Appendix D

Specialist Studies

Appendix D1

Ecological Specialist Study

TRANSNET MANGANESE ORE LINE UPGRADE

FAUNA & FLORA SPECIALIST REPORT FOR BASIC ASSESSMENT

PRODUCED FOR ERM

ON BEHALF OF

TRANSNET

BY

SIMON TODD CONSULTING

Simon.Todd@3foxes.co,za

April 2013

CONTENTS

EXECUTIVE SUMMARY

Transnet (SOC) Ltd is in the process of upgrading the existing manganese ore railway line, which runs from the vicinity of Kathu and Hotazel in the Northern Cape to the Port Elizabeth Port Terminal. As part of the upgrade a new port terminal will be developed within the Coega Industrial Development Zone (IDC) and the export capacity of the railway line will be increased from 5.5 Million tons per annum (MTPA) to 16 Mtpa. As part of the rail component several railway loops will be extended / new railway loops will be constructed. This report details the ecological impacts likely to be associated with the development of 15 loop extensions along the railway line. A site visit to each of the loop extensions was conducted in October 2012. At each site, the affected area was investigated and a full plant species list for the site was created. All listed and protected species present were noted and their locations recorded with the GPS. Sensitive features such as drainage lines and wetlands were also noted and located using a GPS. Five different impacts were identified as being associated with the development and were assessed for each site:

- Impacts on vegetation and protected plant species
- Alien Plant Invasion Risk
- Increased erosion risk
- Direct Faunal impacts
- Impacts on Critical Biodiversity Areas

The loop extensions will result in a limited extent of transformation, amounting to less than a few hectares at each site. A large proportion of the development footprint at each site is also within previously disturbed areas (ie within the existing railway reserve). The development of the loop extensions will create transient disturbance within the affected areas which will create a significant local impact during construction, but will return to preconstruction levels, once construction has been completed. Although there are some protected plant species at the majority of loop sites, the actual numbers of affected individuals is quite low. As the affected species are not rare or locally restricted, these impacts would not be of wider significance. In terms of erosion risk, the majority of sites are within flat areas and it is only at sites with steeper areas and drainage lines, that there is some risk of erosion.

The railway line acts as a dispersal corridor for alien plant species and alien plants were common at all of the sites. Woody species such as *Prosopis* pose the most significant ecological risk and should be controlled where present.

Given the limited extent of the developments, it is not likely that any of the loop extensions will result in significant faunal impact. The sites within the Eastern Cape are mostly within Critical Biodiversity Areas (CBAs), which raises the potential for impact on these areas. However, the CBAs are all designed as broad-scale corridors and not as a result of the known presence of significant biodiversity. Given the proximity of the development to the existing railway line, the loop extensions would not contribute significantly to the disruption of landscape connectivity and ecological functioning of the CBAs. Overall,

there are no highly sensitive features present at any of the sites which would pose a significant obstacle to the development.

DECLARATION OF CONSULTANTS INDEPENDENCE

The author of this report, Simon Todd, does hereby declare that he is an independent consultant appointed by ERM for Transnet (SOC) Ltd and has no business, financial, personal or other interest in the activity, application or appeal in respect of which he was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of the specialist performing such work. All opinions expressed in this report are his own.

Simon Todd Pr.Sci.Nat

April 2013

1 INTRODUCTION

Transnet is in the process of upgrading the existing manganese ore railway line, which runs from the vicinity of Kathu and Hotazel in the Northern Cape to the Port Elizabeth Port Terminal. As part of the upgrade a new port terminal will be developed within the Coega Industrial Development Zone (IDC) and the export capacity of the railway line will be increased from 5.5 Million tons per annum (MTPA) to 16 Mtpa. As part of the rail component several railway loops will be extended / new railway loops will be constructed. As some of these developments will extend into currently intact vegetation, a basic assessment process for 15 loop extensions has been initiated. Environmental Resources Management (ERM) is conducting the EIA process for the above developments and has appointed Simon Todd consulting to provide the ecological component for each of the 15 loop extensions. Five of the loop extensions are in the Eastern Cape and the remaining ten in the Northern Cape. A map of the location of the different loop extensions is provided below in Figure 1.

The broad terms of reference for the assessment of each site includes the following:

- Assess and detail the potential impacts of the proposed development on both vegetation and fauna at the site.
- Identify the existence of protected flora species for the purpose of undertaking permit applications for their removal / disturbance.
- Outline possible mitigation measures, rehabilitation procedures and or vegetation removal procedures that would reduce the potential impacts of the development.
- Identify and rate the significance of potential impacts and outline additional management guidelines.

2 METHODOLOGY

2.1 Relevant Aspects of the Development

As already mentioned the study encompasses 15 loop extensions, the purpose of which are to enable trains coming from opposite directions to pass each other safely. Although each is an independent site, they are included here in a single report as they are part of the same larger development and subject to similar impacts. Each site is however described and assessed independently within the report. Although the nature of the developments at each site vary slightly, in the majority of cases the primary development component is a loop extension to accommodate a 200 wagon train within each loop.

The following loop extensions are part of the study:

- Witloop
- Wincanton
- Sishen new loop
- Glosam
- Postmasburg

- Tsantsabane
- Trewil
- Ulco
- Gong Gong
- Fieldsview
- Drennan
- Thorngrove
- Sheldon

Certain sections of the line need to be doubled. This is also an extension of the loop however it is between two stations. The sections to be doubled which are part of this study are:

- Cookhouse to Golden Valley
- Rippon to Kommadagga

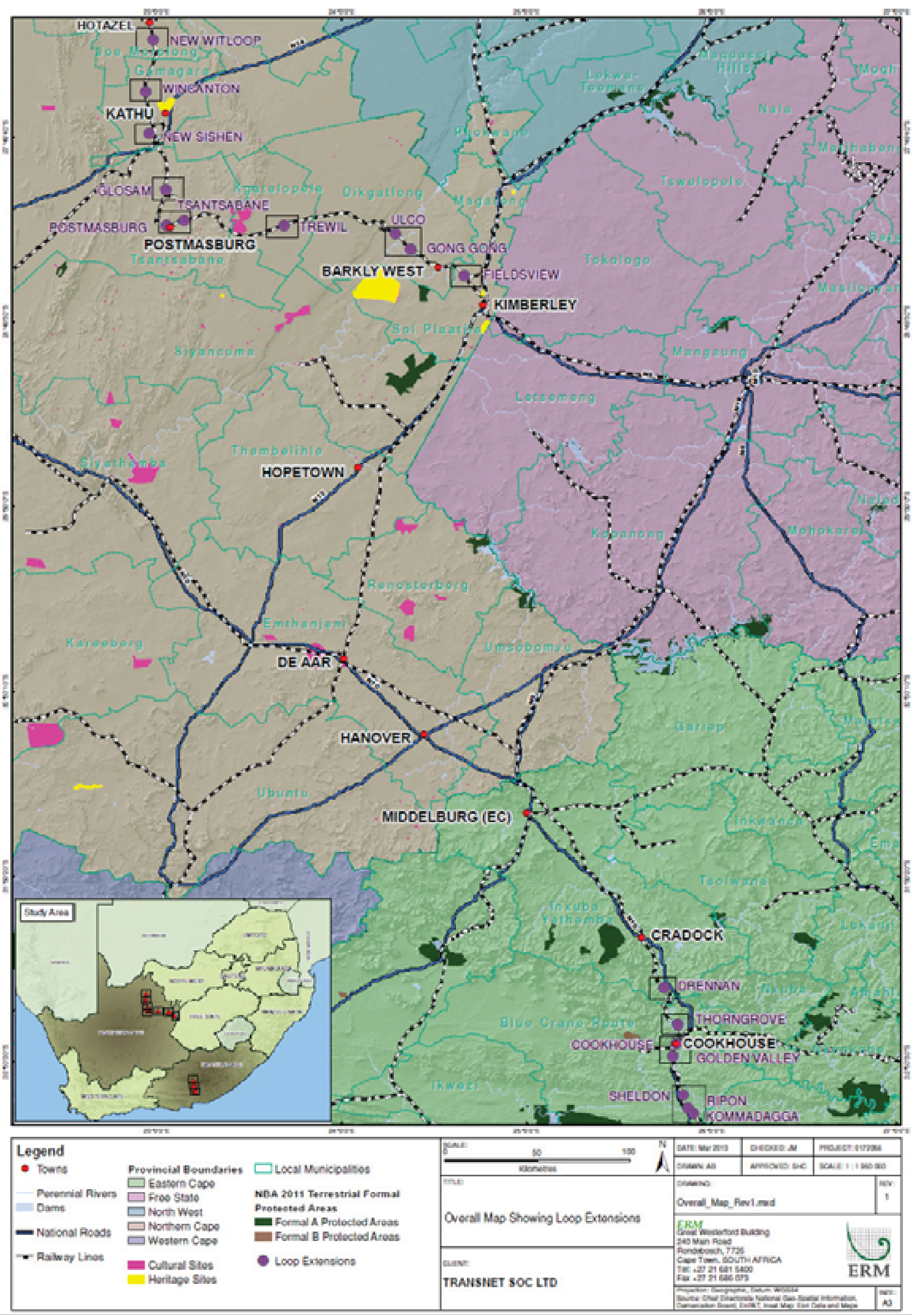


Figure 1. Map of the study area, indicating the location of the loop extensions which form part of the study. Map provided by ERM.

2.2 SITE VISITS

Each of the study components was visited during an extended fieldtrip, which took place from the 1-5 November for the sites within the Northern Cape and from 9-12 November for the sites within the Eastern Cape. At each site, the affected area was investigated and a full plant species list for the site was created. All listed and protected species present were noted and their locations recorded with the GPS. Sensitive features such as drainage lines and wetlands were also noted and located using a GPS. Photographs of all significant features observed were also taken for documentation purposes. The sensitivity of each site was also investigated in terms of the faunal species and habitats present. Any animal burrows present within the development footprint were recorded with the GPS and the species present noted. Evidence of faunal activity such as diggings and scat were also observed and noted. The Sheldon loop was added to the study after the site visits had taken place and was not assessed in the field. The consultant is however familiar with the area, having worked on a variety of different projects in the immediate vicinity and the assessment of this site is therefore based on this experience.

2.3 DATA REVIEW & SOURCING

Following the site visits, lists of mammals, reptiles and amphibians which were observed at each site were augmented with species likely to occur at the site based on distribution records from the literature and various spatial databases (SANBI's SIBIS and BGIS databases). Literature consulted includes Branch (1988) and Alexander and Marais (2007) for reptiles, Du Preez and Carruthers (2009) for amphibians, Friendmann and Daly (2004) and Skinner and Chimimba (2005) for mammals. The lists provided are based on species which are known to occur in the broad geographical area as well as an assessment of the availability and quality of suitable habitat at the site. For each species, the likelihood that it occurs at the site was rated according to the following scale:

Low: The available habitat does not appear to be suitable for the species and it is unlikely that the species occurs at the site.
Medium: The habitat is broadly suitable or marginal and the species may occur at the site.
High: There is an abundance of suitable habitat at the site and it is highly probable that the species occurs there.
Definite: Species that were directly or indirectly (scat, characteristic diggings, burrows etc) observed at the site.

The conservation status of each species is also listed, based on the IUCN Red List Categories and Criteria version 3.1 (2012) and where species have not been assessed under these criteria, the CITES status is reported where possible. These lists are adequate for mammals and amphibians, the majority of which have been assessed, however the majority of reptiles have not been assessed and therefore, it is not adequate to assess the potential impact of the development on reptiles, based on those with a listed conservation status alone. In order to address this shortcoming the distribution of reptiles was also taken into account such that any narrow endemics or species with highly specialized habitat requirements occurring at the site were noted.

Table 1. The IUCN categories used to denote the conservation status of species of conservation concerns with the study area.

IUCN Red List Category	Abbreviation
Critically Endangered (CR)	CR
Endangered (EN)	EN
Vulnerable (VU)	VU
Near Threatened (NT)	NT
Critically Rare	
Rare	
Declining	
Data Deficient - Insufficient Information (DDD)	DDD
Data Deficient - Taxonomically Problematic (DDT)	DDT
Least Concern	LC
Total	

2.4 Sampling Limitations and Assumptions

The major potential limitation associated with the sampling approach is the narrow temporal window of sampling. Ideally, a site should be visited several times during different seasons to ensure that the full complement of plant and animal species present are captured. However, this is rarely possible due to time and cost constraints and therefore, the representivity of the species sampled at the time of the site visit should be critically evaluated. Within the Northern Cape section the majority of sites were very dry at the time of sampling and there were not many forbs and annuals present within the natural vegetation. There had been some rain prior to the site visits however, and alien weeds were relatively common along the railway line and adjacent disturbed areas. Within the Eastern Cape section, it was wetter, particularly in the south and although the grasses were dormant, a large proportion of the shrubs and forbs present were growing. Overall, the conditions at the time of sampling were good in the Eastern Cape section and adequate in the Northern Cape section and are not deemed to have a significant influence on the outcome of the study.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT- BASELINE

In this section each site is described in terms of the vegetation types present at each site, the dominant species observed and the presence of listed and protected species. In addition, any other sensitive features present such as wetlands and drainage lines are described and the manner in which the development may impact these features discussed. The sites are described in sequential order from the most northerly site Witloop through to Ripon, the most southerly site.

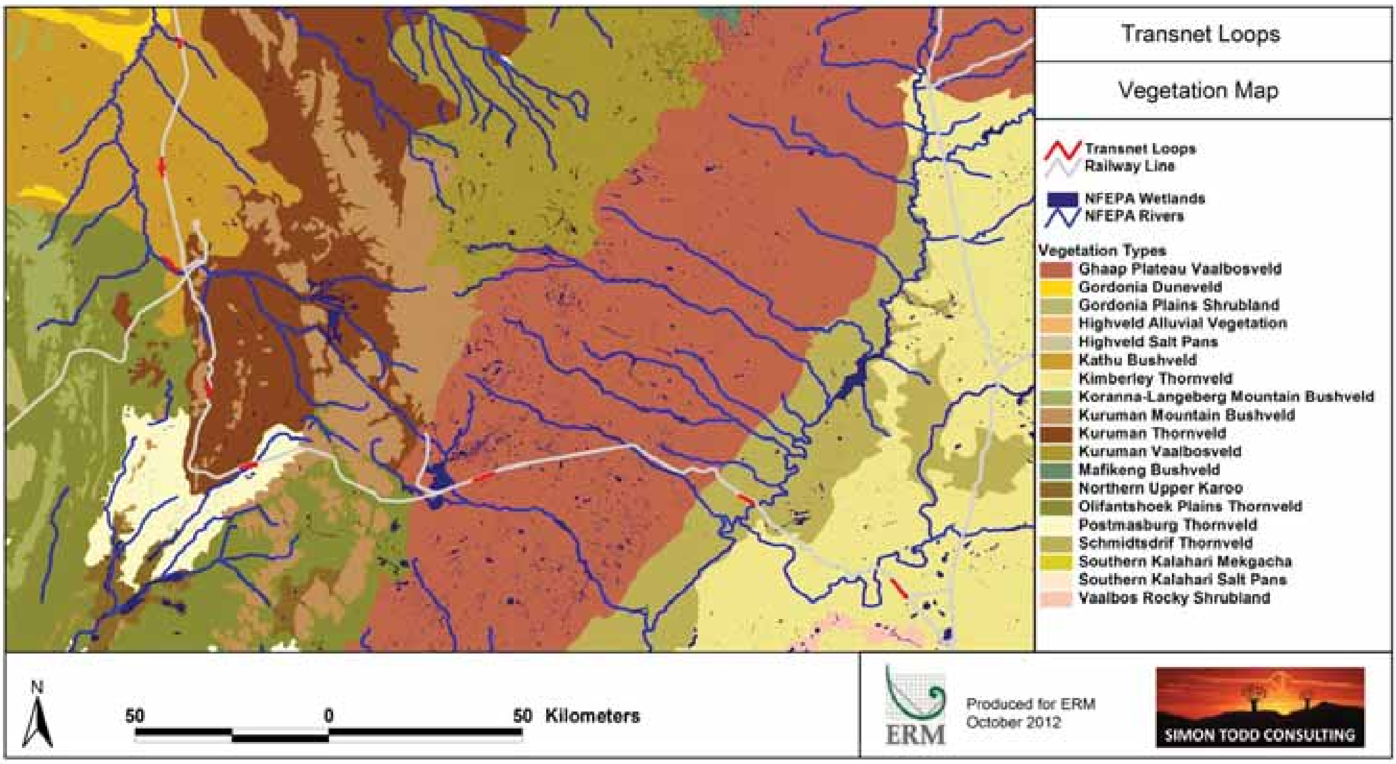


Figure 2. The vegetation within the Northern Cape section of the project. The vegetation map is an extract of the national vegetation map as produced by Mucina & Rutherford (2006), and also includes rivers and wetlands delineated by the National Freshwater Ecosystem Priority Areas Assessment (Nel et al. 2011).

3.1 NORTHERN CAPE SECTION

3.1.1 *Witloop*

According to the national vegetation map (Mucina & Rutherford 2006), the New Witloop site lies entirely within the Kathu Bushveld vegetation type (Figure 2). This vegetation unit occupies an area of 7443 km^2 and extends from around Kathu and Dibeng in the south through Hotazel and to the Botswana border between Van Zylsrus and McCarthysrus. It is associated with Aeolian red sand and surface calcrete, deep sandy soils of the Hutton and Clovelly soil forms. The main land types are Ah and Ae with some Ag. The Kathu Bushveld vegetation type is still largely intact and less than 2% has been transformed by mining activity and it is classified as Least Threatened.

Within the site, the soils are deep pale, deep Kalahari sands, dominated by *Acacia haematoxylon* and *Grewia flava* with occasional *Acacia erioloba* and *Acacia mellifera*. The grass layer is dominated by *Schmidtia pappophoroides*, *Eustachys paspaloides*, *Eragrostis lehmanniana* var. l*ehmanniana*, *Cenchrus ciliaris* and *Aristida meridionalis*. Occasional shrubs are also present including *Gnidia polycephala*, *Hermannia tomentosa* and *Melolobium macrocalyx*, *Plinthus sericeus, Chrysocoma obtusata, Elephantorrhiza elephantina and Senna italica subsp. arachoides*. The vegetation is generally in a good condition and alien species were largely restricted to the immediate vicinity of the railway line itself. There were however some of the alien invasive tree, *Prosopis glandulosa* present around the Witloop platform area. There are no drainage features or other mesic habitats present within the site. Along the railway line, alien species present include *Argemone ochroleuca* subsp. *ochroleuca*, *Conyza bonariensis* as well as indigenous disturbance-adapted species such as *Heliotropium ciliatum* and *Hirpicium echinus*.

Figure 3. Two views of the Witloop site, towards the southern extent of the site on the left and towards the north on the right. The vegetation is dominated by *Acacia haematoxylon* and *Grewia flava* with occasional *Acacia erioloba*.

The major impact associated with development of the site would be on the listed tree species *Acacia haematoxylon* and *Acacia erioloba*, which are common in the area. However, as the vegetation in the area is very homogenous, the loss of relatively few individuals of these species would not amount to a significant impact on the local populations of these species. There are no specific habitats within the site which would be of higher significance for fauna. Overall, the extension of the loop at the Witloop site is not likely to generate any impacts of wider significance.

3.1.2 Wincanton

As with the New Witloop site, the Wincanton site lies within the Kathu Bushveld vegetation type (Figure 2). This vegetation unit occupies an area of 7443 km^2 and extends from around Kathu and Dibeng in the south through Hotazel and to the Botswana border between Van Zylsrus and McCarthysrus. It is associated with Aeolian red sand and surface calcrete, deep sandy soils of the Hutton and Clovelly soil forms. The main land types are Ah and Ae with some Ag. The Kathu Bushveld vegetation type is still largely intact and less than 2% has been transformed by mining activity and it is classified as Least Threatened.

The site occurs on shallow red Kalahari sands overlying calcrete. The vegetation is fairly dense thornveld dominated by low trees, especially *Acacia mellifera* and *Tarchonanthus camphoratus* with occasional *Boscia foetida* and *Acacia erioloba*. The grass layer is dominated by *Eragrostis lehmanianna*, *Cenchrus ciliaris*, *Schmidtia pappophoroides* and *Enneapogon scoparius*. Shrubs were also quite common with species such as *Aptosimum albomarginatum*, *Galenia africana*, *Salago densiflorus* and *Lycium cinereum* being most prominent. A number of alien trees were present around the platform including *Syringa*, *Shinus molle*, *Opuntia ficus-indica* and *Eucalyptus* sp. Other alien species were largely restricted to the railway line area and included *Conyza bonariensis*, *Argemone ochroleuca*, *Lactuca seriola* and *Tagetes minuta*.

Figure 4. The Wincanton site in the vicinity of the platform. This area has recently been cleared and a lot of bare ground was present around the platform area.

In terms of the presence of listed species at the site, there were some *Acacia erioloba* near the platform area and some *Boscia foetida* along the area demarcated for the loop extension. The loss of approximately ten individuals of each species is however not significant at the landscape scale. The site is also very flat and there are not likely to be any highly significant impacts resulting from the loop extension.

3.1.3 New Sishen

As with Wincanton and Witloop, the New Sishen site lies within the Kathu Bushveld vegetation type (Figure 2). This vegetation unit occupies an area of 7443 km^2 and extends from around Kathu and Dibeng in the south through Hotazel and to the Botswana border between Van Zylsrus and McCarthysrus. It is associated with Aeolian red sand and surface calcrete, deep sandy soils of the Hutton and Clovelly soil forms. The main land types are Ah and Ae with some Ag. The Kathu Bushveld vegetation type is still largely intact and less than 2% has been transformed by mining activity and it is classified as Least Threatened.

This will form part of the relocation of the Sishen railway infrastructure currently being constructed by Kumba Iron Ore. The loop will lie adjacent to a new section of railway line that has just been completed by Kumba. As the construction of the new line has resulted in a lot of vegetation clearing at the site, the new loop will lie largely within the current development footprint and is not likely to have a significant impact on the adjacent intact vegetation,which has been cleared for the railway line as well as the ESKOM transmission line which runs through the area. The intact vegetation at the site is quite dense and is dominated by *Tarchonanthus camphoratus*, *Acacia erioloba*, *Acacia mellifera*, *Zizyphus mucronata* and *Grewia flava*. There are very few alien species present within the site and the vegetation can be considered to be in good condition. There are no drainage features or other water-related features within the development area. As the site has recently been cleared and there appears to be sufficient space within the cleared areas to accommodate the new loop, the construction is not likely to result in significant additional impact.

Figure 5. The Sishen site, illustrating the dense nature of the intact vegetation at the site, as well as the extent of cleared ground that has been created by construction activities for the new line at the site, being built by Kumba Iron Ore.

3.1.4 Glosam

The Glosam site lies within the Kuruman Thornveld vegetation type. Kuruman Thornveld occupies 5794 km^2 of the Northern Cape and is classified as Least Threatened. The vegetation type has not been heavily impacted by transformation and 98.10% of the original extent is still intact. Within the site, the vegetation was dominated by low trees such as *Tarchonanthus camphoratus*, *Grewia flava*, *Acacia mellifera*, *Olea europea* subsp. *africana*, *Searsia tridactyla* and *Ziziphus mucronata* subsp. *mucronata*. The grass layer is fairly dense and is composed of species such as *Themeda triandra*, *Cymbopogon pospischilii*, *Eragrostis lehmanniana* var. l*ehmanniana*, *Schmidtia pappophoroides*, *Fingerhuthia africana*, *Eustachys paspaloides* and *Cenchrus ciliaris*. There were also a number of shrub species present including *Gnidia polycephala*, Eriocephalus *ericoides* subsp. *ericoides*, *Asparagus suaveolens* and *Lebeckia macrantha*. The vegetation within the railway reserve was reasonably intact and only the disturbed area immediately adjacent to the railway line was dominated by alien species such as *Argemone ochroleuca* subsp. *ochroleuca*, *Conyza bonariensis*, *Atriplex suberecta* and *Sisymbrium burchellii*. The site is flat and there are no drainage lines or other aquatic features present within the study area. Nearly 30 *Olea europea* subsp. *africana* trees were identified within the potential development footprint at the site. The loss of these individuals from the site would not significantly impact the viability of the local population of this species which is common and widespread in the area.

Figure 6. Two views of the Glosam site. The left image illustrates the relatively intact nature of the vegetation in the railway reserve which was a lot less impacted than at the majority of other sites. The right image illustrates the natural vegetation adjacent to the reserve.

3.1.5 Postmasburg

The Postmasburg loop lies to the west of the Postmasburg station and the town itself. The loop lies entirely within the Kuruman Thornveld vegetation type, which occupies 5794 km^2 of the Northern Cape and is classified as Least Threatened. The vegetation type has not been heavily impacted by transformation and 98.10% of the original extent is still intact. The vegetation around the station was very disturbed and several alien tree species, such as Syringa *Melia azedarach*, Pepper Tree *Schinus molle*, Mesquite *Prosopis glandulosa* and *Eucalyptus camalduensis,* were present as well as several alien forbs, such as *Conyza bonariensi*, *Bidens pilosa* and *Argemone ochroleuca* subsp. *ochroleuca*. Further away from the station area in less disturbed areas the vegetation consisted of dense scrub dominated by species such as *Acacia mellifera*, *Tarchonanthus camphoratus*, *Zizyphus mucronata*, *Searsia tridactyla* and *Searsia burchelii*. The understorey was sparse as a result of heavy grazing as well as the dense scrub layer. Shrubs and grasses present include *Cenchrus cilliaris*, *Heteropogon contortus*, *Aristida adscenionis*, *Selago densiflorus*, *Eriocephalus microcephalus*, *Melolobium candicans*, *Rhigozum trichotomum*, *Exomis microphylla*, and *Lycium cinereum*. The vegetation can be considered to be in reasonably poor condition as a result of bush encroachment which has significantly reduced the productive capacity of the vegetation. No species of conservation concern were observed within the development footprint.

Large parts of the vegetation along the railway line have been disturbed in the past, as illustrated below in Figure 7. There are no drainage lines or other areas of high sensitivity within the development footprint. The extension of the loop along this section of the line is not likely to generate significant ecological impact given the disturbed nature of the receiving environment and abundance of alien species in the area.

be located. The natural bush next to the line is dominated by *Acacia mellifera*, while the alien weed *Argemone ochroleuca* subsp. *Ochroleuca* can be seen in the disturbed area along the line.

3.1.6 Tsantsabane

The Tsantsabane site lies within the Kuruman Thornveld vegetation type. Kuruman Thornveld occupies 5794 km^2 of the Northern Cape and is classified as Least Threatened. The vegetation type has not been heavily impacted by transformation and 98.10% of the original extent is still intact. Within the site, the vegetation was quite dense and dominated by low trees especially *Tarchonanthus camphoratus*, *Acacia mellifera*, *Zizyphus mucronata*, *Grewia flava* and *Olea europea* subsp. *africana*. The grass layer is dominated by *Schmidtia pappophoroides*, *Heteropogon contortus* and *Enneapogon scoparius*. In some places the density of shrubs was quite high, particularly *Eriocephalus ericoides* subsp. *ericoides*, *Pentzia globosa*, *Gnidia polycephala* and *Rhigozum trichotomum*.

The disturbed area immediately adjacent to the railway line was dominated by alien species such as *Laggera decurrens*, *Argemone ochroleuca* subsp. *ochroleuca*, *Bidens* pilosa and *Tagetes minuta*. There is an ephemeral drainage line towards the eastern boundary of the site. As additional culverts will not be built over the drainage line, the development is not likely to have a significant impact on the drainage line and the natural flow of water through the area is not likely to be affected.

Figure 8. Images illustrating the dense nature of the vegetation at the Tsantsabane site and the close proximity of the railway to the intact vegetation.

3.1.7 Trewil

The vegetation of the Trewil site consists of Ghaap Plateau Vaalbosveld which is 98.7% intact and classified as Least Threatened. Within the site, the soils are shallow with exposed calcrete in most areas. The dominant species within the vegetation are *Tarchnonthus camphoratus* and *Searsia tridactyla*, while in some places towards the northern extent of the site *Olea europea* subsp a*fricana* is also common as can be seen in the right image below. The grass was very heavily grazed within the farmland and was generally low and open. Dominant grass species present are *Themeda triandra*, *Heteropogon contortus*, *Digitaria eriantha* and *Eragrostis lehmanianna*. The area likely to be affected by the development has been previously impacted and cleared of large woody species as a result of the Sedibeng water pipeline which runs parallel to the railway line. As a result, few large woody species would be affected by the development. There is however a narrow strip of woody vegetation along the fence between the railway line and the adjacent cleared rangeland which contained some individuals of *Olea europea* subsp africana. Given the largely disturbed nature of the affected area, the development is not likely to have a significant negative impact on fauna or flora.

Figure 9. The natural vegetation along the Trewil section. Although the natural vegetation is quite dense and heavily dominated by *Tachonanthus camphoratus*, the area adjacent to the line has been cleared of larger woody plants on account of the Sedibeng water pipeline which runs adjacent to the railway line.

3.1.8 Ulco

The vegetation of the Ulco site consists of Schmidtsdrif Thornveld which has an extent of 5032 km^2 and is 87% intact and classified as Least Threatened. Soils in the area are shallow and underlain by calcrete with loose stones on the surface in many areas. Within the site, the natural vegetation consist of thorny bushveld dominated by *Acacia mellifera* and *Tarchonanthus camphoratus* with occasional other woody species such as *Searsia lancea*, *Olea europea* subsp *africana*, *Grewia flavaI* and *Acacia tortilis*. The grass layer is also quite well developed and is dominated by *Eragrostis lehmanianna*, *Eragrostis echinochloidea*, *Fingerhutia africana*, *Cenchrus ciliaris* and *Eustachys paspaloides*. Alien species present at the site include *Prosopis glandulosa*, *Opuntia* spp., *Argemone ochroleuca* and *Bidens pilosa*. The site is flat and there are no drainage lines or other mesic features present within the site. Protected species present at the site include several *Boscia foetida* and a number of *Olea europea* subsp a*fricana* trees. A large proportion of the development footprint is within areas that have previously been disturbed and the construction of the loop extension is not likely to result in significant impact on local biodiversity.

Figure 10. The Ulco site, illustrating the relatively dense bush at the site, as well as the disturbance present in the vicinity of the platform.

3.1.9 Gong Gong

The Gong Gong site falls within the Kimberley Thornveld vegetation type. Kimberley Thornveld is an extensive vegetation type that occupies 19 512 km^2 of the Northern Cape, Free State and North-West province. Kimberly Thornveld is classified as Least Threatened and 82.3% of the original extent is still intact, transformation for cultivation being the primary impact to date. Only 2% is however formally conserved. Within the site, the vegetation is highly degraded as a result of bush encroachment and the vegetation is very heavily dominated by *Acacia mellifera*. Apart from the dense stands of *Acacia mellifera*, other trees present include occasional *Boscia foetida* and *Acacia tortillis*. Shrubs present include *Grewia flava, Aptosimum albomarginatum*, *Lycium cinereum*, *Zygohyllum lichtensteinii*, *Selago densiflorus*, *Felicia muricata*, *Chrysocoma ciliata*, *Thesium hystrix* and *Rhigozum trichotomum*. Grasses present include *Stipagrostis anomala*, *Enneapogon cenchroides*, *Enneapogon scaber*, *Heteropogon contortus*, *Cenchrus ciliaris* and *Enneapogon desvauxii*. There were no drainage lines or other sensitive habitats present within the development footprint. Alien density was relatively low and alien species were restricted to the disturbed area next to the line and included species such as *Argemone ochroleuca*, *Laggera decurrens* and *Lactuca serriola*.

Figure 11. The vegetation along the Gong Gong section consists of dense *Acacia mellifera* thicket and can be considered fairly degraded as a result of bush thickening.

3.1.10 Fieldsview

The Fieldsview site falls within the Kimberley Thornveld vegetation type. Kimberley Thornveld is an extensive vegetation type that occupies 19 512 km^2 of the Northern Cape, Free State and North-West province. Kimberly Thornveld is classified as Least Threatened and 82.3% of the original extent is still intact, transformation for cultivation being the primary impact to date. Only 2% is however formally conserved. Within the site, the soils consist of deep red Kalahari sands. The vegetation consists of an open savannah with a varying density of trees. The grass layer is dominated by species such as *Aristida meridionalis*, *Stipagrostis hochstetteriana*, *Stipagrostis uniplumis*, *Cenchrus ciliaris* and *Themeda triandra*. Shrubs and forbs within the grass layer include *Gnidia polycephala*, *Plinthus sericeus*, *Chrysocoma obtusata*, *Hermannia tomentosa* and *Elephantorrhiza elephantina* and *Senna italica* subsp. *arachoides*. The tree layer consists of scattered *Acacia erioloba* trees as well as occasional *Acacia tortilis*, *Ziziphus mucronata* subsp. *mucronata*, *Searsia lancea* and *Lycium hirsutum*. Although the site is generally free of alien species, there were some alien species along the railway line including *Opuntia ficus-indica*. There are no drainage lines or other wetland features within the development footprint. There are approximately 38 *Acacia erioloba* trees within the development footprint. The loss of these individuals from the development footprint is not significant in the broader context. There are no other specific features within the site which have above average species richness or represent sensitive features that should be avoided. The development of the loop at the site is not likely to result in significant impact on biodiversity.

Figure 12. View of the railway line at Fieldsview and right, the vegetation in the area where the loop will be developed. The vegetation in this area is dominated by *Acacia erioloba* and *Acacia tortilis* with an understorey of grasses.

3.2 EASTERN CAPE SECTION

3.2.1 Drennan

The vegetation of the Drennan site consists of Eastern Upper Karoo which is an extensive vegetation type which occupies more than 49 000 km^2, making it the most extensive vegetation type in South Africa, forming a large proportion of the central and eastern Nama Karoo Biome. This vegetation type is classified as Least Threatened and about 2% of the original extent has been transformed largely for intensive agriculture. The vegetation type is however poorly protected and less than 1% of the 21% target has been formally conserved. Within the site, the vegetation consists of an open, grassy shrubland with trees largely restricted to the vicinity of drainage lines. Within the natural vegetation, dominant shrubs include *Pentzia incana*, *Felicia hirsuta*, *Lycium cinereum*, *Asparagus burchellii*, *Chrysocoma ciliata* and *Helichrysum rosum* var. *rosum*. Common grasses include *Eragrostis lehmanniana* var. *lehmanniana*, *Cenchrus ciliaris*, *Digitaria eriantha* and *Heteropogon contortus*. Within the drainage lines, dominant woody species include *Acacia karoo*, *Lycium oxycarpum*, *Diospyros lycioides* subsp. *lycioides*, *Searsia longispina*, *Searsia lancea* and *Ehretia rigida* subsp. *rigida*. Alien species are abundant within the railway reserve, but rare within the undisturbed veld. Common alien species include *Opuntia ficus-indica*, *Cirsium vulgare*, *Bidens pilosa*, *Bromus triandrus*, *Lactuca serriola* and *Atriplex lindleyi* subsp. *inflata*.

There are two relatively small drainage lines within the study area, which both currently run beneath the railway line through box culverts. The development would result in an extension of the existing culvert over the southern drainage line. Provided that reasonable measures are taken to ensure that disruption to the drainage channel is kept to a minimum, then it is unlikely that the construction of the additional box culvert would have a significant impact beyond what is already present.

The whole site lies within an extensive Tier 2 CBA, required as part of a corridor (ie the area is classified as CBA in order to maintain the broad-scale connectivity of the landscape and not on account of the presence of significant biodiversity features within the site). Given the limited extent of the current development which would result in the loss of less than 2 ha of currently intact vegetation and fact that the railway line is already present, the additional impact of the current development on the ecological functioning of the CBA would be minimal.

Figure 13. Typical views of the Drennan site, illustrating the high abundance of alien species immediately adjacent to the railway line and the intact nature of the surrounding natural vegetation.

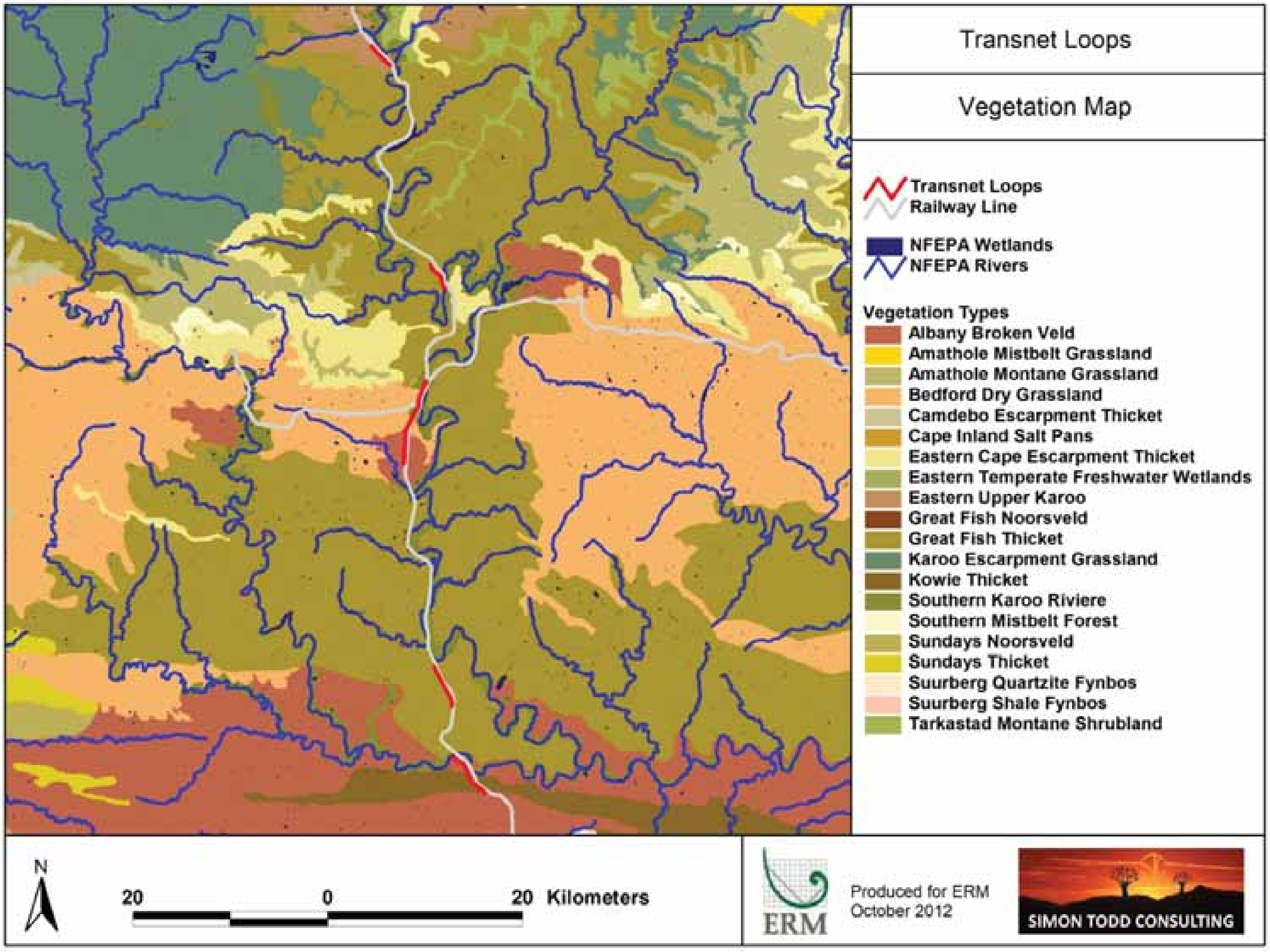


Figure 11. The vegetation within the Eastern Cape section of the Transnet loops. The vegetation map is an extract of the national vegetation map as produced by Mucina & Rutherford (2006), and also includes rivers and wetlands delineated by the National Freshwater Ecosystem Priority Areas Assessment (Nel et al. 2011).

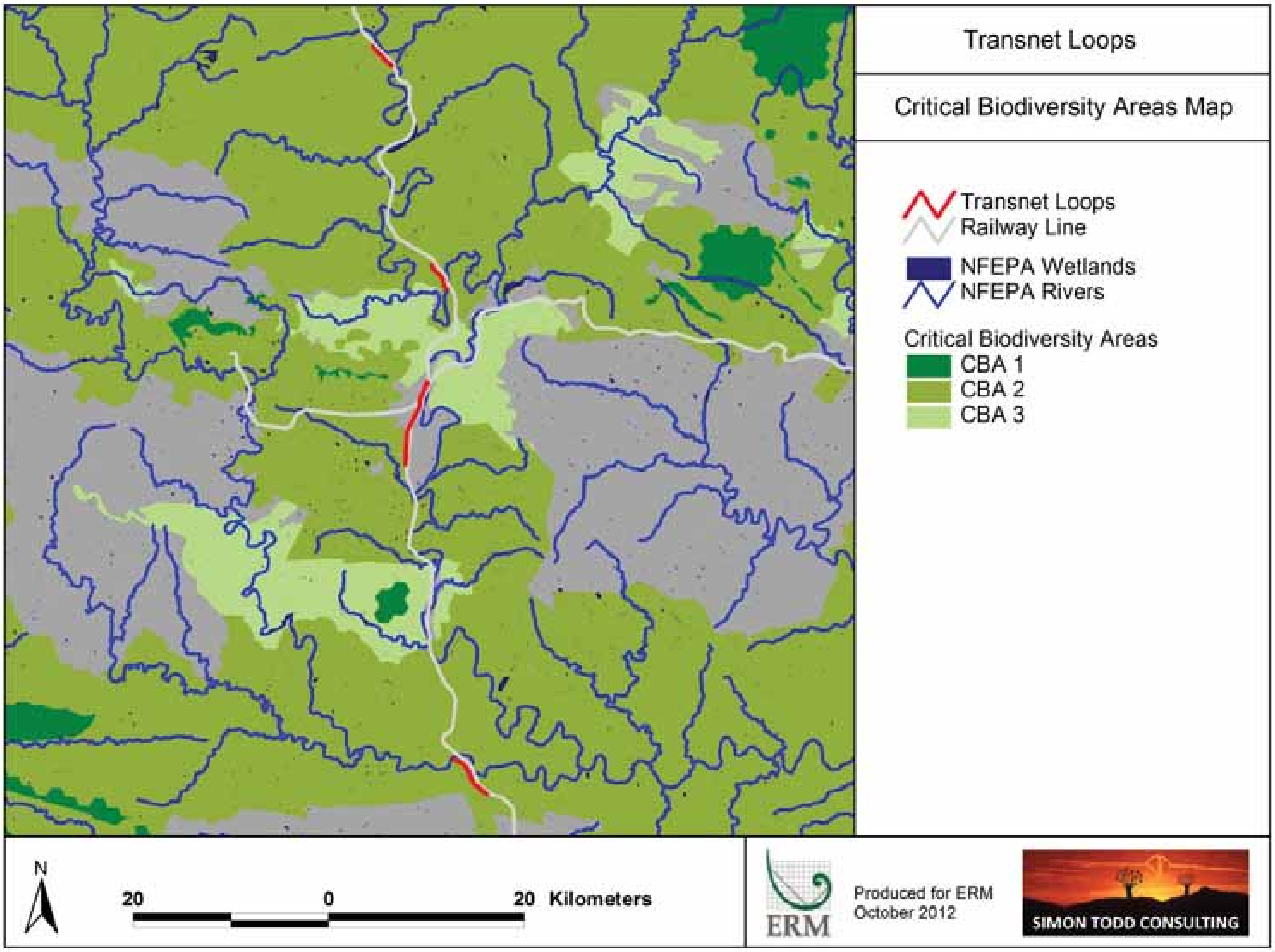


Figure 12. Critical Biodiversity Areas map of the Eastern Cape section of the Transnet loops. The map also includes rivers and wetlands delineated by the National Freshwater Ecosystem Priority Areas Assessment (Nel et al. 2011).

