Seripheum plumosum* (Bankrupt Bush). Table 1 indicates the protected plants identified during the site visit and their locality. Table 2 indicates protected plants that were identified on the adjacent property (Preferred Site: SEF, 2008a). Although these two plants were not identified on the New Site, there is a high possibility that they may occur within the moist grassland on the New Site.

Table 1: List of protected plants identified on the New Site

Species	Protection	Locality
Boophane distichia (Poison Bulb)	Specie	Grassland
Crinum (gramminicola)	Whole genus	Grassland areas and some portions where Bankrupt Bush is evident
Gladiolus crassifolius	Whole genus	Grassland

Table 2: List of protected plants with a possibility of occurring on the site

Species	Protection	Potential Locality
Habenaria falcicormis & Habenaria nyiikana	Whole family: Orhidaceae	Moist grassland
Eulophia specie	Whole family: Orhidaceae	Moist grassland

5.7 Medicinal Plants

The demand for medicinal plants is on the increase, whilst the frequently used plants and the communal land that it is harvested from are on the decline. With an increase in the country's population and the high rate of infectious diseases, this will put an even higher strain on the already scarce natural medicinal resources (Emery *et al*, 2002). Areas of high biodiversity are thus important for the conservation and sustainable use of these resources and should be safe-guarded. Table 3 present the medicinal plants found on the site as well as their conservation status (Emery *et al*, 2002).

Table 3: Medicinal plant species that were identified on the site

Scientific name	Common name	Conservation status (where applicable)
Acalypha angustata	Copper Leaf	
Alloteropsis semialata	Black-seed Grass	
Asparagus cooperi		
Berkeya setifera	Rasperdisseldoring	
*Bidens formosa**	Cosmos	
Boopane disticha	Poison Bulb	NT
Centella asiatica	Marsh Pennywort	
Chamaecrista comosa	Fishbone Cassia	
Comelina africana		
Crinum graminicola	Graslelie	P
Gladiolus crassifolius		P
Haplocarpa scaposa	Tonteldoosbossie	
Helichrysum nudifolium	Hottentot's tea	
Hypoxis rigidula	Kaffirtulp	
Ledebouria ovatifolia		
Monopsis decipiens	Butterfly Lobelia	
Persicaria species*	Knotweed/ Snakeroot	
Pollichia campestris	Waxberry	
Rhynchosia totta		
Schistostephium crataegifolium	Bergkruie	
Senecio coronatus	Sybossie	
Strigia elegans	Large Witchweed	
*Tagetes minuta**	Khaki Bush/ Blackjack	
Typha capensis	Bulrush	

* Naturalised weeds
NT Near Threatened (IUCN Categories)
P Protected (Mpumalanga Nature Conservation Act, 1998)

6. RESULT: FAUNA

The majority of the study area was surveyed on foot. General observations regarding vegetation and ecological features related to faunal aspects, as well as sightings of individual animals and signs of occurrence (spoor, droppings, nests and burrows) were compared to a desktop analysis and used to determine the sensitivity ratings of the various aspects of the study area as set out by the previous faunal assessment (SEF, 2008b). As stated previously, no small mammal trapping sessions, or pit fall trapping (invertebrates), was done within the area. Data obtained from the neighbouring site during April 2008 was considered.

6.1 Observed and Expected Species Richness

Lists of faunal species observed and expected to occur on sight are provided in Appendices G to J. During the survey period no herpetofauna or Red Data faunal species were recorded from the study area. Invertebrates were not assessed but were considered to be similar to the assessment for the adjacent site done in 2008 (SEF, 2008b).

The majority of mammal species are nocturnal and secretive. Confirmation was mostly via direct sightings and supplemented via spoor or droppings. Within the study area, rodent activity was evident in the form of burrows and disturbed plant materials especially seed bearing grasses. It is therefore considered for the study area to be capable of supporting a high diversity of small mammal species.

Also identified via droppings and spoor were scrub hares, porcupines and black backed jackals. Black backed jackals were further confirmed by personal communication with Lindie Moore[1]. The common molerat was identified via numerous burrows. Most confirmations of the mammals mentioned above were obtained from wetland and grassland areas, followed by disturbed grassland areas. During the survey, slender mongooses were sighted in association with grassland areas.

Avifaunal species were encounterd throughout the study area but most were common species listed in Appendix I. Most species were associated with wetland areas and include the yellow billed duck and black headed night heron.

6.2 Faunal Habitat (Ecological Importance and Sensitivity)

During the field survey, the following faunal habitats were observed within the study area (Figure 6):

[1] Project Specialist: Environment and Community
DMO Project, BHP Biliton

1 Hydrophilic vegetation;
2 Grassland;
3 Disturbed grassland; and
4 Alien invasive bush clumps and cultivated areas.

6.2.1 Hydrophilic vegetation

The National Water Act (Act 36 of 1998) highlights the importance of hydrological features and their protection. Wetlands were found within the study area (eastern and western portions), many of which were possibly caused due to seepage from various mine dams. Although mostly anthropogenic, they are considered ecologically functional. The wetland systems are therefore considered to have high sensitivity as they provide habitat for a number of faunal species that are partially or wholly reliant on aquatic systems, and due to the importance of hydrological features in maintaining biodiversity, nutrient cycling and movement corridors. The Mpumalanga Biobase further describes wetlands as valuable ecosystems and any factors impacting on the ecological functioning of these areas is prohibited to within 30m of the wetland (Emery *et al*, 2002).

6.2.2 Alien Invasive Bush Clumps

Alien invasive bush clumps were found scattered across the study area (mainly in the eastern section) and are indicated in Photograph 3. The alien invasive bush clumps are mainly dominated by *Acacia mearsnii* (Black Wattle). Although this vegetation type may be favoured by small mammals over open grasslands (they provide protection from predators and moister soils for easier burrowing) it is an exotic vegetation type and is considered to have a low sensitivity. This vegetation type should not pose constraints to the development as faunal species utilising these areas will relocate to prime areas. It is recommended for the alien invasive bush clumps to be removed in the long term to rehabilitate the areas not used for mining purposes or the construction of the waste water treatment plant.

6.2.3 Grassland

Grassland (Photograph 1), with minimal disturbances due to grazing ,is present within a small section situated in the middle of the study area. This area was higher in faunal activity with a number of faunal indicators observed (spoor and faeces) and is therefore considered to have a medium sensitivity. It should be considered for this section of land to be incorporated into an open space system which links to other areas of pristine grassland and functional wetlands.

6.2.4 Disturbed Grassland

The majority of the study is comprised of disturbed grasslands. The majority of disturbances are contributed towards agricultural practices (overgrazing of livestock) and mining practices in the form of a borrow pit. Faunal species common to this type of

habitat are normally opportunistic species such as rodents and common birds which can relocate to other areas. This habitat type is therefore considered to have a low ecological sensitivity and should not pose constraints to the development.

6.3 Threatened and Conservation Important Species

No threatened or conservation important species were sampled from the study area although habitat for the Marsh Sylph (*Metisella meninx*) was recorded within the hydrophilic area in the eastern portion of the study area (Point 26 – Figure 3). In addition, the grassland and hydrophilic vegetation may provide suitable foraging habitat for vulnerable avifauna species such as *Tyto capensis* (Grass Owl). Owl pellets were observed within the grassland vegetation.

7. RESULTS: WETLAND

As South Africa is a contracting party to the Ramsar Convention on Wetlands, the South African government has taken a keen interest in the conservation, sustainable utilisation and rehabilitation of wetlands in South Africa. This aspect is also reflected in various pieces of legislation controlling development in and around wetlands and other water resources, of which the most prominent may be the National Water Act, Act 36 of 1998. As South Africa is an arid country, with a mean annual rainfall of only 450mm in relation to the world average of 860mm (DWAF, 2003), water resources and the protection thereof becomes critical to ensure their sustainable utilisation. Wetlands perform various important functions related to water quality, flood attenuation, stream flow augmentation, erosion control, biodiversity, harvesting of natural resources, and others, highlighting their importance as an irreplaceable habitat type. Determining the location and extend of existing wetlands, as well as evaluating the full scope of their ecosystem services, forms an essential part in the strive towards sustainable development and protection of water resources.

This section of the report incorporated a desktop study, as well as field surveys, with site visits conducted on the 26th and 27th of March 2009. Additional data sources that were incorporated into the investigation for further reliability included Google Earth images, 1:50 000, cadastral maps and ortho-rectified aerial photographs.

The wetland's boundaries were determined according to the methodology described in the Department of Water Affairs and Forestry's delineation guideline document (DWAF, 2005). Hydrophytic plants and hydromorphic soils were the two main indices relied on in this specific delineation process. In addition interpretations from the 1:50 000 cadastral maps and ortho-rectified aerial photographs with 5m interval contour lines were used to determine wetland boundaries, including portions of wetland area outside the site property.

A total of two hydro-geomorphic (HGM) units were identified within the study area, Figure 7 and 8. These included a midslope-seepage wetland not linked to a stream channel and an un-channelled valley bottom wetland. The hydro-geomorphic units perform important functions in terms of improving water quality, controlling erosion, facilitating sedimentation and supporting biodiversity.

The integrety of the site area's wetlands at the local level, as well as for downstream users, require that any proposed development within the area must follow a wetland sensitive approach. New impacts related to the proposed development must be minimized, while existing impacts should also be mitigated as far as possible. Measures to minimise development related impacts, include the incorporation of all buffered wetland areas into the development layout, implementation of a wetland sensitive stormwater management plan, as well as monitoring wetlands for signs of deterioration, such as erosion after high rainfall events.

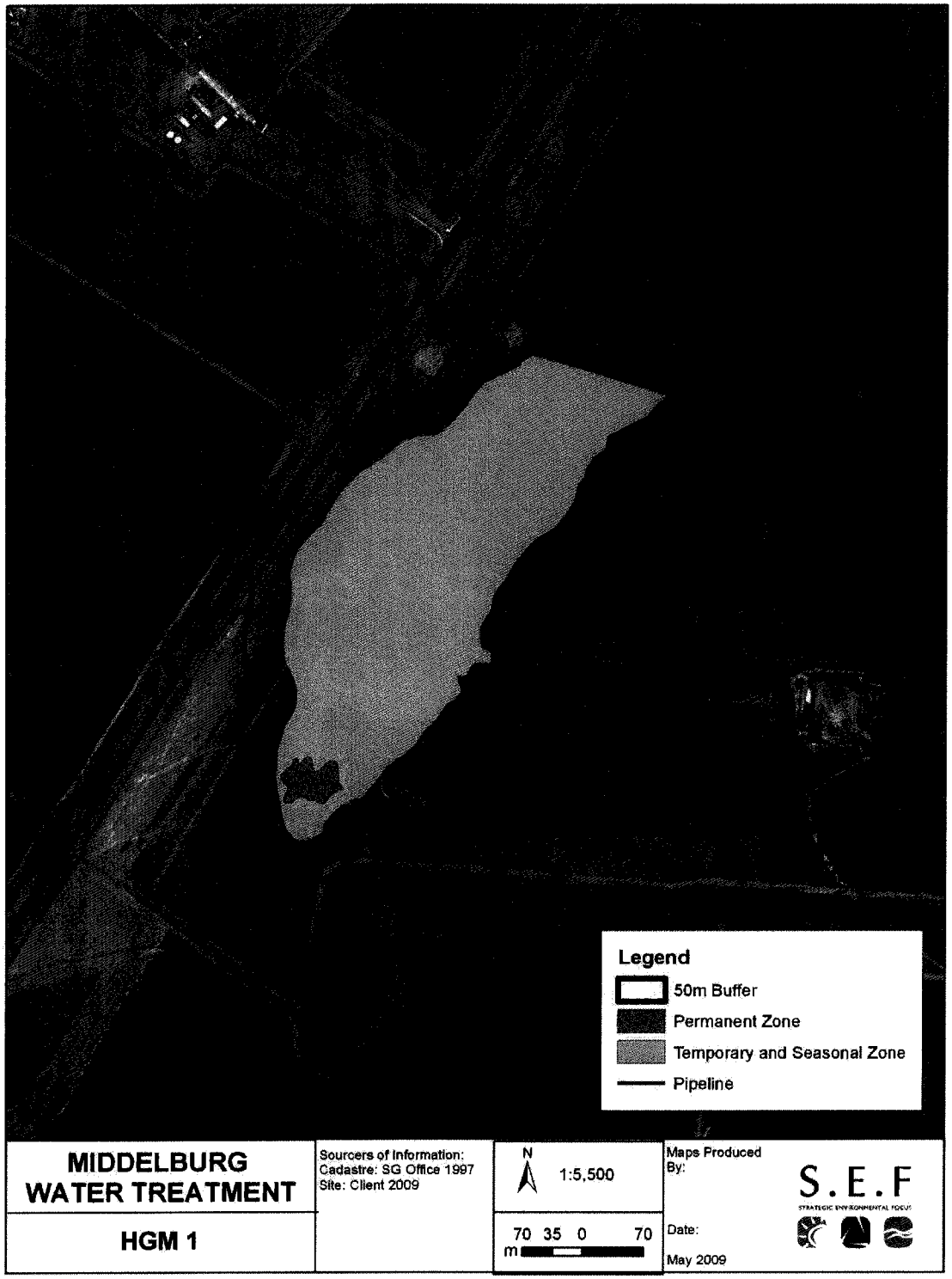


Figure 7: First hydrogeomorphic unit identified within the study area

Figure 8: Second hydrogeomorphic area identified within the study area.

7.1 Delineated Wetland Areas

According to the National Water Act (Act no 36 of 1998) a wetland is defined as, "*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.*"

Wetlands typically occur on the interface between aquatic and terrestrial habitats and therefore display a gradient of wetness – from permanent, to seasonal, to temporary zones of wetness - which is represented in their plant species composition, as well as their soil characteristics. It is important to take cognisance of the fact that not all wetlands have visible surface water. An area which has a high water table just below the surface of the soil is also a wetland, as well as a pan that only contains water for a few weeks during the year.

Hydrophytes and hydric soils are subsequently used as the two main wetland indicators. Wetland delineation was based on DWAF's (2005) wetland delineation document, described under the Methodology (Appendix D), as well as on topography (5m interval contour lines) and aerial photo interpretation. The result of the delineation process is a map that indicates the wetlands' boundaries within the site area.

The soil form indicator examines soil forms, as defined by the Soil Classification Working Group. Typically soil forms associated with prolonged and frequent saturation by water, where present, is an indicator of wetland occurrence (DWAF, 2005). The Soil Classification Working Group has identified the soil types that typically occur within the different zones typically found within a wetland, i.e. a permanent, seasonal and temporary zone. Terrain unit refers to the terrain unit in which the wetland is found. Wetlands can occur across all terrain units, from the crest to valley bottom. Many wetlands occur within valley bottoms, but wetlands are not exclusively found within depressions. Terrain unit is a useful indicator in assessing the hydro-geomorphic form of the wetland.

In practice all four indicators should be used in any wetland assessment / delineation exercise, the presence of redoximorphic features being most important, with the other indicators being confirmatory. An understanding of the hydrological processes active within the area is also considered important when undertaking a wetland assessment. Indicators should be 'combined' to determine whether an area is a wetland and to delineate the boundary of a wetland. According to the DWAF delineation guidelines, the more wetland indicators that are present, the higher the confidence of the delineation. In assessing whether an area is a wetland, the boundary of a wetland or a non- wetland area should be considered to be the point where indicators are no longer present.

7.2 Wetland Soils

According to the document DWAF (2005), the permanent zone of a wetland will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991).

The seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu. Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (DWAF, 2005).

However, for an area to be considered a wetland, redoximorphic features must be present within the upper 500 mm of the soil profile (Collins, 2005). Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of Fe (iron) and Mn (manganese) oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Only once soils within 50cm of the surface display these redoximorphic features can the soils be considered to be hydric (wetland) soils. Redoximorphic features typically occur in three types (Collins, 2005):

- **A reduced matrix** - i.e. an *in situ* low chroma (soil colour), resulting from the absence of Fe^{3+} ions which are characterised by "grey" colours of the soil matrix.
- **Redox depletions** - the "grey" (low chroma) bodies within the soil where Fe-Mn oxides have been stripped out, or where both Fe-Mn oxides and clay have been stripped. Iron depletions and clay depletions can occur.
- **Redox concentrations** - Accumulation of iron and manganese oxides (also called mottles). These can occur as:
  - Concretions - harder, regular shaped bodies;
  - Mottles - soft bodies of varying size, mostly within the matrix, with variable shape appearing as blotches or spots of high chroma colours; and,
  - Pore linings - zones of accumulation that may be either coatings on a pore surface, or impregnations of the matrix adjacent to the pore. They are recognized as high chroma colours that follow the route of plant roots, and are also referred to as oxidised rhizospheres.

According to the DWAF guidelines for the delineation of wetlands (DWAF, 2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence, due to the fact that soil wetness indicators

(redoximorphic features) remain in wetland soils, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil) or non-hydric (non-wetland soil) (Collins, 2005).

The extent of observable redoximorhic features were the primary component used to delineate the wetlands within the study area especially since there have been numerous historic anthropogenic disturbances such as farming, surface mining activities and potential hydrological disturbances through underground mining. Hydromorphic features within the soil profile were clear throughout the various wetland zones and were complimented by the terrain unit indicator as well as through the presence of hydrophytic vegetation growing within the hydric soils.

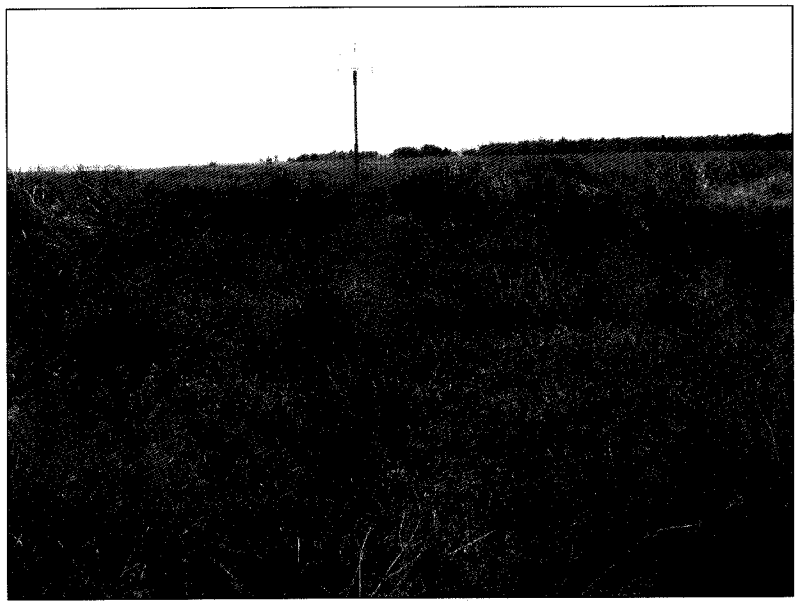
7.3 Wetland Vegetation

DWAF (2005), highlights vegetation as a key component to be used in the delineation procedure. Vegetation also forms a central part of the wetland definition in the National Water Act. Using vegetation as a primary wetland indicator however, requires undisturbed conditions (DWAF, 2005). A cautionary approach must be taken as vegetation alone cannot be used to delineate a wetland; several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind. There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterized by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside of the wetland (DWAF, 2005). It is important to identify the vegetative indicators which determine the three wetness zones (temporary, seasonal and permanent) which characterize wetlands. Each zone is characterized by different plant species which are uniquely suited to the soil wetness within that zone.

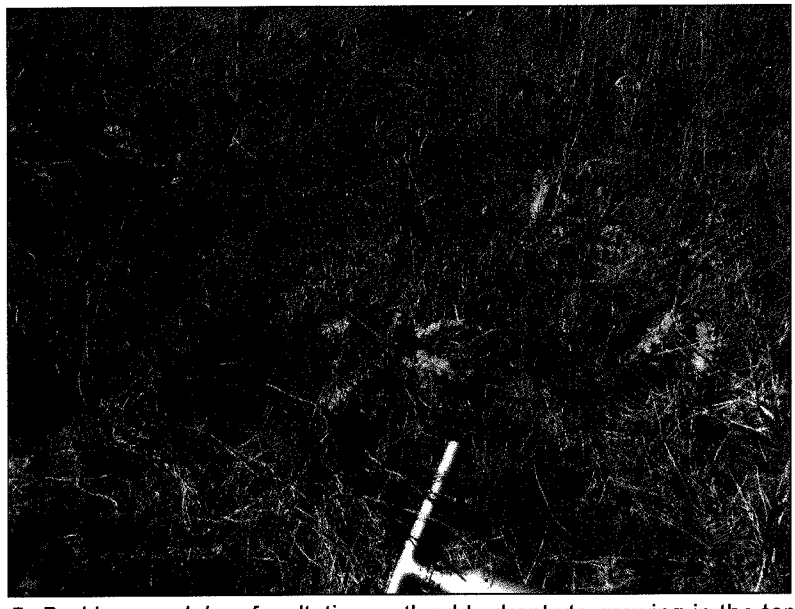
In general, in and around hydro-geomorphic unit 1, grassland vegetation was in a poor condition, with the major disturbances being grazing and agricultural activities. This made vegetation an unreliable wetland indicator and sampling efforts subsequently relied on hydric soils in order to delineate the wetlands.

