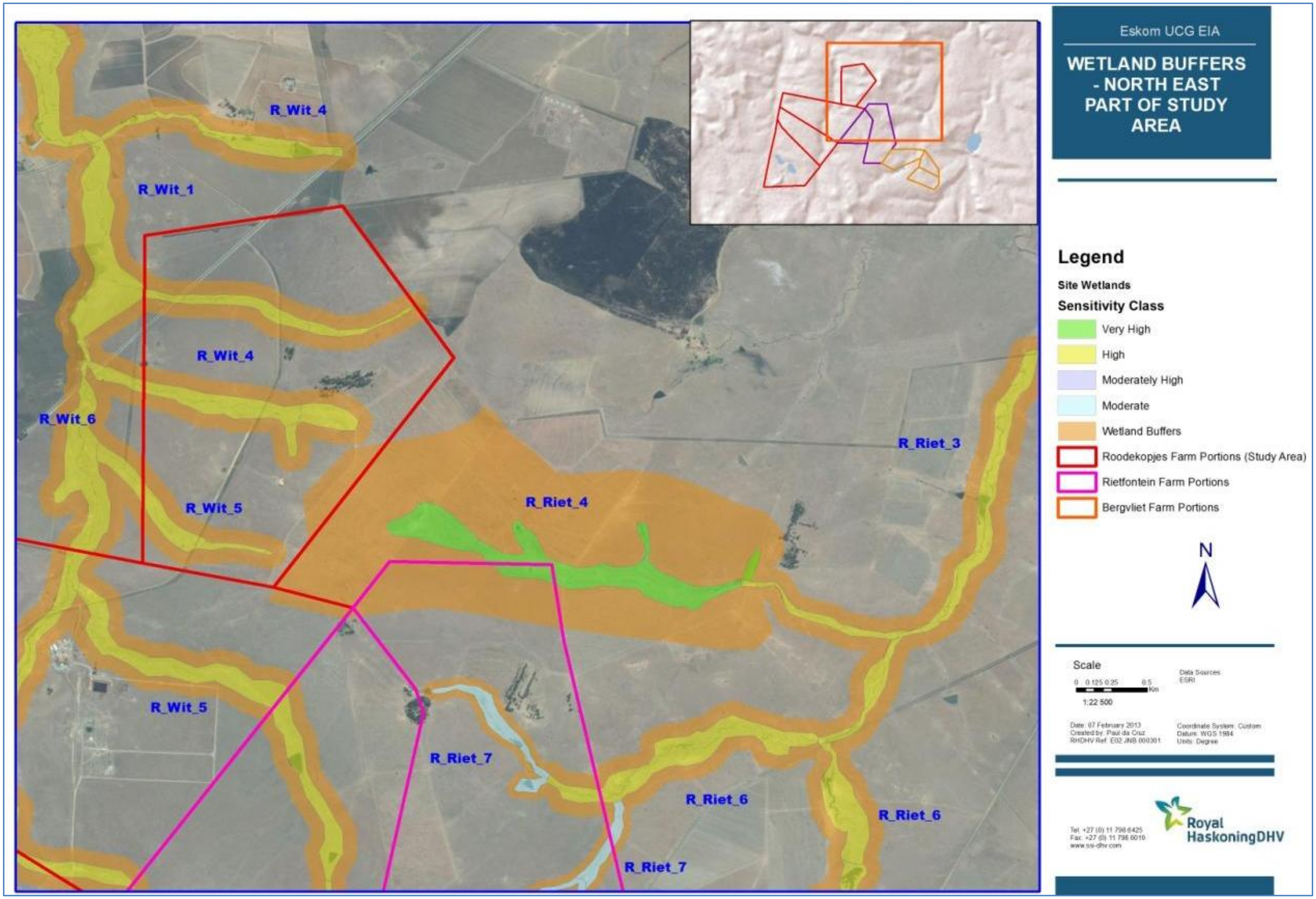


Figure 45: Wetlands and associated buffers – north-east part of the study area

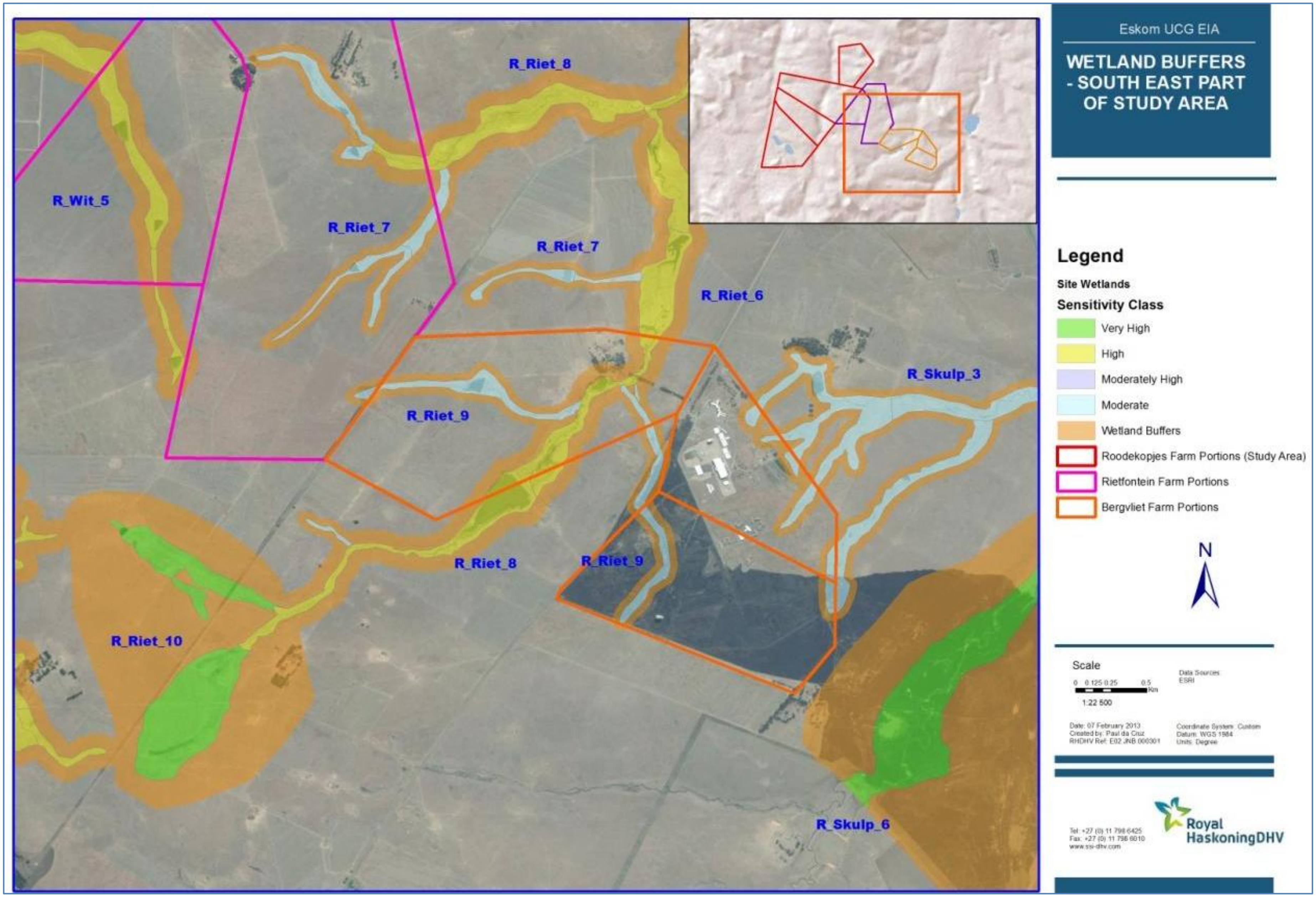


Figure 46: Wetlands and associated buffers – south-east part of the study area

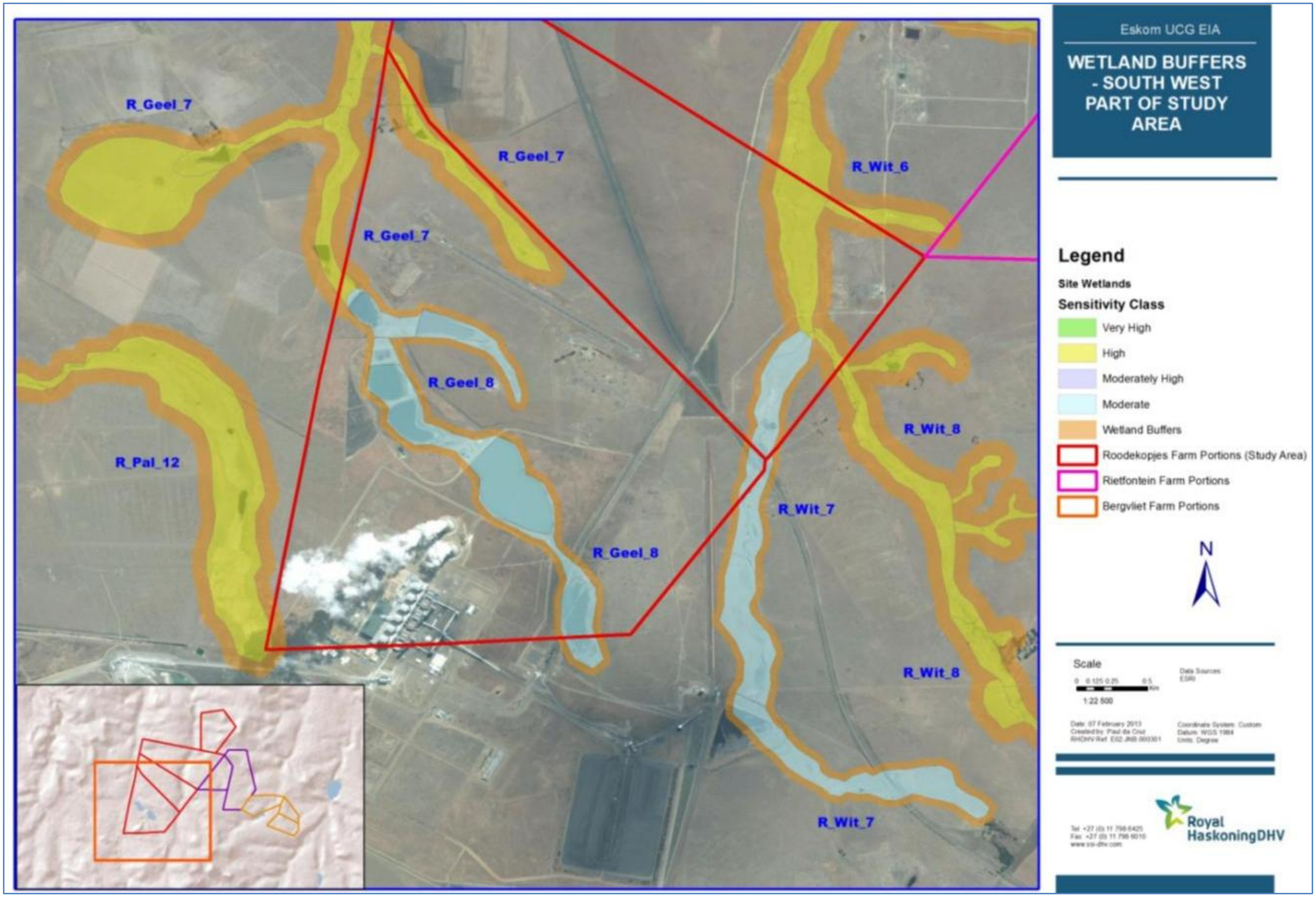


Figure 47: Wetlands and associated buffers – south-west part of the study area

6.6 Soils and Agricultural Potential

The interpretation of the land use, land capability and reconnaissance soil survey results yielded a number of aspects that are of importance to project.

6.6.1 Crop Production

The soils found on the site are generally of medium to low agricultural potential (dryland and irrigated cropping) due to a number of reasons. These are:

- The soils are generally shallow with thin soil profiles overlying weathering rock or distinctly higher clay content sub-soils.
- The soils on the site are generally poorly drained with poor internal drainage that hampers aeration. These conditions are problematic during high rainfall years.
- Due to the high clay content and shallow nature of most of the soils they tend to hold limited quantities of water. This is a restricting factor during low rainfall years.
- Due to the abundance of rocks as well as the presence of strongly developed structure in most of the soils they are difficult to manage and tilling is very challenging.
- Due to the poor drainage as well as the presence of swelling clay throughout the landscape the soils are very susceptible to erosion.

6.6.2 Soil Erosion and Degradation

The soils on the site are very susceptible to erosion. The susceptibility stems from the presence of swelling clays. These clays lead to low water infiltration rates into the soil meaning that surface run-off is a regular occurrence during rainfall events. Once the soil is exposed (through the removal of the vegetation cover or other disturbances) the swelling nature of the clays contributes to dispersive properties of the soil. Under these conditions there is no cohesion between soil particles and they are therefore readily dislodged and transported by water. This aspect is a very real threat to the stability of most of the soils on the site, especially those in drainage depressions and lines. As such eroded stream channels are observed throughout the site.

6.6.3 Derived Soil Quality Parameters

Table 38 provides the estimated soil quality parameters for the site as well as their status. It is important to note that the natural fertility of the high potential soils is considered to be low. These soils only attain their true potential after adequate fertilization.

Table 38: Estimated soil quality parameters for the various soil groups

Soil Group	Natural Fertility	Erodibility	Dry-land crop production potential	Irrigation potential
Shallow and rocky soils on convex topography	High	Medium	Low	Low
Variable depth structured soils in flat terrain outside drainage depressions	Medium to High	Medium	Low to Medium	Low
Structured and swelling soils in drainage depressions (concave topography)	High	Medium to High	Low	Very Low

6.6.4 Agricultural Potential

The agricultural potential of the soils on the farm Roodekopjes 67HS is considered to be low in terms of crop production but medium to high in terms of extensive grazing. This is mainly due to the shallow and rocky nature of the soils as well as their swelling properties.

Post-mining agricultural potential depends to a very large extent on the rehabilitation efforts by the Eskom. The baseline agricultural potential is low though meaning that at best the post-mining agricultural potential will also be low.

6.6.5 Potential Impacts

In terms of soils, impacts are described as different forms of soil degradation.

