Table 1.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	CREST
	Site 1
	2011
Geophyte or other red data species recorded	None recorded

Table 1.3: Trends in species composition, from Table 1.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	CREST	
	Site 1	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	0	0
Increaser I species, excluding sedges (%)	3	6
Increaser II species, excluding forbs (%)	67	94
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser*** **species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

Increaser I **species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

Increaser II **species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 1.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 1
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 1.5: Summary.

SUMMARY	CREST
	Site 1
	ISPD 2056
	2011
Tuft distance (cm)	11
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	11
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	240
Fuel load potential (from Table 1.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**15.2**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.063 LSU/ha**

Table 2.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Sclerocarya birrea / Boscia* Open Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 2	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	7	
PHYTOMASS / FUEL LOAD (in kg/ha)	3523	
CO-ORDINATES: South	23° 11' 48.6"	
East	28° 11' 43.9"	
HEIGHT ABOVE SEA LEVEL (m)	944m	
DIRECTION OF TRANSECT	180°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Stipagrostis uniplumis Silky Bushman Grass	2	2
TOTAL (Decreaser category):	**2**	**2**
INCREASER I		
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Aristida adscensionis Annual Three-awn	2	2
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	25	26
Aristida vestita Aristida	1	1
Eragrostis lehmanniana Lehmann's Love Grass	7	7
Eragrostis rigidior Curly Leaf / Krulblaar	24	25
Melinis repens Natal Red Top	1	1
Perotis patens Cat's Tail	1	1
Schmidtia pappophoroides Sand Quick	34	35
Dicot Herbaceous Perennial Forbs	3	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**98**	**98**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 2.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 2 2011
Geophyte or other red data species recorded	None recorded

Table 2.3: Trends in species composition, from Table 2.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 2	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	2	2
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	95	98
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**
***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**
***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 2.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 2 2011
> 4 000	Very High	
3 000-4 000	High	X
2 000-3 000	Moderate	
less 2000	Low	

Table 2.5: Summary.

SUMMARY	Site 2 ISPD 2057 2011
Tuft distance (cm)	7
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	9
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	POOR
Fuel load (4 tons per ha = threshhold for burning)	3523
Fuel load potential (from Table 2.4)	HIGH
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**33.6**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.064 LSU/ha**

Table 3.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON	Soil Form: Plooysburg (Red Sandy Clay Loam)	
	Site 3	
Acacia karroo Open Woodland	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	17	
PHYTOMASS / FUEL LOAD (in kg/ha)	363	
CO-ORDINATES: South	23° 12' 15.6"	
East	28° 10' 57.7"	
HEIGHT ABOVE SEA LEVEL (m)	944m	
DIRECTION OF TRANSECT	90°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
No Decreaser species recorded	0	0
TOTAL (Decreaser category):	**0**	**0**
INCREASER I		
Brachiaria deflexa False Signal Grass	2	5
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**2**	**5**
INCREASER II		
Aristida adscensionis Annual Three-awn	1	1
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	35	52
Aristida vestita Aristida	**	1
Digitaria velutina Long-plumed Finger Grass	1	1
Enneapogon cenchroides Nine-awned Grass	**	**
Eragrostis lehmanniana Lehmann's Love Grass	4	9
Eragrostis rigidior Curly Leaf / Krulblaar	2	4
Melinis repens Natal Red Top	2	4
Perotis patens Cat's Tail	**	1
Urochloa mosambicensis Bushveld Signal Grass	**	**
Dicot Herbaceous Perennial Forbs	53	
Bare Ground	0	22
TOTAL (Increaser II cat.):	**98**	**95**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 3.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 3 2011
Geophyte or other red data species recorded	None recorded

Table 3.3: Trends in species composition, from Table 3.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 3	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	0	0
Increaser I species, excluding sedges (%)	2	5
Increaser II species, excluding forbs (%)	45	73
Unidentified species (%)	0	0
Bare Ground (%)	0	22
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 3.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 3 2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 3.5: Summary.

SUMMARY	Site 3 ISPD 2058 2011
Tuft distance (cm)	17
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	11
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	363
Fuel load potential (from Table 3.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**14.0**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.054 LSU/ha**

Table 4.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia senegal* Thicket	CALCRETE OUTCROP	
	Soil Form: Coega	
	Site 4	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	7	
PHYTOMASS / FUEL LOAD (in kg/ha)	3150	
CO-ORDINATES: South	23° 12' 43.4"	
East	28° 11' 14.9"	
HEIGHT ABOVE SEA LEVEL (m)	960m	
DIRECTION OF TRANSECT	360°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Cenchrus ciliaris Foxtail Buffalo Grass	9	9
TOTAL (Decreaser category):	**9**	**9**
INCREASER I		
Brachiaria deflexa False Signal Grass	3	3
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**3**	**3**
INCREASER II		
Aristida adscensionis Annual Three-awn	5	5
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	4	5
Aristida vestita Aristida	3	3
Digitaria velutina Long-plumed Finger Grass	1	1
Ehrharta erecta Shade Ehrharta	2	2
Enneapogon cenchroides Nine-awned Grass	21	22
Enneapogon desvauxii Eight Day Grass	32	32
Eragrostis lehmanniana Lehmann's Love Grass	8	8
Eragrostis rigidior Curly Leaf / Krulblaar	1	1
Melinis repens Natal Red Top	9	9
Setaria verticillata Bur Bristle Grass	**	**
Dicot Herbaceous Perennial Forbs	2	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**88**	**88**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 4.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	CALCRETE OUTCROP
	Site 4
	2011
Geophyte or other red data species recorded	None recorded

Table 4.3: Trends in species composition, from Table 4.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	CALCRETE OUTCROP	
	Site 4	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	9	9
Increaser I species, excluding sedges (%)	3	3
Increaser II species, excluding forbs (%)	86	88
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 4.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 4
		2011
> 4 000	Very High	
3 000-4 000	High	X
2 000-3 000	Moderate	
less 2000	Low	

Table 4.5: Summary.

SUMMARY	CALCRETE OUTCROP
	Site 4
	ISPD 2059
	2011
Tuft distance (cm)	7
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	13
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	3150
Fuel load potential (from Table 4.4)	HIGH
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**17.8**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.059 LSU/ha**

Table 5.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia senegal* Closed Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 5	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	6	
PHYTOMASS / FUEL LOAD (in kg/ha)	379	
CO-ORDINATES: South	23° 12' 59.4"	
East	28° 10' 16.4"	
HEIGHT ABOVE SEA LEVEL (m)	939m	
DIRECTION OF TRANSECT	115°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
No Decreaser species recorded	0	0
TOTAL (Decreaser category):	**0**	**0**
INCREASER I		
Brachiaria deflexa False Signal Grass	10	11
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**10**	**11**
INCREASER II		
Aristida adscensionis Annual Three-awn	3	3
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	5	6
Chloris virgata Feather-top Chloris	2	2
Digitaria velutina Long-plumed Finger Grass	7	7
Enneapogon cenchroides Nine-awned Grass	8	8
Eragrostis lehmanniana Lehmann's Love Grass	52	56
Eragrostis pallens Broom Love Grass	**	**
Eragrostis rigidior Curly Leaf / Krulblaar	2	2
Perotis patens Cat's Tail	5	5
Dicot Herbaceous Perennial Forbs	6	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**90**	**89**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 5.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 5 2011
Geophyte or other red data species recorded	None recorded

Table 5.3: Trends in species composition, from Table 5.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 5	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	0	0
Increaser I species, excluding sedges (%)	10	11
Increaser II species, excluding forbs (%)	84	89
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 5.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 5 2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 5.5: Summary.

SUMMARY	Site 5 ISPD 2060 2011
Tuft distance (cm)	6
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	10
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	379
Fuel load potential (from Table 5.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**21.4**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.098 LSU/ha**

Table 6.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Sclerocarya birrea / Acacia tortilis* **Open Woodland**	**Soil Form: Hutton (Red Sandy Clay Loam)**	
	Site 6	
	Incl. Sedges & Forbs	**Excl. Sedges & Forbs**
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	5	
PHYTOMASS / FUEL LOAD (in kg/ha)	2164	
CO-ORDINATES: South	23° 13' 15.0"	
East	28° 12' 28.5"	
HEIGHT ABOVE SEA LEVEL (m)	975m	
DIRECTION OF TRANSECT	300°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	1	1
TOTAL (Decreaser category):	**1**	**1**
INCREASER I		
Brachiaria deflexa False Signal Grass	1	1
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**1**	**1**
INCREASER II		
Aristida adscensionis Annual Three-awn	**	**
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	35	37
Aristida congesta subsp. congesta Tassel Three-awn	2	3
Digitaria velutina Long-plumed Finger Grass	**	**
Enneapogon cenchroides Nine-awned Grass	**	**
Eragrostis lehmanniana Lehmann's Love Grass	14	15
Eragrostis rigidior Curly Leaf / Krulblaar	4	5
Melinis repens Natal Red Top	2	2
Pogonarthria squarrosa Herringbone Grass	**	**
Schmidtia pappophoroides Sand Quick	2	2
Tricholaena monachne Blue-seed Grass	1	1
Urochloa mosambicensis Bushveld Signal Grass	31	33
Dicot Herbaceous Perennial Forbs	7	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**98**	**98**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 6.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 6
	2011
Geophyte or other red data species recorded	None recorded

Table 6.3: Trends in species composition, from Table 6.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 6	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	1	1
Increaser I species, excluding sedges (%)	1	1
Increaser II species, excluding forbs (%)	91	98
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 6.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 6
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	X
less 2000	Low	

Table 6.5: Summary.

SUMMARY	Site 6
	ISPD 2061
	2011
Tuft distance (cm)	5
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	15
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	2164
Fuel load potential (from Table 6.4)	MODERATE
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**19.2**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.086 LSU/ha**

Table 7.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia nigrescens* Closed Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 7	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	8	
PHYTOMASS / FUEL LOAD (in kg/ha)	1011	
CO-ORDINATES: South	23° 13' 36.9"	
East	28° 11' 06.0"	
HEIGHT ABOVE SEA LEVEL (m)	951m	
DIRECTION OF TRANSECT	195°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	9	9
Stipagrostis uniplumis Silky Bushman Grass	2	2
TOTAL (Decreaser category):	**11**	**11**
INCREASER I		
Brachiaria deflexa False Signal Grass	12	12
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**12**	**12**
INCREASER II		
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	**	**
Aristida congesta subsp. congesta Tassel Three-awn	26	26
Aristida vestita Aristida	2	2
Digitaria velutina Long-plumed Finger Grass	25	25
Enneapogon cenchroides Nine-awned Grass	2	2
Eragrostis lehmanniana Lehmann's Love Grass	11	11
Eragrostis rigidior Curly Leaf / Krulblaar	3	3
Melinis repens Natal Red Top	6	6
Perotis patens Cat's Tail	1	1
Urochloa mosambicensis Bushveld Signal Grass	1	1
Dicot Herbaceous Perennial Forbs	0	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**77**	**77**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 7.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 7
	2011
Geophyte or other red data species recorded	None recorded

Table 7.3: Trends in species composition, from Table 7.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 7	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	11	11
Increaser I species, excluding sedges (%)	12	12
Increaser II species, excluding forbs (%)	77	77
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 7.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 7
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 7.5: Summary.

SUMMARY	Site 7
	ISPD 2062
	2011
Tuft distance (cm)	8
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	13
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	1011
Fuel load potential (from Table 7.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**22.4**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.056 LSU/ha**

Table 8.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON	Soil Form: Clovelly	
	Site 8	
Combretum apiculatum Open Woodland	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	5	
PHYTOMASS / FUEL LOAD (in kg/ha)	4199	
CO-ORDINATES: South	23° 14' 06.1"	
East	28° 12' 02.9"	
HEIGHT ABOVE SEA LEVEL (m)	965m	
DIRECTION OF TRANSECT	105°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	20	21
TOTAL (Decreaser category):	**20**	**21**
INCREASER I		
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Aristida congesta subsp. congesta Tassel Three-awn	6	6
Aristida vestita Aristida	22	24
Eragrostis lehmanniana Lehmann's Love Grass	3	3
Eragrostis rigidior Curly Leaf / Krulblaar	10	10
Melinis repens Natal Red Top	2	2
Pogonarthria squarrosa Herringbone Grass	2	2
Schmidtia pappophoroides Sand Quick	14	16
Tricholaena monachne Blue-seed Grass	9	9
Urochloa mosambicensis Bushveld Signal Grass	7	7
Dicot Herbaceous Perennial Forbs	5	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**80**	**79**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 8.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 8
	2011
Geophyte or other red data species recorded	None recorded

Table 8.3: Trends in species composition, from Table 8.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 8	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	20	21
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	75	79
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 8.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 8
		2011
> 4 000	Very High	X
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	

Table 8.5: Summary.

SUMMARY	Site 8
	ISPD 2063
	2011
Tuft distance (cm)	5
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	11
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	4199
Fuel load potential (from Table 8.4)	VERY HIGH
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**36.2**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.051 LSU/ha**

Table 9.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Sclerocarya birrea / Acacia tortilis* Open Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 9	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	6	
PHYTOMASS / FUEL LOAD (in kg/ha)	2813	
CO-ORDINATES: South	23° 15' 09.2"	
East	28° 11' 31.9"	
HEIGHT ABOVE SEA LEVEL (m)	964m	
DIRECTION OF TRANSECT	285°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	12	13
TOTAL (Decreaser category):	**12**	**13**
INCREASER I		
Brachiaria deflexa False Signal Grass	2	2
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**2**	**2**
INCREASER II		
Aristida adscensionis Annual Three-awn	1	1
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	4	4
Aristida congesta subsp. congesta Tassel Three-awn	5	5
Aristida vestita Aristida	1	1
Digitaria velutina Long-plumed Finger Grass	**	**
Enneapogon cenchroides Nine-awned Grass	2	2
Eragrostis lehmanniana Lehmann's Love Grass	10	10
Eragrostis rigidior Curly Leaf / Krulblaar	19	19
Melinis repens Natal Red Top	8	8
Perotis patens Cat's Tail	3	3
Pogonarthria squarrosa Herringbone Grass	**	**
Schmidtia pappophoroides Sand Quick	2	2
Setaria pumila Garden Bristle Grass	1	1
Tricholaena monachne Blue-seed Grass	1	1
Urochloa mosambicensis Bushveld Signal Grass	27	28
Dicot Herbaceous Perennial Forbs	2	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**86**	**85**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 9.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 9
	2011
Geophyte or other red data species recorded	None recorded

Table 9.3: Trends in species composition, from Table 9.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 9	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	12	13
Increaser I species, excluding sedges (%)	2	2
Increaser II species, excluding forbs (%)	84	85
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**
***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**
***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 9.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 9
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	X
less 2000	Low	

Table 9.5: Summary.