The well developed vegetation cover in and around hydro-geomorphic unit 15 wetlands made vegetation a more reliable wetland indicator: A distinctive change was evident within the wetland plant communities, as they shifted from obligated wetland species (obliged to grow where water is present for long periods of time) in the seasonal wetland zones, to facultative wetland species (can grow in a range of very wet to drier conditions) in the seasonal to temporary zone, to upland species (dry land plant species) in the temporary zone (Photograph 4 and 5). Typical obligated hydrophytes included: *Typha capensis, Schoenoplectus corymbosus, Leersia hexandra* and *Persicaria lapathifolia,*

while facultative hydrophytes included *Berkheya radula, Berkheya speciosa, Eragrsotis plana* and *Hyparrhenia tamba* (see Photograph 4 and 5).



Photograph 4: *Persicaria lapathifolia* and *Typha capensis*, obligated wetland hydrophytes growing in the permanent zone of wetness.



Photograph 5: *Berkheya radula* a facultative wetland hydrophyte growing in the temporary zone of wetness.

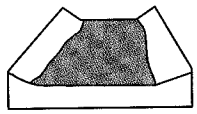
7.4 Identified wetland types and characteristics

Different types of wetland areas were classified within the site boundary. These were categorised into hydro-geomorphic (HGM) units:
Two HGM units were identified within the new site of the study area. These include a valley bottom wetland without a channel, a secondary wetland, a hillslope seepage not feeding a watercourse and an Endorheic Pan wetland. HGM units encompass three key elements (Kotze *et al*, 2005):

- Geomorphic setting. This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
- Water source. There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
- Hydrodynamics, which refers to how water moves through the wetland.

Table 4 describes the characteristics that form the basis for the classification of the HGM units in the study area.

Table 4: Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa (adapted from Kotze *et al*, 2005)

Hydro-geomorphic types	Description	Source of water maintaining the wetland[1]	
		Surface	Sub-surface
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 not feeding a watercourse 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a watercourse.	*	***

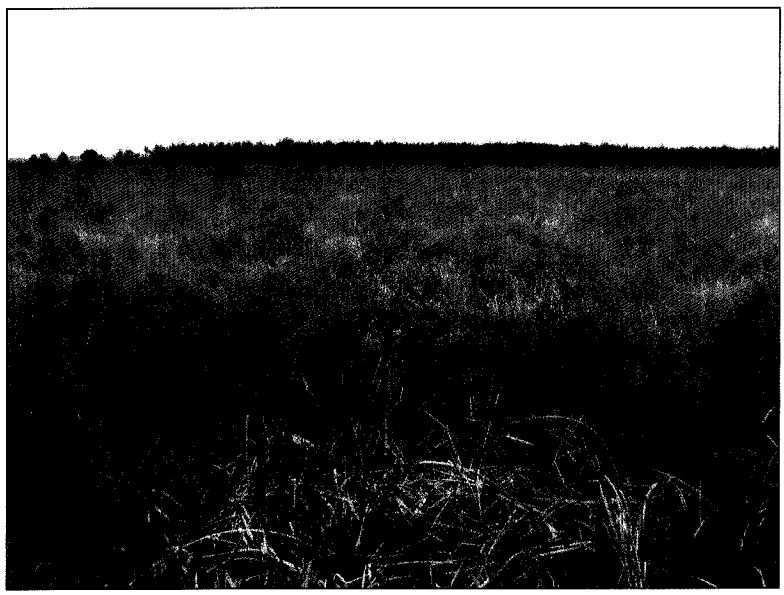
[1] Precipitation is an important water source and evapotranspiration an important output in all of the above settings

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

Wetland

7.4.1 Hydro-geomorphic unit 1

Hydro-geomorphic unit 1 forms part of the same hydro-geomorphic unit 1 identified and delineated in the previous set of studies done on the "Preffered site" (SEF, 2008b). This is a relatively flat and wide valley bottom wetland that connects to the Spookspruit further down the watercourse. Although the wetland is still functionally intact, various historic disturbances are evident and includes, a farm dam, drainage furrows, a transecting national road, borrow pits, soil dumps and moderate to severe overgrazing for an extended period. Due to these disturbances, especially the drainage furrows, zonation within this wetland is disturbed and irregular. Delineation within this unit therefore focused on demarcating the outside edge of the wetland and using hydric soils rather than hydrophytic vegetation as primary principle, vegetation were mostly secondary in nature across large areas of this wetland. Due to the above mentioned disturbances the temporary and seasonal zone were clumped together as an accurate separation of these two zones would be impractical. A number of small permanent zones were identified on the southern extend of this unit and was created anthropogenically through excavations into the water table. Vegetation within the unit included *Typha capensis, Miscanthus junceus* (Sedge-leaved Broom Grass), *Mariscus congestus, Cyperus* species, *Nidorella anomala* and *Berkeya setifera.* For a more comprehensive description of hydric soils and wetland vegetation at selected sample points see Appendix E (Sample points 51 – 751).



Photograph 6: Hydro-geomorphic unit 1 with excavated area in foreground.

7.4.2 Hydro-geomorphic unit 15

This hydro-geomorphic unit consist of a hillslope seep which is not connected to a watercourse. The northern extent of this wetland is disturbed through cultivated fields while evidence of numerous historic surface mining activities persist throughout the rest of this hydro-geomorphic unit. These disturbances have potentially reduced the

temporary and seasonal zones in the northern section of the wetland by approximately 20m as indicated by hydric soils which correspondingly don't carry hydrophilic vegetation. The south western boundary of the temporary zone extends relatively far in a westerly direction, this is most likely the effect of seepage from the two slimes dams located towards the south-west. Vegetation sampled within this unit include *Miscanthus junceus* (Sedge-leaved Broom Grass), *Mariscus congestus, Cyperus species, Leersia hexandra* (Rice Grass) and *Centella asiatica* (Marsh Pennywort) For a more comprehensive description of hydric soils and wetland vegetation at selected sample points see Appendix E (Sample points 755 – 769).

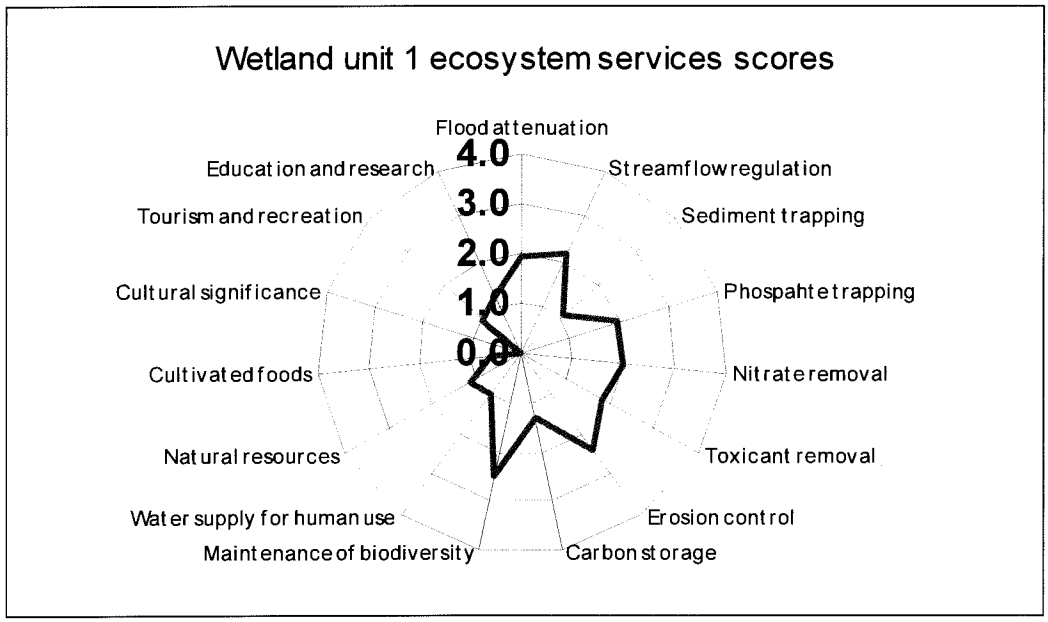
7.5 Functional assesssment

"*Wet-EcoServices*" (Kotze *et al,* 2005) is not ideally suited to determine "the specific level of impact of a current or proposed development" and it is more based on qualitative data as opposed to quantitative data, which opens it up to subjective misuse (Kotze *et al,* 2005). The authors do however highlight the system's value to assist in identifying key wetland issues and functions. It therefore fulfils an important role in assessing wetland functions and value, provided that its limitations are thoroughly taken note of throughout the process.

Ecosystem-services benefit graphs, which illustrate the functional assessment results for each function per wetland. A score value for a specific wetland function indicates the level to which the relative HGM unit can perform the function. Score values are typically calculated as a combination of the effectiveness and the opportunity of a specific HGM unit to perform a particular function.

HGM units are inherently associated with hydrological characteristics related to their form, structure and particularly because of their position in the landscape. This, together with the biotic and abiotic character (or biophysical environment) of wetlands in the study area, means that these wetlands are able to contribute better to some ecosystem services than to others (Kotze *et al.* 2005). Ecosystem services in terms of the biophysical environment will be discussed briefly for each HGM type.

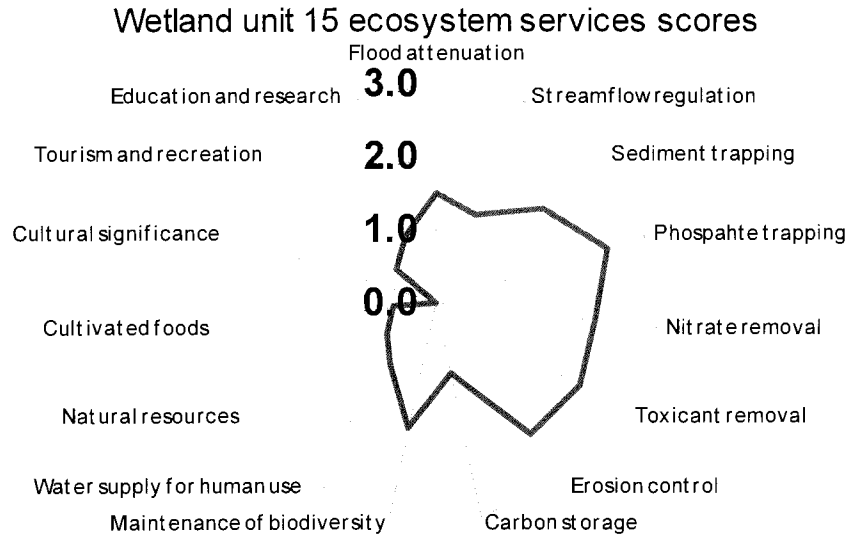
7.5.1 HGM 1 (Non- channelled valley bottom wetland)



Graph 1: Wetland ecosystem services provided by HGM unit 1.

During precipitation events, this type of wetland's stream channel input is spread diffusely across the wetland, even in low flows, resulting in extensive areas of the wetland remaining permanently saturated and tending to have high levels of soil organic matter (Kotze *et al,* 2005). Nitrate and toxicant removal is consequently expected to be higher than in floodplains owing to the greater contact of the wetland with runoff waters, particularly if there is a significant groundwater contribution to the wetland. The area surounding the dam and parts of the dam itself which contain shallow water, promote sunlight penetration, contributing to the photodegradation of certain toxicants. However, phosphate retention levels tend to be lower than in floodplains because a certain amount of phosphate may be re-mobilized under prolonged anaerobic conditions (Kotze *et al,* 2005). In addition, the nitrate removal potential would generally not be as high as in seepage slopes because sub-surface water movement through the wetland (where the greatest levels of nitrate removal generally take place associated with high organic matter levels and low dissolved oxygen levels) occurs to a lesser degree owing to the generally finer, less permeable soils and lower gradients. However, where sub-surface water inputs are high, nitrate removal levels in unchannelled valley bottoms may be similar to hillslope seepage wetlands (Kotze *et al,* 2005). This particular HGM best score were obtained for stream flow regulation, erosion control and particularly for the maintenance of biodiversity.

7.5.2 HGM 15 (Hillslope seepage not feeding a watercourse)



Graph 2: Wetland ecosystem services provided by HGM unit 15.

These systems (hillslope seepages) are normally associated with groundwater discharges, although flows through them may be supplemented by surface water contributions (Kotze *et al,* 2005). The key difference between this wetland type and hillslope seeps connected to a watercourse is that these types of seeps tend to have a lower degree of wetness. This was evident through the lack of permanent zonation within the hydro-geomorphic unit. They do, however in many cases contribute to stream flow regulation by sub-flow water flow (Kotze *et al,* 2005). Erosion control, nitrate removal, phosphate removal and toxicant removal scored highest within this wetland which is particularly important as a large part of the catchment is under maize cultivation.

8. SENSITIVITY ANALYSIS

8.1 Areas of High Sensitivity

8.1.1 Hydrophillic Vegetaion (Wetlands and Watercourses)

All wetland(s) along with corresponding buffer zones (minimum of 30 meters) are designated as sensitive vegetation. The areas surrounding the water bodies on the site (natural or man-made) are suitable to be inhabited by vulnerable avifauna species such as *Tyto capensis* (Grass Owl) and other faunal species. This increases the sensitivity of the areas surrounding water bodies. The grassland surrounding wetland systems are important to the health and functioning of these systems.

8.2 Areas of Medium Sensitivity

8. 2.1. Grasslands

Due to the open cast mining, grazing and cultivation activities, the study area falls within a region classified as not-important to reach biodiversity targets (Ferrar & Lötter, 2007). However, the regional vegetation communities (Rand Highveld Grassland and Eastern Highveld Grassland) are endangered vegetation communities. The purpose of defining vegetation types in terms of their ecosystem status is to identify ecosystems at risk. Furthermore, the conservation of remaining grassland vegetation is important to ensure the functionality and health of wetlands and rivers. The grassland on the site, although not pristine, supports protected plants and is suitable for a number of faunal species. The grassland vegetation is therefore classified as medium sensitivity.

8.3 Areas of Low Sensitivity

8.3.1 Alien Vegetation and Disturbed Grasslands

Large portions of the site are greatly transformed by pioneer plants such as *Seripheum plumosum* (Bankrupt bush). Little to no herbaceous species occurred within the grassland dominated by *Seripheum plumosum*. Furthermore, the invasive Wattle trees are of low conservation concern. These areas are classified as being of Low Sensitivity and could be used for the proposed project.

Although these areas are designated as being of low sensitivity and conservation value, they serve as ecological corridors for the movement of species. Any construction activities in these areas should be undertaken with consideration to the natural fauna and flora that inhabit the site and strive to destroy as little possible of the natural vegetation.

According to the Mpumalanga Tourism and Parks Agency (2008), areas to be disturbed by construction activities as well as areas for auxiliary activities must be clearly demarcated and limited to already disturbed areas or areas where they will cause minimal disturbance. Planning and implementation of the proposed project should adhere to mitigation and recommendations as set out by this report.

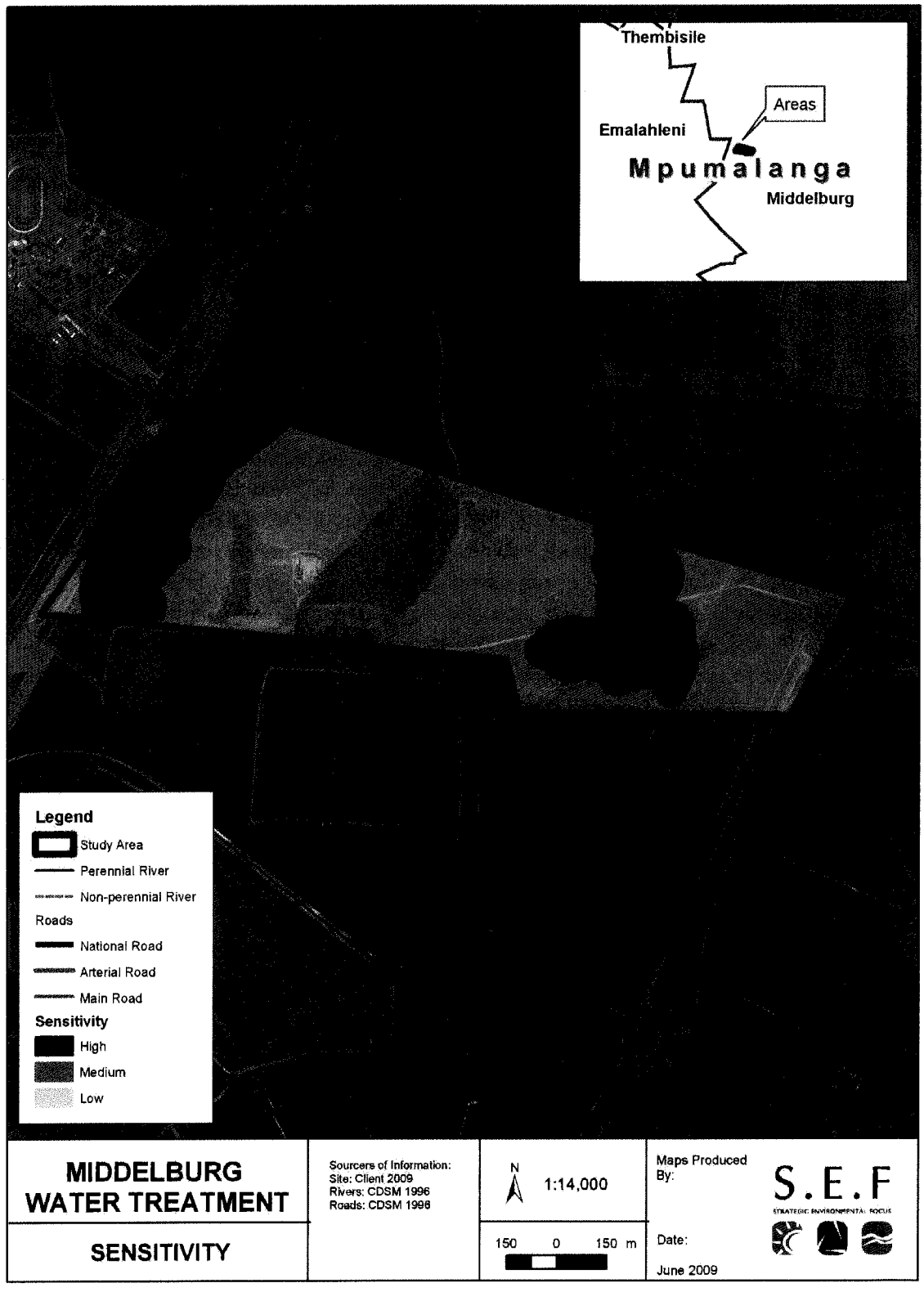


Figure 9: Sensitivity Map

9. ENVIRONMENTAL RISKS AND THEIR ASSESSMENT

9.1 Assessment criteria

The environemtnal impacts are assessed with mitigation meassures (WMM) and without mitigation measures (WOMM) and the results presented in impact tables which summarise the assessment. Mitigation and management actions are also recommended with the aim of enhancing positive impacts and minimising negative impacts.

In order to assess these impacts, the proposed development has been divided into two project phases, namely the construction and operation phase. The criteria against which these activities were assessed are discussed below.

9.1.1 Nature of the Impact

This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

9.1.2 Extent of the Impact

A description of whether the impact will be local (extending only as far as the servitude), limited to the study area and its immediate surroundings, regional, or on a national scale.

9.1.3 Duration of the Impact

This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

9.1.4 Intensity

This indicates the degree to which the impact would change the conditions or quality of the environment. This was qualified as low, medium or high.

9.1.5 Probability of Occurrence

This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

10. IMPACT DESCRIPTION, ASSESSMENT AND MITIGATION

The possible impacts of the water treatment plant and pipeline route on the sites are divided into two phases of activities: Construction phase and Operational phase of the development. Table 5 and Table 6 lists a summary of the Possible Risks that could occur within the two phases.

Table 5: Risks during the Construction Phase.

Possible Risks	Source of the Risk	Site to be affected
Destruction of natural habitat	Construction workers and construction vehicles	Whole site
Exposure of the whole site to erosion	Construction activity	Whole site
Loss of the ecological function of the wetland and pan	Construction activity	Moist grassland
Destruction of sensitive vegetation types and protected plant species	Construction activity	Sensitive habitats
Destruction of faunal habitat	Construction activity	Whole site
Frightening away and poaching of faunal species	Construction workers and Construction activity	Whole site

Table 6: Risks during the Operational Phase of the water treatment plant.