3.2.2 Thorngrove

Two vegetation types occur at the Thorngrove site, Great Fish Thicket which dominates the site and Southern Karoo Riviere which is associated with the larger drainage lines at the site. Great Fish Thicket is 96% intact, while 88.2% of Southern Karoo Riviere is still intact. Both vegetation types are classified as

Least Threatened. Within the site, the areas of Great Fish Thicket consist of broken woodland dominated by tree species such as *Acacia karoo*, *Grewia robusta*, *Ehretia rigida*, *Searsia longispina*, *Diospyros lycioides*, *Pappea capensis* and *Boscia oleoides*. Shrubs are also common, especially *Rhigozum obovatum*, *Helichrysum pumilio*, *Lycium cinereum* and *Hermannia cueneifolia*. Dominant grass species include *Cenchrus ciliaris*, *Enneapogon scoparius*, *Cymbopogon pospischilii* and *Heteropogon contortus*. There is a fairly extensive disturbed areas present around the platform area, and several squares of *Portulaca afra* have been planted as well as a number of *Eucalyptus* trees. Towards the southern extent of the site, the railway line passes through a cutting, which is a relatively sensitive area on account of the rocky nature of this area and the greater species richness of this area.

The site lies within an extensive CBA corridor. Given the limited extent of the current development which would result in the loss of less than 2 ha of currently intact vegetation and fact that the railway line is already present, the additional impact of the current development on the ecological functioning of the CBA would be minimal. In addition, the area is classified as CBA in order to maintain the broad-scale connectivity of the landscape and not on account of the presence of significant biodiversity features within the site.

Figure 14. The northern and southern parts of the Thorngrove site, illustrated in the left and right images respectively. The right image shows the area where the line makes a cutting through the hill before opening out onto the area with some intensive agriculture.

3.2.3 Golden Valley- Cookhouse

Three vegetation types occur at the site, namely, Albany Broken Veld, which is 97% intact, Bedford Dry Grassland, which is 96.8% intact and Southern Karoo Riviere which is 88.2% intact. All these vegetation types are classified as Least Threatened. The southern part of the site lies within Albany Broken Veld and is dominated by trees such as *Acacia karoo*, *Ehretia rigida* and *Searsia longispina*. The grass layer in this area is dominated by *Eragrostis curvula*, *Enneapogon scoparius* and *Cymbopogon pospischilii*.

Shrubs were also common in this area and include species such as *Felicia fillifolia*, *Pentzia incana*, *Felicia muricata*, *Asparagus capensis* and *Rhigozum obovatum*. There was little evidence at the site to differentiate the Bedford Dry Grassland from the Albany Thicket and there was a general thickening of the vegetation present from south to the north . The northern extent of the site lies within the Southern Karoo Riviere vegetation type. As a result of the development in the area, this part of the site is however cut off from the Groot-Vis River itself and is no longer functionally part of the drainage channel. The soils are deep silty soils developed as part of the floodplain of the Groot Vis. This area was more densely wooded than the rest of the site and was dominated by *Acacia karoo* with other low trees and tall shrubs such as *Lycium oxycarpum*, *Rhus lancea*, *Putterlickia pyracantha* and *Plumbago* .

Alien species were common at the site, particularly towards Cookhouse in the north. Species present include *Ricinus communis*, *Echinopsis spachiana*, *Datura stramonium*, *Agave americana*, *Opuntia ficus-indica*, *Salsola kali*, *Conyza bonariensis* and *Argemone ochroleuca.*

There is a storage dam near the railway line towards Golden Valley that may be impacted by the development. As this feature is important for the intensive agricultural activities in the area, the dam itself should not be impacted if possible. In most parts, there should be sufficient space between the intensive agriculture and the railway line to accommodate the planned expansion. Areas currently under irrigation should not be significantly impacted by the development, especially if precautions are taken to ensure that the development footprint is minimized. Any loss of irrigated pasture would not amount to a significant extent or significantly impact the productivity of the affected farms.

The southern part of the site abuts onto a CBA area to the west of the line which has been mapped as having the railway line as its boundary. Therefore, expansion of the line in this area to the west can be considered to be within a CBA, but areas to the east of the line are not within a CBA. Only those areas consisting of natural vegetation are however considered part of the CBA and transformed areas are not subject to the regulations pertaining to development within CBAs. The majority of the site is however not within a CBA.

Figure 15. The southern extent of the site at left, illustrating the intensive agriculture prevalent towards Golden Valley. In the right image, a view looking down the line, showing the dominance of *Argemone ochroleuca* along the railway line and the dense *Acacia* bush along the sides.

3.2.4 Sheldon

The Sheldon loop site lies entirely within the Great Fish Thicket vegetation type. This is a thicket vegetation type usually consisting of dense vegetation associated with the valleys of the Great Fish and Keiskamma River valleys. Great Fish Thicket is 96% intact and is classified as Least Threatened. Within the site, the vegetation is however mostly not very dense and consists of an open low shrubland with scattered *Pappea capensis* trees. Dense bush clumps and patches of taller vegetation are scattered in the landscape within areas of favourable moisture locations or on termitaria. Species associated with the bush clumps include *Acacia karoo*, *Grewia robusta*, *Ehretia rigida*, *Searsia longispina*, *Diospyros lycioides*, *Pappea capensis* and *Boscia oleoides*. The open vegetation is dominated by typical karoo species such as *Pentzia incana*, *Rosenia humilis*, *Rhigozum obovatum*, *Helichrysum pumilio*, *Lycium cinereum* and *Hermannia cueneifolia*, while dominant grass species include *Eragrostis lehmanniana*, *Cenchrus ciliaris*, *Enneapogon scoparius*, *Cymbopogon pospischilii* and *Heteropogon contortus*. *Aloe striata* also forms some very dense stands between the railway line and the N10. In terms of sensitive features within the site, there is a fairly large drainage area from the platform northwards to the gravel access road. This area has however been heavily impacted by agricultural activities and as the loop extension lies south of the platform, this area is not likely to be affected by the extension.

The site lies within an extensive CBA corridor which includes the Ripon-Kommadagga loop which is about 5km south of the Sheldon loop. Given the limited extent of the current development which would result in the loss of less than 2 ha of currently intact vegetation and fact that the railway line is already present, the additional impact of the current development on the ecological functioning of the CBA would be minimal. In addition, the area is classified as CBA in order to maintain the broad-scale connectivity of the landscape and not on account of the presence of significant known biodiversity features within the site. Therefore the extension of the loop in this area is not likely to significantly impact biodiversity pattern or process within the CBA, which is more than 15km wide, from north to south at this point.

3.2.5 Ripon-Kommadagga

Three vegetation types occur in the vicinity of the site, Albany Broken Veld, which is still 97% intact, Kowie Thicket which is 91.7% intact and Southern Karoo Riviere which is 88.2 % intact. All these vegetation types are classified as Least Threatened. The northern extent of the site lies largely within the Albany Broken Veld vegetation type. This is an open shrubland with scattered trees. Dominant shrubs include *Pentzia incana*, *Asparagus striatus*, *Felicia muricata* and *Eriocephalus microphyllus*. Scattered trees include *Pappea capensis*, *Searsia burchellii* and *Ehretia rigida*. Within the southern extent of the site, the vegetation is Kowie Thicket and is more dense than in the northern extent of the site. Common species in this area include *Acacia karoo*, *Carissa haematocarpa*, *Euclea undulata*, *Searsia glauca*, *Portulacaria afra*, *Putterlickia pyracantha* and *Lycium oxycarpum*. Alien species present include *Agave americana*, *Opuntia ficus-indica*, *Salsola kali*, *Conyza bonariensis* and *Argemone ochroleuca.* The alien species present were restricted to the disturbed area along the sides of the railway line as well as the area around the Kommadagga station platform.

The site lies within an extensive CBA corridor. Given the limited extent of the current development which would result in the loss of less than 2 ha of currently intact vegetation and fact that the railway line is already present, the additional impact of the current development on the ecological functioning of the CBA would be minimal. In addition, the area is classified as CBA in order to maintain the broad-scale connectivity of the landscape and not on account of the presence of significant biodiversity features within the site.

Figure 16. Two view of the Ripon-Kommadagga site. At left, Albany Broken Veld near the northern extent of the site, dominated by *Pentzia incana*, with *Pappea capensis* trees visible in the distance. At right, the southern extent of the site with dense Kowie Thicket vegetation.

4 IMPACT ASSESSMENT

4.1 Assessment & Significance Criteria

The assessment criteria used in the assessment are described below and are drawn from the EIA Regulations, published by the Department of Environmental Affairs and Tourism (April 1998) in terms of the Environmental Conservation Act No. 73 of 1989.

Table 2: Impact assessment terminology used in the assessment of environmental impacts

Term	Definition
Impact Nature	
Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Impact Type	
Direct Impact	Impact that results from a direct interaction between a planned project activity and the receiving environment/receptors (e.g. between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect Impact	Impact that results from other activities that are enabled as a consequence of the proposed project (e.g. in-migration for employment placing a demand on natural resources).
Induced Impact	Third level impact caused by a change in the proposed project environment (e.g. employment opportunities created by the increased disposable income of workers hired by the project or its suppliers).
Cumulative Impact	Impact that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the proposed project.
Impact Magnitude	
Duration	*Temporary* - impacts are predicted to be of short duration and intermittent/occasional in nature. *Short-term* - impacts that are predicted to last only for the duration of the construction period. *Long-term* - impacts that will continue for the life of the project, but cease when the project stops operating. These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended time period (e.g. repeated seasonal disturbance of species as a result of, for example, blasting activities, operational employment, etc.). *Permanent* - impacts that occur during the development of the project and cause a permanent change in the affected receptor or resource (e.g. destruction of ecological habitat) that endures substantially beyond the project lifetime.
Scale	*On-site or Local* - impacts that affect an area in a radius of 20 km around the project site.

Term	Definition
	Regional - impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem. *National* - impacts that affect nationally important environmental resources, or affect an area that is nationally important/ protected or have macro-economic consequences. *International / Trans-boundary* - impacts that affect internationally important resources such as areas protected by international conventions.
Severity (for environmental receptors)	*Very Low / Low* – Impact affects the environment in such a way that natural functions and processes are not affected. *Medium* – The affected environment is altered but natural functions and processes continue albeit in a modified way. *High* – Natural functions or processes are altered to the extent that they will *temporarily or permanently cease*.
Impact Likelihood In addition to predicted impacts, those impacts that could result in the event of an accident or unplanned event (non-routine) within the project (e.g. fuel spill, traffic accident) or in the external environment affecting the project (e.g. flooding, earthquake) are required to be taken into account. In these cases the probability of the event occurring needs to be considered.	
Low	The impact does not occur.
Medium	Impact occurs infrequently.
High	Impact occurs frequently or regularly.

Table 3: Assessment of environmental magnitude which forms the basis for the assessment of the significance of environmental impacts resulting from the development.

Magnitude Rating	Level of Criteria Required
Negligible	• Low severity with a site specific extent and construction period duration. • Very low severity with any combination of extent and duration except for regional and long-term implications.
Low	• High severity with a site specific extent and construction period duration. • Medium severity with a site-specific extent and construction period duration. • Low severity with any combination of extent and duration except site specific and construction period or regional and long term. • Very low severity with a regional extent and long term duration.

Medium	• High severity with a local extent and medium term duration. • High severity with a regional extent and construction period duration or a site specific extent and long term duration. • High severity with either a local extent and construction period duration or a site specific extent and medium term duration. • Medium severity with any combination of extent and duration except site specific and construction period duration or regional extent and long term duration. • Low severity with a regional extent and long term duration.
High	• High severity with a regional extent and long term duration. • High severity with either a regional extent and medium term duration or a local extent and long term duration. • Medium severity with a regional extent and long term duration.

4.2 IDENTIFICATION & NATURE OF IMPACTS

Although the sites are widely distributed, they all occur within a semi-arid environment and the nature of the impact at each site is likely to be similar given that the type of development at each site is also similar. Therefore, the impacts likely to be associated with the extension of the loops and associated infrastructure are identified in general terms below and assessed for each site independently in the section thereafter. In addition, there are some impacts such as those relating to the operation of trains on the line which are existing impacts and are not considered part of the current assessment.

The major ecological impacts likely to be associated with the loop extensions include the following impacts:

Impacts on vegetation and protected plant species

Some loss of vegetation is an inevitable consequence of the development. In addition some protected species were present at the majority of sites and some impact on these species is likely to occur.

Alien Plant Invasion Risk

The disturbance created during construction will leave the disturbed areas vulnerable to alien plant invasion. The railway line forms a corridor for the dispersal of alien species and many alien species are common along the line and would represent a ready source for the invasion of the disturbed areas.

Increased erosion risk

Increased erosion risk would result from soil disturbance and the loss of plant cover within cleared and disturbed areas. The site is however largely very flat and the major erosion risk associated with the development would stem from wind erosion rather than water erosion. Cleared and disturbed areas with loose exposed sand would be most vulnerable.

Direct Faunal impacts

Increased levels of noise, pollution, disturbance and human presence will be detrimental to fauna. Sensitive and shy fauna would move away from the area during the construction phase as a result of the noise and human activities present, while some slow-moving species would not be able to avoid the construction activities and might be killed. Some mammals and reptiles such as tortoises would be vulnerable to illegal collection or poaching during the construction phase as a result of the large number of construction personnel that are likely to be present. There are also a number of mammals of conservation concern which occur in the area and impacts on these species would be undesirable. Some habitat loss for these species is likely to occur, but would not be of high significance given the scale of the development relative to the distribution extent of these species. Impacts such as electrocution would be of greater potential significance on account of the long-term cumulative impact that may result.

Impacts on Critical Biodiversity Areas

Negative impacts would result from the transformation of natural habitat within areas classified as CBAs. This impact is only relevant to the sites in the Eastern Cape, as no fine-scale conservation planning has been conducted in the Northern Cape sections.

4.3 Assessment of Impacts

4.3.1 New Witloop

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Definite**
Magnitude:	**Low-Medium**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Acacia erioloba* and *Acacia haematoxylon* is likely to occur and is not avoidable as the affected individuals cannot be translocated. However, as these species are widespread in the area, this impact is not of broader significance and would not compromise the local populations of these species in any way.

Cumulative Impacts:

The development will contribute to cumulative impacts in the area, the other major agent of transformation being the mines in the area. The contribution of the current development to cumulative impact is however minor given the limited extent of the development.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low-Moderate**
Pre-mitigation significance:	**Low-moderate**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular clearing of alien invasive species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**

Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Short-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not significantly any fauna in the area which are all widely distributed.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.2 Wincanton

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Definite**
Magnitude:	**Low-Medium**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Acacia erioloba* and *Boscia foetida* is likely to occur and is not avoidable as the affected individuals cannot be translocated. However, as these species are widespread in the area, this impact is not of broader significance and would not compromise the local populations of these species in any way.

Cumulative Impacts:

The development will contribute to cumulative impact in the area, the other major agent of transformation in the area being the mines in the area. The contribution of the current development to cumulative impact is however minor given the limited extent of the development, as well as the already disturbed nature of the majority of the development footprint.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**

Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Short-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not significantly any fauna in the area which are all widely distributed.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.3 New Sishen

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Acacia erioloba* may occur and is not avoidable as the affected individuals cannot be translocated. However, the development footprint has already been largely cleared due to the current construction activities in the area, and the additional impact created by the current development would be minimal.

Cumulative Impacts:

The development will contribute some extent to cumulative impact in the area, but given the limited extent of the current development and the disturbed nature of the receiving environment, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**

Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Short-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and given the proximity of the site to mining activity, there are not likely to be any significant faunal issues at the site.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.4 Glosam

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Olea europea subsp. africana* may occur and is not avoidable as the affected individuals cannot be translocated. However, as this species is common and widely distributed in the area, the residual impact would not be significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development and the disturbed nature of the receiving environment, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**

Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.5 Postmasburg

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

There were few listed and protected species within the development footprint at the Postmasburg site and residual impacts are likely to be very low.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development and the disturbed nature of the receiving environment, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**

Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale, especially given the proximity of the site to the road and Postmasburg itself.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.6 Tsantsabane

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss which cannot be mitigated is likely to occur, but given the limited extent of the development in relation to the intact nature of the surrounding landscape, the residual impact is not significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**

Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**MediumTerm**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.7 Trewil

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Olea europea subsp. africana* may occur and is not avoidable as the affected individuals cannot be translocated. However, as this species is common and widely distributed in the area, the residual impact would not be significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**

Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Short-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.8 Ulco

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Olea europea subsp. africana* and *Boscia foetida* may occur and is not avoidable as the affected individuals cannot be translocated. However, as these species are common and widely distributed in the area, the residual impact would not be significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**

Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**

Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.9 Gong Gong

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some local impact on the protected tree species *Boscia foetida* may occur and is not avoidable as the affected individuals cannot be translocated. However, as this species is common and widely distributed in the area, the residual impact would not be significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**

Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected species is a possible consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale. The degraded nature of the habitat also significantly reduces its current value for fauna.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.10 *Fieldsview*

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some impact on the protected tree species *Acacia erioloba* may occur and is not avoidable as the affected individuals cannot be translocated. However, as this species are common and widely distributed in the area, the residual impact would not be significant.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Low**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low and there are not likely to be any residual impacts if standard regevetation and erosion mitigation actions are applied.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**

Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and potential impact on protected species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

4.3.11 Drennan

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some residual habitat loss and impact on the protected aloe species *Aloe striata* may occur and is not avoidable. The affected individuals of *Aloe striata* can be translocated which will reduce the residual impact to some extent.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**

Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is moderate and provided that standard regevetation and erosion mitigation actions are applied, erosion should be adequately controlled.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

Impacts on Critical Biodiversity Areas

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

As the development will result in some habitat loss, there will be some residual impact associated with the development, but as the extent of habitat loss is low, the residual impact on the ecological functioning of CBA would be minimal.

Cumulative Impacts:

The development will contribute a small extent to some cumulative impact on the CBA, but this would be an extremely small contribution that would not significantly affect the CBA.

4.3.12 Thorngrove

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**

Post-mitigation significance:	**Low**

Residual Impacts:

Some residual habitat loss will occur as a result of the development and is not avoidable. The extent of the development is however small and the residual impact is not significant at the landscape scale.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**

Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is moderate and provided that standard regevetation and erosion mitigation actions are applied, erosion should be adequately controlled.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

Impacts on Critical Biodiversity Areas

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

As the development will result in some habitat loss, there will be some residual impact associated with the development, but as the extent of habitat loss is low, the residual impact on the ecological functioning of CBA would be minimal.

Cumulative Impacts:

The development will contribute a small extent to some cumulative impact on the CBA, but this would be an extremely small contribution that would not significantly affect the CBA.

4.3.13 Golden Valley-Cookhouse

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**

Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some residual habitat loss will occur as a result of the development and is not avoidable. The extent of the development is however small and the residual impact is not significant at the landscape scale.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	Negative
Duration:	Medium-Term
Scale:	On-site
Severity:	Low
Likelihood:	Low
Magnitude:	Medium
Pre-mitigation significance:	Low
Post-mitigation significance:	Low

Residual Impacts:

Erosion risk at the site is moderate and provided that standard regevetation and erosion mitigation actions are applied, erosion should be adequately controlled.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	Negative
Duration:	Medium-Term
Scale:	On-site
Severity:	Low
Likelihood:	Medium
Magnitude:	Low
Pre-mitigation significance:	Low
Post-mitigation significance:	Low

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

Impacts on Critical Biodiversity Areas

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

As the development will result in some habitat loss, there will be some residual impact associated with the development, but as the extent of habitat loss is low, the residual impact on the ecological functioning of CBA would be minimal, especially given the landscape context of the loop extension and the proximity of the extension to transformed and urban areas.

Cumulative Impacts:

The development will contribute a small extent to some cumulative impact on the CBA, but this would be an extremely small contribution that would not significantly affect the CBA.

4.3.14 Sheldon Loop

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some residual habitat loss will occur as a result of the development and is not avoidable. The extent of the development is however small and the residual impact is not significant at the landscape scale.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, which is currently low except for the areas around the Great Fish River to the north of the site. Given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is low to moderate and provided that standard regevetation and erosion mitigation actions are applied, erosion should be adequately controlled.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**

Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

Impacts on Critical Biodiversity Areas

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

As the development will result in some habitat loss, there will be some residual impact associated with the development, but as the extent of habitat loss is low, the residual impact on the ecological functioning of CBA would be minimal. The CBA in the area is designed to act as a corridor for the movement of fauna and flora and as it is more than 15 km wide from north to south at the point of the loop, the Sheldon loop would not have a significant residual or cumulative impact on the ecological functioning of the CBA.

Cumulative Impacts:

The development will contribute a small extent to some cumulative impact on the CBA, but this would be an extremely small contribution that would not significantly affect the CBA, in terms of biodiversity pattern or process.

4.3.15 Ripon - Kommadagga

Impacts on vegetation and protected plant species

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low-Medium**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some residual habitat loss will occur as a result of the development and is not avoidable. The extent of the development is however small and the residual impact is not significant at the landscape scale.

Cumulative Impacts:

The development will contribute some extent to cumulative transformation in the area, but given the limited extent of the current development, the contribution to cumulative impacts would be minimal.

Alien Plant Invasion Risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**

Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Provided that regular alien clearing of woody species takes place, then there will be no residual impacts.

Cumulative Impacts:

Provided that significant alien invaders are cleared on occasion, then there will be no cumulative impacts in terms of alien plant invaders.

Increased erosion risk

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Erosion risk at the site is moderate and provided that standard regevetation and erosion mitigation actions are applied, erosion should be adequately controlled.

Cumulative Impacts:

There are not likely to be significant cumulative impacts relating to erosion at the site.

Direct Faunal impacts

Nature of Impact:	**Negative**
Duration:	**Medium-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**Medium**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**
Post-mitigation significance:	**Low**

Residual Impacts:

Some habitat loss and impact on protected tree species is an unavoidable consequence of the development. The extent of habitat loss is however minor and would not be significant at the landscape scale.

Cumulative Impacts:

There will be some cumulative impact in terms of habitat loss and faunal disturbance, but given the limited extent of the development, this would not be significant.

Impacts on Critical Biodiversity Areas

Nature of Impact:	**Negative**
Duration:	**Long-Term**
Scale:	**On-site**
Severity:	**Low**
Likelihood:	**High**
Magnitude:	**Low**
Pre-mitigation significance:	**Low**

Post-mitigation significance:	**Low**

Residual Impacts:

As the development will result in some habitat loss, there will be some residual impact associated with the development, but as the extent of habitat loss is low, the residual impact on the ecological functioning of CBA would be minimal, especially given the landscape context of the loop extension and the proximity of the extension to transformed and urban areas.

Cumulative Impacts:

The development will contribute a small extent to some cumulative impact on the CBA, but this would be an extremely small contribution that would not significantly affect the CBA.

4.4 MITIGATION

In this section, mitigation measures are listed, aimed at reducing the likely impacts of the loop extensions and associated infrastructure on the local environment. Given the nature of the development, there is little flexibility in the location of the infrastructure and mitigation measures are therefore aimed at reducing the development footprint and reducing the impact on species of conservation concern.

Impacts on vegetation and protected plant species

- All areas to be cleared should be clearly demarcated.
- A search and rescue operation for protected species within the final development footprint should be conducted prior to construction.
- Cleared areas which are not being used should be revegetated using plants or seed of locally occurring species.
- Where service roads or other infrastructure traverse sensitive areas, specific precautions to limit impacts should be undertaken.

Alien Plant Invasion Risk

- Soil disturbance and vegetation clearing should be kept to minimum.
- Cleared areas that are not going to be used should be re-vegetated with locally-collected seed of indigenous species.
- Invasive alien plants present at the site should be controlled through-out the construction period using the best practice methods for the species present.

Increased erosion risk

- All service roads and tracks running down the slope must have water diversion structures present.
- Any extensive cleared areas that are no longer or not required for construction activities should be re-seeded with locally-sourced seed of suitable species. Bare areas can also be packed with brush removed from other parts of the site to encourage natural vegetation regeneration and limit erosion.
- No construction vehicles should be allowed to drive around the veld. All construction vehicles should remain on properly demarcated roads.
- Regular post-construction monitoring for erosion to ensure that no erosion problems are occurring at the site as a result of the roads and other infrastructure. All erosion problems observed should be rectified as soon as possible.

Direct Faunal impacts

- Any fauna directly threatened by the construction activities should be removed to a safe location by the EO, or other suitably qualified person.
- The collection, hunting or harvesting of any plants or animals at the site should be strictly forbidden.
- No fires will be allowed on-site.
- No fuelwood collection should be allowed on-site.
- No domestic animals will be allowed on-site.
- All hazardous materials should be stored in the appropriate manner to prevent contamination of the site. Any accidental chemical, fuel and oil spills that occur at the site should be cleaned up in the appropriate manner as related to the nature of the spill.

Impacts on Critical Biodiversity Areas

- Preconstruction surveys to locate any listed plant species within the development footprint for translocation.
- Construction areas and work areas will be clearly demarcated avoiding unnecessary disturbance or clearance of vegetation in CBAs.

4.5 SUMMARY ASSESSMENT

The loop extensions will result in a limited extent of transformation, amounting to less than a few hectares at each site. A large proportion of the development footprint is also within previously disturbed areas. It was however, observed that faunal activity in the railway reserve was high, which can be ascribed to the fact that it is not grazed by livestock and the availability of grazing and other forage is higher within the railway reserve as a result. This attracts species such as antelope, hares and porcupine to the area. The development of the loops will create transient disturbance within the affected areas which will create a significant local impact during construction, but will return to preconstruction levels, once construction has been completed. Although there are some protected species at the majority of loop sites, the actual numbers of affected individuals is quite low and would not exceed 50 individuals of any species at any site and is usually much lower. As the affected species are not rare or locally restricted, these impacts would not be of wider significance. The sites within the Eastern Cape are mostly within Critical Biodiversity Areas, which raises the potential for impact on these areas. However, the CBAs are all designed as broad-scale corridors and not as a result of the known presence of significant biodiversity. Given the proximity of the development to the existing line, the loop extension would not contribute significantly to the disruption of landscape connectivity and ecological functioning of the CBAs. As the majority of sites are within flat areas, the risk of erosion at the majority of sites is low, it is only at sites with steeper areas and drainage lines, that there is some risk of erosion, such as at Drennan, Ripon and Fieldsview. The railway line acts as a dispersal corridor for alien plant species and aliens were common at all of the sites. It is however woody species such as *Prosopis* which pose the most significant ecological risk and which should be controlled where present. Overall, there are no highly sensitive features present at any of the sites which would pose a significant obstacle to the development of the loop extensions.

The development of the loop extensions is not likely to create significant ecological impacts given their limited extent and proximity to the existing railway line. Although there are some protected species present at many of the sites, there were no threatened species present. As a result, the impacts of the loop extensions are likely to be local in nature and not of broader significance.

5 REFERENCES

Alexander, G. & Marais, J. 2007. *A Guide to the Reptiles of Southern Africa*. Struik Nature, Cape Town.

Berliner D. & Desmet P. (2007) *Eastern Cape Biodiversity Conservation Plan: Technical Report*. Department of Water Affairs and Forestry Project No 2005-012, Pretoria. 1 August 2007

Branch W.R. 1998. *Field guide to snakes and other reptiles of southern Africa*. Struik, Cape Town.

Brownlie, S. 2005. Guideline for Involving Biodiversity Specialists in EIA Processes: Edition 1. CSIR Report No ENV-S-C 2005 053 C. Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town. 63 pp.

Department of Environmental Affairs and Tourism, 2007. National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): Publication of lists of Critically Endangered, Endangered, Vulnerable and Protected Species. Government Gazette, Republic of South Africa.

De Villiers CC, Driver A, Clark B, Euston-Brown DIW, Day EG, Job N, Helme NA, Holmes PM, Brownlie S and Rebelo AB (2005) *Fynbos Forum Ecosystem Guidelines for Environmental Assessment in the Western Cape.* Fynbos Forum and Botanical Society of South Africa, Kirstenbosch.

Du Preez, L. & Carruthers, V. 2009. *A Complete Guide to the Frogs of Southern Africa*. Struik Nature., Cape Town.

IUCN 2012. IUCN Red List of Threatened Species. Version 2010.2. <www.iucnredlist.org>. Downloaded on 19 January 2012.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Mucina L. & Rutherford M.C. (eds) 2006. *The Vegetation of South Africa, Lesotho and Swaziland*. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Skinner, J.D. & Chimimba, C.T. 2005. The mammals of the Southern African Subregion. Cambridge University Press, Cambridge.

6 ANNEX 1. COORDINATES OF PROTECTED SPECIES

Coordinates of protected species and significant trees within the different loop extension sections.

Id	Y-Coord	X-Coord	Site	Species	Growth Form
1	-28.58368708	24.6642157	Fieldsview	*Acacia erioloba*	Tree
2	-28.5836621	24.66420095	Fieldsview	*Acacia erioloba*	Tree
3	-28.58366755	24.66412291	Fieldsview	*Acacia erioloba*	Tree
4	-28.58378138	24.66404772	Fieldsview	*Acacia erioloba*	Tree
5	-28.58388137	24.66389911	Fieldsview	*Acacia erioloba*	Tree
6	-28.58362421	24.66397765	Fieldsview	*Acacia erioloba*	Tree
7	-28.58344752	24.6637811	Fieldsview	*Acacia erioloba*	Tree
8	-28.58340084	24.66372653	Fieldsview	*Acacia erioloba*	Tree
9	-28.58390895	24.66306746	Fieldsview	*Acacia erioloba*	Tree
10	-28.58390761	24.66303309	Fieldsview	*Acacia erioloba*	Tree
11	-28.58376729	24.66309336	Fieldsview	*Acacia erioloba*	Tree
12	-28.58351936	24.66319688	Fieldsview	*Acacia erioloba*	Tree
13	-28.58339279	24.66301977	Fieldsview	*Acacia erioloba*	Tree
14	-28.58345381	24.66296663	Fieldsview	*Acacia erioloba*	Tree
15	-28.58230323	24.66284911	Fieldsview	*Acacia erioloba*	Tree
16	-28.58226073	24.66282858	Fieldsview	*Acacia erioloba*	Tree
17	-28.5824448	24.66303159	Fieldsview	*Acacia erioloba*	Tree
18	-28.58252174	24.66309269	Fieldsview	*Acacia erioloba*	Tree
19	-28.58260992	24.66310736	Fieldsview	*Acacia erioloba*	Tree
20	-28.58267127	24.66317575	Fieldsview	*Acacia erioloba*	Tree
21	-28.5830353	24.66339285	Fieldsview	*Acacia erioloba*	Tree
22	-28.58309926	24.66348002	Fieldsview	*Acacia erioloba*	Tree
23	-28.58316841	24.66352436	Fieldsview	*Acacia erioloba*	Tree
24	-28.58339614	24.66374187	Fieldsview	*Acacia erioloba*	Tree
25	-28.58339673	24.66376391	Fieldsview	*Acacia erioloba*	Tree
26	-28.58335683	24.66390557	Fieldsview	*Acacia erioloba*	Tree
27	-28.58286775	24.66458618	Fieldsview	*Acacia erioloba*	Tree
28	-28.58262685	24.66455835	Fieldsview	*Acacia erioloba*	Tree
29	-28.58238	24.66421662	Fieldsview	*Acacia erioloba*	Tree
30	-28.58238126	24.66418276	Fieldsview	*Acacia erioloba*	Tree
31	-28.58233952	24.66433304	Fieldsview	*Acacia erioloba*	Tree
32	-28.58233256	24.66438962	Fieldsview	*Acacia erioloba*	Tree
33	-28.58217012	24.66433061	Fieldsview	*Acacia erioloba*	Tree
34	-28.58210466	24.66425342	Fieldsview	*Acacia erioloba*	Tree

35	-28.5819843	24.66399467	Fieldsview	*Acacia erioloba*	Tree
36	-28.5819589	24.66391261	Fieldsview	*Acacia erioloba*	Tree
37	-28.58176662	24.66356551	Fieldsview	*Acacia erioloba*	Tree
38	-28.58167903	24.66312815	Fieldsview	*Acacia erioloba*	Tree
39	-28.3128817	23.67034603	Trewil	*Olea europea africana*	Tree
40	-28.31292361	23.67027026	Trewil	*Olea europea africana*	Tree
41	-28.31296552	23.67011871	Trewil	*Olea europea africana*	Tree
42	-28.31325889	23.66934188	Trewil	*Olea europea africana*	Tree
43	-28.11897576	23.0472905	Glosam	*Olea europea africana*	Tree
44	-28.11287817	23.0492833	Glosam	*Olea europea africana*	Tree
45	-28.11283375	23.04936972	Glosam	*Olea europea africana*	Tree
46	-28.11172089	23.04954305	Glosam	*Olea europea africana*	Tree
47	-28.11162097	23.04964246	Glosam	*Olea europea africana*	Tree
48	-28.11131554	23.0498821	Glosam	*Olea europea africana*	Tree
49	-28.1112743	23.04994924	Glosam	*Olea europea africana*	Tree
50	-28.11114673	23.0497272	Glosam	*Olea europea africana*	Tree
51	-28.11078429	23.04983382	Glosam	*Olea europea africana*	Tree
52	-28.11035849	23.04996165	Glosam	*Olea europea africana*	Tree
53	-28.11017333	23.04984245	Glosam	*Olea europea africana*	Tree
54	-28.11007937	23.04992829	Glosam	*Olea europea africana*	Tree
55	-28.10979573	23.05008235	Glosam	*Olea europea africana*	Tree
56	-28.10975248	23.0501142	Glosam	*Olea europea africana*	Tree
57	-28.10930723	23.05011839	Glosam	*Olea europea africana*	Tree
58	-28.1086376	23.05025459	Glosam	*Olea europea africana*	Tree
59	-28.10758509	23.05046221	Glosam	*Olea europea africana*	Tree
60	-28.10614675	23.05068391	Glosam	*Olea europea africana*	Tree
61	-27.57962435	22.93959503	Wincanton	*Acacia erioloba*	Tree
62	-27.57959157	22.93957391	Wincanton	*Acacia erioloba*	Tree
63	-27.57956601	22.93954139	Wincanton	*Acacia erioloba*	Tree
64	-27.294487	22.98063149	Witloop	*Acacia haematoxylon*	Tree
65	-27.29466319	22.98070039	Witloop	*Acacia haematoxylon*	Tree
66	-27.29469605	22.98069594	Witloop	*Acacia haematoxylon*	Tree
67	-27.29475707	22.9806863	Witloop	*Acacia haematoxylon*	Tree
68	-27.2942099	22.98078186	Witloop	*Acacia haematoxylon*	Tree
69	-27.29441953	22.98090063	Witloop	*Acacia haematoxylon*	Tree
70	-27.29443763	22.98092821	Witloop	*Acacia haematoxylon*	Tree
71	-27.29445188	22.98094698	Witloop	*Acacia haematoxylon*	Tree
72	-27.29447586	22.98099283	Witloop	*Acacia haematoxylon*	Tree
73	-27.29447728	22.98108436	Witloop	*Acacia haematoxylon*	Tree
74	-27.29435725	22.98113281	Witloop	*Acacia haematoxylon*	Tree
75	-27.29432884	22.98114387	Witloop	*Acacia haematoxylon*	Tree

76	-27.29451148	22.98137287	Witloop	*Acacia haematoxylon*	Tree
77	-27.29470384	22.98156515	Witloop	*Acacia haematoxylon*	Tree
78	-27.29455146	22.98159474	Witloop	*Acacia haematoxylon*	Tree
79	-27.29458591	22.98167621	Witloop	*Acacia haematoxylon*	Tree
80	-27.29451911	22.98168761	Witloop	*Acacia haematoxylon*	Tree
81	-27.29444115	22.98164871	Witloop	*Acacia haematoxylon*	Tree
82	-27.29434233	22.98168367	Witloop	*Acacia haematoxylon*	Tree
83	-27.29428031	22.98164821	Witloop	*Acacia haematoxylon*	Tree
84	-27.29422725	22.9816224	Witloop	*Acacia haematoxylon*	Tree
85	-27.29414812	22.98163086	Witloop	*Acacia haematoxylon*	Tree
86	-27.29413714	22.98157244	Witloop	*Acacia haematoxylon*	Tree
87	-27.29418048	22.98139516	Witloop	*Acacia haematoxylon*	Tree
88	-27.294185	22.98134697	Witloop	*Acacia haematoxylon*	Tree
89	-27.29422113	22.98124479	Witloop	*Acacia haematoxylon*	Tree
90	-27.29420831	22.981152	Witloop	*Acacia haematoxylon*	Tree
91	-27.29419582	22.98109911	Witloop	*Acacia haematoxylon*	Tree
92	-27.2941985	22.98105922	Witloop	*Acacia haematoxylon*	Tree
93	-27.29456403	22.9810557	Witloop	*Acacia haematoxylon*	Tree
94	-27.29457493	22.98106475	Witloop	*Acacia haematoxylon*	Tree
95	-27.29467861	22.98106173	Witloop	*Acacia haematoxylon*	Tree
96	-27.29479219	22.98106634	Witloop	*Acacia haematoxylon*	Tree
97	-27.29482513	22.98106316	Witloop	*Acacia haematoxylon*	Tree
98	-27.29485187	22.98108537	Witloop	*Acacia haematoxylon*	Tree
99	-27.29484977	22.98098889	Witloop	*Acacia haematoxylon*	Tree
100	-27.29483846	22.98088295	Witloop	*Acacia haematoxylon*	Tree
101	-27.29468431	22.98090633	Witloop	*Acacia haematoxylon*	Tree
102	-27.29465246	22.98092603	Witloop	*Acacia haematoxylon*	Tree
103	-27.29461508	22.9810013	Witloop	*Acacia haematoxylon*	Tree
104	-27.29460234	22.98102099	Witloop	*Acacia haematoxylon*	Tree
105	-27.29460024	22.98086082	Witloop	*Acacia haematoxylon*	Tree
106	-27.29455515	22.98079904	Witloop	*Acacia haematoxylon*	Tree
107	-27.29445297	22.98080457	Witloop	*Acacia haematoxylon*	Tree
108	-27.29430134	22.98076451	Witloop	*Acacia haematoxylon*	Tree
109	-27.29426614	22.98080407	Witloop	*Acacia haematoxylon*	Tree
110	-32.45039471	25.75358701	Drennan	*Aloe striata*	Succulent
111	-32.45035909	25.75352984	Drennan	*Aloe striata*	Succulent
112	-32.45035901	25.75352758	Drennan	*Aloe striata*	Succulent
113	-32.45033554	25.75349791	Drennan	*Aloe striata*	Succulent
114	-32.45032171	25.75347218	Drennan	*Aloe striata*	Succulent
115	-32.44208397	25.74250362	Drennan	*Aloe striata*	Succulent
116	-27.29917768	22.98183907	Witloop	*Acacia erioloba*	Tree

117	-27.58051098	22.93954189	Wincanton	*Acacia erioloba*	Tree
118	-27.59084478	22.93999896	Wincanton	*Acacia erioloba*	Tree
119	-27.59073372	22.94054068	Wincanton	*Acacia erioloba*	Tree
120	-27.29475154	22.98085487	Witloop	*Acacia erioloba*	Tree
121	-27.2944259	22.98126265	Witloop	*Acacia erioloba*	Tree
122	-27.29475606	22.98165031	Witloop	*Acacia erioloba*	Tree
123	-27.58053135	22.93953703	Wincanton	*Acacia erioloba*	Tree
124	-27.29474424	22.98106081	Witloop	*Acacia erioloba*	Tree
125	-27.29814042	22.98053602	Witloop	*Acacia erioloba*	Tree
126	-27.29818518	22.98049981	Witloop	*Acacia erioloba*	Tree
127	-27.29933845	22.98101831	Witloop	*Acacia erioloba*	Tree
128	-27.29920073	22.98164478	Witloop	*Acacia erioloba*	Tree
129	-27.29606984	22.98029076	Witloop	*Acacia erioloba*	Tree
130	-27.57991989	22.93975647	Wincanton	*Acacia erioloba*	Tree
131	-32.77707922	25.79431149	Golden Valley	*Aloe striata*	Succulent
132	-33.09308745	25.87062729	Kommadagga	*Aloe grandidentata*	Succulent
133	-33.09176705	25.86913046	Kommadagga	*Aloe grandidentata*	Succulent
134	-28.5817232	24.66312747	Fieldsview	*Aloe grandidentata*	Succulent
135	-28.27931251	23.14777661	Tsantsabane	*Aloe grandidentata*	Succulent
136	-28.35571943	24.2922032	Ulco	*Aloe grandidentata*	Succulent
137	-28.35935424	24.29783123	Ulco	*Aloe grandidentata*	Succulent
138	-28.2822471	23.13741499	Tsantsabane	*Aloe grandidentata*	Succulent
139	-28.11180546	23.0496552	Glosam	*Aloe grandidentata*	Succulent
140	-27.58945246	22.94020163	Wincanton	*Aloe grandidentata*	Succulent
141	-33.0921988	25.86954159	Kommadagga	*Aloe striata*	Succulent
142	-33.11597968	25.89262367	Kommadagga	*Aloe striata*	Succulent
143	-33.11165638	25.88564985	Kommadagga	*Aloe striata*	Succulent
144	-33.11186191	25.88606944	Kommadagga	*Aloe striata*	Succulent
145	-33.09237063	25.87001843	Kommadagga	*Aloe striata*	Succulent
146	-33.11143368	25.88541281	Kommadagga	*Aloe striata*	Succulent
147	-33.11634036	25.8933078	Kommadagga	*Aloe striata*	Succulent
148	-33.10948656	25.88236657	Kommadagga	*Aloe striata*	Succulent
149	-28.35998121	24.299144	Ulco	*Boscia foetida*	Tree
150	-27.58480453	22.93995445	Wincanton	*Boscia foetida*	Tree
151	-27.57327883	22.93985663	Wincanton	*Boscia foetida*	Tree
152	-27.56956212	22.93997339	Wincanton	*Boscia foetida*	Tree
153	-27.57049696	22.93982084	Wincanton	*Boscia foetida*	Tree
154	-27.57058664	22.93980936	Wincanton	*Boscia foetida*	Tree
155	-27.57185239	22.9398081	Wincanton	*Boscia foetida*	Tree
156	-27.57497834	22.93988873	Wincanton	*Boscia foetida*	Tree
157	-27.59896735	22.94048837	Wincanton	*Boscia foetida*	Tree
158	-27.60269051	22.9405711	Wincanton	*Boscia foetida*	Tree

