and minimum monthly temperatures are 41.3°C and -0.8°C (Mucina and Rutherford, 2006).

Sundays Thicket vegetation is a tall, dense thicket with an abundance of trees, shrubs and succulents (Mucina and Rutherford, 2006). The thicket is particularly spinescent. The density is further developed in a high abundance of lianas. As rainfall decreases, the proportion of *Portulacaria afra* increases. Endemic, dominant and important taxa of Sundays Thicket are listed in Appendix B.

This vegetation type is considered **Least Threatened** (Mucina and Rutherford, 2006) but is **Poorly Protected** (Mucina and Rutherford, 2006) with 9% formally protected and a target level for protection of 19% (Rouget *et al.*, 2004). Sundays Thicket has a total area of 523 565 ha of which 494 258 ha (or 94%) remains natural (if degraded in places). Erosion ranges from very low to moderate, but overbrowsing has severely degraded this vegetation type.

1.3 Sandman Vegetation

The vegetation at the study site is highly transformed over most of the area (Fig. 3). The **quarry** area has been completely transformed (Plate 1) and contains many of the exotic problem species recorded on the property (Appendix C). For the rest of the site, most of the vegetation has been cleared and now consists of grassy (Plate 2) to bushy (*Acacia karroo* dominated; Plate 3) **pastures** with few Thicket remnants. In the north-east corner of the property, a pocket of Sundays Thicket remains (Plate 4, Fig. 3) and this is the only conservation-worthy portion of vegetation.

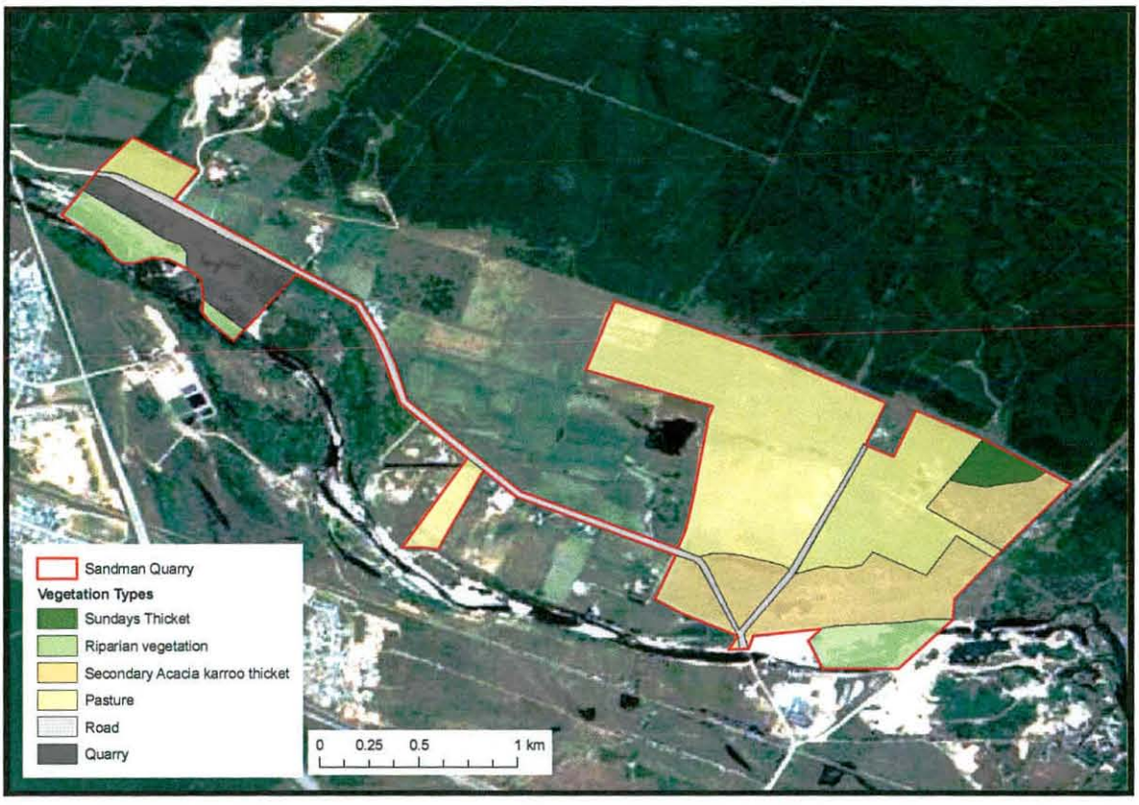

Figure 3. The vegetation of the Sandman Quarry study site.

Plate 1. The quarry area (transformed) at the Sandman Quarry study site.

Plate 2. The grassy pastures of the Sandman Quarry property.

Plate 3. The bushy pastures of the Sandman Quarry property (secondary *Acacia karroo* thicket).

Plate 4. Sundays Thicket in the north-east of the Sandman Quarry site.

1.4 Quarry impacts on the Swartkops River

The mining process had a significant impact on the integrity of the alluvial vegetation and water quality of the adjacent Swartkops River. However, Quarry management has undertaken significant rehabilitation of the River so that the water quality does not deteriorate during passage throught the Sandman Quarry (Plate 5). These rehabilitation efforts are to be encouraged.

Plate 5. Rehabilitation efforts in the Swartkops River basin at the Sandman Quarry have improved the quality of the river.

The National Water Act 26 of 1998 with the General Authorisations published on 26 March 2004 prohibits damaging areas within 500 m of any wetland or water course and prohibits altering the bed or banks of such a water course. However, rehabilitation efforts at Sandman Quarry are already showing improvement of the river banks. Management is to be complemented on their efforts in this regard.

2. Exotic and Problem Plants

Exotic species *per se* do not constitute a threat to vegetation. Those species that aggressively replace indigenous species constitute a threat to the indigenous species on the property and in the area. The Conservation of Agricultural Resources Act 43 of 1983 with amendments R280 of 2001 provides a list of those species that endanger indigenous plants. This list was used to assess the threat posed by weeds and invaders on the Sandman Quarry.

The Sandman Quarry has **14 exotic problem plants** that are listed in the Conservation of Agricultural Resources Act 43 of 1983, amendment R280 of 2001:

Nine category I weeds were found that must be eradicated: *Acacia mearnsii* De Wild. (black wattle); *Cestrum laevigatum* Schlechtd. (inkberry); *Cirsium vulgare* (Savi) Ten.; *Datura ferox* L. (large thorn-apple); *Nicotiana glauca* Graham (wild tobacco); *Opuntia aurantiaca* Lindl. (jointed cactus); and *Opuntia ficus-indica* (L.) Mill. (prickly-pear) as well as *Eichhornia crassipes* (Mart.) Solms-Laub. (water hyacinth); and *Salvinia molesta* D.S. Mitchell in the river.

Five category II invaders must be controlled: *Acacia saligna* (Labill.) H.L.Wendl. (Port Jackson willow); *Agave sisalana* Perrine (sisal); *Eucalyptus camaldulensis* Dehnh. (red river gum); *Pinus pinaster* Ait. (cluster pine); and *Ricinus communis* L. (castor-oil plant).

2.1 Category I weeds

Category I exotics are declared weeds (Conservation of Agricultural Resources Act 43 of 1983 with amendments R280 of 2001). **They are prohibited plants that must be eradicated.** These plants serve no economic purpose and possess characteristics that are harmful to humans, animals or the environment. They are only allowed in bio-control reserves that are designated for the breeding of bio-control agents.

Nine category I weeds were recorded at the Sandman Quarry:

2.1.1 *Acacia mearnsii* De Wild. (black wattle; Plate 6)

Acacia mearnsii was introduced from Tasmania in the 19th century for timber and the production of tannic acid for the leather industry (Bromilow, 2001). Black wattle is planted commercially for timber in KwaZulu-Natal and is used for pulp, firewood and the mining industry. It is a serious invader over much of South Africa (Henderson, 2001) invading veld and indigenous bush but particularly along water courses, roadsides and in farmlands.

Plate 6. The Category I weed *Acacia mearnsii* De Wild. (black wattle).

Acacia mearnsii is extremely difficult to control. It coppices ready and produces seeds that remain viable in the soil for well over 50 years (Bromilow, 2001). Seeds are easily transported by water and their germination is stimulated by fire.

Control is generally by a combination of chemical, mechanical and planting of cover crops. Long-term control is only achieved under replacement plantings (Bromilow, 2001; Henderson, 2001). Herbicides registered include ®Confront, ®Timbrel and ®Garlon (sometimes with diesel).

