GALAGO ENVIRONMENTAL

Fauna and Flora Specialists

PO Box 886
Irene, 0062
Tel: 012-345 4891
Fax: 086 675 6136
Email: Vanessam@lantic.net

Flora Assessment

of

MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT (MCWAP): PHASE 1

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Report edited by: Ms. Vanessa Marais of Galago Environmental
Report author: Dr. J.V. Van Greuning, (Pri. Sci. Nat: D.Sc)

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1. INTRODUCTION

Galago Environmental CC was appointed to undertake a botanical study along the proposed route for the Mokolo and Crocodile Water Augmentation Project pipeline - phase 1. The objective of the study was to delimit and map plant communities along the proposed pipeline route and to list the plant species occurring in each community. Special attention was paid to the presence or possible presence of Red Data species, Orange Listed species, alien species and medicinal species. The current ecological status and the conservation priority of the vegetation on the site were assessed.

2. OBJECTIVES OF THE STUDY

- To assess the current habitat and conservation status on the study site.
- To list the species on the site and to recommend necessary actions in case of occurrence of endangered, vulnerable or rare species.
- To highlight potential impacts of the development on the vegetation of the pipeline route.
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. SCOPE OF STUDY

- All plant species discernable at the date of the survey are listed.
- Medicinal and alien species are indicated with symbols in the tables.
- The ecological sensitivity and conservation priority of the vegetation are evaluated.
- Measures to minimize the negative impact of development on the vegetation are suggested.

4. STUDY AREA

The proposed pipeline route is located in several quarter degree grid cells ranging from Steenbokpan in the west to Lephalale in the east and then south to Mokolo dam (Figure 1). It extends from west to east over the Limpopo Sweet Bushveld and Waterberg Mountain Bushveld up to the Central Sandy Bushveld in the south.

The Limpopo Sweet Bushveld extends from the Crocodile and Marico rivers down the Limpopo river valley into the tropics past Tom Burke. The landscape features plains, some areas undulating or irregular with thickets of *Acacia erubescens, Acacia mellifera* and *Dichrostachys cinerea* in disturbed areas. The vegetation unit is considered least threatened. Less than 1% is statutorily conserved and about 5% transformed, mainly by cultivation (Mucina & Rutherford, 2006).

Waterberg Mountain Bushveld is located in the Waterberg Mountains, including the foothills, escarpment and tablelands south of the line between Lephalale and Marken. The landscape consists of rugged mountains with vegetation grading from *Faurea saligna-Protea caffra* bushveld on higher slopes to *Burkea africana-Terminalia sericea savanna* in the lower-lying valleys. The grass layer is moderately developed. The conservation status is regarded least threatened. About 9% is statutorily conserved

mainly in the Marakele National Park and Moepel Nature Reserve. More than 3% is transformed by cultivation (Mucina & Rutherford, 2006).

The farm Wolvenfontein on which the Mokolo dam is situated, falls in the Central Sandy Bushveld. The sandy plains support tall *Terminalia sericea* and *Burkea africana* vegetation on deep, sandy soils and *Combretum* woodland on shallow gravely soils. Species of *Acacia, Ziziphus* and *Euclea* are found on low-lying eutrophic sandy soils. The conservation status of this vegetation type is considered vulnerable. While the conservation target is 19%, less than 3% is statutorily conserved and an additional 2% in private reserves such as the Nylsvlei wetlands. About 24% is transformed, including 19% cultivated and 4% urban and built-up areas (Rutherford and Mucina, 2006).

Although the vegetation map of Mucina and Rutherford, 2006 also shows a very small section of Western Sandy Bushveld along the pipeline route, refining the vegetation through detailed surveys could not distinguish between Western Sandy Bushveld and Limpopo Sweet Bushveld and the area was therefore classified as Limpopo Sweet Bushveld.

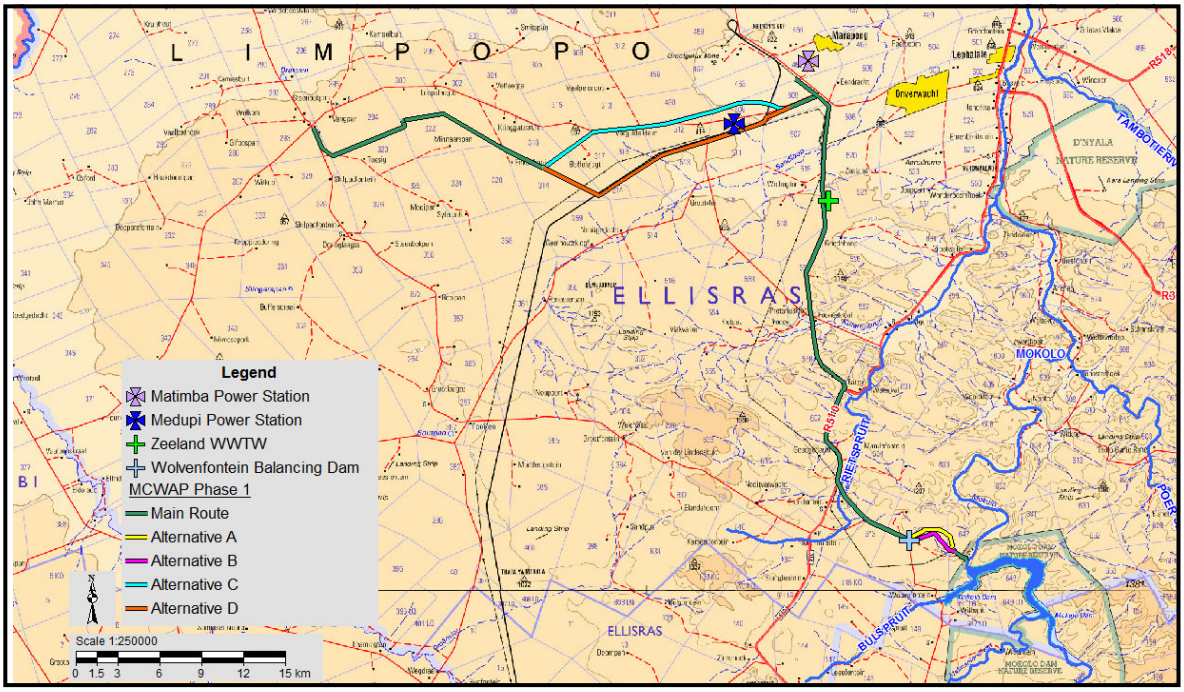

Figure 1: Locality map of the study site.

5. METHODS

The survey was carried out on 25 and 26 March 2009. Eleven waypoints were randomly chosen along the Phase 1 pipeline route and the plants in a strip plot 100m long and 200m wide were identified at each waypoint (Figure 2). A change in the pipeline route resulted in a follow-up survey on 1 and 2 February 2010. The locations of waypoints were precisely determined with GPS and plotted on the pipeline route with GIS. The delimitation of vegetation units is indicated on the satellite maps provided in Annexure A.

The site was scrutinised for Red Data and Orange Listed species that might occur in the different habitats. Attention was also paid to the occurrence of alien species and declared weeds.

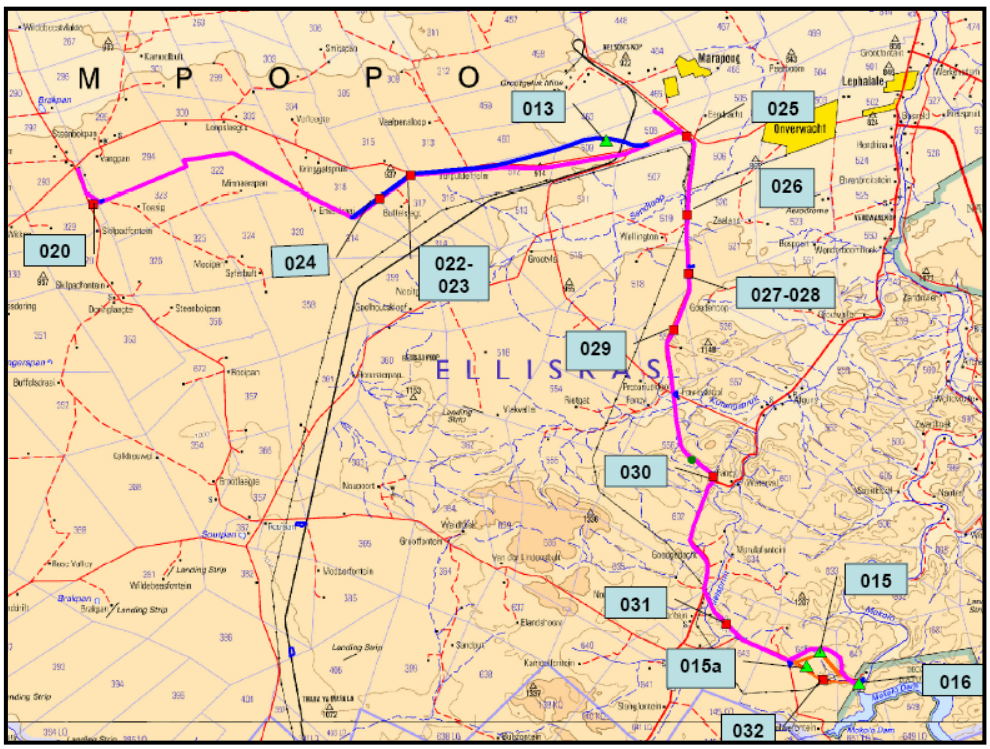

Figure 2: The Phase 1 pipeline route indicating the location of waypoints.

6. RESULTS

6.1 Plant communities

It was not attempted to delimit communities in a study area of such vast extent. However, the different vegetation units were mapped and the variation in species composition as a result of differences in edaphic factors, moisture and altitude in each unit discussed.

6.2 Medicinal species

Medicinal plant species are indicated in tables 1, 2 and 3. Of the 201 plant species recorded on the pipeline route, 12 species were reported to have medicinal properties (Van Wyk *et al.* 2002; Van Wyk & Wink, 2004).