SUMMARY	Site 9
	ISPD 2064
	2011
Tuft distance (cm)	6
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	18
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	2813
Fuel load potential (from Table 9.4)	MODERATE
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**29.5**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.075 LSU/ha**

Table 10.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia senegal* Sparse Open Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 10	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	5	
PHYTOMASS / FUEL LOAD (in kg/ha)	2948	
CO-ORDINATES: South	23° 14' 43.4"	
East	28° 09' 30.7"	
HEIGHT ABOVE SEA LEVEL (m)	930m	
DIRECTION OF TRANSECT	85°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum coloratum Small Buffalo Grass	3	3
Panicum maximum Guinea Grass	2	2
TOTAL (Decreaser category):	**5**	**5**
INCREASER I		
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	5	5
Aristida vestita Aristida	44	46
Eragrostis lehmanniana Lehmann's Love Grass	3	3
Eragrostis rigidior Curly Leaf / Krulblaar	18	19
Melinis repens Natal Red Top	2	3
Schmidtia pappophoroides Sand Quick	16	17
Tricholaena monachne Blue-seed Grass	2	2
Dicot Herbaceous Perennial Forbs	5	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**95**	**95**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 10.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 10
	2011
Geophyte or other red data species recorded	None recorded

Table 10.3: Trends in species composition, from Table 10.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 10	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	5	5
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	90	95
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 10.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 10
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	X
less 2000	Low	

Table 10.5: Summary.

SUMMARY	Site 10
	ISPD 2065
	2011
Tuft distance (cm)	5
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	9
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	POOR
Fuel load (4 tons per ha = threshhold for burning)	2948
Fuel load potential (from Table 10.4)	MODERATE
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**24.5**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.051 LSU/ha**

Table 11.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia senegal / Acacia tortilis* Open Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 11	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	7	
PHYTOMASS / FUEL LOAD (in kg/ha)	3523	
CO-ORDINATES: South	23° 15' 24.9"	
East	28° 09' 42.8"	
HEIGHT ABOVE SEA LEVEL (m)	933m	
DIRECTION OF TRANSECT	140°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	20	20
TOTAL (Decreaser category):	**20**	**20**
INCREASER I		
Brachiaria deflexa False Signal Grass	2	2
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**2**	**2**
INCREASER II		
Aristida adscensionis Annual Three-awn	1	1
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	5	5
Aristida vestita Aristida	7	7
Eragrostis lehmanniana Lehmann's Love Grass	8	10
Eragrostis rigidior Curly Leaf / Krulblaar	28	28
Melinis repens Natal Red Top	6	6
Perotis patens Cat's Tail	7	8
Pogonarthria squarrosa Herringbone Grass	1	1
Schmidtia pappophoroides Sand Quick	9	9
Tricholaena monachne Blue-seed Grass	3	3
Dicot Herbaceous Perennial Forbs	3	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**78**	**78**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 11.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 11
	2011
Geophyte or other red data species recorded	None recorded

Table 11.3: Trends in species composition, from Table 11.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 11	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	20	20
Increaser I species, excluding sedges (%)	2	2
Increaser II species, excluding forbs (%)	75	78
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 11.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 11
		2011
> 4 000	Very High	
3 000-4 000	High	X
2 000-3 000	Moderate	
less 2000	Low	

Table 11.5: Summary.

SUMMARY	Site 11
	ISPD 2066
	2011
Tuft distance (cm)	7
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	13
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	3523
Fuel load potential (from Table 11.4)	HIGH
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**37.8**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.055 LSU/ha**

Table 12.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Acacia tortilis / Boscia* Open-Closed Woodland	Soil Form: Coega	
	Site 12	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	6	
PHYTOMASS / FUEL LOAD (in kg/ha)	1328	
CO-ORDINATES: South	23° 16' 07.3"	
East	28° 14' 23.5"	
HEIGHT ABOVE SEA LEVEL (m)	947m	
DIRECTION OF TRANSECT	70°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Cenchrus ciliaris Foxtail Buffalo Grass	4	4
Panicum maximum Guinea Grass	**	**
TOTAL (Decreaser category):	**4**	**4**
INCREASER I		
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Aristida adscensionis Annual Three-awn	**	**
Aristida bipartita Rolling Grass	8	9
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	8	8
Ehrharta erecta Shade Ehrharta	2	2
Enneapogon cenchroides Nine-awned Grass	8	8
Enneapogon desvauxii Eight Day Grass	59	60
Tragus berteronianus Carrot-seed Grass	1	1
Urochloa mosambicensis Bushveld Signal Grass	6	7
Dicot Herbaceous Perennial Forbs	4	
Bare Ground	**	1
TOTAL (Increaser II cat.):	**96**	**96**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 12.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 12
	2011
Geophyte or other red data species recorded	None recorded

Table 12.3: Trends in species composition, from Table 12.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 12	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	4	4
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	92	95
Unidentified species (%)	0	0
Bare Ground (%)	0	1
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 12.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 12
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 12.5: Summary.

SUMMARY	Site 12
	ISPD 2067
	2011
Tuft distance (cm)	6
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	10
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	1328
Fuel load potential (from Table 12.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**13.9**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.055 LSU/ha**

Table 13.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON	Soil Form: Hutton (Red Sandy Clay Loam)	
***Acacia senegal / Acacia nigrescens* Closed Woodland**	Site 13	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	9	
PHYTOMASS / FUEL LOAD (in kg/ha)	1748	
CO-ORDINATES: South	23° 15' 18.8"	
East	28° 11' 27.5"	
HEIGHT ABOVE SEA LEVEL (m)	961m	
DIRECTION OF TRANSECT	255°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	1	1
Stipagrostis uniplumis Silky Bushman Grass	**	**
TOTAL (Decreaser category):	**1**	**1**
INCREASER I		
Brachiaria deflexa False Signal Grass	4	4
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**4**	**4**
INCREASER II		
Aristida adscensionis Annual Three-awn	2	2
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	7	9
Aristida congesta subsp. congesta Tassel Three-awn	5	6
Aristida vestita Aristida	**	**
Digitaria velutina Long-plumed Finger Grass	6	6
Eragrostis lehmanniana Lehmann's Love Grass	14	15
Eragrostis rigidior Curly Leaf / Krulblaar	5	6
Melinis repens Natal Red Top	3	3
Perotis patens Cat's Tail	1	1
Pogonarthria squarrosa Herringbone Grass	1	1
Schmidtia pappophoroides Sand Quick	1	1
Setaria pumila Garden Bristle Grass	40	41
Tricholaena monachne Blue-seed Grass	3	3
Urochloa mosambicensis Bushveld Signal Grass	1	1
Dicot Herbaceous Perennial Forbs	6	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**95**	**95**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 13.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 13
	2011
Geophyte or other red data species recorded	None recorded

Table 13.3: Trends in species composition, from Table 13.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 13	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	1	1
Increaser I species, excluding sedges (%)	4	4
Increaser II species, excluding forbs (%)	89	95
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 13.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 13
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 13.5: Summary.

SUMMARY	Site 13
	ISPD 2068
	2011
Tuft distance (cm)	9
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	17
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	1748
Fuel load potential (from Table 13.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**17.0**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.059 LSU/ha**

Table 14.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Sclerocarya birrea / Acacia tortilis* Open Woodland	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 14	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	8	
PHYTOMASS / FUEL LOAD (in kg/ha)	4262	
CO-ORDINATES: South	23° 15' 15.3"	
East	28° 12' 46.5"	
HEIGHT ABOVE SEA LEVEL (m)	970m	
DIRECTION OF TRANSECT	105°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Digitaria eriantha Common Finger Grass	2	2
Panicum maximum Guinea Grass	3	3
Stipagrostis uniplumis Silky Bushman Grass	16	17
TOTAL (Decreaser category):	**21**	**22**
INCREASER I		
Brachiaria deflexa False Signal Grass	**	**
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	8	9
Digitaria velutina Long-plumed Finger Grass	**	**
Enneapogon cenchroides Nine-awned Grass	2	2
Eragrostis lehmanniana Lehmann's Love Grass	3	3
Eragrostis rigidior Curly Leaf / Krulblaar	24	25
Melinis repens Natal Red Top	1	1
Perotis patens Cat's Tail	1	1
Pogonarthria squarrosa Herringbone Grass	2	2
Schmidtia pappophoroides Sand Quick	12	12
Setaria pumila Garden Bristle Grass	1	1
Tricholaena monachne Blue-seed Grass	21	21
Urochloa mosambicensis Bushveld Signal Grass	1	1
Dicot Herbaceous Perennial Forbs	3	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**79**	**78**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 14.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 14 2011
Geophyte or other red data species recorded	None recorded

Table 14.3: Trends in species composition, from Table 14.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 14	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	21	22
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	76	78
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**
***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**
***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 14.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 14 2011
> 4 000	Very High	X
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	

Table 14.5: Summary.

SUMMARY	Site 14 ISPD 2069 2011
Tuft distance (cm)	8
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	16
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	4262
Fuel load potential (from Table 14.4)	VERY HIGH
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**44.9**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.054 LSU/ha**

Table 15.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Commiphora pyracanthoides / Combretum apiculatum* Short thicket	Soil Form: Hutton/Glenrosa (Red Sandy Clay Loam)	
	Site 15	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	8	
PHYTOMASS / FUEL LOAD (in kg/ha)	2805	
CO-ORDINATES: South	23° 15' 03.9"	
East	28° 12' 49.9"	
HEIGHT ABOVE SEA LEVEL (m)	975m	
DIRECTION OF TRANSECT	245°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	4	4
Stipagrostis uniplumis Silky Bushman Grass	5	5
TOTAL (Decreaser category):	**9**	**9**
INCREASER I		
Brachiaria deflexa False Signal Grass	2	2
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**2**	**2**
INCREASER II		
Aristida adscensionis Annual Three-awn	3	3
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	3	3
Aristida congesta subsp. congesta Tassel Three-awn	1	1
Aristida vestita Aristida	**	**
Chloris virgata Feather-top Chloris	1	1
Enneapogon cenchroides Nine-awned Grass	1	1
Enneapogon scoparius Bottlebrush Grass	2	2
Eragrostis rigidior Curly Leaf / Krulblaar	19	19
Heteropogon contortus Spear Grass / Assegaaigras	1	1
Melinis repens Natal Red Top	6	6
Pogonarthria squarrosa Herringbone Grass	1	1
Schmidtia pappophoroides Sand Quick	4	4
Setaria pumila Garden Bristle Grass	47	47
Dicot Herbaceous Perennial Forbs	0	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**89**	**89**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 15.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	
	Site 15
	2011
Geophyte or other red data species recorded	None recorded

Table 15.3: Trends in species composition, from Table 15.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 15	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	9	9
Increaser I species, excluding sedges (%)	2	2
Increaser II species, excluding forbs (%)	89	89
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 15.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 15
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	X
less 2000	Low	

Table 15.5: Summary.

SUMMARY	
	Site 15
	ISPD 2070
	2011
Tuft distance (cm)	8
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	16
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	2805
Fuel load potential (from Table 15.4)	MODERATE
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**23.6**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.053 LSU/ha**

Table 16.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON *Commiphora sp./ Acacia burkei & Acacia tortilis* Open-Closed Woodland	Soil Form: Clovelly	
	Site 16	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	8	
PHYTOMASS / FUEL LOAD (in kg/ha)	2977	
CO-ORDINATES: South		
East		
HEIGHT ABOVE SEA LEVEL (m)		
DIRECTION OF TRANSECT	225°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Digitaria eriantha Common Finger Grass	1	1
Panicum maximum Guinea Grass	2	2
TOTAL (Decreaser category):	**3**	**3**
INCREASER I		
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**0**	**0**
INCREASER II		
Chloris virgata Feather-top Chloris	9	9
Digitaria velutina Long-plumed Finger Grass	10	10
Enneapogon cenchroides Nine-awned Grass	3	3
Eragrostis lehmanniana Lehmann's Love Grass	2	2
Eragrostis rigidior Curly Leaf / Krulblaar	38	40
Sporobolus sp. Sporobolus	9	9
Tricholaena monachne Blue-seed Grass	2	2
Urochloa mosambicensis Bushveld Signal Grass	22	22
Dicot Herbaceous Perennial Forbs	2	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**97**	**97**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 16.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 16
	2011
Geophyte or other red data species recorded	None recorded

Table 16.3: Trends in species composition, from Table 16.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 16	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	3	3
Increaser I species, excluding sedges (%)	0	0
Increaser II species, excluding forbs (%)	95	97
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 16.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 16
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	X
less 2000	Low	

Table 16.5: Summary.