159	-27.60389767	22.94067755	Wincanton	*Boscia foetida*	Tree
160	-27.60463569	22.94081242	Wincanton	*Boscia foetida*	Tree
161	-28.35397733	24.28915034	Ulco	*Boscia foetida*	Tree
162	-28.3541666	24.28945284	Ulco	*Boscia foetida*	Tree
163	-32.63338264	25.80838529	Thorngrove	*Boscia oleoides*	Tree
164	-32.644834	25.82043218	Thorngrove	*Boscia oleoides*	Tree
165	-32.44505259	25.7356235	Drennan	*Aloe striata*	Succulent
166	-33.11204547	25.88636532	Kommadagga	*Euphorbia tetragona*	Succulent
167	-33.09239963	25.86998843	Kommadagga	*Gasteria bicolor*	Succulent
168	-28.35441177	24.28984017	Ulco	*Olea europea africana*	Tree
169	-28.30140478	23.70159427	Trewil	*Olea europea africana*	Tree
170	-28.31083685	23.67583056	Trewil	*Olea europea africana*	Tree
171	-28.31101036	23.67544281	Trewil	*Olea europea africana*	Tree
172	-28.31106802	23.67527819	Trewil	*Olea europea africana*	Tree
173	-28.31100147	23.6750399	Trewil	*Olea europea africana*	Tree
174	-28.31145502	23.67427949	Trewil	*Olea europea africana*	Tree
175	-28.31166498	23.67368773	Trewil	*Olea europea africana*	Tree
176	-28.31178669	23.67337139	Trewil	*Olea europea africana*	Tree
177	-28.31254575	23.67127609	Trewil	*Olea europea africana*	Tree
178	-28.35462961	24.29036739	Ulco	*Olea europea africana*	Tree
179	-28.11965704	23.04701893	Glosam	*Olea europea africana*	Tree
180	-28.11896905	23.04725203	Glosam	*Olea europea africana*	Tree
181	-28.11860913	23.04748672	Glosam	*Olea europea africana*	Tree
182	-28.11845055	23.04756241	Glosam	*Olea europea africana*	Tree
183	-28.11808527	23.04764229	Glosam	*Olea europea africana*	Tree
184	-28.11625198	23.04834687	Glosam	*Olea europea africana*	Tree
185	-28.11564194	23.04856757	Glosam	*Olea europea africana*	Tree
186	-28.11486796	23.04885917	Glosam	*Olea europea africana*	Tree
187	-28.11371033	23.04919336	Glosam	*Olea europea africana*	Tree
188	-28.11310256	23.049332	Glosam	*Olea europea africana*	Tree
189	-28.35571691	24.29220219	Ulco	*Olea europea africana*	Tree
190	-28.3557253	24.2921441	Ulco	*Olea europea africana*	Tree
191	-28.35800316	24.29615753	Ulco	*Olea europea africana*	Tree
192	-28.36106951	24.30158129	Ulco	*Olea europea africana*	Tree
193	-28.36357503	24.30610014	Ulco	*Olea europea africana*	Tree
194	-33.09460047	25.87163053	Kommadagga	*Pachypodium succulentum*	Succulent
195	-33.09263147	25.87016964	Kommadagga	*Pachypodium succulentum*	Succulent
196	-32.77691402	25.79436966	Golden Valley	*Pachypodium succulentum*	Succulent
197	-33.11630608	25.89305014	Kommadagga	*Pappea capensis*	Tree
198	-33.09386965	25.87120866	Kommadagga	*Pappea capensis*	Tree

199	-32.63338599	25.80836166	Thorngrove	*Pappea capensis*	Tree
200	-32.63564508	25.80969019	Thorngrove	*Pappea capensis*	Tree
201	-32.63606217	25.80999202	Thorngrove	*Pappea capensis*	Tree
202	-32.64371283	25.81963833	Thorngrove	*Pappea capensis*	Tree
203	-32.6455851	25.82053687	Thorngrove	*Pappea capensis*	Tree
204	-33.11571113	25.89216719	Kommadagga	*Scotia afra*	Tree
205	-33.11092707	25.88461384	Kommadagga	*Scotia afra*	Tree
206	-33.11628462	25.89305568	Kommadagga	*Scotia afra*	Tree
207	-33.09274966	25.87037114	Kommadagga	*Scotia afra*	Tree
208	-33.0923257	25.87012589	Kommadagga	*Scotia afra*	Tree

7 ANNEX 2. COMMON NAMES OF TREES REFERRED TO IN THE TEXT

Scientific Name	English	Afrikaans
Acacia erioloba	Camel Thorn	Kameeldoring
Acacia tortilis	Umbrella Thorn	Basterkameeldoring
Searsia lancea	Karee	Karee
Lycium hirsutum		Rivierkareedoring
Tarchonanthus camphoratus	Camphor tree	Vaalbos/Wildekanferbos
Grewia flava	Wild Currant	Rosyntjiebos
Acacia mellifera	Black Thorn	Blouhaakdoring
Olea europea subsp. *africana*	Wild Olive	Olienhout
Searsia tridactyla		Suurkaree
Ziziphus mucronata	Buffalo Thorn	Blinkblaar
Acacia haematoxylon	Grey Camel Thorn	Vaalkameeldoring
Grewia robusta	Velvet Raisin	Karookruisbessie
Pappea capensis	Jacket Plum	Pruim
Boscia oleoides	Karoo Shepherd Tree	Karoo-witgat
Portulaca afra	Spekboom	Spekboom
Boscia foetida	Foetid Bush	Oumeidbos
Euclea undulata	Common Guarri	Gewone Ghwarrie
Ehretia rigida	Puzzle Bush	Deurmekaarbos
Searsia longispina		Doringtaaibos

8 ANNEX 2. COMMON NAMES OF ALIEN PLANTS REFERRED TO IN THE TEXT

Scientific Name	**English**	**Afrikaans**
Argemone ochroleuca subsp. *ochroleuca*	Mexican Poppy	Bloudissel
Conyza bonariensis	Fleabane	Vaalskraalhans
Atriplex suberecta	Creeping Saltbush	Kruipsoutbos
Sisymbrium burchellii	Wild Mustard	Wildemosterd
Opuntia ficus-indica	Prickly Pear	Turksvy
Cirsium vulgare	Scotch Thistle	Karmedik
Bidens pilosa	Blackjack	Knapsekerel
Bromus driandrus	Ripgut Brome	Predikansluis
Lactuca serriola	Wild Lettuce	Wildeslaai
Atriplex lindleyi subsp. *inflata*	Spong-fruit saltbush	Blasiebrak
Prosopis glandulosa	Honey mesquite	Heuningprosopis
Tagetes minuta	Khakiweed	Kakiebos
Shinus molle	Pepper Tree	Peperboom
Melia azedarach	Syringa	Seringboom
Eucalyptus camaldunensis	River Gum	rooibloekom
Ricinus communis	Castor-oil plant	Kasterolieboom
Echinopsis spachiana	Torch cactus	Orrelkaktus
Datura stramonium	Common Thorn-apple	Olieboom
Agave americana	American agave	Garingboom
Salsola kali	Russian tumbleweed	Tolbos

SHORT CV OF CONSULTANT:

SIMON TODD CONSULTING

P.O.Box 71
Nieuwoudtville
8180
Simon.Todd@uct.ac.za
Grazing.Guidelines@gmail.com

H: 027 218 1276
C: 082 3326 502

SUMMARY OF EXPERTISE:

SIMON TODD

- Profession: Ecological Consultant
- Specialisation: Plant & Animal Ecology
- Years of Experience: 15 Years

Skills & Primary Competencies

- Research & description of ecological patterns & processes in Fynbos, Succulent Karoo, Nama Karoo, Thicket, Arid Grassland and Savannah Ecosystems.
- Ecological Impacts of land use on biodiversity
- Vegetation surveys & degradation assessment & mapping
- Long-term vegetation monitoring
- Faunal surveys & assessment.
- GIS & remote sensing

Tertiary Education:

- 1992-1994 – BSc (Botany & Zoology), University of Cape Town
- 1995 – BSc Hons, Cum Laude (Zoology) University of Natal
- 1996-1997- MSc, Cum Laude (Conservation Biology) University of Cape Town

Employment History

- 1997 – 1999 – Research Scientist (Contract) – South African National Biodiversity Institute
- 2000-2004 – Specialist Scientist (Contract) - South African National Biodiversity Institute
- 2004-2007 – Senior Scientist (Contract) – Plant Conservation Unit, Department of Botany, University of Cape Town
- 2007 Present – Senior Scientist (Associate) – Plant Conservation Unit, Department of Botany, University of Cape Town.

General Experience & Expertise

- Conducted a large number of fauna and flora specialist assessments distributed widely across South Africa. Projects have ranged in extent from <50 ha to more then 50 000 ha.
- Extensive experience in the field and exceptional level of technical expertise, particularly with regards to GIS capabilities which is essential with regards to producing high-quality sensitivity maps for use in the design of final project layouts.
- Strong research background which has proved invaluable when working on several ecologically sensitive and potentially controversial sites containing some of the most threatened fauna in South Africa.
- Published numerous research reports as well as two book chapters and a large number of papers in leading scientific journals dealing primarily with human impacts on the vegetation and ecology of South Africa.
- Maintain several long-term vegetation monitoring projects distributed across Namaqualand and the karoo.
- Guest lecturer at two universities and have also served as an external examiner.
- Reviewed papers for more than 10 international ecological journals.
- Past chairman and current committee member of the Arid Zone Ecological Forum.
- SACNASP registered as a Professional Natural Scientist, (Ecology) No. 400425/11.

A selection of recent work is as follows:

Specialist Assessments:

Bitterfontein Solar Plant - Fauna & Flora Specialist Assessment. Specialist Report for Cape EAPrac. 2012.

Beaufort West Solar Facility, Erf 7388 - Fauna & Flora Specialist Assessment. Specialist Report for Cape EAPrac. 2012.

Plant Sweeps on Portion 2 of the Farm Demaneng 546, Kuruman District, Northern Cape Province for SA Manganese. 2011.

Proposed Olyven Kolk Solar Power Plant, Northern Cape: Botanical and Faunal Specialist Assessment. Specialist Report for Environmental Resources Management (ERM). 2011.

Klawer Wind Farm: Ecological and Biodiversity Assessment: Terrestrial Vertebrate Fauna & Botanical Specialist Study. Specialist Report for Environmental Resources Management. 2011.

Witberg Wind Farm: Ecological and Biodiversity Assessment: Terrestrial Vertebrate Fauna & Botanical Specialist Study. Specialist Report for Environmental Resources Management. 2011.

Lambert's Bay Wind Farm: Ecological and Biodiversity Assessment: Terrestrial Vertebrate Fauna & Botanical Specialist Study. Specialist Report for Environmental Resources Management. 2011.

Environmental Impact Assessment: Terrestrial Ecology Specialist Study for the Proposed Establishment of a Renewable Energy Facility near Sutherland, Western and Northern Cape Provinces. Specialist Report for Environmental Resources Management. 2011.

Environmental Impact Assessment: Terrestrial Ecology Specialist Study for the Proposed Establishment of a Renewable Energy Facility near Beaufort West, Western Cape Province. Specialist Report for Environmental Resources Management. 2010.

Environmental Impact Assessment: Terrestrial Ecology Specialist Study for the Proposed Establishment of a Renewable Energy at Konstabel, Western Cape Province. Specialist Report for Environmental Resources Management. 2010.

Environmental Impact Assessment: Terrestrial Ecology Specialist Study for the Proposed Establishment of a Renewable Energy Facility at Perdekraal, Western Cape Province. Specialist Report for Environmental Resources Management. 2010.

Environmental Impact Assessment: Terrestrial Ecology Specialist Study for the Proposed Establishment of a Renewable Energy Facility near Victoria West, Western and Northern Cape Provinces. Specialist Report for Environmental Resources Management. 2010.

Research Reports & Peer Reviewed Publications:

Todd, S.W. 2010. Vegetation and Plant Communities Associated with the Tillite and Dolerite Renosterveld Types of the Avontuur Conservation Area, Nieuwoudtville, South Africa. DRYNET.

Todd, S.W., Milton, S.J., Dean, W.R.J. Carrick, P.J. & Meyer, A. 2009. Ecological best Practice Guidelines for the Namakwa District. The Botanical Society of South Africa.

Todd, S.W. 2009. Field-Based Assessment of Degradation in the Namakwa District. Final Report. Mapping Degradation in the Arid Subregions of the BIOTA South Transect. SANBI.

Todd, S.W. 2009. A fence-line in time demonstrates grazing-induced vegetation shifts and dynamics in the semi-arid Succulent Karoo. *Ecological Applications*, 19: 1897–1908.

Todd, S.W. 2007. Characterisation of Riparian Ecosystems. D14 of The WADE Project. Floodwater Recharge of Alluvial Aquifers in Dryland Environments. *GOCE-CT-2003-506680- WADE.* Sixth Framework Programme Priority 1.1.6.3 Global Change and Ecosystems.

Todd, S.W. 2006. Gradients in vegetation cover, structure and species richness of Nama-Karoo shrublands in relation to distance from livestock watering points. *Journal of Applied Ecology* 43: 293-304.

Benito, G., Rohde, R., Seely, M., Külls, C., Dahan, O., Enzel, Y., **Todd, S**. Botero, B., Morin, E., Grodek, T., Roberts, C. 2010. Management of Alluvial Aquifers in Two Southern African Ephemeral Rivers: Implications for IWRM. *Water Resources Management*, 24:641–667.

Hahn, B.D., Richardson, F.D., Hoffman, M.T., Roberts, R., **Todd, S.W.** and Carrick, P.J. 2005. A simulation model of long-term climate, livestock and vegetation interactions on communal rangelands in the semi-arid Succulent Karoo, Namaqualand, South Africa*. Ecological Modelling* 183, 211–230.

Malgas, R.R., Potts, A.J., Oettlé, N.M., Koelle, B., **Todd, S.W.**, Verboom G.A. & Hoffman M.T.. 2010. Distribution, quantitative morphological variation and preliminary molecular analysis of different growth forms of wild rooibos (*Aspalathus linearis*) in the northern Cederberg and on the Bokkeveld Plateau. *South African Journal of Botany*, 76, 72-81.

Mills, A., Fey, M., Donaldson, J.D., **Todd, S.W**. & Theron, L.J. 2009. Soil infiltrability as a driver of plant cover and species richness in the semi-arid Karoo, South Africa. *Plant and Soil* 320: 321–332.

Rahlao, J.S., Hoffman M.T., **Todd, S.W**. & McGrath, K. 2008. Long-term vegetation change in the Succulent Karoo, South Africa following 67 years of rest from grazing. *Journal of Arid Environments*, 72, 808-819.

Hoffman, M.T. & **Todd, S.W.** 2010. Using Fixed-Point Photography, Field Surveys, And Gis To Monitor Environmental Change: An Example From Riemvasmaak, South Africa. Chapter In *Repeat Photography: Methods And Applications In The Natural Sciences.* R.H. Webb, Editor. Island Press. In Press.

Appendix D2

Paleontological Specialist Study

Palaeontological specialist assessment: desktop study

PROPOSED 16 MTPA EXPANSION OF TRANSNET'S EXISTING MANGANESE ORE EXPORT RAILWAY LINE & ASSOCIATED INFRASTRUCTURE BETWEEN HOTAZEL AND THE PORT OF NGQURA, NORTHERN & EASTERN CAPE.

Part 1: Hotazel to Kimberley, Northern Cape

John E. Almond PhD (Cantab.)

***Natura Viva* cc, PO Box 12410 Mill Street,**

Cape Town 8010, RSA

naturaviva@universe.co.za

June 2013

EXECUTIVE SUMMARY

Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. In the Northern Cape an additional eight rail loops that were not part of the previous EIA will be extended and two new loops will be constructed, one at Witloop and another close to Sishen (Table 1).The 16 Mtpa expansion will require a new rail compilation yard located at Mamathwane, Northern Cape. The present desktop report forms part of the Basic Assessment process for the ten railway loop developments along the manganese ore railway line between Hotazel and Kimberley in the Northern Cape.

The construction phase of the proposed new and extended railway loops along the Transnet Hotazel to Kimberley manganese ore railway may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (*e.g.* laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed, while palaeontologically highly sensitive rock units along the route, such as the lower Ecca Group and the Vaal River Gravels, will not be directly affected by the construction programme. The operational and decommissioning phases are unlikely to involve significant adverse impacts on palaeontological heritage.

The extended loop development at Gong Gong is underlain by unfossiliferous lavas of the Early Precambrian Allanridge Formation (Ventersdorp Group) and no palaeontological impacts are therefore anticipated here.

Four of the proposed loop developments (Glosam, Postmasburg, Tsantsabane and Trewil) are underlain by Early Precambrian (2.6-2.5 billion year old) marine carbonate rocks of the Campbell

Rand Subgroup (Ghaap Group, Transvaal Supergroup) that are known for their prolific fossil record of stromatolites, *i.e.* laminated microbial reefs constructed by cyanobacteria, in some cases associated with well-preserved microfossils.

The proposed loop developments at Wincanton, Sishen and Ulco are underlain by Late Caenozoic (probably Plio-Pleistocene) calcretes or pedogenic limestones, at least some of which may be attributed to the Mokalanen Formation of the Kalahari Group. The proposed new loop at Witloop and the Fieldsview loop extension overlie Pleistocene aeolian (wind-blown) sands of the Gordonia Formation, Kalahari Group. While a wide spectrum of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from these Kalahari Group sediments, in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Hotazel to Kimberley sector of the railway line upgrade be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

1. INTRODUCTION AND BRIEF

Manganese ore mined in the Hotazel area near Kuruman (Kalahari Manganese Field) in the Northern Cape is transported by rail to a bulk minerals handling terminal at Port Elizabeth, where it is unloaded and placed on stockpiles before being loaded onto ships for export. Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. Twenty-nine project areas were originally assessed when the 12 Mtpa Environmental Impact Assessment was completed in 2009. In the Northern Cape an additional eight rail loops that were not part of the previous EIA will be extended and two new loops will be constructed, one at Witloop and another close to Sishen (Table 1). The 16 Mtpa expansion will also require a new rail compilation yard located at Mamathwane in the Northern Cape.

1.1. Legislative context for palaeontological assessment studies

ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100) has been appointed as the Independent Environmental Assessment Practitioners to undertake a Basic Assessment of an additional fourteen railway loops between Hotazel and Ngqura.

The present desktop study forms part of the Basic Assessment of ten of the fourteen additional loops, located between Hotazel and Kimberley in the Northern Cape, and is to be followed by a brief field-based palaeontological assessment by the author. A list of the loops under consideration is given in Table 1 and these are also shown on the map in Fig. 1 (kindly provided by ERM). The present palaeontological heritage report also falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Plan for this project.

The proposed railway line developments are located in areas that are underlain by potentially fossil-rich sedimentary rocks of Precambrian and younger, Tertiary or Quaternary age (Sections 2 and 3). The construction phase of the developments may entail substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. In addition, substantial areas of bedrock may be sealed-in or sterilized by railway infrastructure, lay-down areas as well as new gravel roads. All these developments may adversely affect potential fossil heritage at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the railway developments are unlikely to involve further adverse impacts on palaeontological heritage, however.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) are currently being developed by SAHRA. The latest version of the SAHRA draft guidelines was circulated for comment in November 2011.

1.2. Scope and brief for the desktop study

This desktop palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the ten proposed loop study areas within the Northern Cape between Hotazel and Kimberley (Fig. 1, Table 1), with recommendations for further specialist palaeontological studies and / or mitigation where this is considered necessary.

The report has been commissioned by ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100). It contributes to the Basic Assessment for the proposed 16 Mtpa railway expansion and it will also inform the Environmental Management Plan for the project. The scope of work for this desktop study, as defined by ERM, is as follows:

> The Contractor's role involves generating a Paleontological Baseline Report and a Paleontological Assessment Report. The findings will be based on one extended field trip (10 days) covering both the Northern Cape and Eastern Cape.

1.3. Approach to the palaeontological heritage Basic Assessment study

The approach to this palaeontological heritage Basic Assessment study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images (Figs. 3 to 8). Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database (Table 2). Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond & Pether 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*e.g.* SAHRA for the Northern Cape). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the

impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;

4. The extensive relevant palaeontological "grey literature" - in the form of unpublished university theses, impact studies and other reports (*e.g*. of commercial mining companies) - that is not readily available for desktop studies;

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous "drift" (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the Transnet 16 Mtpa study areas a major limitation for fossil heritage studies is the low level of exposure of potentially fossiliferous bedrocks such as the Karoo Supergroup, as well as the paucity of previous specialist palaeontological studies in the Northern Cape region as a whole.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A short project outline provided by ERM;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as several desktop and field-based palaeontological assessment studies in the broader Hotazel to Kimberley region by the author (*e.g.* Almond 2010a, 2010b, 2011a, 2011b, 2012a, 2012b, among others).

3. The author's previous field experience with the formations concerned and their palaeontological heritage (See also review of Northern Cape fossil heritage by Almond & Pether 2008).

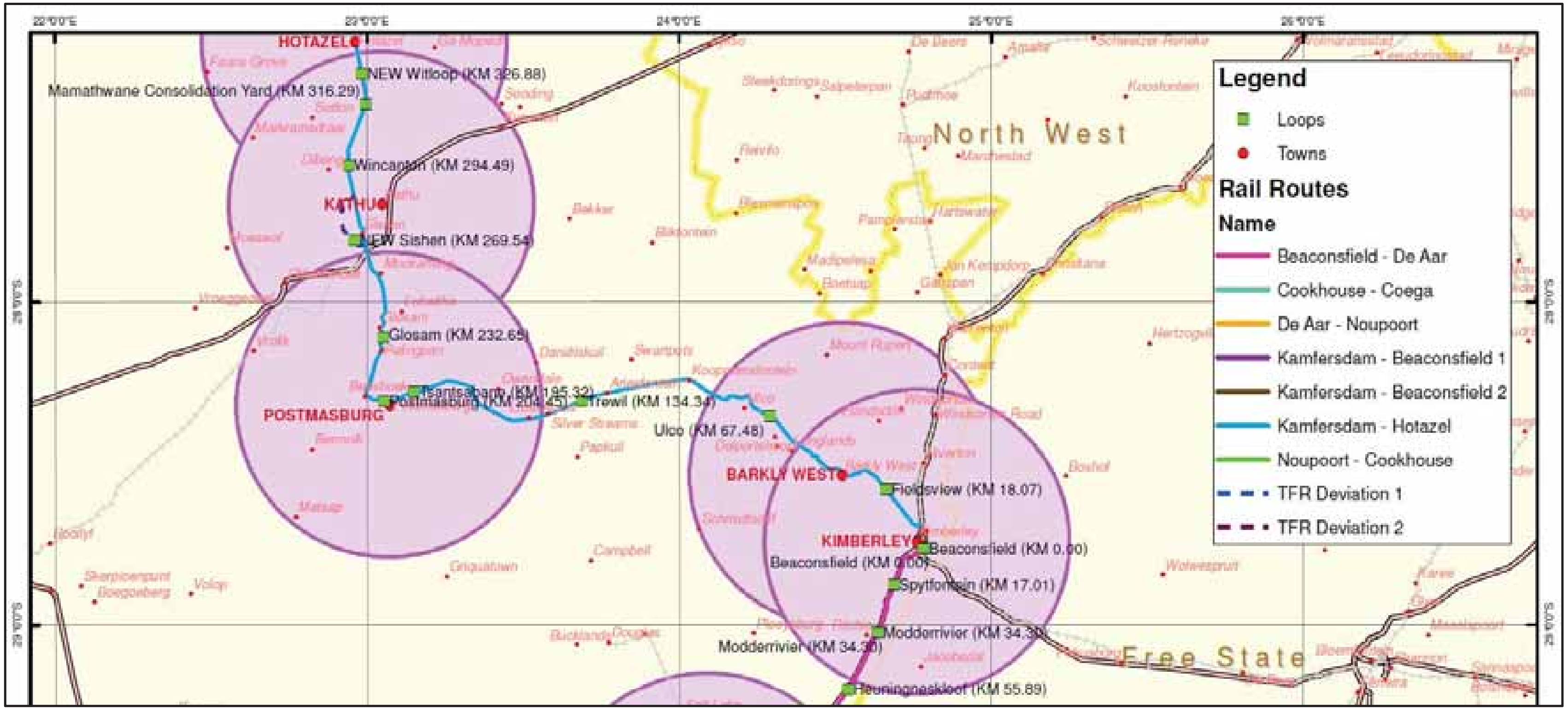


Fig. 1. Map of the Hotazel to Kimberley sector of the Transnet manganese ore export railway line, Northern Cape, showing the ten railway loop sites between Hotazel and Kimberley covered by the present desktop Basic Assessment report (green squares) as well as the location of the proposed Mamathwane Compilation Yard (Map modified from image kindly provided by ERM).

Table 1. Summary of geology and palaeontological sensitivity of the 10 railway loop study sites between Hotazel and Kimberley

LOOP	LOCATION	PROJECT	GEOLOGY	PALAEONTOLOGICAL HERITAGE SENSITIVITY	RECOMMENDATION
1. WITLOOP	27º 17' 54.4" S 23º 00' 59.05" E	New loop	Gordonia Formation (Kalahari Group)	LOW	Brief field assessment of loop development footprints and representative bedrock exposures in the region to assess likely palaeontological impacts based on levels of bedrock exposure, degree of weathering and deformation, and presence of near-surface fossils.
2. WINCANTON	27º 34' 48.1" S 22º 56' 27.02" E	Loop extension	Calcrete	LOW	
3. SISHEN	27º 48' 31.52" S 22º 57' 26.9" E	New loop	Calcrete	LOW	
4. GLOSAM	28º 06' 40.09" S 23º 02' 58.22" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
5. POSTMASBURG	28º 18' 26.63" S 23º 03' 08.92" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
6. TSANTSABANE	28º 16' 45.12" S 23º 08' 51.78" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
7. TREWIL	28º 18' 25.01" S 23º 41' 10.45" E	Loop extension	Campbell Rand Subgroup dolomites	MEDIUM	
8. ULCO	28º 21' 15.12" S 24º 17' 20.11" E	Loop extension	Calcrete	LOW	
9. GONG GONG	c. 28º 28' 27.99" S c. 24º 25' 31.61" E	Loop extension	Allanridge Formation (Ventersdorp Group)	ZERO	
10. FIELDSVIEW	28º 34' 48.76" S 24º 39' 40.98" E	Loop extension	Gordonia Formation (Kalahari Group)	LOW	

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The existing Transnet manganese ore export railway line between Hotazel and Kimberley, Northern Cape, crosses several different physiographic regions of the RSA (Visser *et al.* 1989, their Fig. 2.1.). The initial stretch between Hotazel southwards to Dingleton traverses flat-lying, sandy semi-desert terrain at *c*. 1100-1200 m amsl of the southern Kalahari Region lying between the Korannaberg in the west and the Kurumanheuwels in the East. This region is drained by the Ga-Mogara River (a southern tributary of the Kuruman River) and its tributaries, and bedrock exposure is extremely limited. Between Dingleton, Postmasburg and east to Lime Acres the line runs through the slightly higher-lying (1300-1400m amsl), more rocky terrain of the Griqua Fold Belt Region on the western side of the Ghaap Plateau. This region is characterised by north-south trending rocky ridges and megafolds of Precambrian bedrocks, including the Maremane Anticline in the west and the Asbesberge to the east. From Lime Acres (south of Daniëlskuil) east to Ulco the railway crosses the southern part of the extensive, flat-lying Ghaap Plateau Region (*c*. 1200-1400m amsl) that is underlain by great thicknesses of Precambrian carbonate sediments (limestones, dolomites). The railway line then descends from the eastern edge of the Ghaap Plateau into the western portion of the Upper Karoo Region drained by the Harts and Vaal Rivers. This lower-lying region (*c*. 1100-1200m amsl) includes the sector all the way to Barclay West and Kimberley, situated between the Vaal and Orange Rivers.

The geology of the study area between Hotazel and Kimberley is covered by three adjacent 1: 250 000 scale geological maps, 2722 Kuruman (brief sheet explanation printed on map), 2822 Postmasburg (brief sheet explanation printed on map) and 2824 Kimberley (sheet explanation by Bosch 1993). Relevant extracts from these sheets are provided in Figs. 3 to 8 below. A more regional geological map at 1: 1 000 000 scale is also available (sheet explanation by Visser 1989) but differs in several respects from the more detailed 1: 250 000 maps that form the preferred basis for the present desktop study (*e.g.* regarding the outcrop area of the Dwyka Group).

All major rock units mapped along the railway line between Hotazel and Kimberley are listed in Table 2, together with a brief summary of their geology, age, known fossil heritage and inferred palaeontological sensitivity (largely based on Almond & Pether 2008). The location of these rock units within the stratigraphic column for South Africa is shown in Fig. 2. They include a wide range of sedimentary and igneous rocks ranging in age from Late Archaean (2.7 Ga = billion years old) to Recent. The igneous rocks (*e.g.* lavas, dolerite intrusions) are entirely unfossiliferous and a high proportion of the sedimentary rocks are of low palaeontological sensitivity. The main exceptions are fossiliferous marine shelf carbonates of the Ghaap Group (Vryburg Formation, Campbell Rand Subgroup), interglacial to post-glacial sediments of the Dwyka and Ecca Groups (Karoo Supergroup) and Late Tertiary (Neogene) to Pleistocene alluvial gravels along the Vaal River.

For the purposes of the present Basic Assessment of the proposed new railway loops and loop extensions only those rock units that are mapped within the development footprint (as shown on 1: 250 000 geological maps, Figs. 3 to 8) will be considered further here. As seen in Table 1, the Gong Gong study area is underlain by Late Archaean lavas of the **Allanridge Formation** (**Ventersdorp Subgroup**), the Glosam, Postmasburg, Tsantsabane and Trewil sites by Late Archaean shelf carbonates of the **Campbell Rand Subgroup** (**Transvaal Supergroup**), the Wincanton, Sishen and Ulco sites by Late Caenozoic (probably Plio-Pleistocene) **calcretes** or pedogenic limestones, while the Witloop and Fieldsview sites overlie Pleistocene to Recent aeolian sands of the **Gordonia Formation** (**Kalahari Group**). A short review of the geology of these rock units is given below, while details of their known fossil heritage are given in Section 3.

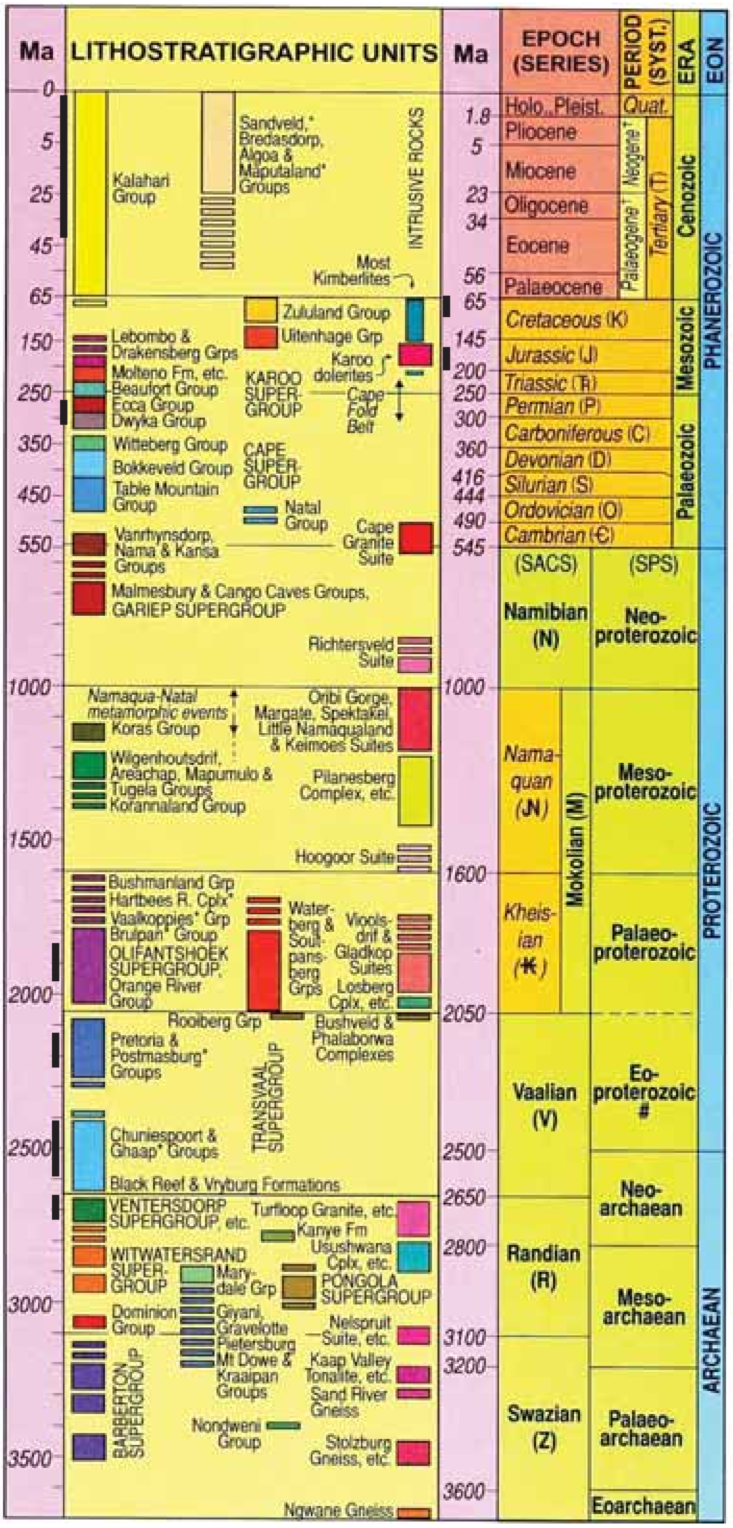


Fig. 2. Stratigraphic column for southern Africa showing the main rock units represented along the manganese ore export line railway between Hotazel and Kimberley, Northern Cape (thick vertical black lines) (See also Table 2).

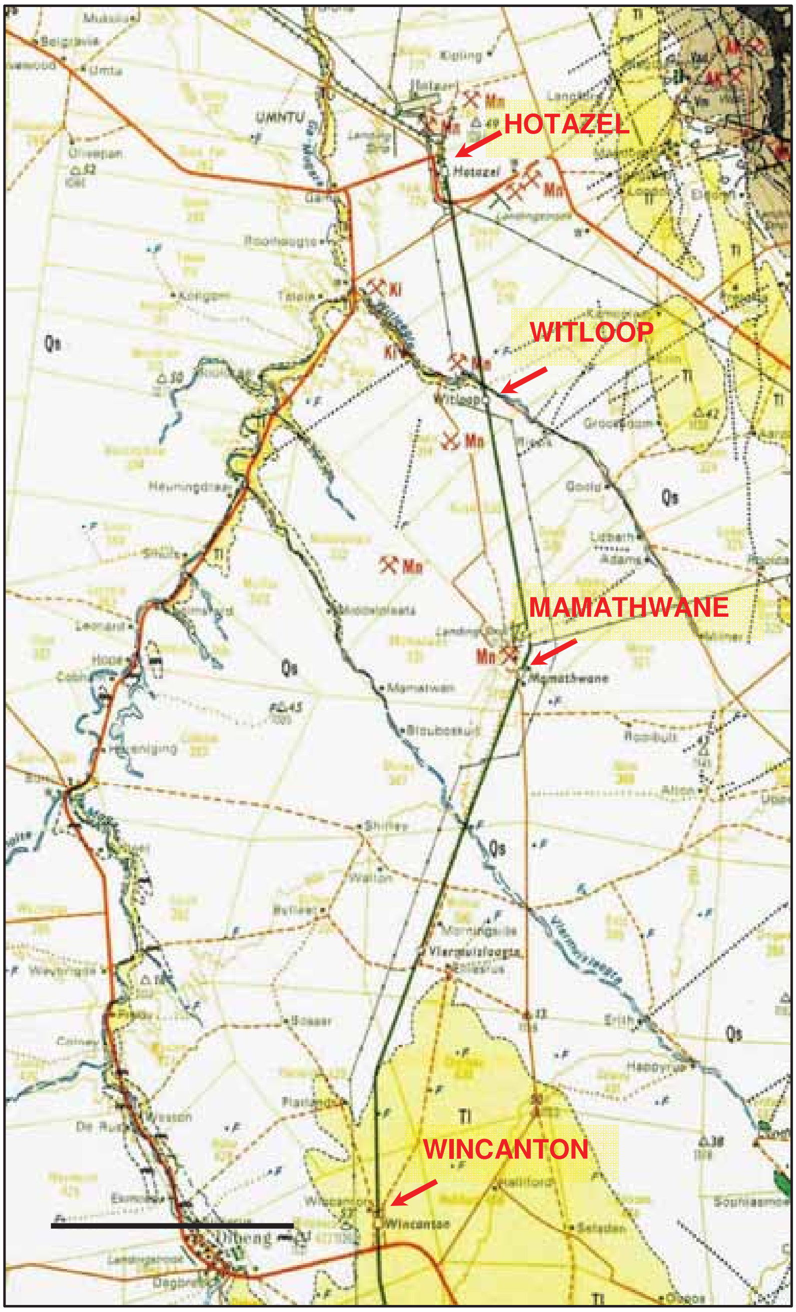


Fig. 3. Extract from 1: 250 000 geology map 2722 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new rail loop at Witloop (underlain by aeolian sands of the Gordonia Formation, Qs) and the loop extension at Wincanton (underlain by surface calcrete, Tl). Note also the position of the proposed new compilation yard at Mamathwane that is underlain by Gordinia Formation aeolian sands. See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

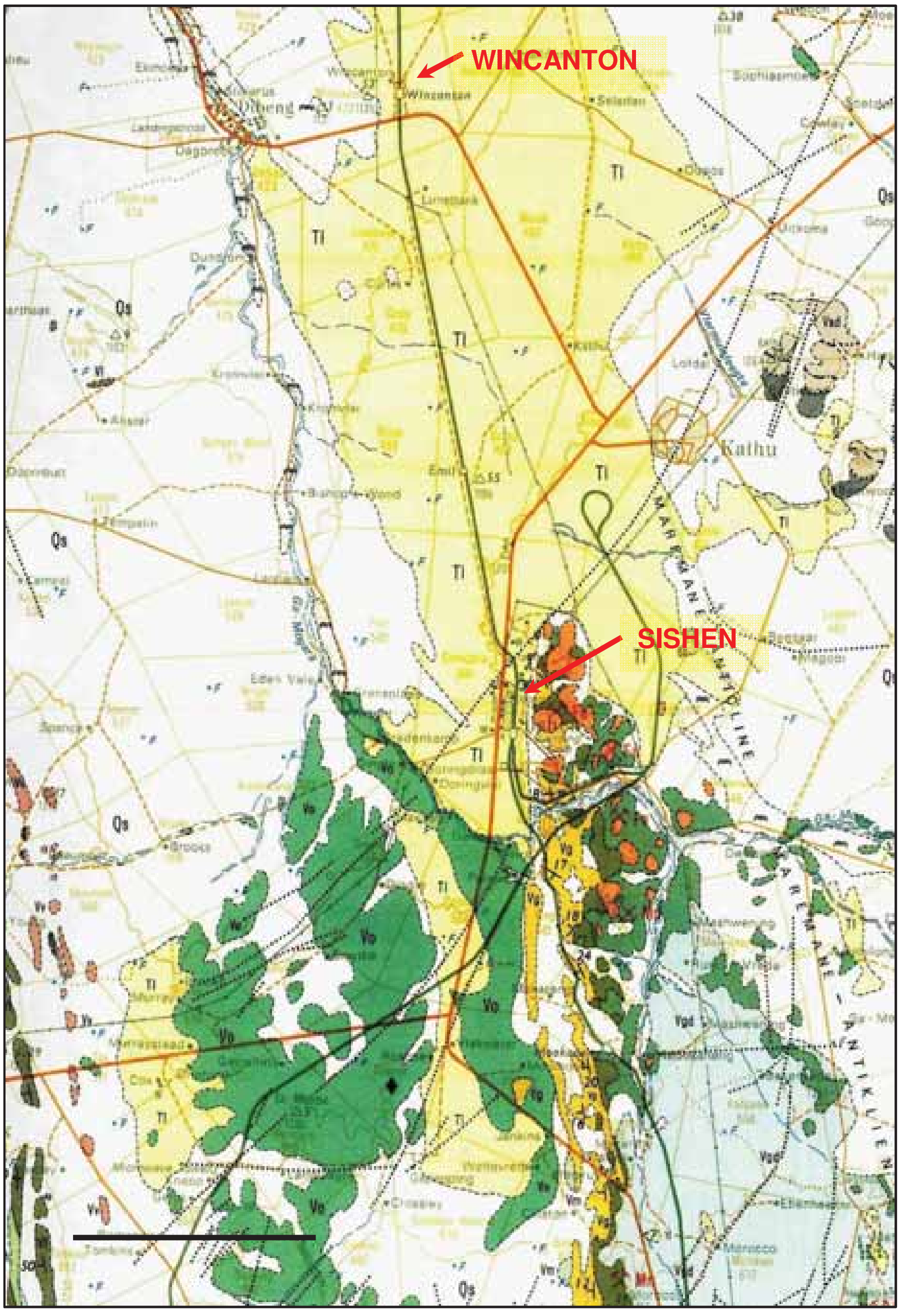


Fig. 4. Extract from 1: 250 000 geology map 2722 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed new loop extensions at Wincanton and new loop at Sishen (both underlain by surface calcrete, Tl). See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

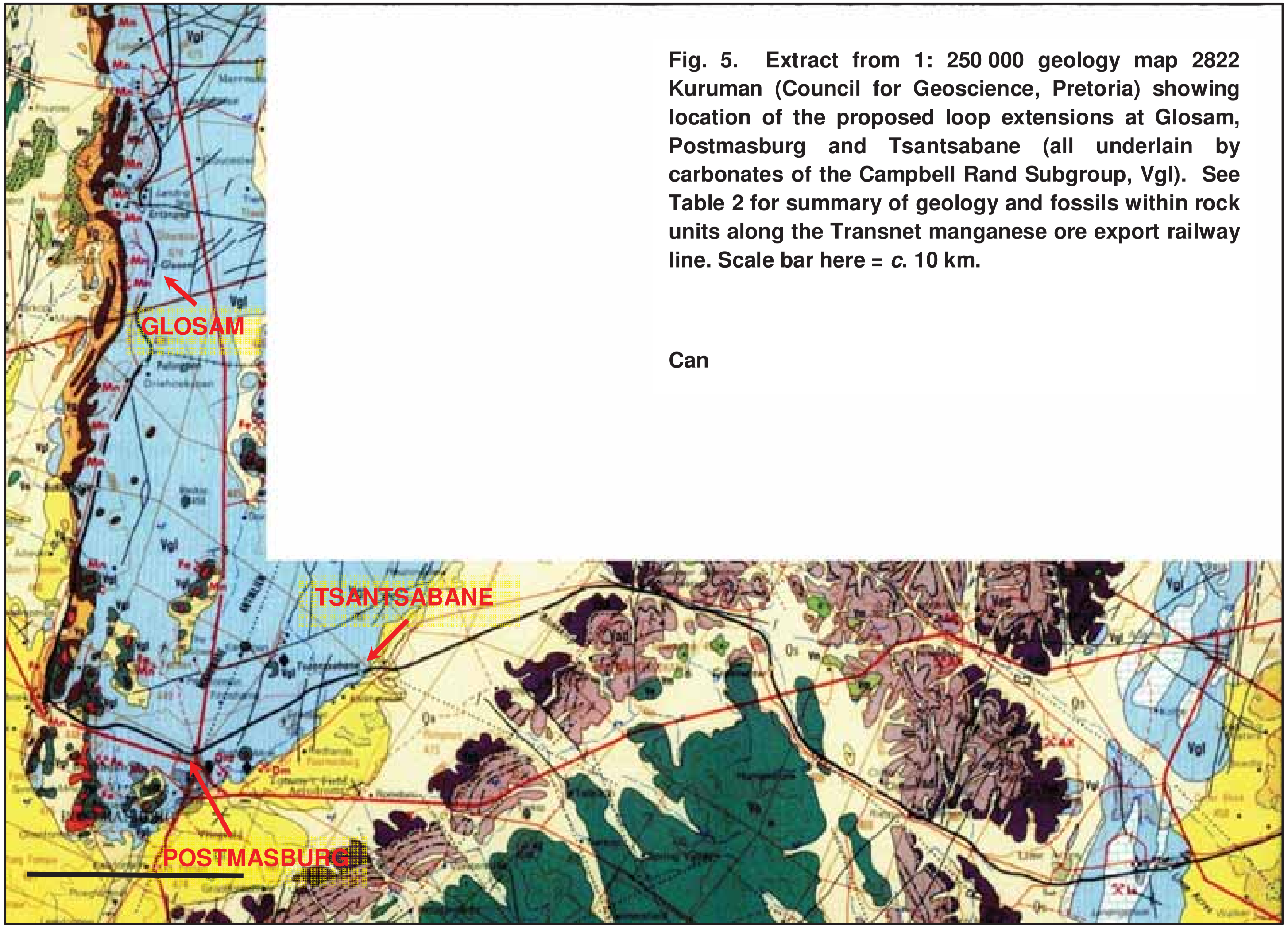


Fig. 5. Extract from 1: 250 000 geology map 2822 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed loop extensions at Glosam, Postmasburg and Tsantsabane (all underlain by carbonates of the Campbell Rand Subgroup, Vgl). See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