6.3 Alien species

The alien plant species are indicated in the tables with an asterisk. The diversity of alien species is low because of the natural condition of the vegetation. The names of Category 1 Declared weeds are printed in bold and the removal of these plants is compulsory by law.

6.4 Orange listed species

No Orange Listed species were found on the study site.

6.5 Red listed species

No Red Data species were found on the study site.

6.6 Limpopo Sweet Bushveld (Annexure A)

The soil is predominantly sandy loam with dominant tree species *Combretum apiculatum, Acacia erubescens, Acacia nigrescens and Commiphora* species; dominant shrub species are *Grewia monticola, Grewia bicolor, Grewia flava* and *Euclea undulata. Eragrostis rigidior, Urochloa mosambicensis* and *Eragrostis congesta* are the most abundant grass species (Figure 3). In disturbed areas and low-lying clayey areas thickets of *Acacia erubescens, Acacia mellifera, Dichrostachys cinerea* and *Spirostachys africana* are dominant (Figure 4).

Of the 126 species recorded, ten species are known to have medicinal properties. Only four alien species were recorded of which *Cereus jamacaru* is a Category 1 Declared weed and must be eradicated. No Red Data or Orange Listed species were found.

Except for the zone running through the town of Steenbokspan and the developed areas near Lephalale, the vegetation along the pipeline route can be regarded as sensitive and has a high conservation priority. The occurrence of protected trees such as *Sclerocarya birrea* is of importance. Two baobab trees occur at waypoint 013 (S 23°41.638'; E27°34.467') north of Madupi site. **The Alternative D pipeline must be laid south of the fence next to the road to leave the natural vegetation to the north intact** (Figure 5).

Figure 3: Trees and shrubs growing on sandy loam.

Figure 4: *Acacia* species and *Spirostachys africana* growing on clayey soils.

Figure 5**:** View to the west indicating the disturbed area south of the road where it is recommended the pipe should be laid.

Table 1: Plant species recorded in the Limpopo Sweet Bushveld.
Alien species are indicated by * and medicinal species by ♥.

SCIENTIFIC NAME	COMMON NAME
Acacia burkei	Black monkey thorn
Acacia caffra	Common hook-thorn
Acacia erioloba	Camel thorn
Acacia erubescens	Blue thorn
Acacia karroo♥	Sweet thorn
Acacia mellifera subsp. *detinens*	Black thorn
Acacia nigrescens	Knob-thorn
Acacia nilotica	Scented pod
Acacia robusta subsp. *rubusta*	Broad-pod robust thorn
Acacia tortilis subsp. *heteracantha*	Umbrella thorn
Achyranthes aspera var. *aspera**	Burweed
Adansonia digitata♥	Baobab
Albizia anthelmintica♥	Worm-bark false-thorn
Albizia harveyi	Bushveld false-thorn
Aloe chabaudii	
Ammocharis coranica	Seeroogblom
Aristida adscensionis	Annual three-awn
Aristida congesta subsp*. barbicollis*	Spreading three-awn
Aristida congesta subsp*. congesta*	Tassel three awn
Aristida stipitata	Long-awned grass
Asparagus sp*.*	Wild asparagus
Bauhinia petersiana subsp. *macrantha*	Kalahari bauhinia
Blepharis integrifolia var. *integrifolia*	
Boscia albitrunca	Shepherd tree
Boscia foetida subsp*. rehmanniana*	Foetid shepherd tree
Bothriochloa insculpta	Pinhole grass

SCIENTIFIC NAME	COMMON NAME
Burkea africana	Wild seringa
Carissa bispinosa	Forest num-num
Cenchrus ciliaris	Foxtail buffalo grass
Cereus jamacaru*	Queen of the night
Chamaecrista capensis var. *capensis*	
Chloris virgata	Feather-top chloris
Clerodendrum ternatum	
Combretum apiculatum	Red bush-willow
Combretum hereroense	Russet bush-willow
Combretum zeyheri	Large-fruited bush-willow
Commelina africana	
Commelina benghalensis	
Commelina erecta	
Commiphora angolensis	Sand corkwood
Commiphora mollis	Velvet-leaved corkwood
Commiphora pyracanthoides	Common corkwood
Crotalaria eremicola subsp*. eremicola*	
Cucumis zeyheri	Wild cucumber
Cyperus margaritaceus var *margaritaceus*	
Dicerocaryum eriocarpum	Devil's thorn
Dichrostachys cinerea subsp. *africana* var. *africana*	Small-leaved sickle bush
Dicoma tomentosa	
Digitaria eriantha	Common finger grass
Diheteropogon amplectens	Broad-leaved bluestem
Dombeya rotundifolia var. *rotundifolia*♥	Wild pear
Ehretia rigida	Puzzle bush
Elephantorrhiza elephantina♥	Elephant's root
Enneapogon cenchroides	Nine-awned grass
Eragrostis gummiflua	Gum grass
Eragrostis pallens	Broom love grass
Eragrostis rigidior	Curly leaf
Eragrostis superba	Saw-tooth love grass
Eragrostis trichophora	Hairy love grass
Euclea natalensis subsp*. angustifolia*	Natal guarri
Euclea undulata♥	Small-leaved guarri
Evolvulus alsinoides	Blue haze
Gardenia volkensii subsp. *spathulifolia*	Bushveld gardenia
Grewia bicolor var. *bicolor*	White raisin
Grewia flava	Velvet raisin
Grewia flavescens	Sandpaper raisin
Grewia monticola	Grey raisin
Gymnosporia buxifolia	Spike-thorn
Gymnosporia tenuispina	Bell spike-thorn
Harpagophytum zeyheri subsp. *zeyheri*♥	
Hermbsteadtia odorata var. *odorata*	Rooiaarbossie
Heteropogon contortus	Spear grass
Heteropogon melanocarpus	
*Hibiscus cannabinus**	Wild stockrose
Indigofera arrecta	
Indigofera daleoides var. *daleoides*	

SCIENTIFIC NAME	COMMON NAME
Indigofera nebrowniana	
Ipomoea magnusiana	Small pink ipomoea
Ipomoea obscura var. *obscura*	Wild petunia
Justicia flava	Yellow justicia
Kyphocarpa angustifolia	Siky burweed
Lannea discolor	Live-long
Lantana rugosa	Bird's brandy
Maerua angolensis	Bead-bean
Melhania forbesii	
Melinis repens subsp. *grandiflora*	Natal red top
Monsonia angustifolia	Crane's bill
Ocimum americanum subsp. *americanum*	Wild basil
Ozoroa paniculosa var. *paniculosa*	Resin tree
Panicum maximum	Guinea grass
Pavetta lanceolata	Bridal bush
Pentarrhinum insipidum	African heart vine
Perotis patens	Cat's tail
Phyllanthus parvulus	Dye bush
Pogonarthria squarrosa	Herringbone grass
Portulaca kermesina	Haaskos
*Portulaca quadrifida**	Wild purslane
Pupalia lappacea	Forest burr
Rhoicissus revoilii	Bushveld grape
Rhynchosia totta	Yellow carpet bean
Sarcostemma viminale subsp. *viminale*	Melktou
Schmidtia pappophoroides	Sand quick
Sclerocarya birrea subsp. *caffra*♥	Marula
Searsia tenuinervis	Roll-leaved currant
Setaria ustilata	
Sida alba	Spiny sida
Sida dregei	Spider-leg
Solanum panduriforme	Poison apple
Solanum tettense var. *renschii*	Mozambique bitter apple
Spirostachys africana	Tamboti
Sterculia rogersii	Star chestnut
Stipagrostis uniplumis var. *uniplumis*	Silky bushman grass
Stylosanthes fruticosa	
Tephrosia rhodesica var. *rhodesica*	
Terminalia sericea♥	Silver cluster-leaf
Tragia rupestris	
Tylosema esculentum	Gemsbok bean
Urochloa mosambicensis	Bushveld signal grass
Vernonia poskeana subsp. *botswanica*	
Waltheria indica	Meidebossie
Xenostegia tridentata subsp. *angustifolia*	Miniature morning glory
Xerophyta humilis	Reënmetertjies
Ximenia americana var. *microphylla*	Blue sourplum
Ximenia caffra var. *caffra*	Sourplum
Ziziphus mucronata♥	Buffalo thorn
Zornia milneana	

6.7 Waterberg Mountain Bushveld (Annexure A)

The soil is mainly coarse-grained shallow and sandy, alternated by outcrops of sandstone and conglomerate. *Diplorhynchus condylocarpon, Bridelia mollis, Pseudolachnostylis maprouneifolia* and *Albizia brevifolia* are common tree species on rocky, shallow-soiled areas (Figure 6). In low-lying areas deep, fine-grained sandy soil is the preferred substrate for *Terminalia sericea, Peltophorum africanum, Combretum zeyheri* and *Dombeya rotundifolia* which are common for Sandy Bushveld (Figure 7). An interesting phenomenon is the occurrence of *Kirkia acuminata* which is common in the Mopane Bushveld (Figure 8).

Seven of the 112 species recorded are known to have medicinal value and three alien species were found. No Red Data or Orange Listed species occur in this vegetation unit.

The zone along the existing pipeline is already transformed; therefore it is not sensitive.

Figure 6**:** Vegetation on rocky, shallow sandy soil.

Figure 7**:** Vegetation on low-lying, deep sandy soil. Note the abundance of Silver cluster-leaf.

Figure 8**:** *Kirkia accuminata* growing at the margin of Waterberg Mountain Bushveld.

Table 2: Plant species recorded in the Waterberg Mountain Bushveld.
Alien species are indicated by * and medicinal species by ♥.