Soil degradation can be divided into the following classes and subclasses:

- Physical degradation:
    - Compaction;
    - Surface crusting;
    - Erosion; and
    - Structural degradation / hardsetting.
- Chemical degradation:
    - Eutrophication:
        - Nitrogen; and
        - Phosphorus.
    - Soil organic carbon losses or alteration;
    - Trace element and heavy metal pollution;
    - Acidification;
    - Salinisation and sodification; and
    - Nutrient mining.
- Biological degradation:
    - Soil microbial activity decrease / increase; and
    - Soil borne human, animal and plant pathogens.
- Soil quality deterioration (compound effects);
- Soil health deterioration; and
- Soil destruction.

Table 39: List of activities and their associated forms of soil degradation

Activity	Form of Degradation
Construction	
Drilling of holes and associated vehicle movement	Physical degradation (surface)
Construction of manifold system and pipes	Physical degradation (surface)
Construction of temporary buildings and other infrastructure	Physical degradation (compound)
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation
Operations	
Operation and gas extraction	No additional degradation
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation
Decommissioning	
Capping and sealing of boreholes	No additional degradation
Removal of manifold system and pipes	No additional degradation
Rehabilitation of access roads and drill areas	No additional degradation
Vehicle operation on site	Physical and chemical degradation (hydrocarbon spills)
Dust generation	Physical degradation
Dust suppression	Chemical degradation

6.6.6 Recommendations

The soils found on the site of the proposed Eskom UCG project are mainly restricted to structured soils of shallow to variable depth.

These soils can be divided into three (3) main categories namely:

a. Shallow and rocky soils on convex topography;
b. Variable depth structured soils in flat terrain outside drainage depressions; and
c. Structured and swelling soils in drainage depressions (concave topography).

The soils found on the site pose a challenge in terms of wetland delineation due to their specific chemical and mineralogical composition. The main land-use is grassland used for extensive grazing. A limited area is used for dryland agriculture and the agricultural potential of these areas is relatively low due to the dominance of structured and limited depth soils.

The proposed mining process will impact large areas but soil conditions will not be altered drastically due to the characteristics of the soils. In the case of swelling soils their self-mulching nature will lead to the disappearance of small disturbances over time. It is anticipated that the grazing potential of the impacted areas will be negatively impacted but it is possible that this potential will improve with time as the signs of impacts fade.

The major risk to the soils is erosion due to the removal of the vegetation cover. All mining construction activities should take into account the erodibility of the soils and make provision for its prevention.

6.7 Biodiversity

6.7.1 Flora

A total of 185 plant species were recorded during the various site investigations (refer to the Biodiversity Report – **Appendix K**). The regional setting within the Grassland Biome dictates the physiognomic dominance of the herbaceous component with 100 (one hundred) forb species and 41 (forty-one) grass species. Trees are present as low shrubs or as stands of exotics. The species composition of untransformed grasslands is regarded representative of the principal regional vegetation type. A total of 47 (forty-seven) plant families were recorded in the study area, dominated by the Poaceae and Asteraceae families.

SANBI records for the region and survey results indicate the presence of eight (8) flora species of conservation importance, none of which are threatened:

- *Acalypha caperonioides* var. *caperonioides* (Data Deficient);
- *Boophone disticha* (Declining);
- *Crinum bulbispermum* (Declining);
- *Eucomis autumnalis* (Declining);
- *Ilex mitis* var. *mitis* (Declining);
- *Khadia alticola* (Rare);
- *Lobelia erinus* (Near threatened); and
- *Nerine platypetala* (Insufficiently known).

The following provincially protected species were recorded within the study area (Mpumalanga Nature Conservation Act No. 10 of 1998):

- *Boophone disticha*;
- *Crinum bulbispermum*; and
- *Gladiolus* species.

The photo analysis and site investigations revealed the presence of the following floristic habitat types:

- **Agricultural Areas (18.2%, Low floristic sensitivity)**

Cultivation represents the major land transformation activity in the region, resulting in a mosaical pattern of agricultural fields within a natural grassland environment. These areas include lands that are either currently actively cultivated for crops, or fallow fields where agricultural activities has ceased some time ago, but the vegetation still reflects the impact of transformation. No Red Data plant species were recorded within these parts. The likelihood of encountering Red Data plant species within these parts is low, mainly as a result of habitat transformation.

- **Degraded Grassland Habitat (3.3%, Low floristic sensitivity)**

Vegetation of these parts is frequently impacted by mowing activities that result in a significantly altered species composition while the physiognomy reflects that of cultivated pastures. The species *Eragrostis curvula*, *E. chloromelas*, *Hyparrhenia hirta* and *Hyperthelia dissolute* are usually particularly dominant and is also a good indicator of the secondary climax status that resulted through succession from a historic disturbance, such as over-grazing or recent pastural practices. No conservation important species were recorded within these areas. The likelihood of encountering Red Data plant species within these areas are regarded low as a result of habitat transformation.

- **Exotic Stands (0.3%, Low floristic sensitivity)**

This habitat type comprises all areas where natural vegetation has been replaced by stands of exotic trees, mostly Eucalyptus species. These areas are frequently in proximity to homesteads and were introduced by settlers or subsequent residents to serve as wind- or visual breaks on the open grasslands.

- **Moist Grassland / Grassland Seepages (1.4%, Low floristic sensitivity)**

This vegetation type is generally termed 'hydromorphic grasslands' or 'ephemeral moist grasslands' and constitutes grassland that occur in-between terrestrial and aquatic systems, usually situated on terrain type 4 (footslopes) in close vicinity to valley bottoms (drainage lines, streams, rivers). Moist conditions are indicated by the presence of several sedges as well as the grasses *Agrostis eriantha*, *Andropogon huillensis*, *Aristida junciformis*, *Fingerhuthia africana*, *Helictotrichon turgidulum*, *Leersia hexandra* and *Setaria nigrirostris* as well as the forbs *Berkheya carlinopsis*, *Boophone disticha*, *Chironia palustris*, *Crinum bulbispermum*, *Senecio achilleifolius* and *Rumex* species. No Red Listed flora species were observed during the site investigation. Habitat is considered particularly suitable for the presence of conservation important flora species.

- **Natural Grassland Habitat – Amersfoort Variations (61.0%, Low floristic sensitivity) (Dominant vegetation type)**

The natural grassland of the study areas are characterised by a short, low cover of herbaceous species, physiognomically dominated by grasses. The floristic status of these parts is largely determined by the intensity of grazing by cattle and sheep. Areas subjected to lower grazing pressure comprises vegetation with a higher floristic status and species diversity. The species diversity in these parts is more diverse, comprising a high degree of forbs and geophytes in particular, including *Boophone disticha*, *Gladiolus crassifolius*, *Gladiolus* species, *Hypoxis iridifolia*, *H. obtusa* and *H. rigidula*. Areas where high grazing pressure predominate is characterised by a vegetation that exhibits high abundance values of the grasses *Eragrostis plana*, *E. chloromelas*, *Cynodon dactylon* and the forbs *Cirsium vulgare*, *Berkheya carlinopsis*, *Alternanthera pungens* and *Crepis hypochoeridea*. No plant species of conservation importance was recorded within these parts of poor quality grasslands. The likelihood of encountering Red Data plant species within these areas are regarded medium as a result of moderate habitat status; pristine areas are however regarded suitable for the potential presence of Red Data flora species.

- **Transformed Habitat (8.9%, Low floristic sensitivity)**

This habitat type represents areas where historical or recent human activities led to transformation of the natural vegetation. No natural vegetation remains in these areas and the floristic status of these areas is therefore regarded low as a result of the secondary vegetation that characterises this habitat type. The likelihood of encountering Red Data species within these areas are regarded low.

- **Wetland / Riparian Habitat (7.0%, Low floristic sensitivity)**

The floristic status of these areas is regarded high and few impacts, other than high grazing pressure are noted. However, an impact that does affect the status of these areas adversely is damming practices of upstream catchment areas, causing changes in the flow patterns and soil moisture content in downstream areas. Trampling of the topsoil by cattle as well as infestation of the streambed by terrestrial species, imported by means of droppings and physical transportation methods, result in species changes in some areas.

Species that were frequently encountered in these parts include the grasses *Leersia hexandra*, *Brachiaria eruciformis*, *Eragrostis plana*, *Paspalum scrobiculatum*, *P. dilatatum*, *Arundinella nepalensis*, *Fingerhuthia africana*, the hydrophilic species *Cyperus* species, *Typha capensis*, *Oxycarpus* species, *Scirpus* species and the forbs *Polygonum lapathifolia*, *Senecio achilleifolius*, *S. inornatus*, *Oenothera rosea*, *Crinum* species, *Falkia oblonga*, *Denekia capensis*, *Helichrysum aureonitens*, *Haplocarpha lyrata*, *Rumex* species, species and *Eucomis* species. The tree *Salix babylonica* frequently infests the streambanks. Taking the Red Data species that occur in the region into consideration, these areas are highly suitable for the potential present of these species. No Red Data species were however recorded during the investigation period.

6.7.2 Fauna

- A total of 12 (twelve) butterflies are known from the ¼-degree grid that is sympatric to the study area. Ten species were recorded during the site investigation. No Red Data species are known from the Q-grids of the study area.
- A total of 15 (fifteen) frog species are listed for the study area and no Red Data species are known to occur in the region.
- A total of 17 (seventeen) reptile species are listed for the study area, including the Red Data species Sungazer lizard (*Cordylus giganteus*, VU) which was recorded during the site investigations and are also known to occur in several localities in the region.
- A total of 318 (three hundred and eighteen) bird species are listed for the Q-grids of the study area, including 37 (thirty-seven) Red Data species. Sixty-three species were recorded during the site visit, including five (5) Red Data species; Botha's Lark (EN), Secretarybird (NT), Blue Korhaan (NT), Bald Ibis (VU) and Black Harrier (VU); and a total of 39 (thirty-nine) mammal species are listed for the region, including 10 (ten) Red Data species. Seven (7) mammal species were recorded during the site visit.

The following habitat types were recognised in the study area:

- **Agricultural Areas (Low faunal sensitivity)**

No natural habitat remains in this unit as all vegetation has been removed for agricultural purposes. The faunal diversity of this area is extremely low and comprises common bird and mammal species that are associated with transformed habitat types.

- **Degraded Grassland Habitat (Medium-low faunal sensitivity)**

Species to be expected in the degraded faunal habitat of the study area include Brown-veined White, African Migrant, African Monarch, Cupreous Blue, Broad-bordered Grass Yellow, Citrus Swallowtail, Boettger's Caco, Guttural Toad, Common Egg Eater, Mole Snake, Grey Heron, Cattle Egret, Hadeda Ibis, Egyptian Goose, Swainson's Spurfowl, Common Quail, Crowned Lapwing, Rock Dove, Cape Turtle-Dove, Laughing Dove, Speckled Mousebird, Black-backed Jackal and Natal Multimammate Mouse.

It should be noted that representative parts of this habitat is situated in close proximity to high sensitivity habitat and will therefore perform an important role in terms of connectivity. A medium-low faunal sensitivity is nonetheless attributed, mainly as a result of the absence of any habitat characteristics that are associated with sensitive fauna species.

- **Exotic Stands (Low faunal sensitivity)**

Stands of exotic trees are useful in providing shelter for a select number of fauna species. It is a well-known area of roosting and nesting for species such as Lesser Kestrel (*Falco naumanni*, VU), Amur Falcon (*Falco amurensis*) as well as for a number of terrestrial species. However, these areas are ultimately still considered as transformed and the utilization of these areas is necessary adaptations rather than indications of good faunal habitat. The faunal diversity of this area is extremely low and comprises some bird species that are frequently associated with transformed habitat types.

- **Moist Grassland / Grassland Seepages (High faunal sensitivity)**

This habitat type is located adjacent to the riparian zones in the north-eastern corner of the study area. It is well-connected to other areas of natural terrestrial grassland as well as riparian habitat. The moist grassland habitat is therefore estimated to have a high faunal sensitivity.

- **Natural Grassland Habitat (Medium-high faunal sensitivity)**

Several Red Data species (Sungazer lizard, Bald Ibis, Secretary bird, Blue Korhaan) were observed in this habitat type, rendering these habitat fragments high in faunal sensitivity.

- **Transformed Habitat (Low faunal sensitivity)**

These parts have low ecological value and biodiversity potential and are consequently considered to have a low faunal sensitivity with regards to the proposed project.

- **Wetland / Riparian Habitat (Low faunal sensitivity)**

The aquatic nature of this unit renders it extremely sensitive in terms of faunal attributes. As a result of the transformation of immediate surrounds (agriculture) the functionality of these parts are fairly low. The conservation of these areas is nonetheless advocated and the connectivity with the nearby Riparian Fringes should be improved by means of basic landscaping.

Habitat types that exhibit high faunal sensitivities are frequently strongly associated with important ecological habitat types such as wetlands, outcrops and pristine grassland habitat types. Red Data species are frequently recorded in these areas and a high likelihood is frequently ascribed to the potential presence of such species. The continued preservation of these habitat types, with particular reference to ensuring a high connectivity, is an important step in conserving the natural and sensitive faunal assemblages of the region.

6.7.3 Ecological Sensitivity

Results of the respective floristic, faunal, wetlands and soils sensitivity analysis were combined to present an overview of the ecological sensitivity of the study area (**Appendix K**). In order to present the reader with an indication of the ecological sensitivity of the respective communities, the highest sensitivity for each ecological unit is selected as being representative of the ecological sensitivity of the specific ecological unit. Results are determined in **Figure 42**.

Table 40: Ecological sensitivity of the study area

Community	Floristic Sensitivity	Faunal Sensitivity	Ecological Sensitivity
Agricultural Fields	Low	Low	**Low**
Degraded Grassland	Low	Medium-low	**Medium-low**
Exotic Stands	Low	Low	**Low**
Moist Grassland	High	High	**High**
Natural Grasslands	Medium	Medium-high	**Medium-high**
Wetland Habitat	High	High	**High**
Transformed Areas	Low	Low	**Low**

Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes. The status of these areas is moderately pristine and are therefore considered suitable habitat for a variety of conservation important flora and fauna taxa. Unfortunately these areas are relative small in size and are not well represented in the general region.

A medium-high ecological sensitivity is exhibited by the natural grassland areas of the study area, particularly as a result of the presence of several conservation important taxa and the high suitability of these areas for Red Data species.