SUMMARY	Site 16
	ISPD 2071
	2011
Tuft distance (cm)	8
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	10
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	2977
Fuel load potential (from Table 16.4)	MODERATE
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**28.3**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.064 LSU/ha**

Table 17.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON	**Soil Form: Hutton (Red Sandy Clay Loam)**	
	Site 17	
***Acacia senegal* Closed Woodland**	**Incl. Sedges & Forbs**	**Excl. Sedges & Forbs**
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	8	
PHYTOMASS / FUEL LOAD (in kg/ha)	1646	
CO-ORDINATES: South	23° 13' 14.49"	
East	28° 11' 08.50"	
HEIGHT ABOVE SEA LEVEL (m)	947m	
DIRECTION OF TRANSECT		
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	1	1
TOTAL (Decreaser category):	**1**	**1**
INCREASER I		
Brachiaria deflexa False Signal Grass	6	6
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**6**	**6**
INCREASER II		
Aristida adscensionis Annual Three-awn	2	2
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	13	14
Aristida congesta subsp. congesta Tassel Three-awn	1	1
Aristida vestita Aristida	1	1
Digitaria velutina Long-plumed Finger Grass	2	2
Enneapogon cenchroides Nine-awned Grass	**	**
Eragrostis lehmanniana Lehmann's Love Grass	57	59
Eragrostis rigidior Curly Leaf / Krulblaar	9	10
Melinis repens Natal Red Top	1	1
Perotis patens Cat's Tail	2	2
Urochloa mosambicensis Bushveld Signal Grass	1	1
Dicot Herbaceous Perennial Forbs	4	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**93**	**93**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 17.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 17
	2011
Geophyte or other red data species recorded	None recorded

Table 17.3: Trends in species composition, from Table 17.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 17	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	1	1
Increaser I species, excluding sedges (%)	6	6
Increaser II species, excluding forbs (%)	89	93
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**
***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**
***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 17.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 17
		2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 17.5: Summary.

SUMMARY	Site 17
	ISPD 2072
	2011
Tuft distance (cm)	8
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	HIGH
Number of grass species present (per 2500 square meters)	14
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	1646
Fuel load potential (from Table 17.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	25.0
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.103 LSU/ha**

Table 18.1: Veld condition assessment table: Grass species cover and composition at Turquoise Moon (2011).

TURQUOISE MOON — *Acacia senegal / Combretum apiculatum/ Boscia / Commiphora* Thicket with *Terminalia prunioides*	Soil Form: Hutton (Red Sandy Clay Loam)	
	Site 18	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
TUFT DISTANCES (in cm) : <5cm = Good, 5-6cm = Moderate, >6cm = Poor	6	
PHYTOMASS / FUEL LOAD (in kg/ha)	1735	
CO-ORDINATES: South	23° 14' 13.3"	
East	28° 10' 09.8"	
HEIGHT ABOVE SEA LEVEL (m)	947m	
DIRECTION OF TRANSECT	150°	
GRASS SPECIES IN CATEGORIES		
DECREASERS		
Panicum maximum Guinea Grass	**	**
Stipagrostis uniplumis Silky Bushman Grass	1	1
TOTAL (Decreaser category):	**1**	**1**
INCREASER I		
Brachiaria deflexa False Signal Grass	4	4
Monocot Forbs, including sedges (Cyperaceae)	0	
TOTAL (Increaser I cat.):	**4**	**4**
INCREASER II		
Aristida adscensionis Annual Three-awn	2	2
Aristida congesta ssp *barbicollis* Spreading Prickle Grass / Witsteekgras	14	14
Aristida vestita Aristida	13	13
Chloris virgata Feather-top Chloris	10	10
Digitaria velutina Long-plumed Finger Grass	8	8
Enneapogon cenchroides Nine-awned Grass	9	9
Enneapogon scoparius Bottlebrush Grass	7	7
Eragrostis lehmanniana Lehmann's Love Grass	15	15
Eragrostis rigidior Curly Leaf / Krulblaar	9	9
Melinis repens Natal Red Top	4	5
Pogonarthria squarrosa Herringbone Grass	**	**
Schmidtia pappophoroides Sand Quick	1	1
Tricholaena monachne Blue-seed Grass	**	**
Urochloa mosambicensis Bushveld Signal Grass	2	2
Dicot Herbaceous Perennial Forbs	1	
Bare Ground	0	0
TOTAL (Increaser II cat.):	**95**	**95**
Unidentified	0	0
TOTAL (All categories):	**100**	**100**

** Less than 1% of species present at site

Table 18.2: Other non-grass herbaceous plant, including protected or geophyte species.

PLANT SPECIES	Site 18 2011
Geophyte or other red data species recorded	None recorded

Table 18.3: Trends in species composition, from Table 18.1.

VELD CONDITION SUMMARY OF TREND (TAINTON'S METHOD)	Site 18	
	Incl. Sedges & Forbs	Excl. Sedges & Forbs
	2011	
Decreaser species (%)	1	1
Increaser I species, excluding sedges (%)	4	4
Increaser II species, excluding forbs (%)	94	95
Unidentified species (%)	0	0
Bare Ground (%)	0	0
Total (%)	100	100
Veld Condition (Tainton's Method)	**Overgrazed**	

Legend: ***Decreaser* species** - Grass and herbaceous species which **decrease** when veld is **over-utilized or burned too frequently**

***Increaser I* species** - Grass and herbaceous species which **increase** when veld is **under-utilized or not burned in high enough frequencies**

***Increaser II* species** - Grass and herbaceous species which **increase** when veld is **over-utilized or burned in too high frequencies**

Table 18.4 : Fuel load (in kg/ha).

VOLUME (kg/ha)	POTENTIAL	SITE NUMBER: 18 2011
> 4 000	Very High	
3 000-4 000	High	
2 000-3 000	Moderate	
less 2000	Low	X

Table 18.5: Summary.

SUMMARY	Site 18 ISPD 2073 2011
Tuft distance (cm)	6
Erodability potential Low is 0-4 cm, Moderate 5-6 cm & High > 6 cm)	MODERATE
Number of grass species present (per 2500 square meters)	17
Grass Species Richness (Good is = 20-30 spp, Poor < 10 species)	REASONABLE
Fuel load (4 tons per ha = threshhold for burning)	1735
Fuel load potential (from Table 18.4)	LOW
Condition on ISPD Degradation Axis (%) - Norm between 60% and 80%	**16.6**
ISPD Veld Condition Assessment	**OVERGRAZED**
Management Recommendation	**Apply rest from fire or grazing for a year and reduce stocking rate to 0.059 LSU/ha**

APPENDIX J: HYDROLOGICAL STUDY

Specialist report prepared by Metago, May 2011

Metago

HYDROLOGICAL ASSESSMENT AND STORMWATER MANAGEMENT PLAN FOR THE PROPOSED MOONLIGHT IRON ORE MINE

Prepared For

Turquoise Moon Trading 157 (Pty) Ltd

Metago Project No. T020-02

REPORT NO. 5- FINAL

May 2011

Hydrological Assessment and Conceptual Stormwater Management Plan for the Proposed Moonlight Iron Ore Mine

Prepared For

Turquoise Moon Trading 157 (Pty) Ltd

Metago Project No. T020-02

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May 2011

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HYDROLOGICAL ASSESSMENT AND CONCEPTUAL STORMWATER MANAGEMENT PLAN FOR THE PROPOSED MOONLIGHT IRON ORE MINE

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AMSL	Above Mean Sea Level
DDF	Depth Duration Frequency
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry (now known as DWA)
FHWA	Federal Highway Administration
IWULA	Integrated Water Use License Application
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NWA	National Water Act
RLMA&SI	Regional L-Moment Algorithm and Scale Invariance
RP	Return Period
SANRAL	South African National Road Agency Limited
SAWS	South African Weather Service
TC	Time of Concentration
TR-55	Technical Report 55
WRC	Water Research Commission
HRU	Hydrological Research Unit
WR2005	Water Resources 2005
IFC	International Finance Corporation

HYDROLOGICAL ASSESSMENT AND CONCEPTUAL STORMWATER MANAGEMENT PLAN FOR THE PROPOSED MOONLIGHT IRON ORE MINE

1 INTRODUCTION

1.1 BACKGROUND

Turquoise Moon Trading 157 (Pty) Ltd (Turquoise Moon) are proposing the development of the Moonlight operation; an iron ore mine near Marnitz in the Limpopo Province. Metago has been appointed by Turquoise Moon to undertake a hydrological assessment of the site, and to thereby provide input into the identification of hydrological impacts and to develop a conceptual stormwater management plan. The hydrological assessment and stormwater management plan will be assessed as part of the overall Environmental Impact Assessment (EIA) and will be incorporated into the Integrated Water Use License Application (IWULA). .

1.2 PURPOSE AND SCOPE OF WORK

The objective of the study was to perform a hydrological assessment to assist in the identification of impacts and to develop a conceptual stormwater management plan for the proposed Moonlight operation for the purposes of meeting the requirements of Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704) as well as the Department of Water Affairs (DWA) Best Practice Guideline G1 for Stormwater Management. This was done by undertaking the following:

- Site examination – The site was visited in January and April 2011 by Luke Wiles of Metago. The site was assessed in terms of the dominant hydrological processes, the identification of clean and dirty areas, and in determining how clean water can be diverted around dirty areas and how dirty water can be contained to ensure compliance with GN 704.
- A detailed hydrological assessment of the area to determine the nature of drainage on site and the nature and size of the flows which require containment or diversion.
- Conceptual designs for all stormwater control infrastructure so as to meet the requirements of GN 704.
- This technical report which includes details of the above, as well as layout drawings with typical sections through proposed stormwater control infrastructure.

1.3 SITE LOCATION

The Moonlight site covers an area of approximately 52.4 km^2, and is located within the Limpopo province of South Africa, at Grid Coordinates 23.2° S and 28.2° E. The nearest town to the project, is Marnitz which lies 3 km north of the site boundary. The Moolight site falls over portions of the farms Moonlight 111 LR, Gouda Fontein 886 (previously known as Gouda Fontein 76 LR) and Julietta 112 LR. Figure 1-1 presents the sites regional setting.

2 BASELINE INFORMATION

2.1 CLIMATE

The annual average rainfall for the Moonlight site is approximately 420mm, mainly occurring as a result of thunderstorms between October and April, peaking in January. The maximum average summer temperatures in the region approximate 32°C, while the minimum average winter temperatures approximate 7°C. Regular frost also occurs during winter. Average monthly temperatures were sourced from the South African Weather Services Station 06743116 at Lephalale located approximately 76km from the proposed site, based on a record length of 8 years from 1982 to 1990.

TABLE 2-1: AVERAGE MONTHLY TEMPERATURES FOR LEPHALALE

Month	Max	Min	Ave
Jan	33.0	20,4	26,7
Feb	32,2	19,8	26,0
Mar	31,8	18,9	25,4
Apr	28,9	15,0	22,0
May	26,6	10,3	18,5
Jun	23,4	6,7	15,0
Jul	23,9	6,9	15,4
Aug	26,3	9,5	17,9
Sep	29,2	13,5	21,4
Oct	30,6	16,9	23,8
Nov	31,5	18,2	24,9
Dec	32,2	19,5	25,9

More site specific rainfall and evaporation information is available in the following sections, as these are important considerations in this project.

2.2 RAINFALL AND EVAPORATION

Rainfall data for the site was considered from various sources including weather stations managed by both the South African Weather Services (SAWS) and the Department of Water Affairs (DWA). The locations of the considered stations in relation to the project area are illustrated in Figure 2-1. In this project, mean annual precipitation (MAP) for the site was sourced from both Marken (SAWS - 0675666 2) located approximately 47km South of the site as well as the Marnitz weather station (DWA - A5E001), located 3km north of the site.

TABLE 2-2: MONTHLY RAINFALL ESTIMATES FOR MARKEN

Month	Mean Monthly Rainfall (mm)
Jan	73
Feb	55
Mar	52
Apr	30
May	11
Jun	4
Jul	4
Aug	0
Sep	4
Oct	21
Nov	73
Dec	70
Total	**398**

The Marken station provides a fairly short record of 17 years between 1993 and 2010 with an average MAP of 398mm. This station represents current rainfall estimates for the greater site. The Marnitz station provides a record length of 24 years between 1956 and 1980, located close to site with an average MAP of 419mm. Based on the above and although the Marnitz site does not represent current rainfall, it was decided that the Marnitz rainfall data is the most appropriate rainfall station as it is located very close to the site, and provides the more conservative data from a design perspective, due to the higher MAP. As a check the WR2005 gridded MAP for the country indicates that the MAP for the site ranges between 393mm and 419mm therefore further justifying the use of the Marnitz data.

Monthly evaporative estimates to be used in the sizing of containment facilities were also taken from the Marnitz gauge (DWA - A5E001). The Marnitz gauge records A-Pan evaporation, which generally exceeds evaporation from a natural water surface. Consequently it was necessary to convert the A-Pan estimates to equivalent Lake estimates. Table 2-3 presents the monthly rainfall and evaporative values.

TABLE 2-3: MONTHLY RAINFALL AND EVAPORATION ESTIMATES FOR MARNITZ

Month	Mean Monthly Rainfall (mm)	Mean Monthly Lake Evaporation (mm)
Jan	85	177
Feb	68	142
Mar	46	150
Apr	35	115
May	7	96
Jun	3	78
Jul	1	90
Aug	3	120
Sep	10	155
Oct	33	184
Nov	63	178
Dec	67	166
Total	**419**	**1654**

For the development of a stormwater management plan, design rainfall was the most important rainfall variable to consider as it is the climatic driver behind peak flows.

2.2.1 DESIGN RAINFALL DEPTHS

Design rainfall depths for various return periods (RP) and storm durations were sourced from the Design Rainfall Estimation Software for South Africa, developed by the University of Natal in 2002 as part of a WRC project K5/1060 (Smithers and Schulze, 2002). This method uses a Regional L-Moment Algorithm in conjunction with a Scale Invariance (RLMA&SI) approach to provide site specific estimates of depth-duration-frequency (DDF) rainfall, based on surrounding observed records. This method of DDF rainfall estimation is considered more robust than previous single site methods. The Water Research Commission (WRC) Report No. K5/1060 provides further detail on the verification and validation of the method.

The rainfall depth estimates from this technique have been compared to the DDF estimates for the site using the Hydrological Research Unit (HRU) methodology. The HRU methodology is a simplistic methodology which enables the estimation of depth-duration-frequency rainfall. The methodology uses the MAP for the Marnitz Gauge (419mm) and a site location factor (inland or coastal) in order to determine the DDF estimate. RLMA&SI estimates, as well as a comparison with HRU estimates are presented in Table 2-4.