SCIENTIFIC NAME	COMMON NAME
Acacia burkei	Black monkey thorn
Acacia erubescens	Blue thorn
Acacia mellifera subsp. *detinens*	Black thorn
Acacia nigrescens	Knob-thorn
Acacia nilotica	Scented pod
Acacia robusta subsp. *robusta*	Broad-pod robust thorn
Acacia senegal var. *rostrata*	Bushy three-hook thorn
Acalypha indica var. *indica*	Indian girl
Achyranthes aspera var. *aspera**	Burweed
Albizia brevifolia	Rock false-thorn
Albizia tanganyicensis	Paper-barked false-thorn
Aloe marlothii subsp. *marlothii*	Mountain aloe
Aristida congesta subsp. *barbicollis*	Spreading three-awn
Aristida congesta subsp. *congesta*	Tassel three-awn
Aristida stipitata	Long-awned grass
Boscia albitrunca	Shepherd tree
Brachiaria nigropedata	Black-footed grass
Bridelia mollis	Velvet sweet-berry
Chamaecrista capensis var. *capensis*	
Chloris virgata	Feather-top chloris
Chrysopogon serrulatus	Golden beard grass
Combretum apiculatum	Red bush-willow
Combretum imberbe	Leadwood
Combretum molle	Velvet bush-willow
Combretum zeyheri	Large-fruited bush-willow
Commelina sp.	
Commiphora mollis	Velvet-leaved corkwood
Corchorus kirkii	
Corchorus longipedunculatus	Langsteelvaringblaartjie
Croton gratissimus var. *gratissimus*	Lavender fever-berry
Dicerocaryum eriocarpum	Devil's thorn

SCIENTIFIC NAME	COMMON NAME
Dichrostachys cinerea subsp. *africana* var. *africana*	Small-leaved sickle bush
Digitaria eriantha	Common finger grass
Diplorhynchus condylocarpon	Horn-pod tree
Dombeya rotundifolia var. *rotundifolia*♥	Wild pear
Elephantorrhiza elephantina♥	Elephant's root
Englerophytum magalismontanum	Stem-fruit
Eragrostis aspera	Rough love grass
Eragrostis pallens	Broom love grass
Eragrostis rigidior	Curly leaf
Eragrostis trichophora	Hairy love grass
Euclea natalensis subsp. *angustifolia*	Natal guarri
Euclea undulata♥	Small-leaved guarri
Euphorbia neopolycnemoides	Klein bont euphorbia
Ficus abutilifolia	Large-leaved rock fig
Flueggea virosa subsp. *virosa*	White-berry bush
Gardenia volkensi subsp. *spathulifolia*	Bushveld gardenia
Gomphocarpus fruticosus♥	Milkweed
*Gomphrena celosioides**	Bachelor's button
Grewia bicolor	White raisin
Grewia flava	Velvet raisin
Grewia flavescens	Sandpaper raisin
Grewia monticola	Grey raisin
Gymnosporia buxifolia	Spike-thorn
Gymnosporia tenuispina	Bell spike-thorn
Hermannia grisea	Vaal gombossie
Heteropogon contortus	Spear grass
Hexalobus monopetalus var. *monopetalus*	Shakama plum
Hibiscus trionum	Bladderweed
Indigofera daleoides var. *daleoides*	
Indigofera oxytropis	
Justicia flava	Yellow justicia
Kirkia acuminata	White seringa
Kyphocarpa angustifolia	Silky burweed
Lannea discolor	Live-long
Limeum sp.	
Melhania burchellii	
Melhania forbesii	
Melinis repens subsp. *grandiflora*	Natal red top
Mimusops zeyheri	Moepel
Mundulea sericea	Cork bush
Ochna inermis	Stunted plane
Ozoroa paniculosa var. *paniculosa*	Resin tree
Panicum maximum	Guinea grass
Pappea capensis	Jacket-plum
Pavetta lanceolata	Bridal bush
Pellaea calomelanos var. *calomelanos*	Black cliff brake
Peltophorum africanum	African wattle
Perotis patens	Cat's tail
Phyllanthus parvulus	Dye bush
*Plumbago zeylanica**	Wild white plumbago

SCIENTIFIC NAME	COMMON NAME
Pogonarthria squarrosa	Herringbone grass
Portulaca kermesina	Haaskos
Pseudolachnostylis maprouneifolia var. *maprouneifolia*	Kudu-berry
Pterocarpus rotundifolius subsp. *rotundifolius*	Round-leaved bloodwood
Pupalia lappacea var. *lappacea*	Forest burr
Rhoicissus revoilii	Bushveld grape
Rhynchosia totta	Yellow carpet bean
Sarcostemma viminale subsp. *viminale*	Melktou
Schotia bracypetala	Weeping boer-bean
Sclerocarya birea subsp. *caffra*♥	Marula
Setaria ustilata	
Sida cordifolia	Flannel weed
Sida dregei	Spider-leg
Solanum panduriforme	Poison apple
Spermacoce senensis	Sena star
Spirostachys africana	Tamboti
Strychnos madagascariensis	Black monkey orange
Tephrosia longipes subsp. *longipes* var. *longipes*	
Terminalia sericea♥	Silver cluster-leaf
Tragia rupestris	
Tricholaena monachne	Blue-seed grass
Trichoneura grandiglumis	Small rolling grass
Triumfetta rhomboidea var. *rhomboidea*	
Vernonia poskeana subsp. *botswanica*	
Vigna vexillata	
Waltheria indica	Meidebossie
Ximenia americana var. *microphylla*	Blue sourplum
Ximenia caffra var. *caffra*	Sourplum
Ziziphus mucronata♥	Buffalo thorn
Zornia linearis	
Zornia milneana	

6.8 Central Sandy Bushveld (Annexure A)

The soil and vegetation on the plateau at altitude 1000 to 1100 m, the intended location of the pipe route, closely resemble that of Sandy Bushveld. Representive species are *Terminalia sericea, Peltophorum africanum* and *Combretum* species (Figure 9). However, many Waterberg Mountain Bushveld species are scattered in between, e.g. *Diplorrhynchus condylocarpon*, *Bridelia mollis* and *Croton gratissimus* (Figure 10). At lower altitudes and on north facing slopes the vegetation is typical Mountain Bushveld with indicator species such as *Albizzia tanganyicensis* and *Albizzia brevifolia* (Figure 11).

Five of the 98 species recorded are known to have medicinal properties and only one is an alien species. The rare species *Euphorbia waterbergensis* and *Euphorbia tortirama* were reported to occur in this area (no co-ordinates could be provided) but were not found. No Red Data or Orange Listed species were found.

The vegetation along this intended pipe route is natural primary savannah and regarded ecologically sensitive. Care must be taken to prevent rocks rolling from the construction site down the ravines where the mentioned *Euphorbia* species occur, so blasting should be

minimised or prevented as far as possible. This area falls within the core area of the Waterberg Biosphere and care must be taken to disturb as little as possible of the natural vegetation through construction activities.

Figure 9**:** Typical vegetation of Sandy Bushveld showing *Burkea africana, Terminalia sericea* and *Combretum zeyheri.*

Figure 10**:** Mountain Bushveld species *Diplorrhynchus condylocarpon* and *Croton gratissimus* can be seen in this picture.

Figure 11: Typical Mountain Bushveld vegetation on the north facing slope.

Table 3: Plant species recorded in the Central Sandy Bushveld.
Alien species are indicated by * and medicinal species by ♥.

SCIENTIFIC NAME	COMMON NAME
Acacia burkei	Black monkey thorn
Acacia caffra	Common hook-thorn
*Acanthospermum hispidum**	Upright starbur
Albizia brevifolia	Rock false-thorn
Albizia tanganyicensis	Paper-barked false-thorn
Aristida congesta subsp. *congesta*	Tassel three-awn
Aristida stipitata	Long-awned grass
Brachiaria nigropedata	Black-footed grass
Brachylaena huillensis	Lowveld silver oak
Bridelia mollis	Velvet sweet-berry
Burkea africana	Wild seringa
Cenchrus ciliaris	Foxtail buffalo grass
Chamaecrista capensis var. *capensis*	
Chamaecrista comosa var. *capricornia*	
Chascanum hederaceum	
Cleome maculata	
Cleome rubella	Pretty lady
Combretum apiculatum	Red bush-willow
Combretum molle	Velvet bush-willow
Combretum zeyheri	Large-fruited bush-willow
Commelina africana	
Commiphora mollis	Velvet-leaved corkwood
Corchorus kirkii	
Croton gratissimus var. *gratissimus*	Lavender fever-berry
Cyperus denudatus	
Cyperus rupestris	Russet rock sedge
Dichrostachys cinerea subsp. *africana* var. *africana*	Small-leaved sickle bush
Digitaria eriantha	Common finger grass
Diplorhynchus condylocarpon	Horn-pod tree
Drimea sanguinea	Red slangkop
Elephantorrhiza burkei	Sumach bean
Eragrostis aspera	Rough love grass

Eragrostis gummiflua	Gum grass
Eragrostis rigidior	Curly leaf
Euclea linearis	Lance-leaved guarri
Euclea natalensis subsp. *angustifolia*	Natal guarri
Evolvulus alsinoides	Blue haze
Felicia mossamedensis	Yellow felicia
Gardenia volkensi subsp. *spathulifolia*	Bushveld gardenia
Geigeria burkei subsp. *burkei* var. *burkei*	Knoppiesvermeerbos
Geigeria elongata	
Gomphocarpus fruticosus♥	Milkweed
Grewia bicolor	White raisin
Grewia flava	Velvet raisin
Grewia flavescens	Sandpaper raisin
Grewia occidentalis	Cross-berry
Gymnosporia tenuispina	Bell spike-thorn
Hermannia grisea	Vaal gombossie
Hermannia micropetala	
Heteropogon contortus	Spear grass
Hexalobus monopetalus	Shakama plum
Hibiscus trionum	Bladderweed
Indigofera sp.	
Kalanchoe paniculata	Krimpsiektebossie
Kirkia acuminata	White seringa
Kleinia longiflora	Sjambok bush
Kyphocarpa angustifolia	Siky burweed
Lannea discolor	Live-long
Limeum viscosum	
Loudetia simplex	Common ruset grass
Melhania burchellii	
Melhania forbesii	
Melinis repens subsp. *grandiflora*	Natal red top
Mundulea sericea	Cork bush
Myrothamnus flabellifolius	Resurrection plant
Ochna inermis	Stunted plane
Oldenlandia herbacea var. *herbacea*	
Ozoroa paniculosa var. *paniculosa*	Resin tree
Panicum maximum	Guinea grass
Pappea capensis	Jacket plum
Pellaea calomelanos var. *calomelanos*♥	Black cliff brake
Peltophorum africanum	African wattle
Perotis patens	Cat's tail
Phyllanthus parvulus	Dye bush
Pogonarthria squarrosa	Herringbone grass
Pseudolachnostylis maprouneifolia var. *maprouneifolia*	Kudu-berry
Pterocarpus rotundifolius	Round-leaved bloodwood
Rhoicissus revoilii	Bushveld grape
Rhynchosia totta	Yellow carpet bean
Schizachyrium sanguineum	Red autumn grass
Sclerocarya birrea subsp. *caffra*♥	Marula
Sida cordifolia	Flannel weed
Solanum panduriforme	Poison apple
Strychnos madagascariensis	Black monkey orange

