Appendix D2
Botanical Biodiversity Baseline and Impact Assessment Report for the Mine Waste Solutions Kareerand Tailings Storage Facility Extension Project
-De Castro and Brits, 2018

BOTANICAL BIODIVERSITY BASELINE AND IMPACT ASSESSMENT REPORT FOR THE MINE WASTE SOLUTIONS KAREERAND TAILINGS STORAGE FACILITY EXTENSION PROJECT
(Stilfontein, North West Province)

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Specialist reports and reports on specialist processes - Checklist		
	NEMA Regs (2014) - Appendix 6	**Reference to section of specialist report or justification for not meeting requirement**
1	A specialist report or a report on a specialised process prepared in terms of these Regulations must contain -	
(a) i	the person who prepared the report; and	Title page
(a) ii	the expertise of that person to carry out the specialist study or specialised process;	Appendix 12
(b)	a declaration that the person is independent in a form as may be specified by the competent authority;	Appendix 13
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	2. TERMS OF REFERENCE
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	3. APPROACH 5. LIMITATIONS
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process;	3. APPROACH 4. METHODOLOGY
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	8. DESCRIPTION OF VEGETATION UNITS AND LANDCOVER TYPES WITHIN THE STUDY AREA
(g)	an identification of any areas to be avoided, including buffers;	11.2 Threatened and Near Threatened species Appendixes 4 and 7
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 2 APPENDIX 4 APPENDIX 7 APPENDIX 9
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	5. LIMITATIONS

Specialist reports and reports on specialist processes - Checklist		
	NEMA Regs (2014) - Appendix 6	**Reference to section of specialist report or justification for not meeting requirement**
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment;	12. DESCRIPTION OF THE PROPOSED INFRASTRUCTURE FOOTPRINTS 13. IMPACT ASSESSMENT
(k)	any mitigation measures for inclusion in the EMPr	14. SUMARRY AND CONCLUSIONS – Mitigation measures
(l)	any conditions for inclusion in the environmental authorisation	14.4 SUMMARY AND CONCLUSIONS - Summary of mitigation measures
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation	14.4 SUMMARY AND CONCLUSIONS – Summary of mitigation measures
(n)	a reasoned opinion -	
.i	as to whether the proposed activity or portions thereof should be authorised and	14.3 SUMMARY AND CONCLUSIONS – Potential impacts of the project
.ii	if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	14.4 SUMMARY AND CONCLUSIONS – Summary of mitigation measures
(o)	a description of any consultation process that was undertaken during the course of carrying out the study;	3. APPROACH 4.3 METHODOLOGY - Analysis of the occurrence of 'species of conservation concern' (*sensu* Raimondo *et al.*, 2009)
(p)	a summary and copies if any comments that were received during any consultation process, and -	-
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1 INTRODUCTION

In July 2017, Clean Stream Biological Services approached De Castro & Brits ecological consultants to conduct a botanical biodiversity survey and impact assessment on the footprint of the infrastructure components forming part of the proposed Mine Waste Solutions Kareerand Tailings Storage Facility (TSF) Extension Project, which will require additional Environmental Authorisation. The proposed infrastructure footprints are included in a study area of 1 495.5ha situated directly adjacent to the northern boundary of the current Mine Waste Solutions (MWS) surface rights area (Figure 1) on portions of the farms Buffelsfontein 443 IP, Hartebeestfontein 442 IP, Megadam 574 IP, Kareerand 444 IP and Kromdraai 420 IP.

This report presents the findings of the requested study.

2 TERMS OF REFERENCE

In accordance with the accepted proposal for this study, and subsequent request from MWS, the botanical specialist study presented in the current report was to assess the footprint of the following infrastructure components proposed as part of the Mine Waste Solutions Kareerand TSF Extension Project:

- TSF Extension footprint (382.6ha in extent)
- Borrow Area 1, or the western borrow area (180.0ha in extent)
- Borrow Area 2, or the central borrow area (299.8ha in extent)
- Borrow Area 3, or the eastern borrow area (186.5ha in extent)
- Return Water Dams (43.2ha).

Though not included in the Terms of Reference provided in the accepted proposal, an additional project infrastructure component is included in the current study as requested by the client (Mine Waste Solutions) prior to the commencement of fieldwork, namely the 43.2ha footprint of four continuous return water dams. In order to meet the clients' project scheduling requirements, all fieldwork was done during a single site visit in early November.

In accordance with the accepted proposal for this botanical study, the following aspects were to be included in this specialist report:

- '*Determination of the Vegetation Type/Types in accordance with existing national vegetation maps (Mucina & Rutherford, 2006) and local vegetation studies, as well as proximity and relationship to any Centre of Endemism (van Wyk and Smith 2001). A description of the regional biodiversity context using all existing information will be provided. Extensive use will be made of the existing baseline botanical biodiversity survey for the Mine Waste Solutions surface rights area (De Castro & Brits, July 2015);*
- *Broad-scale structural classification of the vegetation into homogenous units following the approach of Edwards (1983). A description of the dominant and characteristic species identified within the broad-scale plant communities comprising each of these units, will also be provided. These descriptions will be based on visual estimates of cover/abundance and density following established vegetation survey techniques (Kent & Coker 1992; Mueller-Dombois & Ellenberger 1974). These vegetation survey methods have been used as the basis of a national vegetation survey of South Africa (Mucina et al. 2000). The number of sites will be limited by the relatively short duration of the available time for fieldwork;*
- *Vegetation / habitat types will be mapped on the basis of available information (aerial photography, soil types, geology) and will consist of structurally distinct vegetation units (wetland, grasslands, woodland) as well as transformed areas (cultivated land, areas of alien vegetation). Vegetation / habitat units will be graded according to biodiversity value and*

conservation status. The vegetation mapping and description techniques will be fully compatible to the existing vegetation mapping provided in the baseline botanical biodiversity survey for the Mine Waste Solutions surface rights area (De Castro & Brits, July 2015);

- *Compilation of an annotated plant species list (to provide an accurate indication of the floristic diversity). Nomenclature will be according to New Plants of Southern Africa (POSA) website of the National Herbarium (http://newposa.sanbi.org);*
- *Determination of the occurrence, or possible occurrence, of plant 'species of conservation concern' (Raimondo et al., 2009 and http://redlist.sanbi.org), protected plants and sensitive plant communities, on the basis of field surveys, historical distribution records obtained from the Pretoria Computerised Information System (PRECIS) database of South African National Biodiversity Institute (SANBI), the North West Province threatened plant species database, and available literature. Protected plant species refers to species protected in terms of the National Forests Act (Act 84 of 1998, as amended on the 23rd of September 2010) and Threatened or Protected Species (TOPS) species protected in terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004, as amended on the 16th of April 2013);*
- *Plant species that are Declared alien invasive species in terms the Regulations on Alien and Invasive Plant Species (AIS Regulations) as defined in Notice 3 of the National Environmental Management: Biodiversity Act (Act no. 10 of 2014), will be highlighted and their distribution and relative abundance within the proposed infrastructure footprints will be broadly described*
- *Further botanical assessments regarded as necessary will also be identified and Terms of Reference for these assessments will be recommended. Such further assessments may include additional searches for potentially occurring threatened plant species that were not in flower at the time of the field surveys conducted for this study;*
- *An assessment of envisaged impacts to vegetation and flora associated with the proposed development will also be provided, as will appropriate preliminary mitigation measures for any identified 'species of conservation concern', protected plant species and sensitive plant communities and habitats*.

3 APPROACH

Prior to the field surveys, available literature and database information pertaining to the vegetation and threatened species of the south-eastern region of the North West Province within which the study area is situated was obtained and reviewed. Given the paucity of relevant published literature pertaining to the vegetation of the study area and its immediate surrounds and the absence of information pertaining to the plant 'species of conservation concern' of this region of the province in the North West Province database of 'species of conservation concern' (personal communication: Mr Ray Schaller), the study made extensive use of the following specialist reports which address various aspects of the vegetation and ecology of the Mine Waste Solutions surface rights area which abuts the study area to the south as well as the Vaal Reefs Mine Complex surface rights situated some 7km to the west:

- Botanical Biodiversity Baseline Report for the AngloGold Ashanti's 6 212ha Mine Waste Solutions surface rights area (Stilfontein, North West Province) [De Castro & Brits, July 2015];
- Survey of alien invasive plant species occurring within the 6 212ha Mine Waste Solutions surface rights area (Stilfontein, North West Province) [De Castro & Brits, July 2015];
- Baseline Vegetation Monitoring Survey for the 6 212ha Mine Waste Solutions surface rights area (Orkney, North West Province) – Fixed-point photography and vegetation sampling [De Castro & Brits, August 2015];
- Botanical Biodiversity Baseline report for the AngloAshanti Vaal River Mines surface rights area (Orkney, North West Province) [De Castro & Brits, May 2007];

- Follow-up Floristic and Threatened Plant survey of the 12,725ha Vaal Reefs Mine Complex property (Orkney, North West Province) [De Castro & Brits, August 2013];
- Third Vegetation Monitoring Survey for the 12 735ha Vaal Reefs Mine Complex property (Orkney, North West Province) – Fixed-point photography [De Castro & Brits, July 2017].

Information on the broad-scale biodiversity conservation value of the study area and its surrounds was obtained from the North West Biodiversity Sector Plan (NWBSP) 2015, which was completed in December 2015 and is available on the SANBI or Biodiversity Global Information System (BGIS) websites. Though the NWBSP provided updated guidelines for the assessment of the biodiversity value of the entire province, the shapefiles for the Critical Biodiversity Areas (CBAs) for the North West Province contained in NWBSP remain largely unchanged from those contained in the preceding North West Province Biodiversity Conservation Assessment (North West Department of Agriculture, Conservation, Environment and Rural Development, 2009).

The terms of reference for this study only included vegetation and floristic surveys of the proposed footprint of the main infrastructure components (TSF and borrow areas). However, a study area of 1 495.5ha, which includes all proposed infrastructure footprints, was selected and surveyed in order to contextualise vegetation and floristic descriptions of the infrastructure footprints and thus provide context for the impact assessment. Where the current 1 494.5ha study area overlaps with the MWS surface rights area, the existing vegetation and land-cover type mapping for the MWS solutions surface rights area (De Castro & Brits, July 2015a) was used with minimal modification where necessary.

In order to meet the project scheduling requirements of MWS, all fieldwork was done during a single site visit between the 2nd and 11th of November 2017. The field survey included the entire 1495.5ha study area but focussed on the proposed infrastructure footprints. The survey included quantitative vegetation sampling within 100m^2 sampling quadrats/plots but focussed on searching for plant 'species of conservation concern' and the compilation of comprehensive species lists at all visited sites using the 'timed meander search method' (Goff *et al*., 1982 and Huebner, 2007). Emphasis was placed on compiling a detailed and verified species list (Appendix 1), as species level information forms the basis of any accurate botanical biodiversity assessment.

The wetlands of the study area dealt with in more detail in the specialist wetland report compiled concurrently with this report by De Castro & Brits cc.

4 METHODOLOGY

4.1 Stratification and vegetation and sensitivity mapping

Prior to the initial November field survey, a preliminary broad scale vegetation map was produced at desktop level using the obtained literature, Google Earth imagery, available aerial photographs and 1:50 000 topocadastral maps. Historical aerial photographs were obtained from National Geo-spatial Information (NGI), a component of the Department of Rural Development and Land Reform (DRDLR). The study area was broadly stratified into major classes on the basis of gradient, aspect, terrain units (e.g. crest, midslope, footslope), rock cover, soils, land-use and vegetation physiognomy. Additional stratification units were demarcated along the rivers, streams, drainage lines, and wetlands of the study area. This method has been successfully employed in various studies in the past (e.g. Coetzee *et al*. 1994, 1995) and has been shown to correlate well with observed vegetation patterns. The first approximation map was then used as a basis for selecting representative sampling sites within the study area.

The vegetation and land-cover type units presented here were derived on the basis of structural and functional criteria. The term structure refers to various aspects of vegetation structure such as physiognomy, life-form composition, species composition, species dominance and stand structure (Kent & Coker, 1992). Functional criteria include aspects such characteristic ecosystem processes, habitat characteristics and ecological status (e.g. primary vegetation of untransformed habitats versus secondary vegetation of transformed or severely degraded habitats). The floristic data set gathered in 26 vegetation sampling plots was subjected to analysis to establish differences and similarities, and this analysis was used only to guide the identification of the robust vegetation units described in this report, which are based on qualitative and semi-quantitative floristic, physiognomi and habitat data gathered at a total of 76 sites (including 26 sites where quadrats were surveyed), and observations made whilst travelling between the sites (see Appendix 2).

The criteria for the identification of wetlands as described in the Department of Water Affairs and Forestry (DWAF) document titled "A practical field procedure for identification and delineation of wetlands and riparian areas (Final Draft)" (September, 2005), were used in this study. The DWAF document stipulates the use of the following indicators to identify wetlands: 'Terrain Unit Indicator' (terrain unit morphological classes), 'Soils Form Indicator' (presence of hydromorphic soils), 'Soil Wetness Indicator', and the 'Vegetation Indicator' (presence of hydrophytic and/or hygrophytic species). The identification and mapping of the wetland boundaries was done in conjunction with the wetland specialist (Retief Grobler) currently conducting a wetland assessment for the Kareerand TSF Extension Project, both in the field and in final mapping.

In the current report the term 'untransformed' vegetation refers to vegetation that is in a 'climax' or 'steady state' (Kent & Coker, 1992) or has been somewhat degraded by impacts such as altered fire regimes and overgrazing, but which is considered to still contain pre-disturbance species richness (α-diversity) and will quickly revert to a climax state under appropriate management. 'Secondary' vegetation refers to seral communities of pioneer species in habitats affected by catastrophic historical impacts such as ploughing.

Five, broad-scale botanical biodiversity 'sensitivity' categories are used in this report. These categories were developed for practical mapping purposes and are intended as a simple, yet scientifically sound summary of the perceived botanical biodiversity value and sensitivity, of mapped broad-scale vegetation and land-cover type units, which is described in more detail in the description of each mapping unit. The five sensitivity categories are described in Table 1.

Table 1: Guidelines for botanical biodiversity sensitivity categories.

Category	Synopsis of criteria
Very High	Includes the following: 1) mapping units comprising untransformed plant communities which are representative of vegetation types or broad-scale vegetation units (*sensu* Mucina & Rutherford, 2006) which are currently regarded as Critically Endangered in the national vegetation map (Mucina & Rutherford, 2006) or provincial vegetation classifications (e.g. NWBSP, 2015); 2) mapping units comprising untransformed plant communities which provide confirmed habitat for one or more threatened (Critically Endangered, Endangered, Vulnerable), Critically Rare or Rare plant species (*sensu* Raimondo *et al*., 2009 and http://redlist.sanbi.org); 3) mapping units comprising untransformed plant communities which provide confirmed habitat for a Near Threatened plant species for which "no further habitat loss" is recommended in the 'Guidelines for EIA recommendations for taxa of conservation concern found on proposed development sites' provided in Table 4.1 of the Red List of South African Plants (Raimondo *et al*., 2009), OR which provide confirmed habitat for

Category	Synopsis of criteria
	two or more Near Threatened plant species, including those for which "limited habitat loss may be considered" under certain circumstances [see Table 4.1 of the Red List of South African Plants (Raimondo *et al*., 2009)].
High	Includes the following: 1) mapping units comprising untransformed plant communities which are representative of vegetation types or broad-scale vegetation units (*sensu* Mucina & Rutherford, 2006) which are currently regarded as Endangered or Vulnerable in the national vegetation map (Mucina & Rutherford, 2006) or provincial vegetation classifications (e.g. NWBSP, 2015); 2) mapping units comprising untransformed habitats and plant communities, which are representative of vegetation types or broad-scale vegetation units which are currently regarded as Least Threatened, but which provide confirmed habitat for Near Threatened plant species which do not meet the criteria listed above under point 3 of the criteria for the Very High sensitivity category; 3) mapping units comprising untransformed habitats and plant communities which have one or more of the following (or similar) attributes which lend elevated conservation value: o highly spatially restricted in the region of the study area; o high species richness and/or unique floristic composition; o high functional value (e.g. untransformed wetland habitats).
Moderate	Units comprising untransformed plant communities which are representative of vegetation types or broad-scale vegetation units (*sensu* Mucina & Rutherford, 2006) which are currently regarded as Least Threatened in the national vegetation map (Mucina & Rutherford, 2006) or provincial vegetation classifications (e.g. NWBSP, 2015), and which do not include confirmed habitat for any threatened, Near Threatened, Critically Rare or Rare plant species (*sensu* Raimondo *et al*., 2009 and http://redlist.sanbi.org) and do not have any additional attributes that lend them elevated biodiversity conservation value. Category may also include secondary plant communities of historically transformed habitats which are in an advanced stage of secondary succession and are representative of a vegetation type or broad-scale vegetation unit (*sensu* Mucina & Rutherford, 2006) which is currently regarded as Critically Endangered, Endangered or Vulnerable in the national vegetation map (Mucina & Rutherford, 2006) or provincial vegetation classifications (e.g. NWBSP, 2015).
Low	Units comprising secondary plant communities of historically transformed habitats, other than those which meet the criteria for Moderate sensitivity. Also includes currently cultivated lands and dense stands of alien invasive trees.
Negligible	Units comprising habitats completely and more or less permanently transformed by the construction of infrastructure (e.g. residential areas, industrial premises, offices and mine infrastructure such as tailings storage facilities and waste rock dumps).

4.2 Floristic survey and vegetation sampling

Botanical surveys were conducted at 76 sites (see Appendix 2) and numerous notes on vegetation structure and plant 'species of conservation concern' were made whilst travelling between these sites. At all 76 sites surveyed, use was made of the 'timed meander search' method and the vegetation was classified using visual estimates of woody canopy cover according to the broad-scale structural classification of Edwards (1983). The 'timed meander search' method is a semi-quantitative survey procedure that focuses on the discovery of rare vascular plant species, which include most 'species of conservation concern' (Goff *et al*., 1982 and Huebner, 2007). The 'timed

meander search' method has been shown to be highly effective and time efficient in detecting rare species and documenting α-diversity (Huebner, 2007).

At 26 of the 76 selected sites, units derived from initial desktop stratification were sampled using standard vegetation survey procedures following the Braun-Blanquet approach (Mueller-Dombois & Ellenberger 1974 and Kent & Coker 1992). The sampling quadrat (or plot) size was standardised at 10 x 10 metres (100m^2) in order to facilitate comparisons between vegetation units, and for the purposes of future comparison with studies done in other parts of the country. The floristic data gathered within eighteen of the twenty-six quadrats is presented in Appendix 3. The following parameters were recorded in each plot:

- Floristic parameters:
  - all plant taxa, identifiable at the time of sampling, rooted in the sample site;
  - a growth form (tree, shrub, dwarf shrub, forb, grass) was assigned to each species;
  - projected canopy cover for each species recorded was visually estimated using the Braun-Blanquet cover-abundance scale;
  - in the case of woody communities, each site was classified according to the structural classification of Edwards (1983).
- Environmental parameters:
  - locality in degrees, minutes and seconds using a Global Positioning System (GPS) receiver (see Appendix 2);
  - slope, measured in degrees;
  - aspect, measured in degrees;
  - elevation, measured in metres using a barometric altimeter;
  - terrain unit (midslope, foot slope, etc.);
  - estimated percentage surface rock cover; and
  - any visible disturbances (e.g. grazing, fire, old lands).

Parameters such as geology, topography, etc. were also obtained from the relevant topographical maps and a hard-copy broad-scale map of the surface geology of the study area provided by Mr Gunther Wiegenhagen of AngloAshanti.

Specimens of plant taxa unknown at the time of field sampling were collected for later identification using the appropriate scientific keys, or sent to the National Herbarium in Pretoria for identification. Plant species names or nomenclature is that used by the National Herbarium, Pretoria as provided in the Plants of South Arica web-based database (http//:newposa.sanbi.org). In the text of this report, alien species are indicated by an asterisk.

4.3 Analysis of the occurrence of 'species of conservation concern' (*sensu* Raimondo *et al.*, 2009)

Prior to the field surveys, available database information pertaining to the threatened plant species of the region of the North West Province within which the study area is situated was obtained from the National Herbarium PRECIS database (http://newposa.sanbi.org). All plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009 and http://redlist.sanbi.org, downloaded May 2015) historically recorded from the quarter degree grid square within which the study area is situated (2626DD), as well as the grids immediately to the west (2626DC and 2626CD) and south-west (2726BA) which contain similar habitats, were extracted from these lists and are presented in Appendix 5, together with the eight additional plant 'species of conservation concern' historically recorded by the author and Mr Gunther Wiegenhagen of AngloGold Ashanti within the aforementioned grid squares between 2007 and 2017. During the field surveys emphasis was placed on searching for these plant species, and potentially suitable habitat for these species. All 49 plant

species regarded as 'priority species' for the North West Province (Hahn, June 2011) were also considered, and these 49 species are listed in Appendix 6.

The North West Province database of 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) was not yet completed at the time of writing and historical records for the quarter degree grids within which the study area is situated were therefore not available from the North West Province (personal communication: Mr Ray Schaller). However, the curator of the provincial database did indicate that the awaited database is unlikely to contain any records of plant 'species of conservation concern' for the quarter degree grid 2626DD.

4.4 Diversity analysis

Species richness (α-diversity) was defined as the number of species per sampling plot and was presented as the mean species richness for each vegetation unit (Whittaker 1972). The total number of species recorded in all sampling plots within each vegetation unit is presented in Table 4, and provides an indication of the species richness of the various identified vegetation and land-cover type units.

4.5 Impact Assessment

The potential impacts or risks (pre-mitigation and post-mitigation[1]) associated with the proposed development were assessed based on the following criteria (relative ranking proved in brackets):

- **Applicable phase: Construction, Operational, (Decommissioning/Closure).**
- **Nature of impact:** Provides a description of the expected impacts.

CONSEQUENCE (considers extent, duration and intensity)

- **Extent of impact:**
  - Site: Effect limited to site and its immediate surrounds (1).
  - Local: Effect limited to 3 to 5km of the site (2).
  - Regional: Effect will have an impact on a regional scale (3).
  - National: Effect will have an impact on national scale (4)
  - International: Effect will have an impact internationally (5).
- **Duration of impact:**
  - Short: Effect last for a period of 0 to 5 years (1).
  - Medium: Effect continues for a period between 5 and 10 years (2).
  - Long: Effect will cease after operational life of the activity either because of natural process or by human intervention (3).
  - Permanent: Where mitigation either by natural process or human intervention will not occur in such a way or in such a time span that the impact can be considered transient (4).
- **Intensity of impact:**
  - Low: The impact affects the environment in such a way that natural, cultural and social functions and processes are not affected (1).
  - Medium: Where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way (3).
  - High: Where the natural, cultural or social functions or processes are altered to the extent that it will temporarily or permanently cease (5).

[1] **Residual impacts** are defined as those **impacts** that remain following the implementation of the mitigation measures proposed.

LIKELIHOOD (considers probability and frequency)

- **Probability:**
  - Improbable: Less than 33% chance of occurrence (1)
  - Probable: Between 33 and 66% chance of occurrence (2).
  - Highly probable: Greater than 66% chance of occurrence (3).
  - Definite: Will occur regardless of any prevention measures (4).
- **Frequency**:
  - Annually or less: Impact occurs at least once a year or less frequently (1)
  - 6 Months: Impact occurs at least once in 6 moths (2)
  - Monthly: Impact occurs at least once a month (3).
  - Weekly: Impact occurs at least once a week (4).
  - Daily: Impact occurs daily (5).

SIGNIFICANCE (considers consequence and likelihood):

- Low: Where the impact will have a relatively small effect on the environment and will not have an influence on the decision.
- Medium: Where the impact can have an influence on the environment and the decision and should be mitigated.
- High: Where the impact definitely has an impact on the environment and decision regardless of any possible mitigation.

- **Status**:
  - Positive: Impact will be beneficial to the environment.
  - Negative: Impact will not be beneficial to the environment.
  - Neutral: Positive and negative impact.
- **Confidence:**
  - Low: It is uncertain whether the impact will occur
  - Medium: It is likely that the impact will occur.
  - High: It is relatively certain that the impact will occur.
- **Mitigation:** Provides recommendations for mitigation measures.
- **Significance post mitigation**: Describes the significance after mitigation.

The expected **Cumulative** impacts of the proposed activity is also described qualitatively.

5 LIMITATIONS

The study area is 1 495.5ha in extent, and the approved budget for the survey presented here was seven days (8-hour days) of travel and fieldwork and seven days of data analysis, mapping and reporting.

The most significant limitations for the study presented here were as follows:

- In order to meet the clients' project scheduling requirements, all fieldwork was done during a single site visit in early November;
- The field survey was conducted over seven days during a single site visit between the 2nd and 11th of November 2017. This lack of seasonal coverage reduced the accuracy of the species list provided in Appendix 1 and greatly increased the difficulty of finding inconspicuous plant 'species of conservation concern' that were not in flower at the time of the field survey;
- Due to the large size of the study area and the relatively short duration and lack of seasonal coverage of the field survey, the species list provided in Appendix 1 cannot be regarded as comprehensive. Based on the authors experience in the region the species list is likely to contain approximately 85% of the plant species present within the study area. The species

list provided in Appendix 1 is nevertheless considered to provide an accurate indication of the species richness of the study area;

- The study area experienced low rainfall in the early growing season prior to the field survey (pers. com. Gunther Wiegenhagen) and was very dry and heavily grazed at the time of the field survey. This increased the difficulty in identifying plant species, and in particular grasses, within the selected sampling quadrats and reduced the accuracy of the species lists and cover/abundance estimates provided for each sampled quadrat (see Appendix 3),
- The data pertaining to various aspects of vegetation structure (e.g. species composition, dominance, physiognomy and stand structure) that was used to to guide the determination and mapping of vegetation units, was gathered within a limited number of $100m^2$ sampling quadrats and limited number of sites were species lists and brief descriptions of vegetation physiognomy were compiled. The descriptions and delineations provided for the broad-scale vegetation and land-cover type units must be considered within this context.
- No detailed soils or geological maps of the study area were available for use in stratification and vegetation mapping, but a hard-copy broad-scale map of the surface geology of the study area was provided by Mr Gunther Wiegenhagen of AngloGold Ashanti.

The limitations pertaining to the lack of seasonal coverage of the field survey is mitigated by recommendations for additional brief floristic surveys, aimed at searching for potentially occurring 'species of conservation concern' (*sensu* Raimondo *et al*., 2009), provided in the recommendations section of this report, as well as by the fact that the author has conducted various floristic field surveys including extensive seasonal coverage in the directly adjacent Mine Waste Solutions surface rights area. None of the limitations listed above had a material impact on the suitability of the survey presented here as a basis for the conduction of a scientifically sound botanical biodiversity impact assessment.

6 PROJECT DESCRIPTION

Mine Waste Solutions (MWS) is a tailing dam reclamation operation situated in the North West Province, with tailings dams (tailings storage facilities) in the Klerksdorp-Orkney–Stilfontein–Hartebeestfontein region. MWS is a subsidiary of AngloGold Ashanti (AGA). Currently tailings from the MWS plant are sent to the Kareerand Tailings Storage facility (TSF) (Figure 1). The Kareerand TSF will become a constraint to the capacity of the operation as from the beginning of 2021. In order to maintain operations, it is required to bring further TSF capacity into operation by the beginning of 2021.

MWS has identified that the optimum strategy for creating additional TSF capacity is to construct an extension of the existing 564ha Kareerand TSF whilst at the same time increasing the final design height of the existing footprint. These activities will form part of the Kareerand TFS Extension Project. The extension will be constructed to the north-west of the existing TSF footprint and the extension footprint will be approximately 382.6ha in extent and will abut onto the existing footprint (Figure 2). Due to the increased surface area of the extended TSF there will be additional storm water collection dams (Figure 2) to control run off from the dam. Potential borrow areas (borrow pits) for extraction of soils for use in stabilising the retaining walls of the TSF extension are also included in this project (see Figure 2).

7 DESCRIPTION OF THE STUDY AREA

7.1 Locality and land-use

The 1 495.5ha study area is situated in the North West Province some 6km south-east of Stilfontein and 1.2km south of Khuma. The study area comprises parts of the farms Buffelsfontein 443 IP,

Hartebeestfontein 442 IP, Megadam 574 IP, Kareerand 444 IP and Kromdraai 420 IP. A locality map is provided in Figure 1.

The central parts of the southern boundary of the study area abut directly on the existing 564ha TSF. There is little existing infrastructure within the study area itself. Existing infrastructure comprises a guard house, a pipeline, a small laydown area and engineered dirt roads associated with the existing TSF, as well as farming related infrastructure such as dirt tracks, a small cement reservoir adjacent to the small endorheic pan (Site 31) and two abandoned farm homesteads in the eastern parts of the study area on the farms Kromdraai and Kareerand. Three recently abandoned (ca. 6 years ago) centre pivot irrigation fields are also present in the eastern parts of the farm Kromdraai.

The existing TSF has been fenced off by a 2m game fence for security purposes, and the fence is situated 50m to 390m from the retaining wall of the TSF. Grazing and fire have been excluded from the fenced security area for some eight years, and the vegetation is highly moribund. An area of approximately 157ha in the south-western parts of the study area, situated on the farm Buffelsfontein, is situated within a game fenced area belonging to MWS which is heavily grazed by game animals. The western portions of the study area situated on the farms Kareerand and Kromdraai are fenced with normal cattle fencing and used for grazing by commercial cattle farmers. The remainder of the study area is unfenced, is not subjected to any form of access control and is regularly burnt and heavily grazed by cattle belonging to residents of Khuma.

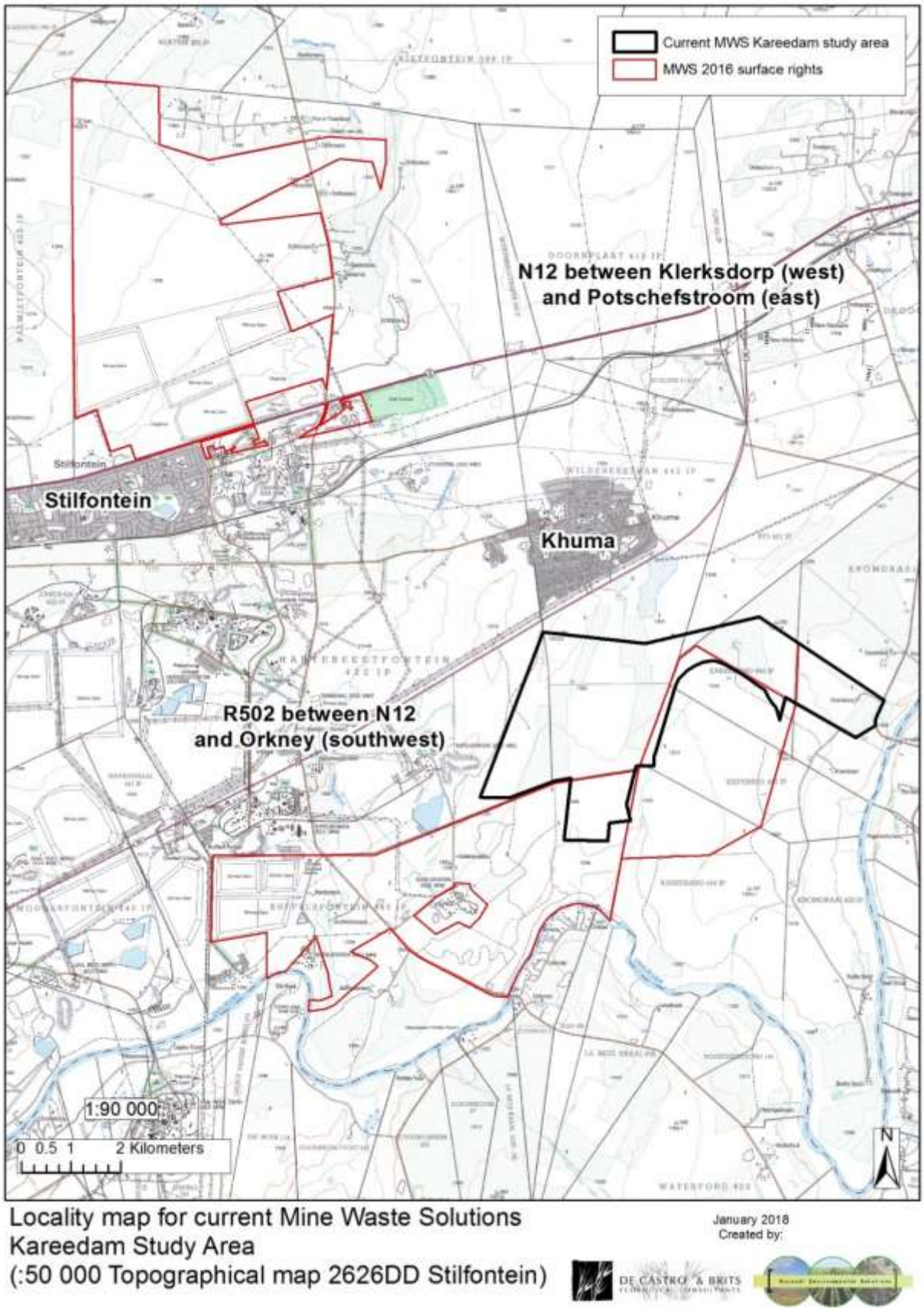

Figure 1: Locality map for the Mine Waste Solutions Kareerand TSF Extension project EIA study area. The 2016 MWS surface rights, for which a Botanical Biodiversity Baseline study was conducted in 2015 (De Castro & Brits, July 2015), is also shown for reference purposes.

7.2 Physiography

The topography of the study area is generally flat to gently undulating and elevation drops gently from north-west to south-east over the majority of the study area. In the north-east parts of the study area, on the farms Kromdraai and Kareerand, the elevation drops gently towards the east-north-east. A low chert ridge (with rare patches of surface dolomite) orientated roughly from north to south is situated along the eastern boundary of the study area on the farm Hartebeestfontein. Four unchannelled valley-bottom wetland systems arise within the study area. The upper catchment of the largest of these valley-bottom wetland systems has been almost entirely destroyed by the footprint of the TSF, but a small, isolated patch of hillslope seep that was once connected to this valley-bottom wetland is still present immediately adjacent to the north-western boundary of the TSF. The two valley bottom wetlands situated in the north-eastern parts of the study area on the farm Kromdraai have been almost entirely cultivated (centre pivot fields) in the past, and the valley-bottom wetland arising in the southern parts of the study area within the farm Buffelsfontein is in a near-pristine state. A small, endorheic, ephemeral pan is situated in the north-western parts of the study area.

The elevation of the study area varies from 1 348m in the north-west to 1 305m along the central parts of the southern boundary and 1307m along the eastern boundary on the farm Kromdraai. In geological terms, the study area falls within the Witwatersrand Supergroup.

The soils of the vast majority of the study area comprise red-brown clay loams or clays overlying basic ingenious rocks, mostly diabase and andesitic lava (see area mapped as Clay Grassland in Figure 2). A small patch (ca. 40ha) of black turf soils is also present adjacent to the central parts of the northern boundary of the study area. A narrow band of light brown sandy loams overlying mostly quartzite, but also shale and siltstone, occurs in the south central parts of the study area (see area mapped as Sandy Grassland in Figure 2). On the low chert ridge (with rare patches of surface dolomite) situated along the eastern boundary of the study area, the soils are mostly stony and shallow brown clay loams or loams with high surface rock cover (chert) generally ranging from 15 to 30%. The climate can be characterised as warm-temperate summer-rainfall region, with overall Mean Annual Precipitation (MAP) of approximately 560mm (Mucina & Rutherford, 2006). The summer temperatures are high, but severe and frequent frost occurs in winter.

7.3 Broad-scale vegetation and habitat patterns

The most recent vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006), maps the vegetation of the vast majority of the study area as Rand Highveld Grassland (Gm 11) and the only other vegetation type mapped for the study area is Vaal Reefs Dolomite Sinkhole Woodland (Gh12) which occurs along the entire eastern boundary and extends up to approximately 1km into the study area. The Mucina and Rutherford (2006) vegetation map, does not map Vaal-Vet Sandy Grassland within the current study area but does show an area of this vegetation type situated some 2km to the north of the north-eastern corner of the study area. The current study confirmed the absence of Vaal-Wet Sandy Grassland from within the study area, though the unit identified as ‘Sandy Grassland ‘in the current study does show some possible floristic and structural elements of this vegetation type. Vaal Reefs Dolomite Sinkhole Woodland forms part of the Dry Highveld Grassland Bioregion of the Grassland Biome and Rand Highveld Grassland forms part of the Mesic Highveld Grassland Bioregion of the Grassland Biome (Mucina & Rutherford, 2006 and Rutherford & Westfall, 1994). A map showing the distribution of the Mucina and Rutherford (2006) vegetation types within the study area is provided in Appendix 9.