2.1.2 *Cestrum laevigatum* Schtdl. (inkberry; Plate 7)

Cestrum laevigatum was introduced from Brazil, South America as an ornamental shrub and planted for windbreaks (Henderson, 2001). It is an aggressive invader that forms dense stands, eliminating the indigenous vegetation (Bromilow, 2001). It is particularly aggressive in coastal bush. Inkberry coppices vigorously and spreads when birds ingest the berries and deposit them under perches. The unripe berries (green as opposed to ripe black berries) and young shoots are very poisonous to humans and livestock.

Plate 7. The Category I weed, *Cestrum laevigatum* Schtdl. (inkberry).

Cestrum laevigatum can only be controlled successfully using herbicides (Bromilow, 2001; Henderson, 2001). Generally ®Garlon (or any herbicide containing fenac or picloram) is used. If physical control is the only alternative, the whole plant, including roots, must be removed.

2.1.3 *Cirsium vulgare* (Savi) Ten. (Scottish thistle; Plate 8)

Cirsium vulgare was introduced from Eurasia and has become widespread in South Africa, and most of the temperate world. It is thought to have arrived in South Africa in imported fodder during the Anglo-Boer War (Bromilow, 2001). The species is biennial, flowering in its second summer season (Henderson, 2001). The seeds are readily taken by birds and the white silky pappus attached to the seed is used for nesting. This makes dispersal possible over long distances. Thistles are common in pastures, along roadsides and other disturbed areas with rich, moist soil (Bromilow, 2001).

Plate 8. The Category I weed *Cirsium vulgare* (Savi) Ten. (Scottish thistle).

Cirsium vulgare is easily controlled with regular cultivation and responds well to contact and hormone herbicides. The registered herbicide is ®Confront . Should manual clearing be attempted, this should be done wearing thick gloves as the thorns make manipulation uncomfortable and irritate the skin. Plants may be discarded if not bearing seeds. Seeds should be burnt.

2.1.4 *Datura ferox* Lam. (large thorn apple; Plate 9)

Datura ferox was introduced from Eurasia and has become widespread weed in South Africa (Bromilow, 2001). These plants are serious weeds, not only because they are poisonous, but because of their aggressive growth habit. The plants are deep germinators and are very difficult to eradicate. They are annuals and produce an abundance of seed each summer (Henderson, 2001).

Plate 9. The Category I weed *Datura ferox* Lam. (large thorn apple).

The removal of large thorn-apple is extremely tedious. The plants are best controlled by spraying them with ®Garlon or ®Roundup before the plants have set seed. Manual removal is not advised. The leaves, flowers and fruits irritate the skin and the whole plant, but particularly the seeds, is poisonous.

2.1.5 *Eichhornia crassipes* (Mart.) Solms-Laub. (water hyacinth; Plate 10)

Water hyacinth is considered to be the world's worst water weed (Bromilow, 2001). It was introduced to South Africa before 1910 from tropical South America (Henderson, 2001). The plant is free-floating, but becomes anchored in shallow water where it flowers and sets seeds. The seeds survive for over 15 years in river muds (Bromilow, 2001). *Eichhornia crassipes* infests lakes and dams and clogs rivers, blocking irrigation systems, navigation and increasing evaporation.

Plate 10. The category I weed *Eichhornia crassipes* (Mart.) Solms-Laub. (water hyacinth).

Eichhornia crassipes (water hyacinth) should be removed using rakes. Plants can be dried and then dumped with garden refuse. Herbicides are not appropriate as they will contaminate the Swartkops River and the decomposing plants cause anoxic conditions, resulting in death of other aquatic biota (Bromilow, 2001).

2.1.6 *Nicotiana glauca* Graham (wild tobacco; Plate 11)

Wild tobacco is an annual plant that was accidentally introduced from Argentina with horse fodder via Namibia in the 19th century during the German occupation (Bromilow 2001). It is widespread in South Africa, especially in pastures, along roadsides and riverbanks, and may even be found in gardens. The capsule fruits contain hundreds of tiny seeds that are spread by water, but the plant will not survive waterlogging. It does, however, tolerate arid conditions well. The plants are poisonous and known for causing death in ostriches (Bromilow, 2001). The flowers are used as a rat poison.

Plate 11. The Category I weed *Nicotiana glauca* Graham (wild tobacco).

Nicotiana glauca (wild tobacco) is an annual plant (Henderson, 2001). Control is cheapest by pulling up the seedlings at the beginning of the growing season before they flower and set seed. Herbicides are largely unsuccessful.

2.1.7 *Opuntia aurantiaca* Lind. (jointed cactus; Plate 12)

Opuntia aurantiaca was introduced from the Americas as an ornamental in the mid-19th century. It escaped gardens near Stockenstroom in the Eastern Cape and has become one of South Africa's most noxious and costly weeds. Each cladode dehisces readily and will survive without rooting for months. These detached cladodes are transported in animal fur, feet and even becomes attached to their mouths while feeding. A serious irritation, the cladodes are dislodged by the animal (if not too seriously attached) and the infestation spreads. The plants are small and inconspicuous, until one is spiked by the unpleasant spines.

Plate 12. The Category I weed *Opuntia aurantiaca* Lind. (jointed cactus).

Opuntia aurantiaca (jointed cactus) is controlled chemically by foliar application and injection of MSMA or glyphosate. The plants are extremely difficult to find. They are widespread and common at the Quarry. It would be best to dig them out during the flowering season as this is the only time that the joints do not abscise easily. All parts of the plant must be destroyed, including the underground cladode (tuber) as the plant rapidly regrows from this basal cladode if not removed.

2.1.8 *Opuntia ficus-indica* (L.) Mill. (prickly-pear; Plate 13)

Opuntia ficus-indica was introduced from Central America for use as a hedge, for fodder and for its fruit. While the species is widespread in South Africa, the major infestations are in the Eastern Cape between Humansdorp and Aliwal North (Bromilow, 2001). The species propagates easily from leaf-pads or cladodes that may fall to the ground where they root.

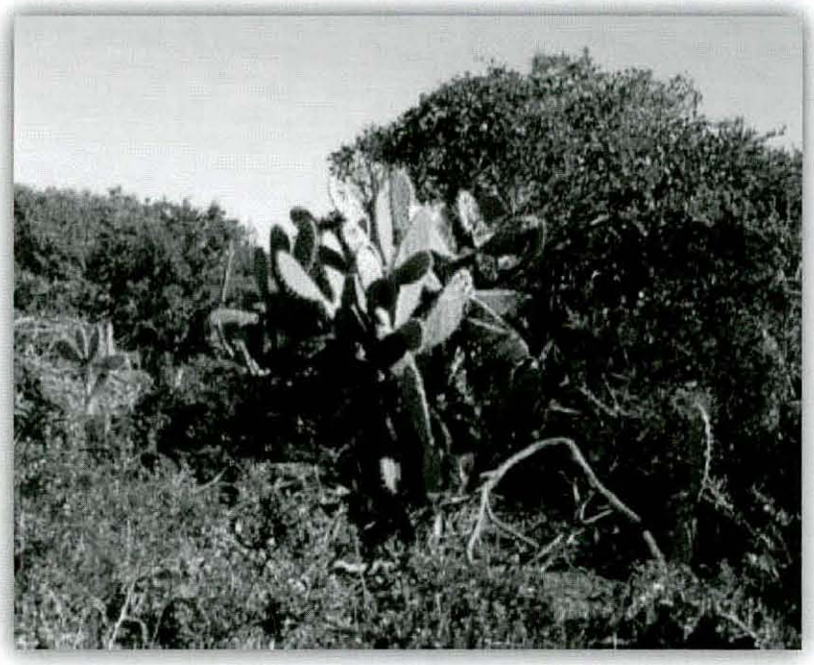

Plate 13. The Category I weed, *Opuntia ficus-indica* (L.) Mill. (prickly pear).

Opuntia ficus-indica (prickly-pear) should be removed manually. Once dried, the cladodes should be burnt. Care should be taken to protect the skin while eradication is carried out. Prickly-pear may also be controlled chemically by foliar application and injection of MSMA or glyphosate. The biological control agents (cactoblastis and cochineal) are unlikely to perform well this close to the coast.