Tephrosia longipes subsp. *longipes* var. *longipes*	
Tephrosia rhodesica var. *evansii*	Pole evans bush pea
Terminalia sericea♥	Silver cluster-leaf
Themeda triandra	Red grass
Trichoneura grandiglumis	Small rolling grass
Vangueria parvifolia	Mountain wild medlar
Vitex pooara	Poora-berry
Waltheria indica	Meidebossie
Xenostegia tridentata subsp. *angustifolia*	Miniature morning glory
Ximenia caffra var. *cafra*	Sourplum
Ziziphus mucronata♥	Buffalo thorn
Zornea milneana	
Zornia linearis	

7. FINDINGS AND POTENTIAL IMPLICATIONS

The vegetation along the Phase 1 route, outside the pipe reserve has a high conservation priority. Land use is aimed mainly on game farming which is not a degrading practice. Most of the areas adjacent to the pipeline zone are primary natural vegetation; consequently ample connectivity with natural vegetation exists. Protected trees occurring in the study area are *Acacia erioloba, Adansonia digitata, Boscia albitrunca, Combretum imberbe* and *Sclerocarya birrea* subsp. *africana.* These species may not be harmed in any way or, if this is unavoidable, the necessary permit must be obtained from the Department of Forestry to remove some of the mentioned trees.

At Alternative C it must be seriously attempted to lay the pipeline south of the new road in the already degraded area rather than disturbing the natural vegetation where *Adansonia digitata* and other protected trees occur. When blasting is undertaken, rocks must be prevented to roll down slopes and destroy rare plants as in the case of the two *Euphorbia* species at the farm Wolvenfontein.

The area around the Mokolo dam falls within the Waterberg Biosphere core area and care must be taken to preserve as much as possible of the vegetation along the pipeline route from the intake of the Mokolo dam to the balancing dams.

8. RECOMMENDED MITIGATION MEASURES

The following recommended mitigation measures were developed in conjunction with the Gauteng Department of Agriculture and Rural Development (GDARD) but are also applicable to the Limpopo province.

- An Ecological Management Plan (to be included in the Environmental Management Plan (EMP)) must be developed for the construction and operational phase of the development and should:
    - include an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species
    - ensure the persistence of all Red and Orange List species
    - minimize artificial edge effects (e.g. water runoff from developed areas and application of chemicals)
    - result in a report back to the Directorate of Nature Conservation on an annual basis.
- Where possible, trees naturally growing within the pipeline servitude should be retained, with specific emphasis on the following species: *Acacia erioloba*,

Adansonia digitata, Boscia albitrunca, *Combretum imberbe*, *Sclerocarya birrea* subsp. *caffra*. Measures to ensure that these trees survive the physical disturbance from the development should be implemented. A tree surgeon should be consulted in this regard. A qualified botanist must mark trees when the route is pegged and permits obtained from the Department of Forestry (previously known as DWAF) before any protected trees are removed.

- The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone.
- The appropriate agency should implement an ongoing monitoring and eradication program for all invasive and weedy plant species growing within the servitude.
- Rehabilitation of natural vegetation should proceed in accordance with a rehabilitation plan compiled by a specialist registered in terms of the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science.
- Any post-development re-vegetation should use species indigenous to South Africa. Plant species locally indigenous to the area are preferred. As far as possible, indigenous plants naturally growing along the route, but would otherwise be destroyed during construction, should be used for re-vegetation.
- Where a pipeline is to traverse a wetland, measures are required to ensure that the pipeline has minimal effect on the flow of water through the wetland, e.g. by using a high level clear span bridge or box culverts rather than pipes.
- Disturbance to any wetlands during construction should be minimized. A plan for the immediate rehabilitation of damage caused to wetlands should be compiled by a specialist registered in accordance with the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science. This rehabilitation plan should form part of the EMP and a record book should be maintained on site to monitor and report on the implementation of the plan.

9. CONCLUSION

The natural vegetation on the proposed alternative pipeline routes is considered sensitive and precautions should be taken to inflict as little damage as possible during the construction phase. Development should preferably take place on degraded areas such as Alternative C at the Madupi site. Care must be taken to minimize or prevent negative impact on vegetation, especially where rare and endangered plants are known to occur. Spilling of oil and fuel, dumping of rubble and water pollution must be strictly monitored. All Category 1 Declared weeds must be eradicated and protected trees should be left intact as far as possible.

It is recommended that the Alternative C pipeline route be situated south of the new road around the Madupi powerstation in the already degraded area rather than disturbing the natural vegetation where *Adansonia digitata* and other protected trees occur. The two Boabab trees that were relocated south of the road when the road was built must be avoided. There are also other large Tamboti and Marula trees along the pipeline route that should be avoided where possible.

When blasting is undertaken, rocks must be prevented to roll down slopes and destroy rare plants. It is therefore also recommended that the Alternative B corridor from the Mokolo dam over the farm Wolvenfontein (that falls within the Waterberg Biosphere) be followed so that the two sensitive *Euphorbia* species in the kloofs are not impacted by falling rocks. Care must be taken with the Alternative B route to disturb as little as possible of the vegetation along the route with construction activities, since this section of the route

falls within the core conservation area of the Waterberg Biosphere. (See Annexure B for the flora sensitivity maps)