Can

Fig. 6. Extract from 1: 250 000 geology map 2822 Kuruman (Council for Geoscience, Pretoria) showing location of the proposed loop extension at Trewil (underlain by carbonates of the Campbell Rand Subgroup, Vgl). See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

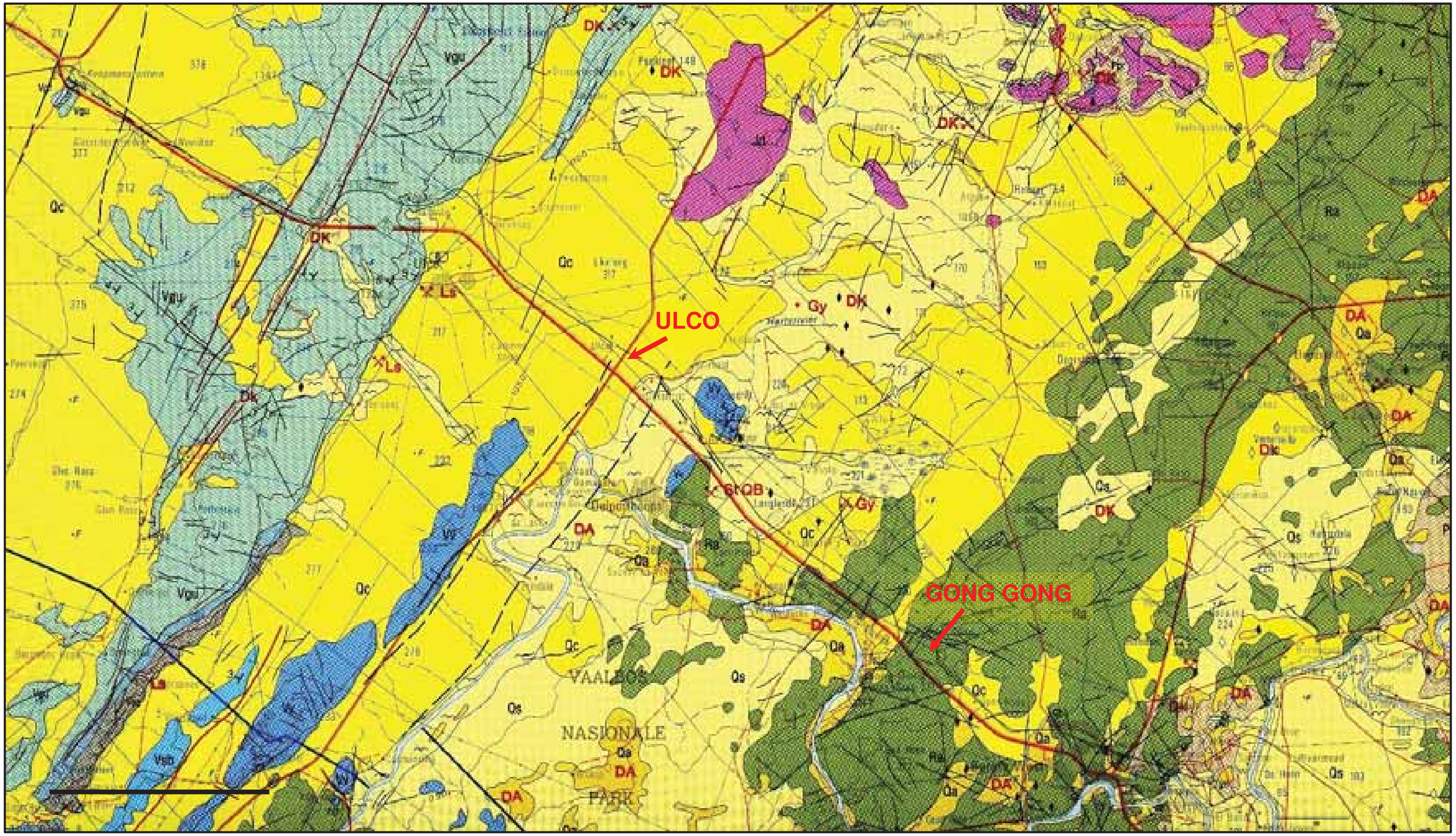


Fig. 7. Extract from 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria) showing location of the proposed loop extensions at Ulco (underlain by surface calcrete, Qc) and Gong Gong (underlain by Allanridge Formation lavas, Ra). See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

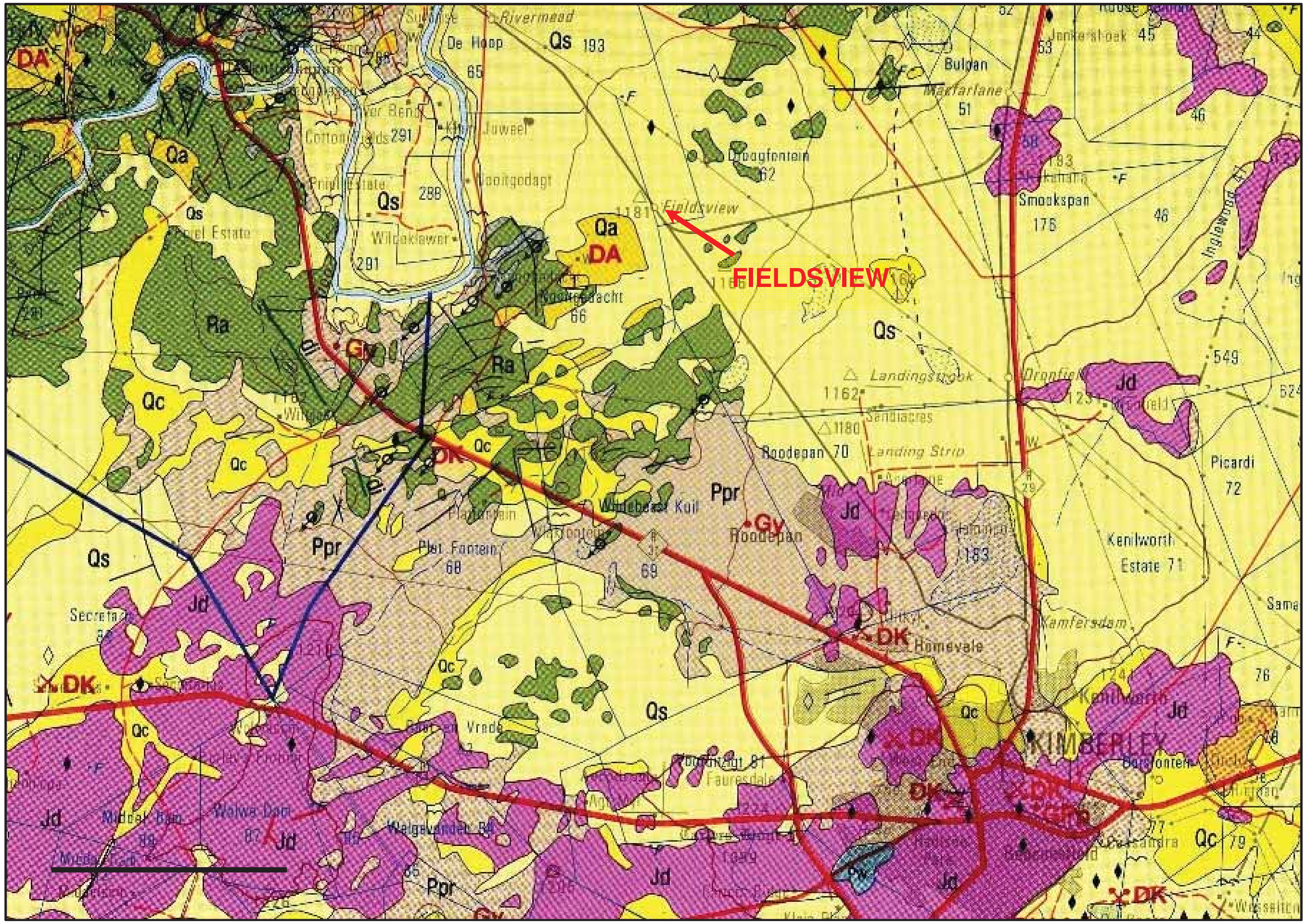


Fig. 8. Extract from 1: 250 000 geology map 2824 Kimberley (Council for Geoscience, Pretoria) showing location of the proposed loop extension at Fieldsview (underlain by Gordonia Formation aeolian sands, Qs). See Table 2 for summary of geology and fossils within rock units along the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

2.1. Allanridge Formation (Ventersdorp Supergroup)

The **Ventersdorp Supergroup** represents a major episode of igneous extrusion (LIP = Large Igneous Province) that is associated with fracturing of the Kaapvaal Craton some 2.7 Ga (billion years) ago. The basal lava pile termed the Klipriviersberg Group - mainly basaltic lavas welling up in fissure eruptions, totalling up to two kilometres thick and 100 000 km^2 in extent - accumulated over a comparatively short period of some six million years (McCarthy & Rubidge 2005). The overlying Platberg Group comprises a range of felsic to mafic volcanic rocks, including lavas and pyroclastics, such as the porphyritic felsites and pyroclastic flows of the Makwassie Formation near Kimberley (Bosch 1993, Van der Westhuizen *et al.* 2006). These igneous rocks are associated with rift-related sediments, including colluvial, alluvial fan and lacustrine deposits, and are overlain by fluvial polymict conglomerates and quartzites of the Bothaville Formation. At the top of the Ventersdorp succession are the greyish-green amydaloidal and porphyritic lavas - mainly basaltic andesites - of the **Allanridge Formation**. Here can be recognised lava flows up to 14m thick with vesicular tops, pipe-like structures due to lava degassing, and pillow structures formed during subaqueous eruptions (Bosch 1993). Gas vesicles within the amygdaloidal lavas are infilled with a range of secondary minerals including reddish chalcedony, quartz, calcite, chlorite and epidote. A thin lenticular succession of conglomerate and cross-bedded quartzites occurs locally just above the base of the succession.

A broad NE-SW trending outcrop area of resistant-weathering Allanridge Formation lavas is mapped to the northwest of Kimberley, including the Gong Gong loop extension study area (Fig. 7). A rusty-brown to metallic (desert varnish) surface weathering patina has developed on many surface boulders; this patina has been exploited locally by Later Stone Age rock engravers (*e.g.* Wildebeest Kuil rock art centre near Kimberley). A number of glacial pavements - glacially-striated and eroded bedrocks - of Dwyka age (*i.e.* Permo-Carboniferous, *c.* 300 Ma) are mapped within the Allanridge Formation outcrop area in the same region. These features, which here indicate consistent ice transport directions to the southwest, are of geological conservation significance (Almond 2012c).

2.2. Campbell Rand Subgroup (Ghaap Group, Transvaal Supergroup)

According to the 1: 250 000 geology maps (Figs. 5 to 7) the majority of the manganese ore railway line between Sishen to just east of Ulco is underlain by Early Precambrian (Late Archaean to Early Proterozoic) marine sediments of the **Transvaal Supergroup**, and in particular by the **Ghaap Group** of the Griqualand West Basin, Ghaap Plateau Subbasin. Useful reviews of the stratigraphy and sedimentology of these Transvaal Supergroup rocks have been given by Moore *et al.* (2001), Eriksson and Altermann (1998) as well as Eriksson *et al.* (1993, 1995, 2006). The Ghaap Group represents some 200 Ma of chemical sedimentation - notably iron and manganese ores, cherts and carbonates - within the Griqualand West Basin that was situated towards the western edge of the Kaapvaal Craton (See also fig. 4.19 in McCarthy & Rubidge 2005).

The **Campbell Rand Subgroup** (previously included within the Ghaapplato Formation) of the Ghaap Group is a very thick (1.6-2.5 km) carbonate platform succession of dolomites, dolomitic limestones and cherts with minor tuffs that was deposited on the shallow submerged shelf of the Kaapvaal Craton roughly 2.6 to 2.5 Ga (billion years ago; see the readable general account by McCarthy & Rubidge, pp. 112-118 and Fig. 4.10 therein). A range of shallow water facies, often forming depositional cycles reflecting sea level changes, are represented here, including stromatolitic limestones and dolomites, oolites, oncolites, laminated calcilutites, cherts and marls, with subordinate siliclastics (shales, siltstones) and minor tuffs (Eriksson *et al.* 2006). Due to their solubility and low resistence to weathering, exposure levels of these rocks are often very low. The outcrop area of chert-rich subunits is often largely covered in downwasted, siliceous rock rubble (*e.g.* Postmasburg sheet area).

Carbonates of the "Ghaapplato Formation" underlie the loop study areas at Glosam, Postmasburg, Tsantsabane and Trewil (Figs. 5 & 6). Note that since the 1: 250 000 geological maps were produced, the Campbell Rand succession has been subdivided into a series of formations, some of which were previously included within the older Schmidtsdrift Formation or Subgroup (Beukes 1980, 1986, Eriksson *et al.* 2006). It is unclear exactly which of these newer carbonate-dominated units are represented in the Transnet railway study areas. However, this level of stratigraphic resolution is not critical for the current baseline report.

2.3. Late Caenozoic superficial sediments (calcretes, aeolian sands)

Large sections of the Transnet manganese ore export railway line study area are mantled by a range of **superficial sediments** of probable Late Caenozoic (*i.e.* Late Tertiary or Neogene to Recent) age, many of which are assigned to the **Kalahari Group**. The geology of the Late Cretaceous to Recent Kalahari Group is reviewed by Thomas (1981), Dingle *et al.* (1983), Thomas & Shaw 1991, Haddon (2000) and Partridge *et al.* (2006). Other superficial sediments whose outcrop areas are often not indicated on geological maps include colluvial or slope deposits (scree, hillwash, debris flows *etc*), sandy, gravelly and bouldery river alluvium, surface gravels of various origins, as well as spring and pan sediments. The colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with pedogenic limestone), especially in the neighbourhood of dolerite intrusions.

Mappable exposures of **calcrete** or **surface limestone** (**Ql** / **Qc**) occur in the southern Kalahari Region (Wincanton and Sishen loop study areas), also to the east of Postmasburg, as well as covering large portions of the Ghaap Group carbonates of the Ghaap Plateau (Ulco loop study area). These pedogenic limestone deposits reflect seasonally arid climates in the region over the last five or so million years and are briefly described by Truter *et al.* (1938) as well as Visser (1958) and Bosch (1993). The surface limestones may reach thicknesses of over 20m, but are often much thinner, and are locally conglomeratic with clasts of reworked calcrete as well as exotic pebbles. The limestones may be secondarily silicified and incorporate blocks of the underlying Precambrian carbonate rocks. The older, Pliocene - Pleistocene calcretes in the broader Kalahari region, including sandy limestones and calcretised conglomerates, have been assigned to the **Mokalanen Formation** of the **Kalahari Group** and are possibly related to a globally arid time period between 2.8 and 2.6 million years ago, *i.e.* late Pliocene (Partridge *et al.* 2006). Thick deposits of calc-tufa ("*kranskalk*") occur along the margins of the Ghaap Plateau, as at Ulco, where lime-rich groundwaters reach the ground surface (Bosch 1993).

Large areas of unconsolidated, reddish-brown to grey aeolian (*i.e.* wind-blown) sands of the Quaternary **Gordonia Formation** (**Kalahari Group**; **Qs** in Figs. 3 to 8) are mapped in the Transnet manganese ore railway study region, including the Witloop and Fieldsview loop study areas. According to Bosch (1993) the Gordonia sands in the Kimberley area reach thicknesses of up to eight meters and consist of up to 85% quartz associated with minor feldspar, mica and a range of heavy minerals. The Gordonia dune sands are considered to range in age from the Late Pliocene / Early Pleistocene to Recent, dated in part from enclosed Middle to Later Stone Age stone tools (Dingle *et al.*, 1983, p. 291). Note that the recent extension of the Pliocene - Pleistocene boundary from 1.8Ma back to 2.588 Ma would place the Gordonia Formation almost entirely within the Pleistocene Epoch.

.

3. PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY AREA

Fossil biotas recorded from each of the main rock units mapped along the Transnet manganese ore export railway line are briefly reviewed in Table 2 (Based largely on Almond & Pether 2008 and references therein), where an indication of the palaeontological sensitivity of each rock unit is also given. The quality of fossil preservation may compromised in some areas due to intense tectonic deformation, while extensive dolerite intrusion has compromised fossil heritage in portions of the Karoo Supergroup sediments (*e.g.* Ecca Group) due to resulting thermal metamorphism. In addition, pervasive calcretisation and chemical weathering of many near-surface bedrocks in the Northern Cape has further compromised their original fossil heritage in many areas (*e.g.* Ecca Group outcrop). The fossil record of the rock units underlying the proposed railway loop developments between Hotazel and Kimberly are reviewed in more detail below.

3.3. Fossils within the Ventersdorp Supergroup

Domical stromatolites are recorded from shallow water lacustrine calcarenites within the volcano-sedimentary succession of the Rietgat Formation at the top of the Platberg Group (Schopf 2006, Van der Westhuizen *et al.* 2006). The overlying predominantly siliciclastic Bothaville Formation contains conical stromatolites (Schopf 2006). Carbonate sediments are not reported in association with the Allanridge Formation lavas at the top of the Ventersdorp Supergroup, however.

3.2. Fossils within the Campbell Rand Subgroup

The shallow shelf and intertidal sediments of the carbonate-dominated lower part of the **Ghaap Group** (*i.e.* **Schmidtsdrif** and **Campbell Rand Subgroups**) are well known for their rich fossil biota of *stromatolites* or microbially-generated, finely-laminated sheets, mounds and branching structures. Some stromatolite occurrences on the Ghaap Plateau of the Northern Cape are spectacularly well-preserved (*e.g.* Boetsap locality northeast of Daniëlskuil figured by McCarthy & Rubidge 2005, Eriksson *et al.* 2006). Detailed studies of these 2.6-2.5 Ga carbonate sediments and their stromatolitic biotas have been presented by Young (1932), Beukes (1980, 1983), Eriksson & Truswell (1974), Eriksson & Altermann (1998), Eriksson *et al* (2006), Altermann and Herbig (1991), and Altermann and Wotherspoon (1995). Some of the oldest known (2.6 Ga) fossil microbial assemblages with filaments and coccoids have been recorded from stromatolitic cherty limestones of the Lime Acres Member, Kogelbeen Formation at Lime Acres (Altermann & Schopf 1995). The oldest, Archaean stromatolite occurrences from the Ghaap Group have been reviewed by Schopf (2006, with full references therein). The Tsineng Formation at the top of the Campbell Rand carbonate succession has yielded both stromatolites (previously assigned to the Tsineng Member of the Gamohaan Formation) as well as filamentous microfossils named *Siphonophycus* (Klein *et al.*1987, Altermann & Schopf 1995).

3.3. Fossils within the Kalahari Group

The fossil record of the **Kalahari Group** is generally sparse and low in diversity. The **Gordonia Formation** dune sands were mainly active during cold, drier intervals of the Pleistocene Epoch that were inimical to most forms of life, apart from hardy, desert-adapted species. Porous dune sands are not generally conducive to fossil preservation. However, mummification of soft tissues may play a role here and migrating lime-rich groundwaters derived from the underlying bedrocks (including, for example, dolerite) may lead to the rapid calcretisation of organic structures such as burrows and root casts. Occasional terrestrial fossil remains that might be expected within this unit include calcretized rhizoliths (root casts) and termitaria (*e.g. Hodotermes*, the harvester termite), ostrich egg shells (*Struthio*) and shells of land snails (*e.g. Trigonephrus*) (Almond 2008, Almond & Pether 2008). Other fossil groups such as freshwater bivalves and gastropods (*e.g. Corbula, Unio*) and snails, ostracods (seed shrimps), charophytes (stonewort algae), diatoms (microscopic algae within siliceous shells) and stromatolites (laminated microbial limestones) are associated with local watercourses and pans. Microfossils such as diatoms may be blown by wind into nearby dune sands (Du Toit 1954, Dingle *et al*., 1983). These Kalahari fossils (or subfossils) can be expected to occur sporadically but widely, and the overall palaeontological sensitivity of the Gordonia Formation is therefore considered to be low. Underlying calcretes of the **Mokolanen Formation** might also contain trace fossils such as rhizoliths, termite and other insect burrows, or even mammalian trackways. Mammalian bones, teeth and horn cores (also tortoise remains, and fish, amphibian or even crocodiles in wetter depositional settings such as pans) may be expected occasionally expected within Kalahari Group sediments and calcretes, notably those associated with ancient, Plio-Pleistocene alluvial gravels.

Table 2. Fossil heritage of rock units cropping out along the Hotazel to Kimberley sector of the Transnet manganese ore export railway line

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
OTHER LATE CAENOZOIC TERRESTRIAL DEPOSITS OF THE INTERIOR (Most too small to be indicated on 1: 250 000 geological maps)	Fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes, spring tufa / travertine, cave deposits, peats, colluvium, soils, surface gravels including downwasted rubble MOSTLY QUATERNARY TO HOLOCENE (Possible peak formation 2.6-2.5 Ma)	Bones and teeth of wide range of mammals (*e.g.* mastodont proboscideans, rhinos, bovids, horses, micromammals), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.* termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs. calcareous tufas at edge of Ghaap Escarpment might be highly fossiliferous (*cf* Taung in NW Province – abundant Makapanian Mammal Age vertebrate remains, including australopithecines)	LOW Scattered records, many poorly studied and of uncertain age	Any substantial fossil finds to be reported by ECO to SAHRA
Gordonia Formation (Qs) KALAHARI GROUP *plus* SURFACE CALCRETES (Tl / Qc)	Mainly aeolian sands *plus* minor fluvial gravels, freshwater pan deposits, calcretes PLEISTOCENE to RECENT	Calcretised rhizoliths & termitaria, ostrich egg shells, land snail shells, rare mammalian and reptile (*e.g.* tortoise) bones, teeth freshwater units associated with diatoms, molluscs, stromatolites *etc*	LOW	Any substantial fossil finds to be reported by ECO to SAHRA
Windsorton & Rietputs Formations HIGH LEVEL ALLUVIAL GRAVELS (Qa) Miocene to Pleistocene	Ancient alluvial gravels, locally diamondiferous and calcretised	Sparse Tertiary vertebrates in older gravels. Rich Pleistocene mammalian fauna (bones, teeth) in younger gravels (*e.g.* equids, elephants, hippo) associated with Acheulian stone artefacts	HIGH	Pre-construction field assessment by professional palaeontologist
KIMBERLITE INTRUSIONS (diamond symbol)	Kimberlite / olivine melilitite / carbonatite volcanic pipes and related intrusions (fissure fills), sometime diamondiferous. JURASSIC, CRETACEOUS TO PALAEOCENE *c.* 200-60 Ma	Rare fossiliferous xenoliths of country rocks (*e.g.* Beaufort Group sediments with fossil fish). Bryophytes, vascular plants (leaves, wood, fruit), fish, pipid frogs (adults, tadpoles), reptiles (tortoises, lizards), rare dinosaurs, birds (ratites), insects, ostracods, palynomorphs (bryophytes, ferns, gymnosperms, angiosperms) within crater lake sediments	LOW	none

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
KAROO DOLERITE SUITE **(Jd)**	**Intrusive dolerites (dykes, sills), associated diatremes** **EARLY JURASSIC** **(182-183 Ma)**	**No fossils recorded**	**ZERO** (also cause baking of adjacent fossiliferous sediments)	**None**
Prince Albert Formation **(Ppr; locally mapped within C-Pd)** **ECCA GROUP**	**Basinal mudrocks with calcareous concretions** **EARLY PERMIAN**	**Marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks,** **Trace fossils, various microfossils, petrified wood**	**HIGH** **IN KIMBERLEY - DOUGLAS REGION**	**Pre-construction field assessment by professional palaeontologist**
Mbizane Formation **(C-Pd)** **DWYKA GROUP**	**Tillites, interglacial mudrocks, deltaic & turbiditic sandstones, minor thin limestones** **LATE CARBONIFER-OUS – EARLY PERMIAN**	**Sparse petrified wood & other plant remains, palynomorphs, trace fossils (*e.g.* arthropod trackways, fish trails,** **U-burrows)** **possible stromatolites in limestones**	**LOW TO MODERATE** **(*N.B.* stratotype section in the Douglas area)**	**Pre-construction field assessment by professional palaeontologist**
Gamagara Formation (Vga / Vg) **OLIFANTSHOEK SUPERGROUP**	**Continental red beds (shales, sandstones, conglomerates), lateritic palaeosols** **EARLY PROTEROZOIC** **(1.9 Ga or older)**	**Lateritic palaeosols reflect terrestrial biomass**	**LOW**	**None recommended**
Ongeluk Formation (Vo) **Makganyene Formation (Vm)** **POSTMASBURG GROUP**	**Lavas** **Glacial diamictites *plus* carbonates** **EARLY PROTEROZOIC** **(2.2-2.3 Ga)**	**None** **Stromatolitic domes within carbonate facies**	**LOW TO MODERATE**	**Recording & sampling of any newly exposed stromatolites by palaeontologist**
Daniëlskuil Formation (Vad) **Kuruman Formation (Vak)** **Asbestos Hills Subgroup (Va)** **GHAAP GROUP**	**BIF (banded iron formations) with cherty bands** **EARLY PROTEROZOIC** **(*c.* 2.5-2.4 Ga)**	**Important early microfossil biotas**	**LOW**	**None recommended**

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Campbell Rand Subgroup (Vca / Vgl, Vgu, Vgd *etc*) **GHAAP GROUP**	**Shallow marine to intertidal limestones / dolomites, siliceous breccias ("Manganese Marker")** **LATE ARCHAEAN** **(*c.* 2.6-2.5 Ga)**	**Rich stromatolite assemblages (stratiform, domical, columnar), important early microfossil biotas**	**MODERATE TO HIGH**	**Recording & sampling of any newly exposed stromatolites in development footprint**
Vryburg Formation (Vv) **GHAAP GROUP**	**Lavas, siliciclastics, carbonates** **Late archaean** **2.64 ga**	**Stromatolites in carbonates**	**Moderate**	**Recording & sampling of any newly exposed stromatolites in development footprint**
Allanridge Formation (Ra / Ral) **VENTERSDORP SUPERGROUP**	**Lavas and volcaniclastic sediments** **LATE ARCHAEAN** **2.7 Ga**	**No fossils recorded**	**LOW**	**None recommended** **Any substantial fossil finds to be reported by ECO to SAHRA**

5. CONCLUSIONS AND RECOMMENDATIONS

The construction phase of the proposed new and extended railway loops along the Transnet Hotazel to Kimberley manganese ore railway may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (*e.g.* laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed, while palaeontologically highly sensitive rock units along the route, such as the lower Ecca Group and the Vaal River Gravels, will not be directly affected by the loop construction programme. The operational and decommissioning phases of the 16 Mtpa railway line are unlikely to involve significant adverse impacts on palaeontological heritage.

The extended loop development at Gong Gong is underlain by unfossiliferous lavas of the Early Precambrian Allanridge Formation (Ventersdorp Group) and no palaeontological impacts are therefore anticipated here.

Four of the proposed loop developments (Glosam, Postmasburg, Tsantsabane and Trewil) are underlain by Early Precambrian (2.6-2.5 billion year old) marine carbonate rocks of the Campbell Rand Subgroup (Ghaap Group, Transvaal Supergroup) that are known for their prolific fossil record of stromatolites, *i.e.* laminated microbial reefs constructed by cyanobacteria, in some cases associated with well-preserved microfossils.

The proposed loop developments at Wincanton, Sishen and Ulco are underlain by Late Caenozoic (probably Plio-Pleistocene) calcretes or pedogenic limestones, at least some of which may be attributed to the Mokalanen Formation of the Kalahari Group. The proposed new loop at Witloop and the Fieldsview loop extension overlie Pleistocene aeolian (wind-blown) sands of the Gordonia Formation, Kalahari Group. While a wide spectrum of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from these Kalahari Group sediments, in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Hotazel to Kimberley sector of the Transnet manganese ore export railway be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

6. ACKNOWLEDGEMENTS

Mr Junaid Moosajee of ERM, Cape Town, is thanked for commissioning this study and providing the relevant background information. I am also grateful to Ms Elize Becker, Environmental Services Group, HATCH, Johannesburg for extensive discussions concerning heritage related issues relating to the Transnet 16 Mtpa project.

7. REFERENCES

ALMOND, J.E. 2008. Fossil record of the Loeriesfontein sheet area (1: 250 000 geological sheet 3018). Unpublished report for the Council for Geoscience, Pretoria, 32 pp.

ALMOND, J.E. 2010a. Proposed photovoltaic power station adjacent to Welcome Wood Substation, Owendale near Postmasburg, Northern Cape Province: desktop palaeontological assessment, 13 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Prospecting application for iron ore and manganese between Sishen and Postmasburg, Northern Cape Province: farms Jenkins 562, Marokwa 672, Thaakwaneng 675, Driehoekspan 435, Doringpan 445 and Macarthy 559: desktop palaeontological assessment, 20 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011a. Proposed Mainstream solar park near Douglas, Northern Cape Province,. Palaeontological specialist study: preliminary desktop screening assessment, 27 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011b. Proposed Solar Thermal Energy Power Park on Farm Arriesfontein, near Daniëlskuil, Postmasburg District, Northern Cape Province. Palaeontological specialist study: desktop assessment, 14 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012a. Proposed PV power stations Welcome Wood II and III adjacent to Welcome Wood Substation, near Daniëlskuil, Northern Cape Province. Palaeontological impact assessment: desktop study, 14 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012b. Proposed westerly extension of Sishen Iron Ore Mine near Kathu, Kalagadi District Municipality, Northern Cape. Palaeontological specialist study" desktop study, 18 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2012c. Proposed !Xun & Khwe PV and CSP Solar Power Facilities on Farm Platfontein (Portion 68) near Kimberley, Northern Cape Province. Palaeontological assessment: combined desktop study & field assessment, 24 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. & PETHER, J. 2008. Palaeontological heritage of the Northern Cape. Interim SAHRA technical report, 124 pp. Natura Viva cc., Cape Town.

ALTERMANN, J. & HERBIG 1991. Tidal flats deposits of the Lower Proterozoic Campbell Group along the southwestern margin of the Kaapvaal Craton, Northern Cape province, South Africa. Journal of African Earth Science 13: 415-435.

ALTERMANN, W. & SCHOPF, J.W. 1995. Microfossils from the Neoarchaean Campbell Group, Griqualand West Sequence of the Transvaal Supergroup, and their paleoenvironmental and evolutionary implications. Precambrian Research 75, 65-90.

ALTERMANN, W. & WOTHERSPOON, J. McD. 1995. The carbonates of the Transvaal and Griqualand West sequences of the Kaapvaal craton, with special reference to the Limje Acres limestone deposit. Mineralium Deposita 30, 124-134.

ANDERSEN, D.T., SUMNER, D.Y., HAWES, I., WEBSTER-BRWON, J. & MCKAY, C.P. 2011. Discovery of large conical stromatolites in Lake Untersee, Antarctica. Geobiology 9, 280-293.

BERTRAND-SARFATI, J. 1977. Columnar stromatolites from the Early Proterozoic Schmidtsdrift Formation, Northern Cape Province, South Africa – Part 1: systematic and diagnostic features. Palaeontologia Africana 20, 1-26.

BEUKES, N.J. 1980. Stratigraphie en litofasies van die Campbellrand-Subgroep van die Proterofitiese Ghaap-Group, Noord-Kaapland. Transactions of the Geological Society of South Africa 83, 141-170.

BEUKES, N.J. 1983. Stratigraphie en litofasies van die Campbellrand-Subgroep van die proterofitiese Ghaap-Groep, Noord-Kaapland. Transactions of the Geological Society of South Africa 83: 141-170.

BEUKES, N.J. 1986. The Transvaal Sequence in Griqualand West. In: Anhaeusser, C.R. & Maske, S. (Eds.) Mineral deposits of Southern Africa, Volume 1, pp. 819-828. Geological Society of South Africa.

BOSCH, P.J.A. 1993. Die geologie van die gebied Kimberley. Explanation to 1: 250 000 geology Sheet 2824 Kimberley, 60 pp. Council for Geoscience, Pretoria.

COETZEE, L.L., BEUKES, N.J. & GUTZMER, J. 2006. Links of organic carbon cycling and burial to depositional depth gradients and establishment of a snowball Earth at 2.3 Ga. Evidence from the Timeball Hill Formation, Transvaal Supergroup, South Africa. South African Journal of geology 109, 109-122.

DINGLE, R.V., SIESSER, W.G. & NEWTON, A.R. 1983. Mesozoic and Tertiary geology of southern Africa. viii + 375 pp. Balkema, Rotterdam.

DU TOIT, A. 1954. The geology of South Africa. xii + 611pp, 41 pls. Oliver & Boyd, Edinburgh.

ERIKSSON, K.A. & TRUSWELL, J.F. 1973. High inheritance elongate stromatolitic mounds from the Transvaal Dolomite. Palaeontologia Africana 15, 23-28.

ERIKSSON, K.A. & TRUSWELL, J.F. 1974. Tidal flat associations from a Lower Proterozoic carbonate sequence in South Africa. Sedimentology 21: 293-309.

ERIKSSON, K.A., TRUSWELL, J.F. & BUTTON, A. 1976. Paleoenvironmental and geochemical models from an Early Proterozoic carbonate succession in South Africa. In: Walter, M.R. (Ed.) Stromatolites, 635-643. Blackwell, Oxford.

ERIKSSON, P.G., SCHWEITZER, J.K., BOSCH, P.J.A., SCHREIBER, U.M., VAN DEVENTER, J.L. & HATTON, C. 1993. The Transvaal Sequence: an overview. Journal of African Earth Science 16, 25-51.

ERIKSSON, P.G., HATTINGH, P.J. & ALTERMANN, W. 1995. An overview of the geology of the Transvaal Sequence and the Bushveld Complex, South Africa. Mineralium Deposita 30, 98-111.

ERIKSSON, P.G. & ALTERMANN, W. 1998. An overview of the geology of the Transvaal Supergroup dolomites (South Africa). Environmental Geology 36, 179-188.

ERIKSSON, P.G., ALTERMANN, W. & HARTZER, F.J. 2006. The Transvaal Supergroup and its precursors. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 237-260. Geological Society of South Africa, Marshalltown.

HADDON, I.G. 2000. Kalahari Group sediments. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp. 173-181. Oxford University Press, Oxford.

HENDEY, Q.B. 1984. Southern African late Tertiary vertebrates. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 81-106. Balkema, Rotterdam.

KLEIN, C., BEUKES, N.J. & SCHOPF, J.W. 1987. Filamentous microfossils in the early Proterozoic Transvaal Supergroup: their morphology, significance, and palaeoenvironmental setting. Precambrian Research 36, 81-94.

KLEIN, C. & BEUKES, N.J. 1989. Geochemistry and sedimentology of a facies transition from limestone to iron formation deposition in the early Proterozoic Transvaal Supergroup, South Africa. Economic Geology 84, 1733-1774.

MACRAE , C. 1999. Life etched in stone. Fossils of South Africa. 305 pp. The Geological Society of South Africa, Johannesburg.

MCCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

MOORE, J.M., TSIKOS, H. & POLTEAU, S. 2001. Deconstructing the Transvaal Supergroup, South Africa: implications for Palaeoproterozoic palaeoclimate models. African Earth Sciences 33, 437-444.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

SCHOPF, J.W. 2006. Fossil evidence of Archaean life. Philosophical Transactions of the Royal Society of London B 361, 869-885.

THOMAS, M.J. 1981. The geology of the Kalahari in the Northern Cape Province (Areas 2620 and 2720). Unpublished MSc thesis, University of the Orange Free State, Bloemfontein, 138 pp.

THOMAS, R.J., THOMAS, M.A. & MALHERBE, S.J. 1988. The geology of the Nossob and Twee Rivieren areas. Explanation for 1: 250 000 geology sheets 2520-2620. 17pp. Council for Geoscience, Pretoria.

THOMAS, D.S.G. & SHAW, P.A. 1991. The Kalahari environment, 284 pp. Cambridge University Press.

TANKARD, A.J., JACKSON, M.P.A., ERIKSSON, K.A., HOBDAY, D.K., HUNTER, D.R. & MINTER, W.E.L. 1982. Crustal evolution of southern Africa – 3.8 billion years of earth history, xv + 523pp. Springer Verlag, New York.

TRUTER, F.C., WASSERSTEIN, B., BOTHA, P.R., VISSER, D.L.J., BOARDMAN, L.G. & PAVER, G.L. 1938. The geology and mineral deposits of the Olifants Hoek area, Cape Province. Explanation of 1: 125 000 geology sheet 173 Olifants Hoek, 144 pp. Council for Geoscience, Pretoria.

VAN DER WESTHUIZEN, W.A., DE BRUIYN, H. & MEINTJES, P.G. 2006. The Ventersdorp Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 187-208. Geological Society of South Africa, Marshalltown.

VISSER, D.L.J. 1958. The geology and mineral deposits of the Griquatown area, Cape Province. Explanation to 1: 125 000 geology sheet 175 Griquatown, 72 pp. Council for Geoscience, Pretoria.

VISSER, D.J.L. et al. 1989. The geology of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland. Explanation of the 1: 1 000 000 geological map, fourth edition, 491 pp. Council for Geoscience, Pretoria.

YOUNG, R.B. 1932. The occurrence of stromatolitic or algal limestones in the Campbell Rand Series, Griqualand West. Transactions of the Geological Society of South Africa 53: 29-36.

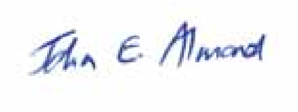
8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed railway project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.



Dr John E. Almond
Palaeontologist, *Natura Viva* cc

Palaeontological specialist assessment: desktop study

PROPOSED 16 MTPA EXPANSION OF TRANSNET'S EXISTING MANGANESE ORE EXPORT RAILWAY LINE & ASSOCIATED INFRASTRUCTURE BETWEEN HOTAZEL AND THE PORT OF NGQURA, NORTHERN & EASTERN CAPE.

Part 2: De Aar to the Coega IDZ, Northern and Eastern Cape

John E. Almond PhD (Cantab.)

***Natura Viva* cc, PO Box 12410 Mill Street,**

Cape Town 8010, RSA

naturaviva@universe.co.za

June 2013

EXECUTIVE SUMMARY

Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. An additional fifteen rail loops that were not part of the previous EIA for the 12 Mtpa proposal will be upgraded including the construction oftwo new loops close to Sishen and Witloop in the Northern Cape. The present desktop report forms part of the Basic Assessment of five railway loop developments along the manganese ore railway line between De Aar in the Northern Cape and Ngqura in the Eastern Cape.

The construction phase of the proposed extended railway loops along the Transnet Hotazel to Coega manganese ore railway may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (*e.g.* laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed. The operational and decommissioning phases are unlikely to involve significant adverse impacts on palaeontological heritage.

The proposed railway loop extensions at **Drennan** and **Thorngrove**, situated between Cradock and Cookhouse, are underlain by Late Permian sediments of the Balfour Formation (Lower Beaufort Group) that are known for their fossil remains of therapsids (mammal-like reptiles) and other terrestrial vertebrates as well as plants and trace fossils. The Beaufort sediments at both localities may well have been baked by nearby intrusions of the Early Jurassic Karoo Dolerite Suite and are in part mantled with alluvial sediments of the Great Fish River that are of low palaeontological sensitivity.

The extended railway loop between **Cookhouse and Golden Valley** is largely underlain by alluvium but near-surface rocks of the Late Permian Middleton Formation (Lower Beaufort Group) might be

impacted in the northern part of the study area near Cookhouse. Comparatively few, but scientifically important, vertebrate remains (*e.g.* various dicynodonts) have been recorded from the Lower Beaufort rocks in the Cookhouse area during recent palaeontological impact assessments. A wide range of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from Late Caenozoic alluvial sediments in the Great Karoo region, but in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

The proposed railway loop extension at **Sheldon**, just south of the Great Fish River, is underlain by Middle Permian continental sediments of the Koonap Formation (Lower Beaufort Group). These rocks have yielded scientifically important vertebrates (*e.g.* dinocephalians, therocephalians) to the west and east of the study area but these fossils are generally very sparse and bedrock exposure levels are low. Fossil invertebrate burrows are recorded from river bank exposures of the Great Fish River at the bridge in the vicinity of Sheldon. The overlying superficial sediments (fluvial gravels, calcretes, soils) are of low palaeontological sensitivity.

The proposed loop extension between **Ripon and Kommadagga**, to the south of Cookhouse, traverses a range of Carboniferous to Middle Permian sedimentary rock units including the Kommadagga Subgroup (Witteberg Group), Elandsvlei Formation (Dwyka Group), as well as the Prince Albert, Whitehill, Collingham and Ripon Formations of the Ecca Group. All of these units, especially the Whitehill Formation that is known for its well-preserved fossil fish, insects, crustaceans and aquatic mesosaurid reptiles, are potentially fossiliferous.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Cradock to Kommadagga sector of the Transnet manganese ore export railway be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

1. INTRODUCTION AND BRIEF

Manganese ore mined in the Hotazel area near Kuruman (Kalahari Manganese Field) in the Northern Cape is transported by rail to a bulk minerals handling terminal at Port Elizabeth, where it is unloaded and placed on stockpiles before being loaded onto ships for export. Transnet SOC Limited is planning to expand the capacity of the existing manganese ore export railway line between Hotazel (Northern Cape) and the Port of Ngqura (Coega IDZ, Eastern Cape) from the originally envisaged 12 Mtpa to 16 Mtpa. Twenty-nine project areas involved were originally assessed when the recent 12 Mtpa Environmental Impact Assessment was completed. An additional fifteen rail loops that were not part of the previous EIA will be upgraded including the construction of two new loops at Sishen and Witloop in the Northern Cape (Table 1). The present desktop report forms part of the Basic Assessment of five railway loop developments along the manganese ore railway line between De Aar in the Northern Cape and Ngqura in the Eastern Cape (Table 1), namely at Drennan, Thorngrove, Cookhouse-Golden Valley, Sheldon and Kommadagga,

1.1. Legislative context for palaeontological assessment studies

ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100) has been appointed as the Independent Environmental Assessment Practitioners to undertake a Basic Assessment of an additional fifteen railway loops between Hotazel and Ngqura.

The present desktop study forms part of the Basic Assessment of five of the fifteen additional loops, located between Cradock and Kommadagga in the Eastern Cape, and is to be followed by a brief field-based palaeontological assessment by the author. A list of the loops under consideration is given in Table 1 and these are also shown on the map in Fig. 1 (kindly provided by ERM). The present palaeontological heritage report also falls under Section 38 (Heritage Resources Management) of the South African Heritage Resources Act (Act No. 25 of 1999), and it will also inform the Environmental Management Plan for this project.

The proposed railway line developments are located in areas that are underlain by potentially fossil-rich sedimentary rocks of Palaeozoic, Mesozoic and younger, Tertiary or Quaternary age (Sections 2 and 3). The construction phase of the developments may entail substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. In addition, substantial areas of bedrock may be sealed-in or sterilized by railway infrastructure, lay-down areas as well as new gravel roads. All these developments may adversely affect potential fossil heritage at or beneath the surface of the ground within the study area by destroying, disturbing or permanently sealing-in fossils that are then no longer available for scientific research or other public good. Once constructed, the operational and decommissioning phases of the railway developments are unlikely to involve further adverse impacts on palaeontological heritage, however.