The largest extent of the study area exhibits low and medium-low ecological attributes and the proposed activity is not expected to result in significant impacts in these areas.

6.7.4 Potential Impacts

6.7.4.1 Destruction of Threatened Flora Species

This impact is regarded a direct impact as it results in the physical damage or destruction of Red Data or Threatened species or areas that are suitable for these species, representing a significant impact on the biodiversity of a region. Threatened species, in most cases, do not contribute significantly to the biodiversity of an area in terms of sheer numbers as there are generally few of them, but a high ecological value is placed on the presence of such species in an area as they represent an indication of pristine habitat conditions. Conversely, the presence of pristine habitat conditions can frequently be accepted as an indication of the potential presence of species of conservation importance, particularly in moist habitat conditions.

Red Data species are particularly sensitive to changes in their environment, having adapted to a narrow range of specific habitat requirements. Habitat changes, mostly a result of human interferences and activities, are one of the greatest reasons for these species having a threatened status. Surface transformation / degradation activities within habitat types that are occupied by flora species of conservation importance will ultimately result in significant impacts on these species and their population dynamics. Effects of this impact are usually permanent and recovery or mitigation is generally not perceived as possible.

One of the greatest drawbacks in terms of limiting this particular impact is that extremely little information is available in terms of the presence, distribution patterns, population dynamics and habitat requirements of Red Data flora species in the study area. In order to assess this impact an approach it is therefore necessary to assess the presence/ distribution of habitats frequently associated with these species. Furthermore, by applying ecosystem conservation principles to this impact assessment and subsequent planning and development phases, resultant impacts will be limited to a large extent.

The presence of Red Data flora species within the study area was confirmed during the site investigations. Furthermore, the likelihood of other Red Data flora species occurring within the parts of the study area is likely as these areas were found to be highly suitable for these species.

6.7.4.2 Direct Impacts on Threatened Fauna Species

Direct threats to threatened fauna species is regarded low in probability, mainly as a result of the ability of fauna species to migrate away from areas where impacts occur, also considering the type of development and activities. Probably the only exception to this statement will be in the event where extremely localised habitat that are occupied by threatened fauna species are impacted by construction and operational activities to the extent that the habitat no longer satisfy the habitat requirements of the particular species, or where an increase in the isolation and fragmentation factors renders the remaining habitat inadequate. Specific reference is made of riparian and moist grassland habitat types that occur in the study area as well as certain grassland areas where the Sungazer lizard occurs.

Most of the threatened fauna species potentially occurring in the study area have relatively wide habitat preferences and ample suitable habitat is presently available throughout the study area. To place this aspect into context, it is estimated that habitat loss and transformation resulting from often overlooked impacts, such as overgrazing, infestation by invasive shrubs and agriculture probably contribute more to impacts on most threatened fauna species than this development. However, some Red Data fauna species occur that have specific habitat requirements.

The presence of Red Data fauna species was confirmed during the site investigations. Furthermore, the likelihood of other Red Data fauna species occurring within the parts of the study area is likely as these areas were found to be highly suitable for these species.

6.7.4.3 Destruction of Sensitive / Pristine Habitat Types

The loss of pristine habitat types or habitat that are regarded highly sensitive due to limited presence in the larger region (atypical habitat) represents a potential loss of habitat and biodiversity on a regional scale. Sensitive habitat types include mountains, ridges, koppies, wetlands, rivers, streams and localised habitat types of significant physiognomic variation and unique species composition. These areas represent centres of atypical habitat and contain biological attributes that are not frequently encountered in the greater surrounds. A high conservation value is generally ascribed to floristic communities and faunal assemblages that occupy these areas as they contribute significantly to the biodiversity of a region.

Furthermore, these habitat types are generally isolated and are frequently linear in nature, such as rivers and ridges. Any impact that disrupts this continuous linear nature will risk fragmentation and isolation of existing ecological units, affecting the migration potential of some fauna species adversely, pollinator species in particular.

Micro-habitat conditions are changed as a result of the removal of the vegetation layer, affecting shade conditions, habitat competition, germination success of the herbaceous layer, etc. and is likely to result in the establishment of a species composition that is entirely different than original conditions and the immediate surrounds, in many cases also comprising species of an invasive nature, particularly shrubs.

Extensive parts of the study area are regarded highly sensitive and are highly likely to be occupied by a diverse species composition as well as flora and fauna species of conservation importance.

6.7.4.4 Direct Impacts on Common Fauna Species

The likelihood of this impact occurring is relatively low as a result of the ability of animal species to migrate away from direct impacts. The tolerance levels of common animal species occurring in the study area is of such a nature that surrounding areas will suffice in habitat requirements of species forced to move from areas of impact. It is also unlikely that the conservation status of common animal species will be affected as a result of direct and indirect impacts of power lines on these species and their habitat.

The extensive nature of the existing development has resulted in direct impacts on fauna species, in spite of the ability to avoid direct contact. It is however noted that the impact will be limited to small areas within the existing site area during construction-like activities.

6.7.4.5 Floristic Species Changes Subsequent to Development

This impact is regarded an indirect impact. The transformation of grassland habitat during the construction process will inevitably result in the establishment of habitat types that are not considered representative of the region. While the impacts are generally regarded to be of low severity, impacted areas are frequently invaded by species not normally associated with the region (exotic and invasive species). In addition, many species that are not necessarily abundant in the region will increase in abundance as a result of more favourable habitat conditions being created as a result of habitat manipulation activities (encroacher species). This effect is more pronounced in the floristic component, but changed habitat conditions in the habitat will inevitably imply changes in the faunal component that occupies the habitat.

If left unmitigated, this risk will result in decreased habitat, increased competition and lower numbers of endemic biota, the genetic pool of species might eventually be influenced by the introduction of non-endemic species.

Different faunal assemblages and plant communities have developed separate gene structures as a result of habitat selection and geographical separation and the introduction of individuals of the same species that might be genetically dissimilar to the endemic species might lead to different genetic selection structures, eventually affecting the genetic structure of current populations and assemblages.

Construction will result in alteration of the vegetation in parts of the study area and it is likely that the current vegetation will become infested with weeds and invasive species.

6.7.4.6 Faunal Interactions with Structures, Servitudes and Personnel

It should be noted that animals generally avoid contact with human built structures, but do grow accustomed to structures after a period. While the structures are usually visible as a result of clearance around footprints areas, injuries and death of animals do occur sporadically as a result of accidental contact. An aspect that is of concern is the presence of vehicles on access roads and infrastructure servitudes, leading to road kills, particularly amongst nocturnal animals that are abundant in the study area. This impact was frequently observed in the study area during the site investigation period.

Alteration of habitat conditions within the development areas does not necessarily imply a decrease in faunal habitation. These areas are frequently preferred by certain fauna species. The establishment of a dominant grass layer generally results in increased presence of grazer species, which might lead to an unlikely, but similar increase in predation within these areas.

The presence of personnel within the development area during construction and maintenance periods will inevitably result in some, but normally limited, contact with animals. While most of the larger animal species are likely to move away from human contact, dangerous encounters with snakes, scorpions and possibly larger predators always remain likely. Similarly, the presence of humans within areas of natural habitat could potentially result in killing of animals by means of snaring, poaching, poisoning, trapping, etc.

The nature of the development has at most resulted in indirect impacts on the movement patterns of fauna species in some parts.

6.7.4.7 Impacts on Surrounding Habitat / Species

Surrounding areas and species present in the direct vicinity of the study area could be affected by indirect impacts resulting from construction and operation activities. This indirect impact could potentially include all of the above impacts, depending on the sensitivity and status of surrounding habitat and species as well as the extent of impact activities. Considering the type of development, the extent of this impact is expected to be relatively small.

The indirect nature of this impact dictates that potential impacts spreading from the construction-like activities into bordering areas is likely to affect natural habitat adversely.

6.7.4.8 Cumulative Impact on SA's Conservation Obligations and Targets

This impact is regarded a cumulative impact since it affects the status of conservation strategies and targets on a local as well as national level and is viewed in conjunction with other types of local and regional impacts that affects conservation areas. The importance of regional habitat types is based on the conservation status ascribed to vegetation types, which include an Endangered (Soweto Highveld Grassland) and Vulnerable (Amersfoort Clay Highveld Grassland) vegetation types. In spite of limited transformation indicated by the development process, a loss of pristine parts of these vegetation types is nonetheless expected.

Loss of parts of the Endangered and Vulnerable grassland vegetation types is a limited, but nonetheless important, indirect impact on the conservation status of the regional vegetation types.

6.7.4.9 Cumulative Increase in Local and Regional Fragmentation / Isolation of Habitat

Uninterrupted habitat is a precious commodity for biological attributes in modern times, particularly in areas that are characterised by moderate and high levels of transformation. The loss of natural habitat, even small areas, implies that biological attributes have permanently lost that ability of occupying that space, effectively meaning that a higher premium is placed on available food, water and habitat resources in the immediate surrounds. This, in some instances might mean that the viable population of plants or animals in a region will decrease proportionally with the loss of habitat, eventually decreasing beyond a viable population size.

The danger in this type of cumulative impact is that effects are not known, or is not visible; with immediate effect and normally when these effects become visible they are beyond repair. Linear developments affect the migratory success of animals in particular.

An important mitigation measure in this regard is to utilise existing causal factors of habitat fragmentation. One factor that will be taken into consideration is the presence of existing power lines in the study area. Habitat fragmentation will not be increased significantly when new power lines are placed adjacent to existing lines or other types of linear structures, such as roads. In contrast, constructing new power lines through areas of unfragmented habitat, the adverse effects of habitat fragmentation and isolation will be maximised. Therefore, where potential servitudes are presented with similar sensitivities, a potential corridor with an existing servitude might result in one being more suitable for the proposed development than an option affecting an area of largely untransformed habitat. Unfortunately this is not always a clear-cut case as it is heavily dependent on the local and regional sensitivity of the existing line, which might be located in areas of high sensitivity, while a line going through untransformed habitat might represent impacts of lower significance in terms of other types of impacts.

Although the general region is characterised by moderate levels of transformation, this ongoing operation / maintenance forms part of a series of impacts on remaining natural habitat in the region.

6.7.4.10 Cumulative Increase in Environmental Degradation

Cumulative impacts associated with this type of development will lead to initial, incremental or augmentation of existing types of environmental degradation, including impacts on the air, soil and water present within available habitat. Pollution of these elements might not always be immediately visible or readily quantifiable, but incremental or fractional increases might rise to levels where biological attributes could be affected adversely on a local or regional scale. In most cases are these effects are not bound and is dispersed, or diluted over an area that is much larger than the actual footprint of the causal factor.

Similarly, developments in untransformed and pristine areas are usually not characterised by visibly significant environmental degradation and these impacts are usually most prevalent in areas where continuous and long-term-impacts have been experienced. Particular reference is made to the use of treated process water for irrigation.

6.7.4.11 Impacts associated with the New Service Road

The extent and significance of the proposed new service road is expected to be significant and severe, as it will result in the construction of an entirely new road. In particular, sensitive habitat, such as wetlands and natural grassland (Amersfoort variation, Vulnerable) will be affected adversely by the construction / maintenance and operational activities. The natural grassland component, which was ascribed a medium-high ecological sensitivity, will comprise approximately 64% of the proposed route. Alternatives to limit the construction / maintenance of additional watercourse crossings should be investigated.

The increase in habitat fragmentation and isolation are particularly important aspects that need to be minimised.

6.7.4.12 Wetland Undermining

Effects of surface dewatering remain one of the most significant impacts that could potentially destroy wetlands within the affected areas. The assessment of potential and likely impacts indicates a significant impact on the status and functionality of affected wetlands. A precautionary approach is therefore strongly recommended in this instance. Furthermore, surface impacts resulting from activities near, or within, the wetland areas (including channelled valley bottoms and hillslope seepages), are likely to result in significant adverse impacts on the status and functionality of the wetlands. Refer to further impacts to wetland ecology in **Section 6.5** (Wetlands).

6.7.5 Recommendations

Considering the types of activities that will take place during the construction and decommissioning phases, impacts on sensitive biodiversity attributes are nonetheless expected to occur, notwithstanding the implementation of mitigation measures, hence the relative high level of impact significance rating after the implementation of mitigation measures. Direct impacts on Red Data flora and fauna species as well as potential destruction of natural habitat are regarded unavoidable and it is strongly recommended that sensitive habitat types be excluded from the proposed development. One of the potential problems that will be encountered is the presence of Red Data fauna species within natural grassland habitat. An existing programme is in place where Sungazer lizards are located and removed to a suitable locality prior to the commencement of construction activities. This programme should be expanded to include other Red Data fauna and flora species and relevant identification and location programmes should be launched in the summer period when these species are most prevalent.

Furthermore, construction and operational activities should be timed to coincide with the most likely absence of migratory species, i.e. the winter period. Areas that should be entirely excluded from the proposed development include outcrops and ridges as well as the wetland/ riparian habitat types. In addition, a suitable buffer zone around these areas should also be included as part of a “no-go” zone. It was furthermore indicated that limited areas of moist grassland habitat will be affected by the proposed activity, but construction will be planned in such a manner that minimal infrastructure is placed within these areas. While any impact within this highly sensitive habitat is regarded severe, significant and undesirable, it was indicated that the exclusion of these areas will result in severe effects on the livelihood of the project. It is therefore strongly recommended that should this activity be allowed within this sensitive habitat type, site specific mitigation measures be put into place in order to prevent, monitor and control activities within these areas.

Areas of lower ecological sensitivities are not expected to be affected significantly by the proposed development and the implementation of generic mitigation measures are expected to prevent significant impacts. These areas should ideally be utilised for the placement of any new footprints for infrastructure and other activities that could potentially affect more sensitive areas. In addition to the proposed extraction of gas from the area, it was also indicated that excess water utilised during the process will be stored in the process water dam and utilised for irrigation of agricultural areas since it is rich in nutrients commonly used for soil enrichment. Extreme caution needs to be taken during the process so that this water does not affect nearby riparian and wetland environments, particularly in view of the proximity of some agricultural areas to riparian environments.

6.8 Waste

The UCG process has some inherent process benefits that are commensurate with the National Integrated Waste Management Strategy in terms of waste minimisation.

The waste impact associated with traditional mining operations in terms of waste ore and ash is not existent due to the in-situ and underground coal gasification process. The extraction of gas and its conversion to energy has followed a process of least waste production.