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ANNEXURE A: VEGETATION MAPS OF THE STUDY ROUTE

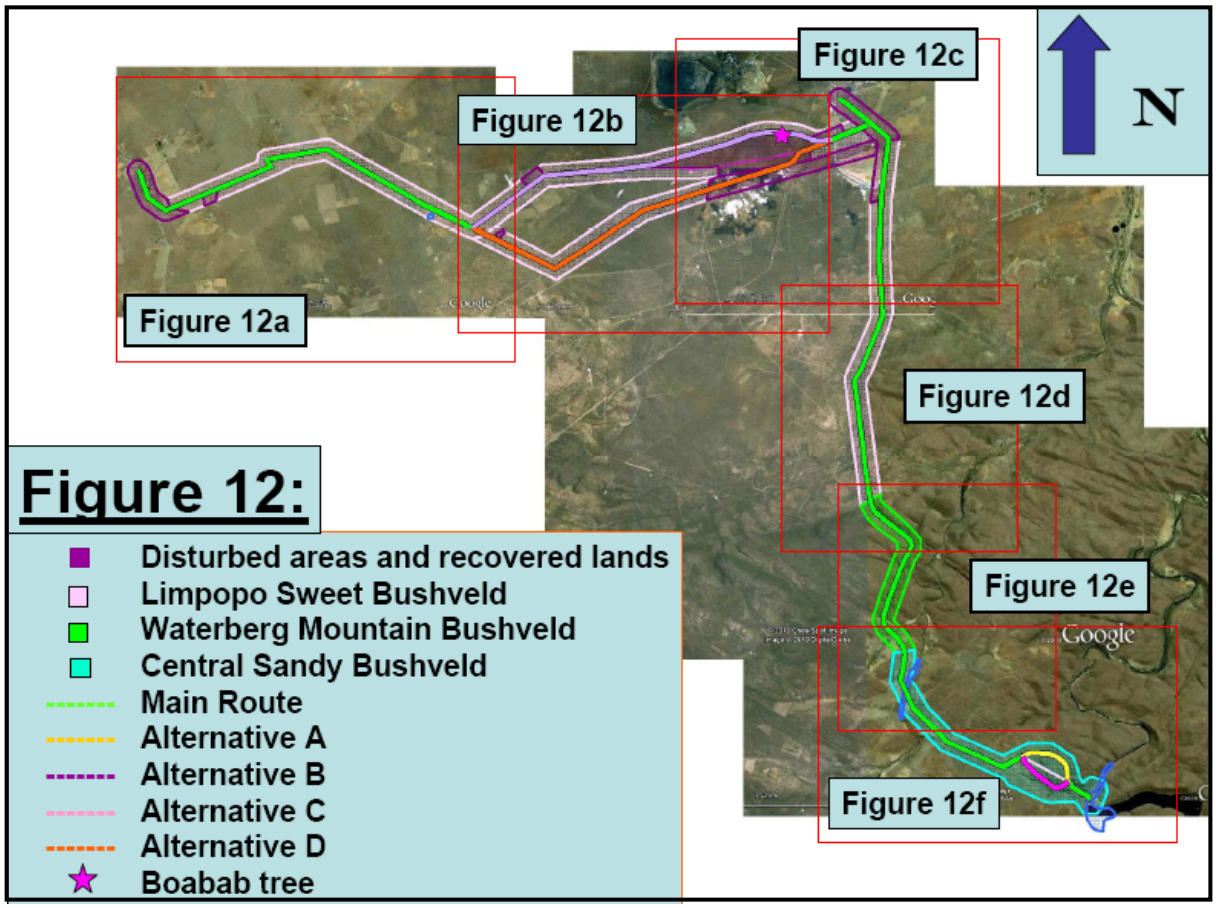


Figure 12: Overall vegetation map of phase one

The following maps have been zoomed in and are marked as shown on this map

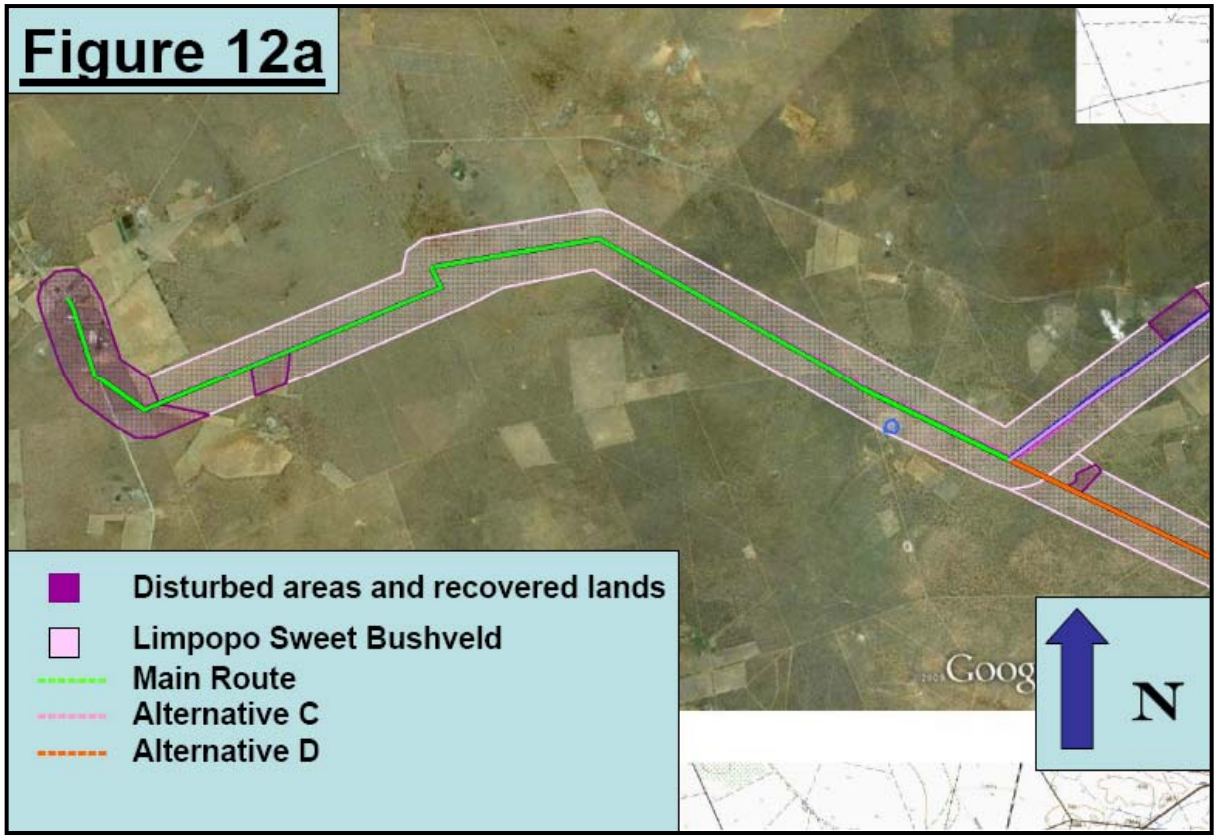


Figure 12a
Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Main Route
Alternative C
Alternative D
N

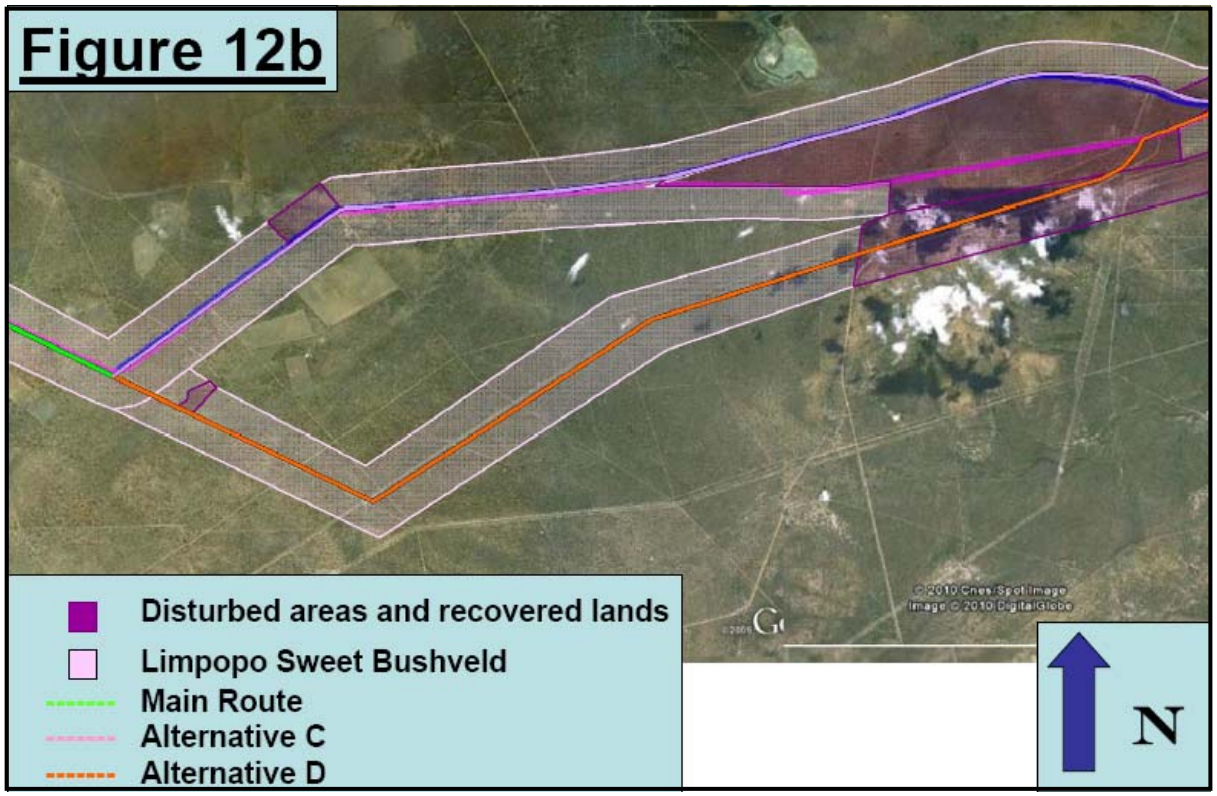


Figure 12b
Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Main Route
Alternative C
Alternative D
N