Possible Risks	Source of the Risk	Site to be affected
Reduction of natural migratory routes and faunal dispersal patterns.	Fragmented landscape	Whole site
Possible increase in exotic vegetation	Alien Bush Clumps spreading to disturbed soils	Whole site
Reduction in faunal biodiversity	Modification of natural habitat by landscaping	Whole site
Increased amounts of surface water runoff increasing the chance of flash floods in the area	Increased hard surface area due to buildings and road surfaces.	Whole site and surrounding area
Disturbance of fauna in sensitive vegetation	Human activity within the development could disturb fauna that depend on the sensitive vegetation (wetland)	Sensitive vegetation

10.1 Construction Phase

10.1.1 Destruction of natural habitat

Due to the nature of the construction activities across the site, even with mitigation much of the existing natural habitat will be destroyed. Heavy motor vehicle usage over the study site and adjacent land will expose the soils on the site to erosion and compaction. This will have a negative effect on the ecosystem and river in that siltation and habitat fragmentation could occur.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Destruction of natural habitat	Whole site	Site	Permanent	High	Definite	High	Medium	High

Mitigating Measures:

- Cordon off the sensitive vegetation (moist grassland) to restrict the movement of construction vehicles and construction personnel;
- Construction areas should be inspected for any occurrence of erosion. Appropriate remedial action (rehabilitation) must be undertaken should any eroded areas be identified;
- Areas designated as sensitive should be incorporated into an open space system which must be managed in accordance with an Environmental Management Plan;
- A comprehensive surface runoff and stormwater management plan should be compiled, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed; and
- No development should take place within any area demarcated as sensitive.

10.1.2 Exposure of the site to erosion

During construction, vegetation will be removed and therefore the soil surface will be exposed to rainfall and high winds which can cause mechanical erosion. This surface soil can wash into the possible wetland area if adequate precautions are not taken. In addition, the increase in hard surfaces could result in decreased filtration of water and additional soil may wash into the wetland area. This occurrence will cause an increase in siltation within the aquatic environments thereby decreasing the quality of the environmental processes.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Exposure of the site to erosion.	Whole site	Site	Short term	High	Probable	High	Medium	High

Mitigating Measures

- Use a sequential construction strategy i.e. phasing the construction of the and rehabilitating the soil with indigenous plants immediately after each phase;
- Not leaving soil surfaces open to erosion for lengthy time periods;
- An ecologically sound stormwater management plan should be designed, implemented and managed; and
- Construction could be timed so that construction takes place outside the rainy seasons, thus reducing opportunities for erosion from rainfall events.

10.1.3 Loss of the ecological function of the wetland

Construction will inevitably alter the landscape and influence the drainage processes on the site. This in turn, will influence the drainage and status of the pan and wetland area.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Loss of the ecological function of the potential wetland	Sensitive, moist grassland	Local	Permanent	High	Highly Probable	High	Medium	High

Mitigating Measures

- The demarcated buffer zones must be fenced during the construction using permeable fencing;
- Plan construction to avoid any impact on the natural drainage of the site and wetland functionality;
- The water treatment plant must be designed in such a way that no spillages can flow from the water treatment plant into the wetlands;
- To avoid accidental spillages or emergencies that could contaminate the wetlands on the site, the water treatment plant must be constructed as far as possible from the wetlands;
- No surface water generated as a result of the activities may be discharged directly into any natural drainage system or the wetlands;
- No activities should take place in a buffer of at least a 30m from the edge of wetlands (Mpumalanga Tourism and Parks Agency, 2008);
- A comprehensive surface water runoff management plan, indicating the management of all surface runoff generated as a result of the activities prior to stormwater entering any natural drainage system or wetland, must be submitted (e.g. stormwater and flood retention ponds if relevant); and

- No activity such as temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment or any other use of the buffer/flood zone whatsoever, may be permitted.

10.1.4 Destruction of sensitive vegetation types and protected plant species

Construction will destroy natural vegetation and alter the habitat in such a way that species cannot colonise the area. This could lead to certain species becoming rare in the local context.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Destruction of sensitive vegetation types and plants species	Grassland	Regional	Permanent	High	Probable	High	Low	High

Mitigating Measures

- No construction should be allowed within sensitive vegetation;
- Sensitive vegetation should be cordoned off to prevent any access to the area while construction takes place;
- Removal and relocation of protected plants should be implemented (Application for permit must be made to MDALA); and
- No vehicles or access roads should be allowed through the sensitive areas.

10.1.5 Destruction of faunal habitat

Heavy motor vehicle usage and construction activities over the study area and adjacent land could result in damage to the habitat as well as exposing the soils in the area to erosion and compaction. This will have a negative effect on the ecosystem habitat fragmentation could occur. However, with the appropriate mitigation measures, this impact is considered to be of medium significance.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Destruction of faunal habitat	Whole site	Site	Permanent	High	Definite	High	Medium	High

Mitigating Measures

- Construction vehicles should be restricted to the existing road network that services the various sections of the site;

- Construction areas should be inspected for any occurrence of erosion. Appropriate remedial action (rehabilitation) must be undertaken should any eroded areas be identified;
- Prior to construction, fences should be erected in such a manner to prevent access and damage to any sensitive areas identified – particularly the river and rocky outcrops along the ridge;
- Areas designated as sensitive should be incorporated into an open space system which must be managed in accordance with an Environmental Management Plan;
- All stormwater structures should be designed so as to block faunal access to road surfaces and other bulk services which may be entered; and
- A comprehensive surface runoff and stormwater management plan should be compiled; indicating how all surface runoff generated as a result of the road development (during both the construction and operational phases) will be managed.

10.1.6 Frightening away and poaching of faunal species

Harassing, snaring and killing of mammal species may occur when construction personnel and visitors are on the site. Other possibilities include the disturbance of the natural faunal species by domesticated pets, i.e. dogs and cats, which have a negative impact on smaller mammal species. In addition, the loud noise associated with the construction phase may frighten mammal species away but this is considered of medium significance and it can be expected for many of the smaller faunal species to return when construction ends provided suitable habitat remains.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Frightening away and poaching of faunal species	Whole site	Site	Short (During construction)	Medium	Probable	Medium	Low	High

Mitigating Measures

- The construction staff should be educated about the value of wildlife and environmental sensitivity;
- Construction personnel should be informed of the Animal Protection Act no. 71 of 1962 and encouraged not to harm any wildlife;
- Access should be restricted to the sections of the study area where construction activities are occurring; and
- If pets are to be allowed on site, they should be isolated from the general wildlife and properly controlled.

10.2 Operational Phase: Water treatment plant

10.2.1 Reduction of natural migratory routes and faunal dispersal routes.

The grassland and hydrophilic vegetation on site provides habitat for faunal species and links the area with other areas of open space. They are therefore able to provide important migration corridors and dispersal patterns for faunal species by linking various sections of open land that would otherwise be fragmented from one another. Should construction occur, the possibility that the connectivity between areas of open space and therefore the migration corridor, would be lost, is high.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Reduction of faunal migratory routes and faunal dispersal patterns.	Fragmented landscape	Regional	Permanent	Medium	High	High	Medium	High

Mitigating Measures

- Leave as much of the natural vegetation intact in order to maintain ecological corridors for the movement of faunal species;
- All areas designated as sensitive should be incorporated into an open space plan which is managed according to an Environmental Management Plan;
- All open spaces should be incorporated and linked to provide corridors for faunal movement within the development; and
- No development or activities allowed to impact or alter the remainder of the natural vegetation.

10.2.2 Possible increase in exotic vegetation

Exotic vegetation may be introduced to the environment via the landscaping around the development. In addition, the sites currently house alien bush clumps, which if not completely removed, could spread. Seedlings from the alien bush clumps can spread easily in disturbed soils after construction and invade natural vegetation

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Possible increase in exotic vegetation.	Site	Site	Permanent	Medium	Probable	High	Medium	High

Mitigating Measures

- Implement a policy within the development that only indigenous plant species be used in the landscaping of the development;
- Natural open spaces should be left in their undeveloped state and any existing or new exotic vegetation that is present on the site be removed and eradicated; and
- Remove all exotic, invasive vegetation and implement a monitoring and eradication plan to keep the site free from invasive plants.

10.2.3 Reduction in faunal biodiversity

The development will modify the natural habitat of various faunal species. These species may no longer be able to find suitable habitat on the site or surrounding land. This could possibly lead to a decline in species numbers and ultimately extinction.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Reduction of indigenous faunal species	Site and surroundings	Regional	Permanent	Medium	Probable	High	Medium	High

Mitigating Measures

- Create open, natural space within the development; and
- All open spaces should be incorporated to provide corridors for faunal movement within the development.

10.2.4 Increased amounts of surface water runoff

The increased amounts of surface water runoff from hard surfaces within the development may increase the chance of flash floods. With a single rainfall event many litres of water are released. These waters would have been absorbed by the displaced grasslands and other vegetation.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Increased amounts of surface water runoff	Site and surroundings	Regional	Permanent	Medium	Probable	Medium	Low	High

Mitigating Measures

- Create open, natural space within the development and reduce the amount of hard paved surfaces;
- Use impermeable paving and grass swales;
- A comprehensive surface water runoff management plan, indicating the management of all surface runoff generated as a result of the activities prior to stormwater entering any natural drainage system or wetland, must be submitted (e.g. stormwater and flood retention ponds if relevant); and
- An Environmental Control Officer should be appointed to oversee mitigation measures during construction and will be responsible for the monitoring and auditing of contractor's compliance with the conditions of the Environmental Management Plan (Mpumalanga Tourism and Parks Agency, 2008);

10.2.5 Disturbances of fauna in sensitive vegetation

Human activity within the development could disturb faunal species that depend on the natural, sensitive vegetation on the site.

Impact	Site	Extent	Duration	Intensity	Probability of occurrence/risk	Significance		Confidence
						WOMM	WMM	
Disturbance of fauna in sensitive vegetation	Sensitive vegetation	Local and regional	Permanent	Medium	Probable	Medium	Low	Medium

Mitigating Measures

- A management plan to prevent the occupants of the development from disturbing or harassing any faunal species; and
- Implement a monitoring programme to regularly assess the presence of faunal species within the sensitive vegetation.

12 CONCLUSION

The vegetation on the New Site contains two sensitive features: the moist grassland (wetland) and portions of grassland which supports protected plants. Ideally, these sensitive areas should be connected to the primary grassland on the adjacent Preferred Site, as they will contribute to maintaining ecosystem functioning for faunal and floral species. Figure 10 combines the sensitivities of the New Site with the sensitivities of the Preferred Site (SEF, 2008). Areas of low sensitivity should be utilised for the contruction of the plant and access road(s). Although the areas of low sensitivity are sizable, the Water Treatments Plant should be located as far as possible from the wetlands and pan, in order to avoid any potential contaminateion of the water courses. The suggested locality for the plant as well as access roads within low sensitivities is indicated in Figure 10. The locality, construction and operation of the Water Treatment Plant are subjected to mitigation measures as set out by this report.

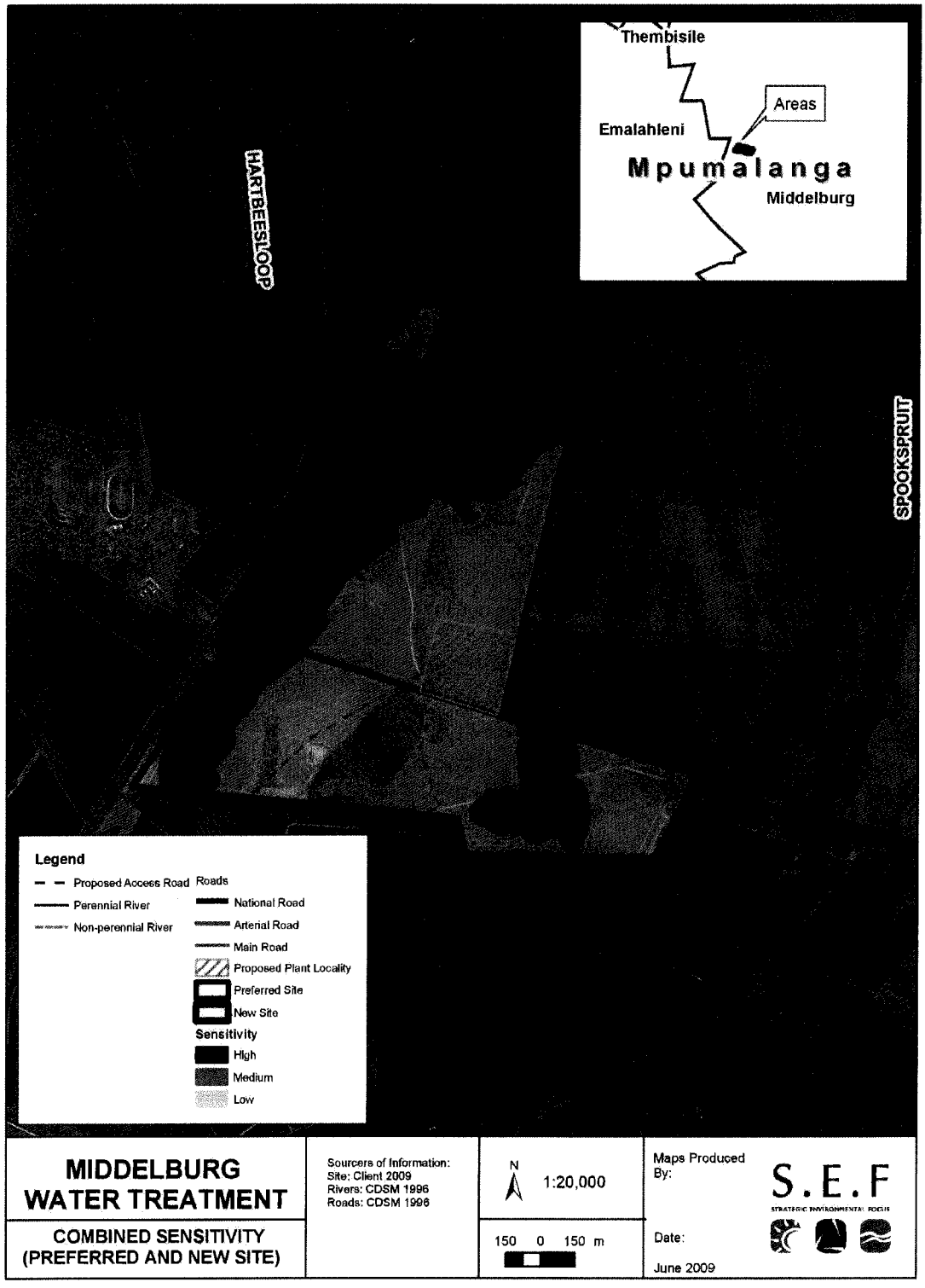


Figure 10: Combined Sensitivity Map (Preferred and New Site)

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14. GLOSSARY

Alien species Plant taxa in a given area, whose presence there, is due to the intentional or accidental introduction as a result of human activity.

Biodiversity Biodiversity is the variability among living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biome A major biotic unit consisting of plant and animal communities having similarities in form and environmental conditions, but not including the abiotic portion of the environment.

Buffer zone A collar of land that filters edge effects.

Conservation The management of the biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations. The wise use of natural resources to prevent loss of ecosystems function and integrity. Critically Endangered A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

Correspondence Analysis Correspondence Analysis simultaneously ordinates species and samples

Detrend Correspondence Analysis Detrend Correspondence analysis (DCA) performs detrending to counteract the arch effect, a defect of correspondence analysis.

Ecosystem Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space.

Ecological Corridors Corridors are roadways of natural habitat providing connectivity of various patches of native habitats along or through which faunal species may travel without any obstructions where other solutions are not feasible.

Edge effect Inappropriate influences from surrounding activities, which physically degrade habitat, endanger resident biota and reduce the functional size of remnant fragments including, for example, the effects of invasive plant and animal species, physical damage and soil compaction caused through trampling and harvesting, abiotic habitat alterations and pollution.

Endangered A taxon is Endangered when it is not Critically Endangered but is facing

	a very high risk of extinction in the wild in the near future.
Exotic species	Plant taxa in a given area, whose presence there, is due to the intentional or accidental introduction as a result of human activity
Fauna	The animal life of a region.
Flora	The plant life of a region.
Forb	A herbaceous plant other than grasses.
Habitat	Type of environment in which plants and animals live.
Indigenous	Any species of plant, shrub or tree that occurs naturally in South Africa.
Invasive species	Naturalised alien plants that have the ability to reproduce, often in large numbers. Aggressive invaders can spread and invade large areas.
Karoid	Dwarf xerophytic woody shrublets and succulents.
Outlier	An observation that is numerically distant from the rest of the data
Primary vegetation	Vegetation state before any disturbances such as cultivation, overgrazing or soil removal
Protected plant	According to the Transvaal Nature Conservation Ordinance of 1983 (No 12 of 1983), no one is allowed to sell, buy, transport, or remove this plant without a permit from the responsible authority.
Threatened	Species that have naturally small populations, and species which have been reduced to small (often unsustainable) population by man's activities.
Red data	A list of species, fauna and flora that require environmental protection. Based on the IUCN definitions.
Species diversity	A measure of the number and relative abundance of species.
Species richness	The number of species in an area or habitat.
Vulnerable	A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

15. APPENDICES

Appendix A	Methodology: Vegetation
Appendix B	Plants identified on the site
Appendix C	Threatened plants that occur in the region
Appendix D	Methodology: Wetlands
Appendix E	Wetland : Sample Descriptions
Appendix F	Methodology: Fauna
Appendix G	Observed and Expected Invertebrate Taxa
Appendix H	Herpetofauna recorded within quarter degree grids 2529CD, 2529DC and 2629AB
Appendix I	Avifauna recorded within quarter degree grids, 2529CD, 2529DC and 2629AB
Appendix J	Observed and Expected Mammal Taxa

Appendix A: Methodology – Vegetation

1. METHODOLOGY: VEGETATION

1.1 Literature surveys

The description of the regional vegetation relied on literature from Acocks (1988), Emery *et al*, (2002) and Mucina & Rutherford (2006). Plant names follow Palgrave (1992), Van Wyk & Van Wyk (1997), Van Wyk & Malan (1997), Pooley (1998), Henderson (2001), Van Oudtshoorn (2002) and Schmidt *et al* (2002).

A list of threatened flora in Mpumalanga was derived from the Mpumalanga Biobase (Emery *et al*, 2002) This, along with the national list of Red Data floral species, was used as a guide to determine the presence and possibility of occurrence of these species on the study sites. Additionally, a list of threatened plant records for the relevant quarter degree squares were obtained from the Mpumulanga Parks Board.

1.2 Field surveys

Images obtained from Jones and Wagner (Pty) Ltd. and topographical maps (scale: 1:50 000) were used to delineate relatively homogeneous units within the study area. The maps indicated that large areas of the site are currently subjected to open cast coal mining activities. The Preferred Site and Alternative Site are largely situated in areas that house natural vegetation that could be separated into homogenous units. The chosen units were then surveyed by means of sampling plots. Sample plots of 6 x 6m were laid out in each of these homogenous units and species cover abundance was recorded according to the Braun-Blanquet cover abundance scale (Brown & Bezuidenhout, 2000; Appendix A). The size of the sample plots was determined by plotting a species accumulation curve by means of nested sampling plots as described by Barbour *et al* (1987; Appendix A).

Data was analysed using the computer programme Mosaic 3.01 (Smith, 2006). This allows for objective descriptions of vegetation communities. Descriptions regarding the methodology used during the assessment can be found in Appendix A.

Transects were walked within the perceived natural habitat types on the site, concentrating on moving through environmental gradients encountered within the vegetation type in order to identify species and communities. This was continued until few to no new species were encountered. Any additional information on any other feature thought to have ecological significance within the site, such as soil type, altitude, erosion, rocky cover, alien/exotic/invasive plants as well as Red Data species and/or their habitat were also recorded.

Estimation of optimal plot size

A number of plots that represent a given community were subjectively chosen. A list of all species encountered was compiled for each plot. An area that best represented the community was located and the minimal area for sampling was determined (the smallest area within which the species of the community were adequately represented). The minimal area was determined by a species-area curve.

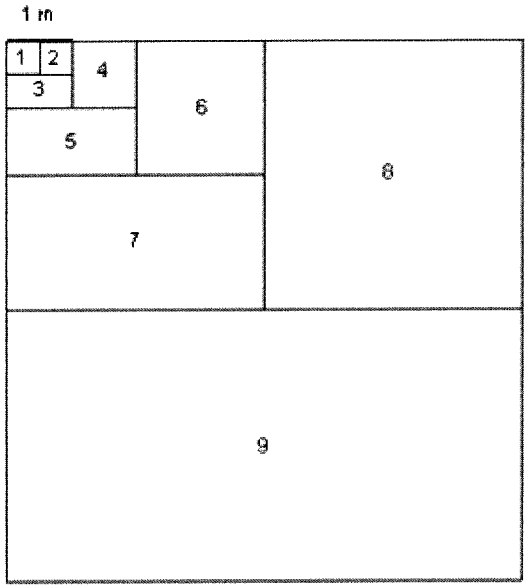


Figure 10: A system of nested plots for determining minimal area (Mueller-Dombois & Ellenberg, 1974).

A species-area curve was compiled by placing larger and larger plots on the ground in such a way that each larger plot encompassed all the smaller ones, an arrangement called nested plots (Barbour et al., 1987; Figure 10). As each larger plot was located, a list of additional species encountered was created. A point of 'diminishing return' was reached, beyond which increasing the plot area results in the addition of only a few more species. The point on the curve where the slope most rapidly approaches the horizontal is called the minimal area (Figure 11). Because this definition of minimal area is subjective, some define it instead as that area which contains some standard fraction of the total flora of a stand, for example, 95%. The most recently proposed solution is to plot the similarity between plots as plot size increases. Minimal area is thought by some ecologists to be an important community trait that is just as characteristic of a community type as the species that make it up.