The various categories of heritage resources recognised as part of the National Estate in Section 3 of the National Heritage Resources Act include, among others:

- geological sites of scientific or cultural importance;
- palaeontological sites;
- palaeontological objects and material, meteorites and rare geological specimens.

According to Section 35 of the National Heritage Resources Act, dealing with archaeology, palaeontology and meteorites:

(1) The protection of archaeological and palaeontological sites and material and meteorites is the responsibility of a provincial heritage resources authority.

(2) All archaeological objects, palaeontological material and meteorites are the property of the State.

(3) Any person who discovers archaeological or palaeontological objects or material or a meteorite in the course of development or agricultural activity must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.

(4) No person may, without a permit issued by the responsible heritage resources authority—

(a) destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or palaeontological site or any meteorite;

(b) destroy, damage, excavate, remove from its original position, collect or own any archaeological or palaeontological material or object or any meteorite;

(c) trade in, sell for private gain, export or attempt to export from the Republic any category of archaeological or palaeontological material or object, or any meteorite; or

(d) bring onto or use at an archaeological or palaeontological site any excavation equipment or any equipment which assist in the detection or recovery of metals or archaeological and palaeontological material or objects, or use such equipment for the recovery of meteorites.

(5) When the responsible heritage resources authority has reasonable cause to believe that any activity or development which will destroy, damage or alter any archaeological or palaeontological site is under way, and where no application for a permit has been submitted and no heritage resources management procedure in terms of section 38 has been followed, it may—

(a) serve on the owner or occupier of the site or on the person undertaking such development an order for the development to cease immediately for such period as is specified in the order;

(b) carry out an investigation for the purpose of obtaining information on whether or not an archaeological or palaeontological site exists and whether mitigation is necessary;

(c) if mitigation is deemed by the heritage resources authority to be necessary, assist the person on whom the order has been served under paragraph *(a)* to apply for a permit as required in subsection (4); and

(d) recover the costs of such investigation from the owner or occupier of the land on which it is believed an archaeological or palaeontological site is located or from the person proposing to undertake the development if no application for a permit is received within two weeks of the order being served.

Minimum standards for the palaeontological component of heritage impact assessment reports (PIAs) have recently been published by SAHRA (1913).

1.2. Scope and brief for the desktop study

This desktop palaeontological specialist report provides an assessment of the observed or inferred palaeontological heritage within the five proposed loop study areas within the Eastern Cape between Cradock and Kommadagga (Fig. 1, Table 1), with recommendations for further specialist palaeontological studies and / or mitigation where this is considered necessary.

The report has been commissioned by ERM Southern Africa (Pty) Ltd (Block A, Silverwood House, Silverwood Close, Steenberg Office Park, Cape Town 7945, South Africa; tel: +27 21 702 9100). It contributes to the Basic Assessment for the proposed 16 Mtpa railway expansion and it will also inform the Environmental Management Plan for the project. The scope of work for this desktop study, as defined by ERM, is as follows:

> The Contractor's role involves generating a Paleontological Baseline Report and a Paleontological Assessment Report. The findings will be based on one extended field trip (10 days) covering both the Northern Cape and Eastern Cape.

1.3. Approach to the palaeontological heritage Basic Assessment study

The approach to this palaeontological heritage Basic Assessment study is briefly as follows. Fossil bearing rock units occurring within the broader study area are determined from geological maps and satellite images (Figs. 4 and 5). Known fossil heritage in each rock unit is inventoried from scientific literature, previous assessments of the broader study region, and the author's field experience and palaeontological database (Table 2). Based on this data as well as field examination of representative exposures of all major sedimentary rock units present, the impact significance of the proposed development is assessed with recommendations for any further studies or mitigation.

In preparing a palaeontological desktop study the potentially fossiliferous rock units (groups, formations *etc*) represented within the study area are determined from geological maps. The known fossil heritage within each rock unit is inventoried from the published scientific literature, previous palaeontological impact studies in the same region, and the author's field experience (Consultation with professional colleagues as well as examination of institutional fossil collections may play a role here, or later following field assessment during the compilation of the final report). This data is then used to assess the palaeontological sensitivity of each rock unit to development (Provisional tabulations of palaeontological sensitivity of all formations in the Western, Eastern and Northern Cape have already been compiled by J. Almond and colleagues; *e.g.* Almond *et al.* 2008). The likely impact of the proposed development on local fossil heritage is then determined on the basis of (1) the palaeontological sensitivity of the rock units concerned and (2) the nature and scale of the development itself, most significantly the extent of fresh bedrock excavation envisaged. When rock units of moderate to high palaeontological sensitivity are present within the development footprint, a Phase 1 field assessment study by a professional palaeontologist is usually warranted to identify any palaeontological hotspots and make specific recommendations for any mitigation required before or during the construction phase of the development.

On the basis of the desktop and Phase 1 field assessment studies, the likely impact of the proposed development on local fossil heritage and any need for specialist mitigation are then determined. Adverse palaeontological impacts normally occur during the construction rather than the operational or decommissioning phase. Phase 2 mitigation by a professional palaeontologist – normally involving the recording and sampling of fossil material and associated geological information (*e.g.* sedimentological data) may be required (a) in the pre-construction phase where important fossils are already exposed at or near the land surface and / or (b) during the construction phase when fresh fossiliferous bedrock has been exposed by excavations. To carry out mitigation, the palaeontologist involved will need to apply for a palaeontological collection permit from the relevant heritage management authority (*e.g.* ECPHRA, the Eastern Cape Provincial Heritage Resources Authority, for the Eastern Cape. Contact details: Mr Sello Mokhanya, 74 Alexander Road, King Williams Town 5600; smokhanya@ecphra.org.za). It should be emphasized that, *providing appropriate mitigation is carried out*, the majority of developments involving bedrock excavation can make a *positive* contribution to our understanding of local palaeontological heritage.

1.4. Assumptions & limitations

The accuracy and reliability of palaeontological specialist studies as components of heritage impact assessments are generally limited by the following constraints:

1. Inadequate database for fossil heritage for much of the RSA, given the large size of the country and the small number of professional palaeontologists carrying out fieldwork here. Most development study areas have never been surveyed by a palaeontologist.

2. Variable accuracy of geological maps which underpin these desktop studies. For large areas of terrain these maps are largely based on aerial photographs alone, without ground-truthing. The maps generally depict only significant ("mappable") bedrock units as well as major areas of superficial "drift" deposits (alluvium, colluvium) but for most regions give little or no idea of the level of bedrock outcrop, depth of superficial cover (soil *etc*), degree of bedrock weathering or levels of small-scale tectonic deformation, such as cleavage. All of these factors may have a major influence on the

impact significance of a given development on fossil heritage and can only be reliably assessed in the field.

3. Inadequate sheet explanations for geological maps, with little or no attention paid to palaeontological issues in many cases, including poor locality information;

4. The extensive relevant palaeontological “grey literature” - in the form of unpublished university theses, impact studies and other reports (*e.g.* of commercial mining companies) - that is not readily available for desktop studies;

5. Absence of a comprehensive computerized database of fossil collections in major RSA institutions which can be consulted for impact studies. A Karoo fossil vertebrate database is now accessible for impact study work.

In the case of palaeontological desktop studies without supporting Phase 1 field assessments these limitations may variously lead to either:

(a) *underestimation* of the palaeontological significance of a given study area due to ignorance of significant recorded or unrecorded fossils preserved there, or

(b) *overestimation* of the palaeontological sensitivity of a study area, for example when originally rich fossil assemblages inferred from geological maps have in fact been destroyed by tectonism or weathering, or are buried beneath a thick mantle of unfossiliferous “drift” (soil, alluvium *etc*).

Since most areas of the RSA have not been studied palaeontologically, a palaeontological desktop study usually entails *inferring* the presence of buried fossil heritage within the study area from relevant fossil data collected from similar or the same rock units elsewhere, sometimes at localities far away. Where substantial exposures of bedrocks or potentially fossiliferous superficial sediments are present in the study area, the reliability of a palaeontological impact assessment may be significantly enhanced through field assessment by a professional palaeontologist.

In the case of the Transnet 16 Mtpa study areas a major limitation for fossil heritage studies is the low level of exposure of potentially fossiliferous bedrocks such as the Karoo Supergroup, as well as the paucity of previous specialist palaeontological studies in the Eastern Cape region as a whole.

1.5. Information sources

The information used in this desktop study was based on the following:

1. A short project outline provided by ERM;

2. A review of the relevant scientific literature, including published geological maps and accompanying sheet explanations as well as several desktop and field-based palaeontological assessment studies in the broader Cradock – Kommadagga region of the Eastern Cape (*e.g.* Almond 2009, 2010b, 2011, 2013).

3. The author’s previous field experience with the formations concerned and their palaeontological heritage (See also review of Eastern Cape fossil heritage by Almond *et al.* 2008).

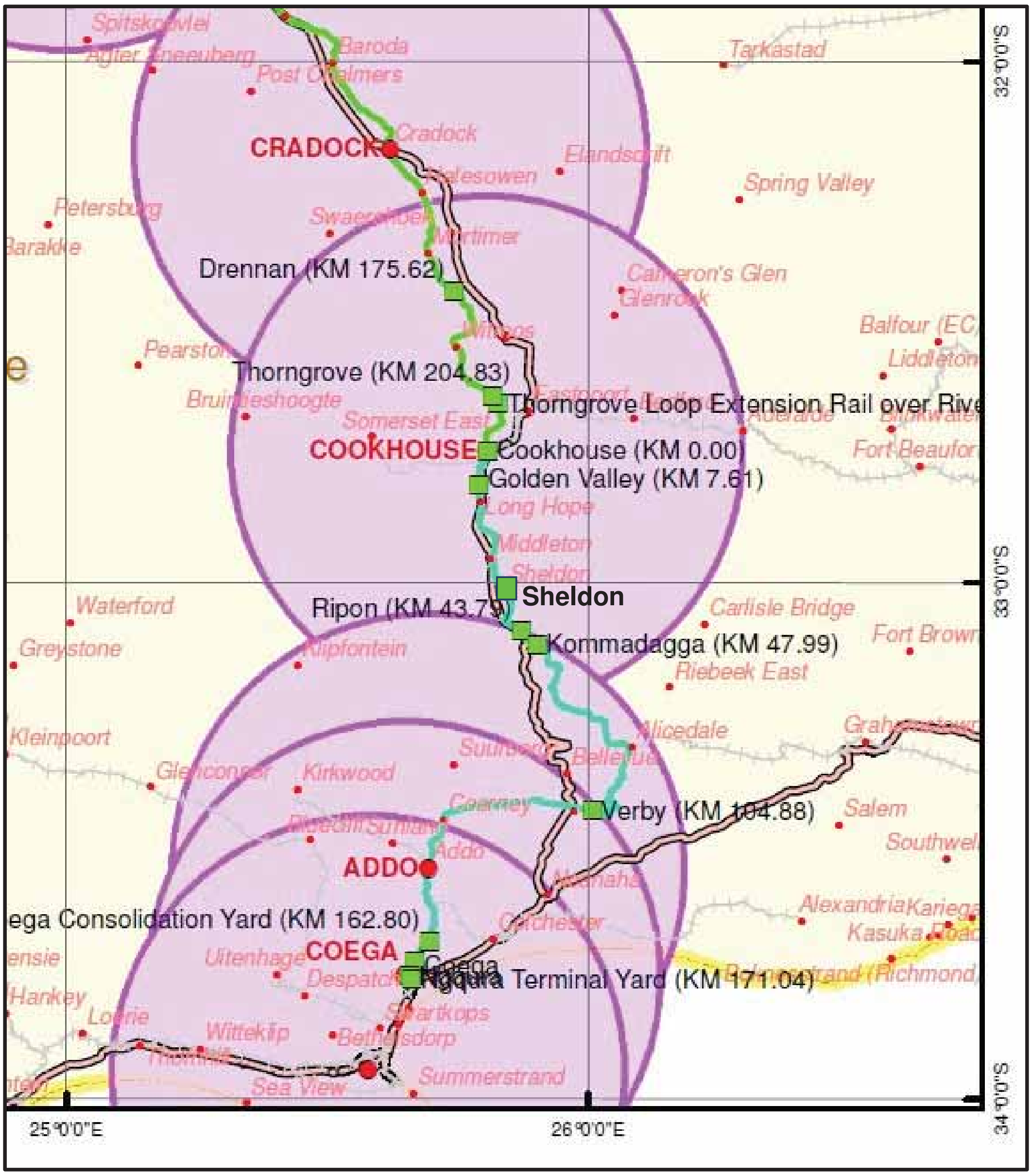


Fig. 1. Map of the Cradock to Coega sector of the Transnet manganese ore export railway line, Eastern Cape, showing the locations of the five railway loops covered by the present desktop Basic Assessment report as well as of the Coega IDZ Compilation Yard (Drennan, Thorngrove, Cookhouse-Golden Valley, Sheldon and Kommadagga. See also Table 1) (Map modified from image kindly provided by ERM).

Table 1. Summary of geology and palaeontological sensitivity of the five railway loop study sites between Cradock and Kommadagga.

LOOP	LOCATION	PROJECT	GEOLOGY	PALAEONTOLOGICAL HERITAGE SENSITIVITY	RECOMMENDATION
1. DRENNAN	c. 32º 26' 30.09" S c. 25º 44' 33.10" E	Loop extension	Balfour Formation (Lower Beaufort Group, possibly baked by nearby dolerite intrusion), river alluvium	HIGH	Brief field assessment of loop development footprints and representative bedrock exposures in the region to assess likely palaeontological impacts based on levels of bedrock exposure, degree of weathering and deformation, and presence of near-surface fossils.
2. THORNGROVE	c. 32º 38' 49.57" S c. 25º 49' 15.70" E	Loop extension	Balfour Formation (Lower Beaufort Group, possibly baked by nearby dolerite intrusion), dolerite, river alluvium	HIGH	
3. COOKHOUSE – GOLDEN VALLEY	c. 32º 46' 28.28" S c. 25º 47' 45.72" E	Loop extension	Alluvium overlying Middleton Formation (Lower Beaufort Group)	LOW	
4. SHELDON	c. 33º 00' 30.22" S c. 25º 51' 53.53" E	Loop extension	Koonap Formation (Lower Beaufort Group) and overlying alluvium	MEDIUM	
5. RIPON – KOMMADAGGA	c. 33º 06' 08.2" S c. 25º 52' 32.14" E	Loop extension	Prince Albert, Whitehill, Collingham & Ripon Formations (Ecca Group), Dwyka Group, Kommadagga Subgroup (Witteberg Group)	HIGH	

2. GEOLOGICAL OUTLINE OF THE STUDY AREA

The sector of the Transnet manganese ore export railway line between Cradock and Kommadagga traverses the eastern part of the Great Karoo Region, extending into the northern edge of the Cape Fold Belt at its southern end (*cf* Visser *et al.* 1989, their Fig. 2.1.). For much of its length it follows the valley of the Great Fish River that flows within a deeply-incised, meandering valley flanked by mountainous terrain (*e.g.* Swaershoekberge, Winterberge ranges) between Cradock and Cookhouse. The railway lies at elevations of around 800-600m amsl within this portion of the study region and crosses the river at several points. At Cookhouse the railway line enters lower-lying (580-500m amsl), hilly terrain known as *Die Smal Deel* on either side of the Great Fish River. The river valley is much wider here and bedrock exposure here is very limited due to the thick development of alluvium. However, good exposures are present in cuttings along the N10 tar road and adjacent hillslopes, in railway cuttings as well as intermittently along the banks of the Great Fish River (Almond 2009, 2010b, 2011). Just north of Ripon the railway line crosses a gravel-capped pediment surface (*c.* 480-500m amsl) and the Little Fish River before cutting through a prominent west-east ridge of Dwyka Group rocks at the base of the Karoo Supergroup succession. The lowermost Karoo Supergroup and uppermost Cape Supergroup bedrocks here are highly folded and lie well within the margins of the Cape Fold Belt, as reflected by the ridge and valley terrain developed at the southern end of the study sector between Ripon and Kommadagga.

The geology of the study area between Cradock and Kommadagga is covered by two adjacent 1: 250 000 scale geological maps, sheets 3224 Graaff-Reinet (sheet explanation by Hill 1993) and 3324 Port Elizabeth (sheet explanation by Toerien & Hill 1989). Relevant extracts from these maps are provided in Figs. 4 to 5 below. A more regional geological map at 1: 1 000 000 scale is also available (sheet explanation by Visser *et al.* 1989) but differs in several respects from the more detailed 1: 250 000 maps that form the preferred basis for the present desktop study.

All major rock units mapped along the railway line between Cradock and Kommadagga are listed in Table 3, together with a brief summary of their geology, age, known fossil heritage and inferred palaeontological sensitivity (largely based on Almond *et al.* 2008). The location of these rock units within the stratigraphic column for South Africa is shown in Fig. 2. They include a wide range of sedimentary and igneous rocks ranging in age from Early Carboniferous (*c.* 320 Ma) to Recent. The intrusive igneous rocks (*i.e.* dolerites) are entirely unfossiliferous while a high proportion of the sedimentary rocks are of moderate to high palaeontological sensitivity, notably the inland sea sediments of the lower Ecca Group and the continental sediments of the Lower Beaufort Group (Adelaide Subgroup), all of which are Early to Middle Permian in age.

For the purposes of the present Basic Assessment of the five proposed loop extensions in the Eastern Cape sector of the manganese ore railway line only those rock units that are mapped within the development footprint (as shown on 1: 250 000 geological maps, Figs. 4 to 5) will be considered further here. As seen in Table 1, the Drennan and Thorngrove loop extensions are largely underlain by sediments of the Late Permian to Early Triassic **Balfour Formation** (**Adelaide Group** / **Lower Beaufort Group**) as well as Late Caenozoic **river alluvium** and / or Early Jurassic **Karoo dolerite**. Most of the long Cookhouse – Golden Valley loop extension study area is mantled with Late Caenozoic alluvium of the Great Fish River which here overlies Middle to Late Permian rocks of the Middleton Formation (**Adelaide Group** / **Lower Beaufort Group**). The loop extension at Sheldon overlies Middle Permian continental sediments of the **Koonap Formation** (**Adelaide Subgroup** / **Lower Beaufort Group**) that here are mantled with Caenozoic alluvium (with a seasonal watercourse crossing the northern part of study area). The loop extension between Ripon and Kommadagga traverses the outcrop areas of the uppermost shallow marine sediments of the **Witteberg Group** (**Kommadagga Subgroup**, for which this is the type area) as well as the basal formations of the Karoo Supergroup, namely the glacial **Elandsvlei Formation** of the **Dwyka Group** and the **Prince**

Albert, **Whitehill**, **Collingham** and **Ripon Formations** of the **Ecca Group** (See Fig. 3 for stratigraphic subdivision of the Karoo Supergroup).

A short review of the geology of these rock units is given below, while details of their known fossil heritage are given in Section 3.

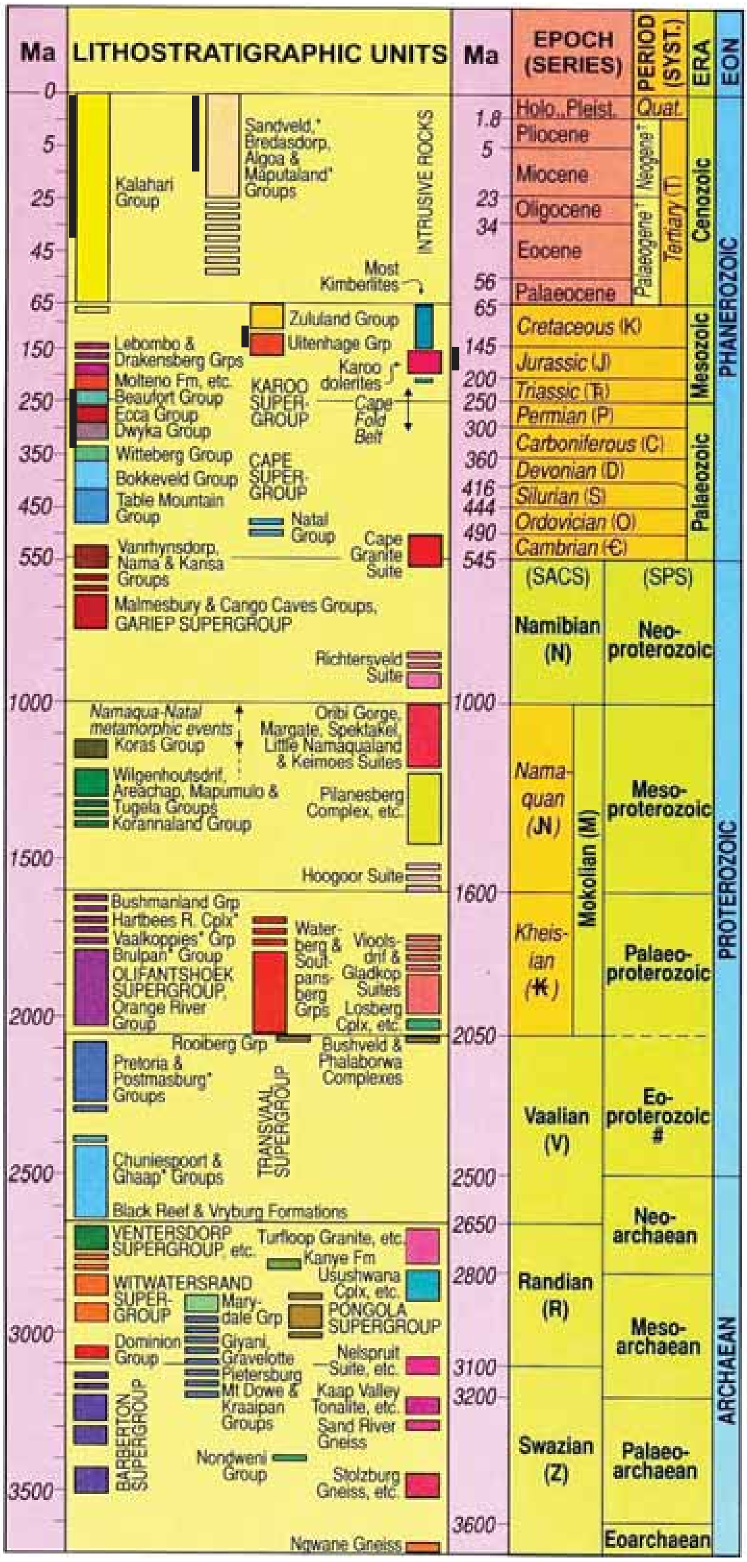


Fig. 2. Stratigraphic column for southern Africa showing the main Phanerozoic rock units represented along the manganese ore export line railway between Cradock and Coega, Eastern Cape (thick vertical black lines) (See also Table 2 for Karoo Supergroup rock units.

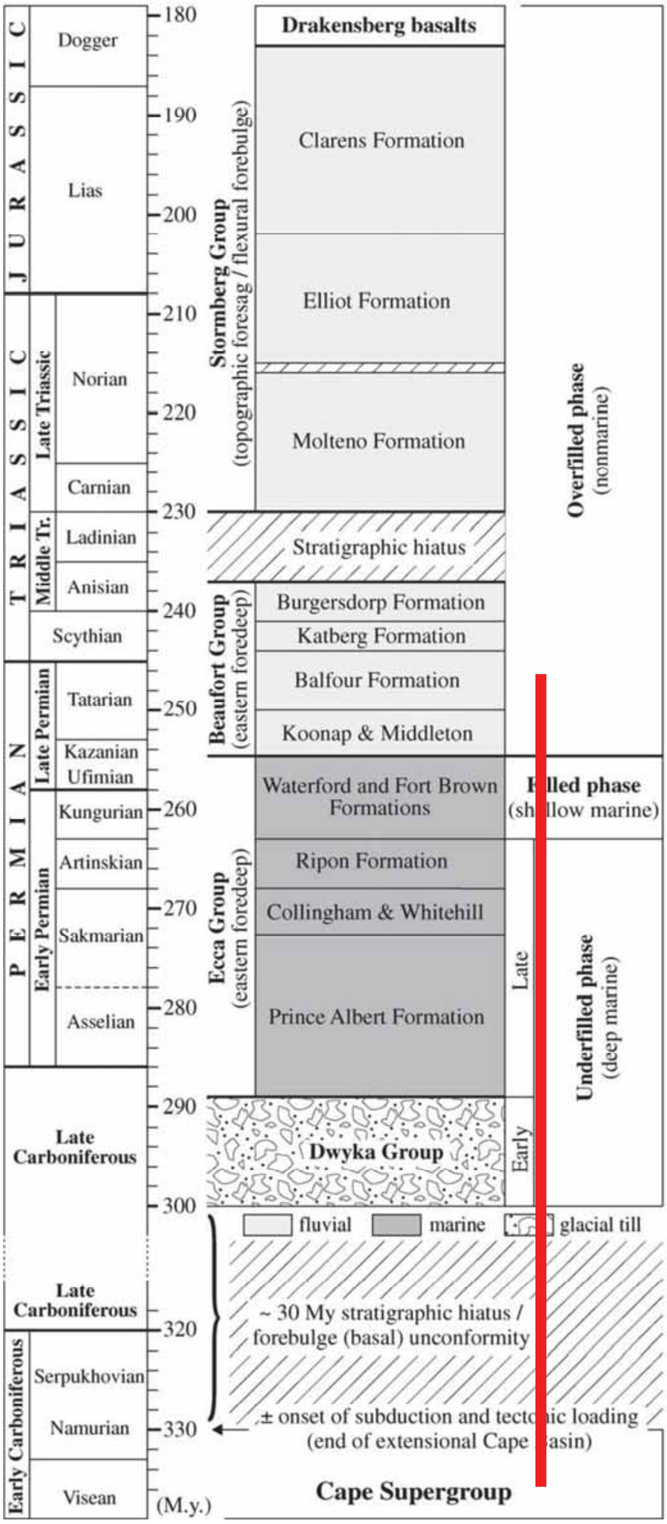


Figure 3. Stratigraphic subdivision of the *c.* 12km-thick Karoo Supergroup (From Catuneanu *et al.* 2005). The Early Carboniferous to Late Permian formations of the Witteberg, Dwyka, Ecca and Lower Beaufort Groups that are represented within the Transnet project area between Cradock and Kommadagga are emphasized by the thick red bar.

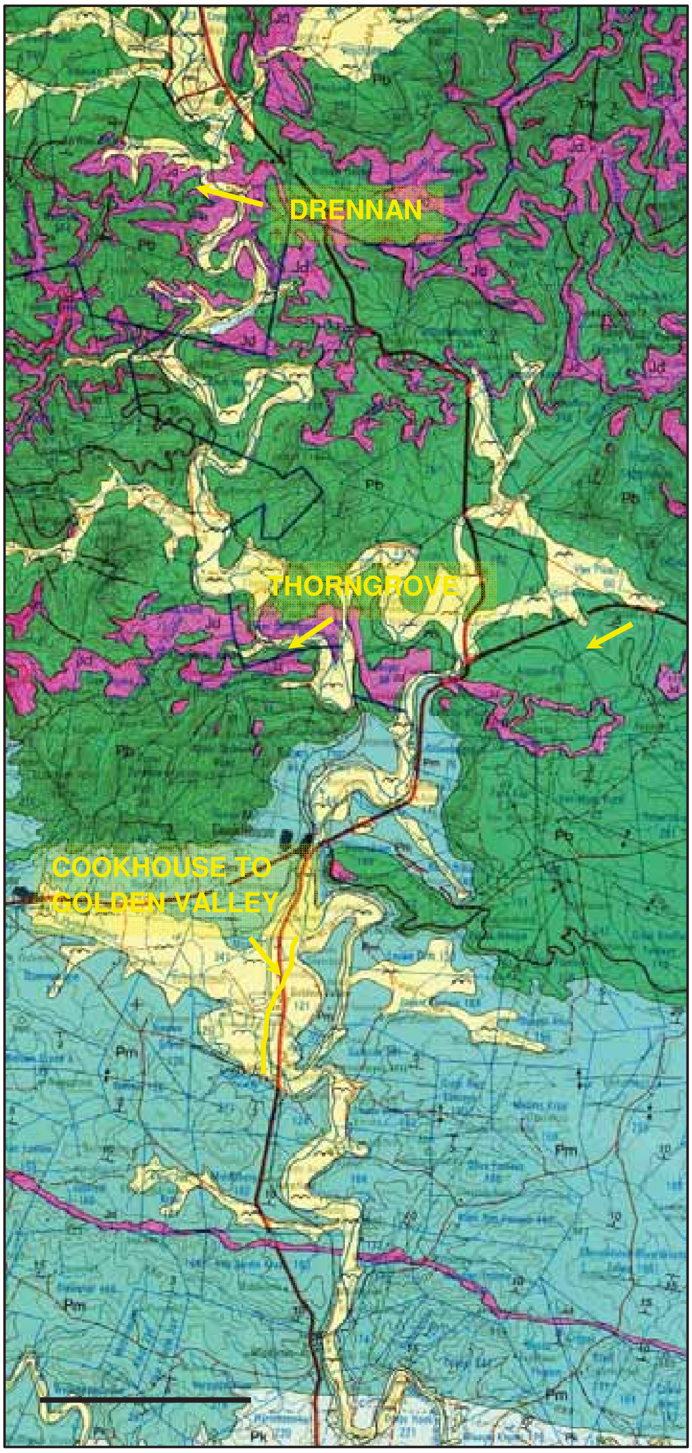


Fig. 4. Extract from 1: 250 000 geology map 3224 Graaff-Reinet (Council for Geoscience, Pretoria) showing location of the proposed loop extensions at Drennan, Thorngrove (both underlain by the Balfour Formation, Pb) and Cookhouse – Golden Valley (underlain by alluvium and the Middleton Formation). See Table 3 for summary of geology and fossils within rock units along this section of the Transnet manganese ore export railway line. Scale bar here = *c*. 10 km.

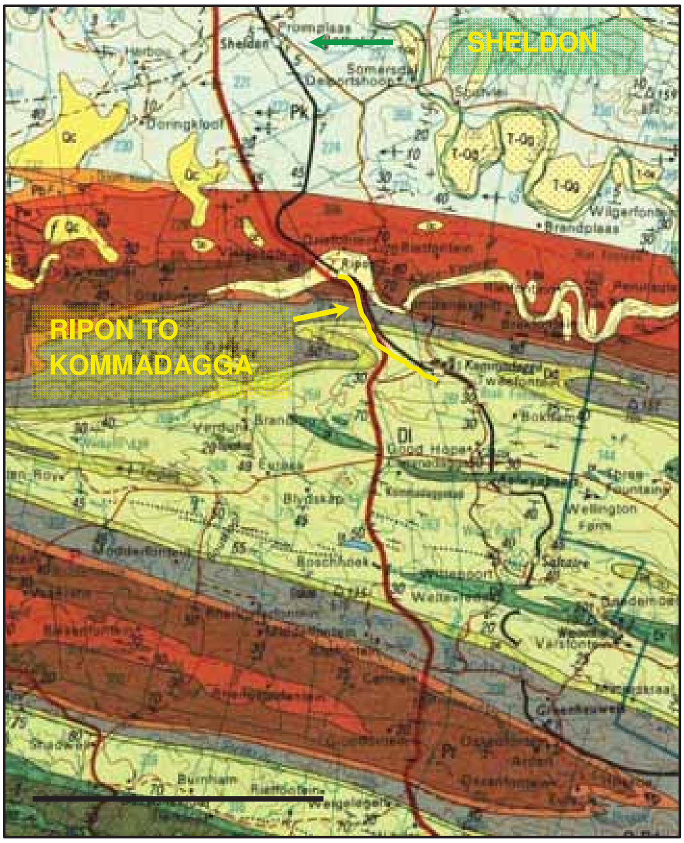


Fig. 5. Extract from 1: 250 000 geology map 3324 Port Elizabeth (Council for Geoscience, Pretoria) showing location of the proposed loop extensions at Sheldon, underlain by sediments of the Koonap Formation (Pk, Lower Beaufort Group), and at Ripon – Kommadagga, underlain by upper Witteberg Group (Dl, Dd), Dwyka Group (C-Pd) and Ecca Group (Pp, Pr) sediments. See Table 2 for summary of geology and fossils within rock units along this section of the Transnet manganese ore export railway line. Scale bar here = *c.* 10 km.

2.1. Kommadagga Subgroup (Witteberg Group)

The Kommadagga Subgroup (Dl in part, Dd) is thin (430m to 250m), glacially-influenced succession of shallow marine siliclastic sediments of Early Carboniferous age that forms the uppermost part of the Witteberg Group in the Eastern Cape (Willowmore – Grahamstown region) (Loock 1967, Rossouw 1970, Johnson 1976, Swart 1982, Loock & Visser 1985, Toerien & Hill 1989, Johnson & Le Roux 1994, Theron 1994, Thamm & Johnson 2006). It is paraconformably or uncomformably overlain by the Dwyka Group. The four constituent formations of the Kommadagga Subgroup vary in thickness along strike and may be absent in some areas, in part due to pre-Dwyka erosion. The lenticular, sparsely pebbly, massive, dark grey, sandy diamictites of the basal **Miller Formation** (10-95m thick) may be of debris flow rather than direct glacial melt-out origin. The pebbles are mainly of quartz and black chert. This unit interfingers with pale, pebbly, laminated quartzites or siliceous sandstones of the **Swartwaterspoort Formation** (*c*. 6-10m or less) that are characterised by chaotic bedding, including convoluted intraformational folds. This deformation has been various linked to slumping or subglacial deformation. The horizontally-laminated pebbly sands may have been originally deposited in a beach setting with wave reworking of poorly-sorted glacial outwash or tillite. Thinly-laminated offshore mudrocks of the overlying **Soutkloof Formation** (45-165m) include rhythmitites towards the base - possibly glacially-related varves. They form the lower portion of a major shallowing-upwards cycle that grades up into the fine- to medium-grained, well-sorted, grey, feldspathic to lithofeldspathic sandstones of the **Dirkskraal Formation** (175m or less; Dd). A shallow shoreface or even beach setting for this last unit has been proposed (Johnson & Le Roux 1994). The Kommadagga Subgroup in its type area near Kommadagga is approximately 260m thick (Toerien & Hill 1989).

2.2. Elandsvlei Formation (Dwyka Group)

The Late Carboniferous to Early Permian sediments of the Elandsvlei Formation (Dwyka Group, C-Pd) were deposited as glacial tillites and interglacial mudrocks in a shallow epicontinental sea on the margins of Gondwana. The geology of the Dwyka Group has been summarized by Visser (1989, 2003), Visser *et al.* (1990) and Johnson *et al.* (2006), among others. A brief account of the Dwyka rocks in the southern part of the study region is given by Toerien and Hill (1989), largely based on Johnson (1976). The Dwyka succession here is *c*. 680m thick and consists of largely of massive, blue-grey to grey-green glacial diamictites with subordinate well-bedded sandstones and shales. There is evidence of several deglaciation cycles, as also recorded in the Western Cape (*e.g.* Visser 1997). Potentially fossiliferous interglacial mudrock successions, including dropstone laminites, are also present here between the massive diamictites but are often obscured by drift cover, including Quaternary alluvium as well as downwasted polymict gravels

2.3. Prince Albert Formation

The Dwyka Group is conformably overlain by post-glacial basinal mudrocks of the Prince Albert Formation (Ppr / Pp in part), the lowermost subunit of the Ecca Group. This thin-bedded to laminated mudrock-dominated succession of Early Permian (Asselian / Artinskian) age was previously known as "Upper Dwyka Shales". Key geological accounts of this formation are given by Visser (1992) and Cole (2005). The Prince Albert succession in the Port Elizabeth sheet area is *c.* 100m thick (Toerien & Hill 1989). It consists mainly of thin-, tabular-bedded mudrocks of blue-grey, olive-grey to reddish-brown colour with occasional thin (dm) buff sandstones and even thinner (few cm), soft-weathering layers of yellowish water-lain tuff (*i.e.* volcanic ash layers). Extensive diagenetic modification of these sediments has led to the formation of thin cherty beds, pearly-blue phosphatic nodules, rusty iron carbonate nodules, as well as beds and elongate ellipitical siliceous concretions impregnated with iron and manganese minerals.

2.4. Whitehill Formation

The Whitehill Formation (Pw / Pp in part) is a thin (*c*. 20 to 90m) succession of well-laminated, carbon-rich mudrocks of Early Permian (Artinskian) age that forms part of the lower Ecca Group. These sediments were laid down about 278 Ma in an extensive shallow, brackish to freshwater basin – the Ecca Sea – that stretched across southwestern Gondwana, from southern Africa into South America (McLachlan & Anderson 1973, Oelofsen 1981, 1987, Visser 1992, 1994, Cole & Basson 1991, MacRae 1999, McCarthy & Rubidge 2005, Johnson *et al*. 2006). Fresh Whitehill Formation mudrocks are black and pyritic due to their high content of fine-grained organic carbon, probably derived from persistent or seasonal phytoplankton blooms that promoted anoxic conditions on the Ecca Sea bed. Near-surface weathering of the pyrite leads to the formation of gypsum, lending a pale grey colour to the Whitehill outcrop (hence informally known as the "*Witband*"). Large (meter-scale) diagenetic nodules and lenses of tough, greyish dolomite are common and often display a stromatolite-like fine-scale banding. According to Almond (2013) the Whitehill Formation in the Kommadagga region is poorly exposed and deeply weathered near-surface.

2.5. Collingham Formation

The tabular-bedded Collingham Formation (*c*. 30m; Pc / Pp in part) is characterized by the regular "striped" alternation of thin, tabular-bedded, well-jointed, greyish siliceous mudrocks and soft-weathering pale yellow tuffs (*i.e.* volcanic ash layers) (Viljoen 1992, 1994). These tuffs have been radiometrically dated to 270-275 Ma or Early to Middle Permian (Tankard *et al.* 2009). Basinal mudrocks and tuffs deposited by suspension settling in the lower part of the Collingham succession give way higher up to thicker, tabular-bedded turbidite units deposited by sediment gravity flows.

2.6. Ripon Formation

The Ripon Formation (Pr) crops out along the southeastern margin of the Main Karoo Basin from Prince Albert eastwards. This is a thick, non-marine submarine fan succession comprising tabular-bedded greywackes, rhythmitites and dark mudrocks deposited by turbidity current and suspension settling processes (Johnson 1976, Kingsley 1977, Kingsley 1981, Johnson & Kingsley 1993, Catuneanu *et al.* 2005, Johnson *et al.* 2006). In the Graaff-Reinet sheet area it reaches thicknesses of 500 to 800m. Within the project area the Ripon Formation crops out along the banks of the Little Fish River as well as in road cuttings along the N10 near Ripon Station (Almond 2011). Gullied exposures of dark, thin-bedded to laminated Ripon mudrocks here are interbedded with thin, buff-coloured fine sandstone event beds. Small-scale sedimentary structures include flaser and lenticular lamination as well as ripple cross-lamination. Fine-scale grading within successive tabular beds results in rhythmitites which build higher order coarsening-upwards cycles. Rusty-brown nodules and lenticles of ferruginous carbonate are common. Weathering styles vary from hackly to well-developed pencil cleavage.

2.7. Lower Beaufort Group (Adelaide Subgroup)

As shown on the relevant 1: 250 000 geological maps (Figs. 4 and 5), the Cradock to Cookhouse study area is largely underlain by Middle to Late Permian continental sediments of the Lower Beaufort Group (Adelaide Subgroup, Karoo Supergroup). In particular the Karoo sediments belong to the **Koonap Formation** (**Pk**), the **Middleton Formation** (**Pm**) and the overlying **Balfour Formation** (**Pb**) (Hill 1993, Cole *et al*. 2004, Johnson *et al*., 2006). In the northern part of the study area, to the north of Cookhouse, the Balfour succession is extensively intruded by major, resistant-weathering intrusive sills of the **Karoo Dolerite Suite** (**Jd**) of Early Jurassic age (*c*. 183 Ma), in part accounting for the more mountainous terrain here. Dips of Beaufort Group sediments in the northern and central study region are generally shallow (< 5°), with small-scale E-W fold axes to the south and east of Cookhouse, so low levels of tectonic deformation and cleavage development are expected here. The lowermost Beaufort Group beds (Koonap Formation) in the south lie within the margins of the Cape Fold Belt, so higher dips and levels of deformation are seen here (seen, for example, along the banks of the Great Fish River), compromising fossil preservation.

2.7.1. Koonap Formation

The main characteristics of the Middle to Late Permian Koonap Formation (Pk), the basal subunit of the Lower Beaufort Group in the Eastern Cape study region with a thickness of up to one-and-a-half or two kilometers, have been briefly described by Hill (1993; see also Johnson 1976, Johnson *et al.* 2006 and refs. therein). This continental fluvial succession comprises grey-green and purple-brown overbank mudrocks with subordinate crevasse splay and lenticular channel sandstones. Palaeocurrents were mainly from the southeast. The basal Koonap succession consists largely of dark bluish-grey or grey-green, hackly-weathering mudrocks but purple-brown mudrocks are common at higher levels. Many of the sandstones display a characteristic coarse mottling. Horizons with abundant calcrete nodules (often ferruginous and rusty-brown in colour) represent ancient floodplain soils. Occasional cherty layers represent volcanic ash layers admixed with siliclastic sediment and should prove of considerable interest for radiometric dating studies in future (*cf* Blignault *et al.* 1948, Rubidge *et al.* 2010). According to recent fieldwork in the broader study region south of Middleton (Almond 2011) the Koonap Formation is only well-exposed here along the southern banks of the Great Fish River as well as on the slopes of a few isolated koppies to the south, apart from deep (and dangerous) railway cuttings and occasional road cuts along the N10. Several cliff sections along both banks of the deeply incised Great Fish River are too steep to be safely accessible. Good mudrock exposures with fossil potential are available close to the Sheldon Bridge on Farm 368.

2.7.2. Middleton Formation

This formation forms the middle portion of the Adelaide Subgroup east of 24°E, including the Graaff-Reinet sheet area (Hill 1993, Johnson *et al*., 2006). The fluvial Middleton succession comprises greenish-grey to reddish overbank mudrocks with subordinate resistant-weathering, fine-grained channel sandstones deposited by large meandering river systems. Because of the dominance of recessive-weathering mudrocks, the Middleton Formation erodes readily to form low-lying *vlaktes* at the base of the Escarpment near Cookhouse and extensive exposures of fresh (unweathered) bedrock are rare.

2.7.3. Balfour Formation

The fluvial Balfour Formation comprises recessive weathering, grey to greenish-grey overbank mudrocks with subordinate resistant-weathering, grey, fine-grained channel sandstones deposited by large meandering river systems in the Late Permian Period (Hill 1993). Thin wave-rippled sandstones were laid down in transient playa lakes on the flood plain. Reddish mudrocks are comparatively rare, but increase in abundance towards the top of the Adelaide Subgroup succession near the upper contact with the Katberg Formation. The base of the Balfour succession is defined by a sandstone-rich zone, some 50m thick, known as the **Oudeberg Member**. The Oudeberg sandstones and interbedded mudrocks crop out along the edge of the low escarpment that lies at the latitude of Cookhouse. Dark grey mudrocks with thin, tabular sandstones and wave ripples (formed in shallow lakes) within the overlying mudrock-dominated **Daggaboersnek Member** are well-exposed at higher elevations in Daggaboersnek itself along the main road between Cookhouse and Cradock (Hill 1993).