Rand Highveld Grassland occurs within Gauteng, North West, Free State and Mpumalanga Provinces. Within the North West Province this vegetation type extends from a few kilometres

south of Westonaria, south-westwards to Potchefstroom and the Vaal River south of Khuma. The study area is therefore situated on the south-western boundary of the distribution range of Rand Highveld Grassland. This vegetation occurs at an altitude of between 1300m and 1635m on highly variable landscape with extensive sloping plains and a series of ridges slightly elevated above the surrounding plains. The vegetation is species rich. Rand Highveld Grassland is considered to be **Endangered** nationally, and though the 'Conservation Target' is 24% (Mucina & Rutherford, 2007), only 1% is conserved in statutory and private conservation areas and almost half has been transformed by cultivation, plantations, urbanisation and dam building. The percentage transformation of this vegetation type may in fact be considerably greater than 50% as many patches of secondary grassland of historically cultivated areas are classified as untransformed grassland in some land-cover classifications. Scattered aliens (predominantly *Acacia mearnsii*) occur in about 7% of this unit, and only about 7% has been subjected to moderate to high erosion levels.

The Vaal Reefs Dolomite Sinkhole Woodland vegetation type is restricted largely to a small area of the North West Province where it is associated with dolomite sinkholes in and around Stilfontein and Orkney, but also extends into a small area of the Free State Province immediately to the south of the Vaal River (Mucina & Rutherford, 2006). The study area includes only the variation of this vegetation type that occurs on low chert ridges and not the typical communities that occur on dolomite in very flat landscapes. This vegetation occurs at an altitude of between 1280m and 1380m on a slightly undulating landscape dissected by prominent rocky chert ridges. The geology comprises almost exclusively of dolomites of the Malmani Subgroup (Chuniespoort Group, Transvaal Supergroup). Most of the soil types are relatively shallow and rocky, with the dominant soil forms being Mispah, Glenrosa and shallow Hutton. This vegetation type is considered to be **Vulnerable** nationally, and though the 'Conservation Target' is 24% (Mucina & Rutherford, 2006), none of this vegetation is currently conserved in statutory reserves and some 25% has already been transformed. Transformation is largely as a result of mining, cultivation, urban sprawl and road building and this region contains possibly the highest concentration of mines in any vegetation region in South Africa. Erosion is generally very low.

The study site is not situated within any Centre of Plant Endemism (Van Wyk & Smith, 2001). The Griqualand West Centre of Plant Endemism (van Wyk & Smith 2001) is situated approximately 130km to the west of the study area, but the study area does not display any of the habitat characteristics and floristic elements of this Centre of Plant Endemism.

A total of 394 plant species and infraspecific taxa were recorded within the study area during the current survey, of which 355 are indigenous taxa and 49 (13.8%) are naturalised aliens. A preliminary figure of 355 indigenous plant species represents a relatively high species richness for an area of this size in this region of the North West Province. This high species richness and diversity of plant communities is probably attributable to the fact that the study area not only includes areas of two vegetation types mapped by Mucina & Rutherford (2006) for the study area, namely Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland, but is also situated in close proximity to a third vegetation type, namely Vaal-Vet Sandy Grassland which extends to within about 2km of the northern boundary of the study area.

Dominant and common plant species listed for Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland by Mucina and Rutherford (2006) are presented in Table 2.

Table 2

Table 2: Dominant and common plant taxa of the Rand Highveld Grassland (Gm 11) and Vaal Reefs Dolomite Sinkhole Woodland (Gh12) vegetation types (extracted from Mucina & Rutherford, 2006). Dominant species indicated with (d).

Rand Highveld Grassland (Gm 11)	
Growth Form	**Species**
Graminoids	*Ctenium concinnum* (d), *Cynodon dactylon* (d), *Digitaria monodactyla* (d), *Diheteropogon amplectans* (d), *Eragrostis chloromelas* (d), *Heteropogon contortus* (d), *Loudetia simplex* (d), *Monocymbium cerisiiforme* (d), *Panicum ntalense* (d), *Schizachyrium sanguineum (d), Setaria sphacelata (d) Themeda triandra (d), Trachypogon spicatus* (d), *Tristachya biseriata* (d), *Tristachya rehmannii* (d), *Andropogon schirensis, Aristida aequiglumis, Aristida congesta, Aristida junciformis subsp. galpinii, Bewsia biflora, Brachiaria nigropedata, Brachiaria serrate, Bulbostylis burchellii, Cymbopogon caesius, Digitaria tricholaenoides, Elionurus muticus, Ergarostis capensis, Eragrostis curvula, Eragrostis gummiflua, Eragrostis plana, Eragrostis raemosa, Hyparrhenia hirta, Melinis nerviglumis, Melinis repens, Michrochloa caffra, Setaria nigrirostris, Sporobolus pectinatus, Trichoneura grandiglumis, Urelytrum agropyroides.*
Herbs	*Acanthospermum australe* (d), *Justicia anagalloides* (d), *Pollichia campestris* (d), *Acalypha angustata, Chamaecrista mimosoides, Dicoma anomala, Helichrysum caespititum, Helichrysum nudifolium var. nudifolium, Helichrysum rugulosum, Ipomoea crassipes, Kohautia amatymbica, Lactuca inermis, Macledium zeyheri subsp. argyrophylum, Nidorella hotentottica, Oldenlandia herbacea, Rotheca hirsuta, Selago densiflora, Senecio coronatus, Sonchus dregeanus, Vernonia oligocephala, Xerophyta retinervis.*
Geophytic herbs	*Boopone disticha, Cheilanthes hirta, Haemanthus humilis* subsp. *humilis, Hypoxis rigidula* subsp. *pilosissima, Ledebouria ovatifolia, Oxalis corniculata.*
Succulent herbs	*Aloe davyana.*
Low shrubs	*Anthospermum rigidum* subsp. *pumilum, Indigofera comosa, Searsia magalismontana, Seriphium plumosa.*
Succulent shrub	*Lopholaena coriifolia.*
Geoxylic suffrutex	*Elephantorrhiza elephantina.*
Vaal Reefs Dolomite Sinkhole Woodland (Gh12)	
Growth Form	**Species**
Trees	*Acacia erioloba* (d), *Celtis africana* (d), *Rhus lancea* (d), *Acacia caffra, Acacia karoo, Acacia robusta* subsp. *clavigera.*
Tall Shrubs	*Diospyros lyciodes* subsp. *luciodes* (d), *Ehretia rigida* (d), *Grewia flava* (d).
Low Shrubs	*Asparagus suaveolens (d), Gymnosporia buxifolia (d), Pavonia burchellii (d), Sida dregei (d), Anthospermum hispidulum, Asparagus laricinus Felicia muricata, Indigofera heterotricha, Menodora africana, Phyllanthus incurvus, Triumfetta sonderi, Ziziphus zeyheriana.*
Geoxylic Suffrutex	*Elephantorrhiza elephantina.*
Woody climber	*Asparagus africanus.*
Graminoids	*Aristida congesta (d), Digitaria eriantha (d), Eragrostis biflora (d), E.curvula (d), Themeda triandra (d), Anthephora pubescens, Aristida canescens, Bewsia biflora, Brachiaria nigropedata, B. serrata, Chloris pycnothrix, Cymbopogon caesius, C. pospischilii,Cynodon dactylon, Cyperus margaritaceus, Diheteropogon amplectans, Elionurus muticus, eragrostis chloromelas, E. lehmanniana, E. racemosa, E. superba, Eustachys paspaloides, Heteropogon contortus,Melinis repens, Panicum coloratum, Setaria sphacelata, Triraphis andropogonoides.*

Herbs	*Commelina africana* (d), *Barleria macrostegia, Chamaecrista mimosoides, Chamaesyce inaequilatera, Chascanum hederaceum, Crabbea angustifolia, Cyanotis speciosa, Dicoma anomala, Hermannia depressa, indigofera daleoides, I. Torulosa* subsp. *angustiloba, Ipomoea obscura, justicia anagalloides, Nidorella hottentotica, Osteospermum muricatum, Pllichia campestris, vernonia oligocephala*.
Geophytic Herb	*Albuca setosa*

According to the NWBSP 2015, the Ecosystem Threat Status of the two vegetation types occurring within the study area is as follows:

- Vaal Reefs Dolomite Sinkhole Woodland (**Vulnerable**), and
- Rand Highveld Grassland (**Endangered**).

The threat status of Vaal Reefs Dolomite Sinkhole Woodland according to the NWBSP 2015 require some clarification as it is somewhat ambiguous. The NWBSP states that Vaal Reefs Dolomite Sinkhole Woodland is not currently threatened in terms of the 'best case scenario' but is threatened (Vulnerable) in terms of the 'worst case scenario' and is predicted to be Vulnerable by 2020. Furthermore the MWBSP 2015 provides figures showing that less than 60% of the original extent of Vaal Reefs Dolomite Sinkhole Woodland remains untransformed, and according to South African National Biodiversity Institute guidelines used by the authors (SANBI, 2014) of the NWBSP, ecosystems/vegetation types where there is less than 60% remaining are categorised as Vulnerable. In the current report Vaal Reefs Dolomite Sinkhole Woodland is therefore considered Vulnerable.

The North West Province Biodiversity Sector Plan (NWBSP) (North West Department of Rural, Environment and Agricultural Development, 2015), provides a map of Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) for the entire province, which is referred to as the CBA Map in the NWBSP. Categories used in the CBA map are as follows:

- Protected Areas – declared and formally protected under the Protected Areas Act, such as National Parks, legally declared Nature reserves, World Heritage Sites and Protected Environments that are secured by appropriate legal mechanisms.
- Critical Biodiversity Areas (CBAs) – terrestrial and aquatic areas of the landscape that need to be maintained in a natural or near natural state in order to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. In other words, if these areas are not maintained in a natural or near-natural state, then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses.
- Ecological Support Areas (ESAs) – terrestrial and aquatic areas that are not essential for meeting biodiversity representation targets (thresholds), but which nevertheless play an important role in supporting the ecological functioning of critical biodiversity areas and/or in delivering ecosystem services that support socio-economic development, such as water provision, flood mitigation or carbon sequestration. The degree or extent of restriction on land use and resource use in these areas may be lower than that recommended for CBA's.
- Other Natural Areas - remaining natural areas not included in the above CBA or ESA categories. Degraded areas falling with the CBA and ESA categories. Areas that still contain natural habitat but that are not require to meet biodiversity targets.
- No Natural Habitat Remaining – areas that have been irreversibly modified (i.e. transformed) and do not contribute to maintaining biodiversity pattern or ecological processes. These include urban and rural settlements, crop lands, mining areas and forest plantations.

The entire study area falls within areas mapped as Critical Biodiversity Area - Category 1 (CBA 1) or Critical Biodiversity Area - Category 2 (CBA 2). The principal 'Land Management Objectives' for CBA 1 and CBA 2 areas provided in the NWBSP 2015 are reproduced in the 'text box' provided below.

TEXT BOX (extracted from Table 12 of the NWBSP 2015)	
CBA Map category	**Land Management Objective**
CBA 1	**Maintain in a natural or near natural state that maximises the retention of biodiversity pattern and ecological process**: • Ecosystems and species fully or largely intact and undisturbed. • These are areas with high irreplaceability or low flexibility in terms of meeting biodiversity pattern targets. If the biodiversity features targeted in these areas are lost then targets will not be met. • These are biodiversity features that are at, or beyond, their limits of acceptable change
CBA 2	**Maintain in a natural or near natural state that maximises the retention of biodiversity pattern and ecological process**: • Ecosystems and species fully or largely intact and undisturbed. • Areas with intermediate irreplaceability or some flexibility in terms of meeting biodiversity targets. There are options for loss of some components of biodiversity in these landscapes without compromising the ability to achieve biodiversity targets, although the loss of these sites would require alternative sites to be added to the portfolio of CBAs. • These are biodiversity features that are approaching, but have not surpassed their limits of acceptable change.

In terms of managing the loss of natural habitat in CBAs, the NWBSP 2015 states, amongst others, that '**further loss of natural habitat should be avoided in CBA 1, whereas loss should be minimised in CBA 2 i.e. land in these two categories should be maintained as natural vegetation cover as far as possible**'. The CBA Map categories of the study area are briefly discussed below.

Maps showing the extent of CBA Category 1 and CBA Category 2 areas within the study area and its immediate surrounds, are provided in Appendix 9. Approximately 1 126.5ha (or 75.3%) of the study area is mapped in the NWBSP 2015 as CBA 2 and the remaining 369.0ha (or 24.7%) of the study area is mapped as CBA 1. The area of CBA 1 comprises the north-eastern portions of the study area on the farms Kareerand and Kromdraai. The area mapped as CBA 2 comprises mostly of untransformed habitats and vegetation but approximately 37% of the area comprises secondary vegetation of habitats transformed by historical cultivation and, to a lesser extent, a plantation of alien trees, infrastructure and seepage from the existing TSF. The area mapped as CBA 1 also comprises mostly of untransformed habitats and vegetation, but approximately 45% comprises secondary vegetation of habitats transformed by historical cultivation (including disused centre pivot fields) and, to a lesser extent, two abandoned homesteads. The existing TSF on the southern boundary of the study area is also mapped as a CBA.

8 DESCRIPTION OF VEGETATION UNITS AND LANDCOVER TYPES WITHIN THE STUDY AREA

Although the original vegetation cover of the 1 495.5ha MWS study area would have been Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland (Mucina & Rutherford, 2006),

approximately 38.5% of the study area has been transformed through historical cultivation, and to a far lesser extent through planting of alien trees, polluted seepage and runoff from the existing TSF and the construction of linear infrastructure (e.g. roads and pipelines) and farm homesteads. These transformed areas are vegetated by secondary vegetation or, in the case of permanently transformed areas (infrastructure) are unvegetated. The figure of 38.5% excludes the historically ploughed wetlands on the farms Kromdraai and Kareerand which have been included in the Valley-bottom wetlands unit (Unit 2). Historical cultivation is by far the greatest contributor to habitat transformation within the study area (see Table 3). The remaining areas of untransformed vegetation, comprise Grassland with small areas of Sparse Woodland localised patches or groves of *Acacia* Closed to Open Woodland (*sensu* Edwards, 1983). Though untransformed, much of the remaining indigenous vegetation has been degraded by anthropogenic impacts such as heavy grazing (or in the case of the existing TSF security area the exclusion of grazing by ungulates), altered fire regimes (e.g. increased or reduced frequency of fire), alterations to hydrological patterns and water quality, various ecological 'edge effects' emanating from surrounding transformed areas such as existing TSF facilities (i.e. dust emissions and polluted seepage and runoff), and planting of alien trees.

The broad-scale vegetation units and land-cover type units described below have been derived on the basis of structural and functional criteria. The term structure refers to various aspects of vegetation structure such as physiognomy, life-form composition, species composition, species dominance and stand structure (Kent & Coker, 1992). Functional criteria include aspects such as characteristic ecosystem processes, habitat characteristics, habitat suitability for threatened species and ecological status (e.g. primary vegetation of untransformed habitats versus secondary vegetation of transformed or severely degraded habitats). The floristic data set gathered at 18 vegetation sampling sites within the study area is provided in Appendix 3.

Despite the relatively significant level of habitat transformation within the study area, many of the remaining areas of untransformed habitat and vegetation remain diverse and species rich (α-diversity), as is reflected by the fact that 394 plant species and infra-specific taxa were recorded during the current, brief survey (see Appendix 1). The Beta diversity (β-diversity), which is the 'rate of change in species composition across habitats or among communities' is also relatively high. The broad-scale vegetation and land-cover type units described below are practical units that combine various plant communities which share structural and functional characteristics and have common management requirements.

A total of seven vegetation and land-cover type units comprising untransformed vegetation and four units comprising transformed habitats with secondary vegetation or no vegetation (i.e. infrastructure) were identified. These eleven units are listed and briefly described in Table 3, and each unit is described in more detail below. Photographs of the vegetation units are provided in Appendix 10. The approximate delineation of the units listed in Table 3 is shown on the vegetation map provided in Appendix 2.

Table 3: Broad-scale vegetation / land-cover type units identified within the MWS Kareerand TSF Extension Project study area.

Veg/land-cover type unit	Description	Equivalent vegetation or land-cover type (BMUs) in the BMP for the adjacent MWS surface rights area*.
1. Pan wetland	Includes the marsh vegetation and hygrophilous grassland of a single, small ephemeral endorheic pan situated in the north-western parts of the study area at Site 31.	None

Veg/land-cover type unit	Description	Equivalent vegetation or land-cover type (BMUs) in the BMP for the adjacent MWS surface rights area*.
2. Valley-bottom wetland - including associated hillslope seeps	Includes marsh vegetation, dominated by hygrophilous grassland and sedges, in valley-bottom wetlands and associated hillslope seeps on the farms Megadam, Kromdraai and Kareerand. Soils are dark-brown to black hydromorphic clays, clay loams or sandy clay loams. The valley-bottom wetland system in the south-western parts of the study area on the farm Kareerand is in a near-pristine state, whereas the other four valley-bottom wetlands have been degraded to various degrees by catchment destruction due to the construction of the existing TSF (Megadam) or historical cultivation of the wetland catchment and central zone (Kromdraai).	BMU 3 (Valley-bottom wetlands)
3. *Acacia karoo* Woodland	Closed to Open Woodland in which *A. karoo* is dominant and few other species of trees and shrubs contribute significantly to woody cover. Occurs mainly on red-brown clay loam soils overlying diabase.	BMU 4 (*Acacia karoo* Woodland)
4. *Acacia erioloba* Woodland	*Acacia erioloba* dominated Short Open/Closed Woodland situate in sinkholes overlying dolomite, on red brown sandy clay loams. Occurs only in two small patches on the farm Hartebeestfontein. The vegetation of this unit is representative of Vaal Reefs Dolomite Sinkhole Woodland, a Vulnerable vegetation type (Mucina & Rutherford, 2007).	BMU 5 (*Acacia erioloba* Woodland)
5. Clay Grassland	This is the identified unit with the greatest extent within the study area. Comprises species rich Closed Grassland, predominately on moderately deep red-brown to brown clay loams, overlying diabase and andesitic lava. This unit also includes species rich Grassland with occasional bushclumps, on low outcrops of diabase boulders on the farms Kromdraai and Megadam, and a ca. 40.5ha patch of distinct (in terms of species composition) grassland on heavy, black turf soils. The vegetation of this unit is representative of Rand Highveld Grassland, an Endangered vegetation type (Mucina & Rutherford, 2007 and NWBSP 2015).	BMU 7 (Clay Grassland -diabase and andesitic lava)
6. Dolomite Grassland	Comprises predominantly of Closed Grassland and Sparse Woodland on shallow and rocky (chert) brown clay loams with surface rock cover usually between 15% and 30%. Confined to a low chert ridge running the length of the eastern boundary of the study area. Comprises the most species rich (highest α-diversity) plant communities found within the study area The vegetation of this unit is representative of Vaal Reefs Dolomite Sinkhole Woodland, a Vulnerable vegetation type (Mucina & Rutherford, 2007).	BMU 8 (Dolomite Grassland – overlying dolomite and chert)
7. Sandy Grassland	Grassland on moderately deep to shallow, light brown sandy loams or sandy clay loams overlying mostly quartzite but also shale and siltstone. Occurs on a low, linear, rocky (quartzitic) outcrop in the south central parts of the study area at the juncture of boundaries of the farms Megadam, Hartebeestfontein and Buffelsfontein. Has high	BMU 9 (Sandy Grassland – including quartzite outcrops)

Veg/land-cover type unit	Description	Equivalent vegetation or land-cover type (BMUs) in the BMP for the adjacent MWS surface rights area*.
	species rich (high α-diversity). The vegetation of this unit is representative of Rand Highveld Grassland, an Endangered vegetation type (Mucina & Rutherford, 2007 and NWBSP 2015), but also possibly displays some floristic and structural elements of Vaal-Vet Sandy Grassland.	
8. Secondary Grassland	Secondary grassland of historically cultivated areas. Time elapsed since termination of cultivation varies from approximately six years (i.e. centre pivot fields on the farm Kromdraai) to more than 15 years. Vegetation structure and species composition varies in accordance with successional stage and soil type.	BMU 10 (Secondary Grassland)
9. Artificial wetland	Secondary wetland vegetation of areas of clay soils that were once representative of Clay Grassland (Unit 5), that have been degraded by contaminated seepage and runoff from the existing TSF. Comprises a thin strip of secondary (ca. 10m to 30m in width) along the western foot of the retaining wall of the existing TSF. Comprises mostly dense *Typha capensis* (a facultative halophyte) reed beds surrounded by seasonally inundated or saturated soils where the vegetation is dominated hygrophytic grasses, sedges and alien weeds indicative of disturbance, including facultative halophytes such as *Cynodon dactylon.*	BMU 11 (Secondary Wetland)
10. Alien trees	Comprises a single, small *Eucalyptus* plantation on the south-western boundary of the study area and a few stands of alien trees around the abandoned homesteads in the north-eastern parts of the study area on the farms Kareerand and Kromdraai.	BMU 12 (Alien Trees)
11. Infrastructure	Includes existing all mine infrastructure and two abandoned farm homesteads in the north-eastern parts of the study area on the farms Kareerand and Kromdraai.	BMU 13 (Infrastructure)

*BMUs (Biodiversity Management Units) as mapped and described in the 'Botanical Biodiversity baseline report for Anglo Ashanti's Mine Waste Solutions surface rights area' (De Castro & Brits, July 2016).

The percentage of the study area occupied by each of the identified vegetation and land-cover type units, number of surveyed quadrats in each unit, number of 'species recorded only in plots placed within the unit ('characteristic' species which show high fidelity to the unit), mean species richness per $100m^2$, and the perceived biodiversity conservation value / sensitivity of each unit is provided in Table 4. A brief description of the vegetation structure, ecological status, habitat characteristics and biodiversity conservation value of each unit is provided below. The terminology used in describing the vegetation physiognomy of the woody and herbaceous plant communities, is that developed by Edwards (1983). In the vegetation descriptions provided below, an asterisk indicates an alien species.

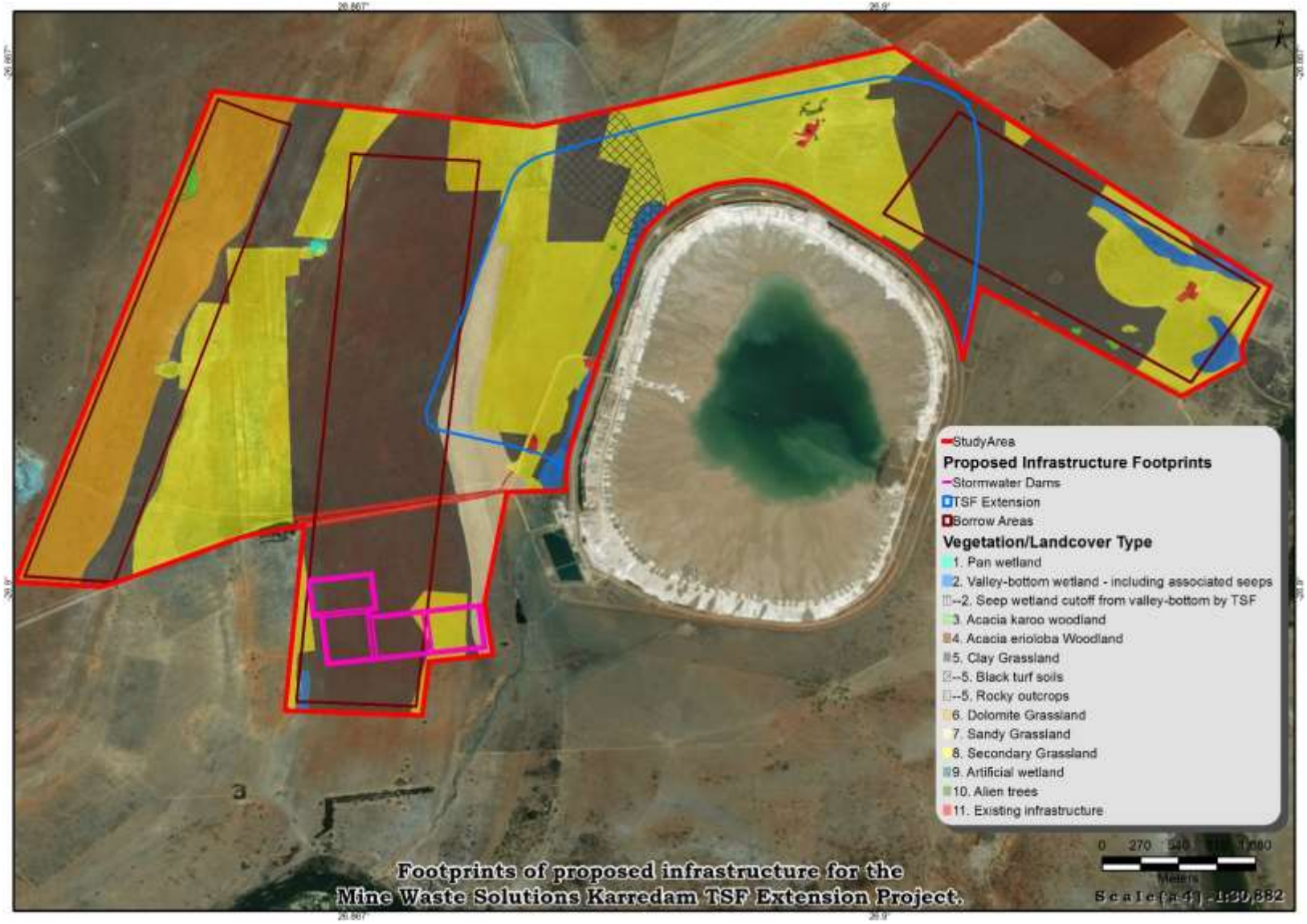

Figure 2: Vegetation and land-cover units identified within the Kareerand TSF Extension Project study area, showing the footprint of proposed infrastructure components.

Unit 1: Pan wetland

The extent of this unit within the study area is 0.7ha (or 0.05% of the study area), which is the smallest surface area covered by any of the eleven identified vegetation and land-cover type units. This unit comprises a single, small ephemeral pan situated at Site 31. The pan is an endorheic ephemeral pan with a central zone that is likely to experience seasonal soil saturation and periodic inundation. The vegetation of the pan and its associated seep is heavily grazed and has most likely been historically overgrazed.

Endorheic pans are shallow, characteristically ephemeral or seasonal, and less often, more or less permanent wetland ecosystems which are closed (no outlet) and are typically round to oval in shape (Allan *et al.* 1995). Endorheic pans comprise unique wetland habitats (due to a peculiar range of physio-chemical characteristics which are mostly unique to these habitats), which contain unique plant communities arranged in concentric zones, and many species that are often largely or entirely restricted to such pan habitats. Untransformed endorheic pans in the Grassland Biome of the northern provinces have well developed concentric vegetation zones that are a reflection of the highly varied habitats occurring in most pans. These observable concentric vegetation zones are caused by variations in species dominance, species composition and stand structure, which in turn reflect changing habitat parameters along an inundation and soil moisture gradient extending from the centre of the pan to the upper edge of the pan catchment. The catchments of the pans are generally small and situated on crests of undulating landscapes, as is the case for the pan within the study area.

Two concentric vegetation zones were discernible at the time of the field survey, namely one with approximately 6% vegetation cover and comprising largely bare muds, and a narrow peripheral zone of approximately 3m to 4m in width which is likely to be very infrequently inundated (only during high rainfall periods) and has higher vegetation cover. According to the DWAF terminology (DWAF, 2005) the central zone is a seasonal zone and the peripheral zone is a temporary zone, and no permanent zone is present in the pan. A hillslope seep connected to the pan is situated immediately to the north of the pan, on a south-facing slope of the pan basin with a gradient of approximately 5°.

The central zone of the small ephemeral pan occurring in the study area was dry at the time of the field survey (November 2017). The heavy hydromorphic clay soils show typical signs of seasonal saturation. Inundation of the central zone is likely to occur in most years during the summer months, other than during drought conditions. The species richness, stand structure and even species dominance of the vegetation of this zone is likely to vary markedly from season to season as is typical for such pans in this region. At the time of the field survey the central zone consisted mostly of bare muds. The dominant species was the obligate hydrophytic grass *Diplachne fusca*, which had a canopy cover of ca. 5%. The only other species recorded in the central zone were an unidentified sedge and the forbs *Alternathera sessilis, Gomphrena closiodes** and *Rumex lanceolatus.* The narrow peripheral zone surrounding the central zone is less frequently inundated and is approximately 3m to 4m in width with various patches of exposed ferricrete. Vegetation canopy cover is ca. 60% and the dominant species is *Cynodon dactylon*. Other recorded grasses were *Eragrostis curvula* and *Diplachne fusca*, which is rare in this zone. Common forbs include *Alternathera sessilis, Bergia decumbens, Bergia pentheriana, Gomphrena closiodes** and *Indigofera cryptantha.*

The hillslope seep on the south-facing slope of the pan basin is vegetated by hygrophilous grassland indicative of soils which experience temporary saturation. Vegetation canopy cover

is approximately 85%. The dominant species are the grasses *Themeda triandra* and *Eragrostis curvula*. Common grasses include *Eragrostis chloromelas, Eragrostis micrantha, Cymbopogon caesius, Cynodon dactylon* and *Eragrostis lehmanniana* subsp. *lehmanniana.* Common forbs include *Bergia decumbens, Bulbine narcissifolia, Gomphrena celosiodes, Helichrysum aureonitens, Hypoxis hemerocallidea, Lotononis listii* and *Vahlia capensis.*

One of the six plant 'species of conservation concern' recorded within the study area (see Table 7) was recorded within this unit, namely the Declining species *Hypoxis hemerocallidea.* This unit does not contain suitable habitat for any of the other five plant 'species of conservation concern' recorded within the study area (see Table 7), or the Protected plant species recorded within the study area. This unit does also not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur.

Spatially restricted habitat such as the small endorheic, ephemeral pan at Site 31 often have ecological importance which is disproportionate to their size and are therefore of great conservation value. Pans provide unique habitat, and many of the plant and animal species that utilise pan habitats are either entirely or largely restricted to such pans, utilise them as important foraging area or are largely dependent on them as breeding habitat (e.g. Giant Bullfrog). Plant species recorded only from the pan within the 1 405.5ha study area include the hydrophytes and hygrophytes *Diplachne fusca, Bergia pentheriana, Alternathera sessilis* and an unidentified sedge (Cyperaceae). No other endorheic pans occur within the 1 495,5ha study area, the adjacent 6 212ha MWS surface rights area of the nearby 12,725ha Vaal Reefs Mine Complex surface rights area, and the pan at Site 31 must therefore be considered to be a unique and conservation-worthy habitat in this region of the North West Province. The vegetation of this unit is therefore considered to have **High** botanical biodiversity conservation value and sensitivity.

Unit 2: Valley-bottom wetlands

The extent of this unit within the study area is 30.3ha (or 2.02% of the study area). This vegetation unit comprises seasonal marsh vegetation, and immediately adjacent hillslope seeps, of the hydromorphic soils of four unchannelled valley-bottom wetlands situated in the southern and eastern portions of the study area. Two of these valley-bottom wetlands are situated on the farms Megadam and Buffelsfontein, and the upper reaches of the two remaining valley-bottom wetlands are situated in the eastern parts of the farm Kromdraai near the Vaal River.

The extreme upper reaches of a small unchannelled valley-bottom wetland situated near the southern boundary of the study area is on the farm Buffelsfontein within the 'game park portion of the MWS surface rights area. Though the catchment of this wetland has historically been heavily grazed by game, the habitats and vegetation of this wetland are regarded as near-pristine, and this view is supported by the wetland assessment report completed for the MWS TSF Extension Project (De Castro & Brits, January 2018). The valley-bottom wetland is unchannelled within the study area, but becomes intermittently channelled and forms small non-perennial pools within 300m of the southern boundary of the study area. The vegetation comprises dense hygrophilous grassland which has high species richness (for such hygrophilous grassland) and is in near-pristine condition. The vegetation is dominated by grasses. Dominant species include *Andropogon appendiculatus, Eragrostis curvula, Setaria sphacelata* and *Themeda triandra.* Common grasses include *Brachiaria*

nigropedata, Cymbopogon caesius, Cynodon dactylon, Eragrostis plana and *Pennisetum thunbergii*. Common forbs, many of which are obligate hygrophytes, include *Ammocharis coranica, Berkheya radula, Crinum bulbispermum, Conyza podocephala, Crabbaea angustifolia, Helichrysum aureonitens, Hypoxis rigidula, Kyllinga erecta, Oenothera rosea*, Rhynchosia minima, Senecio inornatus* and *Vernonia oligocephala*.

The largest of the four valley-bottom wetland systems is a channelled valley-bottom wetland which originates on the farm Megadam, where the original source wetlands of this system have been covered by the footprint of the existing TSF in approximately 2010 (see map in Appendix 4) and only a single cut-off patch (ca. 6ha) of the original source hillslope seeps remains on hydromorphic black turf soils directly adjacent to the north-western corner of the TSF footprint at Site 33. The remaining, short reach of valley-bottom wetland situated directly to the east of the TSF within the study area, has been severely impacted by altered hydrological patterns and poor water quality (in particular high salinity) resulting from seepage and runoff from the tailings facility (Kotze, December 2017). The vegetation of the central zone of the valley-bottom comprises dense 'reed beds' of the facultative halophytes *Typha capensis* and *Phragmites australis* and highly degraded hygrophilous grassland with low species richness (α-diversity). Degradation has occurred as a result of altered hydrological regimes and polluted seepage, and runoff from the TSF. The dominant species is the grass *Cynodon dactylon* (a facultative halophyte). The sedge *Kyllinga erecta* is subdominant to locally dominant in patches. Common species include the grasses *Eragrostis curvula* and *Pasapalum dilatatum*,* the sedge *Schoenoplectus decipiens,* the rush *Juncus punctorius* and the forb *Veronica anagallis-aquatica*. The vegetation of the temporary hydromorphic soils of the hillslope seeps adjacent to the central zone have been largely transformed by historical cultivation, seepage and runoff of polluted water, and altered hydrological patters. The secondary vegetation of these seeps has low overall species richness and high species richness of alien species. The dominant species is *Cynodon dactylon*. The grass *Digitaria eriantha* is subdominant. Common grasses include *Eragrostis curvula, Eragrostis plana, Eragrostis micrantha, Eragrostis trichophora, Cymbopogon caesius* and *Paspalum dilatatum**. Common forbs include *Ciclospermum leptophyllum*, Cirsium vulgare*, Conyza albida*, Pentzia globosa, Tagetes minuta*, Verbena bonariensis** and *Verbena officinalis**. On the remnant patch of cut-off seep on black turf soils (extremely dry and burnt prior to field survey) the dominant grasses include *Digitaria eriantha, Eragrostis curvula* and *Themeda triandra*. Common grasses include *Aristida bipartita, Cynodon dactylon* and *Setaria sphacelata*. Common forbs included *Conyza podocephala, Hermannia resedifolia, Hypochaeris radicata*, Lotononis listii, Oenothera teraptera* and *Verbena officinalis**.

The two small and indistinct unchannelled valley bottom wetlands which originate on the farm Kromdraai, flow over black turf soils, and the majority of wetlands and their catchment have until recently been cultivated (used for centre pivot irrigation) and are vegetated by secondary plant communities typical of the early stages of secondary succession. The vegetation of the heavy, black clay soils which are seasonally saturated but seldom (periodically) inundated, comprises mostly secondary hygrophilous grassland. The vegetation is dominated by grasses. Dominant grasses include *Brachiaria eruciformis, Setaria incrassata,* and *Chloris virgata,* the later species being completely dominant in recently (6 years ago) ploughed areas of the wetland. The alien agrestal weeds *Salsola kali** and *Tagetes minuta** are subdominant in severely degraded areas. Common grasses include *Andropogon appendiculatus, Aristida bipartita, Cynodon dactylon, Digitaria eriantha, Pennisetum sphacelatum, Setaria sphacelata, Setaria verticillata* and *Themeda triandra*. Common forbs

include *Acanthospermum australe*, Berkheya radula, Bidens bipinnata, Chenopodium album*, Crabbaea angustifolia, Monsonia angustifolia, Rhynchosia minima, Salvia runcinata, Senecio inornatus, Verbena bonariensis** and *Verbena officinalis**.