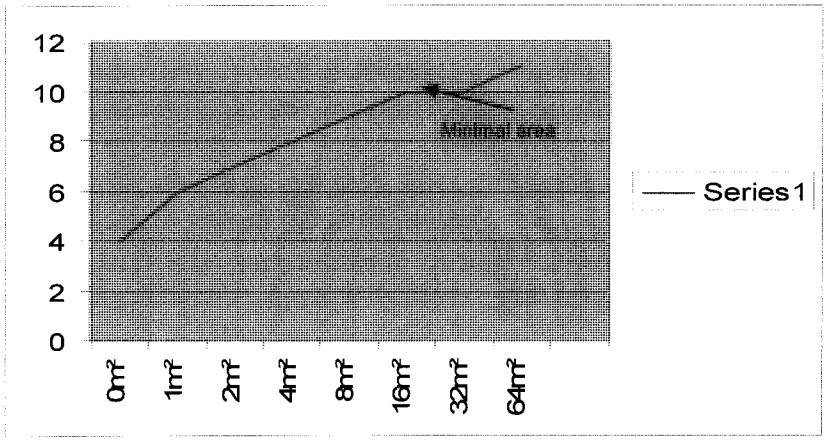


Figure 11: Species-area curve for the study area

1.3 Cover estimates

Cover was not measured precisely but is placed in one of seven categories by a visual estimate (Table 7). Braun-Blanquet and others recognise that plant cover is very heterogeneous from point to point and from time to time even within a small stand. The range of percentage points within each class allows for each observer's deviance from the correct cover percentage.

Table 7: Braun-Blanquet Cover classes (Mueller-Dombois & Ellenberg, 1974).

Class	Range of cover (%)	Mean
5	75-100	87.5
4	50-75	62.5
3	25-50	37.5
2b	13-25	19
2a	6-12	9
1	1-5	2.5
+	<1	0.1
r	<<1	*

* Individuals occurring only once; cover ignored and assumed to be insignificant.

2. SITE SENSITIVITY

2.1 Sensitivity mapping and conservation importance of the study site

Based on the findings of the report and the following criteria, sensitive habitat or areas of conservation importance are classified on the basis of:

2.2.1 Ecological Sensitivity

The ecological sensitivity for each habitat was determined from two criteria; the ecological function and its conservation importance. These are defined as follows:

1. **Ecological Function:** The ecological function describes the intactness of the structure and function of an ecosystem in terms of the relationship between plant and animal assemblages and the surrounding abiotic environment. It also refers to the degree of ecological connectivity between systems within a landscape. Therefore, systems with a high degree of landscape connectivity among each other are perceived to be more sensitive.

   High – Sensitive ecosystems with either low inherent resistance or resilience towards disturbance factors or highly dynamic systems that are considered important for the maintenance of ecosystem integrity. Most of these systems represent late succession ecosystems with high connectivity with other important ecological systems.
   Medium – These systems occur at disturbances of low-medium intensity and representative of secondary succession stages with some degree of connectivity with other ecological systems.
   Low – Degraded and highly disturbed systems with little ecological function.

2. **Conservation Importance:** The conservation importance of the site gives an indication of the necessity to conserve areas based on factors such as the importance of the site on a national and/or provincial scale and on the ecological state of the area (degraded or pristine). This is determined by the presence of a high diversity, rare or endemic species and areas that are protected by legislation. The criteria are defined as follows:

   High –Ecosystems with high species diversity and usually provide suitable habitat for a number of threatened species. These areas should be protected.
   Medium – Ecosystems with intermediate levels of species diversity without any threatened species.
   Low – Areas with little or no conservation potential and usually species poor (most species are usually exotic).

Appendix B Plant species identified on the site

Scientific Name	Common Name	Relevant notes	Grassland	*Seripheum* dominated grassland	Hydrophilic vegetation	Exotic Bush Clumps
GRASSES						
Agrostis eriantha	Large Panicle Agrostis	Often occur in damp areas on basalt			X	
Andropogon schirensis	Stab Grass	Rocky slopes in well-drained soils, often in moist places.	X	X	X	
Cynodon nlemfuensis	Star Grass	Well adapted to any soils, grows mostly on disturbed land such as road reserves and old fields.	X	X		X
Diheteropogon amplectens	Broad-leaved Bluestem	Open grassland as well as open areas within bushveld. Mostly in poor rocky slopes.	X			
Enneapogon cenchroides	Nine-awned Grass	Disturbed veld in sandy and rocky soils.	X	X		
Eragrostis aspera	Rough Love Grass	Disturbed places as old fields, often in or close to light shade.	X			
Eragrostis chloromelas	Curly Leaf	Rocky slopes, mostly in open grassland	X	X		
Eragrostis curvula	Weeping Love Grass	Mostly occurs in disturbed areas	X	X		
Eragrostis gummiflua	Gum Grass	Disturbed areas and often in moist soils		X		X
Eragrostis rigidor	Broad Curly Leaf	Disturbed areas such as old fields and overgrazed land	X	X		
Hyparrhenia hirta	Common	Well drained, rocky soil in open grassland and disturbed	X	X		

Scientific Name	Common Name	Relevant notes	Grassland	*Seripheum* dominated grassland	Hydrophilic vegetation	Exotic Bush Clumps
	Thatching Grass	areas				
Hyperrhenia tamba	Blue Thatching Grass	Road reserves and where water accumulates, also next to rivers	X		X	
Imperata cylindrica	Cotton Wool Grass	Mostly in moist soils			X	
Leersia hexandra	Rice Grass	Grows in or near permanent water, often forming dense stands.			X	
Melinis repens	Natal Red Top	Disturbed grassland	X	X		
Miscanthus junceus	Wireleaf Daba Grass	Riverbanks and vlei's, often in standing water.			X	
Monocymbium ceresiliforme	Boat Grass	Grassland, rocky ridges or vlei's.	X	X		
Panicum natalense	Natal Panicum (Suurbuffelsgras)	Open, mountainous grassland on well drained soil. Often grows on rocky slopes and where veld is frequently burnt.	X	X		
Paspalum urvillei	Vasey Grass	Moist areas such as marshes, vlei's and river banks,			X	
Schizachyrium sanguineum	Red Autumn Grass	Open grassland and Bushveld. Often in moist areas and vlei's.	X		X	
Setaria pallide-fuscua	Garden Bristle Grass	Disturbed areas e.g. next to roads and where rainwater collect			X	
Sporobulus africanus	Ratstail Dropseed	Disturbed places close to water		X	X	
Themedia triandra	Red Grass	Undisturbed or disturbed open grassland	X			

Scientific Name	Common Name	Relevant notes	Grassland	*Seripheum* dominated grassland	Hydrophilic vegetation	Exotic Bush Climax
FORBS						
Acalypha angustata	Copper Leaf		X			
*Bidens formosa**	Cosmos	Weed in disturbed places		X		X
Bidens pilosa	Khaki Bush/ Blackjack	Widespread weed.		X		X
Boophane disticha	Poison Bulb	Grassland, often in rocky places	X			
Centella asiatica	Marsh Pennywort	Marshes, vlei's.			X	
Chamaecrista comosa	Fishbone Cassia	Grassland	X			
Comelina diffusa		Grassland, in moist places	X			
Crinum graminicola	Graslelie	Grassland, usually in sandy soil, localized and rather rare	X			
Gladiolus crassifolius		Grasslands and close to rivers	X			
Haplocarpa scaposa	Tonteldoosbossie	Grassland, often in moist places			X	
Helichrysum acutatum	Sticky everlasting	In damp grassland	X			
Helichrysum krausii		Dry, semi-desert areas		X		
Helichrysum nudifolium	Hottentot's tea	In Grassland, invade eroded banks	X		X	

Scientific Name	Common Name	Relevant notes	Grassland	*Seripheum* dominated grassland	Hydrophilic vegetation	Exotic Bush Climbers
Helichrysum rugulosum		Grassland, summit of ridges	X	X		
Hypoxis rigidula	Kaffirtulp	Grassland	X	X		
Indigofera daleoides		Grasland and bushveld	X			
Kohautia virigata		Moist areas	X			
Ledebouria cooperi		Grassland.	X			
Ledebouria ovatiflora		Grassland	X			
Limosella maior		Grassland			X	
Monopsis decipiens	Butterfly Lobelia	Often in disturbed grassland	X		X	
*Persicaria spp**	Knotweed/ Snakeroot	Grassland			X	
Plantago longissima		Weed in moist areas			X	
Pollichia campestris	Waxberry	Grassland	X	X		
Selago densiflora (Walafrida densiflora)		Grassland and bushveld		X		X
Senecio gregatus		Grassland in rocky ridges localized	X			

Scientific Name	Common Name	Relevant notes	Grassland	*Seripheum* dominated grassland	Hydrophilic vegetation	Exotic Bush Clumps
Seripheum plumosum	Bankruptbush	Grassland and Bushveld, often in disturbed areas.	X	X		
*Sonchus nanus**	Thistle	Parasitic in grassland, often on rocky ridges and moist places.			X	
Striga elegans	Large Witchweed	Grassland, parasite on grasses	X			
*Tagetes minuta**	Khaki Bush/ Blackjack	Grassland		X		X
*Verbena bonariensis**	Wild Verbena	Exotic weed invading moist areas (Naturalised).			X	
Wahlenbergia caledonica		Grassland	X			
TREES						
*Acacia dealbata**	Silver Wattle					X
SEDGES						
Mariscus congestus		Grassland, moist or marshy places			X	
Cyperus sp.					X	

Appendix C: Threatened plants that occur in the region (Emery *et al*, 2002).

The species that were identified on the site are indicated as well as those that have a possibility of occurrence on the site, but might not heave identified due to the end of the flowering season (e.g. suitable habitat exists).

NT- Near Threatened
VU- Vulnerable
EN- Endangered
EW- Extinct in the Wild
CR- Critically Endangered
Y- Yes
N- No

Scientific Name	Conservation Status	Suitable habitat on site Y/N	Identified on site Y/N
Allophylus chaunostachys	NT	N	N
Aloe albida	EN	N	N
Aloe dewetii	VU	N	N
Aloe hlangapies	NT	N	N
Aloe integra	VU	N	N
Aloe kniphofioides	VU	N	N
Aloe kraussii	NT	N	N
Aloe modesta	EN	N	N
Aloe reitzii	VU	N	N
Aloe simii	CR	N	N
Aloe thorncroftii	CR	N	N
Aloe vryheidensis	VU	N	N
Brachystelma chlorozonum	NT	Y	N
Brownleea recurvata	VU	N	N
Cassipourea swaziensis	VU	N	N
Ceropegia distincta	VU	N	N
Cineraria hederifolia (Senecia hederifolia)	VU	Y	N
Crocosmia mathewsiana	VU	N	N
Cyrtanthus bicolor	NT	N	N
Cyrtanthus epiphyticus	NT	N	N
Cytinus sp	VU	N	N
Disa amoena	VU	-	N
Disa extinctoria	NT	N	N

Scientific Name	Conservation Status	Suitable habitat on site Y/N	Identified on site Y/N
Disa hircicornis	NT	N	N
Disa maculomarronina	VU	N	N
Disa montana	CR	N	N
Disperis stenoplectron	VU	N	N
Elephantorrhiza praetermissa	NT	N	N
Encephalartos cupidus	CR	N	N
Encephalartos heenanii	CR	N	N
Encephalartos humilis	VU	N	N
Encephalartos laevifolius	CR	N	N
Encephalartos lanatus	NT	N	N
Encephalartos lebomboensis	CR	N	N
Encephalartos middelburgensis	EN	N	N
Encephalartos paucidentatus	VU	N	N
Erica revolute	EN	N	N
Erica rivularis	VU	N	N
Eucomis vandermerwei	EN	N	N
Eugenia pusilla	EW	N	N
Eulophia leachii	NT	N	N
Faurea macnaughtonii	NT	N	N
Frithia humilis	EN	N	N
Gladiolus appendiculatus	EN	N	N
Gladiolus calcaratus	VU	N	N
Gladiolus cataractarum	CR	N	N
Gladiolus macneilii	EN	(Grassland)	N
Gladiolus rufomarginatus	VU	Y	N
Gladiolus varius	VU	N	N
Gladiolus vernus	NT	N	N
Habenaria ciliosa	VU	N	N
Kniphofia triangularis	NT	N	N
Ledebouria appresifolia	VU	-	N
Ledebouria sp.	EN	Y (Grassland)	N

Scientific Name	Conservation Status	Suitable habitat on site Y/N	Identified on site Y/N
Leucospermum gerrardii	EN	N	N
Leucospermum saxosum	NT	N	N
Nerine gracilis	VU	Y (moist depressions in grassland)	N
Orbea paradoxa	VU	N	N
Orbeanthus hardyi	VU	N	N
Platycoryne mediocris	CR	-	N
Protea comptonii	NT	N	N
Protea curvata	VU	N	N
Protea laetans	VU	N	N
Protea roupelliae	CR	N	N
Protea subvestita	NT	N	N
Resnova megaphylla	VU	-	N
Rhus batophylla	VU	N	N
Satyrium microrrhynchum	VU	N	N
Schizochilus crenulatus	EN	N	N
Schotia latifolia	VU	N	N
Streptocarpus decipiens	VU	N	N
Streptocarpus denticulatus	VU	N	N
Streptocarpus occultus	EN	N	N
Streptocarpus pogonites	VU	N	N
Watsonia latifolia	NT	Y	N
Watsonia occulta	VU	N	N
Watsonia wilmsii	EN	N	N
Zantedeschia pentlandii	VU	N	N

Appendix D: Methodology - Wetlands

1. METHODOLOGY: WETLANDS

The report incorporated a desktop study, as well as field surveys, with site visits from the 26th and 27th of March 2009. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps; and
- ortho-rectified aerial photographs.

Identified wetland areas were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation methodology used was the same as the one set out by the Department of Water affairs and Forestry (DWAF, 2005) document "*A Practical field procedure for the identification and delineation of wetlands and riparian areas*".

The Department of Water affairs and Forestry (DWAF) wetland delineation guide makes use of indirect indictors of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device. All cored samples were analysed for signs of wetness that indicate wetland associated conditions.

The methodology "*Wet-EcoServices*" (Kotze *et al,* 2005) was adapted and used to assess the different benefit values of the wetland units. A level two assessment, including a desktop study and a field assessment were preformed to determine the wetland functional benefits. Other documents and guidelines used are referenced accordingly. During the field survey, all possible wetlands and drainage lines identified from maps and aerial photos were visited on foot. Where feasible, cross sections were taken to determine the state and boundaries of the wetlands.

Following the field survey, the data was submitted to a GIS program for compilation of the map sets. Subsequently the field survey and desktop survey data were combined within a single project report.

Appendix D: Wetlands – Sample Descriptions

1. Hydro-morphic unit 1 & 15

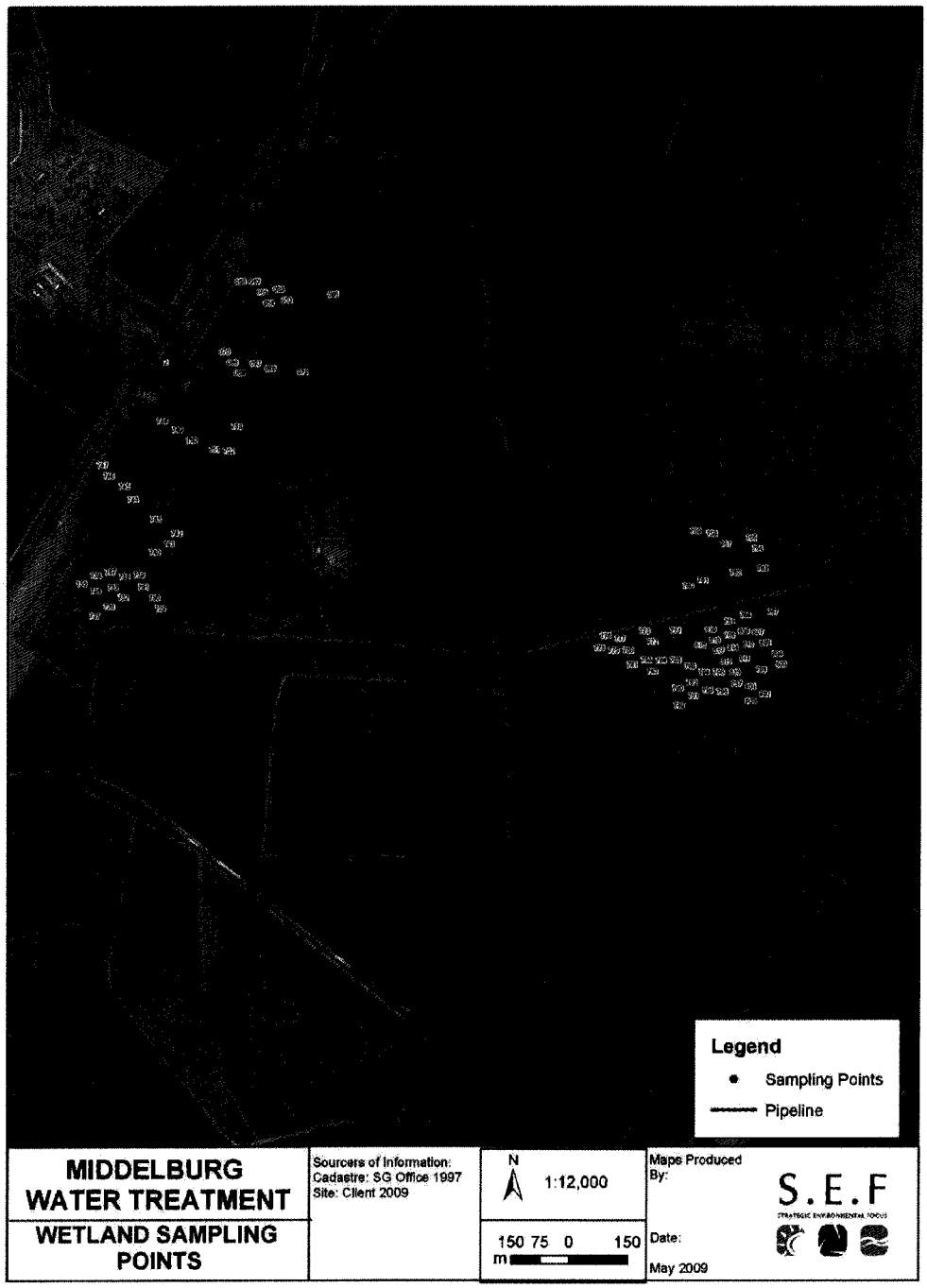
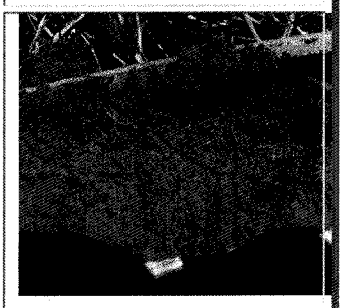
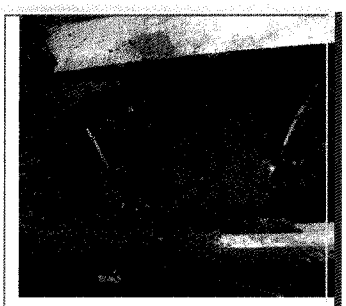
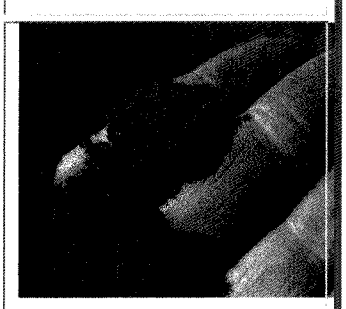
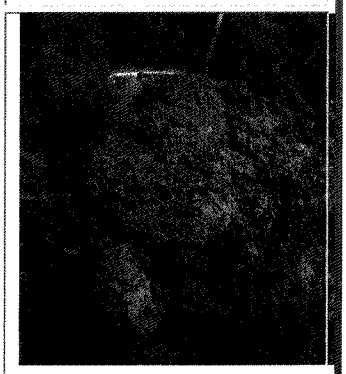
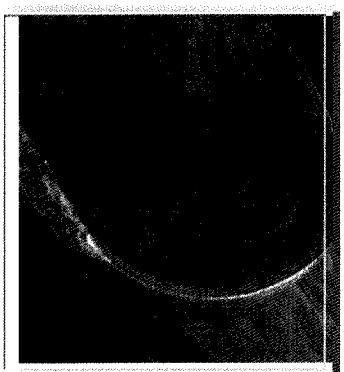
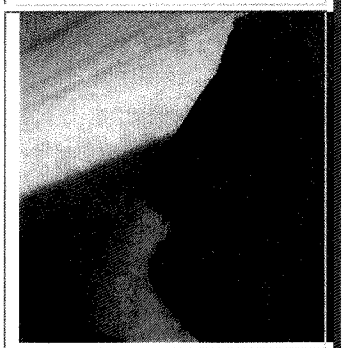
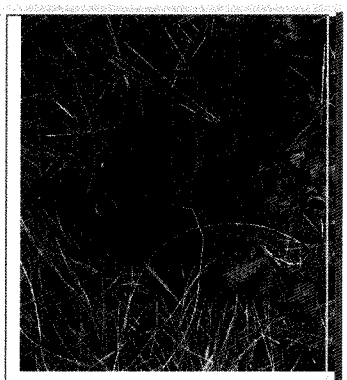


Figure 12: Wetland Sampling Points

Sample	Terrain and site description	Vegetation	Soil characteristics	Photo
51	Centre of macro-channel. Slope increases slightly towards east and west. Drainage towards the north.	*Leersia hexandra* (o) *Paspalum dilatum* (f) *Centella asiatica*	Redoximorphic features present: Very wet, with high organic content, a few mottles visible. Permanent zone	
54	Towards the west within the valley bottom channel, various linear disturbaces such as old drainage furrow between 51 and 55	*Eragrosis plana* (f) *Aristida junciformis* *Cyperaceae* spp. X2	Redoximorphic features present: High organic content in upper layer, lots of mottles with high differentiation and gleying present .	
55	Close to edge of macro channel on western boundary, still evidence of anthropogenic channelling and dumping	*Habanaria* sp. *Eragrostis plana* (f) *Cyperaceae* spp. X3	Redoximorphic features present: Profile dark organic at surface, gleying in mid section with yellow sticky soils at bottom.	