2.1.9 *Salvinia molesta* D.S. Mitchell (water fern; Plate 14)

Salvinia molesta was introduced from tropical America and has become a widespread, perennial water weed in Asia and many parts of Africa (Bromilow, 2001). It often infests natural water bodies from aquaria via rivers. The plant was first recorded from Lake Kariba in 1959 (it is also known as Kariba weed; Henderson, 2001). The fern propagates only vegetatively, but a small fragment may rapidly grow tao cover substantial surfaces of water bodies (Bromilow, 2001) where it chokes waterways and increases water loss.

Plate 14. The Category I weed, *Salvinia molesta* D.S. Mitchell (water fern).

Salvinia molesta may be controlled with snout-beetles. Manual control, by raking is only a reduction measure, as any fragment left behind will rapidly re-establish the infestation.

2.2 Category II invaders

Category II exotics are declared invader plants (Conservation of Agricultural Resources Act 43 of 1983 with amendments R280 of 2001). These are invasive plants that have certain useful qualities, such as a commercial use or for woodlots, animal fodder or soil stabilisation. They are only allowed in demarcated areas under controlled conditions and in bio-control reserves. A water tax may be levied on plantations of Category II

plants in catchments. Because of the proximity to the Swartkops River, it is recommended that all Category II plants should be removed from the Sandman Quarry.

Five category II invaders were recorded at the Sandman Quarry:

2.2.1 Acacia saligna (Labill.) H.L. Wendl. (Port Jackson willow; Plate 15)

Acacia saligna was imported to South Africa from Australia to stabilise the shifting sands along the coast (Bromilow, 2001). From there, the species have become established in many ecosystems of the coastal regions. This species produce a mass of seeds in pods. Birds and animals disperse the seeds that remain viable for a long time and seedlings may be found for decades after clearing of adults is completed. Port Jackson willow forms large monospecific stands that eliminate indigenous vegetation and totally transform the vegetation. The wood is useful, and may be used for fire and for mulch (Henderson, 2001).

Plate 15. The Category I weed, *Acacia saligna* (Labill.) H.L. Wendl. (Port Jackson willow).

Acacia saligna should be controlled using a long-term programme. Plants should be chopped out and newly germinating individuals should be pulled out in their first growing

season. It coppices easily and prolifically and stumps should be painted with ®Garlon, ®Tordon Super or ®Chopper after clearing.

2.2.2 Agave sisalana Perrine (sisal; Plate 16)

Agave sisalana was introduced to South Africa from Central and North America for fodder, ornamentals and fibre. They have become naturalised and may form serious, impenetrable barriers.

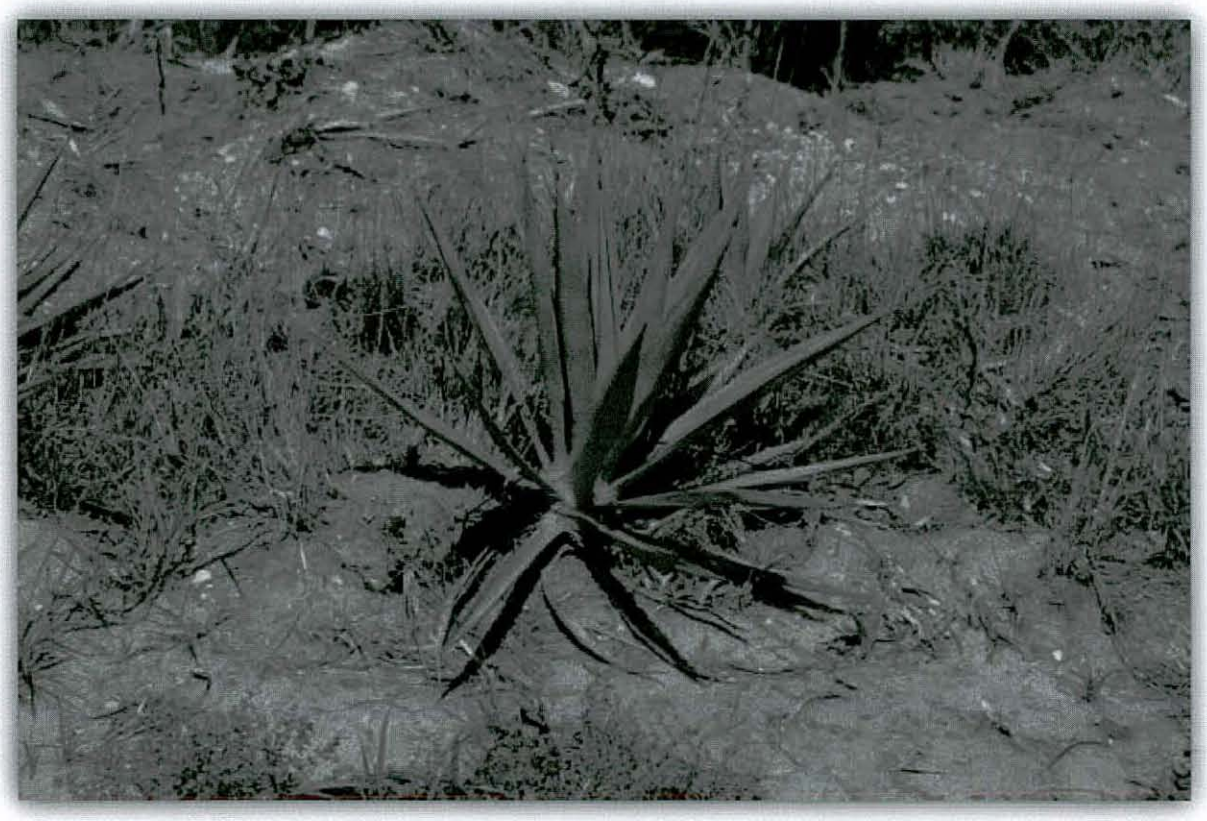

Plate 16. The Category II invader *Agave sisalana* Perrine (sisal).

Agave sisalina should be injected with ®MSMA. Manual removal is generally only by bulldozer (Bromilow, 2001).

2.2.3 Eucalyptus camaldulensis Dehnh. (red river gum; Plate 17)

Eucalyptus species have been planted in South Africa for timber, shelter, shade, firewood and honey (Henderson, 2001). They all originate from Australia. *Eucalyptus camaldulensis* (red river gum) is a particular problem along perennial, seasonal or intermittent watercourses.

Plate 17. The Category II invader *Eucalyptus camaldulensis* Dehnh. (red river gum).

The trees should be removed from the riparian zones. They can be ring barked and then harvested for wood when they have died. The young trees can be sprayed with ®Garlon or ®Mamba and the cut stumps may be treated with ®Timbrel.

2.2.4 *Pinus pinaster* Ait. (cluster pine; Plate 18)

Pine trees (including *Pinus pinaster*) were planted in South Africa as early as 1825 for timber. They originate from Europe, Asia and North America. The seeds germinate readily and the trees invade and transform the landscape. They also increase the fire risk at any site and so should be removed as far as possible.

Plate 18. The Category II invader *Pinus pinaster* Aiton (cluster pine).

The trees should be removed from the riparian zones. They can be ring barked and then harvested for wood when they have died. The young trees can be sprayed with ®Garlon.

2.2.5 *Ricinus communis* L. var. *communis* (castor-oil plant; Plate 19)

The origin of the castor-oil plant is not known, but the species has been in southern Africa for thousands of years (Bromilow, 2001). It is one of the Euphorbiaceae species that does not exude milky latex. The seed of the castor-oil plant is extremely toxic with the toxin from only one seed being fatal (Henderson, 2001). It is a common weed along roadsides, river banks, and waste places. Castor oil is extracted from the seeds, but the oil must be purified before it is safe to use (Bromilow, 2001).

Plate 19. The Category II invader *Ricinus communis* L. var. *communis* (castor-oil plant).

Ricinus communis plants are easily chopped out, preferably before setting seed. Follow-up clearing will be required. The plants can also be sprayed using ®Confront.

3. Natural Vegetation

Indigenous plant diversity is very low over most of the Sandman Quarry property. All conservation-worthy plants were recorded in the Sundays Thicket indicated in Figure 3. Apart from this patch of intact, indigenous vegetation, there is no realistic rehabilitation potential for any of the site other than the river bed and banks. These should be rehabilitated in accordance with the **The National Water Act 26 of 1998**.

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The author cannot be held responsible for any damages whatsoever (including without limitation damages for loss of trade or business profits, business interruption or any other pecuniary loss) arising out of the adoption of any of the scientific advice provided in this report.

Appendix A. Endemic, Dominant and Important Plant Taxa of Albany Alluvial Vegetation

Classification after	Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria. 1231 pp.