Species richness per 100m^2 varies significantly between the various valley-bottom wetlands comprising this vegetation unit, and even between different zones and reaches within the same wetland. Average species richness measured in the three sampling plots placed within this unit was 23.7 species per 100m^2, which is fairly high for Highveld valley-bottom wetlands, but varied fairly widely from 19 to 26 species per 100m^2, and is lower than 19 in degraded vegetation of the historically ploughed wetlands on the farm Kromdraai. The vegetation comprising this unit is floristically distinct from all other units, as indicated by the fact that 35 (or 58% of the total number of species recorded within sampling plots placed in this unit) of the species recorded within the three sampling plot placed in this unit were not recorded within sampling plots located in any of the other unit (see Table 3). One of the six plant 'species of conservation concern' recorded within the study area was recorded within this unit, namely *Hypoxis hemerocallidea.* This unit contains potentially suitable habitat for two of the other five plant 'species of conservation concern' recorded within the study area (see Table 6), namely *Crinum bulbispermum* and *Eucomis autumnalis*. This unit does not contain potentially suitable habitat for the single Protected plant species recorded within the study area. This unit does also not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered fairly likely to occur. In spite of the fact that the upper reaches of the largest of the three valley-bottom wetland has been severely impacted by polluted seepage from the existing TSF, and the two wetlands on black turf soils on the farm Kromdraai have been impacted by historical cultivation, the valley-bottom wetland vegetation comprising this unit is considered to be of elevated conservation importance for the following reasons:

- Performs an important ecological function, e.g. maintaining water purity and constant water supply and reducing soil erosion.
- Provides important breeding and feeding habitat for various animal and bird populations and contains many plant species that are restricted to this habitat.
- Drainage lines and accompanying valley-bottom wetlands are linear systems in which any disturbance will affect the quality of systems further downstream.
- Highveld valley-bottom wetlands have been extensively transformed or are under threat from various anthropogenic impacts such as canalisation, altered hydrological patterns, reduced water quality and invasion by alien plant species (Henderson & Musil, 1987), and any remaining area of untransformed valley-bottom wetland or riparian vegetation must therefore be regarded as of elevated conservation importance
- Within the study area and its immediate surroundings, this vegetation unit represents a unique and restricted habitat type, much of which has already been transformed.

The near-pristine, small unchannelled valley-bottom wetland situated on the farm Buffelsfontein (Sites 20 and 21) is therefore considered to have a **High** botanical biodiversity conservation value and sensitivity and the remaining, largely transformed or degraded wetlands comprising this unit are considered to have **Moderate** botanical biodiversity conservation value and sensitivity.

Unit 3: *Acacia karoo* Woodland

The extent of this unit within the study area is 1.9ha (or 1.3% of the study area), and this surface area comprises numerous patches scattered along the southern boundary of the portion of the study area situated on the farm Kromdraai, and a single large patch (ca. 0.2ha) situated on the farm Megadam near the existing TSF. In accordance with the structural (physiognomic) classification system provided by Edwards (1983), the vegetation can be described as predominately Short Open Woodland, but includes small patches (or groves) of Short Closed Woodland. In some cases, this vegetation seems to have developed as a result of the exclusion of fire for the purposes of protecting grazing, or as a result of soil disturbance (e.g. scouring and trampling), and can therefore be considered to be of a secondary nature. The patches of woodland comprising this unit are all situated on clay or clay loam soils, mostly overlying diabase and often with some surface cover of diabase rock. These woodland patches are therefore embedded in the Clay Grassland vegetation unit (Unit 5), and their herbaceous layer has strong floristic elements of Clay Grassland.

The dominant tree is *Acacia karoo*, and other recorded species with a tree life form (e.g. *Searsia lancea*) are seldom present, and then only at very low densities. Dominant shrubs include *Acacia karoo, Diospyros lyciodes, Searsia lancea* and *Searsia pyroides.* Common shrubs include *Asparagus laricinus, Ehretia rigida, Grewia flava, Gymnosporia buxifolia, Pavonia burchellii* and *Ziziphus mucronata*. The moderately dense herbaceous layer is dominated by grasses and has moderate to high species richness of forbs. Dominant grasses include *Digitaria argyrograpta, Panicum coloratum* var. *coloratum, Setaria sphacelata, Themeda triandra*. Common grasses include *Aristida canescens, Aristida congesta* subsp. *congesta, Cymbopogon pospischilii, Digitaria eriantha, Eragrostis curvula, Eragrostis superba* and *Setaria lindenbergiana* (only in rocky areas). Common forbs and dwarf shrubs include *Achyranthes aspera*, Asparagus suaveolens, Bidens bipinnata*, Chenopodium phillipsianum, Conyza podocephala, Helichrysum nudifolium, Helichrysum rugulosum, Hermannia depressa, Hibiscus pusillus, Lantana rugosa, Lippia scaberrima, Menodora africana, Schkuhria pinnata** and *Teucrium trifidum.* Common climbers include *Asparagus* cf. *cooperi, Clematis brachiata, Pentarrhinum insipidum* and *Rubia horrida*.

No $100m^2$ sampling quadrats were sampled in this vegetation unit during the current survey, but a quadrat sampled in similar *Acacia karoo* Woodland embedded in Clay Grassland during a recent botanical survey of the immediately adjacent MWS surface rights area (De Castro & Brits, July 2015a) had a species richness of 51 plant species, and most of the *A. karoo* Woodland patches in the current study area are similarly species rich. A significant number of the species comprising the species richness are alien ruderal weeds or indigenous pioneer species typical of disturbance and relatively few characteristic species occur. One of the six plant 'species of conservation concern' recorded within the study area was recorded within this unit, namely *Hypoxis hemerocallidea* (Declining). This unit does contain potentially suitable habitat for one of the other five plant 'species of conservation concern' recorded within the study area namely *Boophone disticha* (see Table 6). This unit does not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered quite likely to occur. This BMU does not contain potentially suitable habitat for the single Protected plant species recorded within the study area. In spite of the fact that in some cases, the Woodland communities comprising this unit is vegetation seem to have developed as a result of the exclusion of fire for the purposes of protecting grazing, or from soil disturbance, and can therefore be considered to be of a secondary nature, these communities have high species richness, constitute a unique and

fairly restricted woody habitat within the study area and are embedded in Rand Highveld Grassland, a vegetation type that is categorised as Endangered at a provincial level by the NWBSP 2015, and as Endangered at a national level by Mucina and Rutherford (2006). This unit is therefore considered to have a **High** value in terms of botanical biodiversity conservation.

Unit 4: *Acacia erioloba* Woodland

The extent of this unit within the study area is 2.1ha (or 0.14% of the study area). This vegetation unit comprises two patches of *Acacia erioloba* woodland situated in the eastern parts of the study area on the farm Hartebeestfontein. Both patches of woodland occur in natural sinkholes in areas with dolomitic geology, one embedded in Dolomitic Grassland (Unit 6) on the gentle west-facing slope of the low chert ridge running along the eastern boundary of the study area and the other in a small area of dolomitic geology seemingly embedded in an area of antedesic lava geology vegetated by Clay Grassland (Unit 5). The soils are moderately deep, red-brown sandy clay loams. Rock cover is generally less absent. Tree canopy cover varies from approximately 5% (Site 17) to 65% (Site 38a), and canopy height is approximately 8m. Shrub canopy cover from approximately 1% to 8%. In accordance with the structural (physiognomic) classification system provided by Edwards (1983), the vegetation can be described as predominately Short Open Woodland, but includes small patches (or groves) of Short Closed Woodland. Though untransformed, this vegetation has been moderately degraded by overgrazing and significant cutting of *Acacia erioloba* and other trees as both sites are situated in the unfenced eastern part of the study area where there is no access control. Many of the trees at Site 38a are in fact coppice from stems cut many years ago, an unsustainable cutting of the trees is ongoing.

The dominant tree is *Acacia erioloba*. Common trees include *Searsia lancea* and *Searsia pyroides*. Common shrubs include *Diospyros lyciodes, Ehretia rigida, Grewia flava, Pavonia burchellii, Searsia lancea* and *Searsia pyroides.* In shaded situation below trees in dense groves (Closed Woodland patches) the herbaceous layer is completely dominated by *Cynodon dactylon* and the decumbent forb *Chenopodium philipsianum* is common. In more open woodland patches and in the sinkholes grassland immediately surrounding dense groves, the herbaceous layer is moderately dense (ca. 65% canopy cover) and dominated by grasses. Dominant grasses include *Digitaria eriantha, Eragrostis chloromelas, Eragrostis curvula, Eragrostis superba* and *Themeda triandra*. Common grasses include *Aristida congesta* subsp. *congesta, Aristida stipitata, Cynodon dactylon, Digitaria eriantha, Eragrostis lehmanniana* subsp. *lehmanniana, Enneapogon cenchroides, Enneapogon scoparius, Heteropogon contortus* and *Setaria sphacelata.* Common forbs (including dwarf shrubs) include *Acanthosicyos naudinianus, Barleria macrostegia, Convolvulus sagittatus, Corchorus asplenifolius, Dicoma macrocephala, Hibiscus pusillus, Indigofera daleoides* var. *daleoides, Ledebouria ovatiifolia, Plexipus hederaceum, Raphionacme hirsuta, Sida chrysantha, Solanum eleagnifolium** and *Vernonia oligocephala*. Common climbers include and *Coccinia sessilifolia* and *Pentarrhinum insipidum.* The geoxylic suffrutex *Ziziphus zeyheriana* is also common.

Furthermore, the woody communities comprising this unit constitute a unique and highly restricted woody habitat within the study area, and numerous and far larger patches of *Acacia erioloba* Woodland occur less than 1km to the west of the study area where approximately 88ha of *Acacia erioloba* Woodland has recently been recorded by the author within the MWS surface rights area (De Castro & Brits, July, 2015a). Average species richness measured in

the two sampling plots selected within this unit was 26.5 and varied from 23 to 30 species per $100m^2$, which is moderate for woodland communities in this region of the North West Province. A moderate number of 'characteristic' species occur and only 10 (or 21.3%) of the total number of species recorded within sampling plots placed in this unit were not recorded within sampling plots located in any of the other units (see Table 4). However, the dominant tree species (*Acacia erioloba*) is largely confined to the *Acacia erioloba* communities comprising this unit, and only a few small, stunted trees occur outside this unit in Dolomite Grassland (Unit 6). One of the six plant 'species of conservation concern' recorded within the study area was recorded within this unit, namely *Hypoxis hemerocallidea* (Declining). None of the other five plant 'species of conservation concern' recorded within the study area (see Table 6) was recorded within this unit or are considered likely to occur. This BMU does also not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur. The only Protected plant species recorded within the study area, namely the dominant tree *Acacia erioloba*, is confined almost entirely to this unit.

The *Acacia erioloba* woodland communities comprising this unit form part of the Vaal Reefs Dolomite Sinkhole Woodland vegetation type (Mucina & Rutherford, 2006). According to the NWBSP, Vaal Reefs Dolomite Sinkhole Woodland is endemic to the North West Province and is categorised as 'Not Currently Threatened' at a provincial level, but this vegetation type is categorised as Vulnerable at a national level by Mucina and Rutherford (2006). This unit is therefore considered to have a **High** botanical biodiversity conservation value and sensitivity.

Unit 5: Clay Grassland – Diabase and Andesitic lava

The extent of this unit within the study area is 666.7ha (or 44.58% of the study area), which is the largest surface area covered by any of the eleven identified vegetation and land-cover type units. The vegetation comprising this unit occurs on clay and clay loam soils overlying basic ingenious rocks (predominantly diabase and andesite) and includes highly species rich grassland on small, low outcrops of diabase boulders (ca. 0.5m to 1m in diameter). The soils of the majority of the extent of this unit comprise moderately deep red-brown clay loams, but smaller areas of shallow red-brown clay loams (associated with diabase boulder outcrops) and deep black turf soils are also present. Rock cover is generally absent but may be as high as 70% on diabase boulder outcrops. In accordance with the structural (physiognomic) classification system provided by Edwards (1983), the vegetation can be described as predominantly Short Closed Grassland, with small, scattered stands of trees and shrubs ('bushclumps') present on the diabase boulder outcrops. The vegetation of this unit is representative of Rand Highveld Grassland (Mucina & Rutherford, 2009). Roughly 40% of the original extent of this unit within the study area (Figure 2) has been transformed by historical cultivation. The majority of the vegetation comprising this unit is highly species rich, untransformed and in good condition. However, recent (since approximately 2010) exclusion of fire and grazing from the remaining areas of Clay Grassland surrounding the Existing TSF on the farm Megadam has led to the exclusion of fire and grazing, and much of the vegetation is highly moribund. Overgrazing, increased fire frequency and unseasonal fires, have led to moderate degradation of this grassland in the northern and western parts of the study area, which are unfenced and not subjected to access control. Various ecological 'edge effects' (e.g. seepage of polluted water, dust emissions) emanating from the existing TSF are likely to cause further significant degradation of the remaining areas of this unit situated within the existing TSF in the medium-term, unless these impacts are mitigated.

On moderately deep to deep red-brown clay loams the vegetation is dominated by grasses. Dominant species include *Aristida canescens, Cymbopogon caesius, Panicum coloratum, Setaria sphacelata* and *Themeda triandra*. Common grasses include *Aristida congesta* subsp. *congesta, Aristida* cf. *aequiglumis, Brachiaria serrata, Cymbopogon pospischilii, Digitaria argyrograpata, Digitaria eriantha, Diheteropogon amplectans, Eustachys paspaloides, Eragrostis curvula, Eragrostis lehmanniana, Elionurus muticus, Eragrostis racemosa, Eragrostis superba, Heteropogon contortus* and *Melinis repens.* Common forbs include *Acalypha angustata, Anthospermum rigidum, Barleria macrostegia, Berkheya onopordifolia, Bulbine narcissifolia, Chlorophytum fasciculatum, Crabbaea acaulis, Crabbaea angustifolia, Conyza podocephala, Crabbaea acaulis, Deverra burchellii, Dicoma macrocephala, Felicia muricata, Helichrysum rugulosum, Hermannia depressa, Hypoxis hemerocallidea, Indigofera daleoides* var. *daleoides, Ledebouria* cf. *apertiifolia, Monsonia angustifolia, Plexipus hederaceum, Senna italic, Solanum supinum, Trichodesma angustifolia* and *Vernonia oligocephala.* The geoxylic suffrutex *Ziziphus zeyheriana* is also common.

On shallow red-brown clay loam soils associated with boulder outcrops, the vegetation is dominated by grasses, there is very high species richness in terms of both grasses and forbs and many of the species present show high fidelity to this habitat. The dominant grass is *Andropogon schirensis.* Sub-dominant grasses include *Aristida canescens, Elionurus muticus, Eragrostis chloromelas* and *Melinis repens.* Common grasses include *Bewsia biflora, Brachiaria serrate, Cymbopogon pospischilii, Diheteropogon amplectans, Digitaria tricholaenoides, Eragrostis racemosa, Eustachys paspaloides, Heteropogon contortus, Schizachyrium sanguineum, Setaria sphacelata, Themeda triandra, Triraphis andropogonoides* and *Trachypogon spicatus.* Common forbs (and dwarf shrubs) include *Asclepias adscendens, Asparagus suaveolens, Barleria macrostegia, Bulbostylis hispidula, Berkheya onopordifolia, Boophone disticha, Convolvulus sagittatus, Dicoma anomala, Hermannia depressa, Hibiscus pusillus, Hypoxis hemerocallidea, Hypoxis rigidula, Ipomoea bathycolpos, Ipomoea crassipes, Lotononis calycina, Plexipus hederaceum, Scabiosa columbaria, Tephrosia longipes* and *Vernonia oligocephala*. The small succulent shrub *Aloe davyana* is common, as is the geoxylic suffrutex *Ziziphus zeyehriana.* Small trees and shrubs occur at low densities as widely scattered individuals or in small 'bushclumps'. Common trees include *Ziziphus mucronata* and *Celtis africana.* Common shrubs include *Diospyros austro-africana, Diospyros lycioides, Grewia flava, Searsia rigida, Searsia lancea* and *Zanthoxylum capense.* Common climbers in bushclumps include *Coccinia sessilifolia, Mormordica balsamina, Pentarrhinum insipidum* and *Rubia horrida*.

On deep grey-brown clays to black turf soils the vegetation is dominated by grasses and contains low species richness, particularly in terms of forbs. The area of black turf soils described here was burnt shortly prior to the field survey, and was very dry and heavily grazed at the time of the field survey in early November. The description provided here must be seen in the context of these limitations and it must be emphasised that the vegetation is similar to that of the rest of the Clay Grassland unit. Dominant grasses include *Cymbopogon aesius, Ergarostis curvula, Themeda triandra, Panicum coloratum* and *Setaria sphacelata.* Common grasses include *Aristida bipartita, Aristida congesta* subsp. *congesta, Brachiaria eruciformis, Brachiaria serrata, Digitaria eriantha, Eragrostis chloromelas* and *Ischaemum afrum.* Common forbs include *Asclepias eminens, Barleria macrostegia, Bulbine angustifolia, Chaetacanthus* cf. *burchelli, Crabbaea angustifolia, Gazania krebsiana, Hibiscus pusillus, Hermannia resedifolia, Ledebouria minima, Salvia runcinata, Seddera capensis, Stenostelma canpense, Menodora africana* and *Schkhuria pinnata*.* The geoxylic suffrutex *Elephantorrihza elephantina* is also common.

Average species richness measured in the four sampling plots placed within this unit was 52.8 species per 100m^2, which is very high for Highveld grasslands, and varied significantly from 47 species to 59 species per 100m^2. Species richness is generally highest in communities on a diabase boulder outcrops (e.g. Site M18) and lowest on black turf soils. No quadrats placed in the single, small (ca. 40.2ha) patch of black turf soils recorded within the study area are included in the floristic table provided in Appendix 3 as the vegetation of this patch was extremely dry, heavily grazed and recently burnt at the time of the survey, but a single 100m^2 surveyed on these black turf soils contained only 27 species, many of which were unidentifiable at the time of the survey. A moderate number of 'characteristic' species occur, and 28 (or 22.9% of the total number of species recorded within sampling plots placed in this unit) of the species recorded within the four sampling plots placed in this unit, are characteristic species which were not recorded within sampling plots located in any of the other vegetation or land-cover type units (see Table 4). Many of the characteristic species occur in grassland on diabase boulder outcrops and on black clay soils. Four of the six plant 'species of conservation concern' recorded within the study area (see Table 7) were recorded within this unit, namely the Declining species *Eucomis autumnalis*, *Crinum* cf. *bulbispermum*, *Boophone disticha* and *Hypoxis hemerocallidea*, and within the study area the two first-mentioned species were recorded only from this unit and the latter two species are most abundant within this unit. This unit does not contain potentially suitable habitat for the two other plant 'species of conservation concern' recorded within the study area. This unit does not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur. This unit does not contain potentially suitable habitat for the single Protected plant species recorded within the study area. The vegetation of this unit is representative of Rand Highveld Grassland, a vegetation type that is categorised as Endangered at a provincial level by the NWBSP 2015, and as Endangered at a national level by Mucina and Rutherford (2006). Much of the original extent of Rand Highveld Grassland, both within the study area and its immediate surrounds has already been transformed by cultivation and mining, and the remaining areas of Rand Highveld Grassland within the study area must therefore be regarded as of considerable conservation importance. This BMU is therefore considered to have **High** botanical biodiversity conservation value and sensitivity.

Unit 6: Dolomite Grassland – overlying dolomite

The extent of this unit within the study area is 158.2ha (or 10.58% of the study area), which represents the third largest surface area covered by any of the eleven identified vegetation and land-cover type units. The vegetation comprising this unit occurs predominantly on shallow rocky brown clay loams with surface rock cover usually between 15% and 30%, and is confined to a low chert rich dolomite ridge running the length of the eastern boundary of the study area. Dolomite Grassland on flat to very gently undulating landscapes with little chert, as described in the botanical biodiversity survey for the immediately adjacent MWS surface rights area (De Castro & Brits, July 2015a), is absent from the current 1 495.5ha study area. The vegetation is untransformed, short, moderately dense (60% to 7% canopy cover) grassland with small, stunted, sparsely scattered trees small 'bushclumps', and is representative of the Vaal Reefs Dolomite Sinkhole Woodland vegetation type (Mucina & Rutherford, 2007). In accordance with the structural (physiognomic) classification system provided by Edwards (1983), the vegetation can be described as predominantly Short Closed Grassland. The area of Dolomite Grassland situated within the study area, has remained largely unaffected by development. The majority of the vegetation comprising this BMU is highly species rich, untransformed and in good condition. However, some moderate

degradation, particularly in the northern parts of this unit, is likely to have occurred as a result of the fact that the area is unfenced and not subjected to any form of access control which has led to heavy grazing by cattle belonging to residents of the adjacent Khuma residential area, as well as increased fire frequency and unseasonal fires.

The vegetation is dominated by grasses. The dominant grasses are *Brachiaria serrata, Elionurus muticus, Eragrostis nindensis, Melinis repens* and *Triraphis andropogonoides*. Subdominant species include *Andropogon schirensis* and *Schizachyrium sanguineum*. Common grasses include *Anthephora pubescens, Aristida* cf. *aequiglumis, Aristida canescens, Aristida congesta subsp. congesta, Brachiaria nigropedata, Cymbopogon caesius, Cymbopogon pospischilii, Enneapogon cenchroides, Eragrostis curvla, Eragrostis lehmanniana* var. *lehmanniana, Eragrostis racemosa, Eustachys paspaloides, Heteropogon contortus* and *Setaria sphacelata*. Common forbs include *Acalypha angustata, Anthospermum rigidum, Barleria macrostegia, Blepharis integrifolia, Bulbostylis hispidula, Chaetacathus cf. burchellii, Chamaecrista comosa, Commelina bella, Crabbaea angustifolia, Cyperus obtusiflorus* var. *obtusiflorus,Dianthus zeyheri, Dicoma anomala, Euphorbia inaequilatera, Gnidia capitata, Helichrysum caespititium, Indigofera heterotricha, Ipomoea bathycolpos, Ipomoea obscura, Justicia anagalloides, Kohautia amatymbica, Ledebouria* cf. *apertiifolia, Ledebouria marginata, Lotononis calycina, Monsonia angustifolia, Nolletia rarrifolia, Pearsonia bracteata, Ornithogalum tenuifolium, Plexipus hederaceum, Rhynchosia monophylla, Tephrosia longipes, Triumfetta sonderi* and *Vernonia oligicephala.* The small shrub *Searsia magalismontanum,* and the geoxylic suffrutices *Elephantorrhiza elephantine* are common.

The small, scattered 'bushclumps' are usually no more than approximately 25m^2 in size and vary from 3m to 7m in height. The dominant tree is *Searsia lancea.* Common and widespread trees in these bushclumps are *Celtis africana* and *Searsia pyroides*. Stunted *Acacia erioloba* are also occasionally present in bushclumps but are less common. The dominant shrubs are *Grewia flava* and *Diospyros lycioides*. Common shrubs include *Asparagus laricinus, Ehretia rigida, Gymnosporia buxifolia* and *Pavonia burchellii.* Climbers and scramblers are invariably present in the bushclumps, and common species include *Asparagus cooperi, Coccinia sessilifolia, Mormordica balsamina* and *Pentarrhinum insipidum*. The species poor herbaceous layer is dominated by the grass *Cynodon dactylon.*

Average species richness measured in the four sampling plots placed within this unit was 55.7 species per 100m^2, which is very high for Highveld grasslands, and species richness varied very little (i.e. from 55 to 61 species per 100m^2). A fairly high number of 'characteristic' species occur and 27 (or 30.3% of the total number of species recorded within sampling plot placed in this unit) of the species recorded within the four sampling plots placed in this unit, are characteristic species which were not recorded within sampling plots located in any of the other units (see Table 3). Three of the six plant 'species of conservation concern' recorded within the study area (see Table 6) were recorded within this unit, namely the Declining species *Boophone disticha* and the Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata.* Within the study area the Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata* were recorded only from within this unit, and are highly unlikely to occur within the any other unit. This unit does not contain potentially suitable habitat for any of the three other plant 'species of conservation concern' recorded within the study area, with the possible exception of marginally suitable habitat for *Hypoxis hemerocallidea*. This unit also contains the only potentially suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern'

thus far not recorded within the study area but considered likely to occur. The only Protected plant species recorded within the study area, namely *Acacia erioloba*, was recorded within this unit. According to the NWBSP, Vaal Reefs Dolomite Sinkhole Woodland is endemic to the North West Province and this vegetation type is categorised as Vulnerable at a national level by Mucina and Rutherford (2006). Much of the original extent of Vaal Reefs Dolomite Sinkhole Woodland, both within the study area and its immediate surrounds, has already been transformed by mining and urbanisation, and the remaining areas of this vegetation type within the study area must therefore be regarded as of significant conservation importance. Furthermore, the study area includes a significant and ecologically viable area of the species rich 'chert ridge grassland' variation of Vaal Reefs Dolomite Sinkhole Woodland, and this chert grassland provides habitat for two Near Threatened species known from very few localities within the North West Province. This unit is therefore considered to have a **Very High** botanical biodiversity conservation value and sensitivity.

Unit 7: Sandy Grassland – including quartzite outcrops

The extent of this unit within the study area is 60.1ha (or 4.02% of the study area). The grassland comprising this unit occurs on moderately deep to shallow, light brown sandy loams or sandy clay loams overlying mostly quartzite but also shale and siltstone. This unit is associated with low, linear, rocky (quartzitic) outcrop in the south central parts of the study area at the juncture of boundaries of the farms Megadam, Hartebeestfontein and Buffelsfontein. Rock cover varies from zero to as high as 30% in patches on the low quartzitic ridge at Site 48 on the farm Hartebeestfontein. The vegetation is untransformed, short, dense (70% to 95% cover) grassland, which is representative of the Rand Highveld Grassland vegetation type (Mucina & Rutherford, 2007), but also shows some floristic and structural elements of Vaal-Vet Sandy Grassland. The grasslands comprising this unit have high species richness (α-diversity). In accordance with the structural (physiognomic) classification system provided by Edwards (1983), the vegetation can be described as Short Closed Grassland. A small percentage of the original extent of this unit within the Hartebeestfontein portion of the study area has been transformed by historical cultivation. The majority of the grassland vegetation comprising this is highly species rich, untransformed and in good condition, though exclusion of fire and grazing has led to vegetation on the quartzite ridges on the farm Megadam currently being in a highly moribund state.

The vegetation is dominated by grasses. The dominant grass is *Themeda triandra*, except in patches with high rock cover. Grasses that are sub-dominants or localised dominants include *Elionurus muticus, Eragrostis curvula, Eragrostis chloromelas, Eragrostis lehmanniana* var. *lehmanniana, Heteropogon contortus, Setaria sphacelata* and *Triraphis andropogonoides.* Common grasses include *Anthephora pubescens, Aristida aequiglumis, Aristida canescens, Aristida congesta* subsp. *congesta, Bewsia biflora, Brachiaria nigropedata, Brachiaria serrata, Cymbopogon caesius, Cynodon dactylon, Digitaria argyrograpta, Digitaria tricholaenoides, Eragrostis racemosa, Eragrostis superba, Melinis repens, Panicum coloratum* var. *coloratum, Pogonarthria squarossa* and *Schizachyrium sanguineum.* Common forbs include *Acalypha angustata, Anthospermum rigidum, Barleria macrostegia, Bulbine capitata, Bulbine narcissifolia, Chaetacanthus* cf. *burchellii, Conyza podocephala, Commelina africana, Cyanotis speciosa, Felicia muricata, Gnidia capitata, Gomphrena celosiodes*, Helichrysum nudifolium, Indigofera heterotricha, Kyphocarpha angustifolia, Ledebouria* cf. *apertiifolia, Limeum viscosum, Nolletia rarifolia, Ornithogalum tenuifolium* subsp. *tenuifolium, Plexipus hederaceum, Pollichia campestris, Solanum incanum, Sida* cf.

chrysantha, *Teucrium trifidum* and *Vernonia oligocephala.* The small succulent shrub *Aloe davyana* is common (mostly in rocky areas), is the geoxylic suffrutex *Ziziphus zeyehriana.* The small shrubs *Seriphium plumosum, Disopyros lycioides* and *Sphaedamnocarpus pruriens* subsp. *galphimiifolius* are also common, with the latter two species being largely confined to rocky quartzitic outcrops.

Average species richness measured in the three sampling plots placed within this unit was 48.0 species per $100m^2$, which is high for Highveld grasslands, and species richness varied moderately from 44 to 51 species per $100m^2$. However, the current survey was conducted very early in the growing season (early November) and the vegetation was mostly moribund, so actual species richness may be significantly higher. This assertion is supported by the fact that in the recent baseline botanical survey of the adjacent MWS surface rights area (De Castro & Brits, July 2015a), average (n = 3) species richness measured in similar Sandy Grassland was 56.3 species per $100m^2$, and as high as 67 species per $100m^2$ which is the highest figure ever recorded by the author on the Highveld. A moderate number of 'characteristic' species occur and 15 (or 16.1% of the total number of species recorded within sampling plot placed in this unit) of the species recorded within the three sampling plots placed in this unit, are characteristic species which were not recorded within sampling plots located in any of the other units (see Table 3). One of the six plant 'species of conservation concern' recorded within the study area (see Table 6) was recorded within this unit, namely the Declining species *Boophone disticha.* This unit does however contain potentially suitable habitat for one of the remaining five plant 'species of conservation concern' recorded within the study area, namely *Hypoxis hemerocallidea,* and it is likely that this species is present. This unit does not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur. Dolomite Grassland does not contain potentially suitable habitat for the single Protected plant species recorded within the study area.

The vegetation of this unit is representative of Rand Highveld Grassland, a vegetation type that is categorised as Endangered at both a provincial and national level (Mucina and Rutherford, 2006 and NWBSP 2015). Much of the original extent of Rand Highveld Grassland, within the study area and its immediate surrounds has already been transformed by cultivation and urbanisation, and the remaining areas of Rand Highveld Grassland within the study area must therefore be regarded as of significant value. This BMU is therefore considered to have a **High** botanical biodiversity conservation value and sensitivity.

Unit 8: Secondary Grassland

The extent of this unit within the study area is 557.4ha (or 37.27% of the study area), which is the second surface area covered by any of the eleven identified vegetation and land-cover type units. This unit comprises vegetation of historically cultivated soils. This unit comprises mostly of areas last cultivated from 10 to 15 or more years ago, but also includes areas cultivated as recently as six years ago, such as the centre pivot fields on farm Kromdraai. The historically cultivated soils comprising this unit occur in areas with gentle gradients (less than ca. 3^{o}).

In terms of physiognomy, the secondary vegetation of this unit can be described as predominantly Short Closed Grassland (*sensu* Edwards *et al*., 1983). The vegetation has low species richness and is dominated by indigenous pioneer grasses and other grasses indicative of severe historical disturbance. Species dominance and species composition vary in

accordance with habitat characteristics (e.g. soil type, position in landscape and soil moisture regime) and elapsed time since ploughing. On recently ploughed soils, the vegetation is dominated by ruderal and agrestal weeds which are typical of the early seral communities of disturbed Highveld habitats. Where more time has elapsed since ploughing, as is the case for almost all of the secondary communities of the study area, the vegetation is dominated by pioneer grasses and grasses indicative of severe disturbance, and has higher species richness, though species richness is still low compared with that of untransformed or primary grassland communities.

Dominant grasses on red-brown clay loams to sandy clay loams, which were last ploughed more than a decade ago and are in an advanced state of secondary succession, include *Aristida adscensionis, Cynodon dactylon, Eragrostis curvula, Eragrostis lehmanniana* subsp. *lehmanniana* and *Eragrostis pseudosclerantha.* Common grasses include *Aristida congesta, subsp. congesta, Eragrostis chloromelas, Eragrostis superba, Heteropogon contortus, Hyparhenia hirta, Melinis repens, Pogonarthria squarrossa* and *Themeda triandra*. Common forbs include *Corchorus aspleniifolius, Cucumis zeyheri, Osteospermum muricatum, Osteaspermum scariosum, Pollichia campestris, Gomphocarpus fruticosus, Verbena aristigera** and *Verbena officinalis*.* On recently cultivated (ca. 6 years ago) black turf soils on the farm Kromdraai, where the vegetation is in the relatively early stages of secondary succession, the vegetation is dominated by pioneer grasses and ruderal weeds. The dominant species are the grass *Chloris virgata* and the agrestal weeds *Bidens bipinnata** and *Salsola kali**. Common grasses and forbs include *Aristida bipartita, Brachiaria eruciformis, Digitaria eriantha, Cynodon dactylon, Eragrostis chloromelas* and *Setaria vericillata.* Common forbs include *Hibiscus trionum*, Tagetes minuta** and *Verbena officinalis*.*

This unit comprises secondary vegetation of transformed habitats and has low species richness in terms of indigenous species. Average species richness measured in the three sampling plots placed within this unit was 18.3 species per $100m^2$, and varied from 15 to 21 species per $100m^2$. Many of the species comprising this species richness are alien ruderal and agrestal weeds, which is typical of such secondary grassland. Ten of the species recorded within the three sampling plots placed in this unit, which represents 27.0% of the total number of species recorded within these plots, were not recorded within sampling plots located in any of the other units (see Table 4), but one of these species is an alien weed and the remainder are indigenous pioneer species indicative of disturbance. Species richness of indigenous species increases with elapsed time since ploughing, as secondary succession progresses. Secondary succession in Highveld grassland is known to be extremely slow (usually many decades) and often stalls to produce a more or less stable 'disclimax' plant community, which is not representative of natural 'climax' or 'steady state' vegetation. The species richness of the vegetation comprising this unit is likely to increase significantly over time given correct management practices. One of the six plant 'species of conservation concern' recorded within the study area was recorded within this unit, namely *Hypoxis hemerocallidea* (Declining). This species was however recorded at only one site within this unit and is widespread and common to abundant throughout much of the remainder of the study area. This unit does not contain suitable habitat for any of the other five plant 'species of conservation concern' recorded within the study area (see Table 7), or the Protected plant species recorded within the study area. This unit does also not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur. The vegetation of this unit is therefore considered to have **Moderate** value in terms of botanical biodiversity conservation value and sensitivity.

Unit 9: Artificial Wetland

The extent of this unit within the study area is 2,2ha (or 0.15% of the study area). Comprises secondary wetland vegetation of areas of clay soils that were representative of Clay Grassland (Unit 5) prior to the construction of the existing TSF on the farm Megadam. Occurs as a thin strip (ca. 10m to 30m in width) of secondary hygrophilous grassland and marsh along the western foot of the retaining wall of the existing TSF. The hydrological patterns, soils and vegetation of the areas occupied by these artificial wetlands have been completely transformed by seepage and runoff of polluted water from the tailings storage existing TSF as well as windborne tailings which form a thin, visible layer on the surface of the soils in many places up to 40m away from the TSF retaining wall. The vegetation has very low species richness, and is dominated by hardy indigenous species that are mostly obligate or facultative halophytes and often act as pioneers on soils contaminated by tailings effluent.

In areas where surface water accumulates seasonally or periodically and the soils are saturated permanently or for long periods, the vegetation comprises dense stands of *Typha capensis* (an obligate hydrophyte and facultative halophyte). The vegetation surrounding these *Typha* reed beds comprises secondary hygrophilous grassland usually completed dominated by *Cynodon dactylon* (an obligate hydrophyte and facultative halophyte). Subdominant species include the grasses *Digitaria eriantha* and *Eragrostis trichophora*. Common species include the grasses *Eragrostis curvula, Eragrostis gummiflua, Eragrostis micratha, Calamgrostis epigeios* and *Paspalum dilatatum*.* Common forbs include *Cirsium vulgare*, Oenothera rosea** and *Pentzia incana.*

This vegetation unit comprises secondary marsh vegetation and secondary grassland of habitats transformed by seepage and runoff from the tailings storage facilities and has very low species richness in terms of indigenous species. No 100m^2 plots were formally surveyed within this unit but total species richness is less than 15 species per 100m^2. Effluent from the tailings facilities has not only severely impacted on the hydrology of these areas, but has is also likely to have led to the transformation of soil properties and impacts such as increased levels of salinity. Such increased salinity is suggested in the species composition of the vegetation, which is dominated by facultative halophytes (*Typha capensis* and *Cynodon dactylon*). This unit does not contain suitable habitat for any of the six plant 'species of conservation concern' recorded within the study area (Table 6), or the Protected plant species recorded within the study area. This unit does also not contain suitable habitat for *Drimia sanguinea*, a plant 'species of conservation concern' thus far not recorded within the study area but considered likely to occur. The vegetation of this unit therefore has **Low** value botanical biodiversity conservation value and sensitivity.