56	On western edge of macro channel.	*Aristida junciformis* *Cyperaceae* spp. X2	Redoximorphic features present: Very few mottles present. Edge of temporary zone. (Samples more west had no Redoximorphic features present)	
65	On eastern edge of macro channel (flat). Signs of historic excavations and heavy grazing pressures	*Aristida junciformis* *Cyperaceae* sp	Redoximorphic features present: Very few mottles present. Edge of temporary zone. . (Samples more east had no Redoximorphic features present)	
66	Transect more south in wetland, macro channel even less defined, depressions artifical in some areas which made delineating exact zonations diffcult	*Miscanthus* sp. *Cyperaceae* spp. X2 *Aristida junciformis*	Redoximorphic features present: High differentiation. Mottles present.	

67	Very similar to sample 67	*Aristida junciformis* *Eragrosis plana* (f) *Centella asiatica* *Cyperaceae* spp.	Redoximorphic features present: Rhizospheres. High number of mottles and gleying present.	
69	Towards western edge of flat macro channel.	*Eragrosis plana* (f) *Centella asiatica* *Cyperaceae* spp. *Aristida junciformis*	Redoximorphic features present: Gleying present, very few mottles.	
70	Western edge of wetland	*Imperata cylindrica* (f) *Cyperaceae* spp	Redoximorphic features not present: Ferrocrete present	
71	Eastern edge of wetland	*Monocymbium cereciformii* *Cyperaceae* spp. X2 *Eragrosis plana* (f) *Seripheum plumosum*	Redoximorphic features present: Mottles present (few). Edge of temporary zone	
737	Edge of macro-channel. Temporary zone.	*Paspalum dilatum* (f) *Imperata cylindrica* (f) *Cyperaceae* spp	Redoximorphic features present: Wet, with high organic build up, Mottles & gleying visible.	

738	Towards the west within the valley bottom, various linear disturbaces such as old drainage furrow	*Cyperaceae* sp. *Centella asiatica* *Imperata cylindrica* (f)	Redoximorphic features present: Organic content in upper layer, some mottles with differentiation and gleying present/ .	
745	Seasonal, next to old road	*Centella asiatica* *Eragrostis plana* (f) *Cyperaceae* sp.	Redoximorphic features present: Profile dark organic at surface, wth lots of mottling lower down in profile	
751	On periphery between seasonal and temporary, eastern side of macro-channel	*Aristida junciformis* *Cyperaceae* spp. X2 *Imperata cylindrica* (f)	Redoximorphic features present: Lots of mottles & rhizospheres present.	
755	On eastern edge of macro channel (flat). Signs of historic excavations. Cultivated fields towards north.	*Aristida junciformis* *Imperata cylindrica* (f) *Verbena bonarensis*	Redoximorphic features present: Mottles present. Edge of temporary zone. . (Samples more east had no Redoximorphic features present)	

756	Towards centre of macro channel, seasonal.	*Centella asiatica* *Cyperaceae* sp	Redoximorphic features present: Large mottles present & gleying Standing water at 45cm.	
769	Centre of macro-channel. Seasonal	*Leersia hexandra* *Centella asiatica* *Cyperaceae* spp. x2	Redoximorphic features present: Rhizospheres. High number of mottles and gleying present.	

Appendix F: Methodology – Fauna

1. METHODOLOGY: FAUNA

1.1 Desktop Surveys

1.1.1 Mammals and Herpetofauna

The majority of mammals, reptiles and amphibians are nocturnal by nature and therefore the presence of suitable habitat (a habitat assessment) was used to determine the status of these species through various field guides and atlases.

The probability of occurrence of mammal, reptile and amphibian species was based on their respective geographical area of occupancy and habitat suitability. High probability of occurrence would be applicable to a species with an area of occupancy within the geographic locality of the study site as well as the presence of suitable habitat occurring in the study site. Medium probability of occurrence refers to species whose area of occupancy is marginal to the study site or its habitat is found to be within the surroundings of the study area. Lastly, a low probability of occurrence will indicate that the species' occupy an area surrounding the study area and that unsuitable habitat exists on site.

1.1.2 Avifauna

During the avifaunal assessment the following occurrence probabilities were used to assist with the assessment and were informed through data of the South African Bird Atlas Data.

The status of birds occupying the study area was estimated for all observed and expected species according to the following:

- High probability of occurrence - >50% chance of occurrence;
- Medium probability of occurrence - 10 - 50% chance of occurrence; and
- Low probability of occurrence - <10% chance of occurrence;

1.2 Field Surveys

During the initiation of the survey period, specific areas of habitat structure associated with the various proposed structures (telescopes and infrastructure), were selected and surveyed for specific taxonomic groups according to the methodology described below.

1.2.1 Mammals

Random transect walks were done whereby mammal species were identified [using Stuart and Stuart (2001) and Skinners and Chimimba (2005)] by visual sightings as well as by means of spoor, droppings and roosting sights. Only diurnal searches were carried out.

1.2.2 Avifauna

Bird species were identified and verified using Sinclair (1988) and Sinclair *et al.* (2002). Identifications were supplemented using other means such as feathers, roosing sites, nests and droppings

1.2.3 Herpetofauna

Possible burrows or reptile habitats (rocks and stumps) were inspected for inhabitants. Reptiles were identified using Branch (1998). Amphibians were identified through likely habitat types (water features or drainage lines) using Carruthers (2001).

1.3 Ecological Sensitivity: Conservation Importance and Ecological Function

1.3.1 Ecological Function and Sensitivity

The ecological function of a habitat type relates to the inherent resistance or resilience that a system can accommodate during perturbation periods. Therefore, highly sensitive systems will be unable to resist disturbance factors and are thus classified as sensitive. Secondly, it relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity among each other are perceived to be more sensitive. Three categories were used to describe ecological function (sensitivity):

High – Sensitive ecosystems with either low inherent resistance or resilience towards disturbance factors or highly dynamic systems considered being stable and important for the maintenance of ecosystem integrity. Most of these systems represent late successional ecosystems with high connectivity with other important ecological systems;

Medium – These systems occur at disturbances of low-medium intensity and representative of secondary successional stages with some degree of connectivity with other ecological systems and

Low – Degraded and highly disturbed systems with little ecological function.

Appendix G: Observed and Expected Invertebrate Taxa (Adapted from MPTA, 2008)

Note: Species observed on site are printed in **Bold.**

Family Name	Scientific Name	Common Name	Status
Family Coenagrionidae	*Ishnura senegalensis*	Marsh Bluetail	LC
	Africallagma glaucum	Swamp Bluet	LC
Family Rhinolermitidae	*Trinervitermes*	Snouted Harvester Hermites	LC
Family Tabanidae		**Horse Flies**	**LC**
Family Clliphoridae		**Bluebottles, Greenbottles, Blowflies**	**LC**
	Chrysomya chloropyga	Copper Tailed Blowfly	LC
	Lucilia sericata	European Green Blowfly	LC
Family Ixodidae	*Amblyomma hebraeum*	Bont Ticks	LC
Family Vespidae	*Belonogaster dubia*	Paper Wasps	LC
Family Halictidae		Sweat Bees/Flower Bees	LC
	Nomia amebilis	Flower Bees	LC
Family Apidae	*Apus mellifera*	Honey Bees	LC
	Meliponula sp.	Stingless bees/Mopane Bees	LC
Family Anthophoridae		**Bees**	**LC**
Family Formicidae		**Ants**	**LC**
	Chroplolepis custodiens	Pugnacious Ant	LC
	Camponotus maculatus	Spotted Sugar Ant	LC
	Linepithema humile	Aregentine Ant	LC
	Carebara vidua	Arfrican Thief Ant	LC
	Solenopsis punctaticeps	Fire Ant	LC
	Messos capensis	Harvester Ant	LC

Family Name	Scientific Name	Common Name	Status
	Tetraponera	Slender Ants	LC
	Dorylus helvolus	Red Driver Ant	LC
	Pachycondyla tarsata	African Stink Ant	LC
Family Carabidae		Ground Beetles	LC
	Bradybaenus opulentus	Marsh Ground Beetle	LC
	Craspedophorus bronvouloiri	Yellow Spotted Ground Beetle	LC
	Thermophilum fornasinii	Ground Beetle	LC
	Caminora	Starred Ground Beetle	LC
	Tefflus	Peaceful Giant Ground Beetle	LC
	Manticora	Monster Tiger Beetles	LC
Family Histeridae		Steel Beetles/Hister Beetles	LC
Family Staphylinidae		Rove Beetles	LC
Family Bolboceratidae		Scarab Beetles	LC
Family Scarabaeidae	**Numerous Species**	**Scarab Beetles/Dung Beetles**	**LC**
	Sisyphus	Spider Dung Beetles	LC
	Scarabaeus rusticus	Dung Beetle	LC
	Anomalipus planus	Darkling Beetle	LC
	Aphodius mesontoplatys zulu	Dung Chafers	LC
	Aphodius pharaphodius impurus	Dung Chafers	LC
	Aphodius nobius inoratus	Dung Chafers	LC
	Aphodius pharaphodius posticus	Dung Chafers	LC
	Aphodius pharaphodius teter	Dung Chafers	LC
	Aphodius trichaphodius lanuginosus	Dung Chafers	LC

Family Name	Scientific Name	Common Name	Status
	Aphodius trichaphodius pseudohumilis	Dung Chafers	LC
Family Cleridae		Chequered Beetles	LC
Family Melyridae		Soft-Winged Flower Beetles	LC
Family Coccinellidae		Ladybugs/Ladybirds	LC
Family Tenebrionidae	Various Species	Darkling Beetles	LC
Family Anthicidae		Ant Beetles	LC
Family Mordellidae		Tumbling Flower Beetles	LC
Family Cerambycidae		Longhorn Beetles/Timber Beetles	LC
Family Chrysomelidae		Leaf Beetles	LC
Family Bruchidae		Pea/Bean/Seed Weevils	LC
Family Anthribidae		Fungus Weevils	LC
Family Brentidae		Primitive Weevils	LC
Family Curculionidae		Weevils/Snout Weevils	LC
Blank(No information):Not Recorded			
Red Data Species			
Family Lycaenidae	*Aloeides rossouwi*		EN
	Aloeides barbarae		EN
	Aloeides nubilis		VU
Family Lycaenidae	*Lepidochrysops swanepoeli*	Swanepoel's Blue	EN
	Lepidochrysops jefferyi	Jeffrey's Blue	EN
Family Nymphalidae	*Dingana fraterna*	Stoffberg Widow	EN
Family Hesperiidae	*Metisella meninx*	Marsh Sylph	VU

Appendix H: Herpetofauna recorded within quarter degree grids 2529CD, 2529DC and 2629AB (Adapted from MPTA, 2008 & Branch, 1998)

Note: None of these species were recorded during the site visit.

Scientific Name	Common Name	Habitat	Status
Reptiles			
Atractaspis bibronii	Bibrons stiletto snake		
Pachydactylus bibronii	Bibron's thicktoed gecko		
Dendroaspis polylepis	Black mamba		
Aparallactus capensis	Black-headed centipede eater		
Gerrhosaurus nigrolineatus	Black-lined plated lizard		
Lamprophis fuliginosus	Brown House Snake	Common in highveld grassland and arid karoo regions, also tolerant of urban sprawl.	
Lycodonomorphus rufulus	Brown water snake		
Leptotyphlops conjunctus conjunctus	Cape and Eastern Thread Snakes	Varied:Grassland, coastal bush, mesic and arid savannah	
Aparallactus capensis	Cape Cnetipede eater	Varied including highveld and montan grassland, sabannah and coastal bush	Not Endemic
Mehelya capensis	Cape file snake		
Lycophidion capense	Cape wolf snake		
Python sebae	Common african python		
Lycodonomorphus rufulus	Common Brown Water Snake	Small streams, pans and vleis	
Lygodactylus capensis	Common dwarf gecko		
Dasypeltis scabra	Common egg-eater		
Bitis arietans	Common puffadder		
Mabuya striata	Common striped skink		
Mabuya varia	Common variable skink		
Dasypeltis scabra	Common/Rhombic Egg Eater	All habitats except true desert and canopy forest	
Agama aculeata	Distant's spiny agama		

Scientific Name	Common Name	Habitat	Status
Telescopus semiannulatus semiannulatus	Eastern Tiger Snake	Savannah and sandveld	
Typhlops schlegelii	Giant blind snake		
Acontias plumbeus	Giant legless skink		
Gerrhosaurus validus	Giant plated lizard		
Platysaurus intermedius wilhelmi	Greater flat lizard		
Agama aculeata distanti	Ground Agama	Semi deset and sandveld savannah	
Crotaphopeltis hotamboeia	Herald/Red Lipped Snake	Savannah and Open woodland	
Cordylus tropidosternum	Jones' girdled lizard		
Aspidelaps scutatus	Lebombo shield snake		
Psammophis brevirostris brevirostris	Leopard and Short snouted grass snakes	Rocky area, highveld and montane grassland	
Geochelone pardalis	Leopard Tortoise	Varied	Not Endemic
Leoptotyphlops conjunctus	Lesser worm snake		
Leptotyphlops longicaudus	Long-tailed worm snake		
Dipsadoboa aulica	Marbled tree snake		
Naja mossambica	Mfesi		
Hemirhagerrhis nototaenia	Mopane snake		
Amblyodipsas concolor	Natal purple-glossed snake		
Varanus niloticus	Nile monitor		
Mehelya nyassae	Nyasa file snake		
Psammophis phillipsii	Olive grass snake		
Nucras ornata	Ornate scrub lizard		
Amblyodipsas polylepis	Purple-glossed snake		
Mabuya quinquetaeniata	Rainbow rock skink		
Crotaphopeltis hotamboeia	Red-lipped snake		
Hemachatus haemachatus	Rinkhals	Grassland from the coast upto 2500m	
Varanus albigularis	Rock leguan		
Ichnotropis squamulosa	Rough-scaled sand lizard		
Scelotes mossambicus	Short footed burrowing skink		
Naja annulifera annulifera	Snouted cobra	Svannah particularly in bushveld and lowveld	

Scientific Name	Common Name	Habitat	Status
Causus defilippii	Snouted night adder		
Naja annulifera	South-eastern egyptian (snouted) cobra		
Philothamnus hoplogaster	Southeastern green snake		
Agama atra	Southern Rock and Knobel's Agama	Semi desert to fynbos from sea level to mountain tops	
Thelotornis capensis	Southern vine snake		
Atractaspis bibronii	Southern's Burrowing Asp	Varied, ranging from highveld grassland, semi desert to montane bush	Not Endemic
Kinixys spekii	Speke's hinged-back tortoise		
Lygodactylus ocellatus	Spotted Dwarf Gecko	Well wooded Granite hills	
Prosymna ambigua	Spotted shovel-snout		
Pachydactylus punctatus	Spotted thicktoed gecko		
Psammophylax rhombeatus rhombeatus	Spotted/Rhombic Skapstekaar	Highveld grasslands,mesic thicket and fynbos enetering karroid areas	
Psammophylax tritaeniatus	Striped skaapsteker	Floodplain grassland	
Pachydactylus capensis	Striped Skink	Mangrove Swamp to arid savannah	
Lygosoma sundevallii	Sundevall's writhing skink		
Psammophylax tritaeniatus	Three-lined grass snake		
Cordylus vittifer	Transvaal Girdled Lizard	Mesic Thicket	
Pachydactylus affinis	Transvaal Thick Toed Gecko	Rocky outcrops and dead termite nests in highveld grasslands	
Leptotyphlops distanti	Transvaal worm snake		
Agama atricollis	Tree agama		
Dispholidus typus	Tree-snake		
Hemidactylus mabouia	Tropical house gecko		
Prosymna bivittata	Twinstriped shovel-snout		
Mabuya sp. nov	Typical skink	Varied	
Pachydactylus vansoni	Van Son's thicktoed gecko		
Philothamnus semivariegatus	Variegated bush snake		
Zygaspis violacea	Violet round-headed worm lizard		

Scientific Name	Common Name	Habitat	Status
Panaspis wahlbergii	Wahlberg's snake-eyed skink		
Homopholis wahlbergii	Wahlberg's velvety gecko		
Psammophis subtaeniatus	Western stripe-bellied sand snake		
Gerrhosaurus flavigularis	Yellow throated plated lizard	Varied; montane grassland, savannah, bushveld and low open coastal forest	
Scientific Name	**Common Name**	**Habitat**	**Status**
Amphibians			
Strongylopus wageri	Plain Stream Frog	Rivers systems, foothills and high slopes	VU
Pyxicephalus adspersus	Giant Bullfrog	Pans and wetlands in savanna grassland	VU
Hyperolius semidiscus	Yellow-striped Reed Frog	River systems	VU
Breviceps species	Whistling Rain Frog	Aquatic systems	VU
Bufo gariepensis nubicolus	Karoo Toad	Aquatic systems	VU
Afrixalis fornasinii	Greater-Leaf Folding Frog	Aquatic systems	VU
Heleophryne natalensis	Natal Ghost Frog	River systems	VU

Appendix I: Avifauna recorded within quarter degree grids, 2529CD, 2529DC and 2629AB (Adapted from MPTA, 2008)

Note: Species observed on site are printed in **Bold.**

Scientific Name	Common Name	Habitat	Distribution/Protection Status
Anas sparsa	African Black Duck	Fast flowing water	Resident
Upupa africana	African Hoopoe	Thornveld, open woodland, parks, gardens	Common Resident
Porphyrio madagascariensis	African Purple Swamphen	Reed beds, sedge marshes, flooded grassland	Common Resident
Lagonosticta ribricata	African Quail Finch	Thickets, riverine scrub, suburbia	Common Resident
Theskiornis aethopicus	African Sacred Ibis	Grassland, Vlei areas	Common Resident
Vanellus senegallus	African Wattled Lapwing Plover	Damp Grass, wetland fringes	Common Resident
Myrmecocichla formicivora	Anteating Chat	Grasslands with termite mounds, open sunny areas	Common Resident (SA endemic)
Nycticorax nycticorax	Black Crowned Night Heron	Reedbeds, Shaded Areas	Common Resident
Ardea melanocephala	**Black Headed Heron**	**Grassy areas near water**	**Common Resident**
Himantopus himantopus	Black Winged Stilt	Marshed & pans	Common Resident
Vanellus armatus	**Blacksmith Lapwing Plover**	**Damp Areas & Wetland Margins**	**Common Resident**
Telophorus zeylonus	Bokmakierie	Fynbos, scrub woodland, suburbia	Common Resident (endemic)
Tyto capensis	Grass Owl	Grassy marshes, long grasslands	Uncommon resident
Lonchura cucullata	Bronze Mannikin	Diverse, grassy areas, woodland, edges of water	Common Resident
Phedina borbonica	Brown Throated Martin	Freshwater lakes, rivers, streams	Common Resident
Serinus canicollis	Cape Canary	Grassland, suburbia	Common Resident
Macronyx capensis	Cape Longclaw	Grassland adjoining freshwater areas	Common Resident
Cossyphra caffra	Cape Robin Chat	Diverse	Common Resident
Streptopelia capicola	Cape Turtle Dove	Diverse	Abundant Resident
Motacilla capensis	Cape Wagtail	Usually near fresh water	Common Resident
Ploceus capensis	Cape Weaver	Grassland along river courses, reedbeds, trees	Common Resident (SA endemic)
Passer melanurus	Cape White Eye	Grassland, grain fields	Common Resident (SA near endemic)
Bubulcus ibis	**Cattle Egret**	**Associated with cattle & game**	**Common Resident**
Cisticola textrix	**Cloud (Tink Tink) Cisticola**	**Grassland**	**Common Resident**
Lanius collaris	**Common Fiscal Shrike**	**Diverse**	**Common Resident**