Status:

Threatened	**CE**	**Critically endangered**	SANBI, 2007. Red Data List of Threatened Species. Unpublished, proposed list, NBI, Pretoria. 30 January 2007.
	EN	**Endangered**	
	VU	**Vulnerable**	
	NT	**Near-threatened**	
	DD	**Data-deficient**	
Rare	**R**		SANBI, 2007. Red Data List of Threatened Species. Unpublished, proposed list, NBI, Pretoria. 30 January 2007.
Protected	**B1**	**Protected Schedule B1**	National Environmental Management: Biodiversity Act No. 10 of 2004
	B2-I	**Protected Schedule B2-I**	CITES 2006 Appendix I
	B2-II	**Protected Schedule B2-II**	CITES 2006 Appendix II
	B2-III	**Protected Schedule B2-III**	CITES 2006 Appendix III
	P	**Protected**	Eastern Cape Nature Conservation Act of 2002, Schedule 4. OR Western Cape Nature Conservation Laws Amendment Act 3 of 2000, Schedule 4.
	F	**Protected**	National Forests Act 84 of 1998 as amended in 2002, Schedule A.
Endemic	**EC**	**Eastern Cape**	Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria. 1231 pp.
	SA	**South Africa**	
Important	**Ve**	**Vegetation Type**	Mucina, L. and Rutherford, M.C. (eds.) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria. 807 pp.
	Vd	**Vegetation Dominant**	
	V	**Vegetation Important**	

Division (phyta)/**Class**	**Family**	**Species**	**Status:**	Albany Alluvial
Magnoliopsida (dicots)	Anacardiaceae	*Rhus longispina* Eckl. & Zeyh.	**SA**	**Vd**
Magnoliopsida (dicots)	Apocynaceae	*Carissa bispinosa* (L.) Desf. ex Brenan		**V**
Magnoliopsida (dicots)	Asteraceae	*Amphiglossa callunoides* DC.	**NT,SA**	**V**
Magnoliopsida (dicots)	Asteraceae	*Pentzia incana* (Thunb.) Kuntze		**Vd**
Magnoliopsida (dicots)	Capparaceae	*Cadaba aphylla* (Thunb.) Wild		**V**
Magnoliopsida (dicots)	Fabaceae	*Acacia caffra* (Thunb.) Willd.		**V**

Magnoliopsida (dicots)	Fabaceae	*Acacia karroo* Hayne		Vd
Magnoliopsida (dicots)	Fabaceae	*Schotia afra* (L.) Thunb. var. *afra*	SA	Vd
Magnoliopsida (dicots)	Salicaceae	*Salix mucronata* Thunb. subsp. *capensis* (Thunb.) Immelman		Vd
Magnoliopsida (dicots)	Salvadoraceae	*Azima tetracantha* Lam.		V
Magnoliopsida (dicots)	Solanaceae	*Lycium cinereum* Thunb.		V
Liliopsida (monocots)	Asparagaceae	*Asparagus striatus* (L.f.) Thunb.	SA	V
Liliopsida (monocots)	Asparagaceae	*Asparagus suaveolens* Burch.		V
Liliopsida (monocots)	Asphodelaceae	*Aloe africana* Mill.	SA	V
Liliopsida (monocots)	Asphodelaceae	*Aloe ferox* Mill.	B2-II	V
Liliopsida (monocots)	Poaceae	*Sporobolus nitens* Stent		Vd

Appendix B. Endemic, Dominant and Important Plant Taxa of Sundays Thicket

Classification after	Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria. 1231 pp.

Status:

Threatened	**CE**	**Critically endangered**	SANBI, 2007. Red Data List of Threatened Species. Unpublished, proposed list, NBI, Pretoria. 30 January 2007.
	EN	**Endangered**	
	VU	**Vulnerable**	
	NT	**Near-threatened**	
	DD	**Data-deficient**	
Rare	**R**		SANBI, 2007. Red Data List of Threatened Species. Unpublished, proposed list, NBI, Pretoria. 30 January 2007.
Protected	**B1**	**Protected Schedule B1**	National Environmental Management: Biodiversity Act No. 10 of 2004
	B2-I	**Protected Schedule B2-I**	CITES 2006 Appendix I
	B2-II	**Protected Schedule B2-II**	CITES 2006 Appendix II
	B2-III	**Protected Schedule B2-III**	CITES 2006 Appendix III
	P	**Protected**	Eastern Cape Nature Conservation Act of 2002, Schedule 4.
	F	**Protected**	National Forests Act 84 of 1998 as amended in 2002, Schedule A.
Endemic	**EC**	**Eastern Cape**	Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria. 1231 pp.
	SA	**South Africa**	

	Ve	**Vegetation Type**	Mucina, L. and Rutherford, M.C. (eds.) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria. 807 pp.
Important	Vd	**Vegetation Dominant**	
	V	**Vegetation Important**	

Division (-phyta)/**Class** (-opsida)	**Family**	**Species**	**Status**	
Cycadophyta (cycads)	Zamiaceae	*Encephalartos horridus (Jacq.) Lehm.*	**E,B2-I,E,EC,E**	**Ve**
Cycadophyta (cycads)	Zamiaceae	*Encephalartos lehmannii* Lehm.	**B2-I,NT,SA,E**	**V**
Magnoliopsida (dicots)	Acanthaceae	*Barleria obtusa* Nees		**V**
Magnoliopsida (dicots)	Acanthaceae	*Barleria rigida* Nees		**V**
Magnoliopsida (dicots)	Acanthaceae	*Blepharis capensis* (L.f.) Pers.	**SA**	**V**
Magnoliopsida (dicots)	Acanthaceae	*Hypoestes aristata* (Vahl) Soland. ex Roem. & Schult. var. *aristata*		**V**
Magnoliopsida (dicots)	Acanthaceae	*Hypoestes forskaolii* (Vahl) R.Br.		
Magnoliopsida (dicots)	Acanthaceae	*Justicia cuneata* Vahl subsp. *cuneata*	**EC**	**V**
Magnoliopsida (dicots)	Acanthaceae	*Justicia orchioides* L.f.	**SA**	**V**
Magnoliopsida (dicots)	Aizoaceae	*Aizoon glinoides* L.f.	**SA**	**V**
Magnoliopsida (dicots)	Anacardiaceae	*Rhus glauca* Thunb.	**SA**	
Magnoliopsida (dicots)	Anacardiaceae	*Rhus incisa* L. f. var. *effusa* (Presl) R. Fernandes	**SA**	**V**
Magnoliopsida (dicots)	Anacardiaceae	*Rhus longispina* Eckl. & Zeyh.	**SA**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Brachystelma schoenlandianum* Schltr.	**EX,EC,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Brachystelma tabularium* R.A.Dyer	**EX,EC,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Carissa bispinosa* (L.) Desf. ex Brenan	**E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Ceropegia ampliata* E. Mey. var. *ampliata*	**DD,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Ceropegia dubia* R.A.Dyer	**EC,E**	**Ve**
Magnoliopsida (dicots)	Apocynaceae	*Cynanchum ellipticum* (Harv.) R.A.Dyer	**SA,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Cyphostemma quinatum* (Dryand.) Desc. ex Wild & R.B.Drumm.	**SA,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Fockea sinuata* (E.Mey.) Druce	**E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Huernia longii* Pillans	**EC,E**	**Ve**
Magnoliopsida (dicots)	Apocynaceae	*Orbea pulchella* (Masson) L.C.Leach	**EC,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Pachypodium succulentum* (L.f.) Sweet	**B2-II,SA,E**	**V**
Magnoliopsida (dicots)	Apocynaceae	*Sarcostemma viminale* (L.) R.Br. subsp. *viminale*	**E**	**V**
Magnoliopsida (dicots)	Araliaceae	*Cussonia gamtoosensis* Strey	**F,E,EC**	
Magnoliopsida (dicots)	Araliaceae	*Cussonia spicata* Thunb.		**V**
Magnoliopsida (dicots)	Asteraceae	*Arctotheca calendula* (L.) Levyns		**V**
Magnoliopsida (dicots)	Asteraceae	*Arctotis hispidula* (Less.) Beauverd	**SA**	**Ve**