Unit 10: Alien trees

This extent of this unit within the study area 2.3ha (or 0.15% of the study area). This vegetation unit comprises habitats completely transformed through the planting and invasion of alien trees. Very little invasion of untransformed habitat by alien trees has occurred in the study area and this unit comprises almost entirely of a single **Eucalyptus camaldulensis* plantation on the southern boundary of the study area and a plantation of **Eucalyptus camaldulensis* and other alien trees associated with the abandoned homestead on the farm Kareerand. The herbaceous layer in plantations and invasive stands of alien trees is generally sparse, species poor and comprises entirely of indigenous pioneer grasses such as *Eragrostis*

curvula, *Eragrostis chloromelas* and *Cynodon dactylon* and alien ruderal weeds such as *Bidens pilosa*, Schkuhria pinnata** and *Tagetes minuta*.*

This secondary vegetation has very low species richness in terms of indigenous species. Furthermore, this habitat does not provide potentially suitable habitat for any plant 'species of conservation concern'. This unit therefore has **Low** value in terms of botanical biodiversity conservation value and sensitivity.

Unit 11: Infrastructure

This extent of this unit within the study area is 13.6ha (or 0.91% of the study area). The existing infrastructure comprising this unit consists of a guard house, a pipeline, a small laydown area and engineered dirt roads associated with the existing TSF, as well as farming related infrastructure such a small cement reservoir adjacent to the small endorheic pan (Site 31) and two abandoned farm homesteads in the eastern parts of the study area on the farms Kromdraai and Kareerand. The habitats of these areas have been completely transformed and the natural vegetation cleared.

The little vegetation occurring within this unit is all secondary and comprises alien ruderal weeds and invasive species, indigenous pioneer species or planted aliens, and has very low species richness in terms of indigenous species. This unit does not contain suitable habitat for any plant 'species of conservation concern'. Untransformed vegetation in close proximity to these areas is also often degraded as a result of various 'edge effects' emanating from these transformed habitats. These areas often become infested with alien invasive plant species which act as sources of seeds and other propagules which often infest surrounding habitats. This unit therefore has **Negligible** value in terms of botanical biodiversity conservation value and sensitivity.

Table 4: Percentage of the MWS Kareerand TSF Extension Project study area occupied by each of the identified broad-scale vegetation and land-cover type units, number of surveyed sites in each unit which are included in floristic table in Appendix 3, average species richness per 100m^2, and perceived biodiversity/conservation value of each unit.

Vegetation or land-cover type Unit	Percentage of the study area##	*Number of 100m^2 quadrats surveyed within unit	**Average Species richness per 100m^2 (α-diversity)	Total number of species recorded in 100m^2 sample plots	#Number of species not recorded in sample plots located in other BMU's	Botanical Biodiversity Conservation Value & Sensitivity
1. Pan wetland	0.05% 0.7ha	0	-	-	- (comparatively high % of recorded species restricted to unit)	High
2. Valley-bottom wetland - including associated hillslope seeps	2.02% 30.3ha	3	23.7 (19-26)	56	35 (62.5%)	High or Moderate (varies between wetlands)
3. *Acacia karoo* Woodland	0.13% 1.9ha	0	-	-	-	High

Vegetation or land-cover type Unit	Percentage of the study area##	*Number of 100m^2 quadrats surveyed within unit	**Average Species richness per 100m^2 (α-diversity)	Total number of species recorded in 100m^2 sample plots	#Number of species not recorded in sample plots located in other BMU's	Botanical Biodiversity Conservation Value & Sensitivity
4. *Acacia erioloba* Woodland	0.14% 2.1ha	2	26.5 (23-30)	47	10 (21.3%)	High
5. Clay Grassland	44.58% 666.7ha	4	52.8 (47-59)	122	28 (22.9%)	High
- black turf soils	2.71% 40.5ha	0	-	-	-	-
- diabase outcrops	0.13% 2.0ha	1	-	-	-	-
6. Dolomite Grassland	10.58% 158.2ha	3	57.7 (55-61)	89	27 (30.3%)	Very High
7. Sandy Grassland	4.02% 60.1ha	3	48.0 (44-51)	93	15 (16.1%)	High
8. Secondary Grassland	37.27% 557.4ha	3	18.3 (15-21)	37	10 (27.0%)	Moderate
9. Artificial wetland	0.15% 2.2ha	0	Low	-	-	Low
10. Alien trees	0.15% 2.3ha	0	Very low	-	-	Low
11. Infrastructure	0.91% 13.6ha	0	Very low	-	-	Negligible
TOTAL[#]	1495.5ha					

*Number of sites where quantitative sampling was undertaken within 100m^2 sampling plots/quadrats, and which are included in the floristic analysis provided in Appendix 3.
**Range is provided in brackets.
Number of species recorded only within BMU expressed as a percentage of the total number of species recorded within the BMU is provided in brackets.
##Sub-units shaded grey are not included in Total area as they form part of Unit 1.

9 SPECIES LIST AND ALIENS PLANT SPECIES

According to the National Herbarium PRECIS database records (http://posa.sanbi.org, accessed in December 2017), the quarter degree grid within which the study area is situated (2626DD) has been very poorly explored botanically. The PRECIS database contains herbarium records for only 84 species and infraspecific taxa for this 50 000ha quarter degree grid. During the 2015 botanical biodiversity baseline survey conducted by the current author for the 6 201ha Mine Waste Solutions surface rights area (De Castro & Brits, July 2015), which abuts the current study area and is situated within the grid 2626DD, a total of 508 plant species and infraspecific taxa were recorded. During the current survey of the MWS Kareerand TSF Extension Project study area, a total of 394 plant species and infraspecific taxa were recorded.

In the discussions of the plant species list obtained for the study area provided below, reference is made to declared alien invasive plant species in terms in terms of the Regulations on Alien and Invasive Plant Species (AIS). The AIS regulations are defined in the National Environmental Management: Biodiversity Act (Act no. 10 of 2014), published in the Government Gazette No. 37886, Notice 599 of 1 August 2014. In terms of the AIS regulation declared alien invasive plant species (as listed in Notice 3 of the Act) must be eradicated or controlled by the landowner. The AIS regulations furthermore place each declared alien

invasive plant species into one of four categories, and stipulate measures for the eradication and stipulate of plants in each of the four categories (Table 5).

Table 5: Legal requirements for the control or eradication of the four categories of alien invasive species listed in the 'Regulations on Alien and Invasive Species' (AIS) in terms of the National Environmental Management: Biodiversity Act (Act No 10 of 2014), published in the Government Gazette No. 37885, Notice 598 of 1 August 2014 (as amended).

Categories of Listed Invasive Species	
Category	**Definition and legal requirements**
1a	1. Category 1a Listed Invasive Species are those species listed as such by notice in terms of section 70(1)(a) of the Act as species which must be combatted or eradicated. 2. A person in control of a Category 1a Listed Invasive Species must: a. comply with the provisions of section 73(2) of the Act; b. immediately take steps to combat or eradicate listed invasive species in compliance with sections 75(1), (2) and (3) of the Act; and c. allow an authorised official from the Department to enter onto land to monitor, assist with or implement the combatting or eradication of the listed invasive species. 3. If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must combat or eradicate the listed invasive species in accordance with such programme.
1b	1. Category 1b Listed Invasive Species are those species listed as such by notice in terms of section 70(1)(a) of the Act as species which must be controlled. 2. A person in control of a Category 1b Listed Invasive Species must control the listed invasive species in compliance with sections 75(1), (2) and (3) of the Act. 3. If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme. 4. A person contemplated in sub-regulation (2) must allow an authorised official from the Department to enter onto land to monitor, assist with or implement the control of the listed invasive species, or compliance with the Invasive Species Management Programme contemplated in section 75(4) of the Act.
2	1. Category 2 Listed Invasive Species are those species listed as such by notice in terms of section 70(1)(a) of the Act as species which require a permit to carry out a restricted activity within an area specified in the Notice or an area specified in the permit, as the case may be. 2. Unless otherwise indicated in the notice, no person may carry out a restricted activity in respect of a Category 2 Listed Invasive Species without a permit. 3. A landowner on whose land a Category 2 Listed Invasive Species occurs or person in possession of a permit, must ensure that the specimens of the species do not spread outside of the land or the area specified in the Notice or permit. 4. If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme. 5. Unless otherwise specified in the Notice, any species listed as a category 2 Listed Invasive species that occurs outside of the specified area contemplated in sub-regulation (1), must, for purposes of these regulations, be considered to be a Category 1b Listed Invasive Species and must be managed according to Regulation 3.

Categories of Listed Invasive Species	
Category	**Definition and legal requirements**
	6. Notwithstanding the specific exemptions relating to existing plantations in respect of Listed Invasive Plant Species published in the Government Gazette No. 37886, Notice 599 of 1 August 2014 (as amended), any person or organ of state must ensure that the specimens of such Listed Invasive Plant Species do not spread outside of the land over which they have control.
3	1. Category 3 Listed Invasive Species are species that are listed by notice in terms of section 70(1)(a) of the Act, as species which are subject to exemptions in terms of section 71(3) and prohibitions in terms of section 71A of the Act, as specified in the Notice. 2. Any plant species identified as a Category 3 Listed Invasive Species that occurs in riparian areas, must, for the purposes of these regulations, be considered to be a Category 1b Listed Invasive Species and must be managed according to Regulation 3. 3. If an Invasive Species Management Programme has been developed in terms of section 75(4) of the Act, a person must control the listed invasive species in accordance with such programme.

A total of 394 plant species and infraspecific taxa were recorded within the study area during the current survey, of which 355 are indigenous taxa and 49 (13.8%) are naturalised aliens. The majority of the recorded alien species are found in the large areas of Secondary Grassland (Unit 8) of historically cultivated soils, Artificial Wetlands (Unit 9) created by seepage from the existing TSF, a small *Eucalyptus* plantation on the south-western boundary of the study area (Unit 10), and existing Infrastructure (Unit 11) which includes the TSF and related infrastructure and homesteads. Many alien ruderal weeds also occur within secondary vegetation of historically ploughed areas of valley-bottom wetlands (Unit 2). Of the 49 alien species listed in Appendix 1, eleven are declared alien invasive plant species in terms of the Alien Invasive Species (AIS) regulations, and all eleven are listed as Category 1b invasive species (see Appendix 1). Based on the authors experience the list of 394 plant species provided in this report probably includes approximately 85% of the species actually present.

The untransformed broad scale vegetation units (Units, 1, 2, 3, 4, 5, 6 and 7) that together comprise some 61.52% of the 1 495.5ha study area, remain almost entirely unaffected by alien invasive species that are aggressive habitat transformers. Though historically ploughed portions of valley-bottom wetlands (Unit 2), particularly those within the Kromdraai portion of the study area which were until recently under centre pivot irrigation (Site 36 and Site 34), do have a high cover of alien species, these are ruderal and agrestal weeds which are not habitat transformers and will be replaced by indigenous species as more time elapses and the natural process of secondary succession progresses. This observation is corroborated by the findings of the recent survey of the adjacent MWS surface rights area which found that habitat transformation by alien invasive plant species was largely restricted to the riparian habitats of the Vaal River and other riparian habitats. Nevertheless, it is recommended that the mine should seek to control the *Eucalyptus camaldulensis** (Category 1b invader) plantation near Site M11, as well as all alien invasive species occurring at homesteads in the eastern parts of the study area (Kromdraai).

The landowner should develop and implement an integrated alien plant control programme (as per the AIS Regulations), which identifies the species that pose the greatest threat, in terms of habitat transformation, within the study area and considers

all appropriate chemical, mechanical, biological and cultural control methods for the alien species listed in Appendix 1. Emphasis should be placed on controlling the 11 declared alien invasive species listed in Appendix 1, and in particular any species that are identified as posing a serious risk to untransformed habitat and vegetation within the study area. The existing alien plant survey and control programme for the Anglo Ashanti MWS surface rights area (De Castro & Brits, July 2015b) should be updated to include the current study area.

10 PROTECTED PLANT SPECIES

Two pieces of current legislation grant protected status to selected indigenous plant species within the North West Province, namely:

- National Forests Act (Act 84 of 1998, as amended on the 23rd of September 2010), and
- National Environmental Management: Biodiversity Act (Act 10 of 2004, as amended on the 16th of April 2013).

Schedule A of the National Forests Act (Act 84 of 1998) lists 47 tree species that are Protected in South Africa and may not be removed or damaged without the granting of a licence by the National Department of Agriculture, Forestry and Fisheries. Though protected, most of these species have large distribution ranges, are common to abundant throughout much of their distribution ranges and are not threatened with extinction. **One of the 47 tree species listed in Schedule A of the National Forests Act wase recorded within the study area during the current survey, namely *Acacia erioloba*.** The sampling sites and vegetation units within which *Acacia erioloba* was recorded during the current study are listed in Table 6.

The National Environmental Management: Biodiversity Act (Act 10 of 2004, as amended in April 2013), provides a list of 'Threatened or Protected Species' (TOPS) list which includes plant and animal species that are directly threatened by utilisation and require protection. This Act assigns species threatened by utilisation to one of four categories, namely Critically Endangered, Endangered, Vulnerable and Protected, but it must be emphasised that these categories are not the same as the rigorously defined IUCN Ver. 3.1 categories for threatened plant species (IUCN, 2001). The destruction, collection or trading of any species listed in the Act requires a permit which must be obtained from the Limpopo Department of Agriculture, Conservation and Environment. **No species listed in the TOPS List of the Biodiversity Act were recorded within the study area during the current study.**

The damaging or destruction of plant species that are Protected in terms of the National Forest Act or NEM:BA (Act 10 of 2004, as amended on the 16th of April 2013) during any future development should be avoided wherever possible, and a permit for the destruction of any such protected plant must be obtained from the provincial authorities prior to development. If any herbaceous plant species which are listed in the Biodiversity Act as Critically Endangered, Endangered, Vulnerable and Protected are recorded within proposed development footprints, appropriate *in situ* and / or *ex situ* conservation measures should be developed in consultation with the North West Province Directorate of Biodiversity Management. Where listed species are not highly threatened and a Permit is obtained (from the provincial Directorate of Biodiversity Management) for their removal, it is recommended that such species are rescued and placed in a nursery or donated to a research institute (e.g. SANBI or botanical garden) prior to development, rather than simply being destroyed upon receipt of a permit. Where feasible, viable subpopulations of such species should also be translocated to

transformed (including rehabilitation areas) or untransformed areas within the study area which provide potentially suitable habitats, but such translocations will have to be carried out in a manner that ensures that no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area.

Table 6: Trees recorded within the study area that are protected species in terms of the National Forests Act (Act 84 of 1998, as amended on the 23rd of September 2010).

Species	Family	Vegetation units in which recorded and sites where recorded
Acacia erioloba	Fabaceae	**Unit 4** (*Acacia erioloba* Woodland): Sites 17 and 38a **Unit 6** (Dolomite Grassland): Sites 5, 13a, 13b, 16, 38b

11 PLANT 'SPECIES OF CONSERVATION CONCERN' (*sensu* Raimondo *et al*., 2009)

Prior to the field surveys, available database information pertaining to the threatened plant species of the region of the North West Province within which the study area is situated was obtained from the National Herbarium PRECIS database (http://posa.sanbi.org). All '*threatened species'*, namely Critically Endangered, Endangered and Vulnerable species, and other '*species of conservation concern*', namely Near Threatened, Declining, Critically Rare and Rare species (Raimondo *et al*., 2009 and http://redlist.sanbi.org, downloaded May 2015) historically recorded from the quarter degree grid square within which the study area is situated (2626DD), as well as the grids immediately to the west (2626DC and 2626CD) and south-west (2726BA) which contain similar habitats, were extracted from these lists and are presented in Appendix 5. Emphasis was placed on searching for these plant species within potentially suitable habitat, during the field surveys.

Particular emphasis was placed on searching for plant 'species of conservation concern' recorded during the botanical biodiversity studies recently conducted for the immediately adjacent AngloAshanti Mine Waste Solutions surface rights area (De Castro & Brits, July 2015 and De Castro & Brits, August 2017).

The Red List of South African Plants (Raimondo *et al*., 2009) provided an assessment of all South African Plant taxa. The Red List therefore contains species that are currently regarded as being threatened with extinction (Critically Endangered, Endangered and Vulnerable) or are close to being threatened with extinction (Near Threatened), as well as species that are currently not regarded as being threatened with extinction (Least Concern), in accordance with IUCN Version 3.1 criteria (IUCN, 2001). In addition to the IUCN categories, the South African Red List also includes unique categories for species which do not currently qualify as Threatened or Near Threatened in accordance with IUCN criteria, and are thus categorised as Least Concern by the IUCN, but which are of some conservation concern (Raimondo *et al*., 2009). These South Africa categories are Critically Rare, Rare and Declining, and were developed specifically to highlight species that though not threatened with extinction possibly require some conservation effort and monitoring. In terms of the recommended methodology provided by Raimondo *et al*. (2009), the term 'species of conservation concern' includes the IUCN threatened and Near Threatened categories as well as the South African Red List categories (i.e. Critically Rare, Rare and Declining), and this approach is followed here.

The obtained lists of historically recorded 'threatened species' and other 'species of conservation concern' included no threatened (CR, EN or VU) or Near Threatened species and only one Declining species, namely *Hypoxis hemerocalidea,* which has been historically recorded within the grid 2626DC, and is situated immediately to the west of the grid within which the study area is situated, namely 2626DD (see Appendix 5). However, the region within which the study area is situated has been very poorly explored in a botanical sense. The current survey revealed the presence of subpopulations of two Near Threatened plant species (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) and four Declining plant species (*Boophone disticha, Crinum* cf. *bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocallidea*) within the 1 495.5ha MWS Kareerand Extension Project study area.

In addition to the six aforementioned 'species of conservation concern' that have been recorded within the study area, *Adromischus umbraticola* (NT), *Drimia sanguinea* (NT) and *Nerine gracilis* (VU) have previously been recorded within or in close proximity to the adjacent Mine Waste Solutions surface rights area (De Castro, August 2017) or the nearby Vaal Reefs Mine Complex surface rights area within the quarter degree grid 2626DC (De Castro, August 2013). The six 'plant species of conservation concern' recorded within the current study area are listed in Table 7 together with the sites at which they were recorded and the vegetation / land-cover type units within which they were recorded. All six of these 'species of conservation concern', as well as *Adromischus umbraticola, Drimia sanguinea* and *Nerine gracilis* are listed in Appendix 5, together with relevant information on flowering season, known habitat requirements, known geographical distribution, current conservation status and potential or confirmed occurrence within the current study area. All recorded localities for the Near Threatened species (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) and Declining species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocaliidea*) recorded within the study area are shown on the vegetation map provided in Appendix 7.

Table 7: List of the six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) that were recorded within the study area.

Species	Family	Latest (IUCN version 3.1) Conservation Status Category*	Sites where recorded	Vegetation or land-cover unit where recorded
Boophone disticha	Amaryllidaceae	Declining	1a, 2, 4a, 5, 7, 22, 43b, 44, 48, 50, 54, S5, S6, S14, SU2, SU9b, M18	Common and widespread. Most abundant in rocky areas in Unit 5 (Clay Grassland) where 12 of the 17 recorded localities for this species are situated. Also recorded at sites in rocky areas within Unit 6 (Dolomite Grassland) and Unit 7 (Sandy Grassland).
Crinum cf. *bulbispermum*	Amaryllidaceae	Declining	51b and 51d	Recorded only at 2 Sites situated ca. 40m apart on heavy black turf soils within Unit 5 (Clay Grassland). The identity of the recorded plants requires

Species	Family	Latest (IUCN version 3.1) Conservation Status Category*	Sites where recorded	Vegetation or land-cover unit where recorded
				confirmation (may be *C. lugardiae*).
Lithops lesliei subsp. *lesliei*	Aizoaceae	Near Threatened	39	Recorded at only one site in Unit 6 (Dolomite Grassland) within the footprint of Borrow Area 1.
Pearsonia bracteata	Fabaceae	Near Threatened	8, 9, 11, 12, 14, 15, 39	Recorded at seven sites in Unit 6 (Dolomite Grassland), all within the footprint of Borrow Area 1
Eucomis autumnalis	Hyacinthaceae	Declining	M18	Recorded at only one Site in a rocky, diabase boulder outcrop in Unit 5 (Clay Grassland), within the footprint of Borrow Area 3.
Hypoxis hemerocallidea	Hypoxidaceae	Declining	1a, 1b, 19, 20, 22, 26, 38b, 43a, 43b, 44, 50, 51a, 52, 54, 58, 59, M11, Su3, Su5, Su6	Common and widespread. Most abundant in Unit 5 (Clay Grassland) where 16 of the 20 recorded localities for this species are situated. Also recorded at sites on the margins of Valley-bottom wetlands (Unit 2) and in Unit 4 (*A. erioloba* Woodland) and Unit 8 (Secondary Grassland).

* Status follows the latest Red Data Plant Book of South African Plants (Raimondo *et al*., 2009), and the continuously updated online Red List of SANBI (http://redlist.sanbi.org, downloaded May 2015).

Three of the species listed in Appendix 5 have not yet been recorded within the current study area, and two of these three species, namely *Adromischus umbraticola* and *Nerine gracilis*, are considered to have a Low probability of occurrence as suitable habitat is not present within the study area.

The remaining species, namely the geophyte *Drimia sanguinea*, is considered to have a Moderate probability of occurrence. Potentially suitable habitat for *D. sanguinea* is restricted to Dolomite Grassland vegetation unit (Unit 6) of the study area, but even here the habitat is considered to be marginal. The possibility of this species occurring within Unit 8 of the study area cannot however be excluded and should therefore be verified. **It is therefore recommended that additional, brief floristic surveys, focussed on searching for *Drimia sanguinea* within the proposed infrastructure footprints, should be conducted in late October and early February. The brief floristic surveys should focus on searching those parts of the proposed infrastructure footprints containing potentially suitable habitat for *Drimia sanguinea,* which is likely to be restricted to the Dolomite Grassland vegetation unit (Unit 6). These surveys will also contribute towards confirming the absence of other 'species of conservation concern' within the study area. In the event of any Threatened or Near Threatened species being recorded during follow-up surveys,**

appropriate *in situ* and / or *ex situ* conservation measures should be developed and implemented in conjunction with the provincial Directorate of Biodiversity Management.

The four Declining and two Near Threatened species which have been recorded within the 1 495.5ha study area, are discussed separately below.

11.1 Declining species

Boophone disticha, *Crinum bulbispermum*, *Eucomis autumnalis* and *Hypoxis hemerocallidea* are all categorised as Declining (Raimondo *et al*., 2009 and http://redlist.sanbi.org, accessed in January 2018), and are therefore not 'threatened species' as defined by the IUCN, but are 'species of conservation concern' as defined by Raimondo and her co-authors (2009). Declining is a South African Red List category reserved for species which are not threatened or Near Threatened, but which are declining as a result of over-utilisation, and therefore merit some conservation effort. All four of the aforementioned species have large distribution ranges ('Extent of Occurrence'), which extend over much of the eastern half of South Africa and in some cases southern Africa, and are quite common over much of their ranges, though *Crinum bulbispermum* is highly habitat specific and occurs only in seasonally to periodically flooded and saturated clayey soils along rivers and drainage lines. These species are not under any immediate threat of extinction, and has been categorised as Declining as a result of the fact that they are popular and fairly heavily utilised medicinal plants which are subjected to destructive harvesting (in all cases the underground structures are harvested), and there are concerns that long-term over utilisation of wild plants will lead to a decline in many of the sub-populations of these species. All of these species are also long-lived and slow growing geophytes which are particularly vulnerable to over-exploitation. All four species are conspicuous species, even when not in flower, and the localities listed in Table 6 and mapped in Appendix 4 are therefore likely to provide an accurate indication, but not a complete record, of the distribution of these species within the study area.

Only three sites are listed for *Crinum bulbispermum* in Table 6, but this species is common along the Vaal River and its tributaries to the south of the study area. *Eucomis autumnalis* was recorded at only one site in rocky grassland within Clay Grassland (Unit 5). *Boophone disticha* is widespread and common within untransformed grassland within the study area and is most abundant in rocky grassland within Clay Grassland. *Hypoxis hemerocallidea* is widespread within the study area and is abundant at many of the 20 sites where it was recorded. *Hypoxis hemerocallidea* is most abundant and widespread within Clay Grassland, but was recorded in various vegetation units including Secondary Grassland (Unit 8).

It is recommended that prior to any development that may lead to the destruction of any of the four recorded Declining plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis and Hypoxis hemerocallidea*), permission for their removal should be obtained from the provincial Directorate of Biodiversity Management, and if necessary appropriate *in situ* and / or *ex situ* conservation measures should be developed and implemented in conjunction with the Directorate. Where feasible, viable populations of such species should be translocated to degraded or untransformed areas within the study area which provide potentially suitable habitats, but such translocations will have to be carried out in a way that ensures no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area. Alternatively plants should be offered to research and conservation institutions such as SANBI botanical gardens or

universities. Illegal medicinal plant harvesting should be monitored and discouraged through control of access to untransformed habitats and vegetation within the study area.

11.2 Threatened and Near Threatened species

The two Near Threatened species recorded within the study area (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) are discussed separately below.

Lithops lesliei subsp. *lesliei*

Lithops lesliei subsp. *lesliei* is categorised as **Near Threatened [A4acd]** in the latest Red List of South African plants (Raimondo *et al*., 2009 and http://redlist.sanbi.org) and is included in the B 'Priority Grouping' for Gauteng plant species of conservation concern. *Lithops lesliei* subsp. *lesliei* is a highly inconspicuous, dwarf, succulent, 'stoneplant' which is highly sought after by succulent plant collectors and medicinal plant collectors (Raimondo *et al*., 2009 and http://redlist.sanbi.org). A photograph of the species is provided in Appendix 11. This species is found in arid grasslands, on rocky substrates, often under the protection of grasses and forbs (Raimondo *et al*., 2009). According to Raimondo and co-authors (2009) this species has undergone a 15% population reduction as a result of harvesting for the medicinal plant trade and habitat destruction as a result of urban expansion and agriculture. This habitat loss is ongoing and the species is known from a total of less than 50 sites or subpopulations (http://redlist.sanbi.org), some of which have recently been extirpated by urban expansion in Gauteng (personal communication with Ms Lorraine Mills). The current author has also recorded large-scale harvesting by succulent plant collectors in Gauteng and this is likely to also have contributed significantly to population decline. During the current study, the author and Mr Gunther Wiegenhagen of AngloGold Ashanti recorded this species within the MWS Kareerand Extension Project study area at a single site (Site 39) within Dolomite Grassland (Unit 6), where two plants were found but far more plants are likely to be present. The author and Mr Wiegenhagen have also previously recorded this species from two subpopulation/locality near Orkney some 16km to the south-east of the study area (De Castro & Brits, August 2013) and form a single subpopulation (Site Su 21) of some 210 plants situated some 1.5km's to the south east of the study area on a low chert ridge within the within the adjacent MWS surface rights area (De Castro & Brits, July 2015).

The habitat of the subpopulation recorded within the study area comprises Short Closed Grassland (*sensu* Edwards, 1983) with Unit 6, with herbaceous vegetation cover of approximately 65% and surface rock cover of approximately 35%, on a low chert ridge in a gently undulating landscape (BMU 8). The soils are shallow, brown clay loam soils, strewn with chert stones and pebbles and associated with small, exposed chert rock. The two plants on the crest of the chert ridge, on a 1° slope E-facing slope, but plants at Vaal Reefs and MWS occur on SSW, NE and NNW aspects on gentle (ca. 1° to 2° slopes). All four recorded subpopulations of this species recorded in the Stilfontein and Orkney regions are therefore restricted to gentle slopes near the crest of rocky chert ridges. It is interesting to note that the four subpopulations of *Lithops lesliei* subsp. *lesliei* recorded by the author at West Wits (Carletonville) in 2013 all occur on shallow clay soils overlying shale, an though this species seems to have a wide tolerance to various geological substrates, it seems to be substrate specific (restricted to one geology) at a local scale.

No signs of harvesting were recorded at Site 39. Though only two plants were recorded at Site 39, it is considered highly probable that many more plants, of this highly inconspicuous

species, which is extremely difficult to detect when not in flower, are present on the low chert ridge on which Site 39 is situated. The low chert ridge comprises the Dolomite Grassland vegetation unit (Unit 6) of the study area. It is therefore recommended that a botanist and the personnel of the mines Biodiversity and Heritage section of MWS should conduct additional searches for this species in potentially suitable habitat within Unit 5 between late April and June when the plants are likely to be in flower.

Given the fact that *Lithops lesliei* subsp. *lesliei* is currently categorised as a Near Threatened [A4acd] species, which is known from less than 50 localities and is a heavily harvested medicinal and horticultural species (http://posa.sanbi.org, accessed 17 January 2018), it is recommended that the subpopulation recorded within the study area should be conserved *in situ* and protected by a suitable buffer zone. The recommendation for the *in situ* conservation of the recorded sub-populations of *Lithops lesliei* subsp. *lesliei* is in accordance with the guidelines for EIA recommendations provided by Pfab (2006) and Raimondo *et al.* (2009). The guidelines provided by Raimondo *et al.* (2009), are reproduced in the 'text box' provided below.

TEXT BOX		
Extract from 'Guidelines for EIA recommendations for taxa of conservation concern found on proposed development sites' provided in Table 4.1 of the Red List of South African Plants (Raimondo *et al*., 2009).		
Status	**Criterion**	**Guideline for Recommendation**
Near Threatened	A	If this taxon has a restricted range, EOO < 2 000km^2, then recommended no further loss of habitat. If range size is larger, the taxon is possibly long-lived but widespread, and limited habitat loss may be considered. Conservation of subpopulations is essential if they occur (i) within a threatened ecosystem or (ii) within an area required for biodiversity conservation in terms of a relevant spatial biodiversity conservation plan or (iii) on a site associated with additional ecological sensitivities.

Raimondo *et al*. (2009) recommend that the destruction of a subpopulation (i.e. limited habitat loss) of a Near Threatened species such as *Lithops lesliei* subsp. *lesliei* which is listed only under criterion A, should only be considered under circumstances where certain requirements are met (see Text Box above). In accordance with these guidelines, the *Lithops lesliei* subsp. *lesliei* subpopulation recorded within the study area should be conserved *in situ* for the following reasons:

- no sub-population of this species in the North West Province is currently known to occur in an area formally conserved in terms of the Protected Areas Act (Act 57 of 2003), and it occurs in only one such protected area in Gauteng, namely the Rietvlei Nature Reserve where a small subpopulation occurs;
- the untransformed chert grassland (part of Unit 6) habitat that provides the only habitat for this species within the study area, is representative of Vaal Reefs Dolomite Sinkhole Woodland which is considered to be Vulnerable nationally (Mucina & Rutherford, 2006);
- the habitat of the recorded subpopulation, and its recommended buffer zone (see Appendix 7), is all mapped as a Critical Biodiversity Area 2 in the NWBSP 2015.

The Red List of South African Plants (Raimondo *et al.*, 2009) does not provide accurate guidelines for the setting of buffer zones to mitigate deleterious edge effects which may

impact threatened species, and no such guidelines are available for 'species of conservation concern' in the North West Province. In the absence of guidelines for the North West Province, the Gauteng 'Red List Plant Species Guidelines' document (Pfab, 2006) are regarded as wholly appropriate and are followed in this study. The Gauteng 'Red List Plant Species Guidelines' document states that all Threatened and Near Threatened species should be conserved *in situ*. These guidelines also state that the minimum buffer zone around subpopulations of B 'Priority Grouping' species of conservation concern (e.g. *Lithops lesliei* subsp. *lesliei)* should be at least 300m in rural areas. The recommended preliminary minimum buffer zone for the subpopulation of *Lithops lesliei* subsp. *lesliei* recorded within the study area is therefore 300m, and the exact width and footprint of this buffer zone should be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the 'Extent of Occurrence' within the study area). The final buffer zone resulting from the recommended survey should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The buffer zone will therefore not simply be circular (as shown in Appendix 7), and the footprints of the buffer zones should been adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity with the MWS subpopulation and any other subpopulations discovered in future is enhanced, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.

The recommendations for the conservation of *Lithops lesliei* subsp. *lesliei* within the MWS Kareerand TSF Extension Project study area can be summarised as follows:

- The habitat of the subpopulation of *Lithops lesliei* subsp *lesliei* and its preliminary buffer zone (see Appendix 7) should be excluded from the footprints of any proposed project infrastructure. This will require realignment of the footprint of Borrow Area 1 (western borrow area). Furthermore, until such time as the size and extent of the subpopulation of this species recorded at Site 39 is accurately established, the entire extent of the Dolomite Grassland vegetation unit (Unit 6) should be excluded from any proposed development footprints.
- A botanist and the personal of the mines Biodiversity and Heritage section should conduct additional searches for this species in potentially suitable habitat within Unit 6 between late April and June.
- The recommended preliminary minimum buffer zone for the subpopulation of *Lithops lesliei* subsp. *lesliei* recorded within the study area (300m), and the exact width and footprint of this buffer zone should be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the 'Extent of Occurrence' within the study area). The final buffer zone resulting from the recommended survey should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The buffer zone will therefore not simply be circular, and the footprints of the buffer zones should been adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity between any subpopulations discovered in future is enhanced, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.
- Suitably experienced personnel from the Biodiversity and Heritage section of the mine should conduct simple annual monitoring of the recorded subpopulation of

Lithops lesliei subsp *lesliei*. Such monitoring should simply comprise of visiting each site, photographing the site, counting the number of plants and recording any observed impacts to the species and its habitat (e.g. alien plant invasion, overgrazing, trampling and medicinal plant harvesting).

- A management plan for this species and its habitat should be developed with input from, and the approval of, the North West Province conservation authorities, including the Directorate of Biodiversity Management.

Pearsonia bracteata

Pearsonia bracteata is categorised as Near Threatened **[B1ab (i, ii, iii, iv, v)]** in the latest Red List of South African plants (http://redlist.sanbi.org, accessed in January 2018) and is included in the A3 'Priority Grouping' for Gauteng plant species of conservation concern. *Pearsonia bracteata* is a mesophytic dwarf suffrutex (up to 45 cm in height), that is inconspicuous when not in flower (Retief & Herman, 1997). A photograph of the species is provided in Appendix 11. This species has lost habitat to cultivation in the past, and is threatened by on-going habitat loss and degradation due to urban development, agriculture and mining (http://redlist.sanbi.org, accessed in January 2018). Plants in Gauteng and North West occur in gently sloping Highveld grassland, while those in the Wolkberg (Limpopo Province) were collected from steep wooded slopes and cliffs in river valleys (Gauteng Department of Nature Conservation threatened plant database). The latest Red List (http://redlist.sanbi.org) states that this species is known from only 'eight to fourteen localities', only four of which (including the localities recorded by the author at Vaal Reefs in 2007 and MWS in 2017) are situated within the North West Province. Furthermore the subpopulations found at Vaal Reefs, MWS and the current study area are all situated within mining rights areas. At the subpopulation found at Site M1 at Vaal Reefs a total of 13 plants were counted, and at the subpopulation found at Site Su 21 at MWS a total of 10 plants were counted, though it is almost certain that more plants occur at both these sites. During the current study, at total of 34 plants where found at 7 sites within the MWS Kareerand Extension Project study area, all of which were situated within Unit 6 (Dolomite Grassland), but is it is highly probable that many more individuals of this extremely inconspicuous species are present.

The subpopulation of *P. bracteata* recorded at Vaal Reefs occurs in Short Closed Grassland and Sparse Woodland (*sensu* Edwards, 1983) on shallow, brown, clay loams overlying dolomite. Surface rock cover of dolomite is approximately 18%. The subpopulation recorded at MWS (Site Su 26) occurs on a low chert ridge very similar to the habitat on which the species was found within the current study area. The subpopulation found at seven sites within Dolomite Grassland (Unit 6) within the current study area, all occur in Short Closed Grassland and Sparse Woodland (*sensu* Edwards, 1983) on very gentle slopes to flat areas on the crest of a low chert ridge. The soils are shallow, brown clay loam soils, strewn with chert stones and pebbles and associated with small, exposed chert rock, and surface rock cover varies from approximately 15% to 30%.