Scientific Name	Common Name	Habitat	Distribution/Protection Status
Gallinula chloropus	Common Moorhen	Any water with reeds & tall grass	Common Resident
Trachyphonus vaillantii	Crested Barbet	Woodland, savanna, gardens	Common Resident
Vanellus coronatus	Crowned lapwing plover	Short grass/golf courses	Common Resident
Pycnonotus tricolor	Dark Capped (Black Eyed) Bulbul	Variety of habitats	Abundant Resident
Cisticola aridulus	Desert Cisticola	Arid grassland/old fields	Common Resident
Chrysococcyx caprius	Dideric Cuckoo	Diverse	Common Visitor
Alopochen aegyptiaca	Egyptian Goose	Freshwater	Common Resident
Euplectes axillaris	Fan-tailed Widowbird	Reedbeds, damp grassland, sugarcane fields	Common Resident
Silegus silens	Fiscal Flycatcher	Diverse	Common Resident (SA endemic)
Plegadis falcinellus	Glossy Ibis	Associated with water	Common Resident
Podiceps cristatus	Great CrestedGrebe	Large stretches of freshwater	Common Resident
Cinnyric afer	Greater Double Collared Sunbird	Diverse	Common Resident (endemic)
Hirundo cucullata	Greater Stripped Swallow	Grassland, vleis	Summer Visitor
Ardea cinerea	Grey Heron	Pans, aquatic environments	Common Resident
Bostrychia hagedash	**Hadeda Ibis**	**Widespread**	**Common Resident**
Numida meleagris	Helmeted Guineafowl	Diverse	Common Resident
Apus Horus	Horus Swift	Diverse (mainly aerial)	Summer Visitor
Anas hottentota	Hottentot Teal	Small waterbodies lines with vegetation	Locally Common Resident
Passer domesticus	House Sparrow	Suburbia, gardens	Abundant Resident
Charadrius pecuarius	Kittlitz Plover	Areas near water	Common Resident
Streptopelia senegalensis	Laughing Dove	Widespread	Abundant Resident
Hirundo abyssinica	Lesser Stripped Swallow	Near Water	Common Resident
Cisticola tinniens	LeVaillant's Cisticola	Redbeds, long grasses close to water	Common Resident
Egretta garzetta	Little Egret	Freshwater	Common Resident
Tachybaptus ruficollis	Little Grebe	Open stretch of freshwater	Common Resident
Vidua paradisaea	Longtailed Paradise Wydah	Mixed woodland	Common Resident
Euplectes progne	Longtailed Widowbird	Open grassland, especially in valleys & damp areas	Common Resident
Oxyura maccoa	Maccoa Duck	Quiet Water	Common Resident (SA endemic)
Cisticola fulvicapilla	Neddicky (piping) Cisticola	Grassy understory, woodland	Common Resident

Scientific Name	Common Name	Habitat	Distribution/Protection Status
Turdus olivaceus	Olive Thrush	Diverse	Common Resident
Amandava subflava	Orange Breasted Waxbill	Grassland & weedy areas near water	Common Resident
Spreo bicolor	Pied Starling	Grassland, scrub woodland, around farm houses	Common Resident (SA endemic)
Vidua macroura	**Pin Tailed Wydah**	**Savanna, grassland, scrub**	**Common Resident**
Ardea purpurea	Purple Heron	Aquatic sedges, reeds	Common Resident
Quelea quelea	Red Billed Quelea	Savanna, thornveld, cropland	Common Visitor (nomadic)
Anas erythrorhyncha	Red Billed Teal	Freshwater	Common Resident
Streptopelia semitorquata	Red Eye Dove	Diverse	Common Resident
Fulica cristata	Red Knobbed Coot	Dams, pans, lakes	Common Resident
Phalacrocorax africanus	Reed Comorant	Freshwater dams, lakes & rivers	Common Resident
Hirundo fuligula	Rock Martin	Cliffs, quarried, rocky terrain	Common Resident
Geronticus calvus	Southern Bald Ibis	Short grazed or burnt upland grassland	Vulnerable (protected)
Passer diffusus	Southern Grey Headed Sparrow	Mixed woodland, suburbia	Common Resident
Ploceus velatus	Southern Masked Weaver	Savanna & grassland, close to water	Common Resident
Euplectes orix	Southern Red Bishop	Grasslands, savanna near water. Breeds in reedbeds	Common Resident
Colius striatus	Speckled Mousebird	Thick tangled bush, fruiting trees, gardens, parks	Common Resident
Columba guinea	Speckled Rock Pigeon	Rocky terrain	Common Resident
Burhinus capensis	Spotted Dikkop	Grassland & savanna	Common Resident
Plectropterus gambensis	Spur Winged Goose	Grassland, agricultural fields	Common Resident
Ardeola ralloides	Squacco Heron	Vegetated margins of freshwaterlakes, pans, slow moving rivers	Common Resident
Pternistes swainsonii	Swainson's Francolin	Dry thornveld, agricultural fields	Common (SA Near-Endemic)
Charadrius tricollaris	Three Banded Plover	Waterbodies with sandy/pebble layer	Common Resident
Ploceus cocollatus	Village Weaver	Savanna, overhanging trees	Common Resident
Phalacrocorax lucidus	White Breasted Comorant	Freshwater	Common Resident
Apus cafer	**White Rumped Swift**	**Diverse (mainly aerial)**	**Summer Visitor**
Hirundo albigularis	**White Throated Swallow**	**Closely associated with water**	**Summer Visitor**

Scientific Name	Common Name	Habitat	Distribution/Protection Status
Cisticola ayresii	Wing Snapping (Ayre's) Cisticola	Upland grassland	Common Resident
Anas undulata	**Yellow Billed Duck**	**Open Water**	**Common Resident**
Egretta intermedia	Yellow Billed Egret	Damp, grassy areas	Common Resident
Euplectes afer	Yellow Crowned Bishop	Grassland & vleis	Common Resident
Cisticola juncidis	Zitting (fantailed) Cisticola	Areas of thick grass in damp situations	Common Resident

Appendix J: Observed and Expected Mammal Taxa (Adapted from MPTA, 2008)

Note: Species observed on site are printed in **Bold.**

Scientific Name	Common Name	Protection Status	Habitat
Aethomys namaquensis	Namaqua Rock Rat	LC	Rocky habitats
Cryptomys hottentotus	**Common Molerat**	**LC**	**Occupies a wide range of soils excluding heavy clay**
Cynictus penicillata	**Yellow Mongoose**	**LC**	**Open habitats, short grassland and semi desert scrub**
Galerella sanguinea	Slender Mongoose	LC	Wide habitat tolerance as long as there is adequate cover
Genetta tigrina	Large Spotted Genet		Well watered areas and fairly dense vegetation
Hystrix africaeaustralis	**Cape Porcuine**	**LC (Protected)**	**Wide habitat tolerance**
Lemniscomys roscilia	Single Striped Grass Mouse	LC	Wide ranging as long as there is a consistent presence of grass
Lepus saxatilis	**Scrub Hare**	**LC**	**Cultivated areas, dense scrub or woodland where there is grass**
Otomys angoniensis	Angoni Vlei Rat	LC	Moist, marsh habitats
Ourebia ourebi	Oribi	EN	Open short grassland with taller grasses for cover
Canis mesomelas	**Black Backed Jackal**	**LC**	**Wide habitat tolerance**
Potamochoerus porcus	Bushpig		Forests, dense bush and riverine woodland
Raptucerus campestris	Steenbok	LC	Open country but some cover required
Sylvicapra grimmia	Grey Duiker		Wide range of habitats but prefers scrub and bush covered country
Tatera brantsii	Highveld Gerbil	DD	Wide variety of habitats
Tatera leucogaster	Bushveld Gerbil	LC	Wide variety of habitats
Tragelaphus scriptus	Bushbuck	LC	Riverine woodland and bush
Vulpes chama	Cape Fox	LC	Open areas

Appendix K

REVISED FINAL HERITAGE IMPACT ASSESSMENT REPORT VERSION 2: HERITAGE SPECIALIST STUDY AS INPUT INTO THE EIA, EMP, IWWMP AND IWULA FOR THE PROPOSED MIDDELBURG MINE WATER TREATMENT PLANT, MPUMALANGA PROVINCE

(Cultmatrix, 2011)

Appendix L

DISCHARGE OF TREATED MINE WATER INTO THE SPOOKSPRUIT CATCHMENT– POTENTIAL IMPACTS ON AQUATIC ECOSYSTEMS

(Nepid, 2008, Revised 2010)

MIDDELBURG MINE

-

Specialist Study

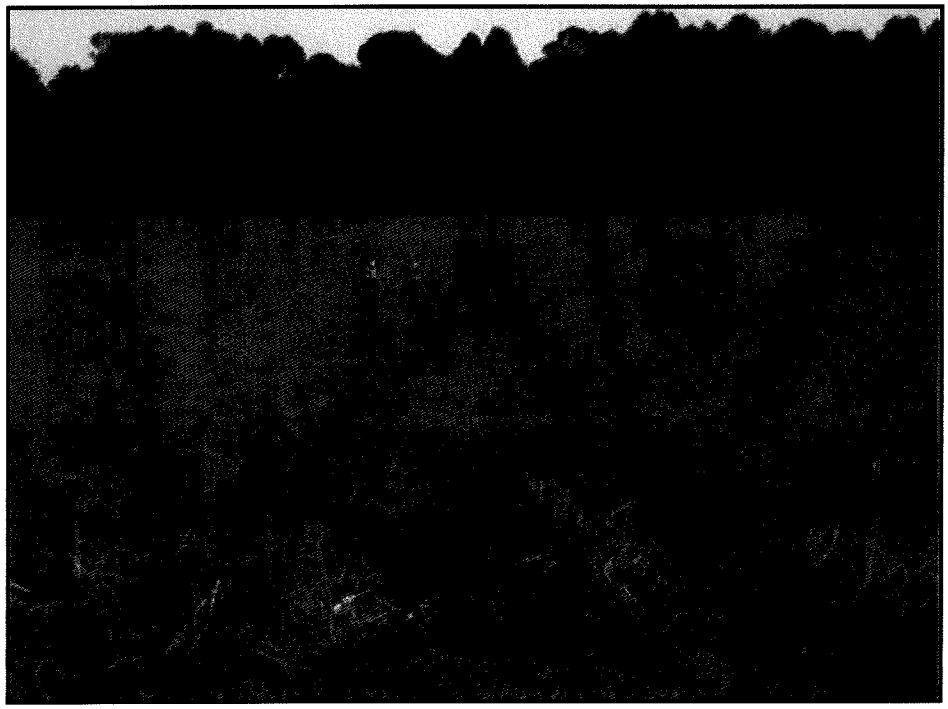
DISCHARGE OF TREATED MINE WATER INTO THE SPOOKSPRUIT CATCHMENT

–

POTENTIAL IMPACTS ON AQUATIC ECOSYSTEMS

31ST August 2008

(Revised 5th November 2010)



[Niekerspruit at proposed discharge point for Option 1]

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EXECUTIVE SUMMARY

Background

This report forms part of an Environmental Impact Assessment and Water Use Licence Application for the proposed Middleburg Mine Water Treatment Plant, near Middelburg. This report concerns the impacts on aquatic ecosystems of discharging between 15 and 25ML/day of water into the Spookspruit Catchment.

Study Area

Three alternative sites for the proposed water treatment plant are under consideration. All sites are located in the middle reaches of the Spookspruit Catchment, quaternary catchment B11H, in the Olifants Water Management Area.

Methods

This study was based on a review of available reports and a field survey undertaken in July 2008. Five sampling sites were visited, and baseline SASS5 and fish biomonitoring data were collected from two sites that contained suitable biotopes. Cross-sectional stream profiles were surveyed at two sites. Field measurements were made of pH and conductivity. Impacts were rated using standard criteria (Magnitude; Reversibility; Duration; Spatial Extent; Probability and Overall Significance)

Baseline Assessment

The cross-sectional profile of the Niekerspruit is about 80 m wide, and the gradient is gentle. The increased flows are unlikely to increase the risks of erosion within this stream, except for the point of discharge.

The main channel of the Spookspruit is about 3 m wide, and while the regional stream slope is gentle, there are local erosion nick points where the gradients are steep, and current speeds are fast (0.8 m/s). The increased flows are expected to increase the risks of erosion within this stream.

Flow patterns in the receiving streams are highly modified from natural flows. Baseflows appear to be significantly higher than natural.

Spot readings of conductivity and very low diversity of aquatic invertebrates, despite good availability of instream biotopes, indicate that the water quality is very poor.

No fish were recorded in the area, although six species are expected to have occurred in the area under natural conditions.

The Present Ecological State of the Spookspruit Catchment is rated as Critically Modified (Category E/F). The stream channel is structurally in good condition, and the main problem appears to be poor quality water.

Potential Impacts and Mitigation

The potential impacts and recommended mitigation of the proposed developments are summarised in Table A. Positive impacts include an improvement of water quality from current conditions, and an associated improvement in instream biodiversity. Negative impacts include possible enroachment of reeds, and increased erosion at existing erosion nick points within the Spookspruit, as well as the point of discharge. Mitigation measures include:

- *Monitor Erosion, particularly after storm events*
- *Monitor Water Quality - monthly for key variables, and annually for comprehensive suite of variables*
- *Annual SASS5 biomonitoring*
- *Re-introduce indigenous fish upstream of weir B1H002 if water quality and biomonitoring results indicate significant improvement, which is expected*
- *Discharge water into well-field located on hillslope adjacent to stream, instead of into the stream directly. This is expected to create an artificial hillslope seepage wetland, and will avoid the problems associated with point discharge. A specialist study of the geohydrology in the proposed receiving area is recommended.*

Options

Option 1 would have the advantage of significantly improving the water quality, and therefore the ecological functioning and biodiversity support, of the Niekerspruit to its confluence with the Spookspruit, a distance of about 600 m. Other than that, there is no significant difference of the three alternative sites in terms of their potential impact on the receiving stream.

Table A. Summary and rating of the main impacts of the proposed Water Treatment Plant on the receiving aquatic ecosystems, before and after mitigation. The overall significance of detrimental impacts is highlighted in colour.

Potential Impact	Environmental significance before mitigation									Environmental significance after mitigation							
	M	R	D	E	C	P	TOTAL	S	MITIGATION	M	R	D	E	C	P	TOTAL	S
Operational Phase																	
Improved Water Quality	4	1	1	2	2	5	**50**	**+ Low**	Monitor	3	1	1	2	2	5	**45**	**+ Low**
Increased Biodiversity	4	1	1	2	2	4	**40**	**+ Low**	Biomonitor	4	1	1	2	2	4	**40**	**+ Low**
Reed Encroachment	3	3	3	2	2	-3	**-39**		Nothing	3	3	3	2	2	-3	**-39**	
Increased Erosion	3	4	5	2	2	-3	**-48**		Monitor; Aquifer Recharge	2	4	5	2	2	-2	**-30**	

M=Magntitude or Severity; R=Reversibility; D=Duration; E=Extent; C=Context; P=Probability; S=Significance

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ABBREVIATIONS

ASPT	Average Score per Taxon
EIA	Environmental Impact Assessment
SASS5	South African Scoring System version 5
WUL	Water Use Licence

1. INTRODUCTION

1.1 Background

Middleburg Mine are investigating the feasibility of constructing a wastewater treatment plant to process excess mine water, and to discharge treated water, via pipeline, into the Spookspruit Catchment. The volume of water discharged is expected to be anything between 15 and 25 ML/day, discharged at a constant rate throughout the year. A detailed Environmental Impact Assessment (EIA) and Water Use License Application (WULA) for the proposed development is being conducted by Jones and Wagener Pty (Ltd). Two alternative sites for the proposed treatment plant are under consideration. This report forms part of the EIA and WUL application, and assesses the potential impacts on the receiving aquatic ecosystem of discharging treated water into the Spookspruit Catchment. The report is based on a review of available information and a site visit conducted on 30th July 2008.

1.2 Study Team

This study was conducted by Rob Palmer, aquatic specialist and director of Nepid Consultants CC. Rob has a BSc in zoology from the University of Cape Town, and a PhD in aquatic ecology from Rhodes University, South Africa. He has over 20 years experience in aquatic systems and specialist knowledge of river regulation and river ecology. He has undertaken numerous environmental assessments throughout southern Africa, mostly concerning water resource developments and mining. He is a member of the South African Advisory Committee on the Safety of Dams (Environmental Portfolio), a certified Environmental Assessment Practitioner (No. 0080/06), a registered Natural Scientist (400108/95), as well as a certified biomonitoring practitioner.

1.3 Declaration

Independent Specialist Consultant

I, , declare under oath that I –

- act as an independent specialist consultant in the field of Freshwater Ecology in this application ;
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2006;
- have and will not have no vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2006; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.

Signature of specialist consultant

Nepid Consultants cc

Name of company:

13/11/2007

Date:

Signature of the Commissioner of Oaths:

2007 - 11 - 13

Date:

Constable

Designation:

Official stamp (below)

SUID AFRIKAANSE POLISIEDIENS
GEMEENSKAPSDIENSSENTRUM
2007 -11- 13
COMMUNITY SERVICE CENTRE
WITRIVIER, WHITE RIVER
SOUTH AFRICAN POLICE SERVICE

2. STUDY AREA

2.1 General Locality

Two alternative sites for the proposed water treatment plant are under consideration (Figure 2-1). All sites are located in the middle reaches of the Spookspruit Catchment, quaternary catchment B11H, in the Olifants Water Management Area. The potential sites are about 15 km south of Middleburg, within the Highveld Ecoregion, Mpumalanga Province.

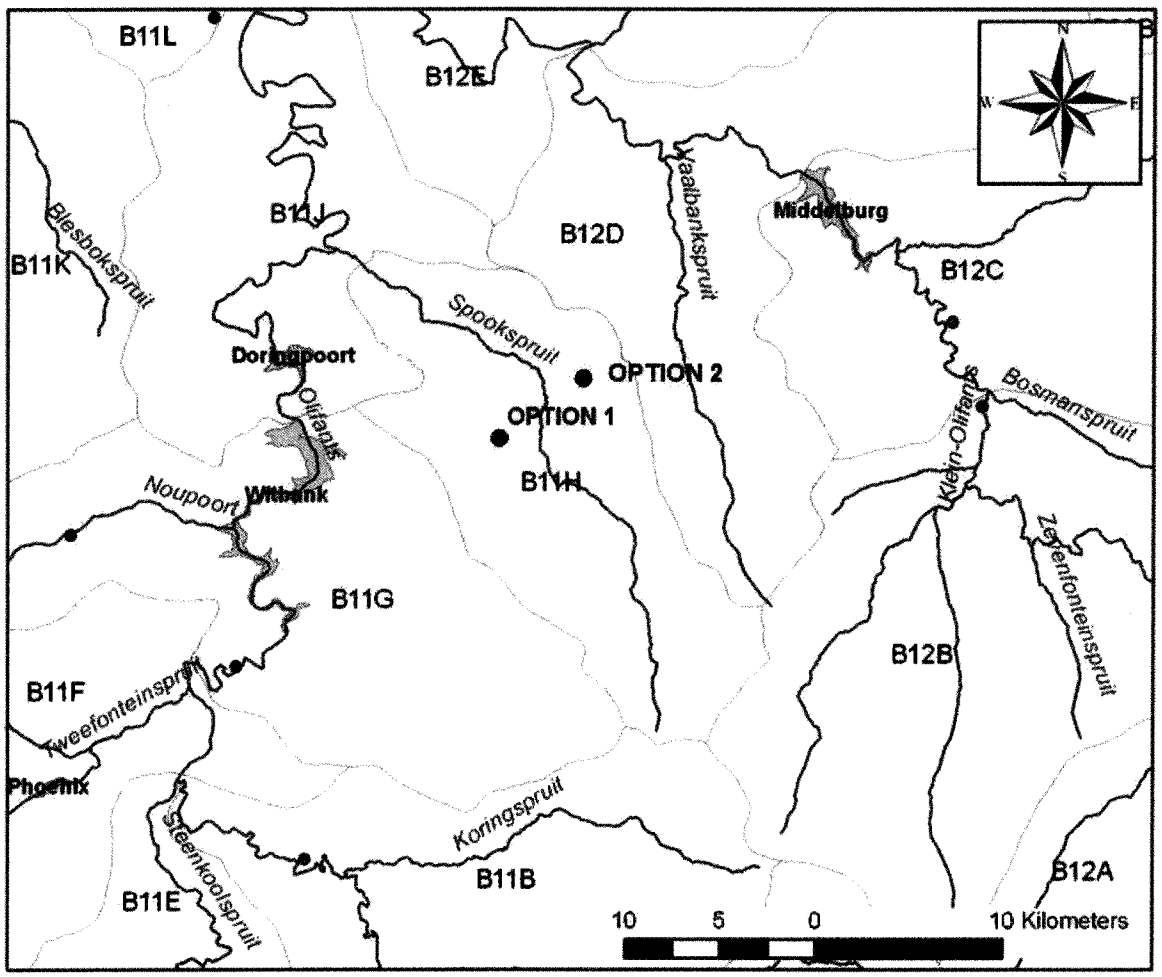

Figure 2-1. General locality map showing the positions of alternative sites for the proposed Middleburg Mine water treatment plant, within the Spookspruit Catchment (B11H).