Magnoliopsida (dicots)	Asteraceae	*Brachylaena ilicifolia* (Lam.) E.Phillips & Schweick.		V
Magnoliopsida (dicots)	Asteraceae	*Chrysanthemoides monilifera* (L.) Norl. subsp. *pisifera* (L.) T. Norl.	SA	
Magnoliopsida (dicots)	Asteraceae	*Chrysocoma ciliata* L.		V
Magnoliopsida (dicots)	Asteraceae	*Cotula heterocarpa* DC.	SA	V
Magnoliopsida (dicots)	Asteraceae	*Cypseodontia eckloniana* DC.	EC	V
Magnoliopsida (dicots)	Asteraceae	*Eriocephalus ericoides* (L.f.) Druce subsp. *ericoides*		V
Magnoliopsida (dicots)	Asteraceae	*Euryops algoensis* DC.	EC	V
Magnoliopsida (dicots)	Asteraceae	*Euryops spathaceus* DC.	SA	V
Magnoliopsida (dicots)	Asteraceae	*Felicia muricata* (Thunb.) Nees subsp. *muricata*		Vd
Magnoliopsida (dicots)	Asteraceae	*Garuleum latifolium Harv.*	SA	V
Magnoliopsida (dicots)	Asteraceae	*Gazania krebsiana* Less.		V
Magnoliopsida (dicots)	Asteraceae	*Osteospermum imbricatum* L.	SA	V
Magnoliopsida (dicots)	Asteraceae	*Pentzia globosa* Less.		Vd
Magnoliopsida (dicots)	Asteraceae	*Pteronia paniculata* Thunb.		V
Magnoliopsida (dicots)	Asteraceae	*Rosenia humilis* (Less.) K.Bremer		V
Magnoliopsida (dicots)	Asteraceae	*Senecio linifolius* L.		V
Magnoliopsida (dicots)	Asteraceae	*Senecio scaposus* DC.	V,SA	Ve
Magnoliopsida (dicots)	Bignoniaceae	*Rhigozum obovatum* Burch.		V
Magnoliopsida (dicots)	Boraginaceae	*Ehretia rigida* (Thunb.) Druce subsp. *rigida*	SA	V
Magnoliopsida (dicots)	Brassicaceae	*Lepidium africanum* (Burm.f.) DC. subsp. *africanum*		V
Magnoliopsida (dicots)	Brassicaceae	*Lepidium africanum* (Burm.f.) DC. subsp. *divaricatum* (Aiton) Jonsell		V
Magnoliopsida (dicots)	Campanulaceae	*Wahlenbergia oocarpa* Sond.	DD,EC	Ve
Magnoliopsida (dicots)	Capparaceae	*Boscia albitrunca* (Burch.) Gilg & Gilg-Ben.		V
Magnoliopsida (dicots)	Capparaceae	*Cadaba aphylla* (Thunb.) Wild		V
Magnoliopsida (dicots)	Capparaceae	*Capparis sepiaria* L. var. *citrifolia* (Lam.) Tölken		V
Magnoliopsida (dicots)	Capparaceae	*Maerua cafra* (DC.) Pax		V
Magnoliopsida (dicots)	Celastraceae	*Gymnosporia buxifolia* (L.) Szyszyl.		V
Magnoliopsida (dicots)	Celastraceae	*Gymnosporia capitata* (E. Mey. ex Sond.) Loes.	SA	V
Magnoliopsida (dicots)	Celastraceae	*Gymnosporia polyacantha* (Sond.) Szyszyl. subsp. *Polyacantha*	EC	V
Magnoliopsida (dicots)	Celastraceae	*Mystroxylon aethiopicum* (Thunb.) Loes. subsp. *aethiopicum*	SA,F	V
Magnoliopsida (dicots)	Celastraceae	*Putterlickia pyracantha* (L.) Szyszyl.		V
Magnoliopsida (dicots)	Chenopodiaceae	*Exomis microphylla* (Thunb.) Aellen var. *axyrioides* (Fenzl) Aellen	WC	V
Magnoliopsida (dicots)	Convolvulaceae	*Cuscuta bifurcata* Yunck.	SA	V
Magnoliopsida (dicots)	Crassulaceae	*Adromischus cristatus* (Haw.) Lem. var. *cristatus*	SA	V
Magnoliopsida (dicots)	Crassulaceae	*Adromischus sphenophyllus* C.A.Sm.	EC	V
Magnoliopsida (dicots)	Crassulaceae	*Cotyledon campanulata* Marloth	SA	V

Magnoliopsida (dicots)	Crassulaceae	*Cotyledon orbiculata* L. var. *oblonga* (Haw.) DC.		V
Magnoliopsida (dicots)	Crassulaceae	*Crassula capitella* Thunb. subsp. *capitella*	SA	V
Magnoliopsida (dicots)	Crassulaceae	*Crassula capitella* Thunb. subsp. *thyrsiflora* (Thunb.) Tölken		V
Magnoliopsida (dicots)	Crassulaceae	*Crassula cotyledonis* Thunb.		V
Magnoliopsida (dicots)	Crassulaceae	*Crassula cultrata* L.	SA	Vd
Magnoliopsida (dicots)	Crassulaceae	*Crassula expansa* Dryand.		V
Magnoliopsida (dicots)	Crassulaceae	*Crassula mesembryanthoides* (Haw.) Dietr. subsp. *hispida* (Haw.) Tölken	EC	V
Magnoliopsida (dicots)	Crassulaceae	*Crassula ovata* (Mill.) Druce	SA	Vd
Magnoliopsida (dicots)	Crassulaceae	*Crassula perforata* Thunb.	SA	Vd
Magnoliopsida (dicots)	Crassulaceae	*Crassula rogersii* Schönland	EC	V
Magnoliopsida (dicots)	Crassulaceae	*Crassula spathulata* Thunb.	SA	V
Magnoliopsida (dicots)	Crassulaceae	*Kalanchoe rotundifolia* (Haw.) Haw.		V
Magnoliopsida (dicots)	Cucurbitaceae	*Kedrostis capensis* (Sond.) A.Meeuse		V
Magnoliopsida (dicots)	Ebenaceae	*Diospyros pallens* (Thunb.) F.White	SA	V
Magnoliopsida (dicots)	Ebenaceae	*Euclea undulata* Thunb.		Vd
Magnoliopsida (dicots)	Euphorbiaceae	*Euphorbia caerulescens* Haw.	B2-II,SA	Vd
Magnoliopsida (dicots)	Euphorbiaceae	*Euphorbia inaequilatera* Sond. var. *inaequilatera*	B2-II	V
Magnoliopsida (dicots)	Euphorbiaceae	*Euphorbia ledienii* A.Berger	B2-II,EC	Vd
Magnoliopsida (dicots)	Euphorbiaceae	*Euphorbia mauritanica* L. var. *mauritanica*	B2-II	V
Magnoliopsida (dicots)	Euphorbiaceae	*Euphorbia tetragona* Haw.	B2-II,SA	V
Magnoliopsida (dicots)	Fabaceae	*Argyrolobium crassifolium* Eckl. & Zeyh.	E,SA	Ve
Magnoliopsida (dicots)	Fabaceae	*Indigastrum costatum* (Guill. & Perr.) Schrire subsp. *macrum* (E.Mey.) Schrire		V
Magnoliopsida (dicots)	Fabaceae	*Indigofera sessilifolia* DC.		V
Magnoliopsida (dicots)	Fabaceae	*Lessertia carnosa* Eckl. & Zeyh.	R,EC	Ve
Magnoliopsida (dicots)	Fabaceae	*Lotononis glabra* (Thunb.) D.Dietr.	SA	V
Magnoliopsida (dicots)	Fabaceae	*Lotononis monophylla* Harv.	CE,EC	Ve
Magnoliopsida (dicots)	Fabaceae	*Schotia afra* (L.) Thunb. var. *afra*	SA	Vd
Magnoliopsida (dicots)	Geraniaceae	*Pelargonium campestre* (Eckl. & Zeyh.) Steud.	EC,E	V
Magnoliopsida (dicots)	Geraniaceae	*Pelargonium carnosum* (L.) L'Hér.	E	V
Magnoliopsida (dicots)	Geraniaceae	*Pelargonium ochroleucum* Harv.	V,NC,E	Ve
Magnoliopsida (dicots)	Geraniaceae	*Pelargonium peltatum* (L.) L'Hér.	SA,E	Vd
Magnoliopsida (dicots)	Lamiaceae	*Leucas capensis* (Benth.) Engl.		V
Magnoliopsida (dicots)	Lamiaceae	*Stachys aethiopica* L.	SA	V
Magnoliopsida (dicots)	Malvaceae	*Abutilon sonneratianum* (Cav.) Sweet		V
Magnoliopsida (dicots)	Malvaceae	*Hibiscus aridus* R.A.Dyer	EC	V
Magnoliopsida (dicots)	Malvaceae	*Hibiscus pusillus* Thunb.		V