The waste stream of concern is related to the high total dissolved solids condensate stream. This stream also has concentration of hydrocarbon-based toxics that can pose a risk to the environment. This stream has been addressed in terms of the advanced wastewater treatment plant which results in a final treated effluent stream with low levels of TDS and toxic hydrocarbons such as poly-aromatic hydrocarbons (PAH) and phenols. The treatment is via an efficient route of activated carbon adsorption. The brine-rich residual waste stream has been to date disposed of to a designated landfill site. However, Eskom will also consider other options such as recovery and re-use option for the brine stream going forward in the parallel EIA process and forwards in the ongoing research process.

6.8.1 Potential Impacts

Table 41: Potential impacts

Phase	Potential Impacts
Construction	• Contamination of surface during drilling with machine oils • Contamination of site with general and hazardous waste during construction
Operations	• Leakage of combustion condensate onto land along pipeline route • Untreated water discharge into environment • UCG condensate treatment and proposed irrigation • Leakage of hydrocarbons in the gas treatment plant • Improper disposal of admin-based waste water, brine, solid sludge and particulates and spent activated carbon
Decommissioning	• Similar to construction phase impacts in terms of general and hazardous waste generation and disposal • Ingress of upper groundwater into combustion void with consequent build-up of contaminants of concern (oils, salts and metals)

6.8.2 Recommendations

It is recommended that the monitoring, analysis and reporting for the various process and effluent streams continue so that there is an adequate databank of objective information to fully comprehend the impact of the proposed development.

The Integrated Water and Waste Management Plan (IWWMP) for the ongoing Eskom UCG Project as it unrolls has been undertaken within the context of latest environmental legislation in South Africa. The legislative underpinnings and key management strategies relate to pollution prevention, waste minimisation, adoption of the precautionary principle, integrated water and water management, cradle to grave analysis and management and all measures that are protective of water resources.

The IWWMP has been backed up by Environmental Scoping Studies in the parallel EIA process, various specialist studies that have a bearing on IWWMP, and the compendium of hydrogeological studies, modelling and ground and surface water monitoring spanning several years. The proposed development has adopted a precautionary approach of ensuring opportunity for collection of baseline "no development" scenario and the gradual stepping up of UCG syngas production.

Undoubtedly the overall system of the three (3) aquifers and its interaction with surface ecology and water systems needs to be well understood and scientifically management with the requisite regulatory measures in place. Ultimately the development after due consideration needs to proceed with clear licences and permits for water usage, generation, treatment and disposal and for waste generation, treatment, containment and safe disposal.

Finally the emerging Environmental Programme (EMPr) emanating from the requirements of the IWWMP and the general environmental impact assessment process will enable the development to occur within a framework that is highly regulated and supported by a dynamic EMPr preventative strategy.

6.9 Socio-Economic

From a social perspective, the respective change processes and the potential impacts that could be experienced by the receiving environment because of the construction and operation of the proposed project and its associated infrastructure are as follows:

- Geographical processes refer to the processes that affect the land uses of the local area.
- Demographical processes refer to the movement and structure of the local community.
- Institution and Legal processes refer to the processes that affect service delivery to the local area.
- Socio-cultural processes refer to the processes that affect the local culture of an affected area, i.e. the way in which the local community live (however, sometimes different cultural groups occupy the same geographical area and these groups are seldom homogenous).

6.9.1 Expectant Change and Resultant Impacts – Social

A summary of the expected impacts are as per the table below.

Table 42: Expected change and resultant impacts

Change Processes	Expected Change and Resultant Impacts	Project Phase(s)
Geographical	**Change in access to resources that sustain livelihoods:** It is not foreseen that the proposed UCG plant will lead to a change in access to resources that sustain livelihoods, as the plant and the bulk of the associated infrastructure will be located on Eskom property.	Construction, extending into Operation
	Land acquisition and disposal, including availability of land: No impact foreseen in this regard, as the project is located on Eskom property.	Construction, extending into Operation
Demographical	**Arrival of Construction workers:** At the time of the study, the estimated size of the construction team was not known. It was therefore difficult to determine the social impact as a result of an influx of construction workers, as the extent and significance of the impact is largely dependent on the number of people.	Construction
	Influx of unemployed work seekers: Given the skills required for the respective construction processes, it is highly unlikely that a job seeker will find formal employment by loitering at the construction camp or site, which would be a natural deterrent to a further influx of job seekers.	Construction, extending into Operation

Change Processes	Expected Change and Resultant Impacts	Project Phase(s)
	Relocation of Households: The relocation process was completed in 2011 and no further relocation will be required.	Pre-construction
Institutional and Legal	**Change in community infrastructure (additional demand on services):** The additional demand on municipal services is a point of concern, as it would appear that most of the surrounding areas (most notably Vlakplaats and Daggakraal) are poorly developed and characterised by poverty.	Construction, extending into Operation
	Change in housing needs/demands: It seems likely that the construction team will be housed in the existing single quarters at the mining offices. The impact is therefore regarded as negligible and has not been assessed in any further detail.	Construction, extending into Operation
	Corporate Social Investment: The Eskom Development Foundation (EDF) delivers on Eskom's CSI objectives by supporting economic and social projects initiated by registered Small, Medium and Micro Enterprises (SMMEs), with a special focus on communities within which Eskom operates its capital expansion projects.	Construction, extending into Operation
Socio-Cultural	**Dissimilarity in social practices:** As it is Eskom's intention to house construction workers on-site in the existing single quarters, it is not expected that dissimilarity in social practices would be evident to the degree that it would affect a large segment of the population.	Construction
	Conflict: At the time of the study, there was no apparent conflict within the local community or between the local community and the project proponent (Eskom) over the proposed UCG plant. The situation is unlikely to change if the project processes proceed in an open and transparent manner.	Not applicable
	Change in sense of place: It is unlikely that the UCG plant itself will change local residents' sense of place, as the plant will be located in the vicinity of the existing Majuba Power Station. Compared to the existing power station, the plant will be significantly smaller and as it will be placed in an area that is already regarded as 'spoilt', it is not foreseen that it will have a primary impact on sense of place.	Construction, extending into Operation

6.9.2 Expectant Change and Resultant Impacts – Economic

- Industrial developments often contribute indirectly to the regional and national economy by improving infrastructure, adding to the country's productive capacity, contributing to the country's capital goods and enabling economic growth. In the case of this project however, the long-term viability of the project still has to be proven and the project will not produce a saleable commodity. As such this impact cannot be defined accurately enough to be rated.
- Use of the farm for agriculture after mining has ceased and the land has been rehabilitated may be possible if the productive capacity of the land is intact as planned and Eskom rents the land to farmers. However, the practicality of this cannot be assessed as no precedence exists for this situation.
- Furthermore, due to the fact that UCG technology is still under research (and considering that the main development would only be localized to one farm with an existing workforce), no to very little money will be spent as part of the social and labour plan. Employment will be evaluated and as far as possible local members of the community will be considered for employment.

6.9.3 Recommendations

- Ensure that social issues identified during the EIA phase are addressed during construction. This could be done by engaging social specialists where necessary or by ensuring that ECOs used during construction have the necessary knowledge and skills to identify social problems and address these when necessary. Guidelines on managing possible social changes and impacts could be developed for this purpose.

- Always inform neighbouring landowners beforehand of any construction activity that is going to take place in close proximity to their property. Prepare them on the number of people that will be on site and on the activities they will engage in.
- Ensure that Eskom employees are aware of their responsibility in terms of Eskom's relationship with landowners and communities surrounding linear infrastructure. Implement an awareness drive to relevant sections to focus on respect, adequate communication and the 'good neighbour principle'.
- Incorporate all mitigation measures in the Social Impact Assessment (SIA) that are relevant to the construction phase in the EMP to ensure these are adhered to by Eskom and the contractor.

6.10 Air Quality

6.10.1 Emissions Inventory

The emissions inventory has been developed in conjunction with the staff from Eskom, who provided mass balance calculations, input parameters and monitored data from various sources. Point sources are identified as non-mobile stacks or sources associated mainly with industrial or commercial operations. In the case of the UCG plant, this is only one point source, the flaring stack. This stack is used to direct flue gas from the UCG pipeline under emergency conditions, the only scenario investigated was the worst-case emergency flaring of flue gas. The emissions inventory and model input are presented in **Table 43** and **Table 44**.

Table 43: Model input parameters

Parameters	Flare
Height (m)	59.4
Diameter (mm)	850
Volumetric Flow (Nm^3/hr)	70,000
Exit Temperature ($^{\circ}$C)	1200

Table 44: Exhaust emissions during flaring

Component	Quantity	Units	Emission Rate (g/s)
Particulate Matter (PM)	< 50	mg/Nm^3	7.80
Sulphur Dioxide (SO_2)	1,596	mg/Nm^3	102.74
Nitrogen Dioxide (NO_2)	942	mg/Nm^3	57.65
Carbon Monoxide (CO)	1,024	mg/Nm^3	49.85
Volatile Organic Compounds (1)	226	mg/Nm^3	14.52
Hydrogen Sulphide (H_2S)	17	mg/Nm^3	1.14
Ammonia (NH_3)	10	mg/Nm^3	0.67

(1) Reported as benzene

6.10.1.1 Potential Impacts

- **Construction activities**

During the construction-like activities (i.e. maintenance, repairs, and rehabilitation activities) it is expected that, the main sources of impact will result due to vehicle movement within the plant area. These predicted impacts cannot be quantified, primarily due to the lack of detailed information related to scheduling and positioning of construction related activities. Instead a qualitative description of the impacts will be provided. This will involve the identification of possible sources of emissions and the provision of details related to their impacts.

Construction is of a temporary nature with a definite beginning and end. Construction usually consists of a series of different operations, each with its own duration and potential for dust generation. Dust emission will vary from day to day depending on the phase of construction, the level of activity, and the prevailing meteorological conditions[31].

The following possible sources of fugitive dust and particulate emissions were identified as activities which could potentially generate air pollution during construction-like / maintenance / rehabilitation operations:

a) Demolition and debris removal:
   - Demolition of obstacles such as boulders, trees, etc.;
   - Loading of debris into trucks;
   - Truck transport of debris; and
   - Truck unloading of debris.

b) Site preparation (earthworks):
   - Bulldozing;
   - Scrapers unloading topsoil;
   - Scrapers in travel;
   - Scrapers removing topsoil;
   - Loading of excavated material into trucks;
   - Truck dumping of fill material, road base, or other materials;
   - Compacting;
   - Motor grading; and
   - Excavating.

c) General Construction:
   - Vehicular traffic;
   - Portable plants – aggregate processing; and
   - Concrete Mixing.

- ***Normal Operations***

During the normal operational phase there is estimated to be no emissions emitted from the project, as all the syngas will be piped to Majuba Power Station. It should also be noted that during this phase the amount of gas generated has been limited with only a few tests run with minimal co-firing events required.

[31] *Ibid.* Footnote 12.

- ***Upset Conditions – Flaring***

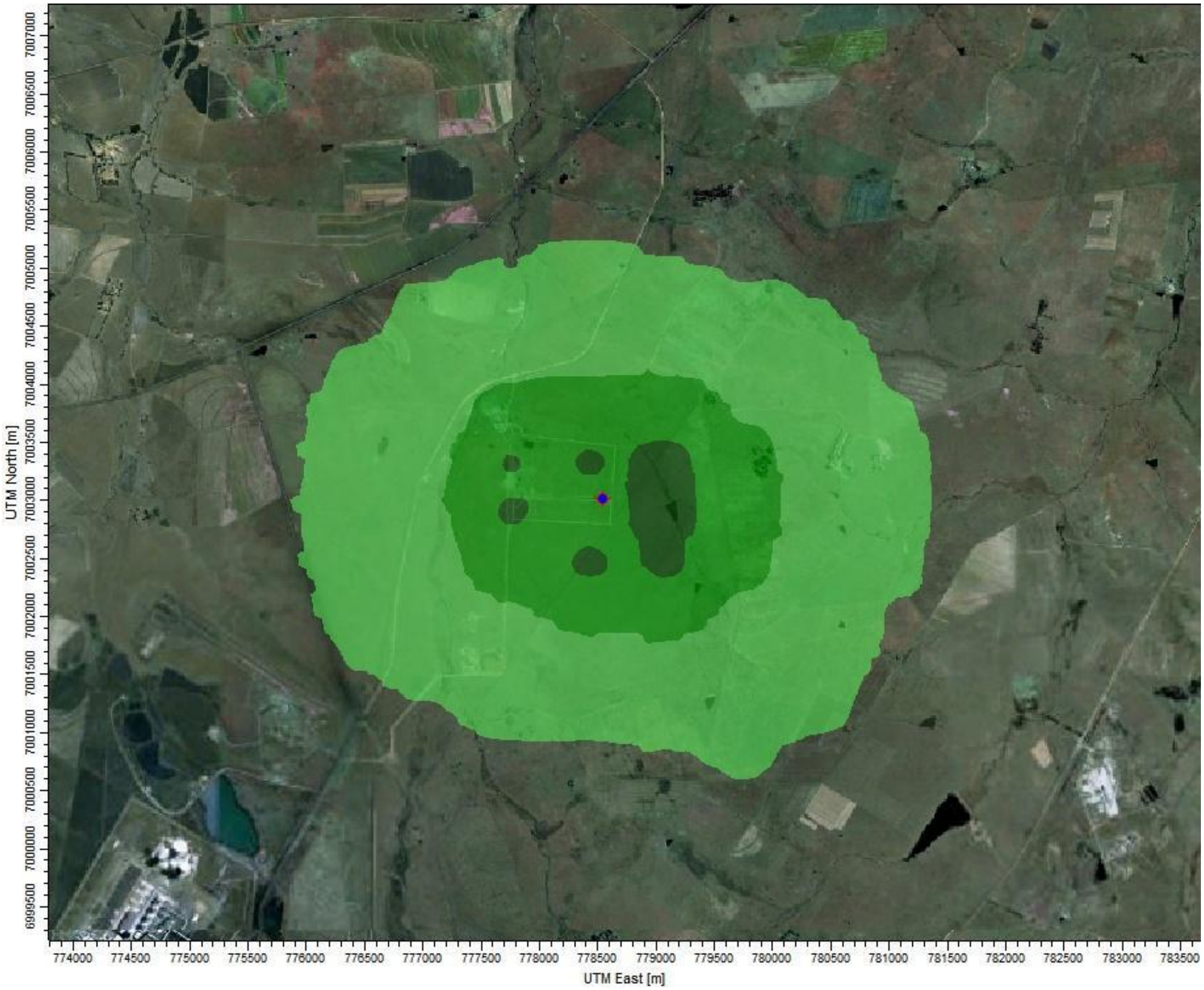
The dispersion modelling results from this worst-case emergency scenario is detailed below. It should be noted that this scenario will not happen every day of the year but only when there is an emergency. The results below present the absolute highest values that were experienced at a receptor for the average period being presented. Both daily and annual average predicted ground level concentrations are thus an over prediction of impacts as these results assume that flaring occurred 24 hours a day 365 days in a year.