2.2 Sampling Sites

Details of aquatic sampling sites that were visited in July 2008 are presented in Table 2-1, and sampling locations are shown in Figure 2.2. Photographs of the sites are shown in Appendix A. Three sites were located in the Niekerspruit, and two sites were located in the Spookspruit.

Table 2-1. Details of sites visited during a field survey in July 2008.

Code	Location (WGS84; dd.mm.mmm)	Altitude (m amsl)	Description
AE01	S25 55.001 E29 25.013	1472 m	Niekerspruit: downstream of Pollution Control Dam 5
AE02	S25 54.749 E29 25.199	1493 m	Niekespruit: farm road culvert
AE03	S25 54.709 E29 25.213	1517 m	Niekerspruit: potential discharge point for Option 1
AE04	S25 53.450 E29 25.337	1519 m	Spookspruit: Road crossing at Burnside Farm
AE05	S25 51.540 E29 23.830	1480 m	Spookspruit: R575 road bridge

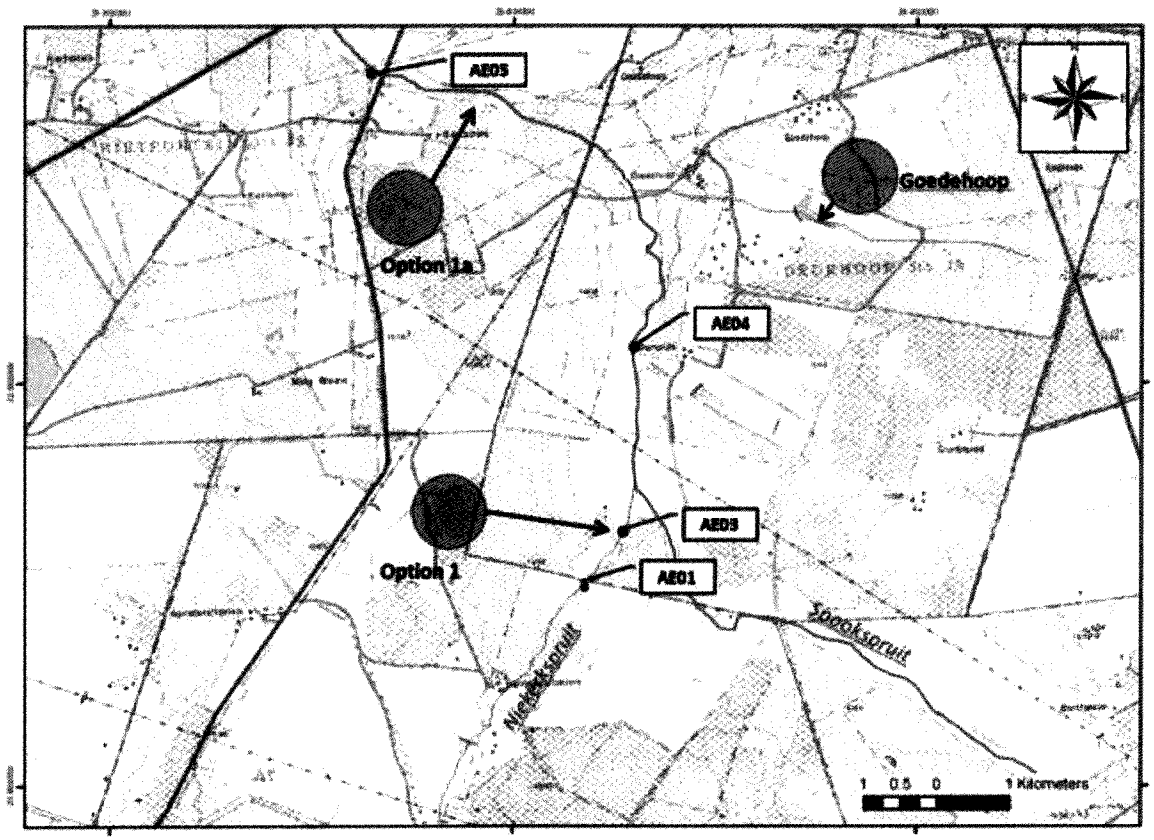

Figure 2-2. Topographical map showing the approximate positions of alternative sites for the proposed Middleburg Mine water treatment plant (red shading), and the aquatic sampling sites visited during this study (AE01 to AE05).

2.3 Alternative Locations

2.3.1 Option 1

Option 1 is located in a Eucalyptus plantation alongside the R575 road. The nearest surface water to the site is the Niekerspruit, a tributary of the Spookspruit, which is about 2 km from the proposed site at its nearest point. The Niekerspruit is a historical seasonal, non-channelled, valley-bottom riparian wetland, which would have naturally risen about 5 km upstream of the proposed point of discharge. However, most of the catchment has been transformed by surface coal mining. There are five pollution control dams located upstream of the proposed point of discharge, and a 90°V-notch weir is located on the lower, larger dam (Dam 5).

2.3.2 Option 2

Option 2 is located on the farm Goedehoop, about 5 km north-east of Option 1. This option will discharge into an impounded, unnamed tributary of the Spookspruit.

3. METHODS

3.1 Review

The National River Health Database was queried for biomonitoring records for the Spookspruit Catchment, but no historical biomonitoring data were available. The Department of Water Affairs and Forestry: Resource Quality Services (Christa Thirion, pers. comm.), as well as the Mpumalanga Parks Board (Johan Engelbrecht, pers. comm..) were contacted for ecological information on the Spookspruit, but neither organisations were aware of any biomonitoring data for the catchment.

3.2 Field Survey

A field survey was undertaken on 30th July 2008. The survey focussed on the Present Ecological State of the Spookspruit Catchment that could be affected by the proposed development, based mainly on the composition and abundance of aquatic invertebrates.

3.3 Cross-sectional Profiles

One of the key considerations of the proposed development is the potential for erosion because of elevated flows. Cross-sectional profiles and local gradients of the receiving stream were therefore surveyed with a dumpy level to assess the potential risks of erosion. The surveys were undertaken at two sites that were considered representative of the two receiving streams: the Niekerspruit at Site AE03, and the Spookspruit at Site AE04.

3.4 Flow

Flows during the field survey in July 2008 were used to indicate the approximate winter baseflows. Flows were measured as follows:

- Site AE01, based on depth at a 90°V-notch weir;
- Site AE05, based on velocity-area method at three pipe culverts at the R575 road bridge (pipe diameter each 0.6 m)
- B1H002, based on stage height over sharp-crested weir and associated discharge table, downloaded from the DWAF website (www.dwaf.gov)

3.5 Water Quality

Field measurements were made of conductivity, pH and spot water temperature.

3.6 Aquatic Invertebrates

Aquatic invertebrates were sampled and identified using the standard SASS5 biomonitoring method (Dickens and Graham 2002). The method was applied at sites AE04 and AE05 only. The method could not be applied at other sites because flows were too low and biotopes were unsuitable for the application of the method.

The SASS5 results were classified into one of six categories, ranging from *Excellent* (Category A), to *Very Poor* (Category F). The classification was based on professional judgement and historical biomonitoring data collected from the Highveld Ecoregion and analysed by the Institute for Water Quality Studies (Table 3-1). This system was used in preference to the guidelines for the interpretation of SASS results, which have recently been published (Dallas 2007). The reason for this is that the guidelines do not address the problem of low SASS scores, other than warning that these should "treated with caution".

Table 3-1. Guide used to classify SASS5 biomonitoring results. [SASS4 data collected in the Highveld Ecoregion by the Institute for Water Quality Studies.]

Category	Condition		SASS4	ASPT
A	Excellent	Unimpaired. High diversity of taxa with numerous sensitive taxa.	>120	>6
	Very Good	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.	91-120	5-6
C	Good	Moderately impaired. Moderate diversity of taxa.	71-90	4.5-5.5
	Fair	Considerably impaired. Mostly tolerant taxa present.	56-70	4.5-5.5
	Poor	Severely impaired. Only tolerant taxa present. Low diversity.	30-55	Variable
F	Very Poor	Very severely impaired. Very few tolerant taxa present. Very low diversity	<30	Variable

3.7 Fish

Sampling of fish was undertaken using a portable, battery operated electro-fisher (Samus 725M).

3.8 Impacts Evaluation

The likely environmental impacts of the proposed development were evaluated using the following criteria:

M = Magnitude or Severity: 1=minor; 2= low; 3=moderate; 4=high; 5=very high or don't know.

R = Reversibility: 1=naturally reversible; 3=reversible with human input; 4= difficult; 5=irreversible.

D = Duration or Frequency: 1=immediate and/or unique impact; 2=short-term (0 to 5 years) and/or infrequent impact; 3=medium-term (5 to 10 years) and/or frequent impact; 4=long-term (impact ceases after operational life) and/or very frequent impact; 5=permanent and/or continuous impact.

E = Spatial Extent: 1=site only; 2=local; 3=regional; 4=national; 5=international.

P = Probability: 1=improbable; 2= low probability; 3=medium probability; 4=high probability; 5=definite or don't know.

S = Significance: The overall significance of each impact was determined by combining the consequence of the impact and the probability of occurrence i.e.: Significance = Consequence (magnitude + reversibility + duration + spatial extent + environmental context) x Probability. The scores were interpreted as follows:

Total Score	Significance
>100	Very High
76-100	High
51-75	Moderate
26-50	Low
<26	Very Low

3.9 Assumptions and Limitations

It is assumed that the quality of the discharged water will consistently meet the water quality targets that have been set by DNWRP (2009) for Management Unit 26 (Appendix E). The expected quality of water discharged from the plant is unknown, but it is certain to be better than the quality of water that is currently in the Niekerspruit and Spookspruit.

4. BASELINE ASSESSMENT

4.1 Cross-Sectional Profiles

Niekerkspruit

The Niekerkspruit at the proposed discharge point (Site AE03) comprises a non-channelled valley-bottom wetland that is about 80 m wide (see Appendix D). The regional and local stream slope is gentle (0.005). The addition of 15 to 25 ML/day of water to this wide stream channel is unlikely to increase the risks of erosion.

Spookspruit

The Spookspruit at Site AE04 comprises a channelled valley-bottom wetland, where the main channel is 3 m wide, but the riparian zone is about 300 m wide in total (see Appendix D). The regional gradient is gentle (0.008), but there are erosion nick-points where the local gradient is steep (0.02). Current speeds of up to 0.8 m/s were recorded in one of the erosion nick points during the field visit in July 2008. The addition of 15 to 25 ML/day of water to this stream channel therefore has the potential to increase the risks of erosion at a few existing erosion nick points.

4.2 Flow

Flow in the Niekerkspruit at Site AE01 during the field survey in July 2008 comprised little more than a trickle (1.8 L/s). Although flows in this catchment are highly altered because of upstream mining activities and impoundments, it is probable that this flow approximates natural baseflow for this time of the year. The proposed discharge is expected to be between 174 and 289 L/s (i.e. 160 times the flows measured in July 2008).

Flow in the Spookspruit at Site AE05 during the field survey in July 2008 was moderate, and calculated to be about 237 L/s. Further downstream, at gauging weir B1H002, the flow was recorded to be 228 L/s. The proposed flows are in the same order of magnitude, which means that the flows seen in July 2008 would be roughly doubled. Flows recorded at gauge B1H002 in the month of July during the late 1950's and early 1960's, when development of the catchment is presumed to have been limited, varied between 69 and 144 L/s. The available information therefore indicates that current winter flows are significantly higher than they may have been under natural conditions.

4.3 Surface Water Quality

Water quality in the Spookspruit Catchment is seriously compromised. Spot readings of conductivity recorded during the field survey in July 2008 were consistently and excessively

high (>200 mS/m) (Table 4.1). These values are equivalent to a Total Dissolved Salt concentration in excess of 1,300 mg/L. A noticeable smell of sulphide was recorded at Site AE04. The pH of the Niekerkspruit (Site AE01) was acidic (6.4), while the Spookspruit was alkaline (7.4 to 7.6). Water at all sites was clear (Secchi depth >1 m), and these conditions are typically associated with elevated salt levels which promotes sedimentation of clays.

Table 4-1. Field measurements of selected water quality variables recorded at selected sites in July 2008.

Code	pH	Temp (°C)	Conductivity (mS/m)
AE01	6.4	7.7	216
AE04	7.6	10.7	207
AE05	7.4	11.9	214

4.4 Aquatic Invertebrates

Data on aquatic invertebrates collected at two sites during this study are shown in Appendix B, and summary results are shown in Table 4-2. The fauna was "Severely Impaired" (Category E), and characterised by a few (10 to 13), hardy SASS taxa, and low population numbers, despite the generally good quality of biotopes available. The Total SASS5 Scores were very low (54 and 56), and the Average Score per Taxon was also very low (4.3 and 5.4). The only taxa that were considered common (>10 in sample) at were non-biting midges (Chironomidae) and whirligig beetles (Gyrinidae). Mayflies and snails were notably absent at both sites, although an empty shell of *Lymnaea* was found at Site AE04. The highest SASS5 score at Site AE04 was for aeshnid dragonflies (SASS5 Score = 8), while the highest scoring taxa at Site AE05 comprised three species of hydropsychid caddisflies (SASS5 Score = 12). The results indicate that poor water quality is the main reason for the low diversity and abundance of invertebrates.

Table 4-2. Summary results of SASS5 biomonitoring data recorded at selected site in July 208.

Code	SASS5 Score	No of taxa	ASPT	Category
AE04	56	13	4.3	E
AE05	54	10	5.4	E

4.5 Fish

No fish were recorded during the field survey in July 2008. Six species of indigenous fish are expected to occur in the Spookspruit under natural conditions, namely *Barbus anoplus;*

B. paludinosus; B. trimaculatus; Chiloglanis pretoriae; Pseudocrenilabrus philander and *Tilapia sparrmanii* (Kleynhans *et al.* 2007). It is therefore concluded that the Present Ecological State of the Spookspruit in terms of fish is "Critically Impaired" (Category F). There are no impoundments that could restrict the movement of fish in the middle and lower reaches, apart from the gauging weir B1H002. The absence of fish in the Spookspruit is therefore attributed to poor quality water. No fish are expected under natural conditions in the Niekerkspruit because there is insufficient habitat.

4.6 Functional Values

The wetlands in the catchment have a number of important functional attributes, including:

- ***Flood Attenuation.*** The valleybottom wetlands cover a significant portion of the catchment, and the gradient is gentle, so the potential influence on flood attenuation is high.
- ***Water Quality Enhancement.*** Water quality improvement within the lateral seepage wetlands and the valleybottom wetlands is likely to be significant, as the contact with vegetation is high. However, natural wetlands are unlikely to serve any significant role in processing high concentrations of salt.
- ***Biodiversity Support.*** The wetlands provide moderate diversity of habitat for flora and fauna, although this has been severely compromised by deterioration in water quality.

5. POTENTIAL ENVIRONMENTAL IMPACTS

This section details the expected environmental impacts of the proposed development on aquatic ecosystems. Impacts are arranged in order of increasing overall significance. A summary and rating of the main impacts is provided in Table 6-1.

5.1 Planning and Construction Phases

The Planning and Construction Phases of the proposed development are not expected to have any impacts on the receiving aquatic environment.

5.2 Operational Phase

5.2.1 Improved Water Quality

The proposed development is certain to improve the quality of the water in the receiving stream because of dilution. The improvement will be most apparent in the Niekerspruit (Option 1). The improvement is expected to be immediate, of moderate magnitude, of local extent, and easily reversible. The impact is positive, and the overall significance is rated as **Low (+ve)**.

5.2.2 Increased Biodiversity

Improved water quality and elevated baseflows (and therefore increased habitat availability), is expected to improve the faunal biodiversity of the receiving stream, irrespective of which option is developed. The improvement is expected to be immediate, of high magnitude, of local extent, and easily reversible. The impact is positive, and the overall significance is rated as **Low (+ve)**.

5.2.3 Reed Encroachment

Elevated constant baseflows could lead to the proliferation of reeds, particularly bulrush (*Typha capensis*), irrespective of which option is developed. This could lead to a single-species dominance; a reduction in wetland plant diversity and wetland habitat diversity; an increase in evapotranspiration losses; and an increase in the risk of fire during dry periods. The changes are expected to take a number of years to develop, and are likely to be of local extent, and moderately difficult to control once established. The overall significance of this impact is rated as ***Low (-ve)***.

5.2.4 Increased Erosion

Erosion is anticipated in the receiving channel during the operational phase, particularly at the point of discharge, and in areas where the flows are constricted, or the gradients steep. The Niekerkspruit has a wide channel with gentle gradient, and is therefore unlikely to be affected, except at the point of discharge. However, there are sections of the Spookspruit that could be moderately susceptible to erosion. In particular, the spillway of the dam located 1.6 km downstream of Site AE04 may be at risk to erosion. The overall significance of this impact is rated as ***Low (-ve)***.

5.3 Options

There is no major difference between the various options in terms of impacts on the receiving aquatic environments. However, Option 1 would have the advantage of significantly improving the water quality, and therefore the ecological functioning and biodiversity support, of the Niekerkspruit to its confluence with the Spookspruit, a distance of about 600 m. Furthermore, the proposed point of discharge for this option has a hillslope that lends itself for creating an artificial hillslope seepage wetland.

Table 5-1. Summary and rating of the main impacts of the proposed Water Treatment Plant on the receiving aquatic ecosystems, before and after mitigation. The overall significance of detrimental impacts is highlighted in colour.

Potential Impact	Environmental significance before mitigation									Environmental significance after mitigation							
	M	R	D	E	C	P	TOTAL	S	MITIGATION	M	R	D	E	C	P	TOTAL	S
Operational Phase																	
Improved Water Quality	4	1	1	2	2	5	**50**	**+ Low**	Monitor	3	1	1	2	2	5	**45**	**+ Low**
Increased Biodiversity	4	1	1	2	2	4	**40**	**+ Low**	Biomonitor	4	1	1	2	2	4	**40**	**+ Low**
Reed Encroachment	3	3	3	2	2	-3	**-39**		Nothing	3	3	3	2	2	-3	**-39**	
Increased Erosion	3	4	5	2	2	-3	**-48**		Monitor; Aquifer Recharge	2	4	5	2	2	-2	**-30**	

M=Magntitude or Severity; R=Reversibility; D=Duration; E=Extent; C=Context; P=Probability; S=Significance

6. RECOMMENDED MITIGATION MEASURES

Recommendations for mitigating the detrimental impacts of the proposed water treatment plant on aquatic ecosystems are detailed below.

6.1 Pre-Construction

6.1.1 Aquifer Recharge

Water discharged from the proposed treatment plant could be used to recharge aquifers adjacent to the receiving stream, instead of discharging it directly into the stream channel. This will reduce the risks of erosion at the point of discharge, and is expected to create a new, artificial hillslope seepage wetland area that could mitigate any potential negative impacts of the proposed development. The left bank of the Niekerkspruit at the point of discharge for Option 1 (Site AE03), has a moderate slope (0.073) that lends itself for creating an artificial hillslope seepage wetland (See Appendix D). However, a specialist geohydrological study of the feasibility of doing this at the selected point of discharge is recommended.

6.2 Operational Phase

6.2.1 Monitor Erosion

The applicant should be responsible for undertaking regular checks of the structural stability of the receiving stream, and correct any problems of erosion as soon as they are noticed. This should be done immediately after any significant rainfall event. Digital photographs of key areas should be kept and maintained as a record of how the stream channel is responding to the changes in flow. Areas of particular concern are:

- the point of discharge;
- existing erosion nick points, and;
- the spillway of the existing dam located 1.6 km downstream of Site AE04.

6.2.2 Monitor Water Quality

Monthly monitoring of the quality of discharged water as well as the receiving stream is recommended. Key variables should include conductivity and pH. Annual monitoring of a comprehensive suite of variables is recommended. Appropriate steps should be taken if levels exceed target levels.

6.2.3 Biomonitoring

Annual SASS5 biomonitoring is recommended at two sites in the Spookspruit, downstream of the selected point of discharge.

6.2.4 Re-introduce Indigenous Fish

Introduction of indigenous fish into the Spookspruit upstream of gauging weir B1H002 should be considered if the water quality and SASS5 biomonitoring results indicate significant improvement, as expected.

6.2.5 Monitor Wetlands in Recharge Zone

The proposed artificial wetland that is expected to be formed near the recharge zone should be monitored in terms of its size, ecological state and plant biodiversity.

7. REFERENCES

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Directorate National Water Resource Planning (DNWRP) Department of Water Affairs and Forestry, South Africa, July 2009. Integrated water resource management plan for the upper and middle Olifants Catchment: Integrated Water Resource Management Plan. Report Number: P WMA 04/000/00/7007.