Magnoliopsida (dicots)	Meliaceae	*Nymania capensis* (Thunb.) Lindb.		V
Magnoliopsida (dicots)	Menispermaceae	*Cissampelos capensis* L.f.		V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Aptenia haeckeliana* (A.Berger) Bittrich ex Gerbaulet	EC,E	Ve
Magnoliopsida (dicots)	Mesembryanthemaceae	*Bergeranthus multiceps* (Salm-Dyck) Schwantes	EC,E	Ve
Magnoliopsida (dicots)	Mesembryanthemaceae	*Delosperma echinatum* (Lam.) Schwantes	EC,E	V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Delosperma uniflorum* L.Bolus	EC,E	V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Erepsia aristata* (L.Bolus) Liede & H.E.K.Hartmann	R,SA,E	Ve
Magnoliopsida (dicots)	Mesembryanthemaceae	*Glottiphyllum grandiflorum* (Haw.) N.E.Br.	DD,EC,E	Ve
Magnoliopsida (dicots)	Mesembryanthemaceae	*Lampranthus productus* (Haw.) N.E.Br.	SA,E	V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Mestoklema tuberosum* (L.) N.E.Br. ex Glen	EC,E	V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Orthopterum coegana* L.Bolus	CE,EC,E	Ve
Magnoliopsida (dicots)	Mesembryanthemaceae	*Psilocaulon articulatum* (Thunb.) N.E.Br.	E	V
Magnoliopsida (dicots)	Mesembryanthemaceae	*Trichodiadema rupicola* L.Bolus	DD,R,EC,E	Ve
Magnoliopsida (dicots)	Molluginaceae	*Limeum aethiopicum* Burm.		V
Magnoliopsida (dicots)	Oleaceae	*Olea europaea* L. subsp. *africana* (Mill.) P.S.Green	F	Vd
Magnoliopsida (dicots)	Oxalidaceae	*Oxalis smithiana* Eckl. & Zeyh.		V
Magnoliopsida (dicots)	Plumbaginaceae	*Plumbago auriculata* Lam.	SA	V
Magnoliopsida (dicots)	Polygonaceae	*Emex australis* Steinh.		V
Magnoliopsida (dicots)	Portulacaceae	*Portulacaria afra* Jacq.		Vd
Magnoliopsida (dicots)	Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz		V
Magnoliopsida (dicots)	Rutaceae	*Ptaeroxylon obliquum* (Thunb.) Radlk.	E	V
Magnoliopsida (dicots)	Salvadoraceae	*Azima tetracantha* Lam.		V
Magnoliopsida (dicots)	Santalaceae	*Osyris compressa* (P.J.Bergius) A.DC.	SA	V
Magnoliopsida (dicots)	Santalaceae	*Rhoiacarpos capensis* (Harv.) A.DC.	SA	V
Magnoliopsida (dicots)	Sapindaceae	*Pappea capensis* Eckl. & Zeyh.	F	Vd
Magnoliopsida (dicots)	Sapotaceae	*Sideroxylon inerme* L. subsp. *Inerme*	F	V
Magnoliopsida (dicots)	Scrophulariaceae	*Aptosimum elongatum* Engl.		V
Magnoliopsida (dicots)	Scrophulariaceae	*Selago fruticosa* L.	WC	V
Magnoliopsida (dicots)	Scrophulariaceae	*Selago geniculata* L.f.	SA	V
Magnoliopsida (dicots)	Solanaceae	*Lycium oxycarpum* Dunal	SA	V
Magnoliopsida (dicots)	Solanaceae	*Solanum capense* L.	SA	V
Magnoliopsida (dicots)	Solanaceae	*Solanum tomentosum* L.		V
Magnoliopsida (dicots)	Sterculiaceae	*Hermannia althaeoides* Link	SA	V
Magnoliopsida (dicots)	Tiliaceae	*Grewia occidentalis* L. var. *occidentalis*		V
Magnoliopsida (dicots)	Tiliaceae	*Grewia robusta* Burch.	SA	V

Magnoliopsida (dicots)	Verbenaceae	*Chascanum cuneifolium* (L.f.) E.Mey.	SA	V
Magnoliopsida (dicots)	Verbenaceae	*Lantana rugosa* Thunb.		V
Magnoliopsida (dicots)	Viscaceae	*Viscum crassulae* Eckl. & Zeyh.	SA	V
Magnoliopsida (dicots)	Viscaceae	*Viscum obscurum* Thunb.		V
Magnoliopsida (dicots)	Viscaceae	*Viscum rotundifolium* L.f.		V
Magnoliopsida (dicots)	Vitaceae	*Rhoicissus digitata* (L.f.) Gilg & M.Brandt	SA,E	V
Magnoliopsida (dicots)	Zygophyllaceae	*Zygophyllum foetidum* Schrad. & J.C.Wendl.	SA	V
Liliopsida (monocots)	Amaryllidaceae	*Cyrtanthus loddigesianus* (Herb.) R.A.Dyer	EC,E	V
Liliopsida (monocots)	Amaryllidaceae	*Cyrtanthus spiralis* Burch. ex Ker Gawl.	E,EC,E	V
Liliopsida (monocots)	Asparagaceae	*Asparagus asparagoides* (L.) Druce		V
Liliopsida (monocots)	Asparagaceae	*Asparagus burchellii* Baker	SA	V
Liliopsida (monocots)	Asparagaceae	*Asparagus crassicladus* Jessop	SA	V
Liliopsida (monocots)	Asparagaceae	*Asparagus multiflorus* Baker	SA	V
Liliopsida (monocots)	Asparagaceae	*Asparagus racemosus* Willd.		V
Liliopsida (monocots)	Asparagaceae	*Asparagus striatus* (L.f.) Thunb.	SA	V
Liliopsida (monocots)	Asparagaceae	*Asparagus subulatus* Thunb.	EC	V
Liliopsida (monocots)	Asparagaceae	*Asparagus volubilis* Thunb.	SA	V
Liliopsida (monocots)	Asphodelaceae	*Aloe bowiea* Schult. & Schult.f.	B2-II,CE,EC,E	Ve
Liliopsida (monocots)	Asphodelaceae	*Aloe broomii* Schönland	B2-II,E	Vd
Liliopsida (monocots)	Asphodelaceae	*Aloe ferox* Mill.	B2-II	V
Liliopsida (monocots)	Asphodelaceae	*Aloe gracilis* Haw.	B2-II,V,SA,E	Ve
Liliopsida (monocots)	Asphodelaceae	*Bulbine frutescens* (L.) Willd.		Vd
Liliopsida (monocots)	Asphodelaceae	*Gasteria bicolor* Haw. var. *bicolor*	EC,E	V
Liliopsida (monocots)	Asphodelaceae	*Haworthia arachnoidea* (L.) Duval var. *xiphiophylla* (Baker) M.B.Bayer	EC,E	Ve
Liliopsida (monocots)	Asphodelaceae	*Haworthia aristata* Haw.	EC,E	Ve
Liliopsida (monocots)	Asphodelaceae	*Trachyandra affinis* Kunth	SA	V
Liliopsida (monocots)	Behniaceae	*Behnia reticulata* (Thunb.) Didr.		V
Liliopsida (monocots)	Commelinaceae	*Commelina benghalensis* L.		V
Liliopsida (monocots)	Commelinaceae	*Cyanella speciosa* (L.f.) Hassk.		V
Liliopsida (monocots)	Cyperaceae	*Cyperus capensis* (Steud.) Endl.		V
Liliopsida (monocots)	Dracaenaceae	*Sansevieria hyacinthoides* (L.) Druce		Vd
Liliopsida (monocots)	Hyacinthaceae	*Drimia altissima (L.f.) Ker Gawl.*		V
Liliopsida (monocots)	Hyacinthaceae	*Drimia anomala* (Baker) Baker	SA	V
Liliopsida (monocots)	Hyacinthaceae	*Drimia intricata* (Baker) J.C.Manning & Goldblatt		Vd
Liliopsida (monocots)	Hypoxidaceae	*Hypoxis argentea* Harv. ex Baker		V