Table 45: Maximum ambient ground level concentrations from the UCG project under flaring conditions

Concentration (µg/m³)	Maximum Hourly Average (µg/m³)	Maximum Daily Average (µg/m³)	Maximum Annual Average (µg/m³)
Particulate Matter (PM)	2.86E+00	7.63E-01	1.14E-01
Sulphur Dioxide (SO_2)	3.77E+01	1.00E+01	1.50E+00
Nitrous dioxide (NO_2)	2.12E+01	5.64E+00	8.43E-01
Carbon Monoxide (CO)	1.83E+01	4.87E+00	7.29E-01
Volatile Organic Compounds (1)	5.33E+00	1.42E+00	2.12E-01
Hydrogen Sulphide (H_2S)	4.19E-01	1.12E-01	1.67E-02
Ammonia (NH_3)	2.44E-01	6.51E-02	9.74E-03

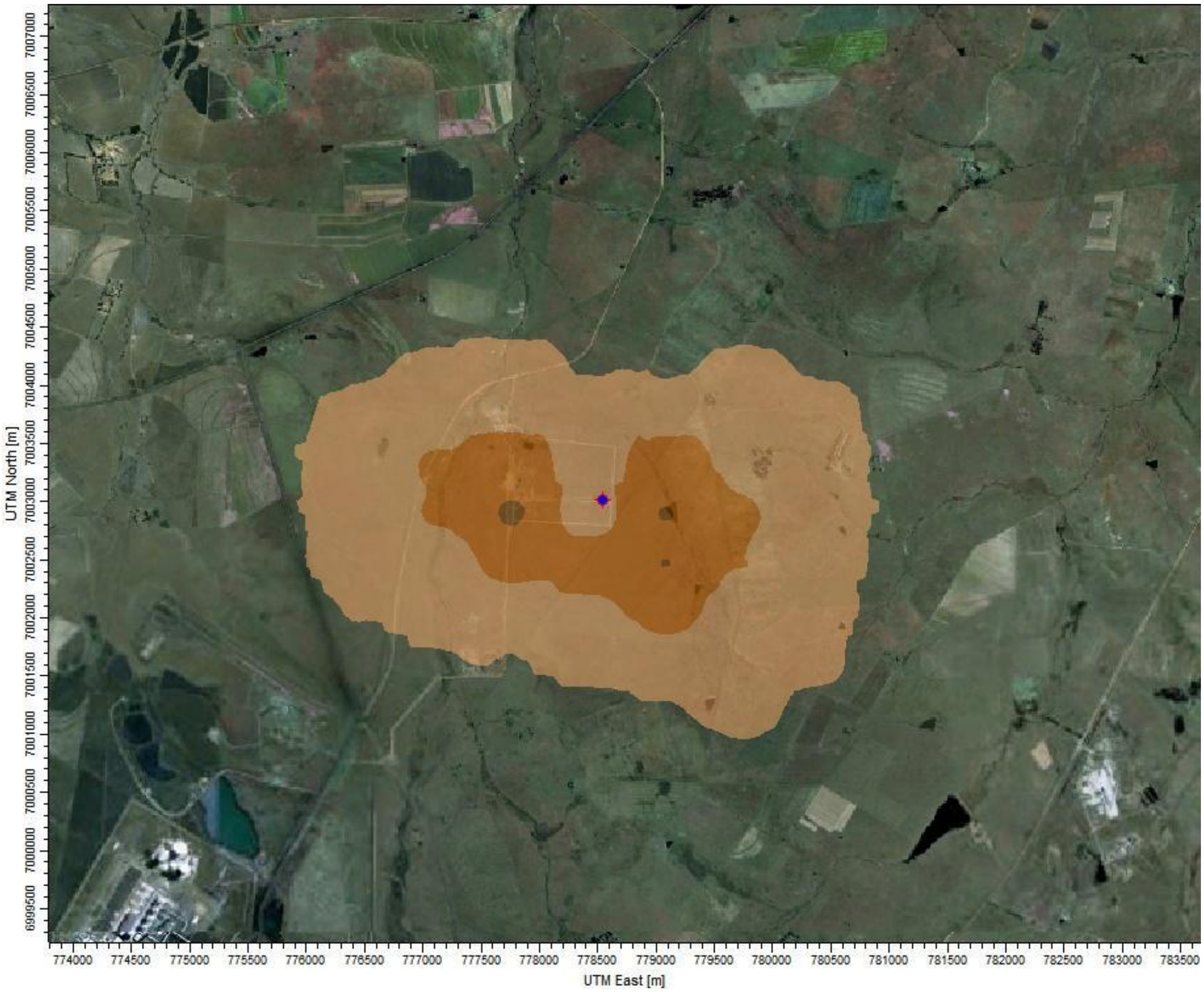
(1) Reported as benzene

Based on the maximum predicted ground level concentrations presented in **Table 45**, as well as the isopleths outlining the spatial distribution of potential impacts presented in **Figure 48** to **Figure 50** all predicted ground level concentrations over an hourly, daily and annual averaging period are noted to fall well below the respective health risk standards, guideline and thresholds for these pollutants.



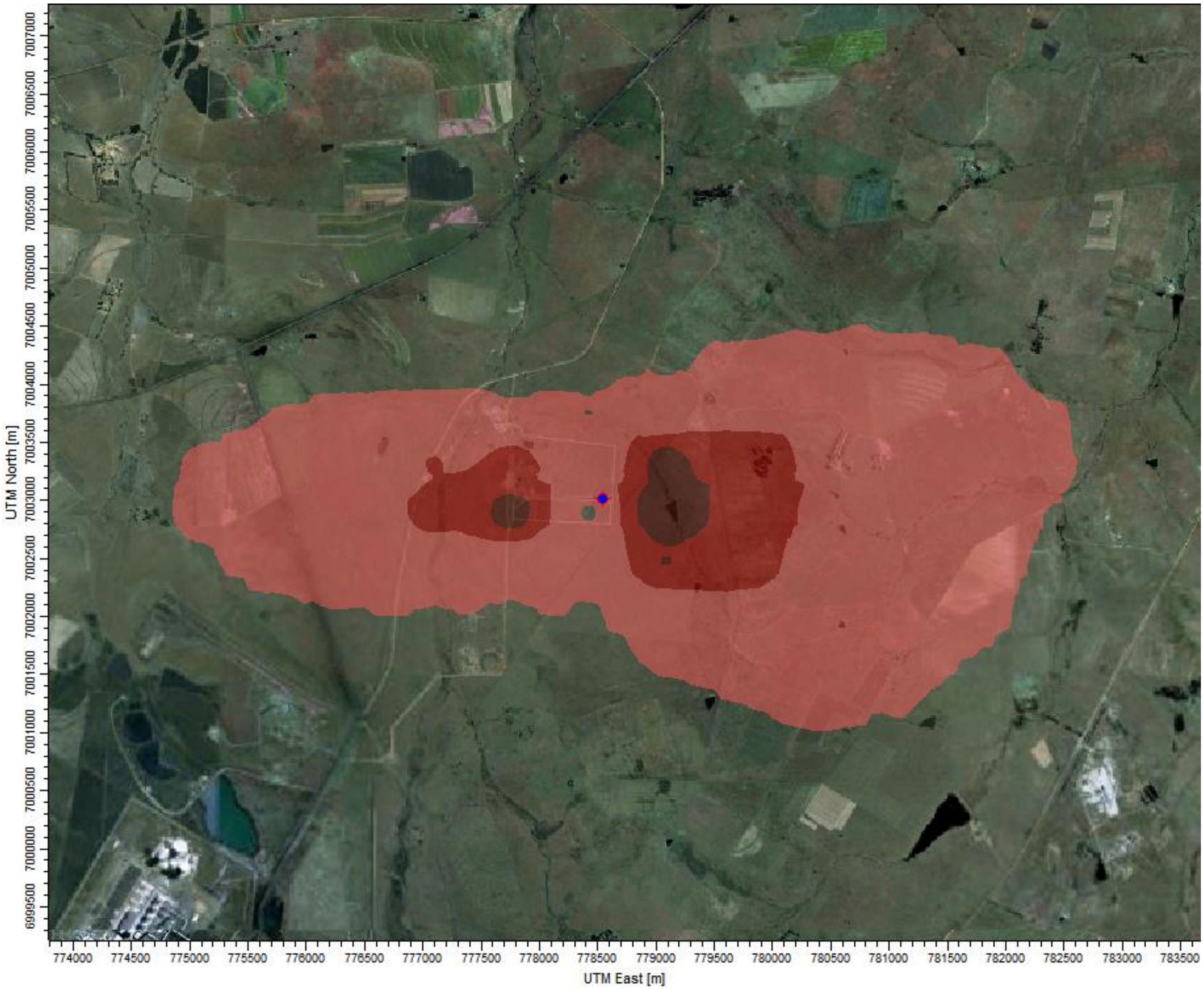
Pollutant key			
Particulate Matter (PM)	2.34E+00	1.56E+00	7.80E-01
Sulphur Dioxide (SO_2)	3.08E+01	2.05E+01	1.03E+01
Nitrous dioxide (NO_2)	1.73E+01	1.15E+01	5.76E+00
Carbon Monoxide (CO)	1.50E+01	9.97E+00	4.98E+00
Volatile Organic Compounds (Benzene)	4.36E+00	2.90E+00	1.45E+00
Hydrogen Sulphide (H_2S)	3.42E-01	2.28E-01	1.14E-01
Ammonia (NH_3)	2.00E-01	1.33E-01	6.66E-02

Figure 48: Hourly average predicted ground level concentrations for various pollutants (µg/m³)



Pollutant key			
Particulate Matter (PM)	7.02E-01	4.68E-01	2.34E-01
Sulphur Dioxide (SO_2)	9.25E+00	6.16E+00	3.08E+00
Nitrous dioxide (NO_2)	5.19E+00	3.46E+00	1.73E+00
Carbon Monoxide (CO)	4.49E+00	2.99E+00	1.50E+00
Volatile Organic Compounds (Benzene)	1.31E+00	8.71E-01	4.36E-01
Hydrogen Sulphide (H_2S)	1.03E-01	6.85E-02	3.42E-02
Ammonia (NH_3)	5.99E-02	4.00E-02	2.00E-02

Figure 49: Daily average predicted ground level concentrations for various pollutants assessed (µg/m³)



Pollutant key			
Particulate Matter (PM)	7.80E-02	5.46E-02	2.34E-02
Sulphur Dioxide (SO_2)	1.03E+00	7.19E-01	3.08E-01
Nitrous dioxide (NO_2)	5.76E-01	4.04E-01	1.73E-01
Carbon Monoxide (CO)	4.98E-01	3.49E-01	1.50E-01
Volatile Organic Compounds (Benzene)	1.45E-01	1.02E-01	4.36E-02
Hydrogen Sulphide (H_2S)	1.14E-02	7.99E-03	3.42E-03
Ammonia (NH_3)	6.66E-03	4.66E-03	2.00E-03

Figure 50: Annual average predicted ground level concentrations for various pollutants assessed (µg/m³)

Due to flaring as indicated in **Table 45**, hydrogen sulphide and ammonia is predicted to be released, these have the potential to result in noticeable odours. Odour thresholds are defined in several ways including absolute perception thresholds, recognition thresholds and objectionability thresholds. At the perception threshold one is barely certain that an odour is detected but it is too faint to identify further. Recognition thresholds are normally given for 50% and 100% recognition by an odour panel. Odour thresholds published in the literature for hydrogen sulphide and ammonia is given together with the WHO guidelines.

Table 46: Odour threshold values for hydrogen sulphide

Pollutant	Detection Threshold		Odour Recognition Threshold		Other Odour Thresholds	WHO GV (30min) [32]
	AIHA[33]	Devos[34]	100% Recognition	50% Recognition		
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Hydrogen Sulphide	---	---	1430	11.2	4.29[35]	7
Ammonia					340	

The hourly average hydrogen sulphide and ammonia ground level concentration converted to an equivalent 10 minute average using Beychok[36] are 5.10E-01 µg/m³ and 3.0E-01 µg/m³ respectively, which are well below the WHO guideline values cited for these pollutants. No detectable or perceptible odour should thus be noted from these flaring operations on site.

6.10.2 Recommendations

6.10.2.1 Construction Phase

During the construction phase the pollutants likely to be emitted are Particulate Matter (PM). The emissions are likely to be generated by the vehicle movement on site and exposed soil to wind erosion. The dust fallout generated by this phase will be more of a nuisance and will not cause a health effect, due to the specified nature of the activity. The dust would likely be confined to fall out within 2 km of the site. If the mitigation measures mentioned in the EMPr are followed, the impact from the construction phase can be reduced thus resulting in a low impact rating.

6.10.2.2 Normal Operational Phase

During normal operations at the site all emissions will be contained within piping and in the processes. Normal operations will commence after the construction phase. It is envisaged that there will be no emissions from this phase of the project.

6.10.2.3 Emergency Incident

During the normal operations, there is a likelihood that some occurrence could result in the syngas being flared. The occurrence could be on site during the production and cleaning of the gas or at the end of the piping line,

[32] ***World Health Organisation, 2000.*** *WHO Guideline Value.*
[33] ***AIHA, 1989.*** *Odour Thresholds for Chemicals with Established Occupational Health Standards, Akron, Ohio, American Industrial Hygiene Association.*
[34] ***Devos M, Patte F, Rouault J, Laffort P and van Gemert LJ (Eds), 1990.*** *Standardized Human Olfactory Thresholds, New York, Oxford University Press.*
[35] *South African guideline (personnel communication, M Lloyd, 8/10/98).*
[36] ***Beychok; M.R, 2005.*** *Fundamentals of Stack Gas Dispersion.*

namely at the Majuba Power Station. The emissions associated with the flaring are predominantly Hydrogen sulphide and other elements that are found in the syngas.