TABLE 2-4: 24-HOUR STORM DEPTHS

RP	24-hour Rainfall Depth (mm)	
	RLMA & SI (2002)	HRU
1 in 2	65	38
1 in 5	92	50
1 in 10	111	61
1 in 20	130	75
1 in 50	157	99
1 in 100	179	122
1 in 200	202	150

In this project, the Smithers and Schulze technique was selected due to the following reasons:

- Estimates are based on localised observed data;
- Estimates are specific to the site location;
- The methodology uses a sub-daily rainfall record by which to estimate design event durations of 24 hours and less; and
- Estimates are more conservative.

2.3 TOPOGRAPHY AND LAND COVER

The topography of Moonlight site is relatively flat, with slopes ranging primarily between 1% and 3%. Elevations on site range from approximately 980m AMSL in the east, to 920m in the south west. Land cover on the site is largely that of natural and is classified as bushveld. There are a few disturbed areas as a result of some agriculture. Figure 2-1 presents the topography of the site.

Both the topography and land cover of the site are regarded as important considerations in the determination of runoff generated during flood events.

2.4 GEOLOGY AND SOILS

According to the WR2005 geology dataset, the site is predominantly underlain by Gneiss lithologies which are igneous in nature, with an area of sedimentary rock in the centre of the site. Overlying the igneous rocks are soils defined as a variation of Sands to Sandy Loams. Soils on site are fairly shallow with a significant proportion of rock fragments distributed throughout the soil profile.

2.5 HYDROLOGY

In terms of surface drainage at (or near to) the site, the non perennial and perennial stream network as per the 1:50,000 topographical map sheets were extracted and used in the generation of Figure 2-1 to give a good indication of the nature of the river systems in the greater area. According to this stream network, there are no perennial or non-perennial streams within the site boundary. This is due to the site's location on a watershed, as well as the aridity of the region, which results in a low drainage density. Significant catchment areas upstream of the site are consequently not present, while the dominant flow regime within the site is that of overland flow.

The site primarily drains in a westerly direction, although the south eastern corner of the site drains to the south. The whole of the Moonlight site sits within quaternary catchment A50H (1945km^2) which is drained by the Lephalala river, which flows northwards to join the Limpopo river.

The Mean Annual Runoff (MAR) for the catchments associated with the proposed project was estimated using rainfall-runoff response parameters from WR2005. The rainfall-runoff response of the catchment was assumed to be the same as the regional rainfall-runoff response as determined for the quaternary catchment in which the project site falls. Using WR2005 quaternary catchments dataset, and an estimated 16.7km^2 of the site's runoff being contained, it expected that approximately 0.04207 million m^3 of the quaternary catchment's 4.9 million m^3 Mean Annual Runoff (MAR), will be held back. This accounts for 0.86% of the MAR for quaternary catchment A50H.

As part of the hydrological study, natural catchment design flows were estimated. For this purpose, six catchments were delineated which cover the site. These catchments are presented in Figure 2-1, while the peak flow estimates are presented in Table 2-5 below. Appendix A provides further information on the methodology used in the estimation of peak flows.

TABLE 2-5: DESIGN PEAK FLOWS FOR THE NATURAL CATCHMENTS

Catchment	Peak Flow (m^3/s) associated with RP						
	1in2	1in5	1in10	1in20	1in50	1in100	1in200
1	4.2	19.7	34.5	51.4	76.9	98.5	121.5
2	5.2	24.7	43.1	64.2	96.1	123.0	151.7
3	2.9	13.7	23.9	35.6	53.3	68.2	84.2
4	3.7	17.5	30.6	45.6	68.2	87.3	107.7
5	4.7	22.4	39.2	58.4	87.3	111.8	137.9
6	1.9	9.1	15.9	23.8	35.5	45.5	56.1

3 STORMWATER MANAGEMENT PLAN

The aim of this stormwater management plan is to fulfil the requirements of the National Water Act (Act 36 of 1998) and more particularly, Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704), which deals with the separation of clean and dirty water. This conceptual stormwater management plan will form a necessary part of the Integrated Water Use License Application (IWULA), to be submitted to the Department of Water Affairs (DWA). This stormwater management plan also complies with the principles of the IFC Environmental Health and Safety Guideline for Mining, the IFC Performance Standard 3 Pollution Prevention and Abatement Guideline and DWAF's Best Practice Guideline G1 for Stormwater Management.

3.1 DWAF GOVERNMENT NOTICE 704

GN 704 was established to provide regulations on the use of water for mining and related activities aimed at the protection of water resources. There are important definitions in the regulation which require understanding.

3.1.1 IMPORTANT DEFINITIONS

Some important definitions from GN 704 appropriate to this project include:

- **Clean water system:** This includes any dam, other form of impoundment, canal, works, pipeline and any other structure or facility constructed for the retention or conveyance of unpolluted water.
- **Dam:** This includes any settling dam, slurry dam, evaporation dam, catchment or barrier dam and any other form of impoundment used for the storage of unpolluted water or water containing waste (i.e. polluted water)
- **Dirty area:** This refers to any area at a mine or activity which causes, has caused or is likely to cause pollution of a water resource (i.e. polluted water)
- **Dirty water system:** This includes any dam, other form of impoundment, canal, works, pipeline, residue deposit and any other structure or facility constructed for the retention or conveyance of water containing waste.

3.1.2 APPLICABLE CONDITIONS

The two main principle conditions of GN 704 applicable to this project are:

- Condition 6 which describes the capacity requirements of clean and dirty water systems. Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these systems do not spill into each other more than once in 50 years

- Condition 7 which describes the measures which must be taken to protect water resources. All dirty water or substances which cause or are likely to cause pollution of a water resource either through natural flow or by seepage are to be mitigated.

3.2 CLEAN AND DIRTY WATER CATCHMENTS

In Figure 3-2, clean and dirty catchments have been delineated. For Moonlight it can be seen that there is only a small upstream clean water catchment area (Clean Water A and B) which will require diversion around the site. The dirty catchments are limited to the mine property and will require routing via channels/berms to a containment facility, all of which should be sized according to the appropriate regulations.

3.2.1 CLEAN CATCHMENTS

Flood peaks for the two clean water catchments (Clean Water A and B as illustrated in Figure 3-2) upstream of the site were determined using the Rational Method, selected to be the most appropriate method for these specific catchment characteristics. Details of the methodology are presented in Appendix A, while peak flow estimates for the Clean Water catchments are presented in Table 3-1.

TABLE 3-1: DESIGN PEAK FLOWS FOR THE CLEAN WATER CATCHMENTS

Catchment	Peak Flow (m^3/s) associated with RP						
	1in2	1in5	1in10	1in20	1in50	1in100	1in200
Clean (A)	3.2	4.9	6.4	8.1	11.1	14.2	16.0
Clean (B)	0.7	1.1	1.4	1.8	2.5	3.2	3.6

3.2.2 DIRTY CATCHMENTS

The area of works located to the west of the Moonlight site has been considered as a continuous dirty water generating area. This is due to the concentration of mine infrastructure including:

- Tailings Dam;
- Waste Dumps;
- Open Pit;
- Plant;
- Mining complex area;
- Haulroads; and
- Soil stockpile.

As per the guidance of GN704, these dirty water generating areas need to be managed appropriately. Furthermore, the storage/handling of fuel, lubricants and chemicals will require special attention due to their hazardous nature. These areas are therefore managed on impermeable floors with appropriate bunding and sumps.

The greater dirty water catchment area has been delineated into a number of subcatchments as illustrated in Figure 3-2. These subcatchments all drain to a section of proposed channel/berm diversion, which has been conceptually sited so as to capture runoff from the dirty water generating areas. Dirty water channels subsequently drain to dirty water containment areas. An east west catchment divide is present and was used as a line of division between drainage infrastructure.

The dirty water area also includes the open pit area, which should be able to store incident rainfall in later years once excavations go below daylight level. It is anticipated, however, that the open pit area will initially generate runoff that will escape into the environment if left unmitigated. For this reason, and due to the open pit position within the greater dirty water area, berms and channels were sized to accommodate runoff from the open pit area.

The following flood peaks as presented in Table 3-2 were calculated for the Dirty Water catchments using the Rational Method. Details of the methodology are presented in Appendix A.

TABLE 3-2: DESIGN PEAK FLOWS FOR THE DIRTY WATER CATCHMENTS

Catchment	Peak Flow (m^3/s) associated with RP						
	1in2	1in5	1in10	1in20	1in50	1in100	1in200
Dirty Central (A)	1.0	1.5	2.0	2.6	3.5	4.5	5.0
Dirty Central (B)	6.4	9.8	12.7	16.2	22.1	28.3	31.9
Dirty South (A)	3.0	4.6	5.9	7.6	10.4	13.2	14.9
Dirty South (B)	4.2	6.5	8.4	10.7	14.7	18.7	21.1

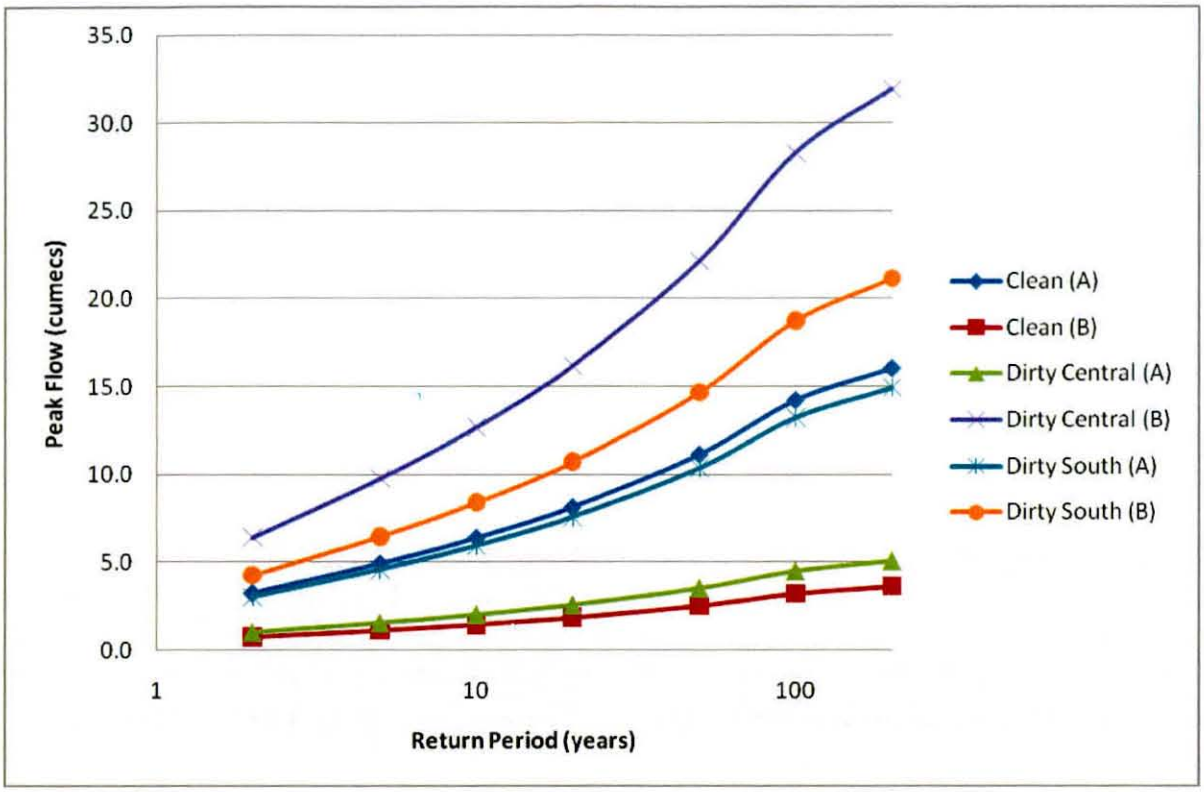

FIGURE 3-1: DESIGN PEAK FLOWS FOR THE CATCHMENTS OF INTEREST

3.3 STORMWATER MANAGEMENT INFRASTRUCTURE

Stormwater management infrastructure has been designed as per the requirements of GN 704. The layout of this infrastructure is illustrated in Figure 3-2. The dirty water containment facilities presented in the figure have been indicatively sized and positioned and do not represent final design.

3.3.1 CLEAN WATER DIVERSIONS

The stormwater management plan includes upstream clean water diversions (Clean Water A and B) which consist of both a berm and channel component (compacted earthfill). Clean water diversion berms are designed to divert upstream clean water around dirty water generating areas (i.e. intercepting clean water runoff and diverting this water around mining activities). These have been sized to cater for the 1:50 year flood event and will serve two main purposes:

- The channel section will divert upstream clean water which would otherwise flow into the identified dirty areas.
- The berm section will ensure containment of dirty water in dirty areas.

Figure 3-3 represents a typical clean water containment earth berm and channel as recommended by Metago. The berm component will be constructed from the material excavated from the channel and supplemented by topsoil stockpiling if required. The side slopes for all berms and channels will be kept constant at 1 vertical: 1.5 horizontal. The channel component has been sized using Manning's equation for trapezoidal channels to meet the requirements of the 1:50 year flood. A Manning's roughness coefficient of 0.035 was used in the calculations, associated with a cropped grass rocky channel.