2.8. Karoo Dolerite Suite

Igneous intrusions intruding the Lower Beaufort Group north of Cookhouse are referred to the Karoo Dolerite Suite of Early Jurassic age (*c.* 182 Ma; Duncan & Marsh 2006). According to Hill (1993) the southernmost dolerites in the Graaff-Reinet sheet area take the form of “crescentic dykes and transgressive sheets with easterly strikes and dipping towards the north” (See extensive WNW-ESE trending dyke near Middleton in Fig. 4). Normally, extensive areas of Beaufort Group outcrop to either side of the larger dolerite intrusions are mantled in rubbly doleritic colluvium (scree deposits) that is often cemented with calcrete to form a resistant, concrete-like near-surface pan. These dolerite scree-mantled slopes are clearly seen as rusty areas on satellite images.

2.9. Caenozoic superficial deposits

Various types of superficial deposits or “drift” of Late Caenozoic (Miocene / Pliocene to Recent) age occur widely throughout the Great Karoo study region. They include pedocretes (*e.g*. calcretes), slope deposits (scree *etc*), river alluvium, as well as spring and pan sediments (*cf* Partridge *et al.* 2006). As a result, surface exposure of fresh Beaufort Group rocks within the development footprint itself is generally poor, apart from stream beds, dongas and steeper hillslopes and artificial exposures in road and railway cuttings. The hill slopes are typically mantled with a thin layer of **colluvium** or slope deposits (*e.g.* sandstone and dolerite scree). Thicker accumulations of sandy, gravelly and bouldery **alluvium** of Late Caenozoic age (< 5Ma) are found in stream and river beds, for example adjacent to the Great Fish River. These colluvial and alluvial deposits may be extensively calcretised (*i.e.* cemented with soil limestone or calcrete), especially in the neighbourhood of dolerite intrusions.

Thick, silty alluvium of the ancient Fish River drainage system overlies riverside cliffs and banks in the southern part of the study area, even where the river is incised quite deeply into Beaufort Group bedrock (Almond 2010b, 2011). Good exposures of silty alluvium are seen in the neighbourhood of Cookhouse and extensive portions of the area along the Fish River (mainly agricultural lands) are mantled with fertile alluvium (yellow areas on geological maps, Figs. 4 and 5). The Fish River was probably a major drainage conduit in Tertiary times, cutting a wide meandering valley. Subsequent regional uplift and aridification in Late Tertiary (Miocene /Pliocene) times has reduced its flow and caused the river to cut a narrower course down though its older alluvium and into the underlying bedrock, while headwards erosion has driven its tributaries to cut well back into the Great Karoo interior as far as Cradock (De Wit *et al.*, 2000).

3. PALAEONTOLOGICAL HERITAGE WITHIN THE STUDY AREA

Fossil biotas recorded from each of the main rock units mapped along the Transnet manganese ore export railway line are briefly reviewed in Table 3 (Based largely on Almond *et al.* 2008 and references therein), where an indication of the palaeontological sensitivity of each rock unit is also given. The quality of fossil preservation may compromised in some areas due to weathering and tectonic deformation, while extensive dolerite intrusion has compromised fossil heritage in portions of the Karoo Supergroup sediments (*e.g.* Lower Beaufort Group) due to resulting thermal metamorphism. The fossil record of the rock units underlying the proposed railway loop developments between Cradock and Kommadagga are reviewed in more detail below.

3.1. Fossils in the Kommadagga Subgroup

Little is known about the fossil record of the Kommadagga Subgroup of Early Carboniferous age which lies at the top of the Witteberg Group succession in the Eastern Cape (Loock 1967, Rossouw 1970, Johnson 1976, Swart 1982, Loock & Visser 1985, Johnson & Le Roux 1994, Theron 1994, Thamm & Johnson 2006). Impoverished contemporary biotas may have been ecologically restricted by high, near-polar palaeolatitudes and intermittent glaciation. The dark sandy diamictites of the Miller Formation have yielded palynomorph assemblages (Stapleton 1977). Fragmentary, poorly-preserved plant material, including lycopods, as well as trace fossils are recorded from the Dirkskraal Formation and, to a much lesser extent, from the Miller Formation. The fossil heritage of the Kommadagga Subgroup in its type area was recently addressed by Almond (2013).

3.2. Fossils in the Dwyka Group

The fossil record of the Permo-carboniferous Dwyka Group is generally poor, as expected for a glacial sedimentary succession (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Visser 1989, Visser *et al*., 1990, MacRae 1999, Visser 2003, Almond 2008a, 2008b). Sparse, low diversity trace fossil biotas from the Elandsvlei Formation along the southern basin margin mainly consist of delicate arthropod trackways (probably crustacean) and fish swimming trails associated with recessive-weathering dropstone laminites (Anderson 1974, 1975, 1976, 1981). Sporadic vascular plant remains (drifted wood and leaves of the *Glossopteris* Flora) are also recorded (Anderson & Anderson 1985, Bamford 2000, 2004), while palynomorphs (organic-walled microfossils) are likely to be present within finer-grained mudrock facies. Glacial diamictites (tillites or “boulder mudstones”) are normally unfossiliferous but do occasionally contain fragmentary transported plant material as well as palynomorphs in the fine-grained matrix (Plumstead 1969). There are biogeographically interesting records of limestone glacial erratics from tillites along the southern margins of the Great Karoo that contain Cambrian eodiscid trilobites as well as diverse assemblages of archaeocyathid sponges. Such derived fossils provide important data for reconstructing the movement of Gondwana ice sheets (Cooper & Oosthuizen 1974, Stone & Thompson 2005).

3.3. Fossils in the Prince Albert Formation

Useful overviews of the geology of the Ecca Group are given by Johnson *et al.* (2006) and Johnson (2009). The fossil record of the Ecca Group in the Cape has recently been reviewed by Almond (2008a, b). The fossil biota of the postglacial mudrocks of the Prince Albert Formation has been summarized by Cole (2005). Epichnial (bedding plane) trace fossil assemblages of the non-marine *Mermia* Ichnofacies, dominated by the ichnogenera *Umfolozia* (arthropod trackways) and *Undichna* (fish swimming trails), are commonly found in basinal mudrock facies of the Prince Albert Formation throughout the Ecca Basin. These assemblages have been described by Anderson (1974, 1975, 1976, 1981) and briefly reviewed by Almond (2008a, b). The presence of more diverse, but incompletely recorded, benthic invertebrate fauna in the Early Permian Ecca Sea is suggested by the recent discovery of complex arthropod trails with paired drag marks in the Prince Albert Formation near Matjiesfontein in the southwestern Great Karoo. These trackways might have been generated by small predatory eurypterids (water scorpions), but this requires further confirmation.

Diagenetic nodules containing the remains of palaeoniscoids (primitive bony fish), sharks, spiral bromalites (coprolites, spiral gut infills *etc* attributable to sharks or temnospondyl amphibians) and petrified wood have been found in the Ceres Karoo (Almond 2008b and refs. therein). Rare shark remains (*Dwykaselachus*) are recorded near Prince Albert on the southern margin of the Great Karoo (Oelofsen 1986). Microfossil groups recorded in this formation include sponge spicules, foraminiferal and radiolarian protozoans, acritarchs and miospores.

3.4. Fossils in the Whitehill Formation

In palaeontological terms the Whitehill Formation is one of the richest and most interesting stratigraphic units within the Ecca Group (McLachlan & Anderson 1973, Anderson & McLachlan 1976, Oelofsen 1981, 1987, Visser 1992, 1994, Cole & Basson 1991, Evans & Bender 1999, Evans 2005, Johnson *et al.* 2006, Almond 2008a and refs. therein). Very briefly, the main groups of Early Permian fossils found within the Whitehill Formation include:

- small aquatic mesosaurid reptiles (the earliest known sea-going reptiles);
- rare cephalochordates (ancient relatives of the living lancets);
- a variety of palaeoniscoid fish (primitive bony fish);
- highly abundant small eocarid crustaceans (bottom-living, shrimp-like forms);
- insects (mainly preserved as isolated wings, but some intact specimens also found);
- a low diversity of trace fossils (*e.g.* king crab trackways, possible shark coprolites / faeces);
- palynomorphs (organic-walled spores and pollens);
- petrified wood (mainly of primitive gymnosperms);
- other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*).

The geographic and stratigraphic distribution of the most prominent fossil groups – mesosaurid reptiles, palaeoniscoid fishes and notocarid crustaceans – within the Whitehill Formation has been documented by several authors, including Oelofsen (1987), Visser (1992) and Evans (2005).

3.5. Fossils in the Collingham Formation

The palaeontology of the Collingham Formation has been reviewed by Viljoen (1992, 1994) and Almond (2008a). Transported, water-logged plant debris and tool marks generated by logs are often associated with thicker turbidite beds, especially within the upper part of the Collingham Formation. Substantial blocks of silicified wood are known from the Laingsburg and Prince Albert areas. The heterolithic character of this succession favours trace fossil preservation, with very high levels of bioturbation recorded locally. The abundance of fossil burrows indicates that oxygenation of bottom waters and the sea bed had improved substantially since Whitehill times. Abundant, moderately diverse trace fossil assemblages have been recorded from the Collingham Formation in the Tanqua Karoo and Laingsburg regions (Anderson 1974) as well as from the Kommadagga regon (Almond 2013). They include horizontal, 2cm-wide epichnial grooves with obscurely segmented levees ("*Scolicia*", possibly generated by gastropods), narrow, bilobate arthropod furrows ("*Isopodichnus*"), reticulate horizontal burrows (perhaps washed out *Megagrapton*-like systems), densely packed horizontal burrows with a rope-like surface texture covering selected bedding planes (*cf Palaeophycus*), narrow branching burrows, rare arthropod trackways (*Umfolozia*) and fish swimming trails (*Undichna*). The trackway of a giant sweep-feeding eurypterid has been identified from the upper Collingham Formation near Laingsburg, and fragmentary body fossils of similar animals are known from coeval sediments in South America (Almond 2002). At over two metres long, these bottom-feeding arthropod predators are the largest animal so far known from the Ecca Sea.

3.6. Fossils in the Ripon Formation

The fossil record within the Ripon Formation is rather sparse and has not received much attention from palaeontologists. Fragmentary, compressed plant remains (*e.g.* stems, leaves) of the *Glossopteris* Flora, mostly unidentified, occur sporadically throughout the Ripon succession, especially within the lowermost part (Johnson 1976). They include flattened silicified logs ("*Dadoxylon*") with well-developed seasonal growth rings (Johnson & Kingsley 1993). Reworked plant debris and a possible large lycopod stem cast were recorded from the region east of Kommadagga by Almond (2013). Fossil plant and wood material from the Ripon Formation was not included in the key reviews by Anderson and Anderson (1985) and Bamford (1999, 2004), however. A range of, mostly unidentified, deep water trace fossils are mentioned in the literature (Anderson 1974, Kingsley 1977, Kingsley 1981, Johnson and Kingsley 1993, Johnson *et al.* 2006). They include sporadic to locally abundant arthropod tracks, trails as well as horizontal and (possible) vertical burrows. *Umfolozia* and *Maculichna* arthropod trackways, probable *Quadrispinichna* resting traces ("small vertebrate footprint"), sinuous *Undichna* fish swimming trails and narrow meandering burrows are recorded from Ripon submarine fan facies in the Grahamstown area (Ecca Pass and Great Fish River; Haughton 1928, Mountain 1946, Anderson 1974, 1976, 1981, Kingsley 1981). It is likely that a wide spectrum of *Mermia* ichnofacies ichnofossils, as well as various organic-walled microfossils, are represented within this formation, similar to those seen in contemporary turbidite fans in the better-sampled southwestern part of the Ecca Basin (Almond 2008a, 2008b).

3.7. Fossils in the Lower Beaufort Group (Adelaide Subgroup)

The overall palaeontological sensitivity of the Lower Beaufort Group sediments is high (Rubidge 1995, Almond *et al*. 2008). These continental sediments have yielded one of the richest fossil records of land-dwelling plants and animals of Permo-Triassic age anywhere in the world. A chronological series of mappable fossil biozones or assemblage zones (AZ), defined mainly on their characteristic tetrapod faunas, has been established for the Main Karoo Basin of South Africa (Rubidge 1995). Maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin have been provided by Keyser and Smith (1977-78) and Rubidge (1995), and for the Graaff-Reinet sheet area they are available in Hill (1993). An updated version based on a comprehensive GIS fossil database is currently in press (Van der Walt *et al.* 2010). The fossil record of the Lower Beaufort Group in the Cookhouse – Middleton region has been addressed in recent desktop and field-based palaeontological heritage assessments by Almond (2009, 2010b, 2011).

3.7.1. Fossils in the Koonap Formation

The Koonap Formation is generally considered to be the eastern stratigraphic equivalent of the much better-studied, and far better-exposed, Abrahamskraal Formation of the western outcrop area of the Lower Beaufort Group (Johnson 1976, Johnson *et al.* 2006). While the latter is for the most part characterized by a rich fauna of Middle Permian vertebrates assigned to the *Tapinocephalus* Assemblage Zone (Smith & Keyser 1995), useful vertebrate fossils are notoriously difficult to find in the Koonap beds. Indeed, the last authors even describe the Koonap Formation as "unfossiliferous" (ibid., p. 11). Fossil locality maps compiled by Kitching (1977), Keyser and Smith (1977-1978) as well as more recently by Nicolas (2007) show a virtual absence of recorded fossil sites within the lowermost Beaufort Group beds of the Eastern Cape.

Recent sedimentological and palaeontological studies across the Ecca / Beaufort boundary in the southern Karoo have been published by Rubidge *et al.* (2000) and Modesto *et al.* (2001). The second work refers to several new fossil localities in the south-eastern Karoo near Jansenville and Fort Beaufort, respectively 100 km to the west and 55 km to the ESE of the Middleton area (Fig. 6). The mainly sparse, and often poorly preserved, therapsid biotas recorded by these authors from the Koonap Formation include anteosaurid and tapinocephalid dinocephalians as well as a scylacosaurid therocephalian but, interestingly, no dicynodonts. This suggests a biostratigraphic equivalence with the lower, dinocephalian-dominated part of the *Tapinocephalus* Assemblage Zone. It is concluded that the older *Eodicynodon* Assemblage Zone is not represented this far to the east within the basin.

The results of Modesto *et al.* (2001) suggest that rare tetrapod remains may be preserved in the Koonap Formation beds in the project area. However, no fossil remains were recorded in the recent field assessment of Koonap exposures in the Great Fish River region to the southeast of Middleton by Almond (2011) apart from centimetre-wide vertical burrows preserved at a mudrock / sandstone interface found near Sheldon Bridge. Extensive, deep railway cuttings in the area were not investigated during this study for safety reasons, however, and might yield fossil remains.

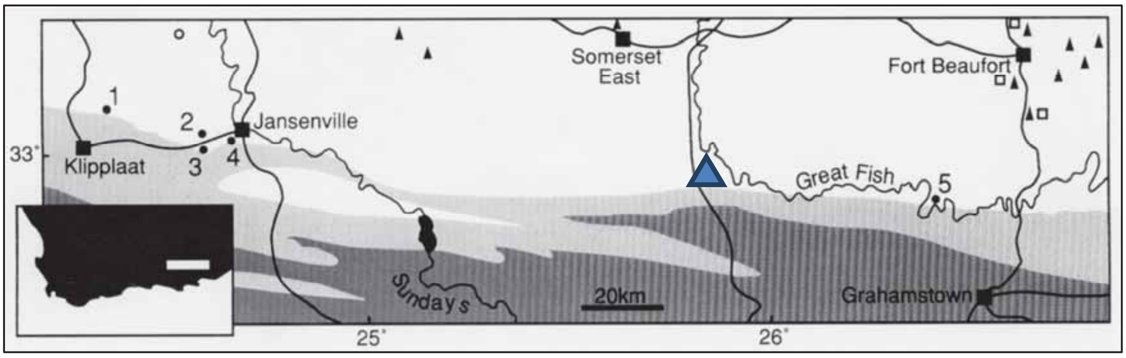


Fig. 6. Vertebrate fossil records from the Ecca / Beaufort contact zone in the Eastern Cape (from Modesto *et al.* 2001). Locality 5 indicated here is situated *c.* 55 km ESE of the Sheldon study area (indicated by the blue triangle).

3.7.2. Fossils in the Middleton Formation

The Middleton Formation comprises portions of three successive Beaufort Group fossil assemblage zones (AZ) that are largely based on the occurrence of specific genera and species of fossil therapsids. These are, in order of decreasing age, the *Pristerognathus*, *Tropidostoma* and *Cistecephalus* Assemblage Zones (Rubidge 1995). The three biozones have been assigned to the

Wuchiapingian Stage of the Late Permian Period, with an approximate age range of 260-254 million years (Rubidge 2005). According to published maps showing the distribution of the Beaufort assemblage zones within the Main Karoo Basin (Keyser & Smith 1979, Hill 1993, Rubidge 1995), the upper Middleton Formation succession near Cookhouse lies within the ***Cistecephalus*** **Assemblage Zone** (= upper *Cistecephalus* Biozone or *Aulacephalodon-Cistephalus* Assemblage Zone of earlier authors; see table 2.2 in Hill 1993).

The following major categories of fossils might be expected within *Cistecephalus* AZ sediments in the study area (Keyser & Smith 1979, Anderson & Anderson 1985, Hill 1993, Smith & Keyser *in* Rubidge 1995, MacRae 1999, Cole *et al*., 2004, Almond *et al*. 2008):

- isolated petrified bones as well as rare articulated skeletons of **terrestrial vertebrates** such as true **reptiles** (notably large herbivorous pareiasaurs, small insectivorous owenettids and turtle-like eunotosaurs) and **therapsids** or "mammal-like reptiles" (*e.g.* diverse herbivorous dicynodonts, flesh-eating gorgonopsians, and insectivorous therocephalians) (Fig. 7);

- aquatic vertebrates such as large **temnospondyl amphibians** (*Rhinesuchus*, usually disarticulated), and **palaeoniscoid bony fish** (*Atherstonia*, *Namaichthys*, often represented by scattered scales rather than intact fish);

- freshwater **bivalves** (*Palaeomutela*);

- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings);

- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterid trees and arthrophytes (horsetails).

As far as the biostratigraphically important tetrapod remains are concerned, the best fossil material is generally found within overbank mudrocks, whereas fossils preserved within channel sandstones tend to be fragmentary and water-worn (Rubidge 1995, Smith 1993b). Many fossils are found in association with ancient soils (palaeosol horizons) that can usually be recognised by bedding-parallel concentrations of calcrete nodules.

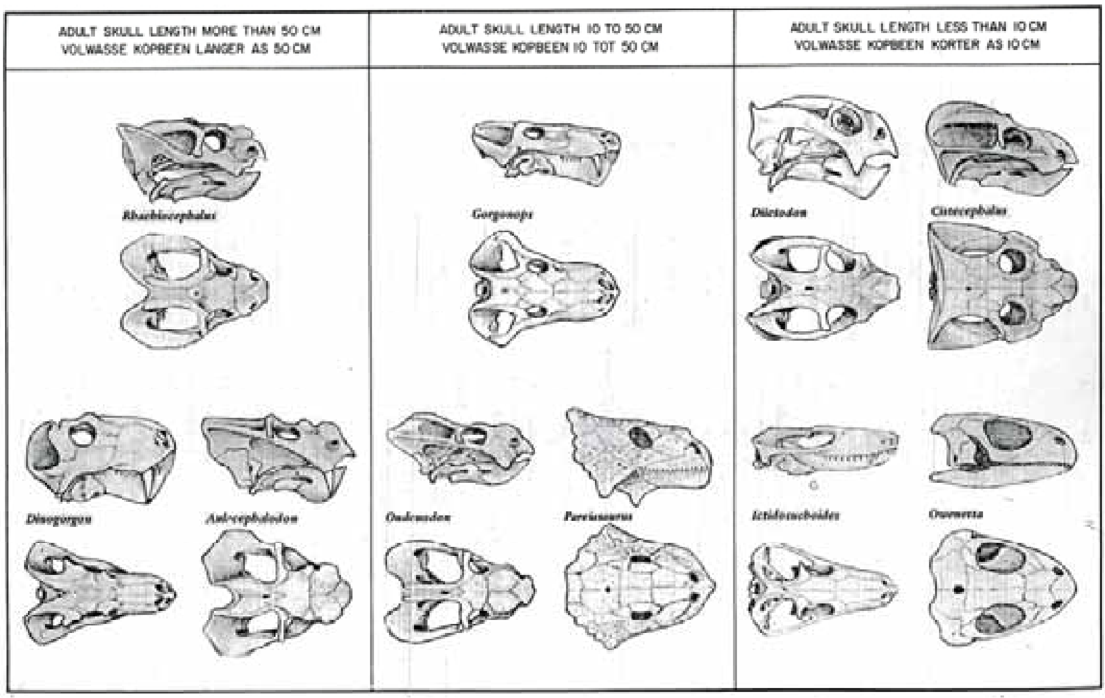


Fig. 7. Skulls of characteristic fossil vertebrates from the *Cistecephalus* Assemblage Zone (From Keyser & Smith 1979). *Pareiasaurus* a large herbivore, and *Owenetta*, a small insectivore, are true reptiles. The remainder are therapsids or "mammal-like reptiles". Of these, *Gorgonops* and *Dinogorgon* are large flesh-eating gorgonopsians, *Ictidosuchoides* is an insectivorous therocephalian, while the remainder are small – to large-bodied herbivorous dicynodonts.

3.7.3. Fossils in the Balfour Formation

The sandstone-dominated Oudeberg Member at the base of the Balfour Formation is also assigned to the *Cistecephalus* Assemblage Zone (Rubidge 1995) whose fossil biota has been treated above. The Assemblage Zone to which the overlying Daggaboersnek Member should be assigned is less clear (Cole *et al.*, 2004). Le Roux and Keyser (1988) report *Cistecephalus* AZ fossils from this member in the Victoria West sheet area, whereas the Daggaboersnek Member in the Middelburg sheet area is assigned to the ***Dicynodon*** **Assemblage Zone** and this certainly applies to the greater part of the Balfour Formation (Rubidge 1995, Cole *et al.*, 2004 p. 21). This younger biozone has been assigned to the Changhsingian Stage (= Late Tartarian), right at the end of the Permian Period, with an approximate age range of 253.8-251.4 million years (Rubidge 1995, 2005).

Good accounts, with detailed faunal lists, of the rich Late Permian fossil biotas of the *Dicynodon* Assemblage Zone have been given by Kitching (*in* Rubidge 1995) and by Cole *et al.* (2004). See also the reviews by Cluver (1978), MacRae (1999), McCarthy & Rubidge (2005) and Almond *et al.* (2008).

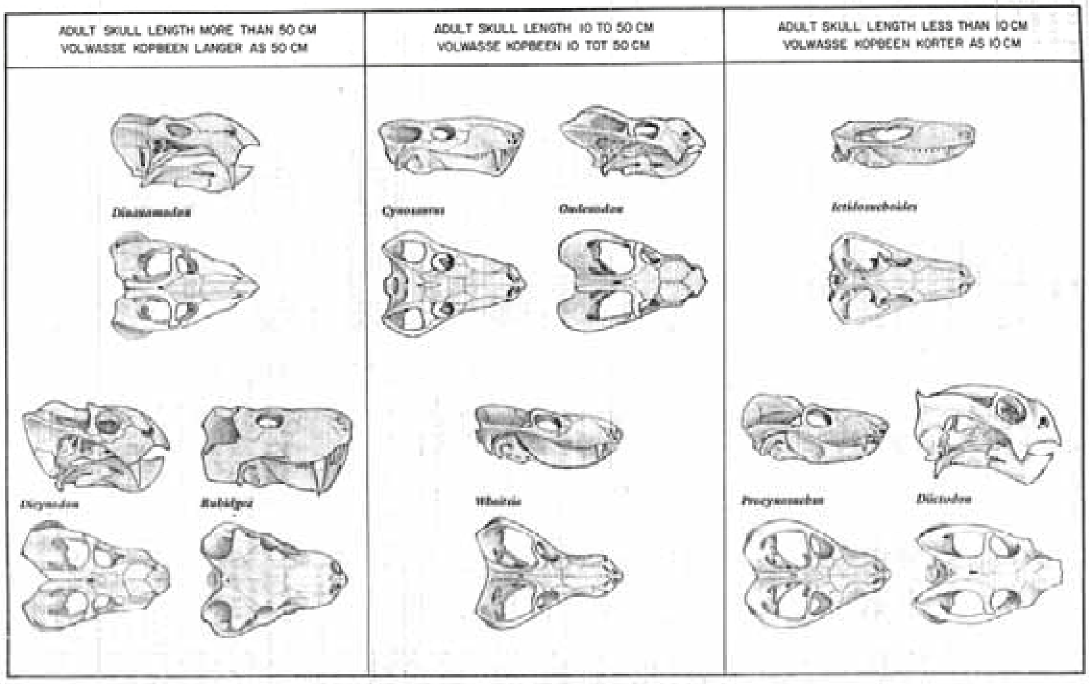


Fig. 8. Skulls of characteristic fossil vertebrates – all therapsids - from the *Dicynodon* Assemblage Zone (From Keyser & Smith 1979). Among the dominant therapsids ("mammal-like reptiles"), *Rubidgea* and *Cynosaurus* are carnivorous gorgonopsians *Whaitsia* (now *Theriognathus*) is a predatory therocephalian while *Ictidosuchoides* is a small insectivorous member of the same group, *Procynosuchus* is a promitive cynodont, and the remainder are large- to small-bodied dicynodont herbivores.

In general, the following broad categories of fossils might be expected within the Balfour Formation in the Cradock - Cookhouse area:

- isolated petrified bones as well as articulated skeletons of terrestrial vertebrates such as true **reptiles** (notably large herbivorous pareiasaurs, small lizard-like millerettids and younginids) and **therapsids** (diverse dicynodonts such as *Dicynodon* and the much smaller *Diictodon*, carnivorous gorgonopsians, therocephalians such as *Theriognathus* (= *Whaitsia*), primitive cynodonts like *Procynosuchus*, and biarmosuchians) (See Fig. 8 herein);

- aquatic vertebrates such as large, crocodile-like temnospondyl **amphibians** like *Rhinesuchus* (usually disarticulated), and palaeoniscoid **bony fish** (*Atherstonia*, *Namaichthys*);

- freshwater **bivalves** (*Palaeomutela*);

- **trace fossils** such as worm, arthropod and tetrapod burrows and trackways, coprolites (fossil droppings);

- **vascular plant remains** including leaves, twigs, roots and petrified woods ("*Dadoxylon*") of the *Glossopteris* Flora (usually sparse, fragmentary), especially glossopterids and arthrophytes (horsetails);

Several key fossil vertebrate sites of the Dicynodon Assemblage Zone are recorded along Great Fish River Valley area between Cradock and Cookhouse (See maps in Kitching 1977, Keyser & Smith 1979). The abundance and variety of fossils within the *Dicynodon* Assemblage Zone decreases towards the top of the succession (Cole *et al.*, 2004). From a palaeontological viewpoint, these diverse *Dicynodon* AZ biotas are of extraordinary interest in that they provide some of the best available evidence for the last flowering of ecologically-complex terrestrial ecosystems immediately preceding the catastrophic end-Permian mass extinction (*e.g.* Smith & Ward, 2001, Rubidge 2005, Retallack *et al.*, 2006).

Fossil vertebrate remains appear to be surprisingly rare in the Lower Beaufort Group outcrop area near Cookhouse compared to similar-aged deposits further west within the Great Karoo (Almond 2010). The important compendium of Karoo fossil faunas by Kitching (1977) lists numerous finds from the *Cistecephalus* Assemblage Zone near Pearston, some 75 km to the WNW of the study area. A few therapsid genera - the dicynodonts *Emydops* and *Cistecephalus plus* the therocephalian *Ictidosuchoides* – are reported from Bruintjieshoogte, between Pearston and Somerset East, although fossils are recorded as rare even here, despite the excellent level of exposure. Sparse dicynodonts are also mentioned from Bedford, *c.* 30km to the east of Cookhouse. Fossils of the long-ranging, small, communal burrowing dicynodont *Diictodon* are recorded from Slaghtersnek to the south of Cookhouse (precise location not provided, Kitching 1977, p. 66). A limited number of well-preserved dicynodont skulls (probably *Oudenodon, Diictodon*) as well as scattered postcranial therapsid remains, sphenophytes (horsetail ferns), locally abundant silicified wood (some showing insect borings), and low diversity assemblages of horizontal burrows (including *Scoyenia* arthropod scratch burrows) were recorded from the Middleton Formation in the Cookhouse – Middleton area during recent palaeontological field studies by the author (Almond 2010b, 2011). A couple of poorly-preserved therapsid tracks are also recorded from this succession near Middleton (Prof. Bruce Rubidge, pers. comm., and Almond 2011.). The recent discovery of a specimen of the rare, turtle-like parareptile *Eunotosaurus* in the same area supports the assignation of the lower Middleton Formation succession to the *Pristerognathus* Assemblage Zone, correlated with the Poortjie Member of the Teekloof Formation of the western Main Karoo Basin (Mike Day *et al.*, in press 2012).

3.8. Fossils in the Karoo Dolerite Suite

The dolerite outcrops in the northern part of the study area are in themselves of no palaeontological significance since these are high temperature igneous rocks emplaced at depth within the Earth's crust. However, as a consequence of their proximity to large dolerite intrusions, the Beaufort Group sediments between Cradock and Cookhouse may well have been thermally metamorphosed or "baked" (*ie.* recrystallised, impregnated with secondary minerals). Embedded fossil material of phosphatic composition, such as bones and teeth, is frequently altered by baking – bones may become blackened, for example - and can be very difficult to extract from the hard matrix by mechanical preparation (Smith & Keyser, p. 23 *in* Rubidge 1995). Thermal metamorphism by dolerite intrusions therefore tends to reduce the palaeontological heritage potential of Beaufort Group sediments.

3.9. Fossils in Late Caenozoic superficial deposits

Karoo "drift" deposits, including river alluvium, have been comparatively neglected in palaeontological terms for the most part. However, they may occasionally contain important fossil biotas, notably the bones, teeth and horn cores of mammals (*e.g.* Skead 1980, Klein 1984, MacRae 1999, Partridge & Scott 2000). Other late Caenozoic fossil biotas from these superficial deposits include non-marine molluscs (unionid bivalves, gastropods, rhizoliths), ostrich egg shells, trace fossils (*e.g.* calcretised termitaria, coprolites), and plant remains such as peats or palynomorphs (pollens) in organic-rich alluvial horizons. Angular to subrounded blocks of resilient silicified wood that have been reworked from the Lower Beaufort Group are locally abundant within ferruginous basal gravels and, to a lesser extent, younger alluvial deposits in the Middleton area (Almond 2011). Stone artefacts, an anthropogenic subcategory of trace fossils, occur widely in association with alluvial gravels and High Level Gravels where an abundant supply of suitable raw materials is present.

Table 2. Fossil heritage of rock units cropping out along the Cradock to Kommadagga sector of the Transnet manganese ore export railway line (Eastern Cape)

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
LATE CAENOZOIC TERRESTRIAL DEPOSITS OF THE INTERIOR (Most too small to be indicated on 1: 250 000 geological maps)	Fluvial, pan, lake and terrestrial sediments, including diatomite (diatom deposits), pedocretes, spring tufa / travertine, cave deposits, peats, colluvium, soils, surface gravels including downwasted rubble MOSTLY QUATERNARY TO HOLOCENE	Bones and teeth of wide range of mammals (*e.g.* mastodont proboscideans, rhinos, bovids, horses, micromammals), reptiles (crocodiles, tortoises), ostrich egg shells, fish, freshwater and terrestrial molluscs (unionid bivalves, gastropods), crabs, trace fossils (*e.g.* termitaria, horizontal invertebrate burrows, stone artefacts), petrified wood, leaves, rhizoliths, diatom floras, peats and palynomorphs.	LOW (but locally high) Scattered records, many poorly studied and of uncertain age	Pre-construction field assessment by professional palaeontologist
KAROO DOLERITE SUITE (Jd)	Intrusive dolerites (dykes, sills), associated diatremes EARLY JURASSIC (182-183 Ma)	No fossils recorded	ZERO (also baking of adjacent fossiliferous sediments)	None
Balfour Formation (Pb) ADELAIDE SUBGROUP (LOWER BEAUFORT GROUP) Middleton Formation (Pm) ADELAIDE SUBGROUP (LOWER BEAUFORT GROUP) Koonap Formation (Pk) ADELAIDE SUBGROUP (LOWER BEAUFORT GROUP)	Fluvial sediments with channel sandstones (meandering rivers), thin mudflake conglomerates interbedded with floodplain mudrocks (grey-green, purplish), pedogenic calcretes, playa lake and pond deposits, occasional reworked volcanic ashes	Diverse continental biota dominated by a variety of therapsids (*e.g.* dinocephalians, dicynodonts, gorgonopsians, therocephalians, cynodonts) and primitive reptiles (*e.g.* pareiasaurs), sparse *Glossopteris* Flora (petrified wood, rarer leaves of *Glossopteris*, horsetail stems), tetrapod trackways, burrows & coprolites. Freshwater assemblages include temnospondyl amphibians, palaeoniscoid fish, non-marine bivalves, phyllopod crustaceans and trace fossils (esp. arthropod trackways and burrows, "worm" burrows, fish fin trails, plant rootlet horizons).	HIGH	Pre-construction field assessment by professional palaeontologist

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Fort Brown Formation (Pf)	Prodeltaic mudrocks and sandstones, including rhythmites. MIDDLE PERMIAN	Low diversity trace fossil assemblages, transported plant material, rare fish remains & tetrapod bone fragments.	LOW	Pre-construction field assessment by professional palaeontologist
Ripon Formation (Pr) ECCA GROUP	Non-marine / lacustrine sediments (basin plain, turbidite fan, prodelta), minor tuffs (volcanic ashes). MIDDLE PERMIAN	Low diversity trace fossil assemblages, petrified wood & other plant remains	LOW	Pre-construction field assessment by professional palaeontologist
Collingham Formation (Pp in part) ECCA GROUP	Offshore non-marine mudrocks with numerous volcanic ashes, subordinate turbidites EARLY PERMIAN	Low diversiy but locally abundant ichnofaunas (horizontal "worm" burrows, arthropod trackways including giant eurypterids), vascular plant remains (petrified and compressed wood, twigs, leaves *etc*).	MODERATE	Pre-construction field assessment by professional palaeontologist
Whitehill Formation (Pp in part) ECCA GROUP	Carbonaceous offshore non-marine mudrocks within minor volcanic ashes, dolomite nodules EARLY PERMIAN	Mesosaurid reptiles, rare cephalochordates, variety of palaeoniscoid fish, small eocarid crustaceans, insects, low diversity of trace fossils (*e.g.* king crab & eurypterid trackways, possible shark coprolites), palynomorphs, petrified wood and other sparse vascular plant remains (*Glossopteris* leaves, lycopods *etc*)	HIGH	Pre-construction field assessment by professional palaeontologist
Prince Albert Formation (Pp in part) ECCA GROUP	Marine to hyposaline basin plain mudrocks, minor volcanic ashes, phosphates and ironstones, post-glacial mudrocks at base EARLY PERMIAN	Marine invertebrates (esp. molluscs, brachiopods), coprolites, palaeoniscoid fish & sharks, trace fossils, various microfossils, petrified wood	MODERATE	Pre-construction field assessment by professional palaeontologist

GEOLOGICAL UNIT	ROCK TYPES & AGE	FOSSIL HERITAGE	PALAEONT-OLOGICAL SENSITIVITY	RECOMMENDED MITIGATION
Elandsvlei Formation (C-Pd) DWYKA GROUP	Predominantly massive to bedded tillites, with interglacial mudrocks at intervals LATE CARBONIFEROUS TO EARLY PERMIAN	Interglacial mudrocks occasionally with low diversity marine fauna of invertebrates (molluscs, starfish, brachiopods, coprolites *etc*), palaeoniscoid fish, petrified wood, leaves (rare) and palynomorphs of *Glossopteris* Flora. Well-preserved non-marine ichnofauna (traces of fish, arthropods) in laminated mudrocks. Possible stromatolites, oolites at top of succession. Occasional limestone erratics with shelly invertebrates (trilobites, archaeocyathid sponges).	LOW	Pre-construction field assessment by professional palaeontologist
Kommadagga Subgroup (Dl, Dd) WITTEBERG GROUP	Glacial and shallow marine siliciclastics EARLY / MID CARBONIFEROUS	Sparse vascular plants (leaves, wood), low diversity trace fossils, palynomorphs	MEDIUM	Pre-construction field assessment by professional palaeontologist

5. CONCLUSIONS AND RECOMMENDATIONS

The construction phase of the proposed railway loop extensions along the Transnet manganese ore railway from De Aar to Ngqura may entail several substantial excavations into the superficial sediment cover as well as locally into the underlying bedrock. These excavations may disturb, damage or destroy scientifically valuable fossil heritage exposed at the surface or buried below ground. Other infrastructure components (*e.g.* laydown areas) may seal-in buried fossil heritage. However, most of the direct impacts will occur within the existing railway reserve, which is already highly disturbed. The operational and decommissioning phases of the 16 Mtpa railway line are unlikely to involve significant adverse impacts on palaeontological heritage.

The proposed railway loop extensions at Drennan and Thorngrove are underlain by Late Permian sediments of the Balfour Formation (Lower Beaufort Group) that are known for their fossil remains of therapsids (mammal-like reptiles) and other terrestrial vertebrates as well as plants and trace fossils. The Beaufort sediments at both localities may well have been baked by nearby intrusions of the Early Jurassic Karoo Dolerite Suite and are in part mantled with alluvial sediments of the Great Fish River that are of low palaeontological sensitivity.

The extended railway loop between Cookhouse and Golden Valley is largely underlain by alluvium but near-surface rocks of the Late Permian Middleton Formation (Lower Beaufort Group) might be impacted in the northern part of the study area near Cookhouse. Comparatively few, but scientifically important, vertebrate remains (*e.g.* various dicynodonts) have been recorded from the Lower Beaufort rocks in the Cookhouse area during recent palaeontological impact assessments. A wide range of vertebrate remains, invertebrates, trace fossils, plant fossils and microfossils have been recorded from Late Caenozoic alluvial sediments in the Great Karoo region, but in general they are of low palaeontological sensitivity and of considerable lateral extent so impacts on fossil heritage here are likely to be of low significance.

The proposed railway loop extension at Sheldon, just south of the Great Fish River, is underlain by Middle Permian continental sediments of the Koonap Formation (Lower Beaufort Group). These rocks have yielded scientifically important vertebrates (*e.g.* dinocephalians, therocephalians) to the west and east of the study area but these fossils are generally very sparse and bedrock exposure levels are low. Fossil invertebrate burrows are recorded from Sheldon Bridge. The overlying superficial sediments (fluvial gravels, calcretes, soils) are of low palaeontological sensitivity.

The proposed loop extension between Ripon and Kommadagga traverses a range of Carboniferous to Middle Permian sedimentary rock units including the Kommadagga Subgroup (Witteberg Group), Elandsvlei Formation (Dwyka Group), as well as the Prince Albert, Whitehill, Collingham and Ripon Formations of the Ecca Group. All of these units, especially the Whitehill Formation that is known for its well-preserved fossil fish, insects, crustaceans and aquatic mesosaurid reptiles, are potentially fossiliferous.

It is recommended that a brief palaeontological field assessment of the sedimentary rock units exposed along the Cradock to Kommadagga sector of the Transnet manganese ore export railway be undertaken before construction commences to assess impacts of the proposed loop developments on local fossil heritage and to make recommendations for any further specialist palaeontological studies or mitigation that should take place before or during the construction phase. These recommendations should also be incorporated into the Environmental Management Plan for the proposed railway developments.

6. ACKNOWLEDGEMENTS

Mr Junaid Moosajee of ERM, Cape Town, is thanked for commissioning this study and providing the relevant background information. I am also grateful to Ms Elize Becker, Environmental Services Group, HATCH, Johannesburg for extensive discussions concerning heritage related issues relating to the Transnet 16 Mtpa project.

7. REFERENCES

ALMOND, J.E. 2002. Giant arthropod trackway, Ecca Group. Geobulletin 45: p28.

ALMOND, J.E. 2008a. Fossil record of the Loeriesfontein sheet area. Unpublished report for the Council for Geoscience, Pretoria, 32pp.

ALMOND, J.E. 2008b. Palaeozoic fossil record of the Clanwilliam sheet area. Unpublished report for the Council for Geoscience, Pretoria, 49pp.

ALMOND, J.E. 2009. Proposed wind energy facility near Cookhouse, Western District Municipality, Eastern Cape Province. Unpublished impact report prepared for Savannah Environmental (Pty) Ltd by Natura Viva cc, Cape Town, 12pp.

ALMOND, J.E. 2010a. Eskom Gamma-Omega 765kV transmission line: Phase 2 palaeontological impact assessment. Sector 1, Tanqua Karoo to Omega Substation (Western and Northern Cape Provinces), 95 pp + appendix. Natura Viva cc, Cape Town.

ALMOND, J.E. 2010b. Palaeontological impact assessment: Cookhouse wind energy project, Blue Crane Route Local Municipality, Eastern Cape Province of South Africa. Unpublished impact report prepared for Coastal & Environmental Services, Grahamstown, 45 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2011. Proposed Middleton Wind Energy Project, Blue Crane Route Local Municipality. Palaeontological Impact Assessment, 48 pp. Natura Viva cc, Cape Town.

ALMOND, J.E. 2013. Proposed Spitskop Wind Energy Facility, Somerset East and Albany Magisterial Districts, Eastern Cape Province. Palaeontological specialist study: combined desktop & field-based assessment, 81 pp. Natura Viva cc, Cape Town.

ALMOND, J.E., DE KLERK, W.J. & GESS, R. 2008. Palaeontological heritage of the Eastern Cape. Draft report for SAHRA, 20 pp. *Natura Viva* cc, Cape Town.

ANDERSON, A.M. 1974. Arthropod trackways and other trace fossils from the Early Permian lower Karoo Beds of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg, 172 pp.

ANDERSON, A.M. 1975. Turbidites and arthropod trackways in the Dwyka glacial deposits (Early Permian) of southern Africa. Transactions of the Geological Society of South Africa 78: 265-273.

ANDERSON, A.M. 1976. Fish trails from the Early Permian of South Africa. Palaeontology 19: 397-409, pl. 54.

ANDERSON, A.M. 1981. The *Umfolozia* arthropod trackways in the Permian Dwyka and Ecca Groups of South Africa. Journal of Paleontology 55: 84-108, pls. 1-4.

ANDERSON, A.M. & MCLACHLAN, I.R. 1976. The plant record in the Dwyka and Ecca Series (Permian) of the south-western half of the Great Karoo Basin, South Africa. Palaeontologia africana 19: 31-42.

ANDERSON, J.M. & ANDERSON, H.M. 1985. Palaeoflora of southern Africa. Prodromus of South African megafloras, Devonian to Lower Cretaceous, 423 pp. Botanical Research Institute, Pretoria & Balkema, Rotterdam.

BAMFORD, M. 1999. Permo-Triassic fossil woods from the South African Karoo Basin. Palaeontologia africana 35, 25-40.

BAMFORD, M.K. 2004. Diversity of woody vegetation of Gondwanan southern Africa. Gondwana Research 7, 153-164.

BENTON, M.J. 2003. When life nearly died. The greatest mass extinction of all time, 336 pp. Thames & Hudson Ltd., London.

BLIGNAULT, J.J.G., ROSSOUW, P.J., DE VILLIERS, J. & RUSSELL, H.D. 1948. The geology of the Schoorsteenberg area, Cape Province, 40 pp. Geological Survey of South Africa / Council for Geoscience, Pretoria.

BUATOIS, L. & MANGANO, M.G. 1991. Trace fossils from a Carboniferous turbiditic lake: implications for the recognition of additional nonmarine ichnofacies. Ichnos 2: 237-258.