The worst-case scenario of the flare being active for an hour under the worst meteorological conditions, the maximum concentration is well below the international standards and also below the odour thresholds. The dispersion plume does not extend far beyond the project boundary and can be reduced over a short time period.

The impact from flaring is rated at medium due to the fact that the plume has the potential to spread over a distance. It should be noted that the sensitive receptors in the region is located more than 4 km from the facility.

6.11 Heritage

No sites, features or objects dating to the Stone Age and Iron Age were identified in the specific study area. The following sites, features or objects of cultural significance were however identified in the greater study area and are mentioned for completeness:

6.11.1 Farmsteads

A number of old farmsteads and associated outbuildings occur sporadically over the larger area. Central to all is the farmhouse with associated outbuildings and in some cases, associated features such as stock enclosures, sheep dips, etc. located some distance away.

Table 47: Farmsteads found on greater UCG site

Location		
No. 2	S 27.08864	E 29.79753
No. 3	S 27.11389	E 29.80690
No. 6	S 27.10190	E 29.80980
No. 9	S 27.06441	E 29.82947
No. 14	S 27.05712	E 29.84322
No. 15	S 27.05405	E 29.84648
No. 18	S 27.06106	E 29.79941
No. 19 – 21	S 27.08301	E 29.80060

Photograph 16: Farmstead (waypoint #6)

6.11.2 Homesteads

Table 48: Homesteads found on greater UCG site

Description	Location	
No. 10 – Remains of farm labourer homestead, built with locally quarried stone.	S 27.06824	E 29.83339
No. 22 – Remains of possible farm labourer homestead, built with locally quarried stone	S 27.08033	E 29.80186
No. 23 – Remains of possible farm labourer homestead, built with locally quarried stone	S 27.08625	E 29.80386

Photograph 17: Homestead (waypoint #23)

6.11.3 Other Features

Table 49: Other heritage features found on greater UCG site

Description	Location	
No. 4 – Old concrete bridge across an old conveyor route, the latter which was demolished some years ago. The bridge is classified as a rigid frame concrete bridge. At present is serves to give access to a farmstead that is still occupied.	S 27.10438	E 29.80821
No. 17 – A number of small half-moon shaped features on a ridge overlooking a valley. At first it was thought to date to the Anglo-Boer War, where it served as sangars. However, it turned out to be hunting blinds that were used in the recent past.	S 27.05802	E 29.80927

Photograph 18: Old concrete bridge and hunting blinds

6.11.4 Cemeteries and Burial Places

Table 50: Cemeteries and burial places found on greater UCG site

Description	Location	
No. 1 – Single grave of child, now vandalised.	S 27.08807	E 29.79571
No. 5 – Small informal farm labourer cemetery. All graves only marked with stone cairns	S 27.10347	E 29.80232
No. 7 – Small farm labourer cemetery, with at least three burial periods. The remains of an old rondawel shape house is located close by.	S 27.09677	E 29.80940
No. 8 – Large farm labourer cemetery. Few have headstones, making it difficult to determine an exact number.	S 27.09341	E 29.81359
No. 11 – A small informal farm labourer cemetery that can probably be linked to old homestead in record no. 10.	S 27.06903	E 29.83311
No. 12 – Single grave marked with stone cairn. Based on its size, it is probably that of a child.	S 27.06670	E 29.83038
No. 13 – Small farm labourer cemetery with possibly as many as 50 graves.	S 27.06669	E 29.83009
No. 16 – Small farm cemetery of the Swanepoel family, containing at approximately 10 graves. At least four of the people died during 1918.	S 27.05263	E 29.84490
No. 20 – Number of old graves, now vandalised, making it difficult to establish the original number or names of the occupants.	S 27.08567	E 29.80128

Photograph 19: Single grave marker with stone cairn (waypoint #12)

6.11.5 Recommendations

Heritage sites are fixed features in the environment, occurring within specific spatial confines. Any impact upon them is permanent and non-reversible. Those resources that cannot be avoided and that are directly impacted by the proposed development can be excavated / recorded and a management plan can be developed for future action. Those sites that are not impacted on can be written into the management plan, whence they can be avoided or cared for in the future.

Further recommendations include:

- Known sites should be clearly marked in order that they can be avoided during construction activities.
- The contractors and workers should be notified that archaeological sites might be exposed during the construction activities.
- Should any heritage artefacts be exposed during excavation, work on the area where the artefacts were discovered, shall cease immediately and the Environmental Control Officer shall be notified as soon as possible.
- All discoveries shall be reported immediately to a heritage practitioner so that an investigation and evaluation of the finds can be made. Acting upon advice from these specialists, the Environmental Control Officer will advise the necessary actions to be taken.
- Under no circumstances shall any artefacts be removed, destroyed or interfered with by anyone on the site.
- Contractors and workers shall be advised of the penalties associated with the unlawful removal of cultural, historical, archaeological or palaeontological artefacts.

6.12 Visual

The nature of the topography – being gently undulating to flat in parts - has implications for visual intrusion of structures across the area. A structure placed on a higher point in the landscape would typically be visible from a wide area, with a structure placed within a valley bottom being visible from a smaller area. The same principle applies to the viewer's position within the landscape setting, with wide-reaching views being visible for a viewer in most locations except for a position within a valley bottom. The nature of the current land cover – mostly open grassland – enhances the visibility of structures, as vegetation does not play an important part in screening objects from view.

Lastly, and very importantly, the omnipresent factor of the Majuba Power Station structure has an important bearing on the visual character and the potential significance of visual intrusion associated with a new development. The power station structure is visible from most parts of the study area and thus a new object in the landscape would be viewed in this context of the view typically being dominated to a large degree by the presence of the power station.

In this context the study area displays a high visual absorption capacity (VAC), with the existing presence of the power station and associated infrastructure in the landscape "offsetting" the intrusion factor associated with a new development. The converse situation (i.e. the area displaying a low VAC) would be if there was little to no structural components or transformation of the landscape, and in which a new development would thus arguably be highly incongruent in terms of the setting.

Note that the visual considerations were carried out for the potential stack height of 9 m proposed for the Pilot Plant Phase 2. Obviously the stack on the existing infrastructure is significantly lower than that (approximately 2 m in height), it was thus decided to use that information as by default the visual impact would be less and if already deemed not to be an issue, then the existing plant remains a non-issue.

6.12.1 Study area visual character

The above structural components of the landscape influence the visual character of the study area.

The nature of the predominant land-use (livestock farming) and the relatively low level of change to the natural vegetation and landscape that this land-use has resulted in (apart from the introduction of typical rural infrastructure to the landscape such as fencing, feedlots and windmills) entails that the study area displays a largely natural or rural visual character.

A natural / rural character is characterised by a low level of transformation of the natural landscape, with the limited introduction of infrastructure and structural changes to landscape features such as vegetation. However the presence of the Majuba Power Station complex and associated infrastructure has introduced a strong industrial element to the study area. The visual influence of the Majuba Power Station is pervasive over the wider area due to the massive bulk of the power station structure that makes it visible from most parts of the immediate area, even those areas which would normally be shielded from viewing nearby areas due to their landscape position, such as locations within valley bottoms with a limited viewshed. The presence of the power station and other visually prominent infrastructure such as high voltage power lines imbues the study area with a strong industrial visual component.

The study area's visual character can thus be described as being rural with a strong industrial component.

6.12.2 Presence of Receptor Locations

Visual impact is related to the presence of human receptors / viewers, thus visual impact is typically experienced from locations inhabited by humans. For the purposes of the study receptor locations have been identified to be locations inhabited by humans, most of which are rural farmsteads as well as worker's dwellings. As measurable visual impact is typically limited to 5 km from an object causing the visual impact, receptor locations within a 5 km radius of the study area have been identified.

Within the 5 km radius of the revised development site, 35 (thirty-five) receptor locations have been identified. Most of these are rural farmsteads as well as worker dwellings. The south-western outskirts of the town of Amersfoort is just outside of the 5 km boundary of the study area, and thus the town has been considered as a receptor location where a number of households, especially those on the outskirts of the town would be classified as receptor locations. Taking a risk-averse approach, it has been assumed that all of these receptor locations could be termed potentially sensitive receptors, i.e. receptors that could potentially perceive a visual impact through the introduction of large-scale infrastructure into the setting.

Photograph 20: A receptor location near the Majuba Power Station turnoff from the Perdekop Road

Receptor locations are not only stationary, but can also be roads along which people travel. The main roads in the study area are the N11, running north-south to the east of the study area, the Perdekop Road which runs to the north and west of the study area, and the access road between the N11 and the Majuba Power Station.

A number of smaller district roads bisect the area, including the Bergvliet road running past the old mine, and the Koppieskraal road to the north of the revised study area.

The map overleaf indicates the location of receptor locations within 5 km of the site.

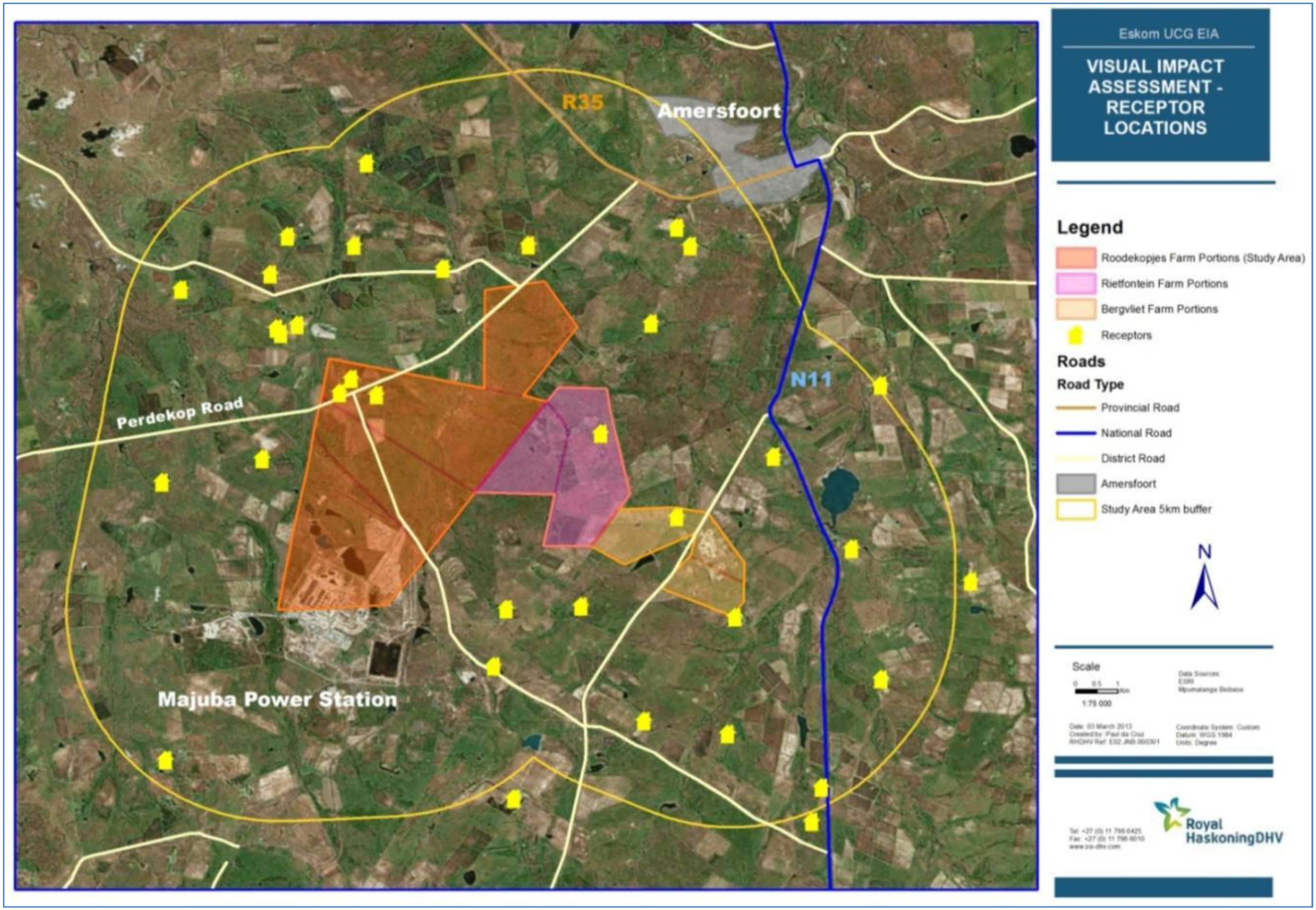


Figure 51: Receptor locations within a 5 km radius of the site

6.12.3 Visual Impact associated with the Gas Treatment Plant

Along with the proposed gasifier units, the GTP is visually the most prominent feature of the existing UCG operations due to the height of some of its components. As described above the GTP has a footprint of is approximately 30 x 60 m and will consist of the following components:

- Heat exchanger – cooling towers;
- Liquid separation vessels;
- Emergency gas flare stack; and
- Auxiliary pumps, motors and other small equipment.

The presence of the stack is important from a visual perspective as the height of the stack makes it visible from around the site. Viewing the stack could be potentially significant due to the presence of a flare (visible flame) if the stack is operational at all times. It should however be noted that the Pilot Plant Phase 1 operation has minimal, episodic flaring operations. The stack and flame can be considered a nuisance factor[37] and importantly would be highly visible at night if operated during that time. This is however noted as being a minimal impact as Gasifier 1 is now effectively is "shut down" mode and thus the chance of additional flaring operations is minimal to zero.

Majuba Power Station comprises a number of massive structures and thus dominates the views towards it, especially those views from locations within 1-15 km. For the receptors in the viewshed of the GTP and stack located to the north and north-west, the GTP would be easily 'overwhelmed by' the view of the power station industrial complex, and is considered to be much less intrusive than if the Majuba Power Station was not there.

A second factor that needs to be considered in terms of the degree of visual intrusiveness of the plant is the relative distance of receptors within the viewshed away from the plant. Beyond a certain distance, even large structures such as multi-storey buildings tend to be much less visible, and are difficult to differentiate from the surrounding landscape. The visibility of an object decreases exponentially with increasing distance away from the object, with maximum impact being exerted on receptors at a distance of 500 m or less. The impact decreases exponentially as one moves away from the source of impact, with the impact at 1,000 m (1 km) being a quarter of the impact at 500 m away (**Figure 52**). At 5,000 m (5 km) away or more, the impact would be negligible.