In Figure 3-3:

- a = Channel Depth
- b = Channel base breadth

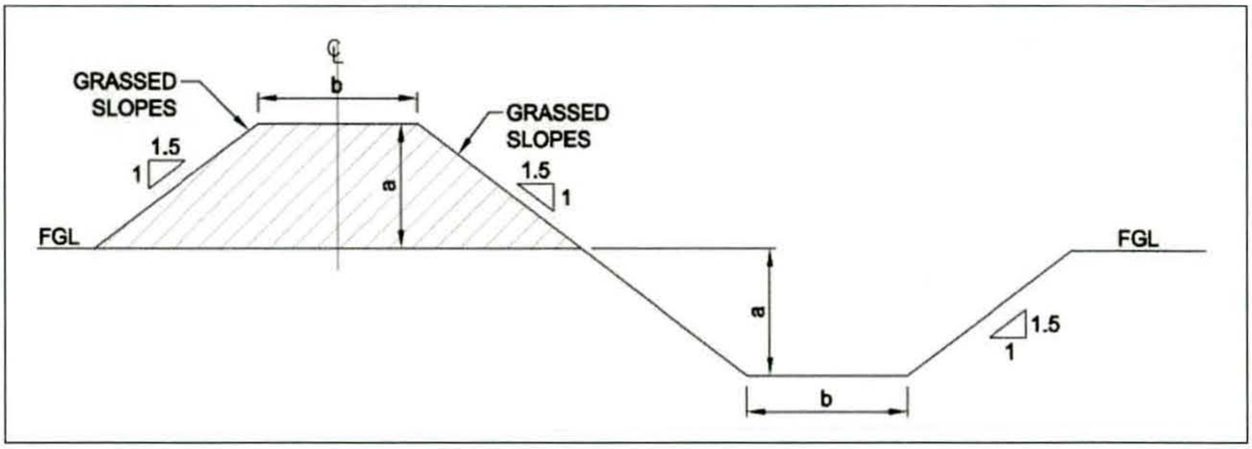

FIGURE 3-3: TYPICAL BERM AND CHANNEL FOR CLEAN STORMWATER DIVERSION SYSTEM

Table 3-3 presents the dimensions for each of the berms and channels associated with the clean water area.

TABLE 3-3: BERM AND CHANNEL DIMENSIONS FOR CLEAN STORMWATER CONTROLS

Catchment	a (m)	b (m)
Clean Water A	1.5	2.0
Clean Water B	0.9	1.3

3.3.2 DIRTY WATER CONTAINMENT (BERMS AND CHANNELS)

As per the clean water diversions, dirty water containment systems have been designed to ensure dirty water generated on the site is contained. These systems will also consist of a berm and channel component. In the event that seepage of pollutants into the soil profile and subsequent percolation into groundwater is significant and requires mitigation, then lining (e.g. concrete) of the affected dirty water channels may be necessary.

The berm and channel component have been designed to accommodate the 1:50 year flood and serve two main purposes:

- Diverting upstream clean water which would otherwise flow into the identified dirty areas.
- Contain dirty water in the identified dirty areas and direct towards the appropriate dirty water containment facility.

Figure 3-4 represents a typical dirty water containment berm and channel as recommended by Metago. The berm component will be constructed from the material excavated from the channel and supplemented by topsoil stockpiling if required. The side slopes for all berms and channels will be kept constant at 1 vertical: 1.5 horizontal. The channel component has been sized using Manning's equation for trapezoidal channels to meet the requirements of the 1:50 year flood. A Manning's roughness coefficient of 0.035 was used in the calculations, associated with a cropped grass rocky channel.

A channel design has not been included for the 'Dirty Water Area – North', since this forms part of the Tailings area, including the return water dam and associated drainage infrastructure. Designs for this area are presented in the Tailings Report (Preliminary Design of the Tailings Storage facility for the Proposed Moonlight Iron Ore Project, Project No. T020-04, Report No. 1, May 2011).

In Figure 3-4:

- a = Channel Depth
- b = Channel base breadth

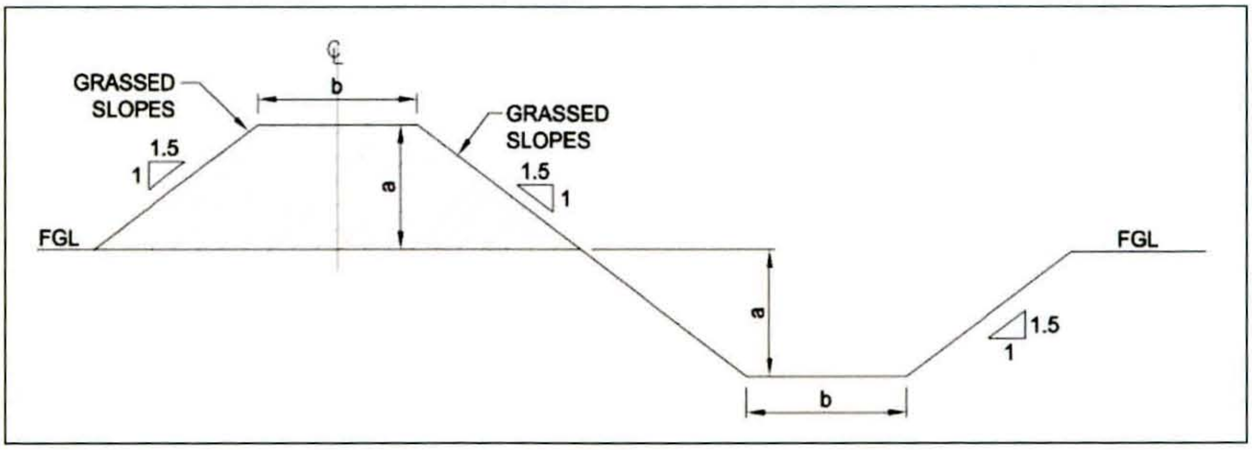

FIGURE 3-4: TYPICAL BERM AND CHANNEL FOR DIRTY STORMWATER DIVERSION SYSTEM

Table 3-4 presents the dimensions for each of the berms and channels associated with the clean water area.

TABLE 3-4: BERM AND CHANNEL DIMENSIONS FOR DIRTY STORMWATER CONTROLS

Catchment	a (m)	b (m)
Dirty Central (A)	1.0	1.2
Dirty Central (B)	1.5	6.3
Dirty South (A)	1.2	2.8
Dirty South (B)	1.2	5.0

3.3.3 DIRTY WATER CONTAINMENT (CONTAINMENT FACILITY)

Condition 6 of GN 704, deals with the capacity requirements of clean and dirty water systems, and states that clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these clean and dirty water systems do not spill into each other as a result of storm events below and including the 1 in 50 year event. A minimum freeboard of 0.8 m above full supply level must also be maintained as per the requirements of GN 704. Water accumulated in this containment facility during the wet season should be used as a priority in the process water circuit to ensure the capacity requirements are not compromised during periods of heavy/extended rainfall.

As with the channel and berm design for the 'Dirty Water Area – North', containment design associated with the return water dam has not been sized, but is presented in the Tailings Report (Preliminary Design of the Tailings Storage facility for the Proposed Moonlight Iron Ore Project, Project No. T020-04, Report No. 1, May 2011).

In this project, the capacity of the dirty water containment facility was calculated based on the summation of the 1:50 year design rainfall (24 hour) event for the catchment area **and** the highest monthly rainfall (January) falling over the catchment, **less** the corresponding monthly evaporation (January) taking place over the surface area of the proposed containment facility. Runoff coefficients used were determined according to the return period of interest, such that maximum monthly rainfall event was associated with a smaller runoff coefficient than the 1 in 50 year design rainfall event. The addition of any process water from mine operations has not been included in the sizing of these facilities.

Both the Central and South dirty water diversions are designed so as to route water into their own containment facility (Central and South containment facilities).

Containment has been sized with the assumption of a 2m effective depth. This has been done so as to estimate evaporative losses, however, in reality it is anticipated that containment depth will vary with the underlying topography.

Table 3-5 presents the volume requirements for a single dirty water containment facility.

TABLE 3-5: DIRTY WATER CONTAINMENT FACILITY VOLUME REQUIREMENTS FOR 1:50 YEAR FLOOD EVENT

Catchment	Volume (m^3)	Approximate Footprint (m^2)
Central Containment	284,761	142,400
South Containment	328,213	164,100

4 EXEMPTION FROM REGULATION 704

Various forms of disturbance to natural drainage will occur as a result of the mine. The primary disturbance will be from the open pit excavation, waste dumps, tailings dam and associated infrastructure, which present an environmental risk should pollutants from these areas enter the environment as a result of runoff. The absence of watercourses within the site boundary mean that works associated with the proposed mine will not intersect any defined watercourses.

Regulation 704 (Government Gazette 20118 of 4 June 1999), under the NWA, stipulates conditions for managing water on a mine. Dependant on the final mine plan, the exemptions required from this regulation could be as follows:

- Condition 5 – *"May not use any residue or substance which causes or is likely to cause pollution of water resource for the construction of any dam or other impoundment or any embankment, road or railway or for any other purpose which is likely to cause pollution of a water resource".*

  The construction of roads and containment facilities may require the use of waste rock, with potentially leachable pollutants.

5 CONCLUSION

Appropriate baseline information including rainfall data, evaporation data, return period rainfall depths and hydrological characteristics have been considered in a hydrological assessment and subsequent stormwater management plan for the Moonlight site. The Moonlight site is located within the headwaters of quaternary catchment A50H. This fact and the sites location in an arid region, result in the absence of any perennial or non-perennial watercourses within the site boundary.

As part of the conceptual stormwater management plan, appropriate flood hydrology calculations were used for the sizing of stormwater infrastructure. This stormwater management plan has been developed by first identifying clean and dirty areas and mitigating these areas with respect to the guidance provided by GN 704. Dirty water producing areas have been isolated by diverting all incoming clean water around them via clean water diversion berms. Water within dirty areas has been routed to dirty containment facilities via dirty water containment channels and berms. The channels, berms and containment facility have been designed based on the catchment area and the associated catchment characteristics and sized to contain the 1:50 year flood event.

It is recommended that a meteorological station measuring rainfall and evaporation at a minimum, be installed on site.

Finally, it is likely that exemptions from GN704 relating to the disposal and use of mine residue or substance, will be required.

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(Project Author)	(Project Reviewer)	(Project Author)

Metago Environmental Engineers (Pty) Ltd

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APPENDIX A: PEAK FLOW ESTIMATES

METHODOLOGY

The Rational Method was used for the calculation of peak flow estimates in order to appropriately size **drainage infrastructure**. The Rational Method was used for this purpose. This method was selected to be the most appropriate since by using it, a combined approach could be implemented whereby flow in the headwaters of the subcatchment could be calculated assuming dominant overland flow regime, while in the lower reaches, flow could be calculated with channel flow as the dominant regime. Furthermore, a spreadsheet based implementation of the Rational method allows for the inclusion of RLMA&SI depth-duration-frequency (DDF) estimates.

Natural catchments draining from the Moonlight site were also assessed with regards to their peak flows. However, unlike the peak flow estimates for drainage infrastructure, the Rational Method was not used. Rather the Standard Design Flood (SDF) method was selected, and implemented using the SANRAL drainage design software. The reason for the difference in methodologies between peak estimation for the natural catchments and the catchments associated with drainage infrastructure, is due to the size of the contributing catchments. The Rational Method is only recommended for catchments up to a size of 15km^2. Of the 6 natural catchments modelled, 3 had catchments over 15km^2. In order to maintain a consistent approach, the SDF method was exclusively applied to all 6 natural catchments.

MODEL INPUTS

Rational Method

The spreadsheet implementation of the Rational Method as applied in this project, is based upon the approach adopted in the Drainage Manual (SANRAL, 2006).

While the Rational method is a simplistic method of peak flow estimation, a modification to the method, which includes a composite estimation of the runoff coefficient, allows for the influence of slope, soil permeability, vegetation and land cover (e.g. residential houses or heavy industry) to be considered. Furthermore, the time of concentration is explicitly calculated, enabling a more realistic estimation of the DDF design rainfall event.

SDF Method

The SDF is a method which uses calibrated discharge parameters based on historical data for 29 homogeneous catchments covering South Africa. The SDF method is a 'black box' approach whereby basic catchment information is input, with peak flow estimates subsequently being derived from the observed rainfall runoff response of the parent catchment. Catchment information required includes the catchment area, river lengh, 10-85 height difference and the homogeneous catchment classification number. Since the catchments of interest as presented in Figure 2-1 extend beyond the boundaries of the LiDAR survey provided, it was necessary to supplement the topographic data with ASTER data. The ASTER GDEM is a product of METI and NASA. In order to maintain a consistent approach, the elevation data extracted for the application of the SDF method, made sole use of the ASTER data.

CATCHMENT CHARACTERISTICS

Catchments modelled in this study, are illustrated in Figure 2-1 and Figure 3-2

For each of the catchments draining to a channel, and subsequently a containment facility, catchment parameters were determined such that the Rational Method could be implemented. The runoff coefficient was estimated by assessing datasets detailing the relevant subcatchment characteristics as listed in Table A-1. The Rational Method as applied in the project also takes into account the return period of the rainfall event, such that a greater proportion of incident rainfall is transformed into runoff for higher return periods. This simulates the saturation of soils that would occur as a result of higher rainfall events.

The landcover of the catchments to be modelled was noted to be largely natural, and consequently a generic proportion of 20% light bush and farmlands and 50% grasslands and 30% no vegetation was used for all catchments. Soils were similarly grouped into 10% very permeable, 30% permeable, 50% semi permeable and 10% impermeable. Although soils on site are sandy to sandy loams, the anticipated thickness of the soil profile, and the amount of fragmented rock in the profile mean a less permeable surface was modelled.

TABLE A-1: RECOMMENDED VALUES FOR RUNOFF FACTOR (SANRAL, 2006)

Rural (C_1)					Urban (C_2)	
Component	Classification	Mean annual rainfall (mm)			Use	Factor
		< 600	600 - 900	> 900		
Surface slope (C_s)	Vleis and pans (<3%)	0,01	0,03	0,05	*Lawns*	
	Flat areas (3 to 10%)	0,06	0,08	0,11	- Sandy, flat (<2%)	0,05 - 0,10
	Hilly (10 to 30%)	0,12	0,16	0,20	- Sandy, steep (>7%)	0,15 – 0,20
	Steep areas (>30%)	0,22	0,26	0,30	- Heavy soil, flat (<2%)	0,13 – 0,17
					- Heavy soil, steep (>7%)	0,25 – 0,35
Permeability (C_p)	Very permeable	0,03	0,04	0,05	*Residential areas*	
	Permeable	0,06	0,08	0,10	- Houses	0,30 – 0,50
	Semi-permeable	0,12	0,16	0,20	- Flats	0,50 – 0,70
	Impermeable	0,21	0,26	0,30		
					Industry	
					- Light industry	0,50 – 0,80
Vegetation (C_v)	Thick bush and plantation	0,03	0,04	0,05	- Heavy industry	0,60 – 0,90
	Light bush and farm lands	0,07	0,11	0,15	*Business*	
					- City centre	0,70 – 0,95
	Grasslands	0,17	0,21	0,25	- Suburban	0,50 – 0,70
	No vegetation	0,26	0,28	0,30	- Streets	0,70 – 0,95
					- Maximum flood	1,00

DEPTH-DURATION-FREQUENCY RAINFALL

Design rainfall depths associated with each catchment were required to be determined. These rainfall depths had to be determined through a depth-duration-frequency approach. This approach requires that both *duration* and *frequency* of rainfall be determined in order to arrive at a design rainfall *depth*. Frequency direcly relates to the RP of the event. *Duration* is defined through the estimation of the critical storm duration for each subcatchment, estimated by calculating the time of concentration (TC) for individual subcatchments. TC was calculated through the application of the TR-55 methodology. This methodology improves on other empirical estimates of TC, through the division of a catchment into 3 primary flow processes of sheet flow, shallow concentrated flow and open channel flow. This subdivision enables the application of an empirical method particular to a specific flow process, in contrast to the single primary flow approaches which have traditionally been used in the past.