BUATOIS, L. & MANGANO, M.G. 1995. The paleoenvironmental and paleoecological significance of the lacustrine *Mermia* ichnofacies: an archetypal subaqueous nonmarine trace fossil assemblage. Ichnos 4: 151-161.

BUATOIS, L. & MANGANO, M.G. 2004. Animal-substrate interactions in freshwater environments: applications of ichnology in facies and sequence stratigraphic analysis of fluvio-lacustrine successions. In: McIlroy, D. (Ed.) The application of ichnology to palaeoenvironmental and stratigraphic analysis. Geological Society, London, Special Publications 228, pp 311-333.

BUATOIS, L.A. & MÁNGANO, M.G. 2007. Invertebrate ichnology of continental freshwater environments. In: Miller, W. III (Ed.) Trace fossils: concepts, problems, prospects, pp. 285-323. Elsevier, Amsterdam.

CATUNEANU, O., WOPFNER, H., ERIKSSON, P.G., CAIRNCROSS, B., RUBIDGE, B.S., SMITH, R.M.H. & HANCOX, P.J. 2005. The Karoo basins of south-central Africa. Journal of African Earth Sciences 43, 211-253.

CICHAN, M. A. AND TAYLOR, T.N. 1982. Wood-borings in *Premnoxylon*: Plant-animal interactions in the Carboniferous. Palaeogeography, Palaeoclimatology, Palaeoecology 39, 123–127.

CLUVER, M.A. 1978. Fossil reptiles of the South African Karoo, 54pp. South African Museum, Cape Town.

COLE, D.I. 2005. Prince Albert Formation. SA Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 8, 33-36. Council for Geoscience, Pretoria.

COLE, D.I. & BASSON, W.A. 1991. Whitehill Formation. SA Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 3: 51-52. Council for Geoscience, Pretoria.

COLE, D.I., NEVELING, J., HATTINGH, J., CHEVALLIER, L.P., REDDERING, J.S.V. & BENDER, P.A. 2004. The geology of the Middelburg area. Explanation to 1: 250 000 geology Sheet 3124 Middelburg, 44 pp. Council for Geoscience, Pretoria.

COOPER, M.R. & OOSTHUIZEN, R. 1974. Archaeocyathid-bearing erratics from Dwyka Subgroup (Permo-Carboniferous) of South Africa, and their importance to continental drift. Nature 247, 396-398.

DE WIT, M.C.J., MARSHALL, T.R. & PARTRIDGE, T.C. 2000. Fluvial deposits and drainage evolution. In: Partridge, T.C. & Maud, R.R. (eds.) The Cenozoic of Southern Africa, pp.55-72. Oxford University Press, Oxford.

DUNCAN & MARSH 2006. The Karoo Igneous Province. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 501-520. Geological Society of South Africa, Marshalltown.

EVANS, F.J.E. 2005. Taxonomy, palaeoecology and palaeobiogeography of some Palaeozoic fish of southern Gondwana. Unpublished PhD thesis, University of Stellenbosch, 628 pp.

EVANS, F.J. & BENDER, P.A. 1999. The Permian Whitehill Formation (Ecca Group) of South Africa: a preliminary review of palaeoniscoid fishes and taphonomy. Records of the Western Australian Museum Supplement No. 57: 175-181

GOTH, K. AND WILDE, V. 1992. Fraβpuren in permischen Hölzern aus der Wetterau. Senckenbergiana Lethaea 72, 1–6.

HAUGHTON, S.H. 1928. The geology of the country between Grahamstown and Port Elizabeth. An explanation of Cape Sheet No. 9 (Port Elizabeth), 45 pp. Geological Survey / Council for Geoscience, Pretoria.

HILL, R.S. 1993. The geology of the Graaff-Reinet area. Explanation to 1: 250 000 geology Sheet 3224 Graaff-Reinet, 31 pp. Council for Geoscience, Pretoria.

JACOBSEN, L., LOOCK, J.C., VAN DER WESTHUIZEN, W.A., HUFFMAN, T.N. & DREYER, J.J.B. 2003. The occurrence of vitrified dung from the Kamdeboo district, southern Karoo, and Den Straat, Limpopo Valley, South Africa: research in action. South African Journal of Science 99, 26-28.

JOHNSON, M.R. 1976. Stratigraphy and sedimentology of the Cape and Karoo sequences in the Eastern Cape province. Unpublished PhD thesis, Rhodes University, Grahamstown, 336 pp.

JOHNSON, M.R. (Ed.) 1994. Lexicon of South African stratigraphy. Part 1: Phanerozoic units, 56 pp. South African Committee for Stratigraphy, Council for Geoscience, Pretoria.

JOHNSON, M.R. 2009. Ecca Group. SA Committee for Stratigraphy Catalogue of South African lithostratigraphic units 10, 5-7. Council for Geoscience, Pretoria.

JOHNSON, M.R. & KINGSLEY, C.S. 1993. Lithostratigraphy of the Ripon Formation (Ecca Group), including the Pluto's Vale, Wonderfontein and Trumpeters Members. South African Committee for Stratigraphy, Lithostratigraphic Series No. 26, 8 pp.

JOHNSON, M.R. & LE ROUX, F.G. 1994. The geology of the Grahamstown area. Explanation to 1: 250 000 geology sheet 3326 Grahamstown, 40 pp. Council for Geoscience, Pretoria.

JOHNSON, M.R., VAN VUUREN, C.J., VISSER, J.N.J., COLE, D.I., DE V. WICKENS, H., CHRISTIE, A.D.M., ROBERTS, D.L. & BRANDL, G. 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 461-499. Geological Society of South Africa, Marshalltown.

KEYSER, A.W. & SMITH, R.M.H. 1979. Vertebrate biozonation of the Beaufort Group with special reference to the western Karoo Basin. Annals of the Geological Survey of South Africa 12, 1-35.

KINGSLEY, C.S. 1977. Stratigraphy and sedimentology of the Ecca Group in the Eastern Cape Province, South Africa. Unpublished PhD thesis, University of Port Elizabeth, 286 pp.

KINGSLEY, C.S. 1981. A composite submarine fan – delta – fluvial model for the Ecca and Lower Beaufort Groups of Permian age in the Eastern Cape Province, South Africa. Transactions of the Geological Society of South Africa 84, 27-40.

KLEIN, R.G. 1984. The large mammals of southern Africa: Late Pliocene to Recent. In: Klein, R.G. (Ed.) Southern African prehistory and paleoenvironments, pp 107-146. Balkema, Rotterdam.

LOCK, B.E. & JOHNSON, M.R. 1976. A crystal tuff from the Ecca Group near Lake Mentz, eastern Cape Province. Transactions of the Geological Society of South Africa 77, 373-374.

LOOCK, J.C. 1967. The stratigraphy of the Witteberg – Dwyka contact beds. Unpublished MSc thesis, University of Stellenbosch, 139 pp, 2 pls.

LOOCK, J.C. & VISSER, J.N.J. 1985. South Africa. In: Diaz, C.M. (Ed.) The Carboniferous of the world. Volume II, Australia, Indian Subcontinent, South Africa, South America and North Africa. IUGS Publication No. 20, pp 167-174. Instituto Geológico y Minero de España.

LUCAS, D.G. 2009. Global Middle Permian reptile mass extinction: the dinocephalian extinction event. Geological Society of America Abstracts with Programs 41, No. 7, p. 360

MACRAE, C. 1999. Life etched in stone. Fossils of South Africa. 305pp. The Geological Society of South Africa, Johannesburg.

MCCARTHY, T. & RUBIDGE, B. 2005. The story of Earth and life: a southern African perspective on a 4.6-billion-year journey. 334pp. Struik, Cape Town.

MCLACHLAN, I.R. & ANDERSON, A. 1973. A review of the evidence for marine conditions in southern Africa during Dwyka times. Palaeontologia africana 15: 37-64.

MODESTO, S.P., RUBIDGE, B.S., DE KLERK, W.J. & WELMAN, J. 2001. A dinocephalian therapsid fauna on the Ecca-Beaufort contact in Eastern Cape Province, South Africa. South African Journal of Science 97, 161-163.

MOUNTAIN, E.D. 1946. The geology of an area east of Grahamstown. An explanation of Sheet No. 136 (Grahamstown), 56 pp. Geological Survey / Council for Geoscience, Pretoria.

NICOLAS, M.V. 2007. Tetrapod diversity through the Permo-Triassic Beaufort Group (Karoo Supergroup) of South Africa. Unpublished PhD thesis, University of Witwatersrand, Johannesburg.

NICOLAS, M. & RUBIDGE, B.S. 2010. Changes in Permo-Triassic terrestrial tetrapod ecological representation in the Beaufort Group (Karoo Supergroup) of South Africa. Lethaia 43, 45-59.

OELOFSEN, B.W. 1981. An anatomical and systematic study of the Family Mesosauridae (Reptilia: Proganosauria) with special reference to its associated fauna and palaeoecological environment in the Whitehill Sea. Unpublished PhD thesis, University of Stellenbosch, 259 pp.

OELOFSEN, B.W. 1986. A fossil shark neurocranium from the Permo-Carboniferous (lowermost Ecca Formation) of South Africa. In: Uyeno, T, Arai, R., Taniuchi, T & Matsuura, K. (Eds.) Indo-Pacific fish biology. Proceedings of the Second International Conference on Indo-Pacific Fishes. Ichthyological Society of Japan, Tokyo, pp 107-124.

OELOFSEN, B.W. 1987. The biostratigraphy and fossils of the Whitehill and Iratí Shale Formations of the Karoo and Paraná Basins. In: McKenzie, C.D. (Ed.) Gondwana Six: stratigraphy, sedimentology and paleontology. Geophysical Monograph, American Geophysical Union 41: 131-138.

PARTRIDGE, T.C., BOTHA, G.A. & HADDON, I.G. 2006. Cenozoic deposits of the interior. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 585-604. Geological Society of South Africa, Marshalltown.

PARTRIDGE, T.C. & SCOTT, L. 2000. Lakes and pans. In: Partridge, T.C. & Maud, R.R. (Eds.) The Cenozoic of southern Africa, pp.145-161. Oxford University Press, Oxford.

PETER, B. 2001. Vitrified dung in archaeological contexts: an experimental study on the process of its formation in the Mosu and Bobirwa areas. Pula: Botswana Journal of African Studies 15, 125-143.

PLUMSTEAD, E.P. 1969. Three thousand million years of plant life in Africa. Alex Du Toit Memorial Lectures No. 11. Transactions of the Geological Society of South Africa, Annexure to Volume 72, 72pp. 25 pls.

RETALLACK, G.J., METZGER, C.A., GREAVER, T., HOPE JAHREN, A., SMITH, R.M.H. & SHELDON, N.D. 2006. Middle-Late Permian mass extinctions on land. GSA Buletin 118, 1398-1411.

ROSSOUW, P.J. 1970. The Witteberg – Dwyka contact in the Willowmore and Steytlerville Districts. Second Gondwana Symposium, South Africa, July to August 1970 .Proceedings and Papers, 205-208. CSIR, Pretoria.

RUBIDGE, B.S. (Ed.) 1995. Biostratigraphy of the Beaufort Group (Karoo Supergroup). 46pp. South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

RUBIDGE, B.S. 2005. Re-uniting lost continents – fossil reptiles from the ancient Karoo and their wanderlust. South African Journal of Geology 108: 135-172.

RUBIDGE, B.S. & OELOFSEN, B.W. 1981. Reptilian fauna from Ecca rocks near Prince Albert, South Africa. South African Journal of Science 77, 425-426.

RUBIDGE, B.S., HANCOX, P.J. & CATUNEANU, O. 2000. Sequence analysis of the Ecca-Beaufort contact in the southern Karoo of South Africa. South African Journal of Geology 103, 81-96.

RUBIDGE, B., DE KLERK, B. & ALMOND, J. 2008. Southern Karoo margins, Swartberg and Little Karoo. Palaeontological Society of South Africa, 15th biennial meeting, Matjiesfontein, Post-conference field excursion guide, 35 pp. Natura Viva cc, Cape Town.

RUBIDGE, B.S., ERWIN, D.H., RAMEZANI, J., BOWRING, S.A. & DE KLERK, W.J. 2010. The first radiometric dates for the Beaufort Group, Karoo Supergroup of South Africa. Proceedings of the 16th conference of the Palaeontological Society of Southern Africa, Howick, August 5-8, 2010, pp. 82-83.

SAHRA 2013. Minimum standards: palaeontological component of heritage impact assessment reports, 15 pp. South African Heritage Resources Agency, Cape Town.

SKEAD, C.J. 1980. Historical mammal incidence in the Cape Province. Volume 1: The Western and Northern Cape. 903pp. Department of Nature and Environmental Conservation, Cape Town.

SMITH, R.M.H. 1993a. Sedimentology and ichnology of floodplain paleosurfaces in the Beaufort Group (Late Permian), Karoo Sequence, South Africa. Palaios 8, 339-357.

SMITH, R.M.H. 1993b. Vertebrate taphonomy of Late Permian floodplain deposits in the southwestern Karoo Basin of South Africa. Palaios 8: 45-67.

SMITH, R.M.H. & KEYSER, A.W. 1995a. Biostratigraphy of the *Tapinocephalus* Assemblage Zone. Pp. 8-12 *in* Rubidge, B.S. (ed.) Biostratigraphy of the Beaufort Group (Karoo Supergroup). South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria.

SMITH, R.M.H. & KEYSER, A.W. 1995b. Biostratigraphy of the *Pristerognathus* Assemblage Zone. Pp. 13-17 *in* Rubidge, B.S. (ed.) *Biostratigraphy of the Beaufort Group (Karoo Supergroup).* South African Committee for Stratigraphy, Biostratigraphic Series No. 1. Council for Geoscience, Pretoria

SMITH, R.H.M. & WARD, P.D. 2001. Pattern of vertebrate extinction across an event bed at the Permian-Triassic boundary in the Karoo Basin of South Africa. Geology 29, 1147-1150.

STAPLETON, R.P. 1977. Carboniferous unconformity in southern Africa. Nature 268, 222-223.

STONE, P. & THOMSON, M.R.A. 2005. Archaeocyathan limestone blocks of likely Antarctic origin in Gondwanan tillite from the Falkland Islands. Geological Society, London, Special Publications 246, 347-357.

SWART, R. 1982. The stratigraphy and structure of the Kommadagga Subgroup and contiguous rocks. Unpublished MSc thesis, Rhodes University, Grahamstown.

TANKARD, A., WELSINK, H., AUKES, P., NEWTON, R. & STETTLER, E. 2009. Tectonic evolution of the Cape and Karoo basins of South Africa. Marine and Petroleum Geology 26, 1379–1412.

THAMM, A.G. & JOHNSON, M.R. 2006. The Cape Supergroup. In: Johnson, M.R., Anhaeusser, C.R. & Thomas, R.J. (Eds.) The geology of South Africa, pp. 443-459. Geological Society of South Africa, Marshalltown.

THERON, J.N. 1994. The Devonian –Carboniferous boundary in South Africa. Annales de la Societé géologique de Belgique 116: 291-300.

TOERIEN, D.K. & HILL, R.S. 1989. The geology of the Port Elizabeth area. Explanation to 1: 250 000 geology Sheet 3324 Port Elizabeth, 35 pp. Council for Geoscience. Pretoria.

VAN DER WALT, M., DAY, M., RUBIDGE, B., COOPER, A.K. & NETTERBERG, I. In press, 2010. Utilising GIS technology to create a biozone map for the Beaufort Group (Karoo Supergroup) of South Africa. Palaeontologia Africana.

VILJOEN, J.H.A. 1992. Lithostratigraphy of the Collingham Formation (Ecca Group), including the Zoute Kloof, Buffels River and Wilgehout River Members and the Matjiesfontein Chert Bed. South African Committee for Stratigraphy, Lithostratigraphic Series No. 22, 10 pp.

VILJOEN, J.H.A. 1994. Sedimentology of the Collingham Formation, Karoo Supergroup. South African Journal of Geology 97: 167-183.

VILJOEN, J.H.A. 2005. Tierberg Formation. SA Committee for Stratigraphy, Catalogue of South African Lithostratigraphic Units 8: 37-40.

VISSER, J.N.J. 1989. The Permo-Carboniferous Dwyka Formation of southern Africa: deposition by a predominantly subpolar marine ice sheet. Palaeogeography, Palaeoclimatology, Palaeoecology 70, 377-391.

VISSER, J.N.J. 1992. Deposition of the Early to Late Permian Whitehill Formation during a sea-level highstand in a juvenile foreland basin. South African Journal of Geology 95: 181-193.

VISSER, J.N.J. 1994. A Permian argillaceous syn- to post-glacial foreland sequence in the Karoo Basin, South Africa. In Deynoux, M., Miller, J.M.G., Domack, E.W., Eyles, N. & Young, G.M. (Eds.) Earth's Glacial Record. International Geological Correlation Project Volume 260, pp. 193-203. Cambridge University Press, Cambridge.

VISSER, J.N.J. 1997. Deglaciation sequences in the Permo-Carboniferous Karoo and Kalahari Basins of southern Africa: a tool in the analysis of cyclic glaciomarine basin fills. Sedimentology 44: 507-521.

VISSER, J.N.J. 2003. Lithostratigraphy of the Elandsvlei Formation (Dwyka Group). South African Committee for Stratigraphy, Lithostratigraphic Series No. 39, 11 pp.

VISSER, D.J.L. *et al*. 1989. The geology of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland. Explanation of the 1: 1 000 000 geological map, fourth edition, 491 pp. Council for Geoscience, Pretoria.

VISSER, J.N.J., VON BRUNN, V. & JOHNSON, M.R. 1990. Dwyka Group. Catalogue of South African Lithostratigraphic Units 2, 15-17. Council for Geoscience, Pretoria.

WICKENS, H. DE V. 1984. Die stratigraphie en sedimentologie van die Group Ecca wes van Sutherland. Unpublished MSc thesis, University of Port Elizabeth, viii + 86 pp.

WICKENS, H. DE V. 1996. Die stratigraphie en sedimentologie van die Ecca Groep wes van Sutherland. Council for Geosciences, Pretoria Bulletin 107, 49pp.

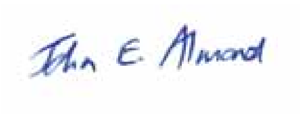
8. QUALIFICATIONS & EXPERIENCE OF THE AUTHOR

Dr John Almond has an Honours Degree in Natural Sciences (Zoology) as well as a PhD in Palaeontology from the University of Cambridge, UK. He has been awarded post-doctoral research fellowships at Cambridge University and in Germany, and has carried out palaeontological research in Europe, North America, the Middle East as well as North and South Africa. For eight years he was a scientific officer (palaeontologist) for the Geological Survey / Council for Geoscience in the RSA. His current palaeontological research focuses on fossil record of the Precambrian - Cambrian boundary and the Cape Supergroup of South Africa. He has recently written palaeontological reviews for several 1: 250 000 geological maps published by the Council for Geoscience and has contributed educational material on fossils and evolution for new school textbooks in the RSA.

Since 2002 Dr Almond has also carried out palaeontological impact assessments for developments and conservation areas in the Western, Eastern and Northern Cape under the aegis of his Cape Town-based company *Natura Viva* cc. He is a long-standing member of the Archaeology, Palaeontology and Meteorites Committee for Heritage Western Cape (HWC) and an advisor on palaeontological conservation and management issues for the Palaeontological Society of South Africa (PSSA), HWC and SAHRA. He is currently compiling technical reports on the provincial palaeontological heritage of Western, Northern and Eastern Cape for SAHRA and HWC. Dr Almond is an accredited member of PSSA and APHP (Association of Professional Heritage Practitioners – Western Cape).

Declaration of Independence

I, John E. Almond, declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed railway project, application or appeal in respect of which I was appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.



Dr John E. Almond
Palaeontologist, *Natura Viva* cc

Appendix D3

Heritage Study – Phase 1

Project Report

20 February 2013

Transnet Capital Projects
Ngqura 16 Mtpa Manganese Rail

Phase 1 Heritage Impact Assessment Hotazel to Kimberley and De Aar to Port of Ngqura

Table of Contents

Safety ● Quality ● Sustainability ● Innovation

1. Introduction

A Phase 1 Heritage Impact Assessment (HIA) was completed as part of an environmental authorisation process for the upgrade of Transnet (SOC) Limited's existing manganese ore railway line. The proposed project aim to increase the capacity of the manganese railway line that runs from Hotazel to the Port of Ngqura over a distance of ~800km to 16 Mtpa.

The purpose of this Phase 1 HIA is to provide the South African Heritage Agency (SAHRA), Heritage Eastern Cape and Ngwao Boswa Kapa Bokoni (Northern Cape Provincial Heritage Resources Agency) with sufficient details concerning the proposed upgrade. The HIA aimed to identify areas of concern and issues that require legal input from the relevant statutory bodies. As an output, the gathering of information pertaining to heritage resources will allow for the buffering of sensitive areas and the creation/delineation of no-go sites.

The extensive size of the project has resulted in a decision to divide it into three different working areas that are inclusive of the following:

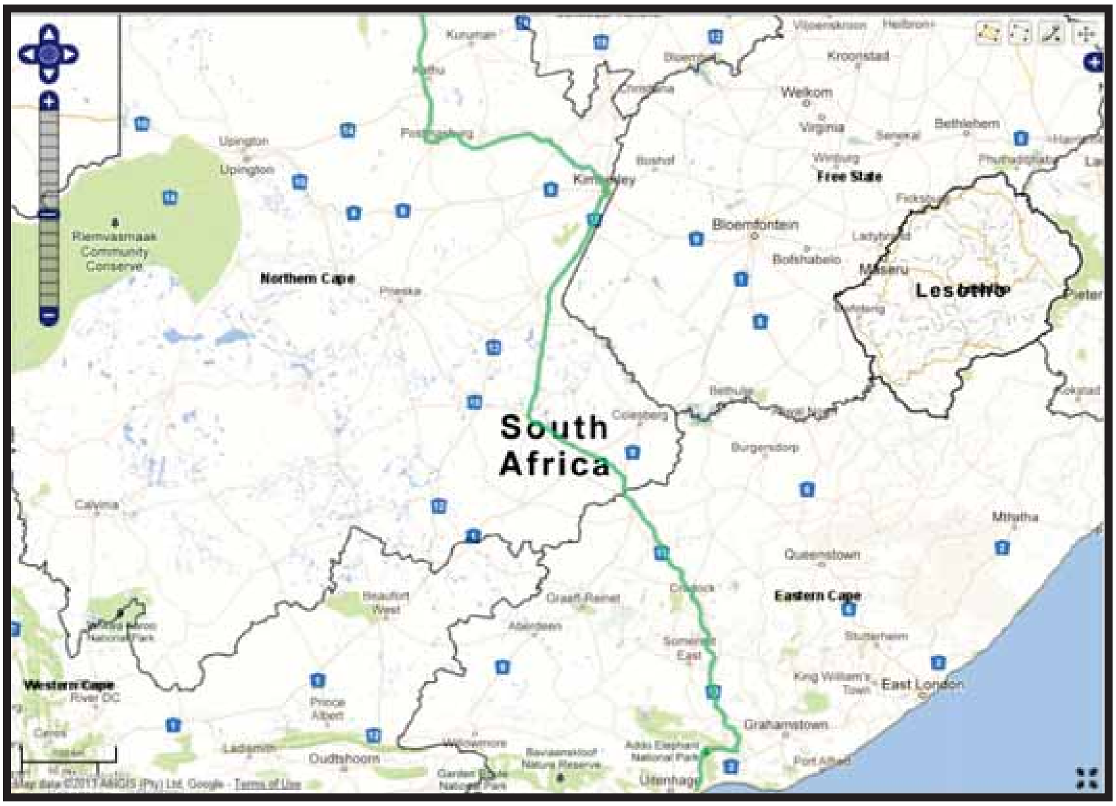


Figure 1: The extent of the development stretches from Hotazel to Port of Ngqura (SAHRIS, 2013)

- Area 1: Hotazel to Kimberley, currently being assessed as part of an environmental authorisation process, and the focus of this report
- Area 2: Kimberley to De Aar, received an environmental authorisation in 2009, and is not discussed in this report
- Area 3: De Aar to Port of Ngqura, currently being assessed as part of an environmental authorisation process, and the focus of this report

The project scope and work packages described in Section 2 provide detail in terms of the various components that may be impacted by the proposed development.

2. Background

In South Africa the main concentration of manganese mines producing predominantly higher grade ores is in the Kalahari Manganese basin, around Hotazel in the Northern Cape. It is anticipated that the manganese industry will experience strong export demand in the coming years. Given the quality of the manganese ore reserves, South Africa is in a position to benefit from the projected growth in the manganese industry if constraints on the current transport logistics are addressed.

In 2008 Transnet, in association with the manganese ore mining industry identified the need to increase the capacity of the export corridor beyond the current capacity of 5.5 Mtpa. An environmental authorisation process commenced in this regard and the project was authorised to proceed with construction in 2009. The project proposal on which this authorisation was issued was based on achieving an export capacity of 12 Mtpa. Based on the increased demand of manganese ore, Transnet, in conjunction with the mining industry has indicated the need for an increased export capacity of 16 Mtpa. As such, changes to the original project scope necessitate additional environmental authorisation processes.

In 2008, when the original environmental authorisation process was undertaken for the 12 Mtpa upgrade, an Archaeological Impact Assessment (AIA) was undertaken by Archaic who identified scattered Stone Age material, grave sites, rock art and historical sites. Although a study was done a new assessment is required for the following reasons:

- The study done by Archaic was for the 12 Mtpa upgrade and the scope for this 16 Mtpa upgrade is different.
- The National Department of Environmental Affairs (DEA), as the competent authority, authorised the 12 Mtpa project prior to receiving comments from SAHRA, who subsequently indicated shortcomings in Archaic's assessment which need to be addressed.
- The change in scope has resulted in a change of where loop extensions are proposed.
- The section between Ripon and Kommadagga has been removed from the scope of work, because of the heritage as well as social sensitivities that are associated with the area.

3. Project Scope

The project scope described below is inclusive of work packages planned for Areas 1 and 3 within the Northern and Eastern Cape provinces respectively. These work packages are inclusive of the development of new rail loops, rail loop extensions and a compilation yard. Loops are railway line arrangements which allow one train to cross over to another rail line, allowing a second train, approaching from the other direction, to pass safely. A compilation yard is used for the compilation and de-compilation of wagon trains.

The following table summarises the scope proposed at the section between Ngqura and Kimberley.

Table 3-1: Scope of work proposed for the Northern Cape area (Area 1: Hotazel to Kimberley)

Work packages planned	Description
Witloop	New loop
Wincanton	Loop extension
Sishen	New loop
Glosam	Loop extension
Postmasburg	Loop extension
Tsantsabane	Loop extension
Trewil	Loop extension
Ulco	Loop extension
Gong Gong	Loop Extension
Fieldsview	Loop extension
Mamathwane	Compilation yard

The following table summarises the scope proposed between De Aar and Port Elizabeth.

Table 3-2: Scope of work proposed for the Eastern Cape area (Area 3: De Aar to Port of Ngqura)

Work packages planned	Description
Burgervilleweg	Loop extension
Rosmead	Loop extension
Linde	Loop extension
Tafelberg	Loop extension
Knutsford	Loop extension
Drennan	Loop extension
Thorngrove	Loop extension
Cookhouse – Golden Valley	Line doubling
Sheldon	Loop extension
Verby	Loop extension

4. Location of work packages planned in the Northern Cape

The following work packages are proposed at Area 1 (Hotazel to Kimberley).

4.1 Area 1: Hotazel to Kimberley

The section below provides portions of 1:50 000 maps downloaded from the South African Heritage Resources Information System (SAHRIS) and the aim of the information is to provide a reference point related to the proposed impacted areas.

4.1.1 Witloop New Loop

At Witloop Station a new loop is proposed.

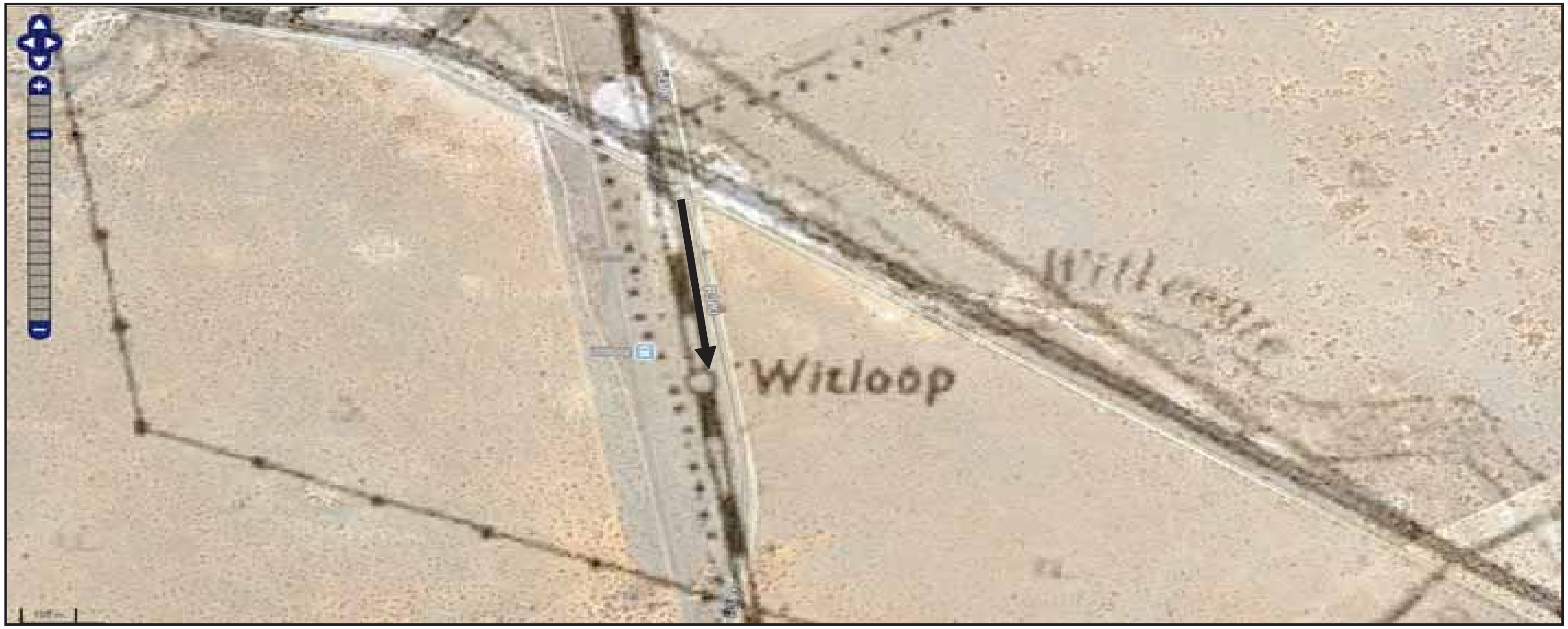


Figure 2: Location of the proposed new loop at Witloop Station (SAHRIS, 2013) Witloop Station is located north of Mamathwane Station

Figure 3: Aerial view of the proposed new loop at Witloop Station (SAHRIS, 2013)

4.1.2 *Wincanton Loop Extension*

A loop extension is proposed at Wincanton Station.

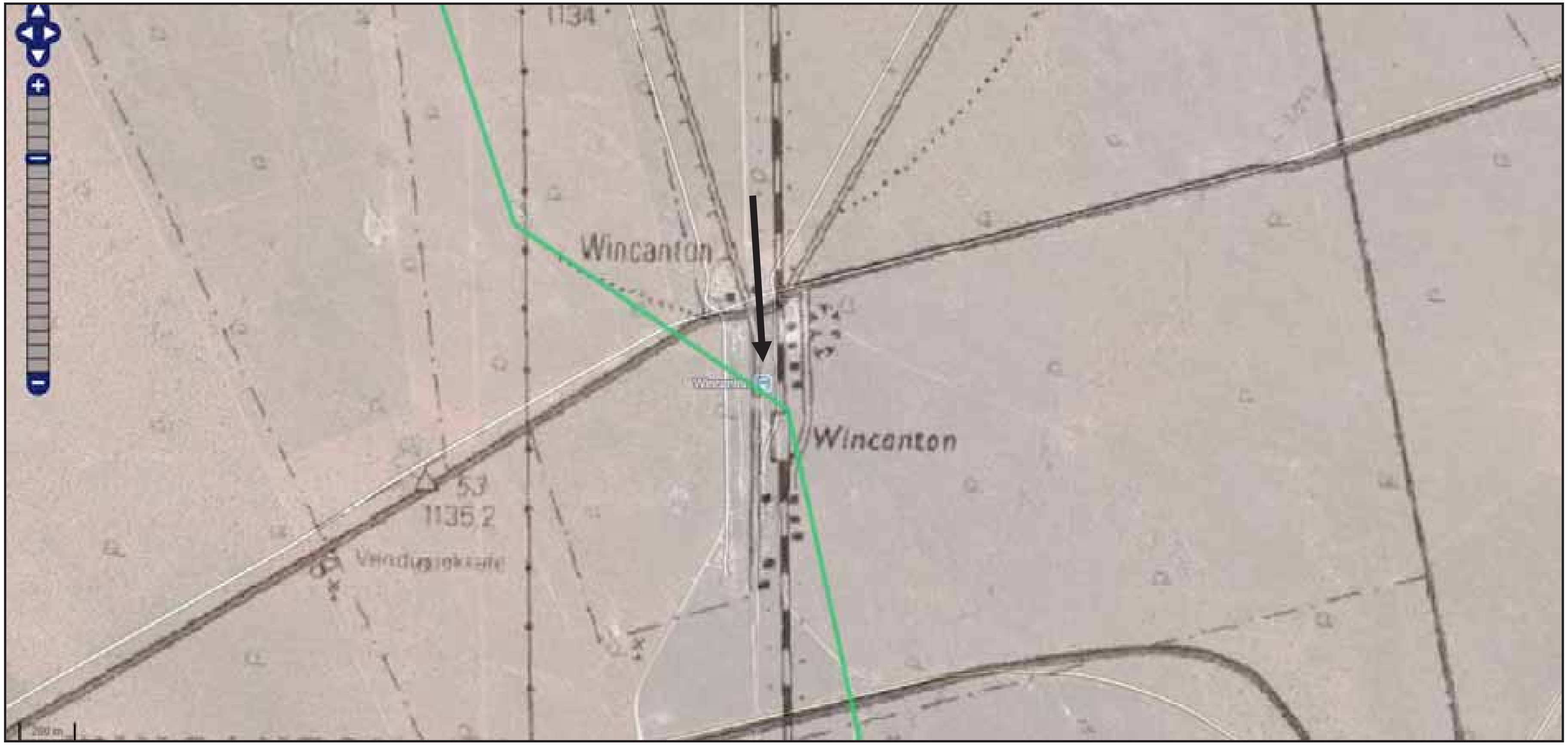


Figure 4: Location of the proposed loop extension at Wincanton Station (SAHRIS, 2013)

Figure 5: Aerial view of the proposed loop extension at Wincanton Station (SAHRIS, 2013)

4.1.3 *Sishen New Loop*

A new loop is proposed at Sishen Station.

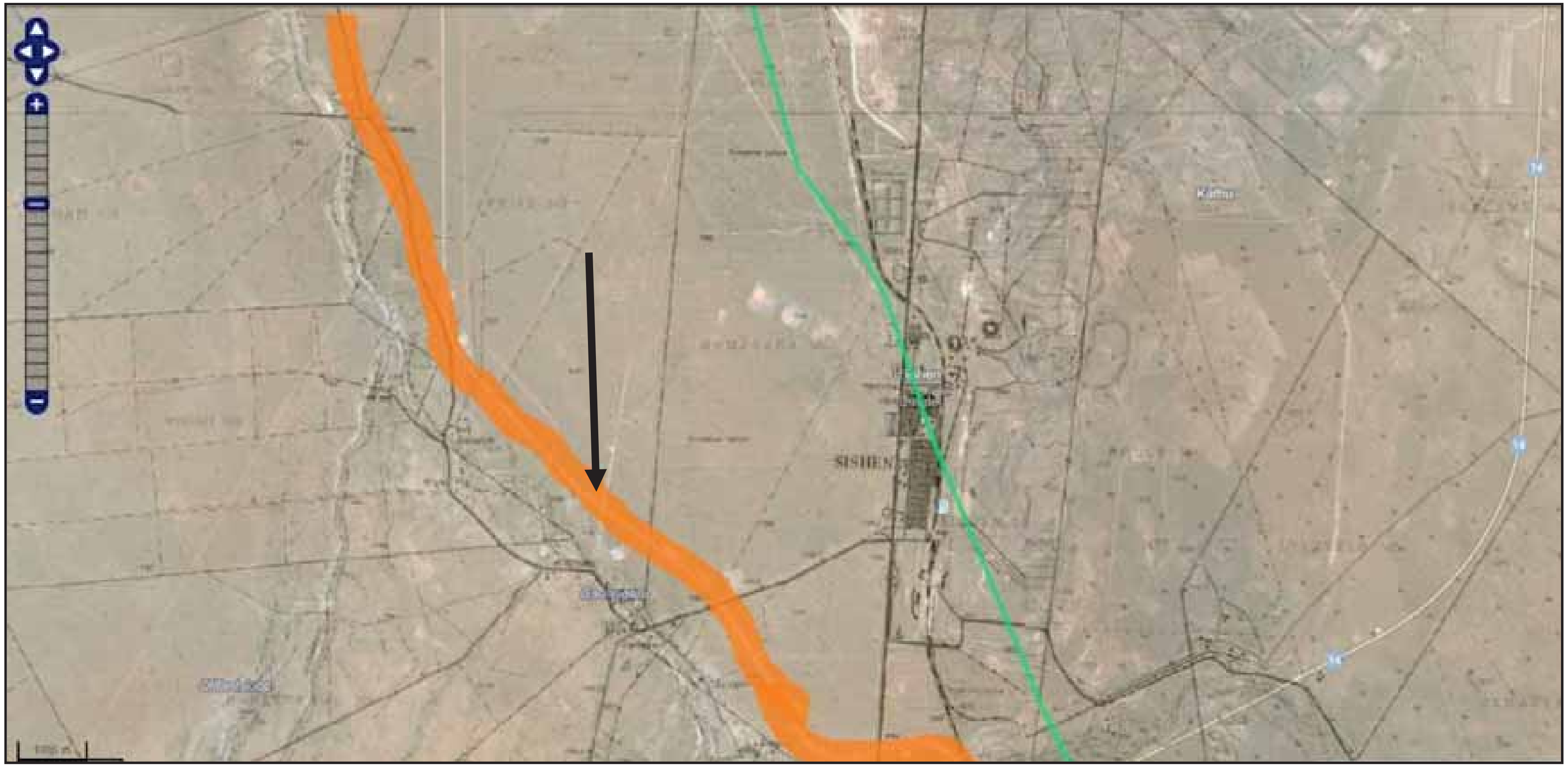


Figure 6: Location of the proposed new loop at Sishen Station (SAHRIS, 2013)

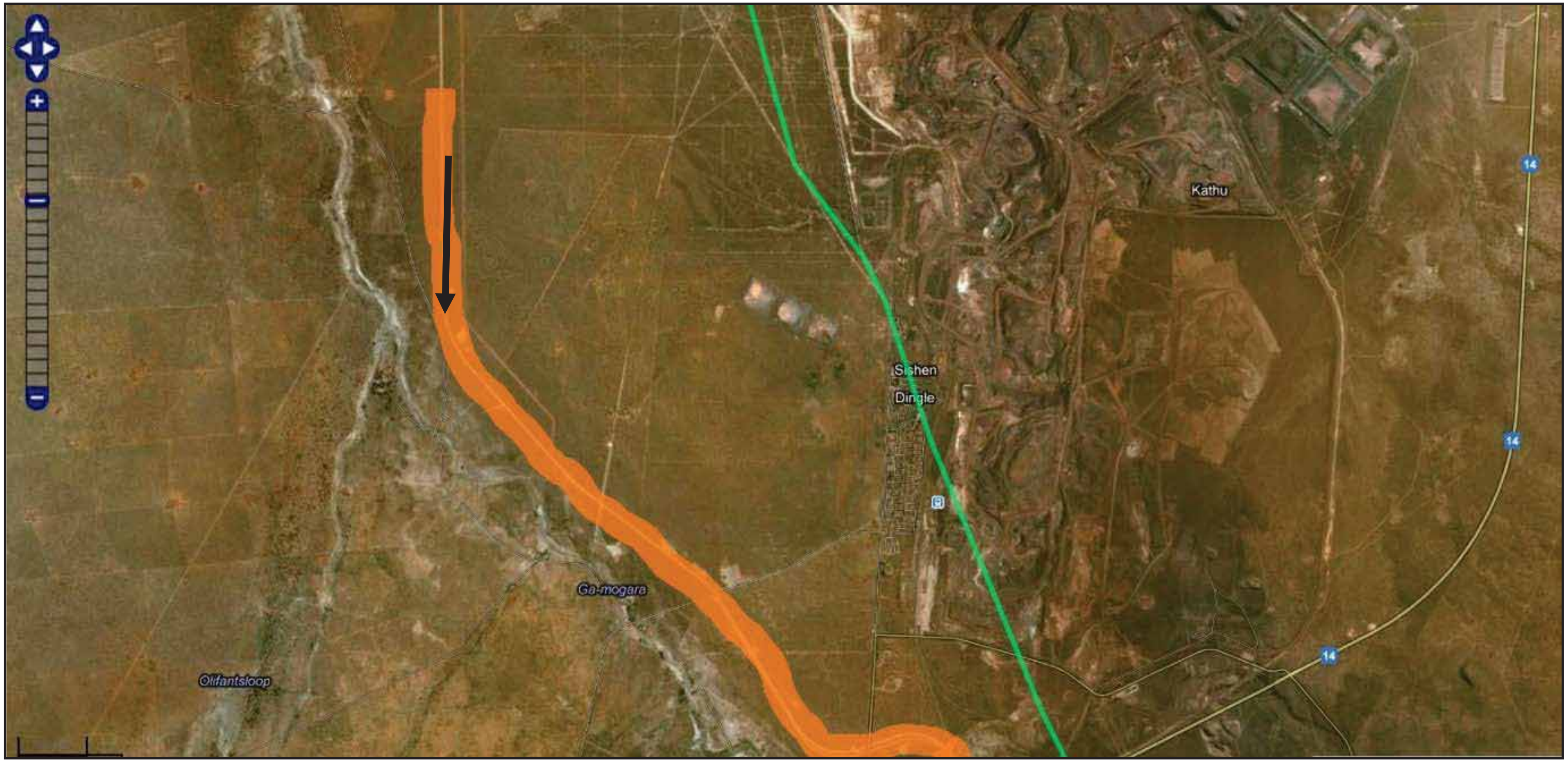


Figure 7: Aerial view of the proposed new loop at Sishen Station (SAHRIS, 2013)

4.1.4 *Mamathwane Compilation Yard*

A new compilation yard is proposed at Mamathwane which is located approximately 22km south of Hotazel in the Northern Cape. The proposed development area covers approximately 120 ha and will be used for the compilation and de-compilation of wagon trains.