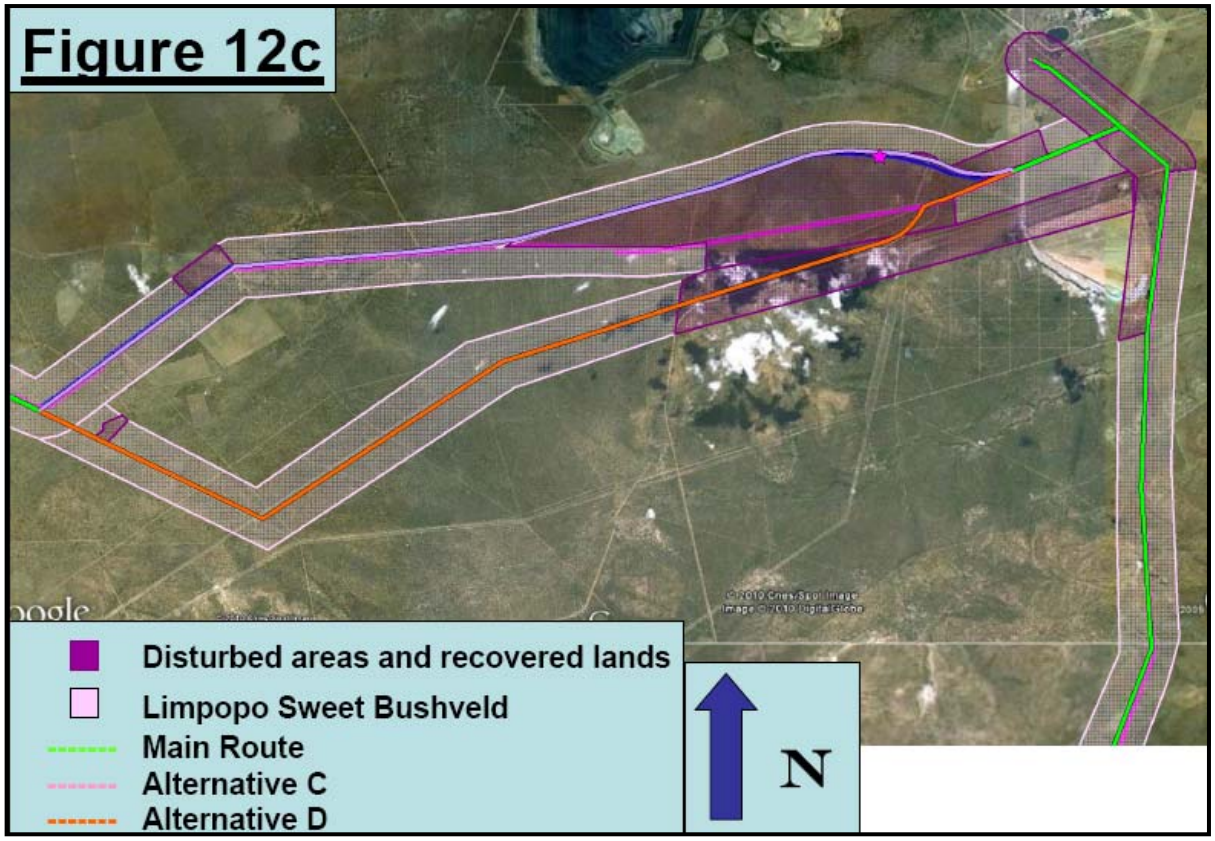
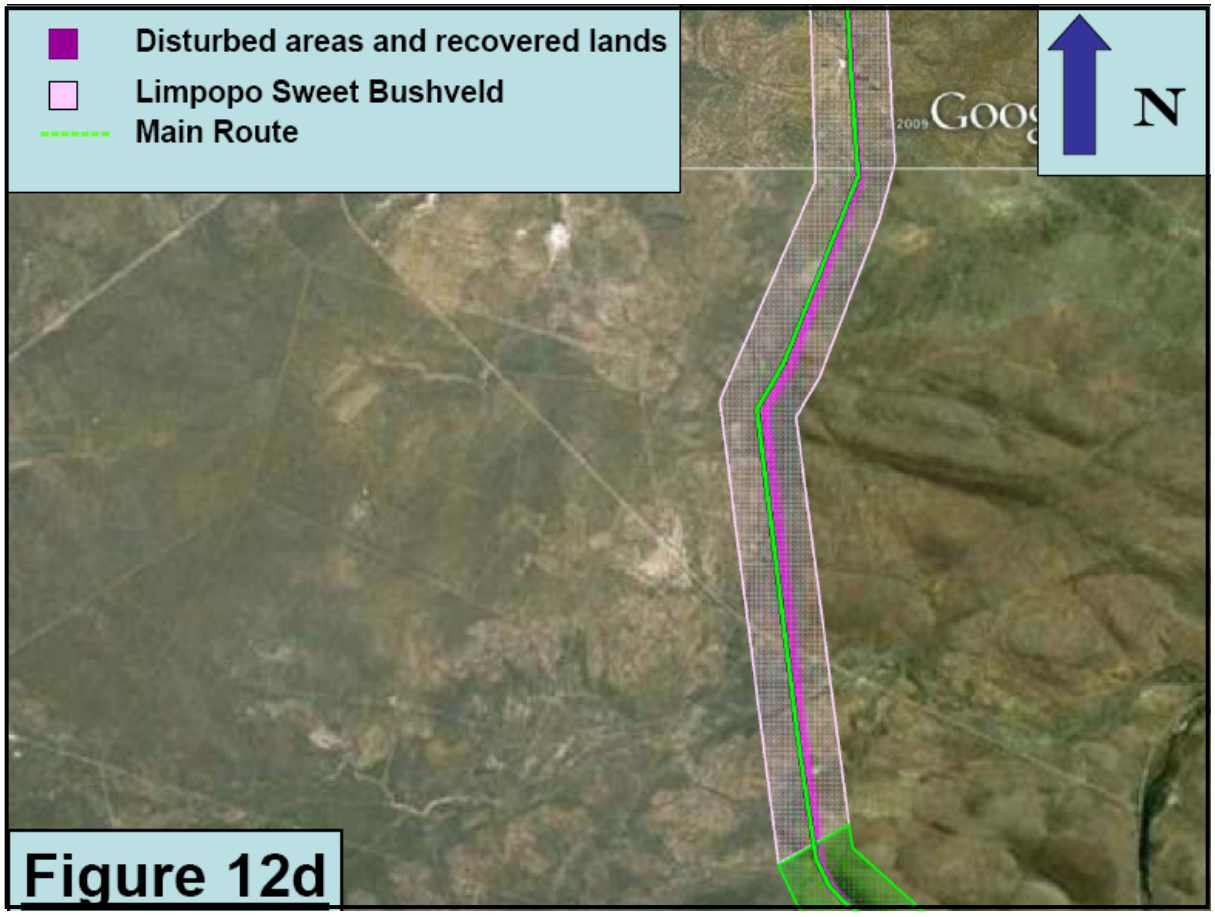
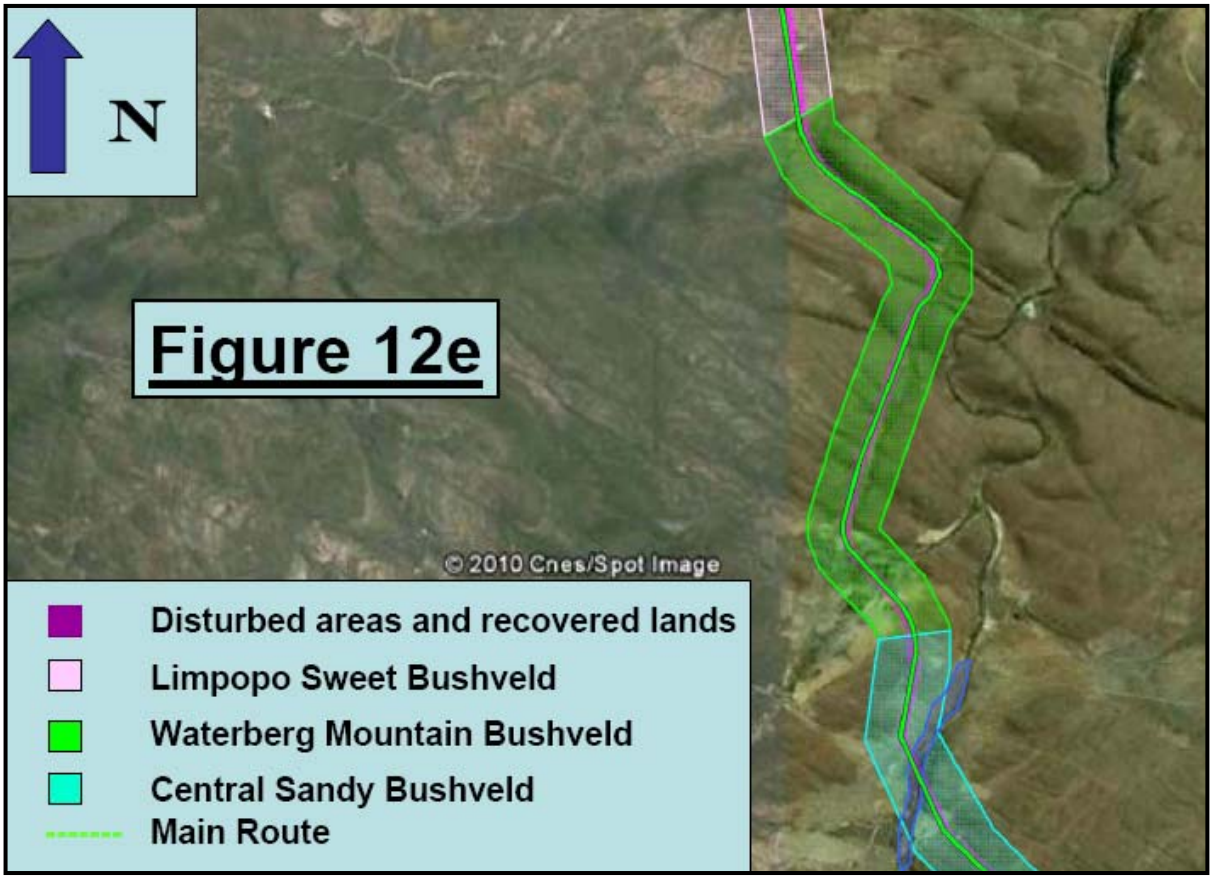


Figure 12c
Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Main Route
Alternative C
Alternative D
N


Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Main Route
N
Figure 12d


N
Figure 12e
© 2010 Cnes/Spot Image
Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Waterberg Mountain Bushveld
Central Sandy Bushveld
Main Route

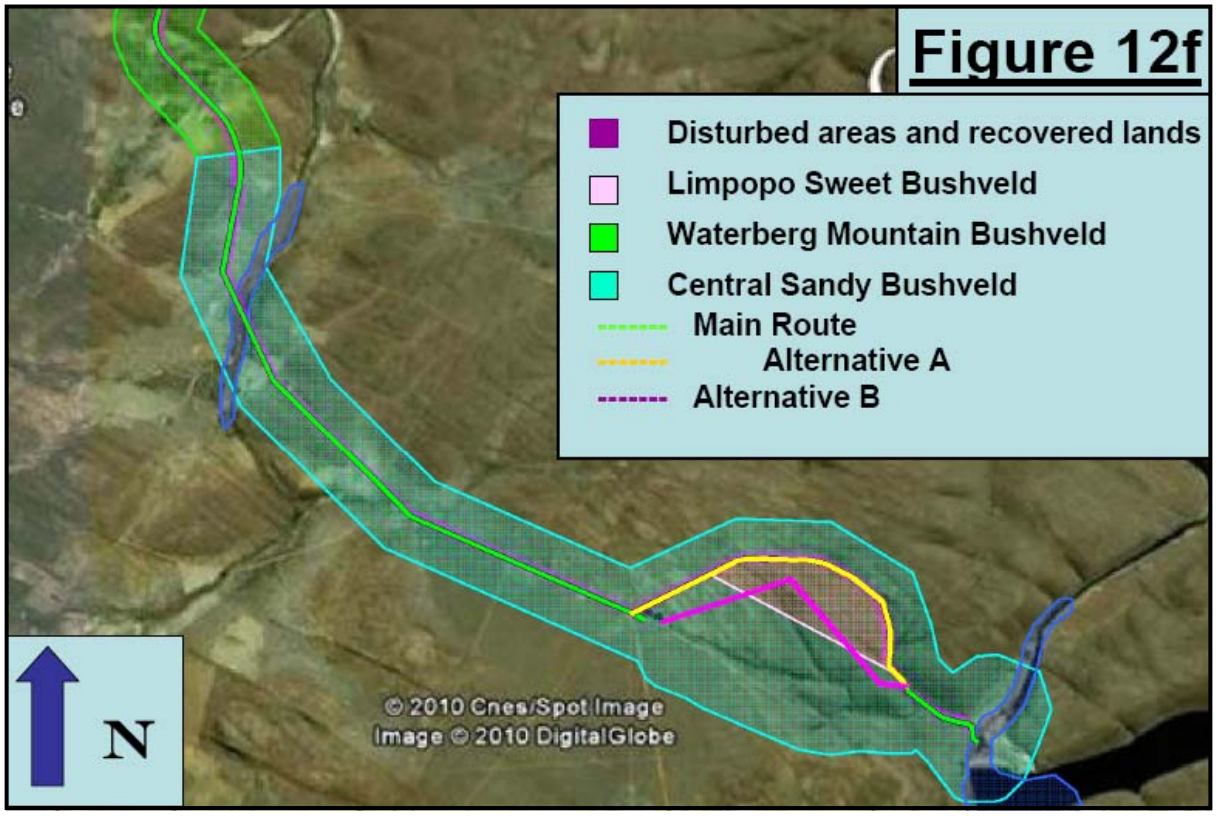


Figure 12f
Disturbed areas and recovered lands
Limpopo Sweet Bushveld
Waterberg Mountain Bushveld
Central Sandy Bushveld
Main Route
Alternative A
Alternative B
N
© 2010 Cnes/Spot Image
Image © 2010 DigitalGlobe