With TC, and thereby the design rainfall duration calculated, subcatchment specific critical storm depths for return periods of interest were derived from the output of the RLMA&SI method as implemented in the Design Rainfall for South Africa software (Smithers and Schulze, 2002). The RLMA&SI methodology provides an average estimate, lower estimate and upper estimate. Seeing as the application of the average estimates are most easy to validate (in that they are neither of the two extremes) and that the average RLMA&SI estimate exceeded the HRU estimates, it was decided that the average RLMA&SI estimate would be used.

Table A-2 presents the inputs derived for application as part of the Rational Method, while Table A-3 presents the catchment characteristics of the natural catchments as applied in the SDF methodology.

TABLE A-2: STORMWATER CATCHMENT CHARACTERISTICS

Description	Catchment					
	Clean		Dirty			
	Clean (A)	Clean (B)	Central (A)	Central (B)	South (A)	South (B)
Subcatchment Area (km^2)	3.76	0.41	0.65	4.62	2.83	3.34
Runoff Coefficient for the 1 in 100 year event	0.26	0.26	0.29	0.29	0.29	0.29
Time of Concentration (min)	131	38	58	71	115	83
Rainfall Intensity (mm/h) for the 1 in 100 year event	52	108	85	76	58	69

TABLE A-3: NATURAL CATCHMENT CHARACTERISTICS

Description	Catchment					
	1	2	3	4	5	6
Subcatchment Area (km^2)	21.74	24.55	12.71	13.05	31.20	8.54
River Length (km)	7.52	7.8	5.87	5.0	9.10	6.96
10-85 height difference (m)	25	40	21	27	21	34

PEAK FLOW ESTIMATES

Rational Method

The calculated rainfall depths were subsequently converted into rainfall intensities (mm/hr), which through the inclusion of a subcatchment specific runoff coefficient, and subcatchment area (km^2) enabled the application of the Rational Method:

Rational Method

$$Q_T = 0.278\ C\ I\ A$$

Where:

- Q_T = Peak Flow (m^3/s for specific return period)
- C= Runoff Coefficient (%)
- I = Rainfall Intensity (mm/hr)
- A = Area (km^2)

The resulting peak flows are presented in Table A-4 and Figure 3-1.

TABLE A-4: DESIGN PEAK FLOWS FOR STORMWATER INFRASTRUCTURE SIZING

Catchment	Peak Flow (m^3/s) associated with RP						
	1in2	1in5	1in10	1in20	1in50	1in100	1in200
Clean (A)	3.2	4.9	6.4	8.1	11.1	14.2	16.0
Clean (B)	0.7	1.1	1.4	1.8	2.5	3.2	3.6
Dirty Central (A)	1.0	1.5	2.0	2.6	3.5	4.5	5.0
Dirty Central (B)	6.4	9.8	12.7	16.2	22.1	28.3	31.9
Dirty South (A)	3.0	4.6	5.9	7.6	10.4	13.2	14.9
Dirty South (B)	4.2	6.5	8.4	10.7	14.7	18.7	21.1

The peak flows estimates for catchments 1 to 6 are presented in Table A-5

TABLE A-5: DESIGN PEAK FLOWS FOR THE NATURAL CATCHMENTS

Catchment	Peak Flow (m^3/s) associated with RP						
	1in2	1in5	1in10	1in20	1in50	1in100	1in200
1	4.2	19.7	34.5	51.4	76.9	98.5	121.5
2	5.2	24.7	43.1	64.2	96.1	123.0	151.7
3	2.9	13.7	23.9	35.6	53.3	68.2	84.2
4	3.7	17.5	30.6	45.6	68.2	87.3	107.7
5	4.7	22.4	39.2	58.4	87.3	111.8	137.9
6	1.9	9.1	15.9	23.8	35.5	45.5	56.1

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APPENDIX K: GEOHYDROLOGICAL STUDY

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Hydrogeological Investigation and Impact Assessment for the Proposed Moonlight Iron Ore Mine

Prepared For

Turquoise Moon Trading 157 (PTY) Ltd

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This report summarises the hydrogeological investigation conducted in support of the Environmental Impact Assessment (EIA) being prepared by Metago Environmental Engineers for the Turquoise Moon Trading 157 (PTY) Ltd Moonlight iron ore operation. The intrusive investigation included two hydrocensus runs, ground geophysics, drilling of boreholes, pumping tests and the development of a regional groundwater flow model to predict the impact of mining operations on the groundwater environment. The study wasn't limited to the proposed mining site and hydrogeological, geological and rainfall data was analysed for an area of approximately 5 400 km^2.

The Moonlight iron ore deposit to be mined is underlain by crystalline basement aquifers of the Limpopo Mobile Belt. Hydrogeological investigations conducted in the larger Moonlight study area suggest highly heterogeneous conditions associated with the underlying weathered/fractured basement rock aquifer. Generally hydraulic conductivities are low, and borehole yields are likely to be less than 1 l/s for the majority of boreholes, however, yields of more than 5 l/s is not uncommon along the major surface water drainages and in the Baltimore and Tolwe area. These higher yielding boreholes may be associated with more extensive fracture systems in the deeper aquifer, or hydraulically linked to surface water sources in the shallow aquifer. Groundwater is used almost exclusively for domestic purposes, stock-watering and game ranching, although large scale irrigation from boreholes do occur in selective regions. In some areas declining water levels have been noted since the early 1950s and recent observations suggest that the drop in water levels may be attributed to over-abstraction in addition to below average rainfall years. Groundwater resources within the study appear to be heavily utilised but is limited to areas of large scale irrigation.

Based on the water level dataset collated, groundwater flows from higher lying ground towards lower lying ground and is generally towards the major river systems. Despite a relatively thick weathering zone (≈ 50 m), the proposed site is characterised by deep water strikes (> 60 m), which results in a thin saturated weathered/fractured rock overlying a semi-confined fractured bedrock aquifer. As a result two main aquifer types exist in the project area: an upper more permeable weathered/fractured rock aquifer and a deeper less permeable fractured bedrock aquifer.

A number of groundwater samples taken from boreholes in the vicinity of the mining project site during the investigation suggest acceptable drinking water quality limits. However, numerous samples exceed maximum allowable drinking limits due to elevated nitrates (NO_3 as N). In addition, several samples show major ion concentrations (e.g. Na, Cl) and subsequently electric conductivities beyond acceptable limits. This can mostly be related to the low recharge values leading to prolonged residence and fluid-rock interaction times in the subsurface. Groundwater contaminants may travel relatively quickly in the upper weathered/fractures zone with permeability ranges of 0.05 to 1 m/d, but considerably more slowly in the underlying fractured bedrock with permeability ranges of 0.001 to 0.1 m/d.

Eight lateral hydraulic conductivity zones were incorporated into the three layer numerical groundwater flow model. Calibrated hydraulic parameters were related to the pumping test result and literature values. The regional steady-state groundwater contours are as expected closely related to the topography, and groundwater flows from higher lying ground towards lower lying areas. The influence of the Melinda fault on the groundwater contours is clearly evident. The less permeable gneisses north of the fault zone result in a slight retardation of flow, and flow is enhanced in the orientation of the fault zone. The Melinda Fault is recharged mainly via the Waterberg Group sandstones to the south, upstream of the proposed Moonlight operation. Groundwater flow from the centre of the modelled domain is away to the east and west of the hydraulic groundwater divide (more or less to the east of the surface water divide).

The regional groundwater model was used to estimate pit inflows and to determine the extent of the drawdown depression. The impact of the modelled inflow rate of ~8 L/s (~690 m^3/d) due to dewatering for the open pit seem to be limited to an approximate 3 km radius of the Moonlight site after life of mine (30 years). Although a pit-lake study wasn't performed, it is predicted that the water level in the pit will slowly rebound but will not reach the pre-dewatering level due to evaporation eventually exceeding inflow. It is expected that the potential impacts of the pit inflows on the regional groundwater flow are:

- Highly likely to occur.
- Widespread and will impact beyond the site boundaries.
- Of moderate severity with potential loss of discharge and regional groundwater flow for the affected catchment. However, higher recharge rates expected from the TSF and WRDs sites can reduce the extent of the drawdown depression.
- Yields of boreholes and wells of groundwater users located in the zone of pit dewatering could be negatively impacted and some may dry up during the life of mine.
- Reversible over time once pit dewatering stops.

A contaminated groundwater plume is not expected to extend beyond the site boundaries as the open pits will act as long term groundwater sinks and will therefore "capture" contaminated groundwater emanating from the tailings storage facility (TSF) and waste rock dumps (WRD). The potential impacts associated with the TSF and WRD on the ambient groundwater quality are:

- Highly likely to occur.
- Localised within site boundaries and of minor severity.
- Long-term beyond closure with moderate increases of pollutant concentrations.
- The intensity of the impact is a minor to moderate deterioration of the ambient groundwater quality within the site boundary.

Due to the inherent heterogeneity of the aquifer, a low to medium confidence has been assigned to the numerical groundwater model. Monitoring of groundwater levels and groundwater quality during and after mine operation will help to verify the model predictions, and are strongly recommended.

MOONLIGHT HYDROGEOLOGICAL INVESTIGATION AND IMPACT ASSESSMENT

1 INTRODUCTION

1.1 SCOPE OF WORK

Metago Water Geosciences was contracted by Metago Environmental Engineers to develop a site specific groundwater flow and contaminant transport model for the potential impact of the Moonlight mining operations may have on local groundwater resources. The proposed Moonlight operation is situated approximately 45 km northeast of Lephalale on the farms Gouda Fontein, Julietta and Moonlight within the Limpopo Province.

In a previous report, Water Geosciences Consulting (cc) presented a baseline groundwater study of the Moonlight mining area, which included an assessment on water supply options required for the mining operations. As part of the Environmental Impact Assessment a more comprehensive hydrogeological investigation is required. This report presents the details of the hydrogeological field investigation carried out between January and May 2011 and describes the numerical modelling undertaken. The investigation focused mainly 1) on establishing the impact on groundwater resources caused by the dewatering of the opencast mine workings, and 2) to predicted the movement of potential pollutants from the tailings storage facility (TSF) and associated waste rock dumps (WRD). Accordingly the study objectives include:

- Characterise the aquifers underlying the region;
- Determine the static water level depth;
- Determine the base line groundwater quality;
- Recommendations for future investigations in order to refine model predictions.

In order to achieve the objectives the following investigations was necessary:

- Assessment of existing reports and available information;
- Collection of hydrocensus data of existing boreholes located within and surrounding the proposed mining area (an approximate 15 km radius);
- Collection of all national and provincial borehole databases within the larger study area (60 x 90 km) was collated and used for the regional description of groundwater resources.
- A geophysical survey run within the project area aimed at identifying drilling positions to allow confirmation of the depth to groundwater at the proposed TSF site and open pit;
- Drilling of 12 exploratory/test/monitoring boreholes aimed at providing direct field data (geological, water strike and aquifer information);
- Hydraulic testing of selected boreholes to determine the aquifer parameters; and
- Collection of groundwater samples from successful boreholes to augment the baseline groundwater quality assessment.

1.2 DATA SOURCES, DEFICIENCIES AND AVAILABLE LITERATURE

The field data collected is essential inputs to assist with the groundwater flow and contaminant transport impact assessment modeling. Additional data sourced include regional borehole datasets such as the National Groundwater Archive (NGA) and the Limpopo Groundwater Resource Information Programme (GRIP) maintained by the Department of Water Affairs. However, the NGA dataset is often outdated and requires verification. In contrast the GRIP dataset was implemented and initiated in 2002 and the majority of these boreholes have been verified in the field. Unfortunately due to the difficulty in obtaining data from private groundwater users (i.e. agricultural sector) the dataset covers mainly rural communal land of the Limpopo Province, where groundwater supplies is being developed on a daily basis.

Although, no prior impact assessment or predictive modeling was undertaken for the study area, numerous historic groundwater investigations under the auspices of the former directorate geohydrology of the Department of Water Affairs was conducted for the Beauty and Swartwater areas, west and north of the proposed Moonlight mining operation respectively. These studies conducted in the early 1980s were mainly to aid in the siting of successful boreholes in the light of the periodic occurrence of severe water shortages in these areas. A more recent assessment of the NGA borehole dataset was conducted by Vegter (2001) on the Limpopo Granulite-Gneiss Belt groundwater region. In this report data of boreholes drilled into rocks of the Limpopo Mobile Belt have been analysed statistically in terms of water level frequency, water strike frequency below surface and below water level, cumulative borehole depths, water level and water strike frequencies and yield - strike depth relationship.

The following information and data made available to the project team or gathered as part of the data compilation phase include:

- 1:250 000 Geology Map sheets (2326 and 2328) (Council for Geoscience).
- 1:500 000 Hydrogeological Map sheet (2326 Polokwane).
- 25 m digital elevation model (National Geo-Spatial Information) and the site specific 1m Lidar elevation survey.
- 1:50 000 digital topographic data (raster and vector data) (National Geo-Spatial Information).
- Digital pit, WRD and TSF layouts including estimated TSF leakage rates provided by Metago Environmental Engineers.