[37] ***MetroGIS, 2011***. *Visual Impact Assessment for the proposed 40MW Demonstration Plant, Gas Treatment Plant and Gasifier near Amersfoort, Draft Report.*

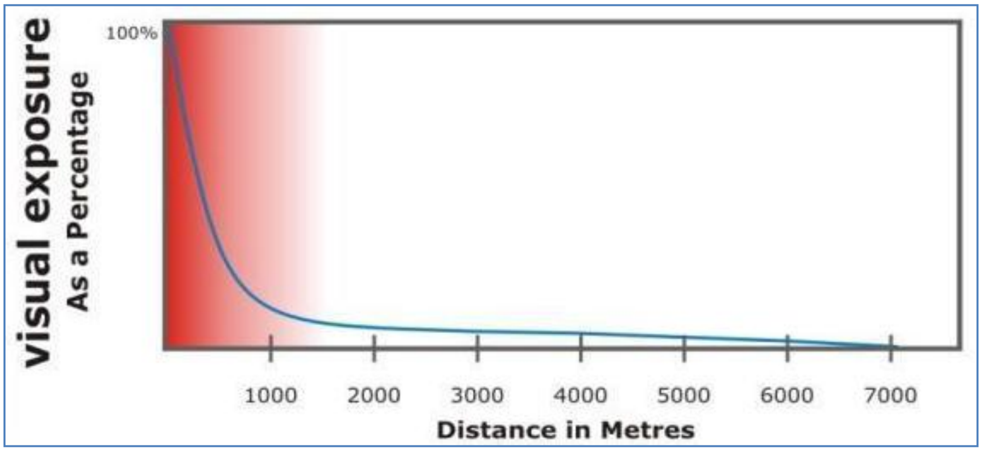


Figure 52: Diagram illustrating diminishing visual exposure over distance

Any receptors within 500 m or less of the GTP would be exposed to the greatest degree of potential visual intrusion. A lesser, but nonetheless potentially high degree of visual intrusion would be associated with receptors located between 500 and 2,000 m of the GTP. It is important to note that no receptor locations fall within these zones of high visual intrusion, partly due to the fact that much of the area of the Roodekopjes property (owned by Eskom) is uninhabited.

The closest receptor locations are over 2.5 km distant. At this distance the visibility and potential visual intrusion factor of the GTP and stack would be greatly reduced. At greater distances beyond 2 km of the plant, the plant and stack would be increasingly difficult to distinguish against the background of the view.

Only four (4) receptor locations that are within the viewshed of the plant are located within 5 km of the GTP. For these four receptors, the degree of visual intrusion of the GTP and stack would be low to negligible. For all other receptor locations within the viewshed, the distance (>5 km) would entail that the visual intrusion factor and thus the visual impact of the GTP, stack and flare would be negligible.

Thus when the mitigating factors of distance of view and domination of existing views by the Majuba Power Station are taken into account, the overall visual impact of the GTP and stack on the receptors in the surrounding area is likely to be low.

Flaring from the GTP's stack could be associated with a visual intrusion factor, in spite of the distance. This would especially be the case at night, when in spite of the high degree of lighting associated with the Majuba Power Station, the flare would be visible in a night-time context. It is however understood that flaring will only be done as an emergency measure.

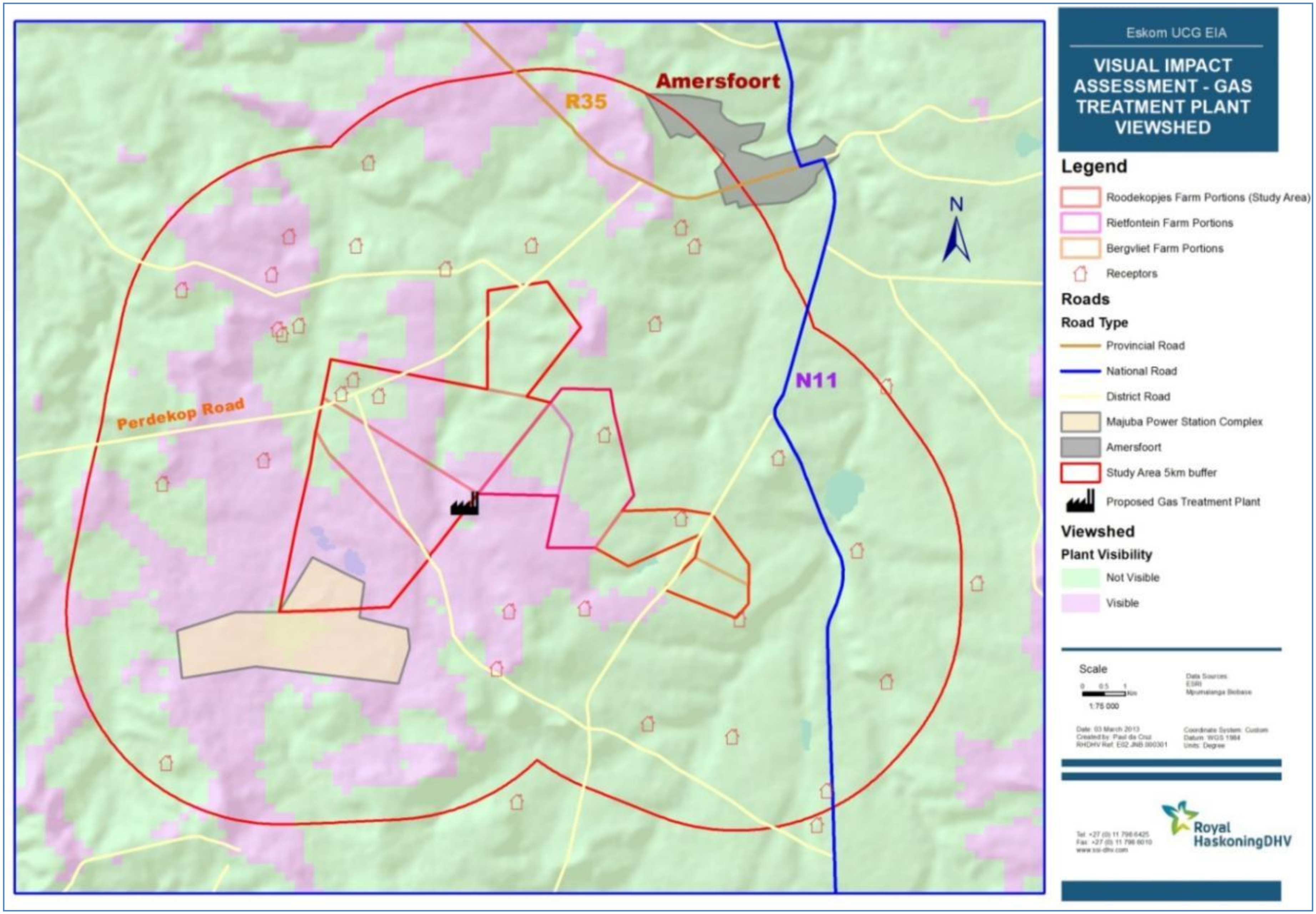


Figure 53: Viewshed of the Gas Treatment Plant's 9 m-high stack

6.12.4 Visual Impact Associated with the Gasifier Units

Gasifier units are proposed to be developed across the Roodekopjes site, the Pilot Plant Phase 1 unit is the first developed and has a total footprint with its associated infrastructure of approximately 50 ha with a maximum height of 2 m.

The viewer is presented with a view of a network of pipelines. As with the gas treatment plant discussed above, the degree of visual intrusion associated with gasifier units depends on a number of factors including the distance between the receptor locations and the gasifier, as well as on the topography of the area in which the gasifier is located that determines the area in which the gasifiers would be visible.

As with the gas treatment plant, many of the receptors would view the Pilot Plant gasifier in the same view that is dominated by the structures of the Majuba Power Station, thus already presenting a view of an industrialised context. In this context (a high VAC) the distant gasifier unit would be less likely to be perceived to be incongruous with the setting.

6.12.5 Visual Impact Associated with other UCG-related activities

6.12.5.1 Subsidence

The UCG process may cause the subsidence of areas of ground that are undermined, due to the collapse of the coal seam once it has been combusted. To date no subsidence has occurred.. It is expected that areas are likely to subside evenly, and thus there will be unlikely to be a marked impact on the micro-topography within undermined parcels of land. However a “micro-escarpment” or gulley wall may form between areas subsiding and those not. This could form a visible scar or landscape feature in the environment as the level of subsidence is expected to be up to 0.75 m deep. This feature would be likely to create a linear band within a landscape that would be visible and prominent due to its linear nature, especially if it started to erode.

Insufficient information is available at this point to accurately determine how and where subsidence would affect the micro-topography of the site. Thus the location-specific visual impacts of subsidence are unable to be determined at this point. Should more detailed information relating to the impacts of subsidence become available, this will be able to be assessed in a further revision of this report.

It should be noted that the existing Pilot Plant Phase 1 is effectively a test area forming part of the ongoing research process to determine whether issues such as subsidence may become an issue when rolled out on a larger scale.

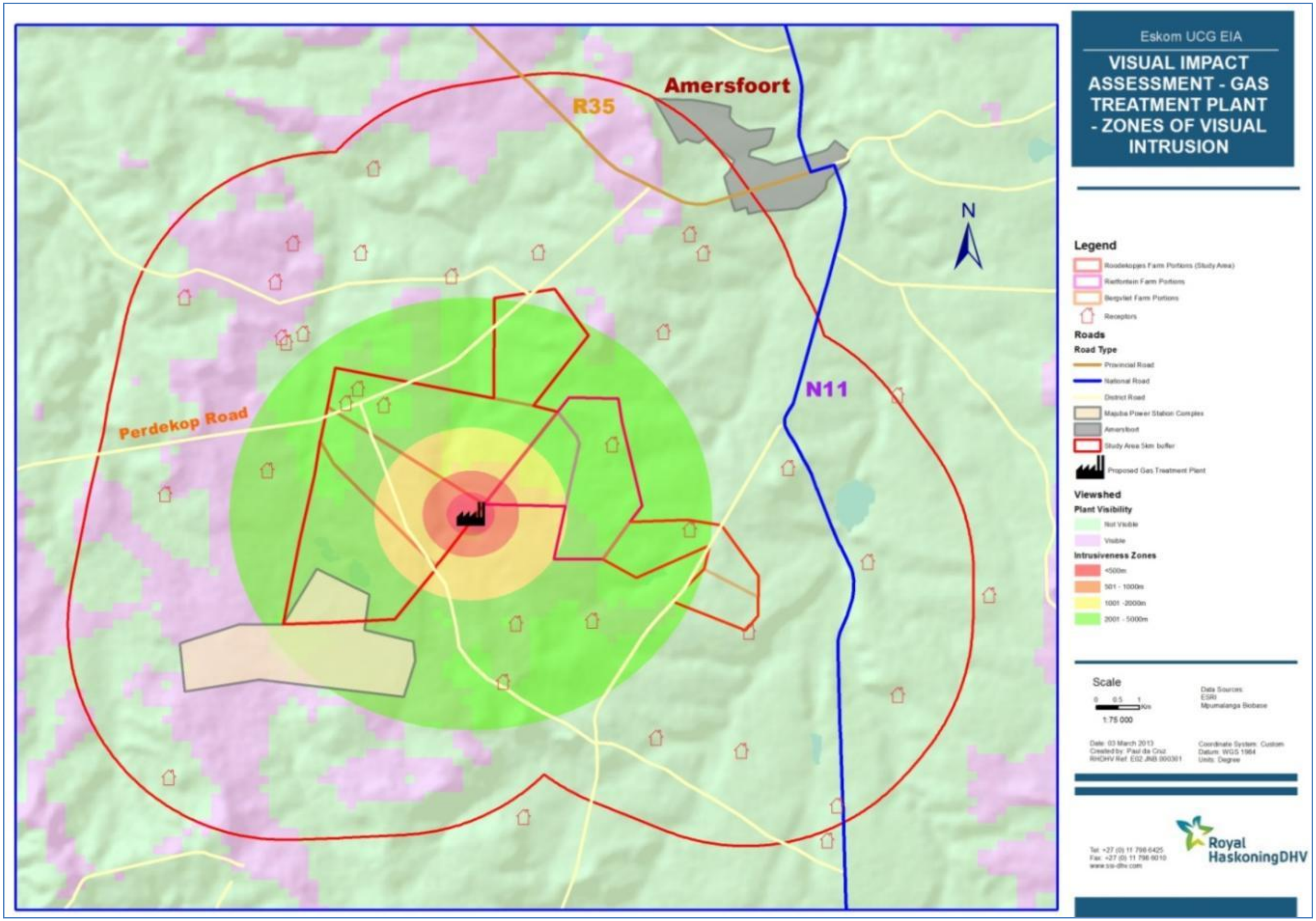


Figure 54: Location of receptors in relation to the distance bands from the gas treatment plant

6.12.5.2 Irrigation of land with effluent

One of the proposals being considered by the proponent would be to use effluent from the gas treatment plant to irrigate certain parcels of land on, and in the immediate vicinity of the Roodekopjes site. Areas to be irrigated would be planted with the grass species *Eragrostis curvula*, a widely cultivated grass. Irrigation is proposed to be undertaken by a vehicle that would dispense the effluent into the area under irrigation. If adopted, this process is unlikely to result in a visual impact, as the area under irrigation would retain a similar texture and colour to the natural grassland that currently occurs over most of the Roodekopjes site and immediately adjacent areas, and due to the absence of large-scale irrigation equipment. This alternative will only be considered in the parallel EIA process.

6.12.6 Recommendations

- Flaring should be prevented as much as possible, and be limited to daylight hours.

7 IMPACT ASSESSMENT

7.1 Methodology

The potential environmental impacts associated with the project will be evaluated according to its nature, extent, duration, intensity, probability and significance of the impacts, whereby:

Table 51: Environmental criteria

Environmental Criteria	Description
Nature	A brief written statement of the environmental aspect being impacted upon by a particular action or activity
Extent	The area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact. For example, high at a local scale, but low at a regional scale
Duration	Indicates what the lifetime of the impact will be
Intensity	Describes whether an impact is destructive or benign
Probability	Describes the likelihood of an impact actually occurring
Cumulative	In relation to an activity, means the impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.