Liliopsida (monocots)	Hypoxidaceae	*Spiloxene trifurcillata* (Nel) Fourc.	**EC,E**	**V**
Liliopsida (monocots)	Iridaceae	*Freesia corymbosa* (Burm.f.) N.E.Br.	**SA,E**	**V**
Liliopsida (monocots)	Iridaceae	*Moraea stricta* Baker	**E**	**V**
Liliopsida (monocots)	Iridaceae	*Tritonia dubia* Eckl. ex Klatt	**EC,E**	**Ve**
Liliopsida (monocots)	Iridaceae	*Tritonia securigera* (Aiton) Ker Gawl.	**SA,E**	**V**
Liliopsida (monocots)	Iridaceae	*Tritonia strictifolia* (Klatt) Benth. ex Klatt	**EC,E**	**V**
Liliopsida (monocots)	Poaceae	*Aristida adscensionis* L. subsp. *Adscensionis*		**Vd**
Liliopsida (monocots)	Poaceae	*Aristida congesta* Roem. & Schult. subsp. *congesta*		**Vd**
Liliopsida (monocots)	Poaceae	*Cenchrus ciliaris* L.		**V**
Liliopsida (monocots)	Poaceae	*Cynodon dactylon* (L.) Pers.		**Vd**
Liliopsida (monocots)	Poaceae	*Cynodon incompletus* Nees	**SA**	**Vd**
Liliopsida (monocots)	Poaceae	*Digitaria argyrograpta* (Nees) Stapf		**V**
Liliopsida (monocots)	Poaceae	*Ehrharta calycina* Sm.		**V**
Liliopsida (monocots)	Poaceae	*Enneapogon scoparius* Stapf		**V**
Liliopsida (monocots)	Poaceae	*Eragrostis curvula* (Schrad.) Nees		**V**
Liliopsida (monocots)	Poaceae	*Eragrostis obtusa* Munro ex Ficalho & Hiern		**Vd**
Liliopsida (monocots)	Poaceae	*Eustachys paspaloides* (Vahl) Lanza & Mattei		**V**
Liliopsida (monocots)	Poaceae	*Heteropogon contortus* (L.) Roem. & Schult.		**V**
Liliopsida (monocots)	Poaceae	*Panicum deustum* Thunb.		**V**
Liliopsida (monocots)	Poaceae	*Panicum maximum* Jacq.		**Vd**
Liliopsida (monocots)	Poaceae	*Sporobolus fimbriatus* (Trin.) Nees		**V**
Liliopsida (monocots)	Poaceae	*Stipa dregeana* Steud.		**V**
Liliopsida (monocots)	Poaceae	*Themeda triandra* Forssk.		**V**
Liliopsida (monocots)	Poaceae	*Tragus berteronianus* Schult.		**Vd**
Liliopsida (monocots)	Strelitziaceae	*Strelitzia juncea* Link	**EC,E**	**Ve**
Liliopsida (monocots)	Tecophylaeaceae	*Cyanella lutea* L.f.	**SA**	**V**

Appendix C. Exotic Problem Plant Species recorded at the Sandman Quarry

Classification after Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. Strelitzia 14. National Botanical Institute, Pretoria. 1231 pp.

Status:

Exotic	**Ex**	Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria. 1231 pp.
Declared weed	**I**	Table 3, Category I Conservation of Agricultural Resources Act 43 of 1983 and amendments R280 of 2001.
Declared invader	**II**	Table 3, Category II
Ornamental invaders	**III**	Table 3, Category III
Bush encroachers	**4**	Table 4

Division	Class	Family	Species	Status	Pastures	River	Common name
Pinophyta (pine-like gymnosperms)		Pinaceae	*Pinus pinaster* Ait.	**Ex,II**	**P**	**R**	cluster pine
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Asteraceae	*Cirsium vulgare* (Savi) Ten.	**Ex,I**		**R**	Scotch thistle
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Cactaceae	*Opuntia aurantiaca* Lindl.	**Ex,I**	**P**	**R**	jointed cactus
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Cactaceae	*Opuntia ficus-indica* (L.) Mill.	**Ex,I**	**P**		prickly pear
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Euphorbiaceae	*Ricinus communis* L.	**Ex,II**	**P**	**R**	castor-oil plant
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Fabaceae	*Acacia mearnsii* De Wild.	**Ex,I**	**P**	**R**	black wattle
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Fabaceae	*Acacia saligna* (Labill.) H.L.Wendl.	**Ex,II**		**R**	Port Jackson willow
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Myrtaceae	*Eucalyptus camaldulensis* Dehnh.	**Ex,II**	**P**	**R**	red river gum
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Pontaderiaceae	*Eichhornia crassipes* (Mart.) Solms-Laub.	**Ex,I**		**R**	water hyacinth
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Solanaceae	*Cestrum laevigatum* Schlechtd.	**Ex,I**	**P**	**R**	inkberry
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Solanaceae	*Datura ferox* L.	**Ex,I**	**P**	**R**	large thorn-apple
Magnoliophyta (flowering plants)	Magnoliopsida (dicotyledons)	Solanaceae	*Nicotiana glauca* R.C. Grah.	**Ex,I**	**P**	**R**	wild tobacco
Magnoliophyta (flowering plants)	Liliopsida (monocotyledons)	Agavaceae	*Agave sisalana* Perrine	**Ex,II**	**P**		sisal

18. SPECIALIST STUDIES ON SWARTKOPS RIVER FLOW DYNAMICS

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SANDMAN QUARRIES

RIVER FLOW DYNAMICS ASSESSMENT

This report is an Impact Assessment of possible mining activities on the Swartkops River's flow dynamics. This report is undertaken in compliance with the Minerals and Petroleum Resources Development Act, Act 28 of 2002.

August 2009

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1. INTRODUCTION

River flow dynamics assessments have been conducted from a stochastic perspective, because the river flow process has traditionally been assumed to be a result of a very large number of variables. However, recent studies employing non-linear deterministic and chaotic dynamic concepts have reported that the river flow process could also be the outcome of a deterministic system with only a few dominant variables. In the wake of such reports, a preliminary attempt is made in this study to investigate the greater Swartkops River flow dynamics with regards to the chaotic - and stochastic approach. This investigation is limited only to possible impacts of mining activities on the Swartkops River flow dynamics.

2. EXISTING STATUS OF THE ENVIRONMENT

2.1. CATCHMENT DESCRIPTION

The catchment M - area (approximately 1395 hectares) is bordered on the north and west by the easterly extremities of the Groot Winterhoek mountains and rapidly descend from here to the coastal plains if Port Elizabeth. The catchment consists of four tertiary catchments. The two main channels that join to form the Swartkops River arise in two clearly demarcated sub-catchments : the Elands to the southwest and the Kwazunga to the north. However, both originate in the Groot Winterhoek mountains. Multiple, narrow, well-watered ravines are found in KwaZunga but the Elands is much drier and those tributaries draining from north to south usually flow throughout the year. The Brak- and Chatty Rivers originate in the plains to the north of Port Elizabeth and join the Swartkops River below the confluence of the Elands - and the KwaZunga Rivers. Within the wider catchment area there are four smaller river systems : the Baakens River, Van Stadens River, the Shark River and the Maitland River that drain directly into the sea. Only the Van Stadens River contributes water to Port Elizabeth from three dams with a total capacity of 0,643 million cubic metres. However, some of these dams are silted and consequently the capacity cited will have been compromised.

In large part of the Elands River catchment there has apparently been a decrease in the depths of pools due to sedimentation (Wadeson, 2000). Several land use changes in the catchment could have contributed to increased sediment yields. The two dams in the Bulk Rivier and the Sand Rivier would have altered the flow regime and reduced the

water volume of the river. The entire catchment has been infested with black wattle, eucalyptus and pine plantations, which reduces the runoff while extensive cultivation of the hill slopes in the upper Elands catchment could have contributed to the aeolian sedimentation. In the KwaZunga the Groendal Dam has only a small bottom release gate restricting flow. Extensive cultivation and urban development in the entire catchment would have contributed to sediment production.