2 DESCRIPTION OF STUDY AREA

2.1 LOCALITY AND TOPOGRAPHICAL SETTING

The proposed Moonlight mining operation is located along the N11 between Mokopane (Potgietersrus) and the Botswana border, near to the town of Marnitz, and approximately 60 km north and 145 km north-west of Lephalale (Ellisras) and Polokwane, respectively (Figure 2.2). The study area includes quaternary catchments A50H and A63A up to the Lephalala- and Mogalakwena Rivers. In the vicinity of the Moonlight project area the topographic watershed rises to 950 metres above mean sea level (mamsl) and reduces to approximately 750 to 800 mamsl along the major Rivers (Figure 2.1). The topography is generally flat to rolling, with the Palala Granite inselbergs, the Koedoesrand formation and the Waterberg Group towards the south as main topographic features (Figure 2.2, Photo 2.1).

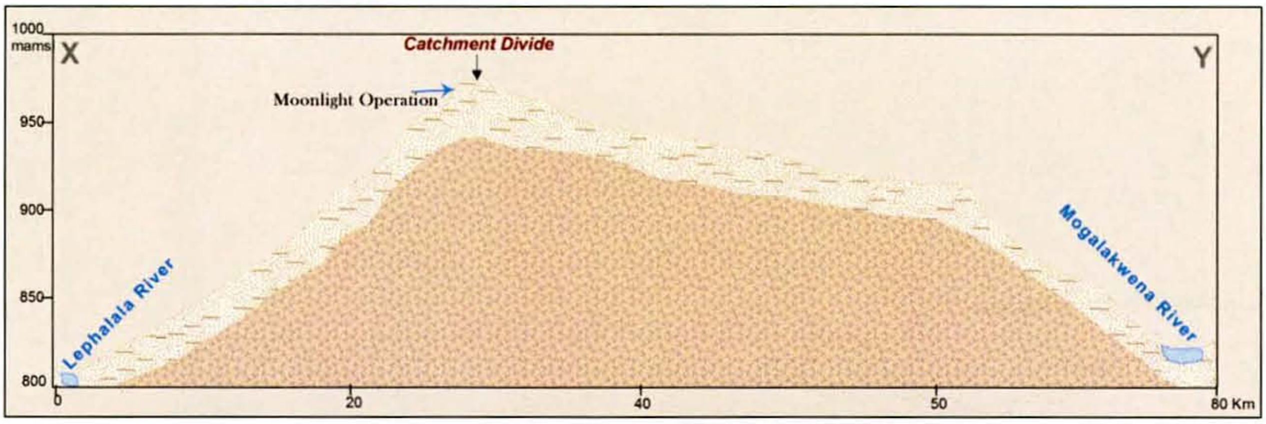

FIGURE 2.1: TOPOGRAPHICAL PROFILE FROM WEST TO EAST (SECTION X-Y IN FIGURE 2.2)

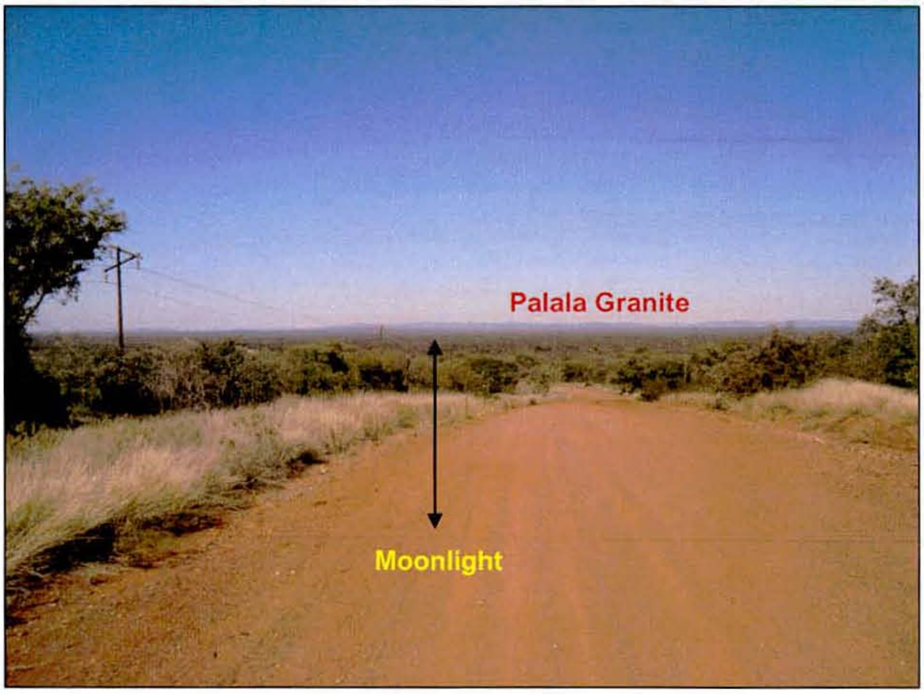

PHOTO 2.1: PHOTO TAKEN FROM MOONLIGHT TOWARDS THE SOUTH, SHOWING THE TOPOGRAPHIC FEATURES.

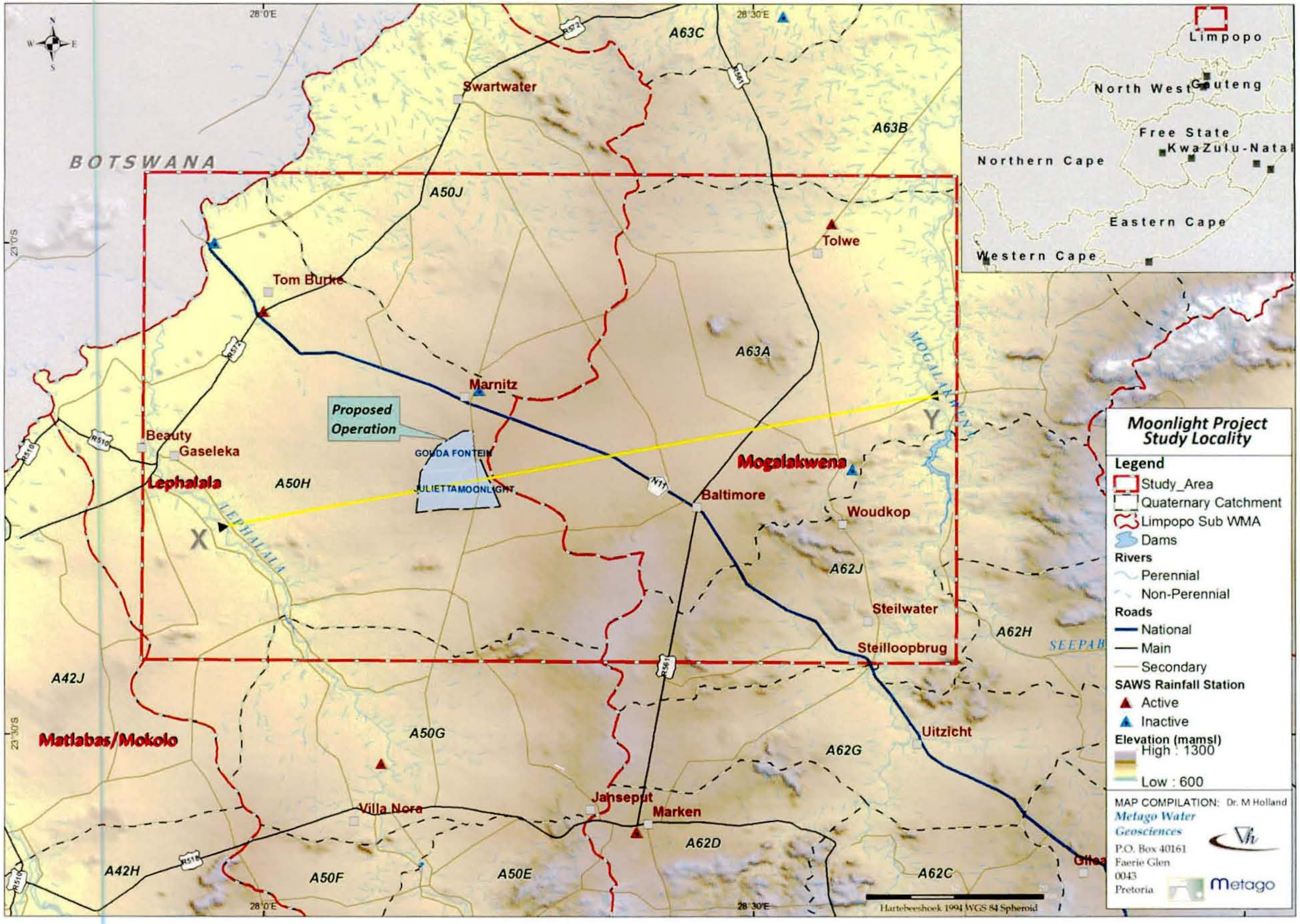

FIGURE 2.2: LOCATION OF THE PROPOSED MOONLIGHT OPERATION.

The study area is virtually devoid of surface water drainages suggesting a dominant overland flow regime as opposed to channel flow (Figure 2.1). The major rivers of importance for the study area are the Mogalakwena- and Lephalala Rivers, which together with some smaller tributaries, all flow northwards into the Limpopo River.

2.2 RAINFALL AND EVAPORATION

The region is characterised by semi-arid temperatures with dry, warm winters and hot summers. Mean annual rainfall varies from between 400 mm in the vicinity of Beauty in the west to about 500 mm in the southeast. Three monthly rainfall stations in the vicinity of the Moonlight project area were obtained from the South African Weather Services (SAWS) for this study. The mean monthly rainfall values for Marken, Tolwe and Tom Burke is illustrated in Table 2.1.

TABLE 2.1: RAINFALL DATA FOR SELECTED STATIONS DISTRIBUTED WITHIN THE MOONLIGHT STUDY AREA.

Nr*	Station*	*Start Date*	Annual Rainfall (mm)		*Elevation (mamsl)*
			Mean	*Median*	
0763149	**Tolwe**	1969	388	384	850
0721665	**Marken**	1993	386	416	990
0718874	**Tom Burke**	1960	403	387	810
A5E001	**Marnitz#**	1956	419	426	958

*- South African Weathers Services.

- Department of Water Affairs rainfall station (Closed in 1980).

Rainfall occurs mainly in summer, (i.e. October to March) but tends to be highly erratic (Figure 2.3). Below long term average rainfall occurred throughout the last two decades which emphasises the potential for drought. The low and variable rainfall together with evaporation rates (2 000 mm) considerably exceeding rainfall result in a low expectation of natural recharge to groundwater. According to Vegter (2000) the requirements to qualify as a major recharge season, is a seasonal rainfall of greater than 500 mm of which at least 300 mm must fall within a period of 2 months or 400 mm within 4 months.

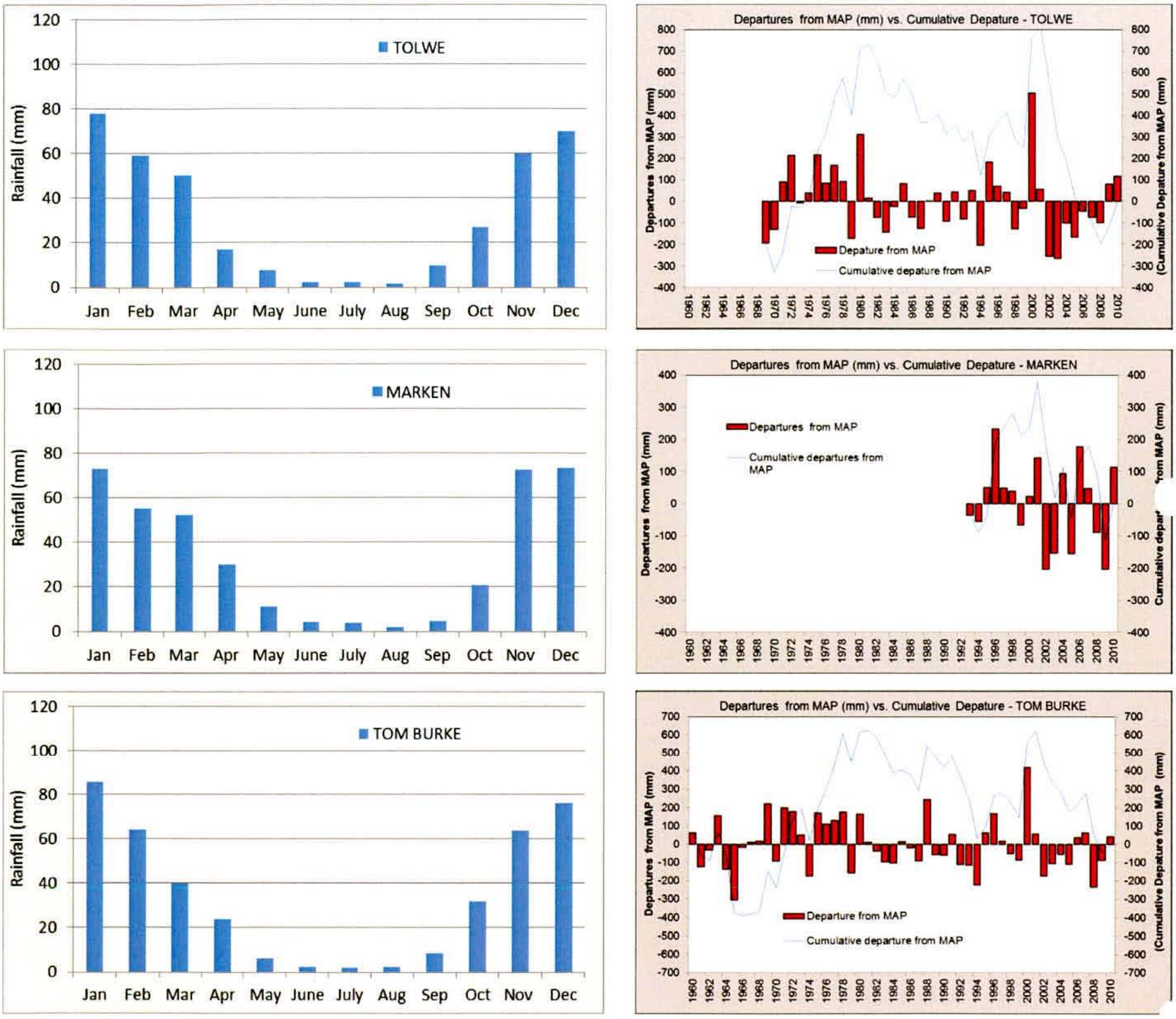

FIGURE 2.3: MONTHLY AVERAGE RAINFALL AND DEPARTURES FROM THE MEAN ANNUAL RAINFALL (ACTIVE STATIONS).