Given the fact that *Pearsonia bracteata* is currently categorised as a Near Threatened [B1ab (i, ii, iii, iv, v)] species, which is known from less than 14 localities (possibly as few as 8) at a global level and only four localities (including the Vaal Reefs, MWS and Kareerand localities) within the North West Province (http://posa.sanbi.org, accessed in January 2018), it is essential that the subpopulation recorded within the study area should be conserved *in situ* and protected by suitable preliminary buffer zones as mapped in Appendix 7. The

recommendation for the *in situ* conservation of the recorded subpopulation of *Pearsonia bracteata* is in accordance with the guidelines for EIA recommendations provided by Raimondo *et al.* (2009) and Pfab (2006). The guidelines provided by Raimondo *et al.* (2009), are reproduced in the 'text box' provided below.

TEXT BOX		
Extract from 'Guidelines for EIA recommendations for taxa of conservation concern found on proposed development sites' provided in Table 4.1 of the Red List of South African Plants (Raimondo *et al*., 2009).		
Status	**Criterion**	**Guideline for Recommendation**
Near Threatened	B, C	The taxon is approaching thresholds for listing as threatened but there are still a number of subpopulations in existence and therefore there is a need to minimise habitat loss. Conservation of subpopulations is essential if they occur (i) within a threatened ecosystem or (ii) within an area required for biodiversity conservation in terms of a relevant spatial biodiversity conservation plan or (iii) on a site associated with additional ecological sensitivities.

Raimondo *et al*. (2009) recommend that the destruction of a subpopulation (i.e. limited habitat loss) of a Near Threatened species such as *Pearsonia bracteata* which is listed only under criterion B should only be considered under circumstances where certain requirements are met (see Text Box above). In accordance with these guidelines, the *Pearsonia bracteata* subpopulations recorded within the study area should be conserved *in situ* for the following reasons:

- the subpopulation of *Pearsonia bracteata* recorded within the study is one of only four subpopulations / localities known from the North West Province, and this species is not currently known to occur in an area formally conserved in terms of the Protected Areas Act (Act 57 of 2003);
- the subpopulation of *Pearsonia bracteata* recorded within the study area is the largest of the three subpopulations recorded by the author in the Stilfontein and Orkney region and is quite possibly the largest subpopulation in the North West Province;
- the untransformed Chert grassland (part of Unit 6) that provides the only habitat for this species within the study area, is representative of Vaal Reefs Dolomite Sinkhole Woodland which is considered to be Vulnerable nationally (Mucina & Rutherford, 2006);
- the habitat of the recorded subpopulation, and its recommended buffer zones (see Appendix 7), is mapped as a 'Critical Biodiversity Area 2 in the NWBSP 2015.

The Red List of South African Plants (Raimondo *et al.*, 2009) does not provide accurate guidelines for the setting of buffer zones to mitigate deleterious edge effects which may impact threatened species, and no such guidelines are available for 'species of conservation concern' in the North West Province. In the absence of guidelines for the North West Province, the Gauteng 'Red List Plant Species Guidelines' document (Pfab, 2006) are regarded as wholly appropriate and are followed in this study. The Gauteng 'Red List Plant Species Guidelines' document states that all threatened and Near Threatened species should be conserved *in situ*. These guidelines also state that the minimum buffer zone around

subpopulations of A3 ‘Priority Grouping’ species of conservation concern (e.g. *Trachyandra erythrorrhiza)* should be at least 400m in rural areas. The recommended preliminary minimum buffer zone for the subpopulation of *Pearsonia bracteata* recorded within the study area is therefore 400m, and the exact width and footprint of this buffer zone can be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the ‘Extent of Occurrence’ within the study area). The final buffer zone should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The final buffer zone will therefore not simply be circular (as shown in Appendix 7), and the footprints of the buffer zones should be adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity with other untransformed habitats is maintained, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.

The recommendations for the conservation of *Pearsonia bracteata* within the MWS Kareerand TSF Extension Project study area can be summarised as follows:

- The habitat of the subpopulation of *Pearsonia bracteata* and its preliminary buffer zones (see Appendix 7) should be excluded from the footprints of any proposed project infrastructure. This will require realignment of the footprint of Borrow Area 1 (western borrow area), to exclude almost the entire extent of Dolomite Grassland (Unit 6) within the study area. It is therefore recommended that the entire extent of the Dolomite Grassland vegetation unit (Unit 6) should be excluded from any proposed development footprints.
- The recommended preliminary minimum buffer zones for the subpopulation of *Pearsonia bracteata* recorded within the study area is 400m around each of the seven recorded localities. The exact width and footprint of the overall buffer zone can be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the ‘Extent of Occurrence’ within the study area). The final buffer zone should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The final buffer zone will therefore not simply be circular, and the footprints of the buffer zones should been adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity between any subpopulations discovered in future is enhanced, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.
- Suitably experienced personnel from the Biodiversity and Heritage section of the mine should conduct simple annual monitoring of the recorded subpopulation of *Pearsonia bracteata*. Such monitoring should simply comprise of visiting each site, photographing the site, counting the number of plants and recording any observed impacts to the species and its habitat (e.g. alien plant invasion, overgrazing, trampling and medicinal plant harvesting).
- A management plan for this species and its habitat should be developed with input from, and the approval of, the North West Province conservation authorities, including the Directorate of Biodiversity Management.

12 DESCRIPTION OF THE PROPOSED INFRASTRUCTURE FOOTPRINTS

The percentage of the surface area of each of the five proposed infrastructure footprints (i.e. TSF extension, 3 borrow areas and return water dams) comprised of the various vegetation and land-cover type units identified within the study area, is provided in Table 8. The sum of the footprints of the five proposed infrastructure components is 1 092.1ha (Table 8). However there is some overlap between the footprint of the TSF Extension and the footprints of Borrow Area 2 and Borrow Area 3, and between the footprint of Borrow Area 2 and the footprint of the Return Water Dams (see Figure 2). If the overlapping areas of the various infrastructure footprints are accounted for, the total combined footprint of the proposed infrastructure components (excluding overlapping footprints) is 1 017.2ha. The percentage of the 1 017.2ha total combined footprint of the proposed infrastructure components occupied by each of the identified broad-scale vegetation and land-cover type units is provided in

Table 9.

The footprints of Borrow Area 1, Borrow Area 2 and the Storm Water Dams are situated entirely within areas mapped in the NWBSP as CBA 2, and Borrow Area 3 is situated entirely within areas mapped as CBA 1 (Appendix 9). Approximately 39.2% of the TSF Extension footprint falls within areas mapped as CBA 1 and the remaining 60.8% falls within areas mapped as CBA 2 (Appendix 9).

The five infrastructure components have a total combined footprint of 1 017.2ha, of which **324.5ha (or 31.90%)** comprises transformed habitats with secondary vegetation (Units 8, 9 and 10) or no vegetation (Unit 11). All the aforementioned transformed vegetation and land-cover type units have Moderate to Negligible botanical biodiversity value and sensitivity. The vast majority of the transformed areas comprises Secondary Grassland (Unit 11) of historically ploughed soils.

The vast majority of the area of untransformed habitats and vegetation included in the footprints of the five infrastructure components comprises Clay Grassland (Unit 5), Dolomite Grassland (Unit 6) and Sandy Grassland (Unit 7), all of which are regarded as being of High (Units 5 and 7) or Very High (Unit 6) botanical biodiversity value and sensitivity. Though untransformed and largely in near-pristine condition, some patches within these untransformed grassland vegetation units have been moderately degraded by altered fire regimes and overgrazing or the exclusion of grazing. Approximately **669.1ha (or 65.78%)** of the 1 017.2ha total combined footprint of the five infrastructure components comprises untransformed grassland (Units 5, 6 and 7). The Clay Grassland and Sandy Grassland vegetation units are representative Rand Highveld Grassland, a vegetation type which is categorised as Endangered at both a national and provincial level (Mucina & Rutherford, 2007 and MWBSP 2015). The Dolomite Grassland vegetation unit is representative of Vaal Reefs Dolomite Sinkhole Woodland, a vegetation type that is categorised as Vulnerable at a national level (Mucina & Rutherford, 2006). The Dolomite Grassland vegetation unit is regarded as the most sensitive vegetation unit within the study area and has been categorised as being of Very High botanical biodiversity value and sensitivity as it is in near-pristine condition, is representative of a Vulnerable vegetation type and provides highly restricted habitat for two Near Threatened plant species, namely *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*. Approximately 135.0ha (or 85.34%) of the total extent of Dolomite Grassland mapped for the study area is included in the proposed footprint of Borrow Area 1.

As previously stated, the five infrastructure components have a total combined footprint of 1 017.2ha, of which 324.5ha (or 31.90%) comprises transformed habitats with secondary vegetation or no vegetation, and 669.1ha (or 65.78%) comprises untransformed grassland (Units 5, 6 and 7). The remaining **23.6ha (or 2.32%)** of the total combined footprint comprises of the following spatially restricted untransformed habitats and vegetation:

- A total of 21.9ha of Valley-bottom wetland (Unit 2) comprising 10.1ha within the TSF Extension footprint, 1.4ha in the Borrow Area 2 footprint and 10.4ha in the Borrow Area 3 footprint. The areas of valley-bottom wetland within the TSF Extension footprint and the Borrow Area 3 footprint have been severely degraded by polluted seepage and runoff from the exiting TSF and by cultivation respectively and are regarded as being of Moderate sensitivity. The 1.4ha of valley-bottom wetland situated in the south-western corner the Borrow Area 2 footprint is in near-pristine condition and is regarded as being of High sensitivity.

- A total of 0.2ha of *Acacia karoo* Woodland' (Unit 3), all of which is situated within the TSF Extension footprint.
- A total of 1.5ha of *Acacia erioloba* Woodland' (Unit 4), all of which is situated within the footprint of Borrow Area 1.

The only habitat type or vegetation unit recorded within the study area which does not occur within the footprints of any of the infrastructure components is Pan wetland (Unit 1) which is represented by a single small, ephemeral endorheic pan situated some 100m to the west of the proposed footprint of Borrow Area 2.

The current survey revealed the presence of subpopulations of two Near Threatened plant species (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) and four Declining plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocallidea*) within the 1 495.5ha MWS Kareerand Extension Project study area. All the localities of these six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) recorded within the study area are situated within the proposed infrastructure footprints with the exception of two of the seventeen recorded localities of *Boophone disticha* and two of the twenty recorded localities of *Hypoxis hemerocallidea* (Table 6 and Appendix 7). The Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata,* were recorded from one and seven localities respectively, all of which are situated with the footprint of Borrow Area 1. The 'species of conservation concern' recorded within each of the five infrastructure footprints are as follows:

- TSF Extension: *Boophone disticha, Crinum bulbispermum* and *Hypoxis hemerocallidea*.
- Borrow Area 1: *Boophone disticha, Hypoxis hemerocallidea, Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata.*
- Borrow Area 2: *Boophone disticha* and *Hypoxis hemerocallidea.*
- Borrow Area 3: *Boophone disticha, Hypoxis hemerocallidea* and *Eucomis autumnalis.*
- Storm Water Dams: *Boophone disticha.*

Acacia erioloba, a tree which is Protected in terms of the National Forests Act, was recorded within the footprint of Borrow Area 1 and the adjacent western parts of the study area. No other species that are protected in terms of the National Forests Act or the Biodiversity Act were recorded within any of the other proposed infrastructure footprints or the study area as a whole.

Table 8: Vegetation and land-cover types occurring within the infrastructure proposed as part of the MWS Kareerand TSF Extension Project.

Veg/land-cover type unit	**TSF Extension**	**Borrow Area 1 (western borrow area)**	**Borrow Area 2 (central borrow area)**	**Borrow Area 3 (eastern borrow area)**	**Return Water Dams**	**Botanical Biodiversity Conservation Value & Sensitivity**
1. Pan wetland	-	-	-		-	High

2. Valley-bottom wetland	10.1ha	-	1.4ha	10.5ha	-	High or Moderate (varies between wetlands)
3. *Acacia karoo* Woodland	0.2ha	-	-	-	-	High
4. *Acacia erioloba* Woodland	-	1.5ha	-	-	-	High
5. Clay Grassland	108.8ha	32.5ha	279.3ha	117.2ha	32.5ha	High
6. Dolomite Grassland	-	135.0ha	-	-	-	Very High
7. Sandy Grassland	27.6ha	-	3.0ha	-	2.0ha	High
8. Secondary Grassland	230.5ha	11.0ha	9.8ha	57.6ha	8.7ha	Moderate
9. Artificial wetland	1.6ha	-	-	-	-	Low
10. Alien trees	1.1ha	-		-	-	Low
11. Infrastructure	2.7ha	-	6.3ha	1.2ha	-	Negligible
TOTAL area of footprint	**382.6ha**	**180.0ha**	**299.8ha**	**186.5ha**	**43.2ha**	

Table 9: Percentage of the 1017.2ha total combined footprint of the proposed infrastructure components (excluding overlapping footprints) occupied by each of the identified broad-scale vegetation and land-cover type units. Total combined footprint includes the footprints of the TSF extension, the three Borrow Areas and the Return Water Dams.

Veg/land-cover type unit	Percentage of combined footprint of the proposed infrastructure components (excluding overlapping footprints)	Botanical Biodiversity Conservation Value & Sensitivity
1. Pan wetland	-	High
2. Valley-bottom wetland	2.15% (21.9ha)	High or Moderate (varies between wetlands)
3. *Acacia karoo* Woodland	0.02% (0.2ha)	High
4. *Acacia erioloba* Woodland	0.15% (1.5ha)	High
5. Clay Grassland	49.46% (503.1ha)	High
6. Dolomite Grassland	13.36% (135.9ha)	Very High
7. Sandy Grassland	2.96% (30.1ha)	High
8. Secondary Grassland	30.63% (311.6ha)	Moderate
9. Artificial wetland	0.16% (1.6ha)	Low
10. Alien trees	0.11% (1.1ha)	Low
11. Infrastructure	1.00% (10.2ha)	Negligible
TOTAL area of combined footprints	**1 017.2ha**	

13 IMPACT ASSESSMENT

The potential impacts of the project on the botanical biodiversity of the study area are assessed under four broad impacts, namely:

- loss of vegetation types (*sensu* Mucina & Rutherford, 2006 and the NWBSP 2015);
- loss of spatially restricted vegetation units / plant communities;
- loss of flora (species richness);
- loss of plant 'species of conservation concern' (*sensu* Raimondo *et al.*, 2009).

The impact assessment provided below describes each broad impact, determines the significance of the impact and provides summarised mitigation and monitoring measures for each impact. The summarised mitigation and monitoring measures provided are described in more detail in the section of this report entitled 'Recommendations for mitigation'.

13.1 Loss of vegetation types

Applicable Phase: Construction, and to a lesser extent Operation.

Nature of impact: This impact refers to the loss of vegetation types (or broad-scale vegetation units) described and mapped in the national vegetation map (Mucina & Rutherford, 2006) and the NWBSP 2015. The NWBSP 2015 equates these vegetation types with ecosystems. The remaining untransformed vegetation of the vast majority of the 1 495.5ha study area comprises Clay Grassland (Unit 5), Dolomite Grassland (Unit 6) and Sandy Grassland (Unit 7), all of which are regarded as being of High (Units 5 and 7) or Very High (Unit 6) botanical biodiversity value and sensitivity (Table 3). The Clay Grassland and Sandy Grassland vegetation units are representative of Rand Highveld Grassland, a vegetation type which is categorised as Endangered at both a national and provincial level (Mucina & Rutherford, 2007 and MWBSP 2015). The Dolomite Grassland vegetation unit is representative of Vaal Reefs Dolomite Sinkhole Woodland, a vegetation type that is categorised as Vulnerable at a national level (Mucina & Rutherford, 2007). Loss of untransformed Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland, will result from the clearing of vegetation and topsoils within the construction footprints of the 1 017.2ha combined footprint of the five proposed infrastructure components during the construction phase.

The five infrastructure components have a total combined footprint of 1 017.2ha, of which 324.5ha (or 31.90%) comprises transformed habitats with secondary vegetation (Units 8, 9 and 10) or no vegetation (Unit 11), and 669.1ha (or 65.78%) comprises untransformed grassland representative of Rand Highveld Grassland (Units 5 and 7) or Vaal Reefs Dolomite Sinkhole Woodland (Unit 6). The remaining 23.6ha (or 2.32%) of the total combined infrastructure footprint comprises spatially restricted untransformed habitats and vegetation (Units 2, 3 and 4).

The extent of untransformed Rand Highveld Grassland (Units 5 and 7) within the 1 495.5ha study area is 726.8ha, 73.36% (or 533.2ha) of which is situated within the 1 017.2ha combined footprint of the proposed infrastructure components and will be cleared during construction. The extent of untransformed Vaal Reefs Dolomite Sinkhole Woodland (Unit 6) within the 1 495.5ha study area is 158.2ha, 85.90% (or 135.9ha) of which is situated within the 1 017.2ha combined footprint of the proposed infrastructure components and will be cleared during construction. Most of the loss of untransformed Rand Highveld Grassland will occur as a result of the clearing of the footprint Borrow Area 2 during construction, but large areas of this vegetation type will also be cleared during the clearing of the TSF Extension and Borrow Area 3 footprints and smaller areas will be lost to clearing within the Return Water Dams footprint (Table 7). All of the loss of Vaal Reefs Dolomite Sinkhole Woodland will occur as a result of the clearing of the footprint of Borrow Area 1 (Table 7).

An additional loss of an unpredictable extent of Rand Highveld Grassland may also result from soil pollution caused by contaminated seepage, runoff and spillage from the TSF extension, and to a lesser extent other edge effects such as dust emissions alien plant invasion. Polluted tailings effluent is likely to cause salinisation of soils, contamination with heavy metals and changes in soil chemistry which will make the soils more dispersive and increase erosion risk. All these impacts will cause severe and largely irreversible changes to various aspects of vegetation structure (e.g. physiognomy, life-form composition, species richness, species composition, species dominance and stand structure).

The clearing of 533.2ha of Rand Highveld Grassland (an Endangered vegetation type) and 135.9ha of Vaal Reefs Dolomite Sinkhole Woodland (a Vulnerable vegetation type) within areas mapped in the NWBSP as CBA 1 or CBA 2, is rated as an impact of high severity.

Extent of impact: **Construction**: National; **Operation**: Local. Though the destruction of Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland will be restricted largely to the construction footprints (and possibly a local scale as a result of edge effects such as soil contamination and dust emissions), the loss of significant areas of these two vegetation types which are regarded as Endangered and Vulnerable respectively at a national level, is regarded as an impact on a national scale. The loss or degradadtion of an unpredictable, but probably small extent of Rand Highveld Grassland that may also result from soil pollution caused by contaminated seepage, runoff and spillage from the TSF extension, and to a lesser extent other edge effects such as dust emissions alien plant invasion, is regarded as an impact on a local.

Duration: **Construction**: Permanent; **Operation**: Permanent. This impact will occur predominately during the construction phase (vegetation clearing) but will extend into the operational and decommissioning phases in the likely event of soil contamination in areas surrounding the TSF during the life of the mine and after decommissioning.

Intensity of impact: **Construction**: High; **Operation**: Medium.

Probability: **Construction**: Definite; **Operation**: Highly probable.

Frequency: **Construction**: Daily; **Operation**: Weekly.

Significance: **Construction**: HIGH; **Operation**: MEDIUM.

Status: Negative.

Confidence: **Contruction**: High; **Operation**: High.

Mitigation:

1. Realign the footprints of the proposed Borrow Areas so that the greatest extent possible of the Borrow Area footprints is located within the footprint of the TSF Extension.
2. Modify the remaining infrastructure footprints so as to reduce the area of untransformed Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland (Units 5, 6 and 7), as well as other untransformed vegetation units (Units 1 to 4), situated within the infrastructure footprints wherever possible. Realigned footprints should be placed within the transformed vegetation and land-cover type units (Units 8 to 11) in as far as possible.
3. Borrow Area 1 should be removed from the proposed infrastructure plan, or a major realignment of its footprint should be conducted in order to ensure it is not situated with any area of Dolomite Grassland (Unit 6) or the recommended buffer zones for the two recorded Near Threatened species (see map in Appendix 7).
4. Limit construction impacts only to the final, demaracated development footprints.
5. Develop and implement an alien plant control programme for the study area, with emphasis on areas surrounding infrastructure footprints.
6. Implement dust control measures during the construction and operational phases.

7. Implement design and operational measures to avoid or reduce soil contamination by polluted seepage and runoff from the TSF (e.g. pollution control dams and lining of the TSF). These pollution control measures should be based on soil, geotechnical and hydrological specialist reports for the project.
8. Develop and implement a veld management plan for the study area, which emphasises the use of sustainable grazing and controlled fires to ensure optimal vegetation condition and biodiversity levels in areas of untransformed grassland (Units 5,6 and 7) and spatially restricted untransformed vegetation units (Units 1 to 4) not destroyed by the project.
9. Develop and implement a rehabilitation plan for any borrow areas not placed within the TSF Footprint. The principal objective of the plan should be the establishment of indigenous seral plant communities through the natural process of secondary succession.

Significance post mitigation: **Construction**: HIGH; **Operation**: MEDIUM. Even if the loss of untransformed grassland is optimally minimised through the realignment of the footprints of the TSF Extension, Borrow Areas and Return Water Dam footprints, it is still likely to lead to the loss of a significant area of Rand Highveld Grassland, an Endangered vegetation type (Mucina & Rutherford, 2006 and MWBSP 2015). However, the implementation of the recommended mitigation measures will lead to a significant and meaningful reduction in the area of Rand Highveld Grassland destroyed by construction and operation of project infrastructure.

Predicted risk matrix for impact 1.

IMPACT 1:	**Loss of vegetation types**				
	CRITERIA	**CONSTRUCTION**		**OPERATION**	
		Rating	**Description**	**Rating**	**Description**
PRE-MITIGATION	Extent	4	National	2	Local
	Duration	4	Permanent	4	Permanent
	Intensity	5	High	3	Medium
	CONSEQUENCE	**13**		**9**	
	Probability	4	Definite	3	Highly probable
	Frequency	5	Daily	4	Weekly
	LIKELYHOOD	**9**		**7**	
	SIGNIFICANCE	**22**	**HIGH**	**16**	**MEDIUM**
POST-MITIGATION	Extent	4	National	1	Site
	Duration	4	Permanent	4	Permanent
	Intensity	3	Medium	3	Medium
	CONSEQUENCE	**11**		**8**	
	Probability	2	Probable	2	Probable
	Frequency	5	Daily	3	Monthly
	LIKELYHOOD	**7**		**5**	
	SIGNIFICANCE	**18**	**HIGH**	**13**	**MEDIUM**

13.2 Loss of spatially restricted plant communities / habitats

Applicable Phase: Construction and Operation.

Nature of impact:
This impact refers to the loss of spatially restricted untransformed habitats and plant communities, embedded within Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Grassland, which have been included in the following vegetation units identified for the 1 495.5ha study area:

- Pan wetland (Unit 1), which comprises 0.05% (or 0.7ha) of the study area.
- Valley-bottom wetlands (Unit 2), which comprises 2.02% (or 30.3ha) of the study area.
- *Acacia karoo* Woodland' (Unit 3), which comprises 0.13% (or 1.9ha) of the study area.
- *Acacia erioloba* Woodland' (Unit 4), which comprises 0.14% (or 2.1ha) of the study area.

The only habitat type or vegetation unit recorded within the study area which does not occur within the footprints of any of the infrastructure components is Pan wetland (Unit 1) which is represented by a single small, ephemeral endorheic pan situated some 100m to the west of the proposed footprint of Borrow Area 2. Though not situated within any of the proposed infrastructure footprints, this small pan is nevertheless at risk from changes to surface runoff and geohydrological regimes as a result of the proposed construction of Borrow Area 2 approximately 100m to the east and therefore almost certainly within its catchment. No other endorheic pans occur within the 1 495.5ha study area, the adjacent 6 212ha MWS surface rights area of the nearby 12 725ha Vaal Reefs Mine Complex surface rights area, and the pan at Site 31 must therefore be considered to be a unique and conservation-worthy habitat in this region of the North West Province.

A total of 23.6ha (or 2.32%) of the 1 017.2ha total combined infrastructure footprint, comprises of the following spatially restricted, untransformed vegetation units:

- A total of 21.9ha of Valley-bottom wetland (Unit 2) comprising 10.1ha within the TSF Extension footprint, 1.4ha in the Borrow Area 2 footprint and 10.4ha in the Borrow Area 3 footprint. The areas of valley-bottom wetland within the TSF Extension footprint and the Borrow Area 3 footprint have been severely degraded by polluted seepage and runoff from the exiting TSF and by cultivation respectively and are regarded as being of Moderate botanical biodiversity value and sensitivity. The 1.4ha of valley-bottom wetland (a tributary of the Vaal River) situated in the south-western corner the Borrow Area 2 footprint is in near-pristine condition and is regarded as being of High sensitivity.
- A total of 0.2ha of *Acacia karoo* Woodland (Unit 3) occurs within the combined infrastructure footprints, all of which is situated within the TSF Extension footprint. This unit is regarded as being of High botanical biodiversity value and sensitivity.
- A total of 1.5ha of *Acacia erioloba* Woodland' (Unit 4) occurs within the combined infrastructure footprints, all of which is situated within the footprint of Borrow Area 1. Though woodland communities comprising this unit constitute a unique and highly restricted woody habitat within the study area, numerous and far larger patches of *Acacia erioloba* Woodland occur immediately adjacent to the study area and less than 1km to the west of the study area where approximately 88ha of *Acacia erioloba* Woodland has recently been recorded by the author within the MWS surface rights

area (De Castro & Brits, July, 2015a).This unit is regarded as being of High botanical biodiversity value and sensitivity.

At total of 23.6ha spatially restricted untransformed vegetation units will therefore be lost due to clearing of the proposed infrastructure footprints. An additional loss of the vegetation of valley-bottom wetlands (Unit 2) may also result from reduced water quality, sedimentation and soil pollution caused by contaminated seepage, runoff and spillage from the TSF extension, and to a lesser extent other edge effects such as dust emissions alien plant invasion during the operational phase. Polluted tailings effluent is likely to cause salinisation of soils, contamination with heavy metals and changes in soil chemistry which will make the soils more dispersive and increase erosion risk. All these impacts will cause severe and largely irreversible changes to various aspects of vegetation structure (e.g. physiognomy, life-form composition, species richness, species composition, species dominance and stand structure).

The severity of this impact is largely attributable to the loss approximately 72.8% (or 21.9ha) of the extent of the Valley-bottom wetland unit (Unit 2) within the study area as a result of the construction of the proposed infrastructure as well as the likely long-term degradation of the wetlands of this unit as a result of reduced water quality, sedimentation and soil pollution. Of particular concern is the loss of the near-pristine valley-bottom wetland situated in the south-western corner of the Borrow Area 2 footprint. Though the wetlands of the study area are considered here, a more detailed description, impact assessment and mitigation description (including detailed recommendations for appropriate buffer zones) is provided in the wetland assessment report compiled for the study area (De Castro & Brits, January 2018).

Extent of impact: **Construction**: Site; **Operation**: Local. Sedimentation and reduced water quality emenating from the existing TSF have already severely impacted the entire approximately 2.5km reach of the Kareerand stream (valley-bottom wetland) situated between the existing TSF and the Vaal River (De Castro & Brits, July 2017 and Kotze, 2017).

Duration: **Construction**: Permanent; **Operation**: Permanent. The loss of the wetland areas within the proposed infrastructure footprints will be permanent. The impacts associated with polluted seepage and runoff from the TSF may be considered to be Long duration as they are likely to continue for at least as long as the operational life of the TSF.

Intensity of impact: **Construction**: High; **Operation**: High.

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Probability: **Construction**: Definite; **Operation**: Highly probable.

Frequency: **Construction**: Daily; **Operation**: Daily.

Significance: **Construction**: HIGH (attributable to the loss and deterioration of valley-bottom wetlands); **Operation**: HIGH (attributable to the deterioration of wetlands).

Status: Negative.

Confidence: **Construction**: High; **Operation**: Medium.

Mitigation:

1. Realign the footprints of the proposed Borrow Areas so that the greatest extent possible of the Borrow Area footprints is located within the footprint of the TSF Extension.
2. Modify the remaining infrastructure footprints so as to reduce the area of spatially restricted untransformed vegetation units (Units 1 to 4), situated within the infrastructure footprints wherever possible. Realigned footprints should be placed within the transformed vegetation and land-cover type units (Units 8 to 11) in as far as possible.
3. No infrastructure footprints should be situated within a minimum buffer of 100m of the boundaries of valley-bottom wetlands (Unit 2). In the case of the near-pristine valley-bottom wetland situated at Sites 20 and Sites 21 in the south-western parts of the study area on the farm Buffelsfontein, the buffer should be increased as per the recommendations provided in the wetland impact assessment for this project (De Castro & Brits, January 2018).
4. No infrastructure footprints should be situated within a minimum preliminary buffer of 200m of the Pan Wetland (Unit 1) situated at Site 31. The final buffer for the pan should be extended to include the entire catchment of the pan which should be determined using accurate contour line data.
5. The two small patches of *Acacia erioloba* Woodland (Unit 4) at Sites 17 and 38a (see Appendix 2) should be excluded from the infrastructure footprints.
6. Implement design and operational measures to avoid or reduce soil contamination by polluted seepage and runoff from the TSF. These pollution control measures should be based on soil, geotechnical and hydrological specialist reports for the project.
7. Historical illegal cutting and felling of *Acacia erioloba* trees was recorded at Sites 17 and 38, is ongoing within the study area, and should be discouraged through control of access to the western parts of the study area.

Significance post mitigation: **Construction**: Medium; **Operation**: Medium.
The reduction of the significance of this impact is dependent principally on the realignment of footprint of Borrow Area 2 so that it excludes the near pristine valley-bottom wetland and the exclusion of infrastructure from a suitable buffer around the valley-bottom wetlands and the pan wetland (buffer zone should include entire pan catchment) as recommended in the specialist wetland assessment for this project (De Castro & Brits, January 2018). The realignment of the footprint of Borrow Area 3 so that it excludes the two degraded (historically cultivated) wetlands will reduce the significance of the impacts to a lesser extent.

Predicted risk matrix for impact 2.

IMPACT 2:	Loss of spatially restricted plant communities / habitats				
	CRITERIA	CONSTRUCTION		OPERATION	
		Rating	Description	Rating	Description
PRE-MITIGATION	Extent	1	Site	2	Local
	Duration	4	Permanent	4	Permanent
	Intensity	5	High	5	High
	CONSEQUENCE	**10**		**11**	
	Probability	4	Definite	3	Highly probable
	Frequency	5	Daily	5	Daily
	LIKELYHOOD	**9**		**8**	
	SIGNIFICANCE	**19**	**HIGH**	**19**	**HIGH**
POST-MITIGATION	Extent	1	Site	2	Local
	Duration	4	Permanent	4	Permanent
	Intensity	3	Medium	3	Medium
	CONSEQUENCE	**8**		**9**	
	Probability	4	Definite	2	Probable
	Frequency	5	Daily	3	Monthly
	LIKELYHOOD	**9**		**5**	
	SIGNIFICANCE	**17**	**MEDIUM**	**14**	**MEDIUM**

13.3 Loss of flora

Applicable Phase: Construction, and to a lesser extent Operation.

Nature of impact: This impact refers to the loss of species richness (α-diversity) and of plant species that are Protected in terms of the National Forests Act (Act 84 of 1998, as amended on the 23rd of September 2010) and the Biodiversity Act (Act 10 of 2004, as amended on the 16th of April 2013). A total of 355 indigenous plant species have thus far been recorded within the study area, one of which is protected in terms of the National Forests Act, namely *Acacia erioloba*. *Acacia erioloba* was recorded only within the small area (1.5ha) of *Acacia erioloba* Woodland (Unit 4) and Dolomite Grassland (Unit 6), and most of the individuals recorded within the study area are likely to be lost due to the construction of Borrow Area 1. Though the woodland communities comprising this unit constitute a unique and highly restricted woody habitat within the study area, numerous and far larger patches of *Acacia erioloba* Woodland occur less than 1km to the west of the study area where approximately 88ha of *Acacia erioloba* Woodland has recently been recorded by the author within the MWS surface rights area (De Castro & Brits, July, 2015a).

The most extensive and species rich (high α-diversity) untransformed vegetation units identified for the 1 495.5ha study area are Clay Grassland (Unit 5), Dolomite Grassland (Unit 6) and Sandy Grassland (Unit 7). The construction of the proposed infrastructure footprints will lead to the loss of approximately 75.46% (or 503.1ha) of the extent of Clay Grassland recorded within the study area, approximately 85.90% (135.9%) of the extent of Dolomite Grassland recorded within the study area and approximately 50.08% (135.9%) of the extent of Sandy Grassland recorded within the study area.

A very significant reduction in the species richness (α-diversity) of the study area can therefore be expected. For example, all of the localities of these six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) recorded within the study area are situated within the proposed infrastructure footprints with the exception of two of the seventeen recorded localities of *Boophone disticha* and two of the twenty recorded localities of *Hypoxis hemerocallidea* (Appendix 7 and Table 6). At the scale of the 1 495.5ha study area (or Site), it is therefore expected that many species will be lost and that almost all other species will suffer significant reductions in numbers (i.e. subpopulation size). The loss of flora as a result of the construction of the proposed infrastructure footprints is therefore expected to be an impact of high severity at the scale of the study area. However, the vast majority, if not all, of the 355 indigenous plant species recorded within the study area occur in areas immediately adjacent to the study area (i.e. at a Local scale) and almost all were recorded within the MWS surface rights area situated immediately to the south of the current study area during a recent survey (De Castro & Brits, July 2015a). The impact of the loss of flora within the study area is therefore far less severe at a regional or even local scale.

Extent of impact: **Construction**: Site; **Operation**: Site.

Duration: **Construction**: Permanent; **Operation**: Long. Though the natural process of secondary succession will lead to the establishment of indigenous vegetation on rehabilitated Borrow Areas, these seral plant communities are species poor (low α-diversity). The majority of the indigenous species comprising the flora of the study area will not colonise the rehabilitated areas.

Intensity of impact: **Construction**: Medium; **Operation**: Low.

Probability: **Construction**: Definite; **Operation**: Probable.

Frequency: **Construction**: Daily; **Operation**: Weekly.

Significance: **Construction**: MEDIUM; **Operation**: LOW.

Status: Negative.

Confidence: **Construction**: High; **Operation**: Medium.

Mitigation:

1. Realign the footprints of the proposed Borrow Areas so that the greatest extent possible of the Borrow Area footprints is located within the footprint of the TSF Extension.
2. Modify infrastructure footprints so as to reduce the area of untransformed vegetation units (Units 1 to 7) situated within the footprints wherever possible. Realigned footprints should be placed within the transformed vegetation and land-cover type units (Units 8 to 11) in as far as possible.
3. The damaging or destruction of any plant species Protected in terms of the National Forest Act or the Biodiversity Act should be avoided wherever possible, and a permit for the destruction of *Acacia erioloba* or any other such protected plant species recorded in future must be obtained from the provincial Directorate of Biodiversity Management prior to development.

4. Botanical research and conservation institutions (e.g. SANBI and universities), should also be afforded an opportunity to search the final infrastructure footprints for species that are of research or horticultural interest, prior to commencement of development.
5. A Biodiversity Management Plan that indicates areas of the mines property that are important and sensitive in terms of botanical biodiversity should be developed by the mine and strict protocols established for any extension of mining activities into these areas during the operational phase.

Significance post mitigation: **Construction**: LOW; **Operation**: LOW. The only mitigation than can reduce this impact from a Medium significance at the construction phase is the realignment of the proposed borrow areas such that the majority of their footprints overlap with the footprint of the TSF Extension footprint and the remaining areas of their footprints are modified so as to reduce the extent of untransformed vegetation units included within the footprints.

Predicted risk matrix for impact 3.

IMPACT 3:	Loss of flora (species richness)				
	CRITERIA	CONSTRUCTION		OPERATIONAL	
		Rating	Description	Rating	Description
PRE-MITIGATION	Extent	1	Site	1	Site
	Duration	4	Permanent	3	Long
	Intensity	3	Medium	1	Low
	CONSEQUENCE	**8**		**5**	
	Probability	4	Definite	2	Probable
	Frequency	5	Daily	4	Weekly
	LIKELYHOOD	**9**		**6**	
	SIGNIFICANCE	**17**	**MEDIUM**	**11**	**LOW**
POST-MITIGATION	Extent	1	Site	1	Site
	Duration	4	Permanent	3	Long
	Intensity	1	Low	1	Low
	CONSEQUENCE	**6**		**5**	
	Probability	2	Probable	2	Probable
	Frequency	3	Monthly	2	6 mothly
	LIKELYHOOD	**5**		**4**	
	SIGNIFICANCE	**11**	**LOW**	**9**	**LOW**

13.4 Loss of plant 'species of conservation concern'

Applicable Phase: Construction, and to a far lesser extent Operation.