Table 52: Criteria to be used for the rating of impacts

Impact criteria	Description			
Extent	**National (4)** Whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of construction site	**Site (1)** Within construction site
Duration	**Permanent (4)** Mitigation either by man or natural proc ess will not occur in such a way or in such a time span that the impact can be considered transient	**Long-term (3)** Impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter. The only class of impact which will be non-transitory	**Medium-term (2)** Impact will last for period of construction phase, where after it will be entirely negated	**Short-term (1)** Impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase
Intensity	**Very High (4)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**High (3)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Moderate (2)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (1)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected
Probability of occurrence	**Definite (4)** Impact will certainly occur	**Highly Probable (3)** Most likely that the impact will occur	**Possible (2)** Impact may occur	**Improbable (1)** Likelihood of the impact materialising is very low

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

The significance rating, as given in **Table 54**, is calculated as:

Extent + Duration + Intensity + Probability

This formula gives a maximum value of 16 and a minimum value of 0 (zero). Note that a value of zero is only possible if no impact is triggered (either positive or negative).

Table 53: Significance rating of classified impacts

<table>
<tr><th>Impact rating</th><th colspan="2">Description</th></tr>
<tr><td>Neutral / negligible (0 to –2 points)</td><td colspan="2">Impact is either positive or negligible as the change from the status quo is almost impossible to quantify.</td></tr>
<tr><td>Low (–3 to –5)</td><td colspan="2">Low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.</td></tr>
<tr><td>Medium (–6 to –8)</td><td colspan="2">Mitigation is possible with additional design and construction inputs.</td></tr>
<tr><td>Medium-high (–9 to –11)</td><td colspan="2">Mitigation is possible with additional design and construction inputs, but the alternatives need to be carefully considered for possible changes to reduce the risk to the site and wider environment.</td></tr>
<tr><td>High (–12 to –14)</td><td colspan="2">Design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. Effects of the impact <u>will</u> affect the broader environment.</td></tr>
<tr><td>Very high (–15 to –16)</td><td colspan="2">Permanent and important impacts. Design of the site <u>must</u> be affected. Intensive remediation will be needed during construction and/or operational phases. Any activity which results in a “very high impact” is considered to be a fatal flaw.</td></tr>
<tr><td>Status</td><td colspan="2">Denotes the perceived effect of the impact on the affected area.</td></tr>
<tr><td>Positive (+)</td><td colspan="2">Beneficial impact.</td></tr>
<tr><td>Negative (-)</td><td>Deleterious or adverse impact.</td><td rowspan="2">Note that negative and neutral impacts are considered similarly as “negative” in significance.</td></tr>
<tr><td>Neutral (/)</td><td>Impact is neither beneficial nor adverse.</td></tr>
</table>

Note that no one factor is weighted over any other for this risk as given the nature of the application, the uncertainties inherent in this being a research project, and, the potential scale of impacts. That is, no one factor is deemed to be more important than any other.

“**Unmitigated**” is the taken as the *status quo* which is to a certain extent already mitigated. “**Mitigated**” is taken as the best practice moving forward, that is, what in addition can be done to further reduce the risk while the pilot plant continues operation (if allowed). The values are not the extreme worst case as the site is being run to a high standard already with no significant contamination events to date.

As such the risk value does not change as much as would be encountered in a standard EIA where the preferred option is considered against the worst case scenario or an undeveloped *status quo* situation. Further, the nature of the surroundings is such that contamination events, should they occur, would be buffered to a certain extent.

The suitability and feasibility of all proposed mitigation measures will be included in the assessment of significant impacts. This will be achieved through the comparison of the significance of the impact before and after the proposed mitigation measure is implemented. Mitigation measures identified as necessary will be included in an EMPr.

The subsequent sections will provide a description of the potential impacts as identified by the specialists, EAP and through the public participation process as well as the assessment according the criteria described in **Table 52** and **Table 53**.

A point to note in terms of the phase description given in the impact tables hereafter – the term “construction” is given for activities that may be “actual construction activities”, “maintenance activities” and “decommissioning activities” as these all have similar impacts.

Further note that many of the true construction activities have already occurred and as such are completed or significantly completed. The mitigation requirements thus remain in place as they will still need to be monitored and where required enhanced.

7.2 Infrastructure item-related impact consideration

As an overview the *status quo* impact of the various activities taking place currently on the site is presented in this section according to the specific activity. Thereafter in **Sections 0** to **7.17** the issues are considered by environmental factor.

Table 54: Significance rating of impacts by infrastructure item already constructed

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Raw water dam **Impacts:** – Removal of soils and vegetation for establishment of the dam – Erosion due to exposed soils	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Ensure that the operation of the dam is part of an endorsed water use license. • It is essential to have an adequately sized dam to contain raw water.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-9)**
Condensate (process) water dam **Impacts:** – Removal of soils and vegetation for establishment of the dam – Erosion due to exposed soils – Incorrect design and construction of dam i.e. placement of dam in drainage line – Possible groundwater and soil contamination – Odour	Extent: Site (-3) Duration: Long-term (-3) Intensity: High (-3) Probability: Highly probable (-3) **Significance: High (-12)**	• Current condensate must be transferred to the new dam (once authorised) via the filter plant. Sludge must be removed and disposed of at a licensed hazardous waste disposal site. • Existing dam, lining and associated infrastructure must be dismantled, removed and disposed of at a licensed hazardous waste disposal site. • Soils excavated must be tested and if it is established that there is contamination, the soils should be disposed of properly by a reputable waste management company at a licensed hazardous waste disposal site. • Rehabilitation of the existing dam site: – Rehabilitate disturbed areas with natural vegetation. – Exposed areas must be rehabilitated immediately to prevent soil erosion. – Compile and implement environmental monitoring programme, the aim of which should be ensuring long-term success of rehabilitation and prevention of environmental degradation. Environmental monitoring should be conducted at least twice per year (i.e. Summer, Winter). – Ensure proper surface restoration and re-sloping in order to prevent erosion, taking cognisance of local contours and landscaping. – Exposed areas with slopes less than 1:3 should be rehabilitated with a grass mix that blends in with the surrounding vegetation. – The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. – Re-vegetated areas showing inadequate surface coverage (less than 30% within eight (8) months after re-vegetation) should be prepared and re-vegetated from scratch.	Extent: Site (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium-high (-9)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
		• Damage to re-vegetated areas shall be repaired promptly. **Re-purposing the condensate so that it becomes a by-product, rather than a waste which needs to be removed to Gauteng for treatment, will further reduce the risk.** **This will form part of the parallel EIA process and is NOT considered in terms of mitigation at this time.**	
<u>Borrow pit</u> **Impacts:** – Removal of soils for establishment of the dam – Loss of vegetation and faunal habitat – Erosion due to exposed soils – Alien invasive weed infestation – Visual – Safety	Extent: Site (-1) Duration: Permanent (-4) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Closure and rehabilitation of the borrow pit: – The borrow pit must be rehabilitated in a way that blends with the surrounding area and appears as a natural extension to the adjacent, undisturbed ground profile. – Even contours are created and no slopes steeper than 1:3 are created. – All material in and around the borrow pit, whether spoils, excess stockpiled material, material resulting from clearing and grubbing or excess overburden should be used for shaping or appropriately disposed of. – The level of compaction of areas disturbed by heavy-duty machinery should be addressed preferably prior to the spreading of topsoil by scarifying the ground surface wither by plough or mechanical ripper to a depth of approximately 150 mm to break down soil clods. – Approximately 50 to 100 mm of topsoil should be applied to the scarified borrow pit. – Before placing topsoil, all visible weeds should be removed. – On completion of the rehabilitation process, the borrow pit should drain properly and the run-off water should not cause erosion. Measures to prevent soil erosion include: appropriate shaping of the borrow pit; ensuring that slopes are no steeper than 1:3; stabilisation by re-vegetation and the application of chemical stabiliser. – The borrow pit should be free draining, in this way ponding will be minimised. – Exposed areas should be re-vegetated with a grass mix that blends in with the surrounding vegetation. – The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. – Re-vegetated areas showing inadequate surface coverage (less than 30% within eight months after re-vegetation) should be prepared and re-vegetated from scratch. – Damage to re-vegetated areas shall be repaired promptly. – Any runnels or erosion channels developing after re-vegetation should be backfilled and consolidated and the areas restored to a proper stable condition.	Extent: Site (-1) Duration: Medium-term (-2) Intensity: Low (-1) Probability: Possible (-2) **Significance: Medium (-6)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Gasifier Roads – including linked watercourse crossings **Potential impacts:** – Loss of riparian vegetation – Erosion of banks – Siltation – Flow modification – Water quality impairment	Extent: Local (-2) Duration: Permanent (-4) Intensity: High (-3) Probability: Definite (-4) **Significance: High (-14)**	• Road design at the watercourse crossing must incorporate a sufficient number and volume of culverts to allow flow within the watercourse to pass under the road in as natural a manner as possible; i.e. flow within wetlands should be kept as diffuse as possible where diffuse flow occurs. • Structures e.g. culverts must be inspected regularly for accumulation of debris and blockages - debris must be removed and damages must be repaired and reinforced immediately. • Stormwater management structures must be constructed, operated and maintained in a sustainable manner throughout the affected area and, should include but not be limited to the following: – Increased run-off because of vegetation clearance and/or soil compaction must be managed, and steps must be taken to ensure that stormwater does not lead to bank instability and excessive levels of silt entering the watercourse. – Stormwater must be diverted from the gasification area and roads and must be managed in such a manner so as to disperse run-off and to prevent concentrated stormwater flow (silt traps, barriers such as sand-bags). – The velocity of stormwater discharges must be attenuated and the banks of the watercourses protected. • Any impacted areas within the riparian zone should be rehabilitated, specifically to re-vegetate the area with suitable vegetation. • The re-vegetated areas (where possible), should be temporarily fenced to prevent damage by grazing animals. • Only appropriate indigenous riparian vegetation may be used for rehabilitation and re-vegetation within the disturbed area.	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**
Gas treatment plant **Impacts:** – Loss of vegetation – Groundwater and soil contamination through leaks – Release of fugitive emissions	Extent: Local (-2) Duration: Permanent (-4) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-11)**	• Implementation of inspection programs to maintain the mechanical integrity and operability of pressure vessels, tanks, piping systems, relief and vent valve systems, containment infrastructure, emergency shutdown systems, controls and pumps, and associated process equipment. • Regularly monitor fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapour detection equipment, and maintenance or replacement of components in a prioritized manner. • Regular groundwater monitoring programme. • Institute clean up protocol should there be a local leakage. • On-going raw gas transfer pressure measurement with pressure change alarm signal control.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-3) **Significance: Medium-high (-9)**

Aspect	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Hazardous substance storage (e.g. diesel) **Impact:** – Spillage and contamination – Uncontrolled releases of hazardous materials to the environment or uncontrolled reactions that might result in fire or explosion	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Definite (-4) **Significance: Medium-high (-11)**	• Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Appropriate secondary containment structures consist of berms or walls (bunds) capable of containing a minimum of the larger of either 110% of the largest tank or 25% percent of the combined tank volumes in the area, with above-ground tanks with a total storage volume equal or greater than 1,000 litres and will be made of impervious, chemically resistant material. • Fire prevention systems and secondary containment should be provided for storage facilities, where necessary or required by regulations, to prevent fires or the release of hazardous materials to the environment. • Exercise appropriate emergency preparedness programmes (plans, schedules, procedures and methods) for addressing environmental accidents, incidents and events such as the spillage of fuel. • Conducting periodic (e.g. daily or weekly) reconciliation of tank contents and inspection of visible portions of tanks and piping for leaks. • Periodic pressure testing should be undertaken. • The constraints of the SANS codes with respect to the aboveground tank storage requirements must be met.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium (-8)**
Condensate water treatment plant **Impact:** – Groundwater and soil contamination through leaks – Functional integrity of the water treatment plant – unable to remove hydrocarbons	Extent: Local (-2) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Highly probable (-4) **Significance: Medium-high (-10)**	• Dismantle current 15,000 Nm^3/hr water treatment plant and replace with a pilot activated carbon filtration system. • Ensure that the decommissioning of the current water treatment plant and the new activated carbon filtration system have the necessary environmental approvals. • All plant components to be disposed of at a licensed hazardous waste disposal facility. • Rehabilitation of the existing water treatment plant site: – Rehabilitate disturbed areas with natural vegetation. – Exposed areas must be rehabilitated immediately to prevent soil erosion. – Ensure proper surface restoration and re-sloping in order to prevent erosion, taking cognisance of local contours and landscaping. – Damage to re-vegetated areas shall be repaired promptly.	Extent: Site (-1) Duration: Long-term (-3) Intensity: Moderate (-2) Probability: Possible (-2) **Significance: Medium (-8)**

7.3 Geology

Table 55: Significance rating of geological impacts

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	Drilling of wells to coal seam depth	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** High (-3) **Probability:** Definite (-4) **Significance: Medium-high (-9)**	• On-going development of mining methodology / plan describing specifications (i.e. depth, size, spacing), sequencing and well location. • Appointment of a qualified drilling contractor. • All wells must be sealed all the way into the coal seam and grouted with cement. • A lot of care should be taken during well construction to ensure that there are no air voids and no contacts points with the upper aquifer. • All drill cuttings should be disposed off at a licensed landfill site.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	High concentration gas accumulation in gasification chamber leading to underground explosions	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	• Gasification process linked to specially designed process software to ensure early detection of upset / emergency conditions underground. • During operation gasification can be controlled and the flow of air into the well can be stopped thereby stopping the gasification process.	**Extent:** Site (-1) **Duration:** Long-term (-3) **Intensity:** Low (-1) **Probability:** Improbable (-1) **Significance: Medium (-6)**
	Surface subsidence as a result of undermining the entire farm.	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** Very High (-4) **Probability:** Definite (-4) **Significance: High (-13)**	No mitigation proposed other than for subsidence and the related impact on wetland systems, surface water resources, groundwater inputs into wetlands, and, surface water resources (refer to: **Hydrogeology**, **Hydrology, Wetlands**)	**No direct mitigation**
	Goafing (gasification chamber roof collapse)	**Extent:** Site (-1) **Duration:** Permanent (-4) **Intensity:** High (-3) **Probability:** Possible (-2) **Significance: Medium-high (-10)**	***No mitigation proposed.***	**No mitigation**