2.3 GEOLOGY

The Moonlight project area is underlain by rocks of the Archaean age Beit Bridge Complex, comprising mainly of gneiss, granulite, quartzite and marble. The iron ore to be mined occurs mainly in coarse-grained magnetite within the well-developed mineral layered metapelitic migmatitic gneisses of the Mount Dowe Group (Figure 2.4). The study area lies north of the junction between the highly metamorphic rocks of the Central zone of the Limpopo Mobile Belt and the Waterberg Group Strata overlying the Kaapvaal Craton (Figure 2.5). The Limpopo Mobile belt is truncated by large E-W trending faults (e.g. Melinda Fault) with younger cover rocks (e.g. Waterberg Group) and the northern lobe of the Bushveld Complex on the down faulted side of the fault.

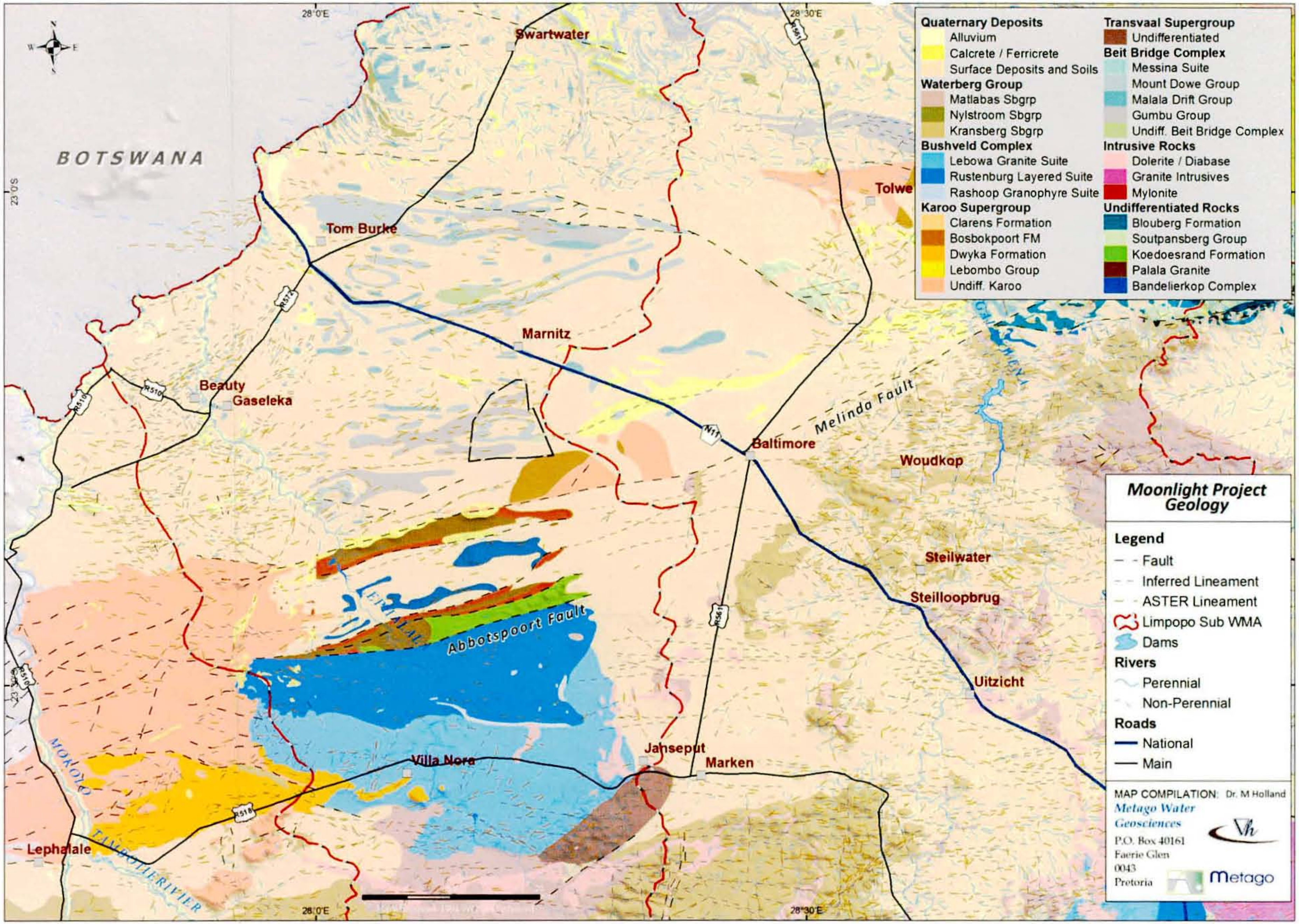

FIGURE 2.4: REGIONAL GEOLOGY OF THE STUDY AREA.

South of the Limpopo Mobile Belt the Waterberg Group sandstones overlies predominantly Nebo Granite of the Lebowa Granite Suite and covers most of the south western quadrant of the region. Upper Karoo strata lie unconformably on the Limpopo Mobile Belt gneisses southeast of the study but occur more extensively towards the southwest overlying the Waterberg Group and the Busheld Complex (Figure 2.4).

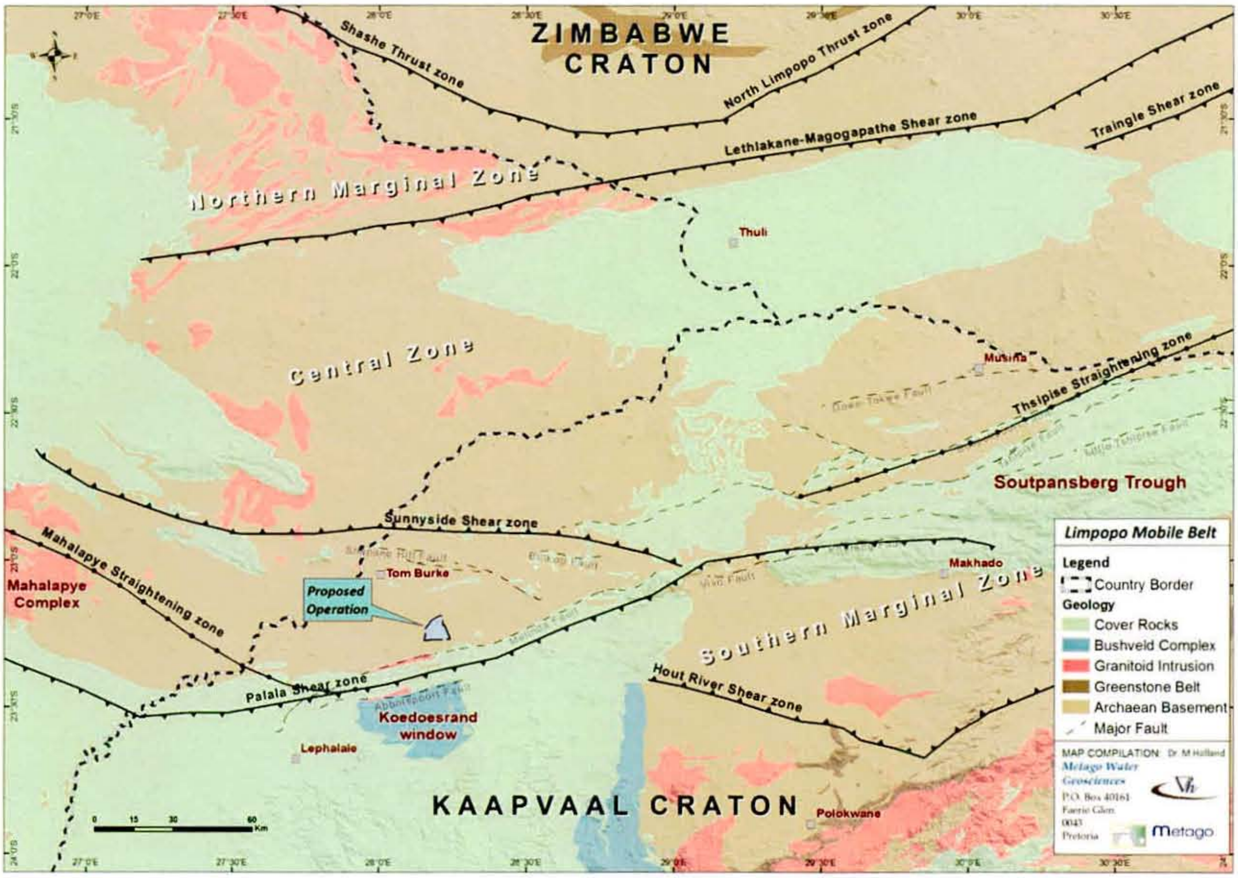

FIGURE 2.5: GENERALISED MAP OF THE LIMPOPO MOBILE BELT SHOWING THE MAIN FEATURES AND SUBDIVISIONS.

The southern margin of the Central Zone of the Limpopo Mobile Belt is bound by the Palala Shear zone (Figure 2.5). The Palala Shear Zone is a 12 km belt of near vertical ultramylonite and mylonite, trending ENE. The shear zone is exposed for approximately 30 km. The northern boundary has been reactivated by a brittle fault zone known as the Melinda Fault. South of the Koedoesrand Formation the Abbotspoort Fault is the southernmost well-defined portion of the Palala shear zone and has affected the Bushveld related Palala Granites. The Sunnyside shear zone is associated with E-W striking structures and appears to be a tectonic boundary, north of the Mahalapye complex (Kramers et al., 2006). Faults parallel to this trend are the Shapane Hill Fault which extends from Tom Burke in the west to the south of Tolwe and the less extensive Bulkop Fault cutting through the younger Karoo strata.

Major east to north-easterly trending zone of shearing and faulting are present in the Limpopo Mobile Belt, as is revealed by the presence of a number of extensive regional inferred lineaments as well as local lineaments (Figure 2.4). It is important to note that these shear zones (e.g. the Sunnyside shear zone) are regional ductile deformation zones tens of kilometres wide, that develop at great depth and are not primarily related to current near-surface fracture networks which provides the permeability for groundwater flow in crystalline rocks. If however, a sliding movement has occurred along the shear plane and caused crushing of the rock into a breccia or brittle mylonitic rocks (e.g. amphibolite); this will increase the chances for ground water to be collected in the shear zone.

On the other hand, fracturing and fissuring in the near surface may occur at or close to lithological contacts for instance, between the major intruded plutons, along contact zones of dykes or sills and in fault zones. Fracture systems may be further caused by surface decompression and by tension or compression depending on the regional stress field. As a result fracture zones or faults can develop in a variety of orientations relative to the regional tectonic stresses, however, fractures or lineaments are not universally conductive features. In many cases, the relationship between lineaments and subsurface permeability is unresolved (Mabee, et al., 2002; Sander, 2007). In impermeable rocks the ground water yield is entirely dependent on the rate of infiltration in the faults and fractures. This, in turn, depends on whether formed by the accumulation of large shear strain the fractures are open or tight. A tight fracture contains no water, while an open one may produce a considerable yield of groundwater.

3 CONCEPTUAL MODEL DEVELOPMENT

3.1 GROUNDWATER PERSPECTIVE

Based on the 1:500 000 hydrogeological map sheet (2326 Polokwane), the aquifer is classed as a minor intergranular and fractured aquifer with potential groundwater yields between 0.1 and 2 l/s (Du Toit et al. 2003). Hydrogeological findings by Bush (1989) in the Swartwater area revealed that 66 % of boreholes surveyed had yields below 1 l/s. Vegter (2000) indicated that only 19 % of boreholes recorded yielded more than 1 l/s in an area east of Beauty. This area was also identified by the Geological Survey (Council for Geoscience) in the late 1940s as a problem groundwater area, in terms of yields and drilling success rates (Bush, 1989). Investigations in the late 1980s revealed that when drilling in areas adjacent to major rivers reasonable success rates were achieved, however, away from these rivers even with the application of various geophysical exploration tools would not guarantee the siting of successful boreholes. Based on historical drilling results it's clear that groundwater yields are generally low with some farms having no independent water supply and rely on piped water from adjacent farms. Based on the aquifer classification map (Parsons and Conrad, 1998) the majority of study area is regarded a "minor aquifer" while the aquifer underlying the proposed Moonlight project area is regarded as "poor" (Figure 3.1). A summary of the classification scheme is provided in Table 3.1. In this classification system, it is important to note that the concepts of Major, Minor and Poor Aquifers are relative and that yield is not quantified. Within any specific area, all three classes of aquifers should therefore, in theory, be present.

TABLE 3.1: AQUIFER CLASSIFICATION SCHEME (PARSONS, 1995; PARSONS AND CONRAD, 1998).

Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources, should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality water.
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilised for water supply and that will not contaminate other aquifers.
Special aquifer region	An aquifer designated as such by the Minister of Water

In the vicinity of the proposed project area, groundwater is used almost exclusively for domestic purposes, stock-watering and game ranching (and could be classified as a sole source aquifer), although large scale irrigation from boreholes takes place in the east towards Baltimore and Tolwe (suggesting a major aquifer). According to Holland (2011) these are exceptionally high yielding areas not known anywhere else in Africa within the basement aquifer system. These aquifers have sustained large scale irrigation for the last few decades, however, seeing that abstraction rates far exceed vertical recharge rates which amount to a few millimetre of the 400 mm annual rainfall, the sustainability of large scale