Nature of impact: This impact refers to the loss of 'species of conservation concern' (*sensu* Raimondo *et al*., 2009). Plant 'species of conservation concern' are species that are currently categorised as threatened (Critically Endangered, Endangered and Vulnerable), Near Threatened, Declining, Rare or Critically Rare in accordance with SANBI's continually updated online Red List (http://redlist.sanbi.org). The destruction of plant 'species of conservation concern' will result from the construction of all five proposed infrastructure footprints, and the most significant impact will result from the construction of Borrow Area 1. A lesser impact to plant 'species of conservation concern' located in close proximity

to the construction footprints may occur during the Operational phase as a result of increased dust emissions which may affect plant species for distances of up to between 100m and 300m from the construction sites (Pfab, 2001b), and as a result of soil contamination by polluted seepage and runoff from the TSF.

The current survey revealed the presence of subpopulations of two Near Threatened plant species (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) and four Declining medicinal plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocallidea*) within the 1 495.5ha MWS Kareerand Extension Project study area. All of the localities of these six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) recorded within the study area are situated within the proposed infrastructure footprints with the exception of two of the seventeen recorded localities of *Boophone disticha* and two of the twenty recorded localities of *Hypoxis hemerocallidea* (Appendix 7 and Table 6). The Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata,* were recorded from one and seven localities respectively, all of which are situated with the footprint of Borrow Area 1. The 'species of conservation concern' recorded within each of the five infrastructure footprints area as follows:

- TSF Footprint: *Boophone disticha, Crinum bulbispermum* and *Hypoxis hemerocallidea*.
- Borrow Area 1: *Boophone disticha, Hypoxis hemerocallidea, Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata.*
- Borrow Area 2: *Boophone disticha* and *Hypoxis hemerocallidea.*
- Borrow Area 3: *Boophone disticha, Hypoxis hemerocallidea* and *Eucomis autumnalis.*
- Storm Water Dams: *Boophone disticha.*

Though not recorded within the study area, the Near Threatened *Drimia sanguinea* is considered to have a Moderate probability of occurring within the study area. Potentially suitable habitat for *D. sanguinea* is restricted to Dolomite Grassland vegetation unit (Unit 6) of the study area

The severity of this impact is largely attributable to the loss of the Near Threatened species *Lithops lesliei* subsp. *lesliei* and, in particular, *Pearsonia bracteata. Lithops lesliei* subsp. *lesliei* is known from a total of less than 50 sites or subpopulations (http://redlist.sanbi.org) and no sub-population of this species in the North West Province is currently known to occur in an area formally conserved in terms of the Protected Areas Act (Act 57 of 2003). The subpopulation of *Pearsonia bracteata* recorded within the study is one of only four subpopulations / localities known from the North West Province, and this species is not currently known to occur in an area in South Africa that is formally conserved in terms of the Protected Areas Act (Act 57 of 2003). Furthermore, this species is endemic to South Africa and is known from only "eight to fourteen localities" (http://redlist.sanbi.org).

Extent of impact: **Construction**: National; **Operation**: Local. Though the destruction of plant 'species of conservation concern' will be restricted largely to the construction footprints and possibly their immediate surrounds, the loss of two Near Threatened species must be regarded as an impact on a national scale, though it constitutes an even more significant impact at a regional scale due to the fact the subpopulation of *Pearsonia bracteata* recorded entirely from within the footprint of Borrow Area is one of only four subpopulations recorded within the North West Province.

Duration: **Construction**: Permanent; **Operation**: Permanent. The duration of the loss of plant 'species of conservation concern' within the proposed infrastructure footprints would be permanent, other than for *Hypoxis hemerocallidea* which is a pioneer species and may colonise rehabilitated Borrow Areas within the life of the mine.

Intensity of impact: **Construction**: High; **Operation**: Medium.

Probability: **Construction**: Definite; **Operation**: Highly Probable.

Frequency: **Construction**: Daily; **Operation**: Weekly.

Significance: **Construction**: HIGH; **Operation**: MEDIUM.

Status: Negative.

Confidence: **Construction**: High; **Operation**: Medium.

Mitigation:

1. Borrow Area 1 should be removed from the proposed infrastructure or a major realignment of its footprint should be conducted in order to ensure it is not situated with any area of Dolomite Grassland (Unit 6) or the recommended buffer zones for the two recorded Near Threatened species (see map in Appendix 7).
2. A botanist and the personal of the mines Biodiversity and Heritage section should conduct additional searches for *Lithops lesliei* in potentially suitable habitat within Unit 6 between late April and June.
3. Realign the footprints of the proposed Borrow Areas so that the greatest extent possible of the Borrow Area footprints is located within the footprint of the TSF Extension.
4. Modify infrastructure footprints so as to reduce the area of untransformed vegetation units (Units 1 to 7) situated within the footprints wherever possible. Realigned footprints should be placed within the transformed vegetation and land-cover type units (Units 8 to 11) in as far as possible.
5. Conduct additional, brief floristic surveys, focussed on searching for *Drimia sanguinea* within the final / realigned infrastructure footprints, should be conducted in late October and early February. The brief floristic surveys should focus on searching those parts of the proposed infrastructure footprints containing potentially suitable habitat for *Drimia sanguinea,* which is likely to be restricted to the Dolomite Grassland vegetation unit (Unit 6). These surveys will also contribute towards confirming the absence of other 'species of conservation concern' within the study area.
6. In the event of any threatened (i.e. Critically Endangered, Endangered and Vulnerable) or additional Near Threatened plant species being recorded within the study area or proposed development footprints in future, appropriate *in situ* and/or *ex situ* conservation measures should be developed in consultation with the North West Province Directorate of Biodiversity Management.
7. It is recommended that prior to any development that may lead to the destruction of any of the four recorded Declining plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis and Hypoxis hemerocallidea*), permission for their removal should be obtained from the provincial Directorate of Biodiversity Management, and if necessary appropriate *in situ* and / or *ex situ* conservation

measures should be developed and implemented in conjunction with the Directorate. Where feasible, viable populations of such species should be translocated to degraded or untransformed areas within the study area which provide potentially suitable habitats, but such translocations will have to be carried out in a way that ensures no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area.

8. A Biodiversity Management Plan that indicates areas of the mines property that are important and sensitive in terms of botanical biodiversity should be developed by the mine and strict protocols established for any extension of mining activities into these areas during the operational phase.
9. Implement dust control measures during the construction and operational phases.
10. Implement design and operational measures to avoid or reduce soil contamination by polluted seepage and runoff from the TSF.
11. Illegal medicinal plant harvesting should be discouraged through control of access to untransformed habitats and vegetation within the study area.

Significance post mitigation: **Construction**: LOW; **Operation**: LOW: The only mitigation than can reduce this impact from a High significance is the removal of Borrow Area 1 from the proposed infrastructure or the major realignment of its footprint so that it is not situated with any area of Dolomite Grassland or the proposed buffer zones for the recorded Near Threatened species (see map in Appendix 7).

Predicted risk matrix for impact 4.

IMPACT 4:	**Loss of plant 'species of conservation concern'**				
	CRITERIA	**CONSTRUCTION**		**OPERATIONAL**	
		Rating	**Description**	**Rating**	**Description**
PRE-MITIGATION	Extent	4	National	2	Local
	Duration	4	Permanent	4	Permanent
	Intensity	5	High	3	Medium
	CONSEQUENCE	**13**		**9**	
	Probability	4	Definite	3	Highly probable
	Frequency	5	Daily	4	Weekly
	LIKELYHOOD	**9**		**7**	
	SIGNIFICANCE	**22**	**HIGH**	**16**	**MEDIUM**
POST-MITIGATION	Extent	1	Site	1	Site
	Duration	3	Long	3	Long
	Intensity	1	Low	1	Low
	CONSEQUENCE	**5**		**5**	
	Probability	2	Probable	2	Probable
	Frequency	3	Monthly	3	Monthly
	LIKELYHOOD	**5**		**5**	
	SIGNIFICANCE	**10**	**LOW**	**10**	**LOW**

13.5 Closure/Decommissioning Phase

No detail was available during the conduction of this study as to the exact processes and schedules that will be followed during closure/decommissioning. No detailed closure impact assessment could therefore be completed. This should be assessed and described in detail as part of the closure and rehabilitation plan for the mine. It is strongly recommended that rehabilitation should be carried out in an ongoing manner and not deferred to the end of the 'life of mine'. For example, whereas the rehabilitation on the TSF footprints and Storm Water Dams can only be carried out at the end of the 'life of mine', the Borrow Areas should be rehabilitated as soon as the required material has been removed from the Borrow Areas at the end of the construction phase. Though rehabilitation cannot restore the areas of untransformed grassland vegetation to their pre-construction state, the objective of rehabilitation should be the establishment of habitats vegetated by seral plant communities which are dominated by indigenous pioneer plant species and are free of alien plant species that are habitat transformers. Such secondary vegetation will have some biodiversity value, will contribute to local ecosystem processes, will enable succession to progress towards more bio-diverse habitats in the long-term and should also have some socio-economic value in terms of providing grazing for livestock.

13.6 Cumulative Impacts

The construction of the existing 564ha Kareerand TSF in 2010 led to the destruction (permanent loss) of approximately 460ha of untransformed Rand Highveld Grassland, a vegetation type which is categorised as Endangered at both a national and provincial level (Mucina & Rutherford, 2007 and MWBSP 2015), and approximately 35ha of valley-bottom wetland and associated hillslope seep wetland habitats comprising the approximately 1.3km long uppermost reach of the Karreerand Stream. In addition, the construction of the existing 564ha Kareerand TSF has led to ongoing impacts to the botanical biodiversity of the study area and its surrounds associated principally with seepage and runoff of polluted water and dust emissions and from the existing TSF. The remaining ca. 4.km reach of the Kareerand Stream situated between the TSF and its confluence with the Vaal River has been particularly severely impacted by reduced water quality, sedimentation and soil contamination resulting from seepage and controlled runoff and spills from the existing TSF.

The impacts to botanical biodiversity resulting from the proposed Kareerand Extension Project, as described and assessed in the current report, must therefore be considered within the context of the extensive and severe historical and ongoing botanical biodiversity loss to which the local ecosystems have already been subjected. These cumulative impacts to botanical biodiversity are regarded as being of High significance at both a local and regional level. The principal cumulative impacts to botanical biodiversity which are envisaged to result for the proposed Kareerand TSF Extension project are briefly listed and described below:

- The loss of an additional 533.2ha of vegetation representative of Rand Highveld Grassland, a vegetation type categorised as Endangered at both a national and provincial level (Mucina & Rutherford, 2007 and MWBSP 2015), and the fragmentation and degradation of much of the 193.6ha of vegetation representative of Rand Highveld Grassland which will remain within the 1 495.5ha Kareerand Extension Project study area. This severe reduction and of the extent of Rand Highveld Grassland at a local scale, and fragmentation of remaining areas of this vegetation, is likely to further reduce the ecological viability of this Endangered vegetation type / ecosystem at a local scale.

- The construction of Borrow Area 1 will lead to the loss of 135.9ha of Vaal Reefs Dolomite Sinkhole Woodland, a vegetation type categorises as Vulnerable at a National level (Mucina & Rutherford, 2007). Though no loss or significant degradation of Vaal Reefs Dolomite Sinkhole Woodland occurred as a result of the construction or operation of the existing Kareerand TSF, the loss and degradation of many hundreds of hectares of this vegetation type has already occurred at a local and regional scale as a result of mining activities within the Vaal Reefs Mine Complex and Mine Waste Solutions surface rights areas, urbanisation (Stilfontein, Klerksdorp and Orkney) and cultivation. Furthermore, the construction of Borrow Area 1 will lead to the fragmentation of the remaining areas of Vaal Reefs Dolomite Sinkhole Woodland, which occur mostly to the west but also to the north and east of the study area.
- The development of the Kareerand Extension Project will lead to the loss of 21.9ha of valley-bottom wetland habitat and the degradation of an additional undetermined area of wetland habitat as a result of seepage and run-off of polluted water from the TSF, disruption of hydrological patterns and edge effects such as dust emissions and invasion by alien plants. The further degradation of the Kareerand stream as a result of an increase in seepage and runoff of polluted water from the extended TSF is also likely to occur.
- Though no loss of Threatened or Near Threatened plant species (*sensu* Raimondo *et al*., 2009 and http://redlist.sanbi.org) is known to have occurred (and is unlikely to have occurred) as a result of the construction of the existing TSF, the loss of subpopulations of Declining species such *Boophone disticha, Hypoxis hemerocallides, Eucomis autumnalis* and *Crinum bulbispermum* did occur. All the localities of these four Declining plant recorded within the current Kareerand TSF Extension study area are situated within the proposed infrastructure footprints with the exception of two of the seventeen recorded localities of *Boophone disticha* and two of the twenty recorded localities of *Hypoxis hemerocallidea* (Table 6 and Appendix 7). The loss of these Declining species within the Kareerand TSF Extension study area is therefore seen as a significant cumulative impact at a local scale.

14 SUMMARY AND CONCLUSIONS

14.1 Description of the study area

This report presents the findings of botanical biodiversity survey and impact assessment for the footprints of the five principal infrastructure components proposed as part of the Mine Waste Solutions (MWS) Kareerand TSF Extension Project. The study area selected for this this survey is 1 495.5ha in extent and is situated approximately 6km south-east of Stilfontein and 1.2km south of Khuma, directly adjacent to the northern boundary of the current Mine Waste Solutions surface rights area on portions of the farms Buffelsfontein 443 IP, Hartebeestfontein 442 IP, Megadam 574 IP, Kareerand 444 IP and Kromdraai 420 IP. The footprints of the following five infrastructure components were assessed:

- Tailings Storage Facility (TSF) Extension (382.6ha in extent);
- Borrow Area 1, or the western borrow area (180.0ha in extent);
- Borrow Area 2, or the central borrow area (299.8ha in extent);
- Borrow Area 3, or the eastern borrow area (186.5ha in extent);
- Return Water Dams (43.2ha).

The most recent vegetation map for South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006), maps the vegetation of the vast majority of the study area as Rand

Highveld Grassland (Gm 11) and the only other vegetation type mapped for the study area is Vaal Reefs Dolomite Sinkhole Woodland (Gh12) which occurs along the entire eastern boundary and extends up to approximately 1km into the study area. Rand Highveld Grassland is categorised as **Endangered**, at both a national and provincial level, and Vaal Reefs Dolomite Sinkhole Woodland is categorised as **Vulnerable** at both a national and provincial level (Mucina & Rutherford, 2006 and MWBSP 2015). However, the habitats and vegetation of approximately 38.5% (or 575.5ha) of the study area has been transformed through historical cultivation, and to a far lesser extent through planting of alien trees, polluted seepage and runoff from the existing TSF and the construction of linear infrastructure (e.g. roads and pipelines) and farm homesteads. These transformed areas are vegetated by secondary vegetation or, in the case of permanently transformed areas (infrastructure) are unvegetated. Historical cultivation is by far the greatest contributor to habitat transformation within the study area. The remaining areas of untransformed vegetation, comprise Grassland with small areas of Sparse Woodland and localised patches or groves of *Acacia* Closed to Open Woodland (*sensu* Edwards, 1983). Though untransformed, much of the remaining indigenous vegetation has been degraded by anthropogenic impacts such as heavy grazing (or in the case of the existing TSF security area the exclusion of grazing), altered fire regimes (e.g. increased or reduced frequency of fire), alterations to hydrological patterns and water quality, various ecological 'edge effects' emanating from surrounding transformed areas such as existing TSF facilities (i.e. dust emissions and polluted seepage and runoff) and planting of alien trees.

Approximately 1 126.5ha (or 75.3%) of the study area is mapped in the NWBSP 2015 as CBA 2 and the remaining 369.0ha (or 24.7%) of the study area comprising the north-eastern portions of the study area on the farms Kareerand and Kromdraai is mapped as CBA 1. In terms of managing the loss of natural habitat in CBAs, the NWBSP 2015 states, amongst others, that '**further loss of natural habitat should be avoided in CBA 1, whereas loss should be minimised in CBA 2 i.e. land in these two categories should be maintained as natural vegetation cover as far as possible**'. However, approximately 37% of the area mapped as CBA 2 comprises secondary vegetation of habitats transformed by historical cultivation and, to a lesser extent, a plantation of alien trees, infrastructure and seepage from the existing TSF.

Approximately 45% of the area mapped as CBA 1 comprises secondary vegetation of habitats transformed by historical cultivation (including disused centre pivot fields) and, to a lesser extent, a small plantation and two abandoned homesteads. The existing TSF on the southern boundary of the study area is also mapped as a CBA. All the proposed infrastructure footprints and the proposed final tailings pipeline alignment fall entirely within areas mapped as a CBA 1 or CBA 2 in the NWBSP 2015. The ground-trothed vegetation and land-cover type map and map of 'botanical biodiversity value and sensitivity' provided in the current report (Figure 2 and Appendix 4), provide a far more accurate indication of the distribution of untransformed habitats and vegetation which are of most importance in terms of botanical biodiversity conservation.

Eleven broad-scale vegetation or land-cover units were identified and mapped for the 1 494.5ha study area. The eleven vegetation and land-cover type units identified for the study area have been derived on the basis of structural and functional criteria. The term 'structure' refers to various aspects of vegetation structure such as physiognomy, life-form composition, species composition, species dominance and stand structure (Kent & Coker, 1992). Of the units described, seven comprise untransformed vegetation, and four comprise

transformed habitats with secondary vegetation or no vegetation (i.e. infrastructure). The seven untransformed vegetation and land-cover type units comprise approximately 920.00ha (or 61.52%) of the study area and the four transformed units comprise approximately 575.5ha (or 38.48%) of the study area. The seven untransformed vegetation units are 'Clay Grassland', 'Sandy Grassland' and 'Dolomite Grassland', as well as the following far smaller units embedded in the grassland matrix: 'Pan Wetland', 'Valley-bottom wetlands', '*Acacia karoo* Woodland' and '*Acacia erioloba* Woodland'. Clay Grassland and Sandy Grassland are representative of the Rand Highveld Grassland vegetation type and Dolomite Grassland is representative of the Vaal Reefs Dolomite Sinkhole Woodland vegetation type. All of the untransformed vegetation units were assigned High botanical biodiversity value and sensitivity, with the exception of Dolomite Grassland which was assigned Very High sensitivity. The four transformed vegetation units are 'Secondary Grassland', 'Artificial wetland', 'Alien trees' and 'Infrastructure', all of which have been assigned Moderate to Negligible botanical biodiversity value and sensitivity.

A total of 394 plant species and infraspecific taxa were recorded within the 1 495.5ha study area, 355 of which are indigenous taxa, and 49 (13.8%) of which are naturalised aliens. It should also be emphasised that the species list provided in Appendix 1 is based on relatively limited fieldwork which lacked seasonal coverage and can therefore not be regarded as complete. Based on the authors experience the species list probably includes approximately 85% of the species actually present. Of the 49 alien species listed in Appendix 1, eleven are declared alien invasive plant species in terms of the Alien Invasive Species (AIS) regulations, and all eleven are listed as Category 1b invasive species in the AIS regulations. The untransformed broad scale vegetation units (Units 1 to 7) that together comprise 61.52% of the 1 495.5ha study area, remain almost entirely unaffected by alien invasive species that are aggressive habitat transformers. Even in the transformed habitats with secondary vegetation, habitat transformation by alien is largely insignificant and the alien species present are almost all ruderal and agrestal weeds.
Despite the relatively high level of habitat transformation within the study area, the remaining areas of untransformed habitat and vegetation remain diverse (in the context of the region) and species rich (α-diversity), as is reflected by the fact that 355 indigenous plant species and infra-specific taxa were recorded during the current, brief survey (see Appendix 1). The Beta diversity (β-diversity), which is the 'rate of change in species composition across habitats or among communities' is also relatively high.

Six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009 and http://posa.sanbi.org, accessed January 2018) were recorded within the study area during the current survey, namely the Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata,* and the Declining medicinal plant species *Boophone disticha, Crinum* cf. *bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocaliidea.* The Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata* are entirely restricted to Dolomite Grassland (Unit 5) on the chert ridge situated along the western boundary of the study area. One of additional 'species of conservation concern', which has not yet been recorded but is considered to have a moderate to high probability of occurring within the study area (see Appendix 5), namely the Near Threatened species *Drimia sanguinea*, should be searched for during future botanical surveys. One tree species that is Protected species in terms of Schedule A of the National Forests Act, namely *Acacia erioloba* which is restricted to Dolomite Grassland and *Acacia erioloba* Woodland, was recorded during the current survey. Mitigation measures (including preliminary buffer zones for the two Near Threatened species) for potential impacts to these species are provided in this report.

14.2 Description of the project infrastructure footprints

The percentage of the surface area of each of the five proposed infrastructure footprints (i.e. TSF extension, three borrow areas and return water dams) comprised of the various vegetation and land-cover type units identified within the study area, is provided in Table 7. The total combined footprint of the proposed infrastructure components (excluding overlapping footprints) is 1 017.2ha. The percentage of the 1 017.2ha total combined footprint of the proposed infrastructure components occupied by each of the identified broad-scale vegetation and land-cover type units is provided in Table 8.

The five infrastructure components have a total combined footprint of 1 017.2ha, of which **324.5ha (or 31.90%)** comprises transformed habitats with secondary vegetation (Units 8, 9 and 10) or no vegetation (Unit 11). Approximately **669.1ha (or 65.78%)** of the total combined footprint comprises untransformed grassland (Units 5, 6 and 7). The Clay Grassland (Unit 5) and Sandy Grassland (unit 6) vegetation units are Representative Rand Highveld Grassland, a vegetation type which is categorised as Endangered at both a national and provincial level (Mucina & Rutherford, 2007 and MWBSP 2015). The Dolomite Grassland vegetation unit is representative of Klerksdorp Dolomite Sinkhole Woodland (Unit 6), a vegetation type that is categorised as Vulnerable at a national level (Mucina & Rutherford, 2007). The remaining **23.6ha (or 2.32%)** of the total combined infrastructure footprint comprises of the following spatially restricted untransformed habitats and vegetation:

- A total of 21.9ha of Valley-bottom wetland (Unit 2) comprising 10.1ha within the TSF Extension footprint, 1.4ha in the Borrow Area 2 footprint and 10.4ha in the Borrow Area 3 footprint.
- A total of 0.2ha of *Acacia karoo* Woodland (Unit 3), all of which is situated within the TSF Extension footprint.
- A total of 1.5ha of *Acacia erioloba* Woodland (Unit 4), all of which is situated within the footprint of Borrow Area 1.

Two Near Threatened plant species (*Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*) and four Declining plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis* and *Hypoxis hemerocallidea*) were recorded within the 1 495.5ha study area. All of the localities of these six plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) recorded within the study area are situated within the proposed infrastructure footprints with the exception of two of the seventeen recorded localities of *Boophone disticha* and two of the twenty recorded localities of *Hypoxis hemerocallidea* (Table 6 and Appendix 7). The Near Threatened species *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata,* were recorded from one and seven localities respectively, all of which are situated with the footprint of Borrow Area 1. The 'species of conservation concern' recorded within each of the five infrastructure footprints are as follows:

- TSF Extension: *Boophone disticha, Crinum bulbispermum* and *Hypoxis hemerocallidea*.
- Borrow Area 1: *Boophone disticha, Hypoxis hemerocallidea, Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata.*
- Borrow Area 2: *Boophone disticha* and *Hypoxis hemerocallidea.*
- Borrow Area 3: *Boophone disticha, Hypoxis hemerocallidea* and *Eucomis autumnalis.*
- Storm Water Dams: *Boophone disticha.*

Acacia erioloba, a tree which is Protected in terms of the National Forests Act, was recorded within the footprint of Borrow Area 1 and the adjacent western parts of the study area.

14.3 Potential impact of the project

The potential impacts of the project on the botanical biodiversity of the study area are assessed under four broad impacts, namely:

- loss of vegetation types (*sensu* Mucina & Rutherford, 2006 and the NWBSP 2015);
- loss of spatially restricted vegetation units / plant communities;
- loss of flora (species richness);
- loss of plant 'species of conservation concern' (*sensu* Raimondo *et al.*, 2009).

Table 10 summarises the impact rating assigned to each of the identified impacts both with mitigation and in the absence of mitigation. A formal Impact Assessment which describes the nature of the impacts, determines the significance of each impact and provides mitigation and monitoring measures for each impact, is provided in the Impact Assessment section of this report.

Table 10: Impact significance rating with and without mitigation.

SIGNIFICANCE OF IMPACTS		CONSTRUCTION		OPERATIONAL	
IMPACT		Pre-mitigation	Post-mitigation	Pre-mitigation	Post-mitigation
1	Loss of vegetation types	HIGH	HIGH	MEDIUM	MEDIUM
2	Loss of spatially restricted plant communities / habitats	HIGH	MEDIUM	HIGH	MEDIUM
3	Loss of flora (species richness)	MEDIUM	LOW	LOW	LOW
4	Loss of plant 'species of conservation concern'	HIGH	LOW	MEDIUM	LOW

The assessed project infrastructure layout will have various impacts of High significance without mitigation. The development of Borrow Area 1 is seen as a potential fatal flaw due to the fact that it will lead to the loss of 135.0ha of near-pristine Dolomite Grassland (Unit 5) which provides habitat for two Near Threatened plant species and is regarded as having Very High botanical biodiversity value and sensitivity. The exclusion of Borrow Area 1 from the project is regarded as a key mitigation measure. Provided mitigation recommendations suggested in this report are accurately implemented, the project is not considered to contain any fatal flaws in terms of botanical biodiversity and there is therefore no objection to the project from a botanical biodiversity perspective.

14.4 Summary of mitigation and management measures

The following measures are recommended in order to minimise envisaged negative impacts of the proposed project infrastructure on botanical biodiversity within the MWS Kareerand TSF Extension Project study area:

- The TSF Extension footprint should if possible be slightly realigned so that it extends further to the north into secondary grassland of historically cultivated areas, and the extent of untransformed grassland (Unit 5 and Unit 7) with High sensitivity occurring in the western and eastern parts of the footprint is reduced.
- Realign the footprints of the proposed Borrow Areas so that the greatest extent possible of the Borrow Area footprints is located within the footprint of the TSF Extension. **This is regarded as the single most effective possible mitigation measure for mitigating**

impacts to botanical biodiversity and should be thoroughly considered by the design engineers.

- Borrow Area 1 should be removed from the proposed infrastructure plan, or a major realignment of its footprint should be conducted in order to ensure it is not situated with any area of Dolomite Grassland (Unit 6) or the recommended buffer zones for the two recorded Near Threatened species (see map in Appendix 7).
- Modify the remaining infrastructure footprints so as to reduce the area of untransformed Rand Highveld Grassland and Vaal Reefs Dolomite Sinkhole Woodland (Units 5, 6 and 7), as well as other untransformed vegetation units (Units 1 to 4), situated within the infrastructure footprints wherever possible. Realigned footprints should be placed within the transformed vegetation and land-cover type units (Units 8 to 11) in as far as possible.
- No infrastructure footprints should be situated within a minimum buffer of 100m of the boundaries of valley-bottom wetlands (Unit 2). In the case of the near-pristine valley-bottom wetland situated at Sites 20 and Sites 21 in the south-western parts of the study area on the farm Buffelsfontein, the buffer should if necessary be increased as per the recommendations provided in the wetland impact assessment for this project (De Castro & Brits, January 2018).
- No infrastructure footprints should be situated within a minimum preliminary buffer of 200m of the Pan Wetland (Unit 1) situated at Site 31. The final buffer for the pan should be extended to include the entire catchment of the pan which should be determined using accurate contour line data.
- The two small patches of *Acacia erioloba* Woodland (Unit 4) at Sites 17 and 38a (see Appendix 2) should be excluded from the infrastructure footprints.
- The recommendations for the conservation of *Lithops lesliei* subsp. *lesliei* within the study area can be summarised as follows:
    - The habitat of the subpopulation of *Lithops lesliei* subsp *lesliei* and its preliminary buffer zone (see Appendix 7) should be excluded from the footprints of any proposed project infrastructure. This will require realignment of the footprint of Borrow Area 1 (western borrow area). Furthermore, until such time as the size and extent of the subpopulation of this species recorded at Site 39 is accurately established, the entire extent of the Dolomite Grassland vegetation unit (Unit 6) should be excluded from any proposed development footprints.
    - A botanist and the personal of the mines Biodiversity and Heritage section should conduct additional searches for this species in potentially suitable habitat within Unit 6 between late April and June.
    - The recommended preliminary minimum buffer zone for the subpopulation of *Lithops lesliei* subsp. *lesliei* recorded within the study area (300m), and the exact width and footprint of this buffer zone should be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the 'Extent of Occurrence' within the study area). The final buffer zone resulting from the recommended survey should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The buffer zone will therefore not simply be circular, and the footprints of the buffer zones should been adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity between any subpopulations discovered in future is enhanced, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.

- Suitably experienced personnel from the Biodiversity and Heritage section of the mine should conduct simple annual monitoring of the recorded subpopulation of *Lithops lesliei* subsp *lesliei*. Such monitoring should simply comprise of visiting each site, photographing the site, counting the number of plants and recording any observed impacts to the species and its habitat (e.g. alien plant invasion, overgrazing, trampling and medicinal plant harvesting).
- A management plan for this species and its habitat should be developed with input from, and the approval of, the North West Province conservation authorities, including the Directorate of Biodiversity Management.

- The recommendations for the conservation of *Pearsonia bracteata* within the study area can be summarised as follows:
  - The habitat of the subpopulation of *Pearsonia bracteata* and its preliminary buffer zones (see Appendix 7) should be excluded from the footprints of any proposed project infrastructure. This will require realignment of the footprint of Borrow Area 1 (western borrow area), to exclude almost the entire extent of Dolomite Grassland (Unit 6) within the study area. It is therefore recommended that the entire extent of the Dolomite Grassland vegetation unit (Unit 6) should be excluded from any proposed development footprints.
  - The recommended preliminary minimum buffer zones for the subpopulation of *Pearsonia bracteata* recorded within the study area is 400m around each of the seven recorded localities. The exact width and footprint of the overall buffer zone can be refined on the basis of future surveys which accurately establish the number or plants present and the boundaries of the area occupied by the subpopulation (i.e. the 'Extent of Occurrence' within the study area). The final buffer zone should take into account aspects such as the habitat requirements of the species, habitat characteristics and sensitivities and historical and current land-use. The final buffer zone will therefore not simply be circular, and the footprints of the buffer zones should been adjusted to ensure that developed industrial sites and other unsuitable transformed habitats have been excluded, connectivity between any subpopulations discovered in future is enhanced, the area included in the buffer zone is large enough to constitute a viable ecosystem, and as much as possible potentially suitable habitat for the species is included in the buffer zones.
  - Suitably experienced personnel from the Biodiversity and Heritage section of the mine should conduct simple annual monitoring of the recorded subpopulation of *Pearsonia bracteata*. Such monitoring should simply comprise of visiting each site, photographing the site, counting the number of plants and recording any observed impacts to the species and its habitat (e.g. alien plant invasion, overgrazing, trampling and medicinal plant harvesting).
  - A management plan for this species and its habitat should be developed with input from, and the approval of, the North West Province conservation authorities, including the Directorate of Biodiversity Management.
- Prior to any development that may lead to the destruction of any of the four recorded Declining plant species (*Boophone disticha, Crinum bulbispermum, Eucomis autumnalis and Hypoxis hemerocallidea*), permission for their removal should be obtained from the provincial Directorate of Biodiversity Management, and if necessary appropriate *in situ* and / or *ex situ* conservation measures should be developed and implemented in conjunction with the Directorate. Where feasible, viable populations of such species should be translocated to degraded or untransformed areas within the study area which provide potentially suitable habitats, but such translocations will have to be carried out in a way that ensures no ecological degradation of the host habitat occurs, and will have to

be evaluated by a botanist for each species and each potential translocation area. Alternatively plants should be offered to research and conservation institutions such as SANBI botanical gardens or universities. Illegal medicinal plant harvesting should be monitored and discouraged through control of access to untransformed habitats and vegetation within the study area.

- Additional, brief floristic surveys, focussed on searching for *Drimia sanguinea* within the proposed infrastructure footprints, should be conducted in late October and early February. The brief floristic surveys should focus on searching those parts of the proposed infrastructure footprints containing potentially suitable habitat for *Drimia sanguinea,* which is likely to be restricted to the Dolomite Grassland vegetation unit (Unit 6). These surveys will also contribute towards confirming the absence of other 'species of conservation concern' within the study area. The identity of the *Crinum* cf. *bulbispermum* (may be *C. lugardiae*) plants recorded at Sites 51b and 51d should also be confirmed during these survey. In the event of any threatened or near threatened species being recorded during follow-up surveys, appropriate *in situ* and / or *ex situ* conservation measures should be developed and implemented in conjunction with the provincial Directorate of Biodiversity Management.
- The damaging or destruction of *Acacia erioloba* or any other plant species that are Protected in terms of the National Forest Act or NEMBA (Act 10 of 2004, as amended on the 16th of April 2013) during any future development should be avoided wherever possible, and a permit for the destruction of any such protected plant must be obtained from the provincial authorities prior to development. If any herbaceous plant species which are listed in the Biodiversity Act as Critically Endangered, Endangered, Vulnerable and Protected are recorded within proposed development footprints, appropriate *in situ* and / or *ex situ* conservation measures should be developed in consultation with the North West Province Directorate of Biodiversity Management. Where listed species are not highly threatened and a Permit is obtained (from the provincial Directorate of Biodiversity Management) for their removal, it is recommended that such species are rescued and placed in a nursery or donated to a research institute (e.g. SANBI or botanical garden) prior to development, rather than simply being destroyed upon receipt of a permit. Where feasible, viable subpopulations of such species should also be translocated to transformed (including rehabilitation areas) or untransformed areas within the study area which provide potentially suitable habitats, but such translocations will have to be carried out in a manner that ensures that no ecological degradation of the host habitat occurs, and will have to be evaluated by a botanist for each species and each potential translocation area.
- The landowner (MWS) should develop and implement an integrated alien plant control program (as per the AIS Regulations) which identifies the alien invasive species that pose the greatest threat, in terms of habitat transformation, within the study area and considers all appropriate chemical, mechanical, biological and cultural control methods for the alien species listed in Appendix 1. Emphasis should be placed on controlling the 11 declared alien invasive species listed in Appendix 1, and in particular any species that are identified as posing a serious risk to untransformed habitat and vegetation within the study area. The existing alien plant survey and control programme for the Anglo Ashanti MWS surface rights area (De Castro & Brits, July 2015b) should be updated to include the current study area.
- The implementation of a simple vegetation monitoring programme that focuses on the use of annual, repeatable fixed point photography to monitor sensitive habitats within the untransformed BMU's and periodic (every three years or as suggested by annual photographic monitoring), simple quantitative methods to monitor vegetation condition,

is strongly recommended. Representative monitoring sites should be selected within sensitive areas (e.g. habitat for 'species of conservation concern' and wetlands) of all identified untransformed vegetation units (Units 1 to 7). This is regarded as the only practical method of evaluating the impact of current and possible future anthropogenic impacts and management practices on the floristic biodiversity of the study area. A brief evaluation of the success of any future rehabilitation activities should also be included in monitoring. The nature of secondary succession in disturbed areas (previously mined areas) should be evaluated in order to determine whether a favourable successional pathway is occurring towards indigenous vegetation cover and whether the establishment of alien invasive plants is occurring.