ANNEXURE B: VEGETATION SENSITIVITY MAPS

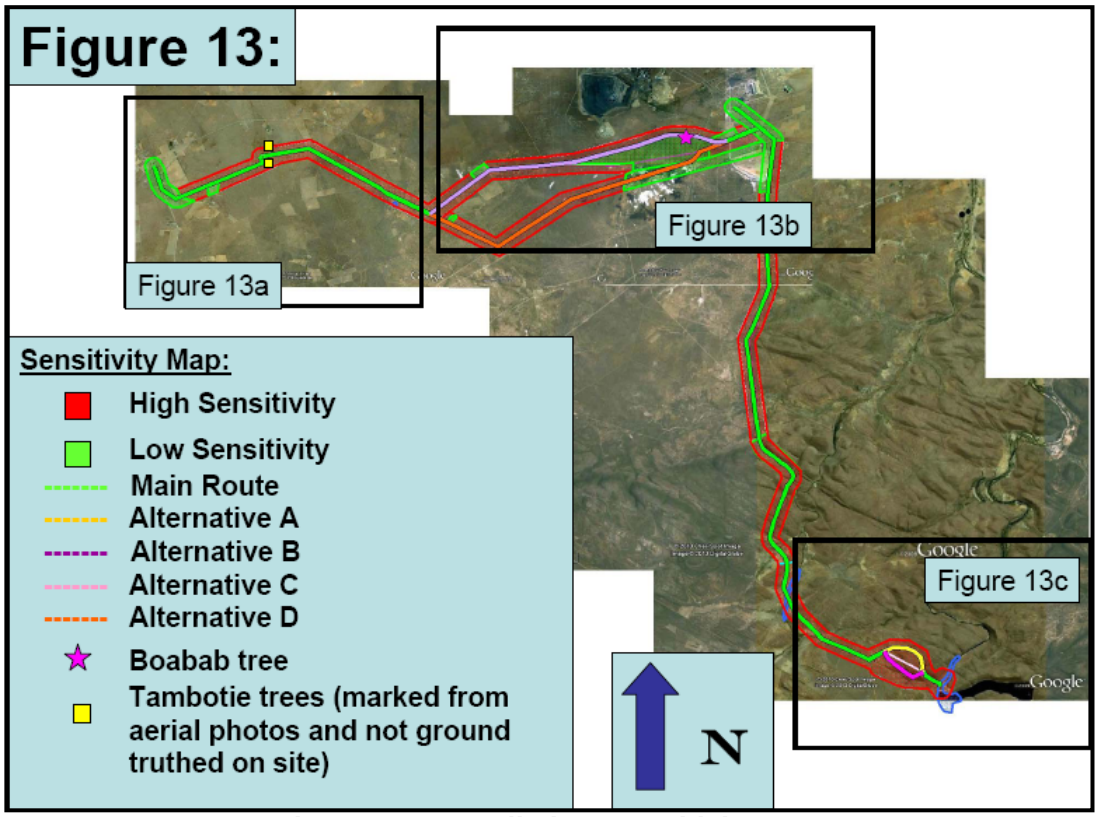
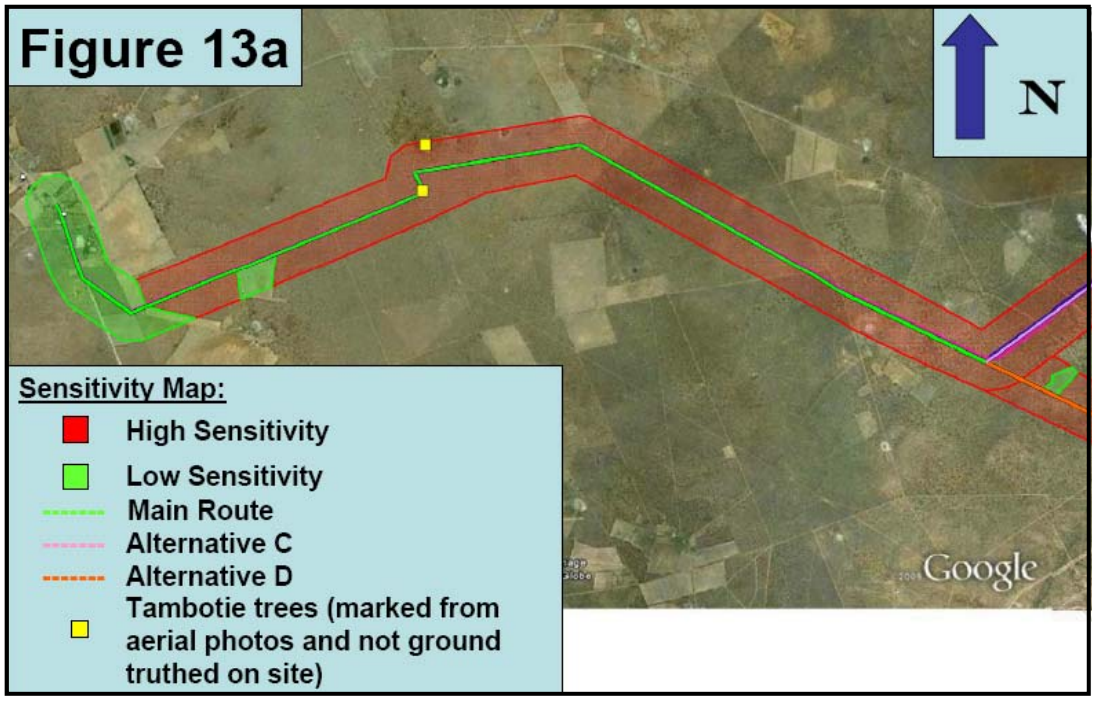


Figure 13: Overall Flora sensitivity map

The following maps have been zoomed in and are marked as shown on this map



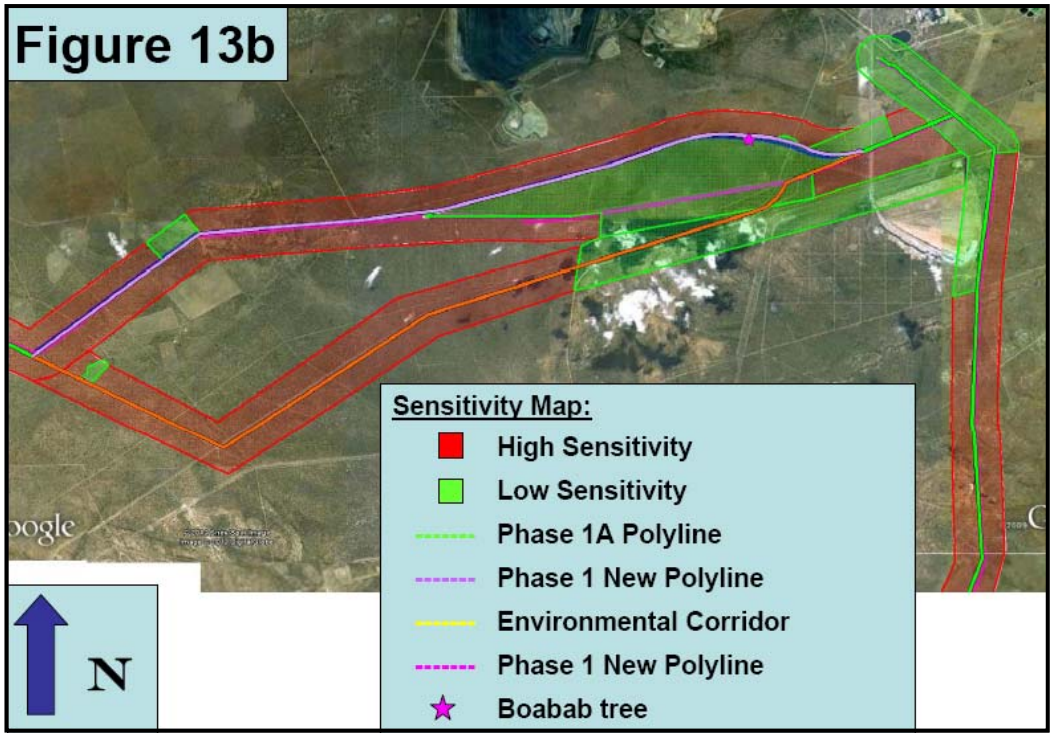
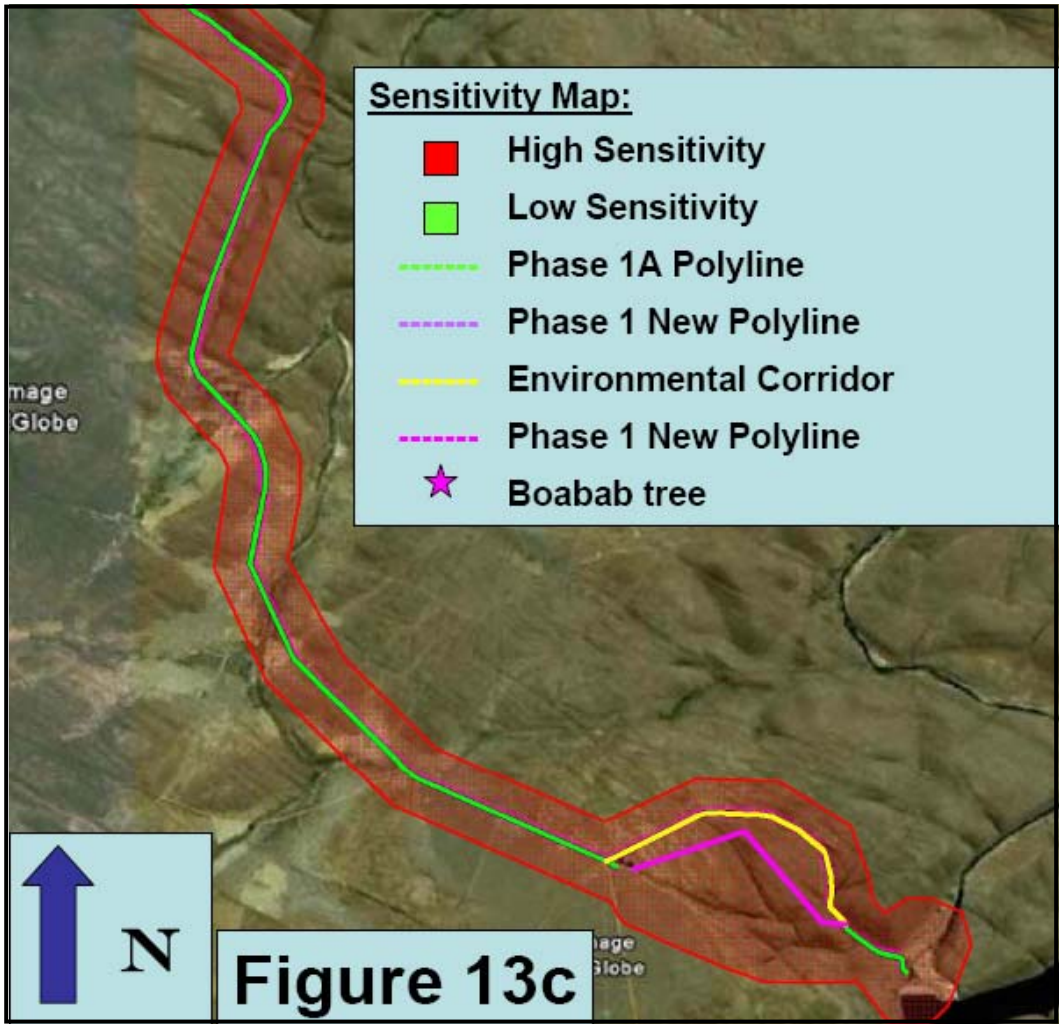