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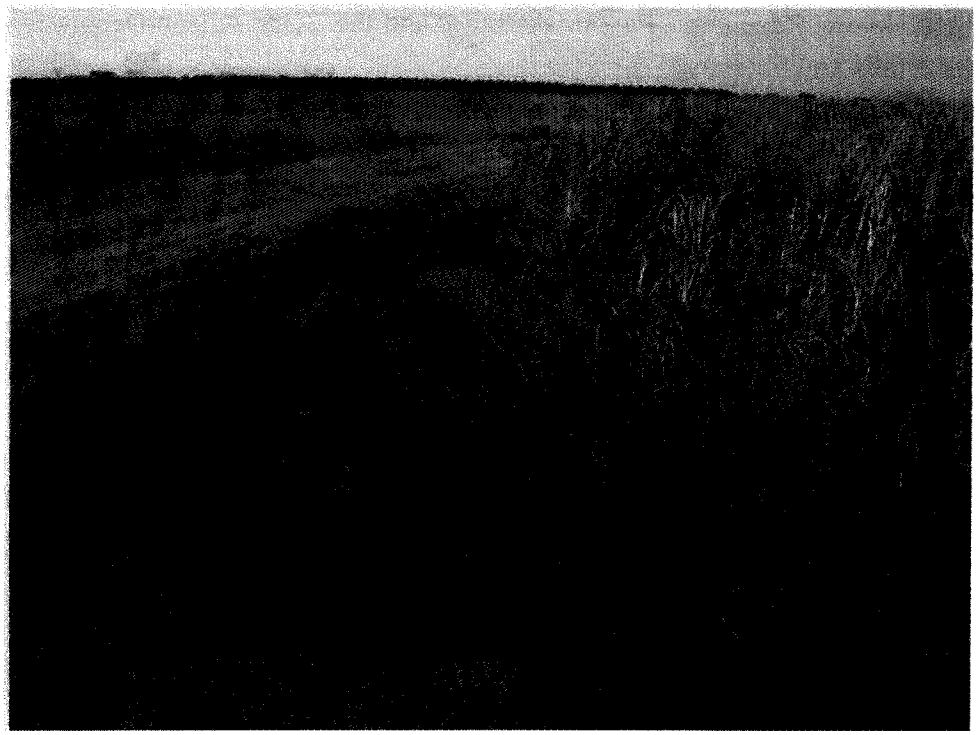
8. APPENDICES

8.1 Appendix A: Photographs

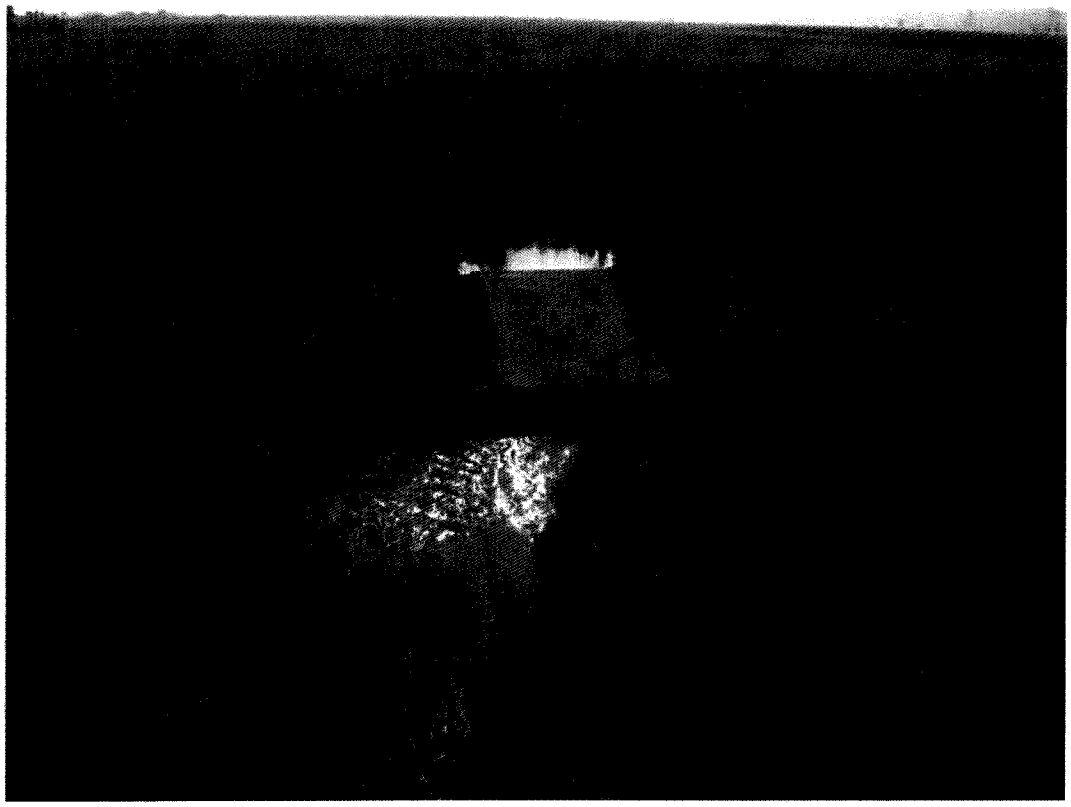
Photograph A: V-notch flow gauge in the Niekespruit, downstream of pollution control dams (Site AE01)



Photograph B: Niekerkspruit and road crossing (Site AE02)

Photograph C: Niekerkspruit and proposed discharge point for Option 1 (Site AE03)

Photograph D: Spookspruit on the farm Burnside (Site AE04)



Photograph E: Spookspruit immediately downstream of the R575 road bridge (Site AE05)

8.2 Appendix B: Detailed Results - Aquatic Invertebrates.

Date (dd.mm.yr):	30-Jul-08					
Site Code:	AE04					
Collection/Sampler:	Rob Palmer					
River:	Spookspruit					
Level 1 Ecoregion:	11: HIGHVELD					
Quaternary Catchment:	B11H					
	Temp (°C):	10.7				
Site Description:	pH:	7.6				
Road crossing on Jaap Visser's farm (Burnside)	DO (mg/L):	-				
	Cond (mS/m):	207				
	Riparian Disturbance:					
	Instream Disturbance:					

		(dd.ddddd)
Grid reference (dd mm ss.s) Lat:	S	25 53 27.4
Long:	E	29 25 20.0
Datum (WGS84/Cape):		WGS84
Altitude (m):		1519
Zonation:		E: Lower Foothills

Routine or Project? (circle one)	
Project Name:	Middleburg Mine - Proposed Water Treatment Plant
Flow:	Low
Clarity (cm):	>1m
Turbidity:	V Low
Colour:	Normal Transparent

Biotopes Sampled (tick & rate)	Rating	Weight	ne (min)
Stones In Current (SIC)	3		
Stones Out Of Current (SOOC)	4		
Bedrock	0		
Aquatic Veg	3		
MargVeg In Current	0		
MargVeg Out Of Current	4		
Gravel	0		
Sand	2		
Mud	1		
Hand picking/Visual observation	yes		
OVERALL BIOTOPE SUITABILITY		41%	Category D

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1			1	1
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3	1			1
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8	A			A
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6			1	1
Libellulidae (Darters/Skimmers)	4		1		1
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3		1		1
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4	A	1		A
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6		1		1
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5		B		B
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5	1			1
Chironomidae (Midges)	2		A	A	B
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	A			A
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalves)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					56
No. of Taxa					13
ASPT					4.3

Other biota:

Empty shell - Lymnaea
Cheumatopsyche afra

Comments/Observations:

Sulphide smell

Date (dd:mm:yr):	30-Jul-08		
Site Code:	AE05	Grid reference (dd mm ss.s) Lat: S	25 51 32.6 (25.85905d)
Collector/Sampler:	Rob Palmer	Long: E	29 23 49.7 (29.39713d)
River:	Spookspruit	Datum (WGS84/Cape):	WGS84
Level 1 Ecoregion:	11: HIGHVELD	Altitude (m):	1480
Quaternary Catchment:	B11H	Zonation:	E: Lower Foothills
Site Description: R575 road bridge	Temp (°C): 11.9	Routine or Project? (circle one)	Flow: Medium (237 L/s)
	pH: 7.4	Project Name:	Clarity (cm): >1m
	DO (mg/L): -	Middleburg Mine - Proposed Water Treatment Plant	Turbidity: V Low
	Cond (mS/m): 214		Colour: Normal Transparent
	Riparian Disturbance:		
	Instream Disturbance:		

Biotopes Sampled (tick & rate)	Rating	Weight
Stones In Current (SIC)	4	[illegible]
Stones Out Of Current (SOOC)	4	[illegible]
Bedrock	0	[illegible]
Aquatic Veg	4	[illegible]
MargVeg In Current	4	[illegible]
MargVeg Out Of Current	4	[illegible]
Gravel	4	[illegible]
Sand	0	[illegible]
Mud	3	[illegible]
Hand picking/Visual observation	yes	
OVERALL BIOTOPE SUITABILITY		66%
Category		B

Taxon	QV	S	Veg	GSM	TOT
PORIFERA (Sponge)	5				
COELENTERATA (Cnidaria)	1				
TURBELLARIA (Flatworms)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1				
Hirudinea (Leeches)	3				
CRUSTACEA					
Amphipoda (Scuds)	13				
Potamonautidae* (Crabs)	3	A		1	A
Atyidae (Freshwater Shrimps)	8				
Palaemonidae (Freshwater Prawns)	10				
HYDRACARINA (Mites)	8				
PLECOPTERA (Stoneflies)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA (Mayflies)					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC (Spiny Crawlers)	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae ST,T (Demoiselles)	10				
Chlorocyphidae (Jewels)	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies/Spreadwings)	8				
Platycnemidae (Stream Damselflies)	10				
Protoneuridae (Threadwings)	8				
Aeshnidae (Hawkers & Emperors)	8	1			1
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters/Skimmers)	4	A			A
LEPIDOPTERA (Aquatic Caterpillars/Moths)					
Crambidae (Pyralidae)	12				

Taxon	QV	S	Veg	GSM	TOT
HEMIPTERA (Bugs)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3				
Gerridae* (Pond skaters/Water striders)	5				
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies & Dobsonflies)	8				
Sialidae (Alderflies)	6				
TRICHOPTERA (Caddisflies)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12	A			A
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6		1		1
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)	5		A		A
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5	A	A		A
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae (Marsh-Loving Beetles)	10				
Psephenidae (Water Pennies)	10				

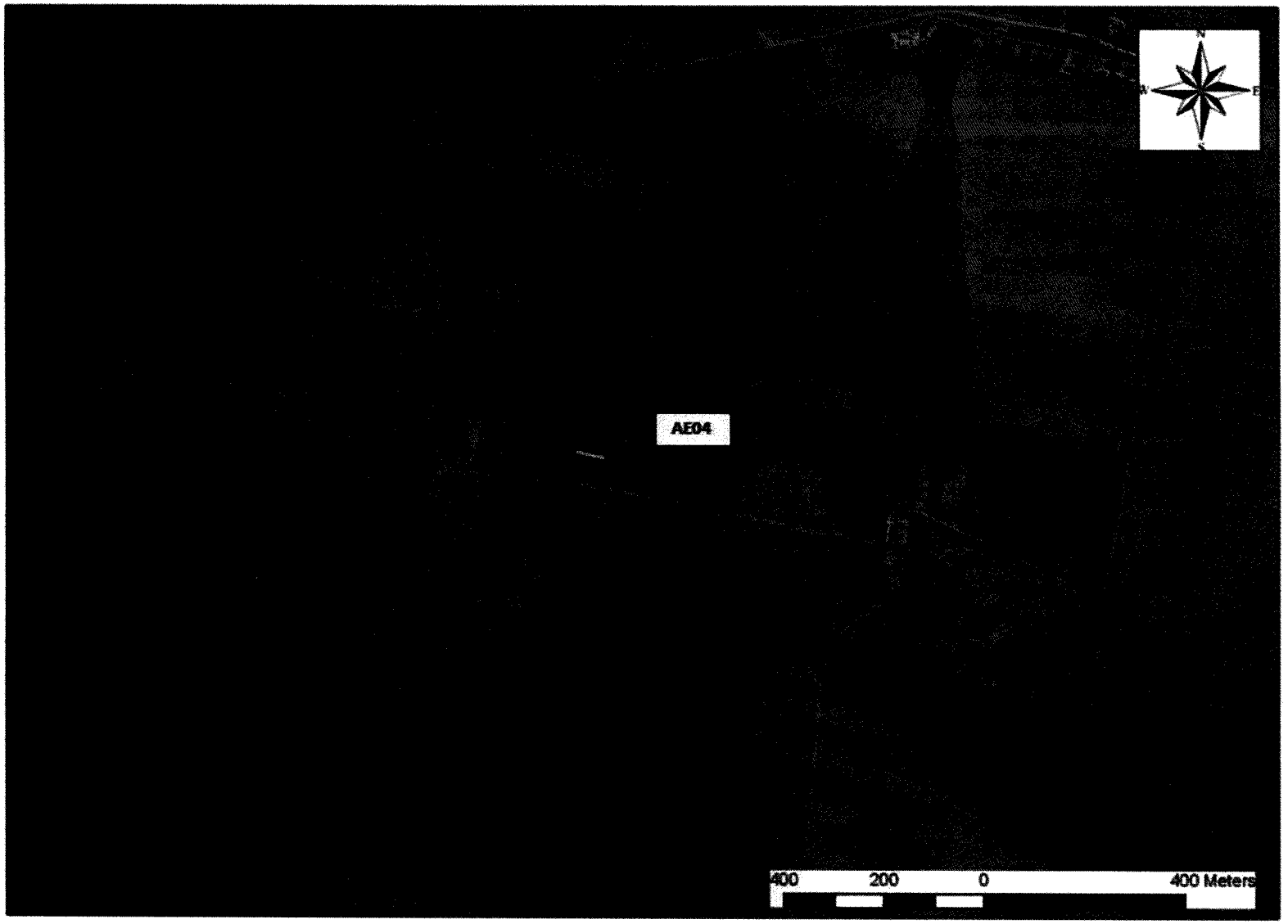
Taxon	QV	S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae (Snipe flies)	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2			A	A
Culicidae* (Mosquitoes)	1	A	A	A	B
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (Snails)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3				
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (Bivalvies)					
Corbiculidae (Clams)	5				
Sphaeriidae (Pill clams)	3				
Unionidae (Perly mussels)	6				
SASS Score					54
No. of Taxa					10
ASPT					5.4

Other biota:
Cheumatopsyche tomasetti; Chuematopsyche afra; Macrostemum capense

Comments/Observations:
Tadpole present; Current speed over Potamogeton pectinatus about 0.68 m/s

8.3 Appendix C: Aerial Photographs

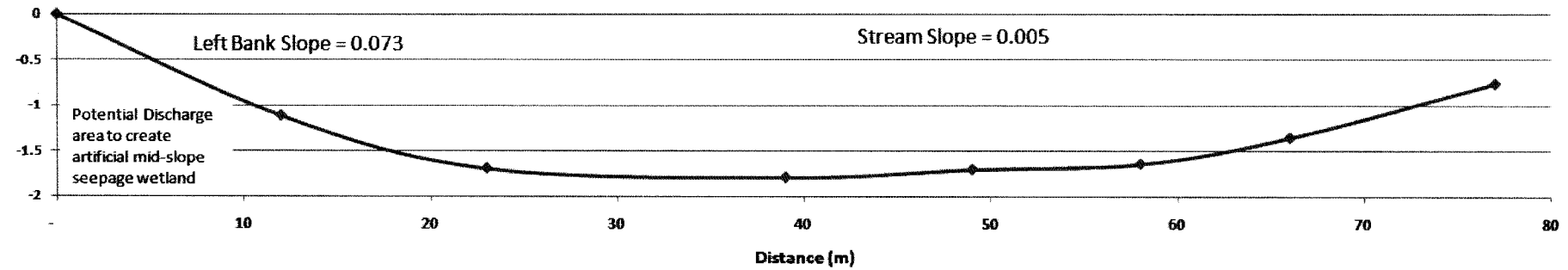
Aerial Photograph A: Site AE03



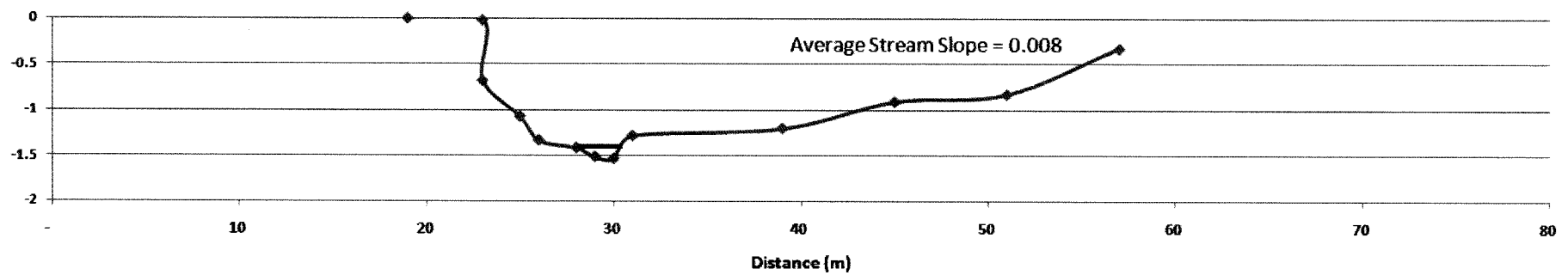
Aerial Photograph B: Site AE04

Appendix D: Cross-sectional Profiles

Site AE03



Site AE04



Appendix E: Target Water Quality Guidelines

Target water quality guidelines applicable to the Spookspruit, located in Management Unit 26, extracted from DNWRP (2009).

Water quality Variables	Units	Management Units			
		16, 17, 18	26	27, 28, 29, 30	Loskop Dam
PHYSICAL					
Conductivity	mS/m	120 (PRWQ)	90 (IMS)	90 (IMS)	40 (PS)
Dissolved Oxygen	% Sat	70 (AER)	70 (AER)	70 (AER)	70 (AER)
pH	-	6.0-9.0 (PRWQ)	6.5-8.4 (IMS)	6.5-8.4 (IMS)	6.5-8.4 (IMS)
Suspended solids	mg/ℓ	-	-	-	-
Turbidity	NTU	-	-	-	-
CHEMICAL, INORGANIC					
Alkalinity	mg $CaCO_3/\ell$	120 (PS)	120 (PS)	120 (PS)	85 (PS)
Boron	mg/ℓ	0.5 (IMS)	0.5 (IMS)	0.5 (IMS)	0.5 (IMS)
Calcium	mg/ℓ	150 (DI)	150 (DI)	150 (DI)	32 (PS)
Chloride	mg/ℓ	60 (PS)	20 (PS)	175 (IMS)	25 (PS)
Fluoride	mg/ℓ	0.75 (AET)	0.75 (AET)	0.75 (AET)	0.75 (PS)
Magnesium	mg/ℓ	100 (DI)	100 (DI)	70 (AET)	20 (PS)
Potassium	mg/ℓ	50 (DI)	20 (PS)	50 (DI)	10 (PS)
Sodium	mg/ℓ	115 (IMS)	70 (PS)	70 (AET)	25 (PS)
SAR	$meql^{0}_{5}$	2.0 (IMS)	2.0 (IMS)	2.0 (IMS)	1.5 (PS)

Appendix E. continued...

Water quality Variables	Units	Management Units			
		16, 17, 18	26	27, 28, 29, 30	Loskop Dam
Sulphate	mg/ℓ	500 (PRWQ)	400 (DI)	120 (AET)	120 (PS)
Total Dissolved Solids	mg/ℓ	820 (PRWQ)	650 (IMS)	650 (PS)	260 (PS)
CHEMICAL, ORGANIC					
Dissolved Organic Carbon	mg/ℓ	10 (DI)	10 (DI)	10 (DI)	10 (DI)
METALS, DISSOLVED					
Iron	mg/ℓ	1.0 (PRWQ)	1.0 (DI)	1.0 (DI)	1.0 (DI)
Manganese	mg/ℓ	1.0 (PRWQ)	0.4 (AER)	0.4 (AER)	0.18 (AER)
Aluminium	mg/ℓ	0.2 (PRWQ)	0.02 (AER)	0.02 (AER)	0.02 (AER)
Chromium (VI)	mg/ℓ	0.05 (DF)	0.05 (DF)	0.05 (DF)	0.05 (DF)
PLANT NUTRIENTS					
Ammonia*	mg/ℓ as N	0.007 (AER)	0.007 (AER)	0.007 (AER)	0.007 (AER)
Nitrate	mg/ℓ as N	6 (DF)	6 (DF)	6 (DF)	6 (DF)
Phosphate	mg/ℓ as P	0.05 (AER)	0.05 (AER)	0.05 (AER)	0.02 (AER)
Total Phosphorus	mg/ℓ as P	0.25 (AER)	0.25 (AER)	0.25 (AER)	0.05 (AER)
Total Inorganic Nitrogen	mg/ℓ as N	2.5 (AER)	2.5 (AER)	2.5 (AER)	0.2 (AER)
MICROBIOLOGICAL					
E Coli	# per 100mℓ	130 (RFC)	130 (RFC)	130 (RFC)	130 (RFC)
Chlorophyll a	mg/ℓ	0.02 (RIC)	0.02 (RIC)	0.02 (RIC)	0.02 (RIC)

**Free unionised NH_3*