- A 'veld management plan' should be implemented for all parts of the study area that are not utilised for mining activities. Grazing (by domestic livestock or game) is an essential environmental factor in maintaining veld condition and floristic diversity. Overgrazing can however be detrimental to the vegetation, and the mine should therefore establish the carrying capacity of the untransformed areas of the mine property and ensure that overgrazing is prevented. A crucial component of the 'veld management plan' would be the recommendation of an appropriate 'burning plan'. Appropriate burning intervals for areas that are managed for high biodiversity, are those that mimic the 'natural' fire regimes of the area. In the Grassland Biome of Africa, fire is a natural environmental factor that does not normally produce serious residual effects and is in fact a natural and beneficial disturbance of the vegetation structure (including species composition), prevents vegetation from becoming moribund, is essential in nutrient recycling and distribution and, at correct intervals, assists in maintaining high levels of biodiversity (Goldammer & de Ronde, 2004). Within the study area, appropriate fire cycles may vary from approximately two to six years, but must be determined by factors such biomass, veld condition and rainfall in the preceding two years.
- The management of the biodiversity of the study area (or any area) is contingent upon the control of access by people and livestock to the area. The study area should therefore be fenced (a normal six-strand cattle fence is recommended) and regularly patrolled by security staff in order to control access. Access control should commence immediately upon MWS acquiring the area and continue throughout the construction, operational and decommissioning phases of the project.
- The following generic mitigation measures are of great relevance in terms of minimising the likely impacts to botanical biodiversity resulting from the proposed TSF Extension Project and should be strictly implemented by MWS in the event that the project is authorised:
    - Implement design and operational measures to avoid or reduce soil contamination by polluted seepage and runoff from the TSF. These pollution control measures should be based on soil, geotechnical and hydrological specialist reports for the project.
    - Implement dust control measures during the construction and operational phases.
    - Ensure that construction activities are strictly restricted to the approved infrastructure footprints.
    - Develop and implement a rehabilitation plan for any borrow areas not placed within the TSF Footprint. The principal objective of the plan should be the establishment of indigenous seral plant communities through the natural process of secondary succession.

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APPENDIX 1: Checklist of plant species recorded within the Mine Waste Solutions Kareerand TSF Extension project study area during the field surveys conducted during November 2017 as well as during previous floristic surveys of parts of the 2016 MWS surface rights area which fall within the current 1 495.5ha study area. Species taxonomy is according to the National Herbarium PRECIS database (http://newposa.sanbi.org). During the current study, a total of 394 plant species and infraspecific taxa were recorded within the study area, 355 of which are indigenous taxa, and 49 (13.8%) of which are naturalised aliens. Alien species are indicated by an asterisk. Species highlighted in red are taxa currently categorised as 'species of conservation concern' (Raimondo *et al.*, 2009 and http://redlist.sanbi.org, downloaded January 2018). All voucher numbers are A. de Castro numbers and all specimens requiring identification were submitted to the National Herbarium in Pretoria. Site localities given are only examples of sites where a species was recorded and are not all-inclusive.

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Pteridophytes			
ADIANTACEAE			
Cheilanthus hirta			48
Pellaea calomelanos			48, M18
Monocotyledons			
ALLIACEAE			
Tulbaghia cf. acutiloba			48, 50
AMARYLLIDACEAE			
Ammocharis coranica			19, 20, 32
Boophane disticha		Declining	1a, 2, 4a, 5, 7, 22, 43b, 44, 48, 50, 54, S5, S6, S14, SU2, SU9b, M18
Crinum bulbispermum		Declining	21, 51b, 51d
Crinum cf. *lugardiae*			51d
ANTHERICACEAE			
Chlorophytum cooperi			4a, 50
Chlorophytum fasiculatum			15
ASPARAGACEAE			
Asparagus cooperi			6
Asparagus laricinus			59
Asparagus suaveolens			38a
ASPHODELACEAE			
Aloe davyana [*Aloe greatheadii* var. *davyana*]			43b
Bulbine abyssinica			47, M18
Bulbine capitata			1a, 44
Bulbine narcissifolia			1a, 17
Trachyandra asperata var. *macowanii*			48
Trachyandra saltii var. *saltii*			5, 39
COMMELINACEAE			
Commelina africana			17, 58, M18
Commelina bella [=*Commelina livimgstonii*]			15, 39, 40

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Cyanotis speciosa			1a, 40
CYPERACEAE			
Abildgaardia ovata			54
Bulbostylis burchellii			18
Bulbostylis hispidula			2
Bulbostylis humilis	ADC 1642		15
Eleocharis dregeana			21, 23, 28
Cyperus congestus			26
**Cyperus eragrostis*		-	28
**Cyperus esculentus*		-	26
Cyperus longus			26
Cyperus obtusiflorus var. obtusiflorus			6, 8, 15, 39
Cyperus rupestris			18
Eleochris dregeana			23, 26
Kyllinga alba			15
Kyllinga erecta			26, 29
Cyperus congestus [Mariscus congestus]			26
Schoenoplectus decipiens			21, 26
ERIOSPERMACEAE			
Eriospermum abyssinicum			18
HYACINTHACEAE			
Albuca setosa			4a
Albuca sp.			1a
Dipcadi viride			25, 50
Eucomis autumnalis		Declining	M18
Ledebouria cf. *apertiflora*			8, 15, 39, 40, 45, 48, 50
Ledebouria cooperi			23
Ledebouria cf. *luteola*			38b
Ledebouria marginata			8, 15
Ledebouria minima			31
Ledebouria ovatifolia			40
Ledebouria revoluta			2
Ornithogalum tenuifolium subsp. *tenuifolium*			6
Schizocarpus nervosus			9
HYPOXIDACEAE			
Hypoxis hemerocallidea		Declining	1a, 1b, 19, 20, 22, 26, 38b, 43a, 43b, 44, 50, 51a, 52, 54, 58, 59, M11, Su3, Su5, Su6
Hypoxis obtusa			50, M11
Hypoxis rigidula			9, 15, 21, M18
IRIDACEAE			
Babiana bainesii			1b

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Gladiolus crassifolius			21, 43b
Gladiolus dalenii			M18
JUNCACEAE			
Juncus exsertus			26
Juncus punctorius			26
ORCHIDACEAE			
Eulophia tuberculata			4a
Habenaria sp.			M18
POACEAE			
Agrostis lachnantha			28
Andropogon appendiculatus			21
Andropogon schirensis			15
Anthephora pubescens			8, 17
Aristida adscensionis			46
Aristida cf. *aequiglumis*			15
Aristida bipartita			51a
Aristida canescens			1a, 2
Aristida congesta subsp. *congesta*			4b, 21
Aristida congesta subsp. *barbicollis*			46
Aristida diffusa			17
Aristida cf. *meriodionalis*			13b
Aristida stipitata var. *graciliflora*			46
Aristida sp. 2			1b
Bewsia biflora			40, M18
Brachiaria deflexa			36
Brachiaria eruciformis			33, 35, 51b
Brachiaria nigropedata			8, 21
Brachiaria serrata			1a, 8
**Bromus catharticus*		-	26
Calamagrostis epigeios			26
Chloris virgata			34
Cymbopogon caesius			1a, 2
Cymbopogon pospischilii			1b
Cynodon dactylon			1b
Digitaria argyrograpta			24, 43a
Digitaria eriantha			27, 33
Digitaria sanguinalis			disturbed areas
Digitaria tricholaenoides			10
Diheteropogon amplectans			24, 43b
Diplachne fusca			31
**Eleusine coracana* subsp. *africana*		-	disturbed areas
Elionurus muticus			2, 4a
Enneapogon cenchroides			17

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Enneapogon scoparius			13b, 15
Eragrostis capensis			26
Eragrostis chloromelas			1b
Eragrostis curvula			1a, 1b
Eragrostis gummiflua			20
Eragrostis lehmanniana var. *lehmanniana*			1a, 21
Eragrostis micrantha			25, 51a
Eragrostis nindensis			15
Eragrostis obtusa			M11
Eragrostis plana			21
Eragrostis planiculmis			21
Eragrostis x *pseudo-obtusa*			21
Eragrostis pseudosclerantha			42, 46
Eragrostis racemosa			2
Eragrostis superba			1a, 51a
Eragrostis cf. *trichophora*			25
Eustachys paspaloides			1b, 2, 8
Fingerhuthia africana			2, 9
Helictotrichon turgidulum			23
Heteropogon contortus			2
Hyparrhenia dregeana			
Hyparrhenia hirta			1a
Leersia hexandra			26
Loudetia simplex			48
Melinis repens			1a
Michrochloa caffra			2
Panicum coloratum var. *coloratum*			51a
Panicum maximum			17
Panicum repentellum			21
Panicum schinzii			19
**Paspalum dilatatum*		-	23
Paspalum distichum			21, 23
**Paspalum urvillei*		-	26
**Pennisetum clandestinum*		Category 1b in Protected Areas and wetlands in which it does not already occur.	26
Pennisetum thunbergii			22, 36
Phragmites australis			23, 26
Pogonarthria squarrosa			7, 15
Schizachyrium sanguineum			2, 8
Setaria incrassata			35, 36, 37
Setaria pumila			32

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Setaria sphacelata			15, 33
Setaria verticillata			34
Sporobolus africanus			46
Sporobolus stapfianus			48
Stipagrostis uniplumis var. *neesii*			17
Themeda triandra			1a
Trachypogon spicatus			2
Tragus racemosa			M11
Trichoneura grandiglumis			M18
Tristachya rehmannii			58
Triraphis andropogonoides			2, 8
Urelytrum agropyroides			M18
Urochloa mossambicensis			1a, 8
Urochloa panicoides			53a
TYPHACEAE			
Typha capensis			23
VELLOZIACEAE			
Xerophyta sp.			10, 15
Dicotyledons			
ACANTHACEAE			
Barleria macrostegia			44
Blepharis integrifolia			1a, 43b
Blepharis squarrosa			M11
Chaetacanthus burchelli			1a, 6, 40
Chaetacanthus costatus			M11, M18, 24
Crabbea acaulis			1a, 18
Crabbea angustifolia	ADC 1647		40
Justicia anagalloides			2
AMARANTHACEAE			
Alternathera sessilis			31
**Alternanthera pungens*		-	31
**Amaranthus hybridus*		-	26
**Gomphrena celosioides*		-	2
Kyphocarpa angustifolia			18
Pupalia lappacea var. *lappacea*			6
Sericorema remotiflora			40
ANACARDIACEAE			
Searsia lancea			5, 6, 9
Searsia magalismontanum			9, 15
Searsia pyroides			6, 31
Searsia rigida var. *rigida*			2
APIACEAE			
**Ciclospermum leptophyllum*		-	32

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Deverra burchelii			43b
APOCYNACEAE			
Asclepias adscendens			M18
Asclepias eminens	ADC 1645		51a
Gomphocarpus fruticosus			4a
Orbea lutea subsp. lutea			1a
Orthanthera jasminiflora			
Pachycarpus schinzianus			19
Pentarrhinum insipidum			49
Raphionacme hirsuta			1a
Raphionacme velutina			17
Stapelia gigantea			1a, 43b, 50
Stenostelma capense	ADC *s.n.*		33, 52
ASTERACEAE			
**Acanthospermum australe*		-	35
**Aster squamatus*		-	23
Berkheya onopordifolia var. *onopordifolia*			44
Berkheya pinnatifida subsp. *ingrata*			18
Berkheya radula			23, 51a
**Bidens bipinnata*		-	34, 36
**Bidens pilosa*		-	
**Cirsium vulgare*		Category 1b	26, 30, 32
**Conyza albida*		-	29
**Conyza bonariensis*		-	53a
Conyza podocephala			23, 26
Dicoma anomala			8, 46
Dicoma macrocephala			44
Euryops transvaalensis subsp. transvaalensis			M18
Felicia muricata			39
Gazania krebsiana			1a, 39
Geigeria burkei			52, 51a
Haplocarpha scaposa			21
Haplocarpha lyrata			23
Helichrysum argyrosphaerum			46
Helichrysum aureonitens			21, 33
Helichrysum callicomum			
Helichrysum caespititium			39
Helichrysum nudifolium *[H. coriaceum]*			45, 48, M11, M18
Helichrysum aff. nudifolium			24, 42, 44
Helichrysum rugulosum			51a, M11
**Hypochaeris radicata*			33

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Lactuca inermis			42
Lactuca serriola			25
Nidorella anomala			32
Nidorella hottenttotica			1a, 45
Nidorella resediifoia			1a
Nolletia rarifolia			1a
Osteospermum muricatum			4a
Osteospermum scariosum var. *scariosum*			4a, 44
Pentzia globosa			30
**Pseudognaphalium luteo-album*		-	26
**Schkuhria pinnata*		-	26, 33
Senecio cf. *affinis*			24
Senecio erubescens			33, 58
Senecio coronatus			1a
Senecio harveianus			8
Senecio cf. *inaequidens*			46
Senecio inornatus			26, 32
Senecio lydenburgensis			12
Senecio venosus			4a
Senecio sp. 1			21
Senecio sp. 2			33
Seriphium plumosum			24
**Sonchus oleraceus*		-	33
**Tagetes minuta*		-	34
Vernonia galpinii			39
Vernonia oligocephala			1a, 46
**Zinnia peruviana*		-	17
BORAGINACEAE			
Ehretia rigida			13a
Trichodesma angustifolium			15, 22
BRASSICACEAE			
Lepiidium africanum subsp. *africanum*			5
**Lepidium bonariense*		-	Disturbed areas
CAPPARACEAE			
Cleome rubella			12
CARYOPHYLLACEAE			
Dianthus mooiensis			
Dianthus zeyheri subsp. *zeyheri*			4a
Pollichia campestris			7
CELASTRACEAE			
Gymnosporia buxifolia			7
CELTIDACEAE			

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Celtis africana			5, 7
CHENOPODIACEAE			
**Chenopodium album*		-	36
**Chenopodium carinatum*		-	26
**Chenopodium* cf. *phillipsianum*		-	59
**Salsola kali*		Category 1b	34, 53b
CONVOLVULACEAE			
Convolvulus sagittatus subsp. sagittatus var. phyllosepalus			M18, 50
Falkia oblonga			23
Ipomoea bathycolpos			12, 18
Ipomoea crassipes			54, M18
Ipomoea obscura			6, 8, 12
Ipomoea oenotherae			1a
Ipomoea transvaalensis			2, 15
Seddera capensis			35, 51a
Xenostegia tridentata *[Merremia tridentata]*			1b
CRASSULACEAE			
Crassula capitella			2
CUCURBITACEAE			
Acanthosicyos naudinianus			15, 16
Coccinia sessilifolia			31
Cucumis hirsutus			12, M18
Cucumis zeyheri			2
Kedrostis africana			31
DIPSACACEAE			
Scabiosa columbaria			19, 35
EBENACEAE			
Diospyros austro-africana			M18
Diospyros lycioides			7, 38a
ELATINACEAE			
Bergia decumbens			21
Bergia pentheriana	ADC *s.n.*		31
EUPHORBIACEAE			
Acalypha angustata var. *glabra*			1a, 2
Euphorbia inaequilatera			1a
Euphorbia striata var. *striata*			1a
Phyllantus burchellii			8, 16
Phyllanthus incurvus			18
FABACEAE			
Acacia erioloba			13a, 16, 17, 38a, 38b
Acacia karoo			31, 48, 59
Acacia robusta subsp. *robusta*			17

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Chamaecrista comosa			2
Chamaecrista mimosoides			20
Crotalaria brachycarpa			16, 40
Crotalaria lotoides			44
Elephantorrhiza elephantina			1a, 2, 43a
Eriosema burkei			12, 18
Indigastrum parviflorum			21
Indigofera burkeana			16
Indigofera cryptantha var. cryptantha			22, 31
Indigofera daleoides var. daleoides			39
Indigofera heterotricha			24, 45
Indigofera torulosa			22, M11
Indigofera sp.			50
Lotononis calycina			15
Lotononis listii			27, 28, 31
Lotononis cf. minima			1
Neorautanenia ficifolius			45
Pearsonia bracteata	ADC *s.n.*	Declining	8, 9, 11, 12, 14, 15, 39
Pearsonia cajanifolia			6, 9, 40
Pearsonia sessilifolia			
Rhynchosia cf. adenodes			40
Rhynchosia minima			20
Rhynchosia monophylla			8, 39
Rhynchosia totta			19
Senna italica subsp. arachoides			13b
Tephrosia elongata			4b, 40
Tephrosia capensis			33, 43a
Tephrosia longipes			8, 39, M18
Tephrosia cf. rhodesiaca			18
Vigna vexillata var. vexillata			26
Vigna oblongifolia var. parviflora			8, 15
Zornia cf. milneana			39
GERANIACEAE			
Monsonia angustifolia			4a
Monsonia burkeana			2
LAMIACEAE			
Becium obovatum			58
Salvia radula			3
Salvia repens			26
Salvia runcinata			19, 26
Stachys hyssopoides			51a
Teucrium trifidum			47
LOBELIACEAE			

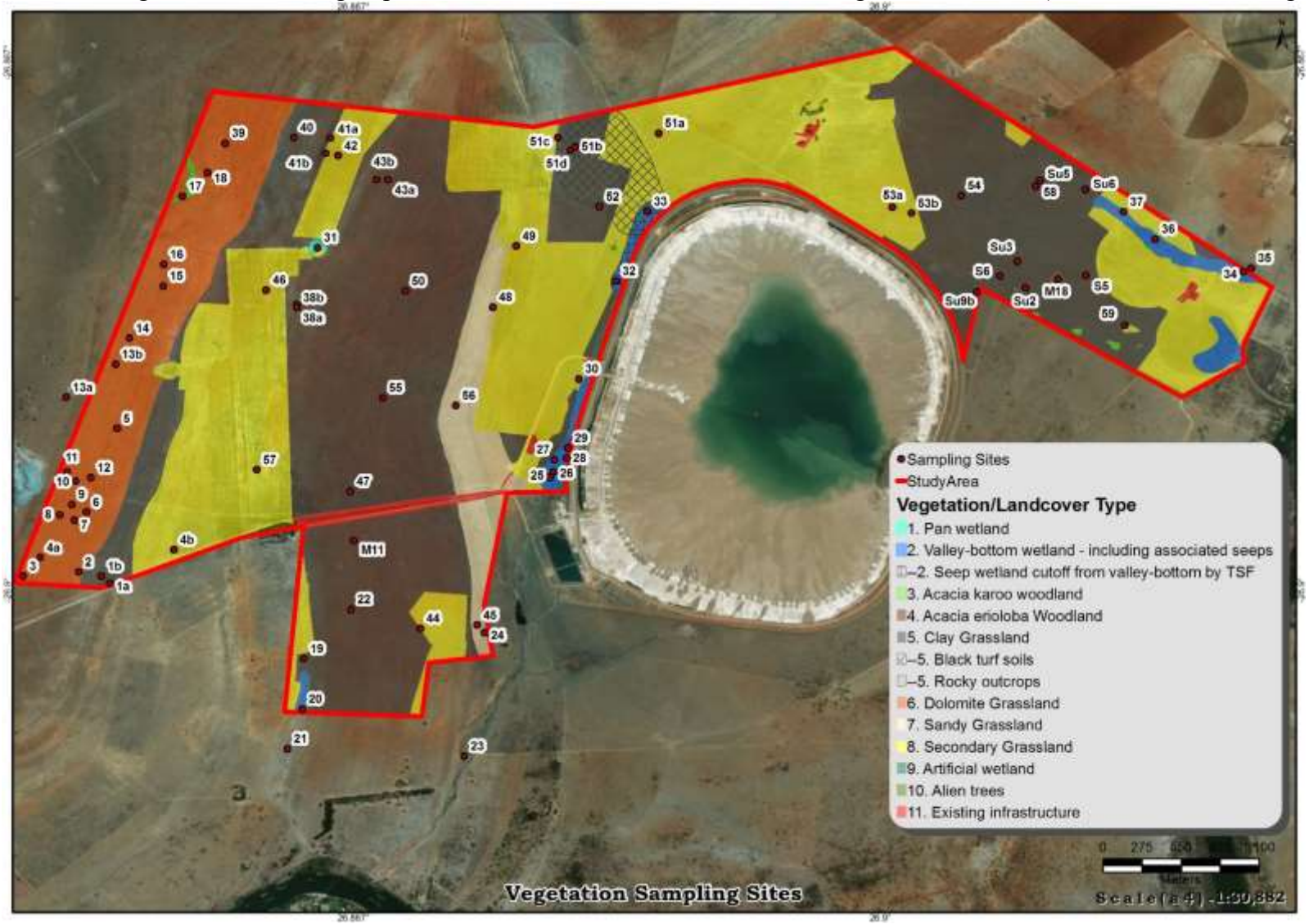
FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Monopsis decipiens			27
MALVACEAE			
Hibiscus aethiopicus			4b
Hibiscus microcarpus			1a, 1b
Hibiscus pusillus			15, 24, 38b, 42, M18
**Hibiscus trionum*		-	36
Hermannia depressa			1a, 40
Hermannia lanceolata			
Hermannia resedifolia			33, 51a
Hermannia transvaalensis			
**Malvastrum coromandelianum*		Category 1b	38b
Pavonia burchellii			6
Sida cf. *chrysantha*			18
MESEMBRYANTHEMACEAE			
Delosperma herbeum			18
Lithops lesliei subsp. lesliei		Near Threatened	39
MYRTACEAE			
**Eucalyptus camaldulensis*		In study area: Category 1b in riparian areas, Category 2 in plantations, wind-rows etc. Not listed within 50m of main farmhouse. Not listed in urban area if diameter at 1m greater than 40cm.	Homestead and plantation
NYCTAGINACEAE			
**Boerhavia diffusa*		-	57, 59
OLEACEAE			
Menodora africana			1a, 45
ONAGRACEAE			
**Oenothera rosea*		-	21
**Oenothera tetraptera*		-	26
OROBANCHACEAE			
Cycnium tubulosum			28
OXALIDACEAE			
**Oxalis corniculata*		-	26
PAPAVERACEAE			
**Argemone ochroleuca*		Category 1b	Disturbed areas
PEDALIACEAE			
Dicerocaryum eriocarpum			5
Pterodiscus speciosus			38b, 50
Sesamum alatum			M18
PLANTAGINACEAE			
Plantago lanceolata			23
POLYGALACEAE			

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
Polygala amatymbica			54
Polygala hottentota			40
Ploygala uncinata			15
POLYGONACEAE			
Oxygonum dregeanum			
Persicaria decipiens [*P. salacifolia*]			21
**Persicaria lapathifolia*		-	28
Persicaria limbata			21
**Rumex crispus*		-	23
Rumex lanceolatus			31
PORTULACACEAE			
**Portulaca oleracea*		-	38b
Talinum caffrum			2, 59
RANUNCULACEAE			
Clematis brachiata			24, 59
Ranunculus multifidus			21, 23, 29
RHAMNACEAE			
Ziziphus mucronata			9
Ziziphus zeyheriana			1a, 4a
RUBIACEAE			
Anthospermum rigidum			50, M11
Kohoutia amatymbica			15
Pentanisia angustifolia			39
Pygmaeothamnus zeyheri			5, 9
**Richardia brasiliensis*		-	31, 46
SANTALACEAE			
Thesium racemosum			5
Thesium cf. transvaalense *[pubescent]*			15, 40
SCROPHULARIACEAE			
Aptosimum procumbens var. elongatum			52
Jamesbittenia aurantiaca			33
Mimulus gracilis			21
Nemesia fruticans			24
Selago densiflora			33a
Veronica anagallis-aquatica			23
SOLANACEAE			
**Datura ferox*		Category 1b	
**Datura stramonium*		Category 1b	26
**Solanum elaeagnifolium*		Category 1b	38b
Solanum incanum			1a, 49
**Solanum nigrum*		-	31

FAMILY & Species	Voucher no.	Declared Invaders and Weeds# and conservation status category##	Examples of sites were recorded
**Solanum sisymbrifolium*		Category 1b	46
Solanum supinum			1b, 44
THYMELAEACEAE			
Gnidia capitata			1a, 6
Gnidia sericocephala			6
TILIACEAE			
Corchorus asplenifolius			1a, 2
Grewia flava			2, 38a
Triumfetta sonderi			2
VAHLIACEAE			
Vahlia capensis			31
VERBENACEAE			
Lantana rugosa			9
Lippia scaberrima			24, M18
Plexipus hederaceum			8, 40
**Verbena aristigera*		-	26, 33
**Verbena bonariensis*		Category 1b	21
**Verbena officinalis*		-	25, 33
VISCACEAE			
Viscum rotundifolium			17
VITACEAE			
Cyphostemma hereroense			1a, 8
ZYGOPHYLLACEAE			
Tribulus terrestris			48, 57

As included in the List of Alien Invasive Plant Species under National Environmental Management: Biodiversity Act (10/2004): Alien and Invasive Species List, 2014 (Government Gazette, 37886, 1 August 2014). Referred to in table as 'AIS Regulations'.
Extracted from Raimondo *et al.* (2009) and the SANBI online Red List of South African plants (http://redlist.sanbi.org).
* Indicates and alien species.
** Indicates species that are indigenous to South Africa but not the study area, and have been planted.

APPENDIX 2: Maps of localities of the main vegetation survey sites in the study area. The prefix 'M' denotes sites surveyed during the 'Baseline Vegetation Monitoring Report' for the Mine Waste Solutions surface rights area in 2017 (De Castro & Brits, August 2017).



APPENDIX 3: List taxa recorded from eighteen 100m^2 (10m x 10m) vegetation sampling quadrats surveyed within the Mine Waste Solutions Kareerand TSF Extension Project study area. Estimated cover-abundance values* (using Braun-Blanquet method) for each of the species recorded at each site are provided. The list comprises 246 species and infra-specific taxa. In the section of the table listing trees and shrubs, yellow highlighting indicates a tree species that contributes to cover within the quadrat mostly as a shrub (life-form).

MWS Kareerand TSF Extension Project study area																		
Species	**Site numbers** (all site numbers are as shown and geo-referenced on aerial images in Appendix 2, and sites are grouped in vegetation types/units and habitats)																	
	Unit 2 Valley-bottom wetland - incl. associated seeps			**Unit 4** *Acacia erioloba* Woodland		**Unit 5** Clay Grassland				**Unit 6** Dolomite Grassland			**Unit 7** Sandy Grassland			**Unit 8** Secondary Grassland		
	Untransformed valley-bottom vegetation	Veg of black turf soils of cut-off seep	Secondary veg of historically ploughed seep	Grassland patch with *A. erioloba* Woodland	Grassland patch with *A. erioloba* Woodland	Brown, shallow sandy clay loam	Red clay loam, overlying Andesite?	Red clay loam overlying Andesite	Diabase rocky outcrop; 55% rock cover	Shallow, brown clay loam; 20% chert rock cover	Shallow, brown clay loam; 15% chert rock cover	Shallow, brown clay loam; 30% chert rock cover	Brown sandy clay loam	Light-brown sandy loam	Quartzitic rocky outcrop; 10% rock cover	Deep, light red-brown clay loam	Deep, red-brown sandy clay loam	Deep, red-brown sandy clay loam
	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Grasses																		
Andropogon appendiculatus	2a		+															
Andropogon schirensis									2a	2a	1	1						
Anthephora pubescens										1	+				1			
Aristida adscensionis						+							+			2a	2b	2a
Aristida cf. aequiglumis						1	1			1	1	1	2a		1			
Aristida bipartita		+																

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Aristida canescens						1	2b	1	2a	+	1				1			
Aristida congesta subsp. congesta								2a		+	+	1	+		+	+	1	
Aristida stipitata												+						
Bewsia biflora						R			+				+	R	1			
Brachiaria nigropedata	1					1				1	+	1						
Brachiaria serrata						1		1	1	2a	2a	2a			2a			
Calamagrostis epigeios			+															
Chloris virgata									R									
Cymbopogon caesius	2a		1			+		2a		1	1	1	1	1			+	
Cymbopogon pospischilii							+		1			+						

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	Untransformed valley-bottom vegetation	Veg of black turf soils of cut-off seep	Secondary veg of historically ploughed seep	Grassland patch with *A. erioloba* Woodland	Grassland patch with *A. erioloba* Woodland	Brown, shallow sandy clay loam	Red clay loam, overlying Andesite?	Red clay loam overlying Andesite	Diabase rocky outcrop; 55% rock cover	Shallow, brown clay loam; 20% chert rock cover	Shallow, brown clay loam; 15% chert rock cover	Shallow, brown clay loam; 30% chert rock cover	Brown sandy clay loam	Light-brown sandy loam	Quartzitic rocky outcrop; 10% rock cover	Deep, light red-brown clay loam	Deep, red-brown sandy clay loam	Deep, red-brown sandy clay loam
	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Cynodon dactylon	1	1	5	1								+		+	1	1	1	4
Digitaria argyrograpta							1	+					1	1	1			
Digitaria eriantha		3	2a		2a	+	+	1	1					1				
Digitaria tricholaenoides									1	+								
Diheteropogon amplectans							+	1	1				1					
Elionurus muticus							1		1	2b	2b	2a	1	2a				
Enneapogon cenchroides				1						+	1							
Enneapogon scoparius				+	+													
Eragrostis chloromelas				4					2a	+	1		1	2b				

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Eragrostis curvula	2b	2a	1		2a	2a					1	1	2b	1		1	+	2b
Eragrostis lehmanniana var. lehmanniana				1	1	2b				1	1		1	2a	1	3	2b	1
Eragrostis cf. micrantha			1															
Eragrostis nindensis										2b	1	2a						
Eragrostis obtusa								+										
Eragrostis plana	1																	
Eragrostis x pseudo-obtusa							1								+			
Eragrostis cf. pseudosclerantha																2b	2b	
Eragrostis racemosa						1				+	1							
Eragrostis superba				2b			1	1	+		1			1	+	2a	1	

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Eragrostis cf. trichophora			1					1										
Eustachys paspaloides							1	1	1	1	1	1		+	1			
Hemarthria altissima																		
Helictotrichon turgidulum			+															
Heteropogon contortus					1	1	1	1	1	1	1	1	1	1	2a	1		
Hyparrhenia hirta																1	R	
Melinis repens						1	+	2b	2a	2a	2a	2b			+		+	1
*Paspalum dilatatum	+																	
Panicum coloratum var. coloratum							2a	2b	1				1		1		+	
Panicum schinzii																		1

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Pennisetum thunbergii	1																	
Pogonarthria squarossa											+				1	1	1	
Schizachyrium sanguineum						+			1	1		2a			1			
Setaria sphacelata	2a	1		1		1	+	2a	1	+	1	1	2a	1	1			
Sporobolus stapfianus															1			
Stipagrostis uniplumis												+						
Themeda triandra	2a	2a			2b		2a	2a	1	+			2b	2a	1		1	1
Tragus racemosa								+										
Trichoneura grandiglumis									+									

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Triraphis andropogonoides									1	1	2a	1			2b			
Urochloa mossambicensis										R								
Urochloa panicoides																		+
Forbs & low shrubs																		
Acalypha angustata						+		+		+	+	1	1		1			
Albuca setosa				R														
Aloe davyana							+		1									
*Alternanthera pungens					+													
Anthericum cooperi							+											
Anthericum cf. fasciculatum											R							

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Anthospermum rigidum		R					R	+		+	+			+				
Asclepias adscendens									R									
Asparagus suaveolens									R									
Barleria macrostegia					+	R	1	+		+	+	+	+	+	+			
Bergia decumbens	+																	
Berkheya onopordifolia		+					+	+	R				+	+				
Berkheya radula	1																	
*Bidens bipinnata													+					
Blepharis integriifolia					R	+	+				R	+						
Blepharis squarossa								R										

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
*Boerhavia diffusa																		
Boophone disticha							R		R						R			
Bulbine abyssinica																		
Bulbine capitata						R							+	+				
Bulbine narcissifolia				2b	2a	R	1	+					R	+				
Bulbostylis hispidula									+	1	1	1						
Chaetacanthus costatus								R	+				R					
Chaetacanthus cf. burchellii						+	+				+	+		R	+			
Chamaecrista comosa								+	R	+	+	+						
*Chenopodium album					R													

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Clematis brachiata													+					
Clutia pulchella																		
*Ciclospermum leptophyllum			1															
*Cirsium vulgare			+															
Commelina africana				+														
Commelina bella						R					+	+						
Convolvulus sagittatus							R		+									
*Conyza albida			1															
Conyza podocephala		2a	R					1					1	1	+			
Corchorus aspleniifolius				+		+	+	+			+					+	R	

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Crabbaea angustifolia	R					R		1			+	+						
Crabbaea acaulis					R		+	+	R									
Crassula capitella												R						
Crinum bulbispermum	R																	
Crotalaria brachycarpa						1												
Crotalaria lotoides					R		R									R		
Cucumis hirsutus														R				
Cucumis zeyeheri						R	R									R		
*Cuscuta cf. campestris																		
Cyanotis speciosa						R							+					

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Cyperus obtusiflorus var. obtusiflorus										+	+	+						
Cyphostemma hereroense							R											
*Datura ferox																		R
Deverra burchellii							R	+						R				
Dianthus zeyheri										+	R	R						
Dicoma anomala								R	1	R	+		+					
Dicoma macrocephala				R		+	R											
Dipcadi viride		R		R														
Elephatorrhiza elephantina										1	+			+				
Eriospermum abyssinicum															+			

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Euphorbia inaequilatera										R	R							
Felicia muricata		+					+	+	R			+	+	+	+	+		
Gazania krebsiana		R				R				R				+				
Geigeria burkei								1										
Gladiolus crassifolius	R																	
Gnidia capitata							R			R	+	1	R	R	R			
Gnidia sericocephala																		
Gomphocarpus fruticosus								R		R								R
*Gomphrena celosiodes					R	+		R					+					
Habenaria sp.									R									

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Haplocarpha scaposa	R																	
Helichrysum argyrosphaerum																	R	
Helichrysum aureonitens	1	R																
Helichrysum caespititium										+		R						
Helichrysum callicomum																		
Helichrysum nudifolium								R	1					R	R			
Helichrysum aff. nudifolium													R			+		
Helichrysum rugulosum								1										

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	Untransformed valley-bottom vegetation	Veg of black turf soils of cut-off seep	Secondary veg of historically ploughed seep	Grassland patch with *A. erioloba* Woodland	Grassland patch with *A. erioloba* Woodland	Brown, shallow sandy clay loam	Red clay loam, overlying Andesite?	Red clay loam overlying Andesite	Diabase rocky outcrop; 55% rock cover	Shallow, brown clay loam; 20% chert rock cover	Shallow, brown clay loam; 15% chert rock cover	Shallow, brown clay loam; 30% chert rock cover	Brown sandy clay loam	Light-brown sandy loam	Quartzitic rocky outcrop; 10% rock cover	Deep, light red-brown clay loam	Deep, red-brown sandy clay loam	Deep, red-brown sandy clay loam
	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Hermannia resedifolia		R																
Hermannia depressa						+	+	+	R				+	+		+		
Hibiscus pusillus					+				R		R		R			+		
*Hibicus trionum																		
*Hypochaeris radicata		R																
Hypoxis hemerocallidea					R	R	+							R				
Hypoxis obtusa							R	1	+						R			
Hypoxis rigidula	R								R		R							
Indigastrum indicum																		
Indigofera cryptantha		R						R										

MWS Kareerand TSF Extension Project study area																		
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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Indigofera daleoides var. daleoides				+				1							+			
Indigofera heterotricha											+	1	R	+				
Indigofera torulosa								R										
Indigofera sp.							R											
Ipomoea bathycolpos									1		1							
Ipomoea crassipes									2a									
Ipomoea obscura										R	R	+						
Jamesbrittenia aurantiaca		+																
Justicia anagalloides										+								
Kohautia amatymbica										+	R	R			R			

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Kohautia virgata																		
Kyllinga erecta	+																	
Lactuca inermis																+		
Lactuca serriola			+															
Ledebouria cf. apertiflora						+	+			+	+	+		+	+			
Ledebouria marginata										+	+							
Ledebouria ovatiifolia				R	R							+		R				
Ledebouria cf. luteola				+			R	R	R									
Lippia scaberrima									R				1					
Lithops lesliei subsp. lesliei												R						

MWS Kareerand TSF Extension Project study area																		
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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Lotononis calycina					R	R			+	+	+	R						
Lotononis listii		1																
*Malvastrum coromandelianum					R													
Menodora africana														R				
Mimulus gracilis	R																	
Monsonia angustifolia									+	1	R			R				
Monsonia burkeana												+						
Neorautanenia ficifolius														R				
Nidorella hottentotica														R				
Nolletia rarifolia						+				+	+	+	R	R	+			

MWS Kareerand TSF Extension Project study area																		
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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
*Oenothera rosea	+																	
*Oenothera tetraptera		R																
Ornithogalum cf. tenuifolium subsp. tenuifolium						+	R	R			R	+	R	R		R		
Osteospermum muricatum					R			1	R	+			+	1				
Osteospermum scariosum							R		+								+	+
Oxalis corniculata														R				
Oxygonum dregeanum										R								
Pearsonia bracteata										R	R	+						
Pearsonia cajanifolia						+									+			

MWS Kareerand TSF Extension Project study area																		
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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Pentanisia angustifolia												R						
Pentarrhinum insipidum																+		
Pentzia globosa			1															
Phyllanthus burchellii						+				R	+	1						
Plexipus hederaceum				R	R	+	+	+	+	1	1	+	+	+	+			
Pollichia campestris					+			R		+			R	R		+	+	
Polygala amatymbica								R										
Polygala hottentota		+				R								R				R
Portulaca oleracea					R													