Catchment	Area (km^2)	Decimal Coordinates	MAR (million m^3)	MAP (mm)	MAE (mm)
M10A KwaZunga	265	33,5844 ° S 24,9059 ° E	60	533	1600
M10B Elands	393	33,7990 ° S 25,3077 ° E	67	557	1600
M10C Brak	430	33,6924 ° S 25,2667 ° E	71	565	1550
M10D Chatty	307	33,8653 ° S 25,6345 ° E	18	471	1550
TOTAL =	**1395**	**Averages =**	**56**	**536**	**1574**

2.2. GEOLOGY AND SOILS

The main difference between the geology of the Swartkops catchment and that of the others in the Southern Cape is the large areas of marine and estuarine origin on the floodplain. The Algoa Basin (4000km^2) is one of several small fault controlled basins, which were formed by regional faulting along the Cape South Coast. The Algoa basin is a complex assemblage of sub-basins. The Gamtoos Basin is of the similar origin. The alluvial deposits in the area are underlain by the Uitenhage Group. Many of these geological formations have fairly high porosity and permeability. The underlying geology forms an easily erodable trough comprising layers of coarse conglomerates inter-bedded with sandstone and mudstone of the Enon formation (marine and fluvial origin), greenish-grey slate, siltstones and sandstones ; of the Kirkwood formation (fluvial origin) ; as well as thinly bedded greyish-green mudstones and siltstones of the Sundays formation (marine origin) (CSIR, 1993). Onto this trough, (in tertiary to recent times) silts, clay, sand and gravel have been deposited. The Elands sub-catchment has a higher proportion of Bokkeveld shales (Bush, 1985). Geology on the coastal plain consists mainly of stabilized sand dunes without good water retention ability. The

following layers are found in the stratigraphy : Sand; limestone; sand; loose pebbles; and Table Mountain Sandstone. Blue shales are found in the northerly part of the catchment area.

The geological succession in the Swartkops catchment. (Lomberg *et al* 1997)

Tertiary to Recent (sands & calcareous dune rock)	Aolian Sands
	Nanaga Formation
Uitenhage group (mudstones, conglomerates & subordinate sandstones)	Sundays River Formation
	Kirkwood Formation
	Enon Formation
Table Mountain group (sandstones)	Nardouw Sub-group
	Peninsula Formation
	Sardinia Bay Formation

Three main soil types occur in the Swartkops catchment area : the upper catchment being derived from TMS, while the soils in the middle areas are of deep alluvial nature, while the areas closer to the sea are predominantly sand. Soils in the lower KwaZunga, lower Elands, upper Swartkops, Brak and Chetty sub-catchments are well suited for agriculture. The easily erodable sedimentary deposits allow for the extensive meandering flow path of the river system on the floodplain.

2.3. Climate and Hydrology

The Swartkops River catchment receives rain throughout the year with a mean annual rainfall (MAR) that varies between 655mm to 750 mm as can be seen in Figure 1. The monthly average is approximately 55mm/month but figures as high as 200mm/month have been measured. Groendal is a little drier (MAR 608mm – records since 1935) with monthly averages fluctuating between 30,8mm and 73mm. Rain is mainly cyclonic and orographic. According to Schulze (1984), an average of ten to twenty thunderstorms occur annually. Sometimes one heavy thunderstorm can be responsible for up to one third of the annual precipitation. Two distinctive peaks occur viz. in June and October. The contribution of the Kwazunga / Zwartkops draining system to the total mean annual runoff in South Africa is approximately 0,3% (Noble and Hemens, 1978). The mean

annual evaporation (MAE) exceeds the mean annual precipitation (MAP) by 45% indicated that the Swartkops River catchment is less prone to aridity than the other catchments to the west.

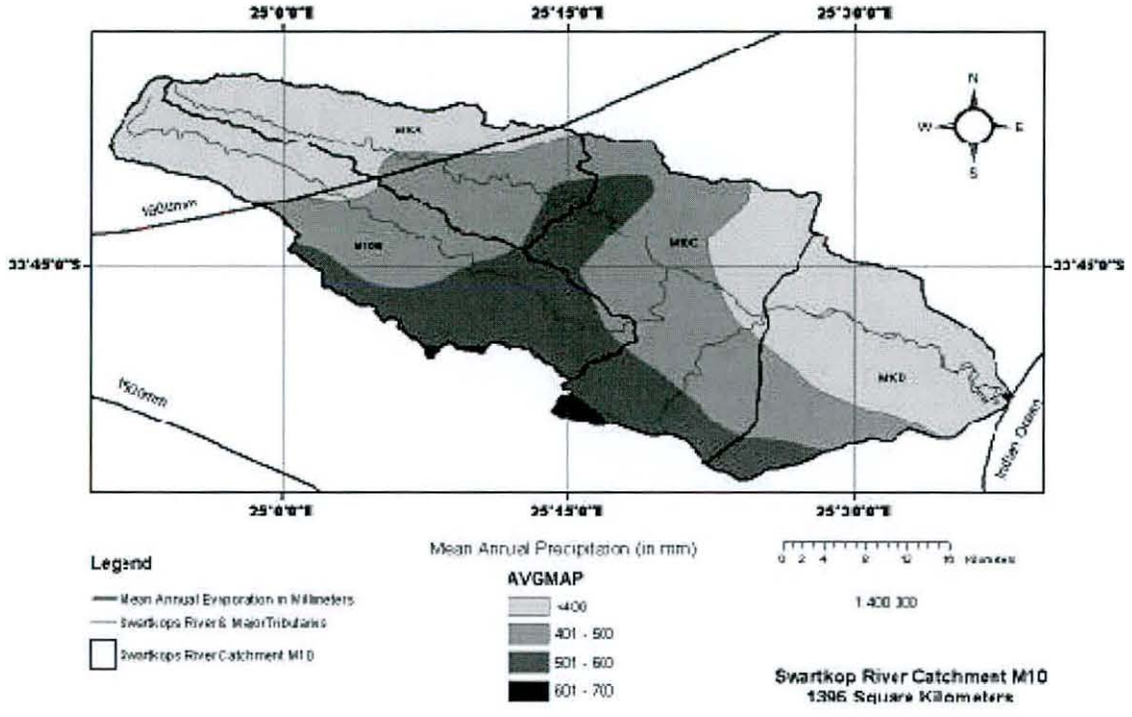

Figure 1 : Map of the quaternary catchments of the Swartkops River depicting the prevailing MAP and MAE.

In Summer the prevailing winds are south-westerly, occasionally interchanged by south-easterly winds that bring in moist air from the sea. In winter the prevailing winds are warm, dry north-westerly and north-easterly winds. The wind plays a big role in the temperature regime by reducing temperatures as well as humidity in the summer.

Generally the climate is warm and temperate with large fluctuations in temperature occurring on a daily as well as a seasonal basis. In the low-lying areas the mean daily maximum temperature is approximately 32°C in January and 18°C in July, with extremes of 45°C and 31°C respectively being recorded. The mean daily minimum temperature is 15°C in January and 5°C in July with extremes of 5°C and -3°C respectively already being recorded.

2.4. GROUNDWATER

The rocks and sediments described above can be classified into two aquifer types. The tertiary to recent sands contain primary aquifers and these formations have high infiltration potential depending on the degree of compaction. The primary aquifer can act as recharge for the secondary aquifer unless it is underlain by the Uitenhage Group mudstones that have low permeability (Lomberg et al 1997). The primary aquifer occurs from the confluence of the Elands & KwaZunga Rivers downstream to Perseverance and is between 2-5m below the surface. The primary aquifer and the river is hydrologically connected and interact continuously as far as recharge and discharge is concerned. Water for the primary aquifer comes from rain, surface storage ponds and the river tends to be of much lower quality due to the marine nature of the sediments as well as industrial return flows.

The TMG form secondary aquifers in which groundwater flow is stored within fractures 20-30m underground in the high-lying area, but are closer to the surface in lower lying areas such as at Perseverance. Groundwater flow is from the west to the east toward the sea. This is an extensive aquifer and is accessed from as far west as Humansdorp and Jeffreys Bay in the immediate vicinity. Boreholes to utilize ground water in Port Elizabeth appear to be confined to the more affluent areas (cost related) and are primarily used for gardening. The outlying area groundwater supplies all water to households that fall outside the municipal reticulation system. Most borehole water appear to derive from the secondary aquifer (except in Summerstrand close to the coast) if the depth of the holes are considered (Lomberg et al 1997).

2.5. FAUNA & FLORA

The Sundays River catchment vegetation is a complex overlapping mosaic of a wide variety of different communities resulting in a specific floristic character. The upper south facing slopes, which have the highest rainfall, are dominated by Mountain Fynbos and the northern slopes by Subtropical Evergreen Forest. The lower northern slopes and plains are covered by Grassy Fynbos. In the upper to middle Elands, Brak and Chatty sub-catchments, Renosterveld is dominant. The rest of the low lying areas of the catchment are dominated by Bushveld or Succulent Thicket. The broken topography and geology, soils and rainfall variation play a major part in establishing a species diversity of more than a thousand identified species (Scharf, 1979). Fynbos and fynbos-