Figure 13b
Sensitivity Map:
High Sensitivity
Low Sensitivity
Phase 1A Polyline
Phase 1 New Polyline
Environmental Corridor
Phase 1 New Polyline
Boabab tree
N


Sensitivity Map:
High Sensitivity
Low Sensitivity
Phase 1A Polyline
Phase 1 New Polyline
Environmental Corridor
Phase 1 New Polyline
Boabab tree
N
Figure 13c

ANNEXURE C: PLANT SPECIES RECORDED ON PROPOSED PHASE 1 PIPELINE ROUTE

ACANTHACEAE
Blepharis integrifolia
Justicia flava

AMARANTHACEAE
Achyranthes aspera
Gomphrena celosioides
Hermbstaedtia odorata
Kyphocarpa angustifolia
Pupalia lappacea

AMARYLLIDACEAE
Ammocharis coranica

ANACARDIACEAE
Lannea discolor
Ozoroa paniculosa
Sclerocarya birrea
Searsia tenuinervis

ANNONACEAE
Hexalobus monopetalus

APOCYNACEAE
Carissa bispinosa
Diplorhynchus condylocarpon
Gomphocarpus fruticosus
Pentarrhinum insipidum
Sarcostemma viminale

ASTERACEAE
Acanthospermum hispidum
Brachylaena huillensis
Dicoma tomentosa
Felicia mossamedensis
Geigeria burkei
Geigeria elongata
Kleinia longifolia
Vernonia poskeana

BOMBACACEAE
Adansonia digitata

BURSERACEAE
Commiphora angolensis
Commiphora mollis
Commiphora pyracanthoides

CACTACEAE
Cereus jamacaru

CAESALPINIACEAE
Bauhinia petersiana
Burkea africana
Chamaecrista capensis
Chamaecrista comosa
Peltophorum africanum
Schotia brachypetala
Tylosema esculentum

CAPPARACEAE
Boscia albitrunca
Boscia foetida
Maerua angolensis

CELASTRACEAE
Gymnosporia buxifolia
Gymnosporia tenuispina

CLEOMACEAE
Cleome maculata
Cleome rubella

COMBRETACEAE
Combretum apiculatum
Combretum hereroense
Combretum imberbe
Combretum molle
Combretum zeyheri
Terminalia sericea

COMMELINACEAE
Commelina africana
Commelina benghalensis
Commelina erecta

CONVOLVULACEAE
Evolvulus alsinoides
Ipomoea magnusiana
Ipomoea obscura
Xenostegia tridentata

CRASSULACEAE
Kalanchoe paniculata

CUCURBITACEAE
Cucumis zeyheri

CYPERACEAE
Cyperus denudatus
Cyperus margaritaceus
Cyperus rupestris

EBENACEAE
Euclea linearis
Euclea natalensis
Euclea undulata

EHRETIACEAE
Ehretia rigida

EUPHORBIACEAE
Acalypha indica
Croton gratissimus
Euphorbia neopolycnemoides
Spirostachys africana
Tragia rupestris

FABACEAE
Crotalaria eremicola
Indigofera arrecta
Indigofera daleoides
Indigofera nebrowniana
Indigofera oxytropis
Mundulea sericea
Pterocarpus rotundifolius
Rhynchosia totta
Stylosanthes fruticosa
Tephrosia longipes
Tephrosia rhodesica
Vigna vexillata
Zornia milneana
Zornia linearis

GERANIACEAE
Monsonia angustifolia

KIRKIACEAE
Kirkia acuminata

LAMIACEAE
Clerodendendrum ternatum
Ocimum americanum
Vitex pooara

LILIACEAE
Aloe chabaudii
Aloe marlothii
Asparagus sp.
Drimia sanguinea

LIMEACEAE
Limeum sp.
Limeum viscosum

MALVACEAE
Hibiscus cannabinus
Hibiscus trionum
Melhania burchellii
Melhania forbesii
Sida alba
Sida cordifolia
Sida dregei

MIMOSACEAE
Acacia burkei
Acacia caffra
Acacia erioloba
Acacia erubescens
Acacia karroo
Acacia mellifera
Acacia nigrescens
Acacia nilotica
Acacia robusta
Acacia senegal var. *rostrata*
Acacia tortilis
Albizia anthelmintica
Albizia brevifolia
Albizia harvei
Albizia tanganyicensis
Dichrostachys cinerea
Elephantorrhiza burkei
Elephantorrhiza elephantina

MORACEAE
Ficus abutilifolia

MYROTHAMNACEAE
Myrothamnus flabellifolius

OCHNACEAE
Ochna inermis

OLACACEAE
Ximenia americana
Ximenia caffra

PEDALIACEAE
Dicerocaryum eriocarpum
Harpagophytum zeyheri

PHYLLANTACEAE
Bridelia mollis
Flueggea virosa
Phyllanthus parvulus
Pseudolachnostylis maprouneifolia

PLUMBAGINACEAE
Plumbago zeylanica

POACEAE
Aristida adscensionis

Aristida congesta subsp. *congesta* *Aristida congesta* subsp. *barbicollis* *Aristida diffusa* *Aristida stipitata* *Bothriochloa insculpta* *Brachiaria nigropedata* *Cenchrus ciliaris* *Chloris virgata* *Chrysopogon serrulatus* *Digitaria eriantha* *Diheteropogon amplectens* *Enneapogon cenchroides* *Eragrostis aspera* *Eragrostis gummiflua* *Eragrostis pallens* *Eragrostis rigidior* *Eragrostis superba* *Eragrostis trichophora* *Heteropogon contortus* *Heteropogon melanocarpus* *Loudetia simplex* *Melinis repens* *Panicum maximum* *Perotis patens* *Pogonarthria squarrosa* *Shizachyrium sanguineum* *Schmidtia pappophoroides* *Setaria ustilata* *Stipagrostis uniplumis* *Themeda triandra* *Tragus berteronianus* *Tricholaena monachne* *Trichoneura grandiglumis* *Urochloa mosambicensis* PORTULACACEAE *Portulaca kermesina* *Portulaca quadrifida* PTERIDACEAE *Pellaea calomelanos* RHAMNACEAE *Ziziphus mucronata* RUBIACEAE *Gardenia volkensii* *Oldenlandia herbacea* *Pavetta lanceolata* *Spermacoce senensis* *Vangueria parvifolia*	SAPINDACEAE *Pappea capensis* SAPOTACEAE *Englerophytum magalismontanum* *Mimusops zeyheri* SOLANACEAE *Solanum panduriforme* *Solanum tettense* STERCULIACEAE *Dombeya rotundifolia* *Hermannia grisea* *Hermannia micropetala* *Sterculia rogersii* *Waltheria indica* STRYCHNACEAE *Strychnos madagascariensis* TILIACEAE *Corchorus kirkii* *Corchorus longipedunculatus* *Grewia bicolor* *Grewia flava* *Grewia flavescens* *Grewia monticola* *Grewia occidentalis* *Triumphetta rhomboidea* VELOZIACEAE *Xerophyta humilis* VERBENACEAE *Chascanum hederaceum* *Lantana rugosa* VITACEAE *Rhoicissus revoilii*