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Pterodiscus speciosus					R		R											
Pygmaeothamnus zeyheri								+										
Raphionacme hirsuta				R	R		R	R			R			R	R			
Raphionacme velutina.				R		R												
Rhynchosia cf. adenodes					+	+								+				
Rhynchosia minima	2a																	
Rhynchosia monophylla										R		+						
Rhynchosia totta													R	R				
Salvia runcinata	R																	
Scabiosa columbaria								R	+									

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
*Schkuhria pinnata															R			
Searsia magalismontanum											2a							
Selago densiflora																		R
Senecio cf. affinis													R					
Senecio cf. harveianus										R								
Senecio cf. inaequidens																	R	
Senecio inornatus		+																
Senecio sp 1	1																	
Senecio sp 2		+																
Senna italica subsp. arachoides							R	1					R				+	

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Sericorema remotiflora						+												
Sesamum alatum									R									
Sida cf. chrysantha		R		R			R	R					+	+				
*Solanum eleagnifolium					1													
Solanum incanum				R			R	R						R	R			
*Solanum nigrum																		
Solanum supinum						R		R										
*Sonchus oleraceus			+															
*Tagetes minuta			+												R			
Tephrosia capensis		R																
Tephrosia elongata						+					+							
Tephrosia longipes									+	R		R						

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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Teucrium trifidum								1					R	+				
Thesium cf. transvaalense						+												
Trachyandra asperata var. macowanii															R			
Trachyandra cf. saltii												R						
Trichodesma angustifolia							+	R										
Triumfetta sonderi										+	1	1			1			
Tulbaghia cf. acutiloba							+								+			
*Verbena aristigera		+											+					2a
*Verbena bonariensis	R																	
*Verbena officinalis		+	+															1

MWS Kareerand TSF Extension Project study area																		
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	Untransformed valley-bottom vegetation	Veg of black turf soils of cut-off seep	Secondary veg of historically ploughed seep	Grassland patch with *A. erioloba* Woodland	Grassland patch with *A. erioloba* Woodland	Brown, shallow sandy clay loam	Red clay loam, overlying Andesite?	Red clay loam overlying Andesite	Diabase rocky outcrop; 55% rock cover	Shallow, brown clay loam; 20% chert rock cover	Shallow, brown clay loam; 15% chert rock cover	Shallow, brown clay loam; 30% chert rock cover	Brown sandy clay loam	Light-brown sandy loam	Quartzitic rocky outcrop; 10% rock cover	Deep, light red-brown clay loam	Deep, red-brown sandy clay loam	Deep, red-brown sandy clay loam
	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Vernonia galpinii				+								R						
Vernonia oligocephala	1				1	+		1	1	R	+	+		1				
Xenostegia tridentata											+							
Xerophyta sp.											R							
Ziziphus zeyheriana					2a		1	1	1				2a					
Zornia cf. milneana												R						
Trees & Shrubs																		
Acacia erioloba				R														
Acacia karoo			+															
Pavonia burchellii					R													
Unidentified taxa																		
Dicotyledon sp. 1									R									

MWS Kareerand TSF Extension Project study area																		
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	21	33#	25	17	38b	40	50	M11	M18	8	15	39	24	45	48	42	46	53a
Dicotyledon sp. 2												R						
Dicotyledon sp. 3													R					
Dicotyledon sp. 4													R					
Monocotyledon sp. 1					R													
Monocotyledon sp. 2							R											
Monocotyledon sp. 3										R								
Monocotyledon sp. 4													R					
TOTAL no. of taxa	26	26	19	23	30	47	51	59	54	57	61	55	49	51	44	21	19	15

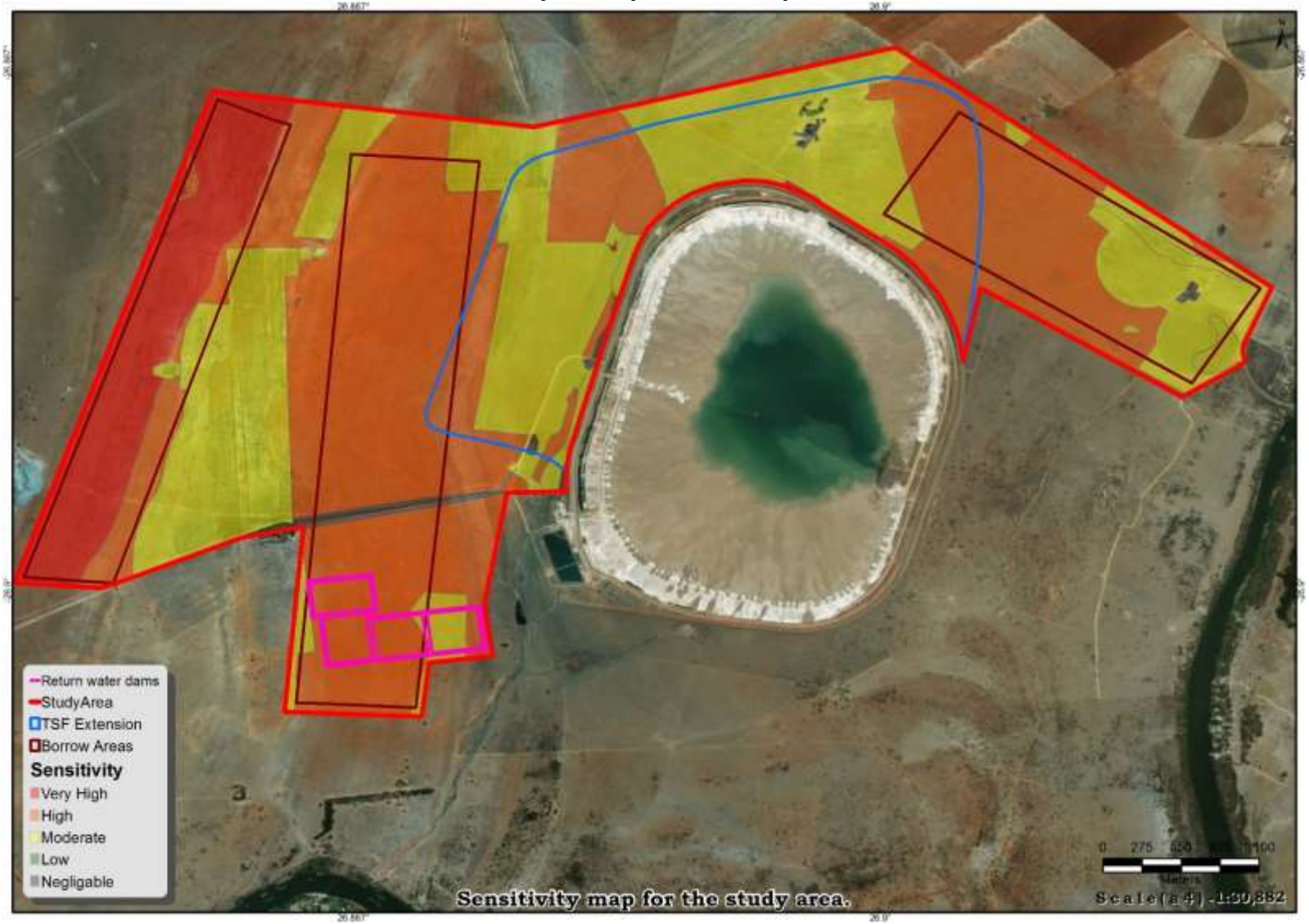
*Estimated Cover Abundance Values:

R = negligible canopy cover (one or two small individuals)
+ = less than 1% canopy cover
1 = 1-5% canopy cover
2a = 6-15% canopy cover
2b = 16-25% canopy cover
3 = 26-50% canopy cover
4 = 51-75% canopy cover

5 = 76-100% canopy cover

Very few species in flower at this site at the time of the survey (early November) and the area was burnt in late winter. Identification of species thus rendered difficult and species richness likely to be under-represented.

APPENDIX 4: Map of sensitivity / botanical biodiversity conservation value of the vegetation and land-cover type units identified within the Kareerand 1 495.5ha Kareerand TSF Extension Project study area the study area.



APPENDIX 5: List of all plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) historically recorded from the quarter degree grid square within which the study area is situated (2626DD), as well as the grids immediately to the west (2626DC and 2626CD), south-west (2726BA), as obtained from the Plants of Southern Africa website (http://newposa.sanbi.org., downloaded in January 2018). Conservation status categories obtained from the latest Red Data List of South African Plants (Raimondo *et al*., 2009 and http://redlist.sanbi.org, downloaded January 2017). The lists for all four grids contained only one plant 'species of conservation concern', namely *Hypoxis hemerocallidea,* which was recorded from the grid 2626DC. All other species are those recorded during the current botanical biodiversity survey of the MWS Kareerand TSF Extension Project study area or during previous surveys conducted in the MWS surface rights area (2626DD) and Vaal Reefs Mine Complex surface rights area (2626DC) between 2007 and 2017 by the current author. Species recorded within the MWS Kareerand TSF Extension Project study area are shaded in yellow. In the absence of guidelines for setting 'buffer zones' in the North West Province, the Gauteng Directorate of Nature Conservation guidelines are used in this report and the Gauteng 'Priority Grouping' for each species is therefore also provided.

Taxon	**Latest (IUCN version 3.1) Conservation Status Category***	**Gauteng Nature Conservation Priority Grouping**	**Habitat**	**Flowering Time**	**Grid squares from which species has been recorded**	**Probability of occurrence within the West Wits mine complex property**
AIZOACEAE						
Lithops lesliei (N.E. Br.) N.E. Br. subsp. *lesliei*	Near Threatened [**NT** A4acd]	B	Primary habitat appears to be the arid grasslands in the interior of South Africa where it usually occurs in rocky places, growing under the protection of surrounding forbs and grasses. In the authors experience, in the North West Province this species does not grow under the protection of forbs and grasses but is closely associated with shallow soils around exposed bedrock, and in the Stilfontein and Orkney areas is always associated with patches of chert on the crests of gently undulating terrain where the geology comprises dolomite.	March to June	**2626DD** 2626DC	**Recorded**
AMARYLLIDACEAE						
Boophone disticha (L. f.*)* Herb.	Declining	N/A	Dry grassland and rocky areas. Widespread in South Africa (known from 9 provinces) and extends up the eastern half of southern Africa to Uganda.	October to January	**2626DD** 2626DC	**Recorded**

Taxon	Latest (IUCN version 3.1) Conservation Status Category*	Gauteng Nature Conservation Priority Grouping	Habitat	Flowering Time	Grid squares from which species has been recorded	Probability of occurrence within the West Wits mine complex property
Crinum bulbispermum (Burm.f.) Mile-Redh. & Schweik.	Declining	N/A	Along rivers and streams or in damp depressions in black clay or sandy soil. In the authors experience always occurs in areas that are seasonally or at least periodically flooded.	September to November	**2626DD** 2626DC	**Recorded**
Nerine gracilis R.A. Dyer	**VU** B1ab (ii, iii, v)	A3	Undulating grasslands in damp, moist areas; the plants grow in full sun in damp depressions, near pans or on the edges of streams; grassland, riverbanks, vleis.	February and March	2626DC	**Low**
CRASSULACEAE						
Adromischus umbraticola C.A. Sm. subsp. *umbraticola*	Near Threatened **[NT** B1ab (ii, iii, v)]	A2	Rock crevices on rocky ridges, usually south-facing, or in shallow gravel on top of rocks, but often in shade of other vegetation.	September to January	2626DC	**Low** (recorded on a quartzite ridge ca. 16km's to the W of the study area by Gunther Wiegenhagen)
FABACEAE						
Pearsonia bracteata (Benth.) Polhill	Near Threatened [**NT** B1ab(i,ii,iii,iv,v)]	A3	Plants in Gauteng and North West occur in gently sloping Highveld grassland, while those in the Wolkberg were collected from steep wooded slopes and cliffs in river valleys. Current authors observations at West Wits indicate that species occurs in untransformed Dolomite Grassland (BMU 6a) and quartzitic grassland (BMU6b).	December to April according to literature, but recorded by the author flowering in late October at Vaal Reefs in 2006.	**2626DD** 2626DC	**Recorded**
HYACINTHACEAE						
Drimia sanguinea (Schinz) Jessop	Near Threatened **[NT** A2d]	B	Open veld and scrubby woodland in a variety of soil types (Raimondo *et al*., 2009). At the locality recorded by the author at MWS and Vaal Reefs within the grids 2626DC and 2626DD, plants occur in Short Closed	August to December	**2626DD** 2626DC	**Moderate to High**

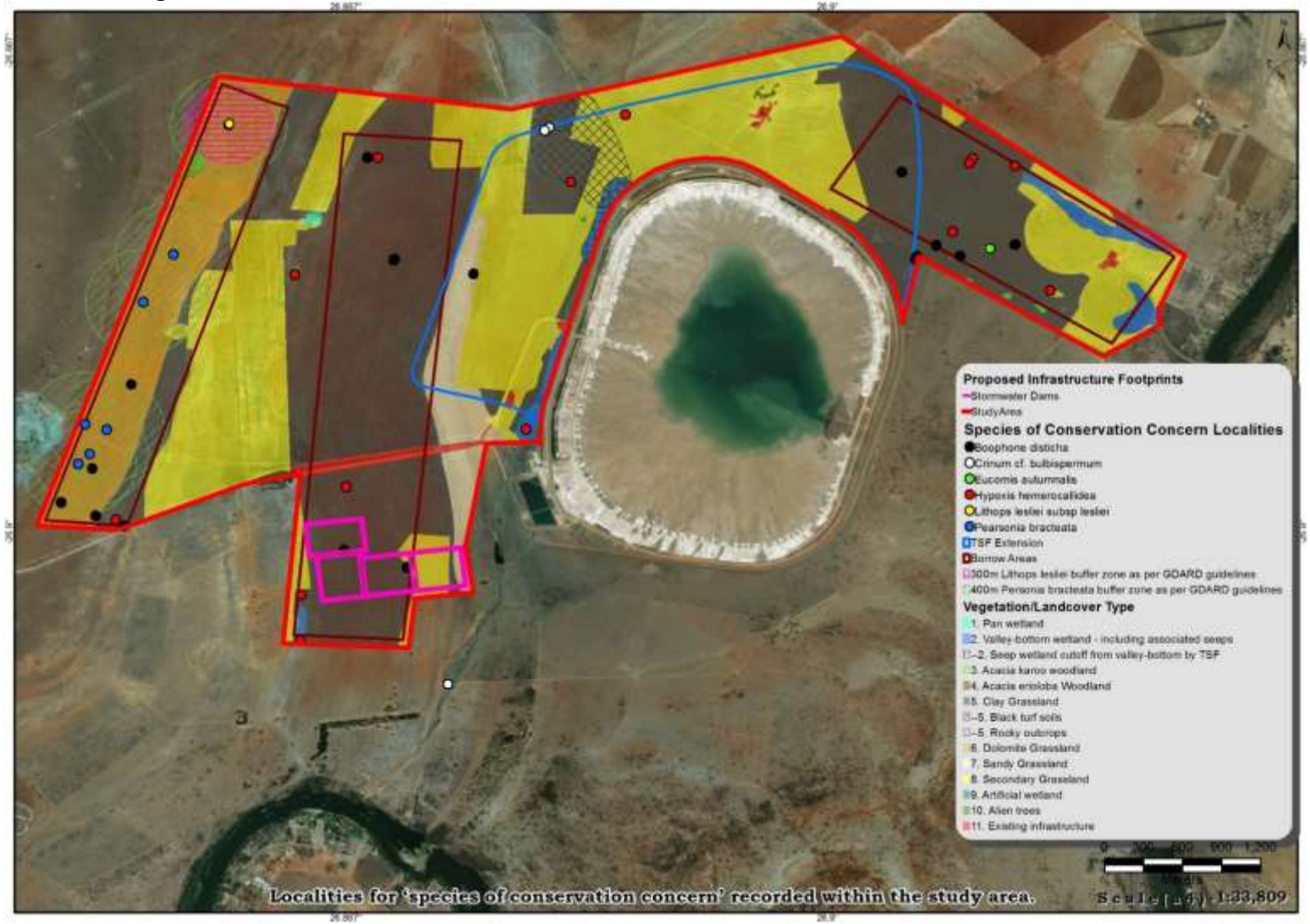
Taxon	Latest (IUCN version 3.1) Conservation Status Category*	Gauteng Nature Conservation Priority Grouping	Habitat	Flowering Time	Grid squares from which species has been recorded	Probability of occurrence within the West Wits mine complex property
			Grassland and Sparse Woodland (*sensu* Edwards, 1983) on flat to very gently undulating terrain with rock cover (dolomite) of approximately 20% and herbaceous vegetation cover of approximately 65%. At neither of these subpopulations do the plants occur on low chert ridges.			
Eucomis autumnalis (Mill.) Chitt. subsp. *clavata* (Baker) Reyneke	Declining	N/A	On hillslope seeps in open grassland, and also along the margins of marshes.	November to April	**2626DD** 2629AA	**Recorded**
HYPOXIDACEAE						
Hypoxis hemerocallidea Fisch. & C.A. Mey.	Declining	N/A	In the authors' experience, in the Highveld region of Gauteng, North West and Mpumalanga this species occurs in various types of grassland including moist grassland on wetland margins and secondary grassland of historically cultivated soils. Raimondo *et al.* (2009) state that this species occurs in a wide range of habitats, including sandy hills on the margins of dune forests, open, rocky grassland, dry, stony, grassy slopes, mountain slopes and plateaus. Appears to be drought and fire tolerant. Widespread in the eastern half of southern Africa, where its distribution extends from the Eastern Cape to Botswana and Mozambique. Western Cape to Malawi.	September to March	**2626DD** 2626DC	**Recorded**

* Status follows the latest Red Data Plant Book of South African Plants (Raimondo *et al*., 2009), and the continuously updated online Red List of SANBI (http://redlist.sanbi.org, downloaded January 2017).

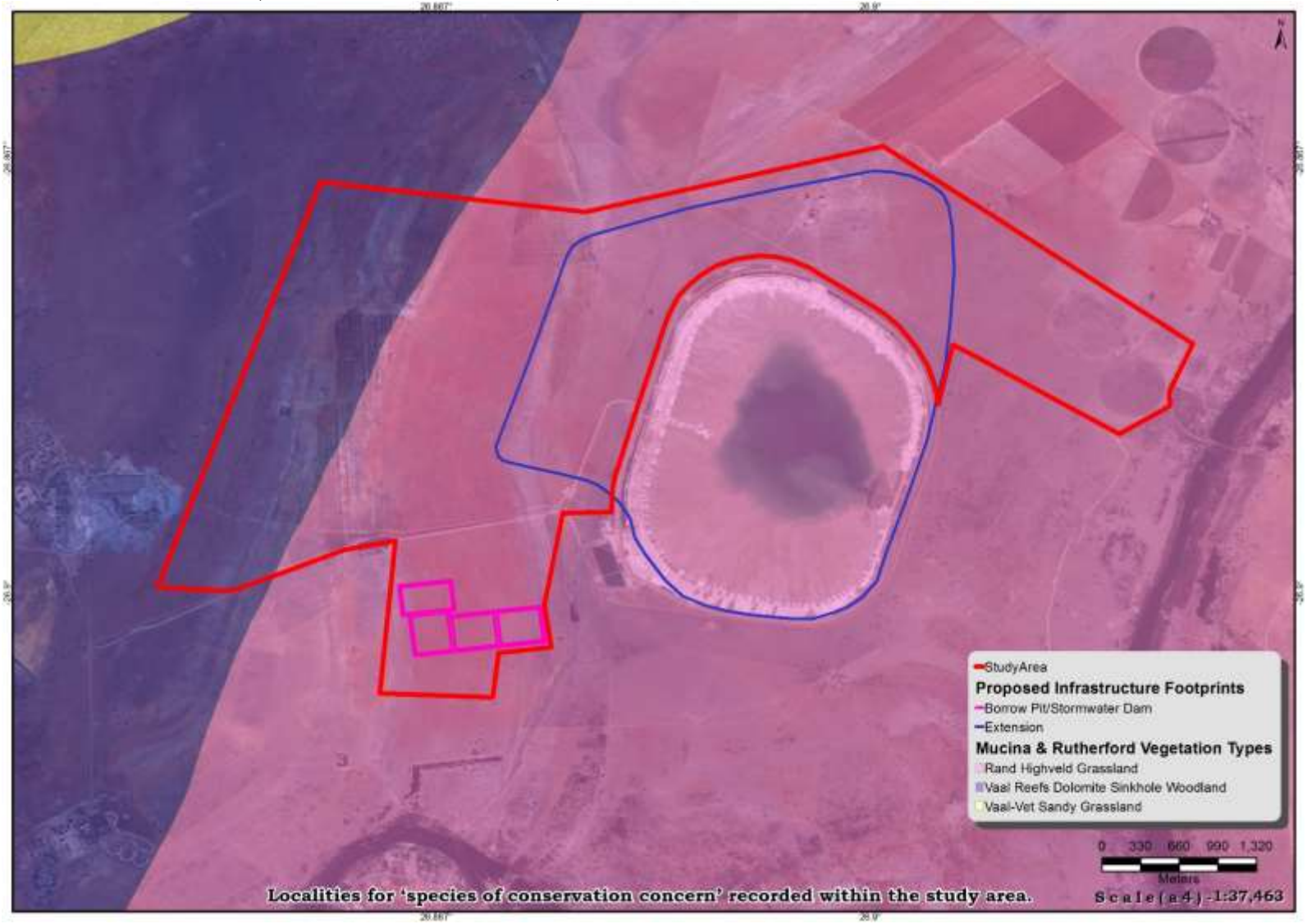
APPENDIX 6: List of 49 plant species regarded as 'priority species' for the North West Province, as extracted from Hahn (June 2011). IUCN conservation status categories are those provided by Raimondo *et al.* (2009). Of the 49 listed species, only the 27 shaded in grey are regarded as 'species of conservation concern' (*sensu* Raimondo *et al*. 2009) in the latest Red List of South African plants (http://redlist.sanbi.org).

Aloe peglerae Schöland	Endangered
Aloe cryptopoda Bak. (Enselsberg Form)	Least Concern
Amphiglossa tecta (Brausse) Koekemoer	Least Concern
Anacampseros dicapitata sp. nov. in ms P. Burgoyne	DDD
Barleria randii S. Moore	Least Concern
Blepharis angustata (Nees) T. Anderson	Least Concern
Brachycorythis conica (Summerh.) subsp. *transvaalensis* Summerh.	Vulnerable
Brachystelma canum R.A. Dyer	Critically Endangered
Brachystelma dimorphum R.A. Dyer *subsp. gratum* R.A. Dyer	Rare
Brachystelma discoideum R.A. Dyer	Endangered
Brachystelma glenense R.A. Dyer	DDT
Brachystelma gracillimum R.A. Dyer	Critically Endangered
Brachystelma incanum R.A. Dyer	Vulnerable
Ceropegia deciduas E.A. Bruce subsp. *pretoriensis* R.A. Dyer	Vulnerable
Ceropegia insignis R.A. Dyer	Rare
Ceropegia stentiae E.A. Bruce	Vulnerable
Ceropegia turricula E.A. Bruce	Near Threatened
Cheilanthes botsawanae Schelpe & N.C. Anthony	Least Concern
Commelina bella Oberm.	DDT
Corchorus pinnatipartitus Wild	DDT
Cynodon polevansii Stent.	DDT
Delopserma macellum (N.E. Br.) N.E. Br.	Endangered
Dicliptera magaliesbergensis K. Balkwill	Threatened
Ebracteola wilmaniae (L. Bolus) Glen	Least Concern
Erythrophysa transvaalensis Verdoorn	Least Concern
Eulophia coddii A.V. Hall	Vulnerable
Euphorbia knobelii Letty	DDT
Euphorbia perangusta R.A. Dyer	Endangered
Euphorbia planiceps A.C. White, R.A. Dyer & E.B. Sloane	Least Concern
Frithia pulchra N.E. Br.	Rare
Gladiolus filiformis Goldblatt & J.C. Manning	Critically Rare
Gnaphalium nelsonii Burtt Davy	Rare
Habenaria culveri Schltr.	Rare
Indigofera commixta N.E. Br.	Least Concern
Jamesbrittenia burgei P. Lemmer	Vulnerable
Ledebouria atrobrunnea S. Venter	Vulnerable
Ledebouria confus S. Venter	Least Concern
Lessertia phillipsiana Burt Davy	Least Concern
Lobelia cuneifolia Link & Otto var, *ananda* E. Wimm.	Least Concern
Marsilea farinosa Launert subsp. *arrecta* J.E. Burrows	Vulnerable
Melolobium subspicatum Conrath	Vulnerable
Miraglossum laeve Kupicha	Least Concern
Nuxia glomerulata (C.A. Sm.) Verdoorn	Least Concern
Prunus africana (Hook f.) Kalkman	Vulnerable
Rennera stellata P.P.J. Herman	Vulnerable
Searsia maricoana (Moffet) Moffet	Vulnerable
Senecio holubii Hutch. & Burt Davy	DDT
Thesium celatum N.E. Br.	DDT
Thesium nationae A.W. Hill	DDT

APPENDIX 7: List of all plant 'species of conservation concern' (*sensu* Raimondo *et al*., 2009) thus far recorded within the 1 495.5ha study area. Buffer zones shown for *Lithops lesliei* subsp. *lesliei* and *Pearsonia bracteata*, are in accordance with the Gauteng Directorate of Nature Conservation guidelines.



APPENDIX 8: Vegetation types of the study area and its immediate surrounds according to the vegetation map of South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006).



APPENDIX 9: North West Biodiversity Sector Plan (NWBSP) 2015 map of Critical Biodiversity areas (NWREAD, 2015) map for the study area.

APPENDIX 10: Photographs of the vegetation and land-cover types identified for the study area.

Unit 1 (Pan wetland): Site 31. Surveyors in central zone of pan behind tussocks of *Diplachne fusca*.

Unit 1 (Pan wetland): Site 31. Seep in basin to north of central zone of pan (foreground).

Unit 2 (Valley-bottom wetlands): Site Su21. Untransformed central zone (discontinuous swale) of unchannelled valley bottom wetland immediately south of footprint of Borrow Area 2.

Unit 2 (Valley-bottom wetlands): Site Su36. Secondary vegetation of central zone of historically ploughed (area recently under centre-pivot irrigation) unchannelled valley-bottom wetland.

Unit 3 (*Acacia karoo* Woodland): Typical A. karoo Woodland patch photographed in adjacent MWS surface rights area (De Castro & Brits, August 2017).

Unit 4 (*Acacia erioloba* Woodland): Site 17. *Acacia erioloba* Woodland patch in natural dolomite sinkhole. Typical sinkhole grassland with high cover of *Bulbine narcissifolia* in foreground.

Unit 5 (Clay Grassland): Site 50. Clay Grassland of Red Clay loam. Heavily grazed.

Unit 5 (Clay Grassland): Site M18. Rocky (diabase) outcrop with Clay Grassland.

Unit 6 (Dolomite Grassland): Site 39. Typical Dolomite Grassland of low chert ridge.

Unit 7 (Sandy Grassland): Site 24. Moribund Sandy Grassland within the Kareerand TSF security area. Grazing and fire have been excluded for a number of years.

Unit 7 (Sandy Grassland): Site 48. Species rich, but heavily grazed Sandy Grassland along quartzitic outcrop.

Unit 8 (Secondary Grassland): Site 42. Heavily grazed secondary grassland on deep, light red-brown clay loam.

Unit 8 (Secondary Grassland): Site 53a. Secondary grassland on deep red-brown, sandy clay loam in lightly grazed, fenced farming area.

Unit 9 (Artificial Wetland): ca. 200m north of Site 30. The thin strip of Artificial Wetland (dominated by dense *Typha capensis* stands) can be seen along the foot of the retaining wall of the TSF.

APPENDIX 11: Photographs of Near Threatened species recorded within the study area.

Figure 1: Lithops lesliei subsp. lesliei on low chert ridge in Dolomite Grassland at Site 39.

Figure 2: *Pearsonia bracteata* on low chert ridge in Dolomite Grassland at Site 11.

Figure 3: *Pearsonia bracteata* on low chert ridge in Dolomite Grassland at Site 8.

APPENDIX 12: Brief Curriculum Vitae for Antonio De Castro.

1. **Name** **: Antonio (Tony) De Castro**
2. **Specialist field** **:** Botanist and Ecologist
3. **Company / consortium** **:** De Castro & Brits Ecological Consultants
4. **Nationality** **:** South African
5. **Date of birth** **:** 17/01/1970
6. **Education**

Name of Institution:	**Degree Obtained:**	**Dates:**
Rand Afrikaans University	BSc Botany and Zoology	1991
Rand Afrikaans University	BSc Hons in Botany	1994

7. Membership of Professional Associations:

Name of Association	**Membership Category:**	**Dates:**
SA Council of Natural Scientists	Professional Natural Scientist in Ecological Science and Botanical Science (Registration number: 400270/07)	2007 to present
SA Wetlands Society	Ordinary Member	2014 to present
International Mire Conservation Group	Ordinary Member	2014 to present

8. Other Training:

Name of Institution:	**Training Details:**	**Dates:**
University of Pretoria	Certificate in Seed Science	1996

9. Countries of Work Experience:

Country	**Dates: from – to**
South Africa	1992 - present
Lesotho	2003, 2005 – 2006, 2011
Swaziland	1999-2006
Mozambique	1996, 2000 - 2005, 2007, 2009, 2010, 2012, 2014, 2015
Botswana	2002
Madagascar	2012
Angola	2009

10. Employment Record

Dates: :	1992 - 1997
Employer:	Rand Afrikaans University (now University of Johannesburg)
Position held:	Part-time Technical Lecturer in the Department of Botany and Research Assistant to Prof. Ben-Erik Van Wyk

Location of Position	Johannesburg
Responsibilities:	Preparation of 3rd Practical Classes. Collection identification and curation of plant material for taxonomic and ethnobotanical research projects. Taxonomic studies in the genus *Alepidea*. Long-term floristic surveys and vegetation sampling in the Zuurberg National Park, Golden Gate National Park and Magaliesburg Protected Natural Environment.
Dates:	1997 - 1999
Employer:	ECOSUN c.c.
Position held:	Senior Botanical and Ecological Consultant.
Location of Position	Johannesburg
Responsibilities:	Responsible for botanical and ecological baseline assessments and Impact Assessments.
Dates:	1999 - present
Employer:	De Castro and Brits Ecological Consultants c.c.
Position held:	Managing Member and Senior Botanical and Ecological Consultant
Location of Position	Johannesburg
Responsibilities:	Botanical and Ecological specialist consultant on projects involving the description of terrestrial, wetland and aquatic ecosystems, the assessment of anthropogenic impacts on these systems and the sustainable utilisation of natural resources. Also coordinating Specialist/Team leader for biophysical aspects of Environmental Impact Assessments, Environmental Management Plans, Strategic Environmental Assessments, Resettlement Plans and Sustainable Utilisation Plans. Specialises in the botany and ecology of the Grassland, Savanna and Forest Biomes.

11. Examples of work undertaken.

Project 1
• Dates (from – to): 2014-2015 • Location: Mozambique. Inhambane Province. Inhassoro District. • Client: Golder Associates on behalf of SASOL Temane (Pty) Ltd. • Main project features: EIA and EMP for the proposed SASOL PSA and LPG development project, comprising the construction of approximately 120km of new hydrocarbon flow lines and 18 new gas and oil wells. • Positions held: Principal Ecologist and Botanist. • Activities performed: Ecologist and Botanist responsible for the description of the wetland and terrestrial habitats and botanical biodiversity of the 49 000ha study area, the identification of potential impacts to habitats and biodiversity and the development of suitable mitigation measures for these impacts. De Castro identified a Critical Habitat (*sensu* IFC) during this study.
Project 2
• Dates (from – to): 2010-2011 • Location: Zinave National Park, Inhambane Province, Mozambique. • Client: EcoAcao Lda on behalf of the Mozambique Government. • Main project features: Ecological Assessment of a 7000ha area within the Zinave National Park earmarked as a breeding area for threatened ungulates.

- Positions held: Ecologist
- Activities performed: Floristic surveys and, together with Professor Noel Van Rooyen, vegetation sampling and mapping, conduction of a grazing and browsing capacity assessment, recommendation of mammal species suitable for introduction, and development of a Management Plan.

Project 3

- Dates (from – to): 2010
- Location: Anglo Coal Landau Colliery, Mpumalanga, South Africa.
- Client: Anglo American: Technical Services
- Main project features: Baseline Ecological assessment and Biodiversity Management Plan, and ongoing Biodiversity Monitoring for the 11 500ha Landau Colliery.
- Positions held: Lead Consultant, Principal Ecologist.
- Activities performed: Vegetation sampling and mapping, compilation of species inventory, alien plant survey, medicinal plant assessment, co-ordination of biological specialists and compilation of a comprehensive Biodiversity Management Plan.
-

Project 4

- Dates (from – to): 2010
- Location: Lesotho and the North West, Gauteng, Free State, Mpumalanga, KwaZulu-Natal and Eastern Cape provinces of South Africa.
- Client: South African National Biodiversity Institute.
- Main project features: National Resource Survey for the medicinal plant *Pelargonium sidoides*.
- Positions held: Lead Consultant and Principal Botanist.
- Activities performed: Field surveys aimed at establishing population size and harvesting pressure on *Pelargonium sidoides*. Co-ordination of a team of three botanists, and main author of the resulting 'National Resource Survey' report.

Project 5

- Dates (from – to): 2008 - 2009
- Location: Linear alignment between Durban and Heidelberg, South Africa
- Client: Mark Wood Consultants on behalf of Petronet
- Main project features: Baseline Vegetation and Faunal Assessment and EIA for the 500km Petronet Multi Products Pipeline alignment situated between Durban and Heidelberg.
- Positions held: Ecologist and Principal Threatened Species Biologist.
- Activities performed: Ecologist responsible for vegetation mapping, threatened species surveys and impact assessment and mitigation for the 220km section of the pipeline between Harrismith and Heidelberg. In the second phase of the project was the principal Threatened Species Biologist leading a team of three biologist responsible for follow-up threatened species surveys and impact mitigation (i.e. route alignment deviations).

Project 6

- Dates (from – to): 2005-2006
- Location: Lesotho highlands. Roma-Semonkong-Sekake Road Construction Project.
- Client: Consult 4 on behalf of the Lesotho Government.
- Main project features: EIA and EMP for road construction project.
- Positions held: Senior Ecologist and EIA.
- Activities performed: Ecologist and Biophysical Specialist Co-ordinator for all biophysical work required for the completion of the EIA and EMP for this 150km long road alignment, including ecological survey (including vegetation and fauna) of the entire road alignment. Author of Biophysical EIA and EMP.

Project 7

- Dates (from – to): 2000 to 2004
- Location: Inhambane Province, Mozambique.

- Client: Mark Wood Consultants on behalf of Sasol (Pty) Ltd.
- Main project features: SASOL Natural Gas Project, comprising gas processing facilities, seismic exploration cutlines and the 520km pipeline route alignment extending from Vilanculos to Ressano Garcia.
- Positions held: Principal Botanist and Ecologist.
- Activities performed: Ecological surveys (including vegetation mapping, floristics and fauna) of 300 000ha Seismic Exploration Block, Temane Central Processing Facility and 520km pipeline route alignment. Specialist surveys conducted include a survey of available commercial timber resources and the sustainable management of these resources.

Project 8

- Dates (from – to): 1999 - 2006
- Location: Maguga Dam, Swaziland
- Client: Maguga Dam Development network
- Main project features: Task MDC-7. Scoping Report, EIA and CMP Reports and Recommendation of Monitoring Programme. Implementation of EMP's for the Reservoir area and the Resettlement area for displaced people.
- Positions held: Senior Botanist, Co-ordinator of all biological specialist, Biophysical EIA Co-ordinator and author.
- Activities performed: All Ecological aspects of the Review of Task MDC-6, all Botanical studies required for the completion of the environmental studies (including a Scoping Report, EIA & CMP Reports and Recommendation of Monitoring Programme). Supervision and Monitoring of implementation of EMP's for the Reservoir area and the Resettlement area for displaced people. Co-ordination of all biological specialists and writing of EMP, CMP and Monitoring Plans for Reservoir and Host Area. Botanical surveys included vegetation mapping, floristic surveys, threatened and medicinal plant surveys, and wood resources surveys, as well as monitoring of all these aspects.

12. Certification:

I, the undersigned certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience.

Signature: **Date:** February, 2016

APPENDIX 13: Specialist Declaration.

I, Antonio D. P. De Castro, declare that I –

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

Antonio D.P. De Castro 22nd of January 2018