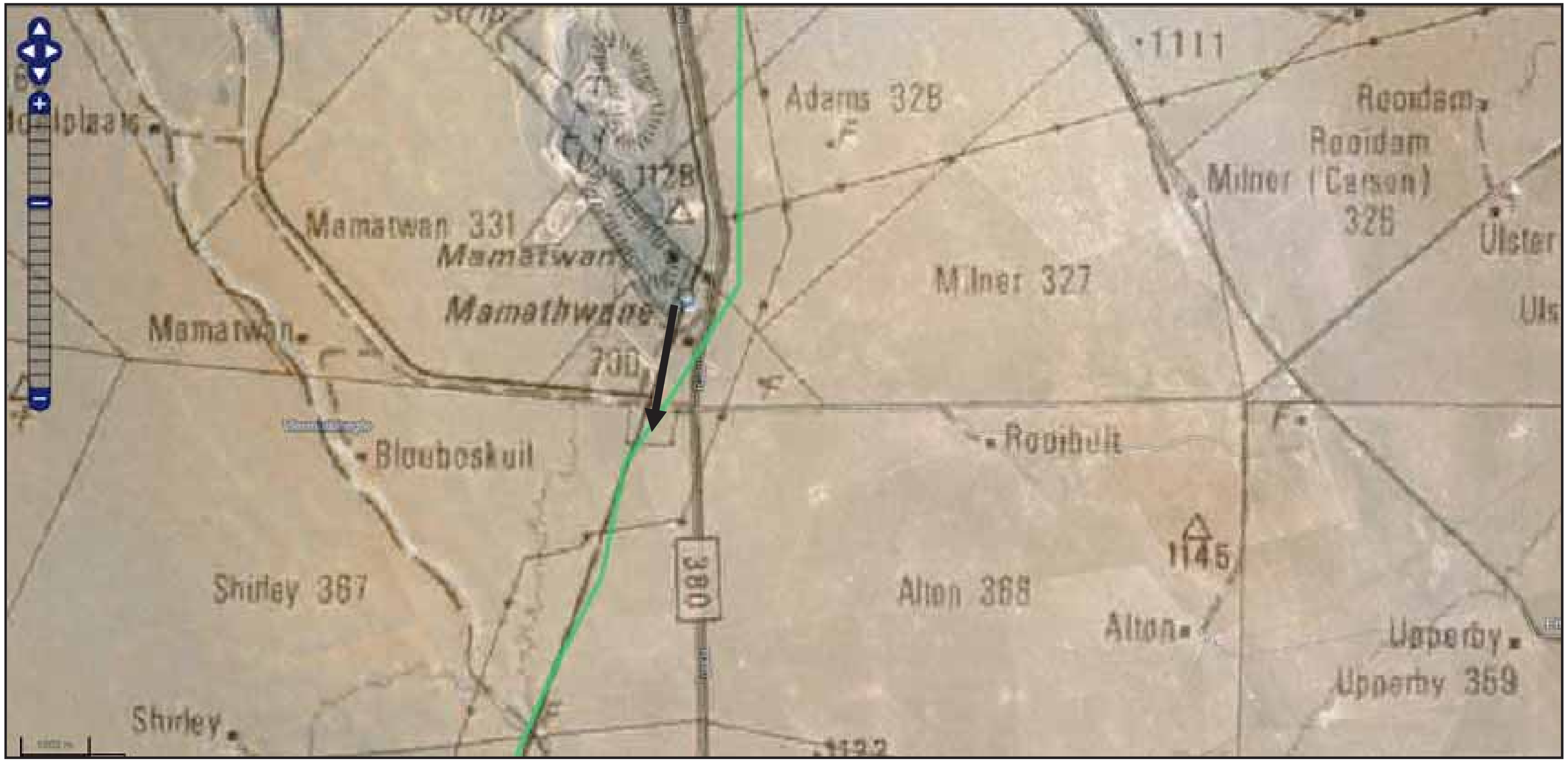


Figure 8: Location of the proposed Mamathwane Compilation Yard (SAHRIS, 2013)

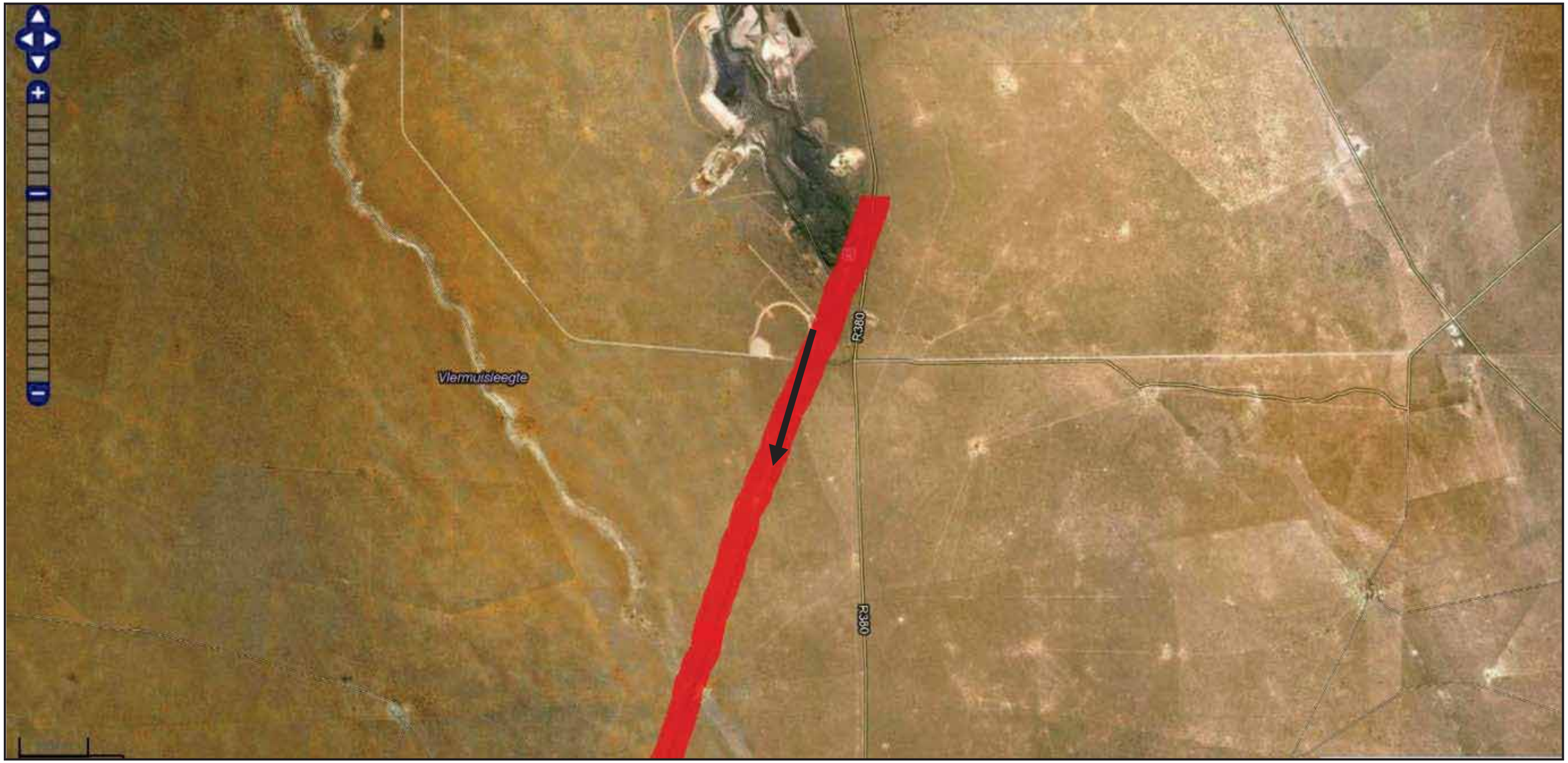


Figure 9: Aerial view of the proposed Mamathwane Compilation Yard (SAHRIS, 2013)

4.1.5 Glosam Loop Extension

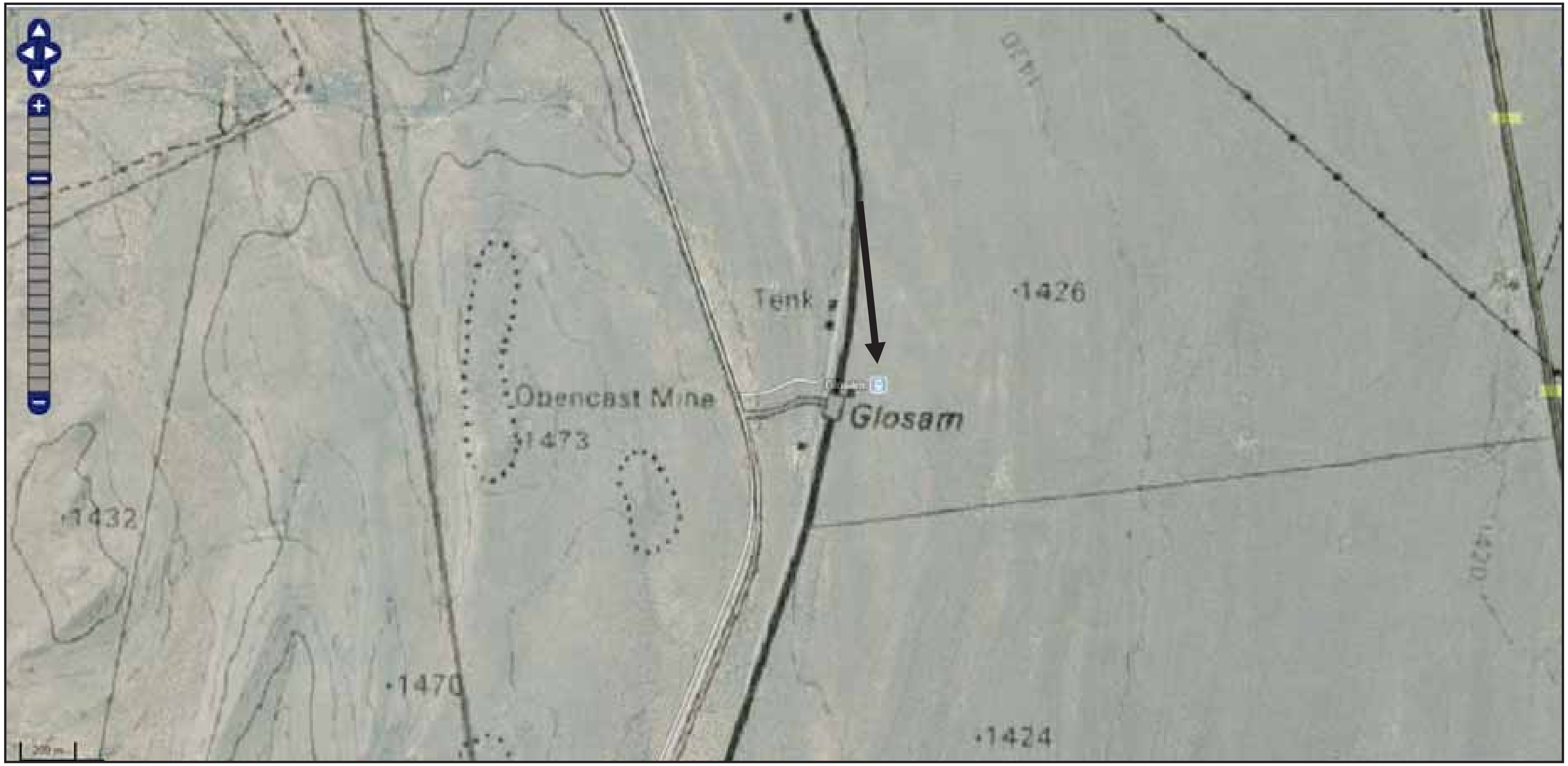


Figure 10: Location of the proposed loop extension at Glosam Station (SAHRIS, 2013)

Figure 11: Aerial view of Glosam Station and surrounds (SAHRIS, 2013)

4.1.6 Postmasburg Loop Extension

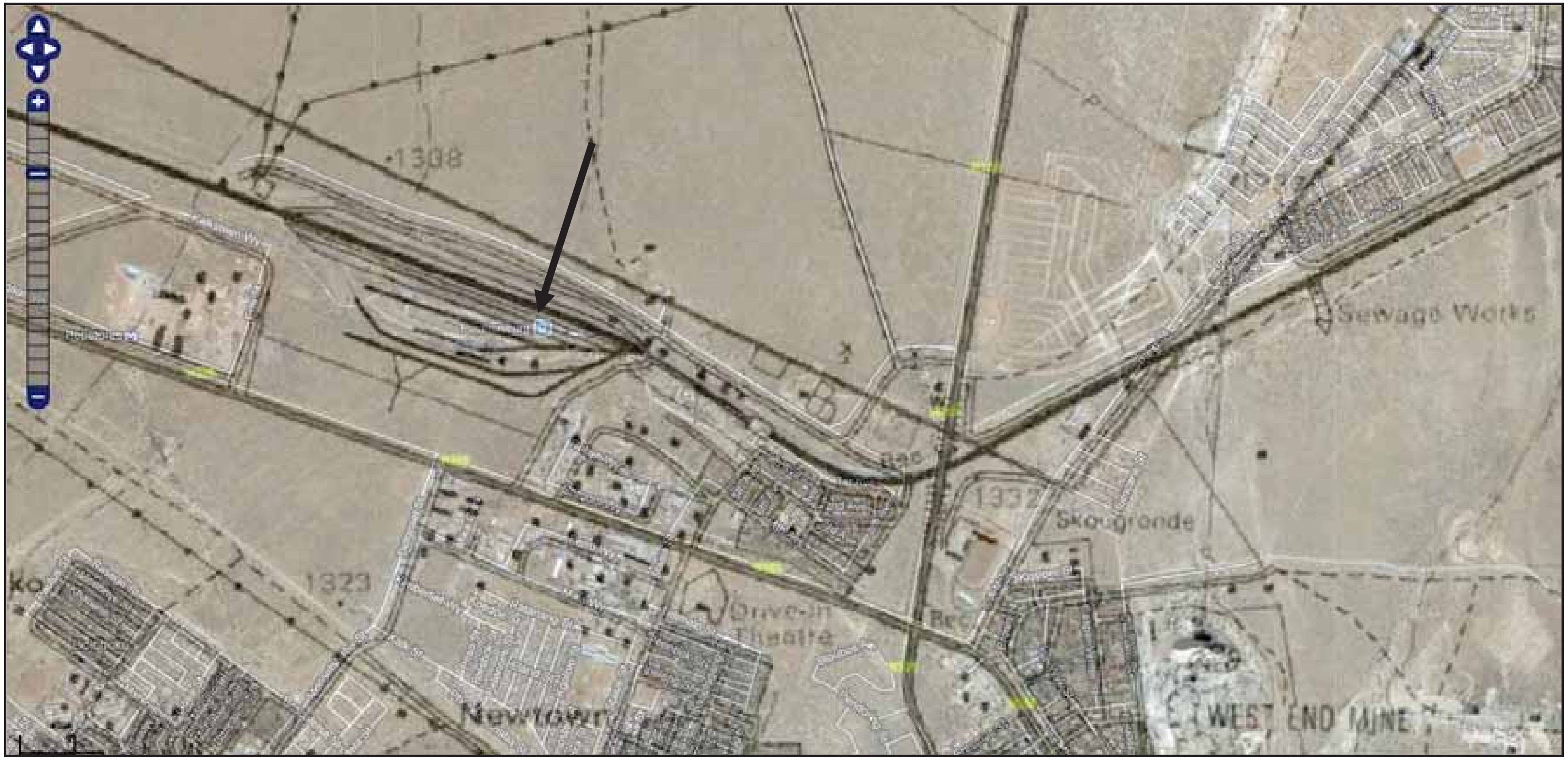


Figure 12: Location of proposed loop extension at Postmasburg Station (SAHRIS, 2013)

Safety • Quality • Sustainability • Innovation

Figure 13: Aerial view of proposed loop extension at Postmasburg Station (SAHRIS, 2013)

4.1.7 *Tsantsabane Loop Extension*

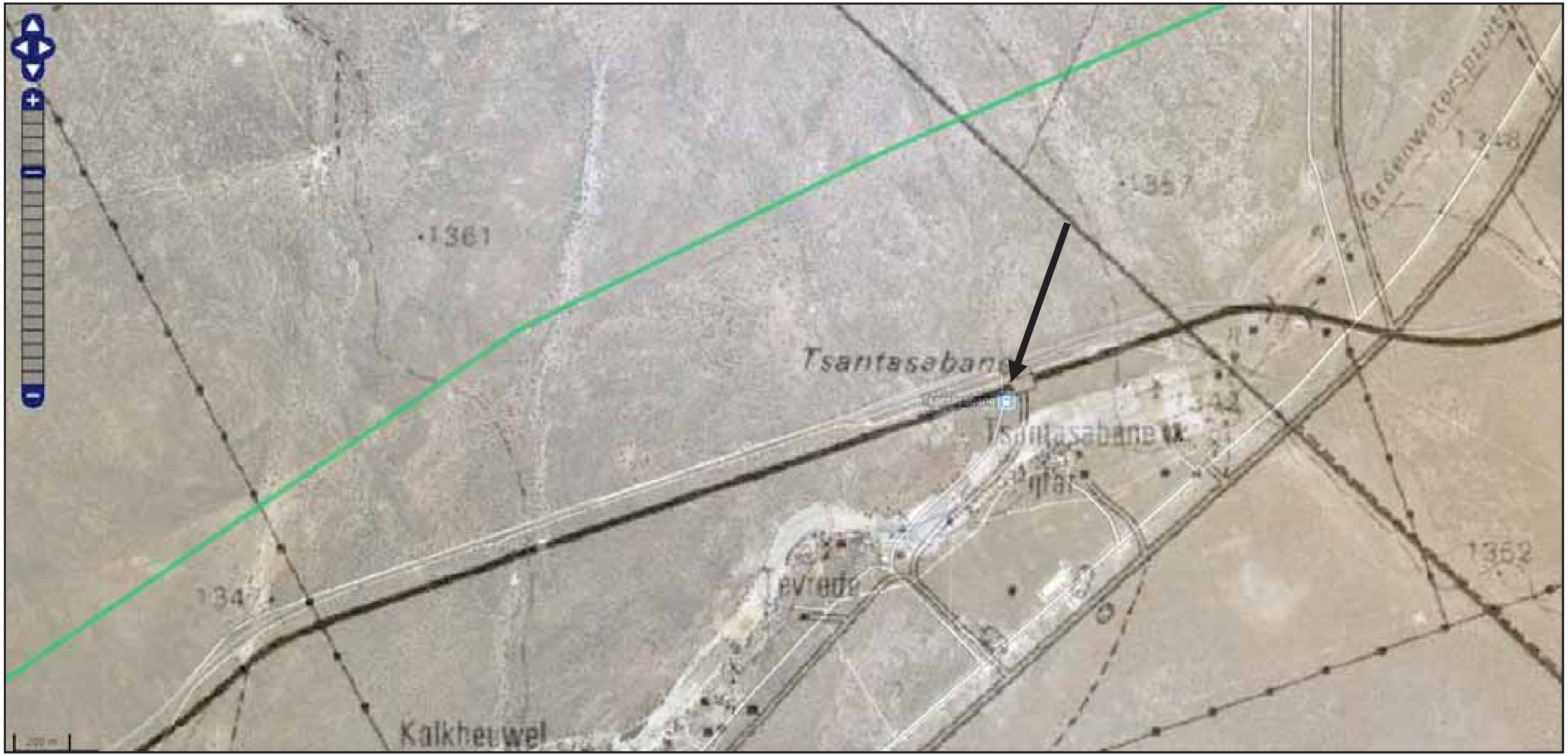


Figure 14: Location of the proposed loop extension at Tsantsabane Station (SAHRIS, 2013)

Figure 15: Aerial view of Tsantsabane proposed loop extension (SAHRIS, 2013)

4.1.8 Trewil Loop Extension

Figure 16: Location of the proposed Trewil loop extension (SAHRIS, 2013)

Trewil is located south of Silver Streams Station in the vicinity of Lime Acres

Figure 17: Aerial view of the proposed Trewil loop extension (SAHRIS, 2013)

4.1.9 *Ulco Loop Extension*

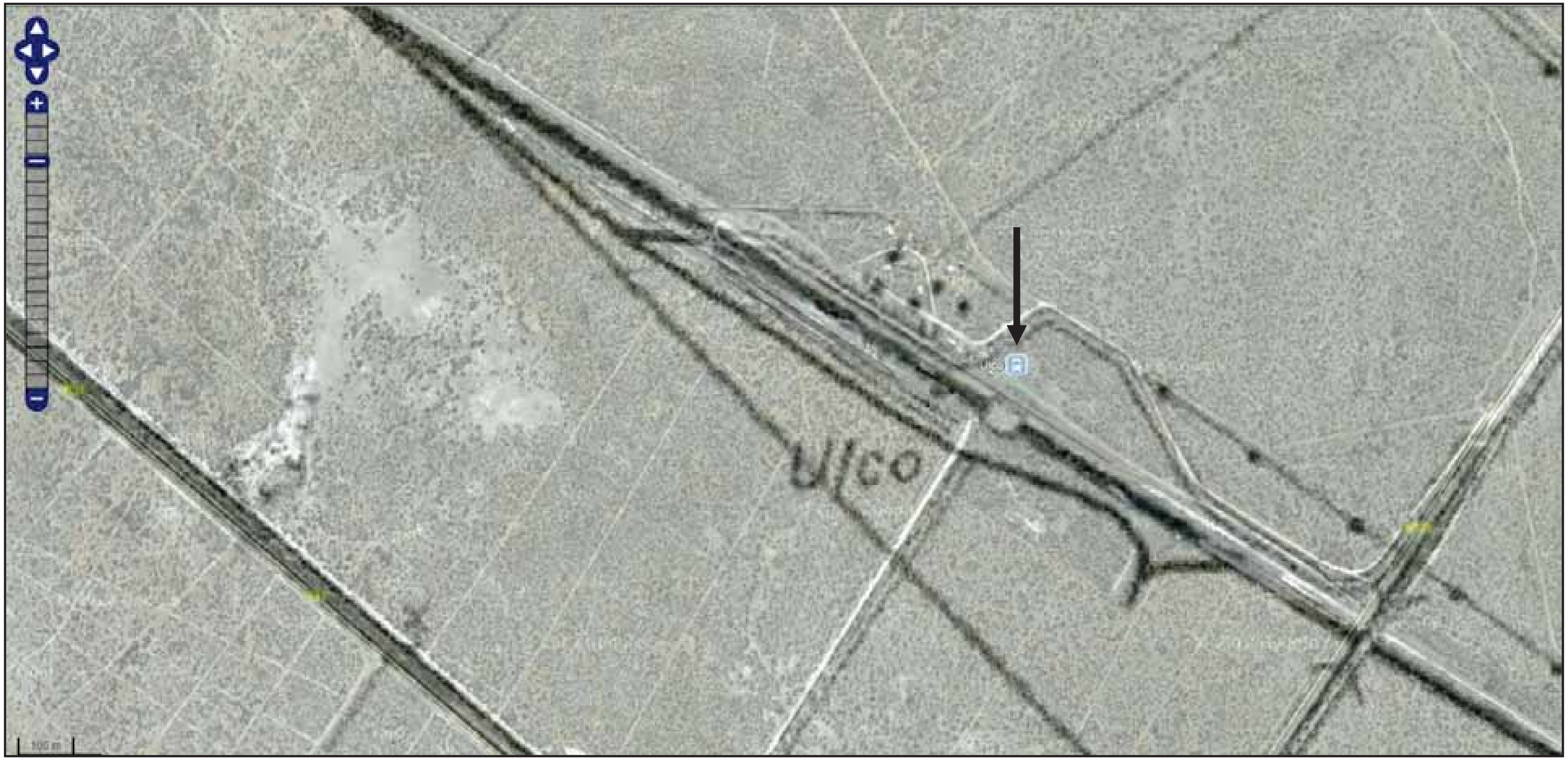


Figure 18: Location of the proposed Ulco loop extension (SAHRIS, 2013)

Figure 19: Aerial view of the proposed Ulco loop extension (SAHRIS, 2013)

4.1.10 Gong Gong Loop Extension

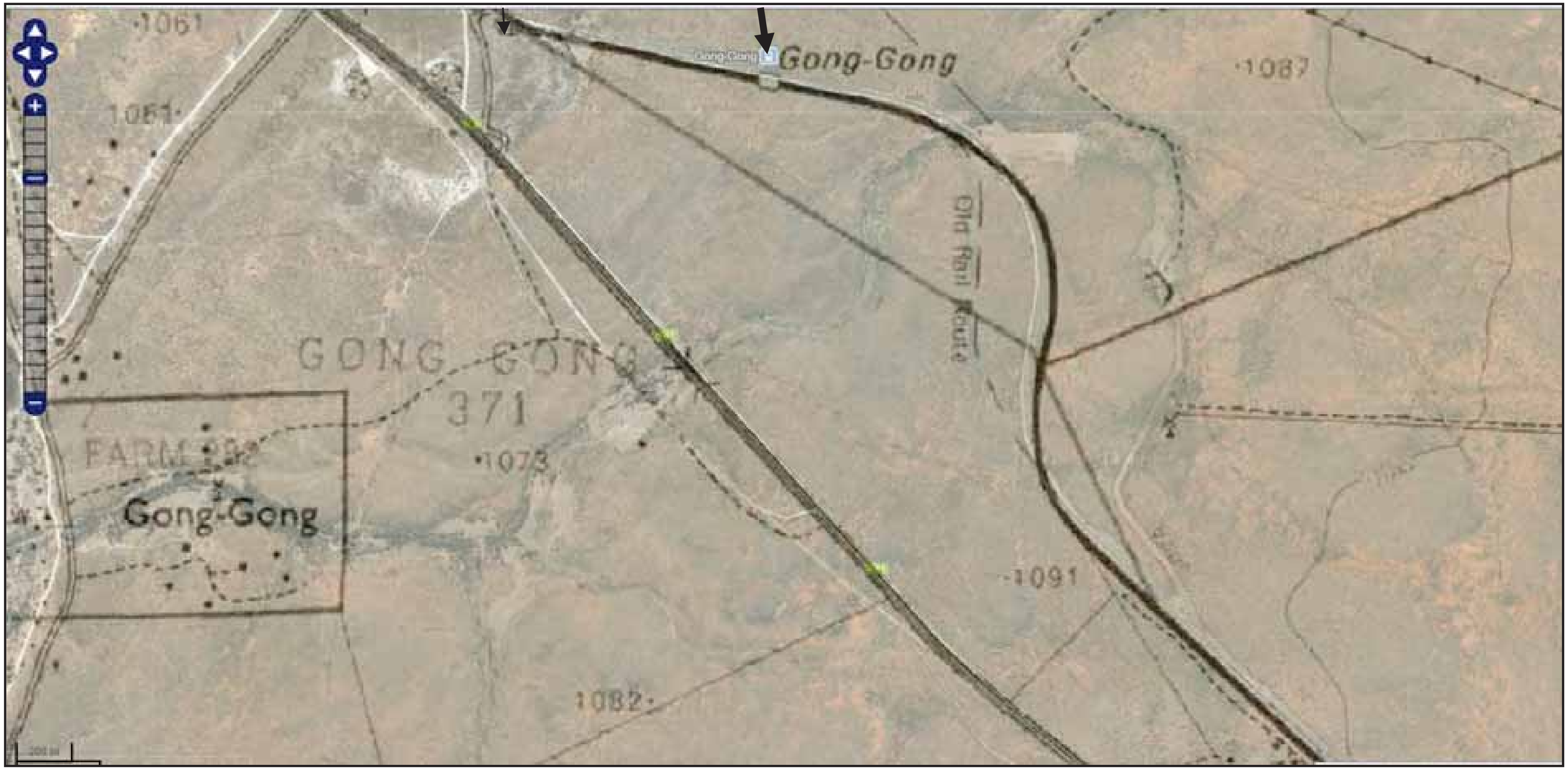


Figure 20: Location of the proposed Gong Gong loop extension (SAHRIS, 2013)

Figure 21: Aerial view of the proposed Gong Gong loop extension (SAHRIS, 2013)

4.1.11 *Fieldsview Loop Extension*

Figure 22: Location of the proposed Fieldsview loop extension (SAHRIS, 2013)

Figure 23: Aerial view of the proposed Fieldsview loop extension (SAHRIS, 2013)

4.2 Area 3: De Aar to Port of Ngqura

The locations of the work packages located within the Eastern Cape (Area 3) are indicated below:

4.2.1 Burgervilleweg Loop Extension

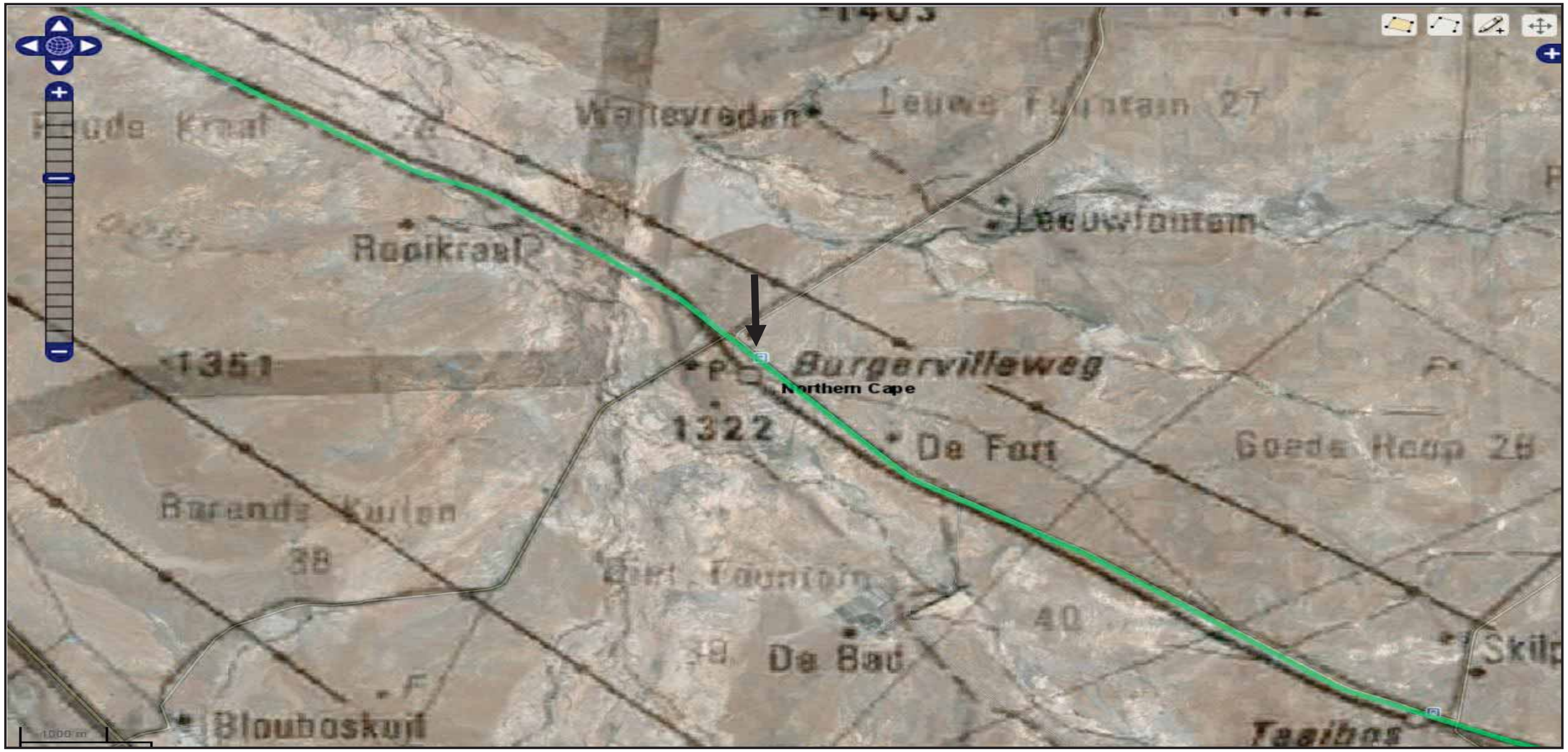


Figure 24: Location of the proposed Burgervilleweg loop extension (SAHRIS, 2013)

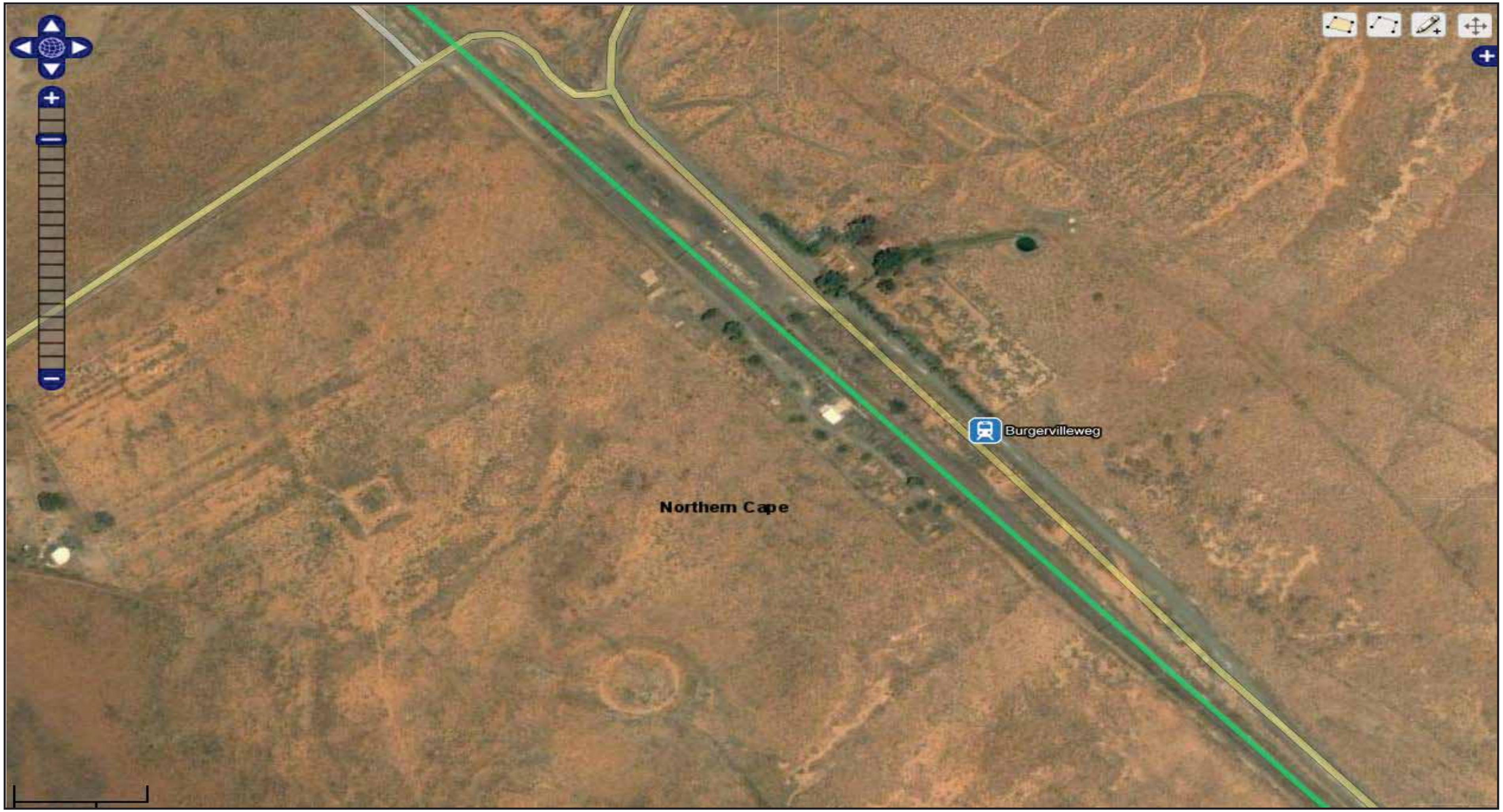


Figure 25: Aerial view of the proposed Burgervilleweg loop extension (SAHRIS, 2013)

4.2.2 Rosmead Loop Extension

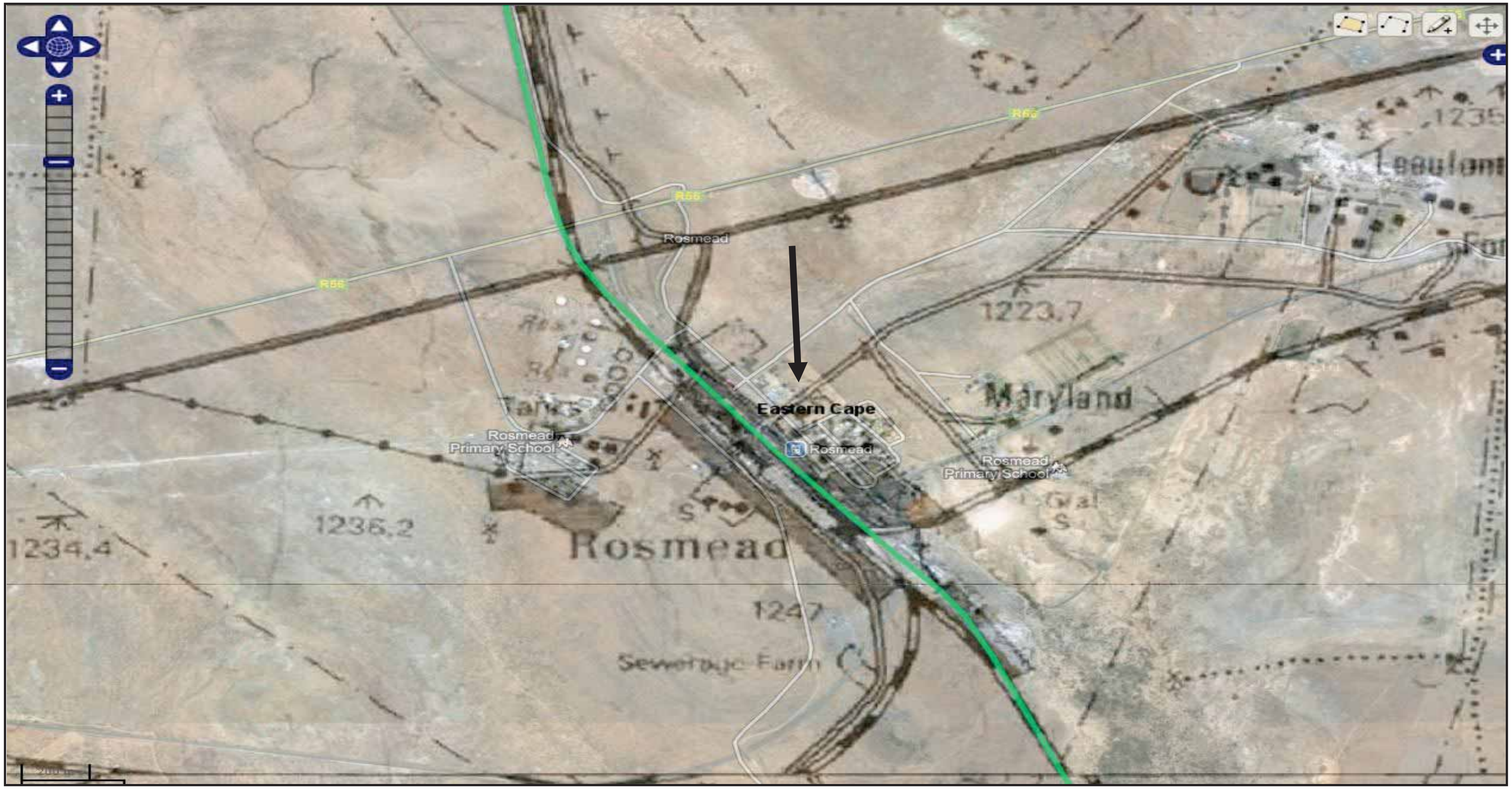


Figure 26: Location of the proposed Rosmead Station

Figure 27: Aerial view of the proposed Rosmead loop extension

4.2.3 *Linde Loop Extension*

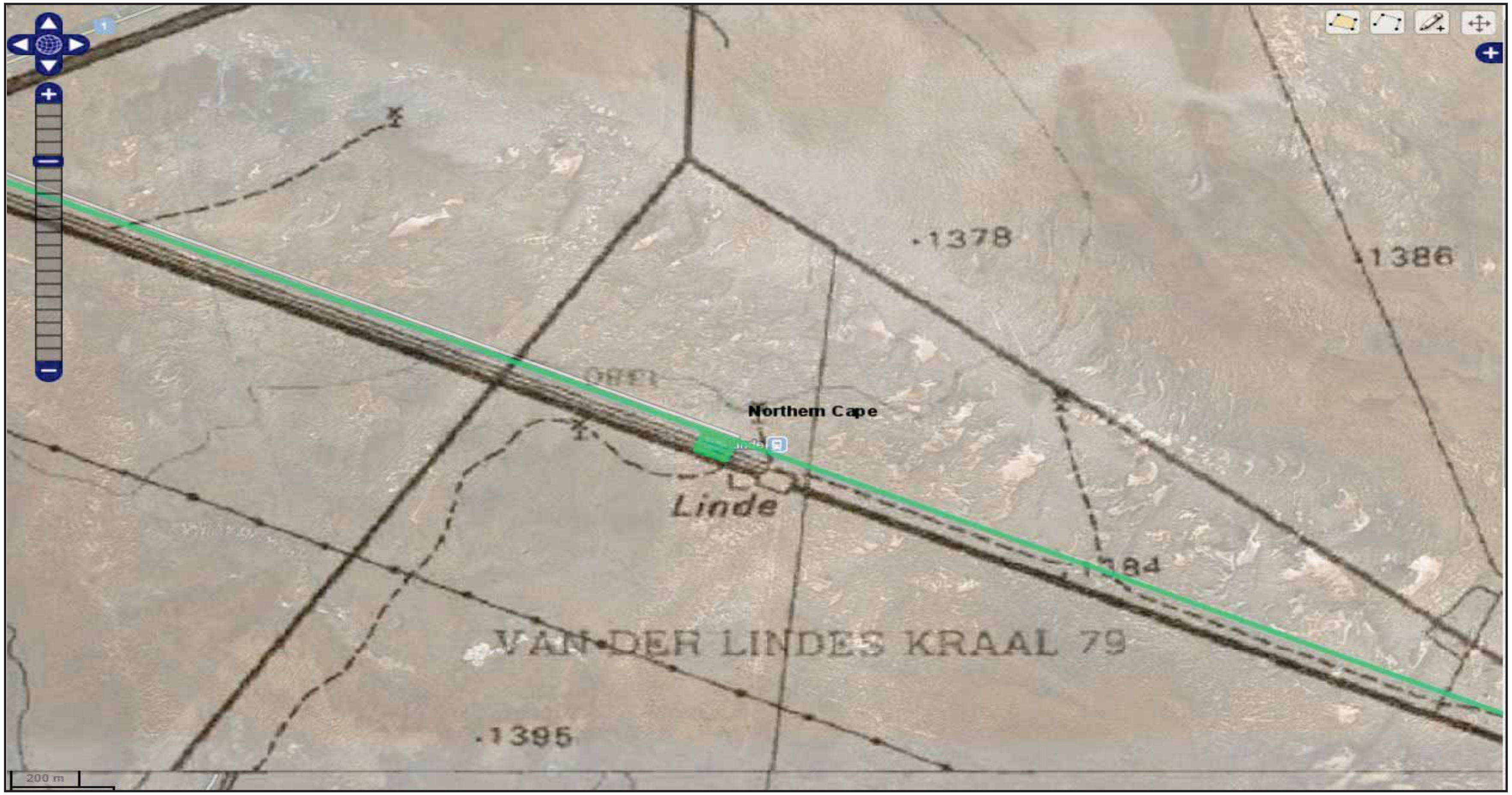


Figure 28: Location of the proposed Linde loop extension

Figure 29: Aerial view of the proposed Linde loop extension

4.2.4 Tafelberg Loop Extension

Figure 30: Location of the proposed Tafelberg loop extension

Figure 31: Aerial view of the proposed Tafelberg loop extension

4.2.5 Knutsford Loop Extension

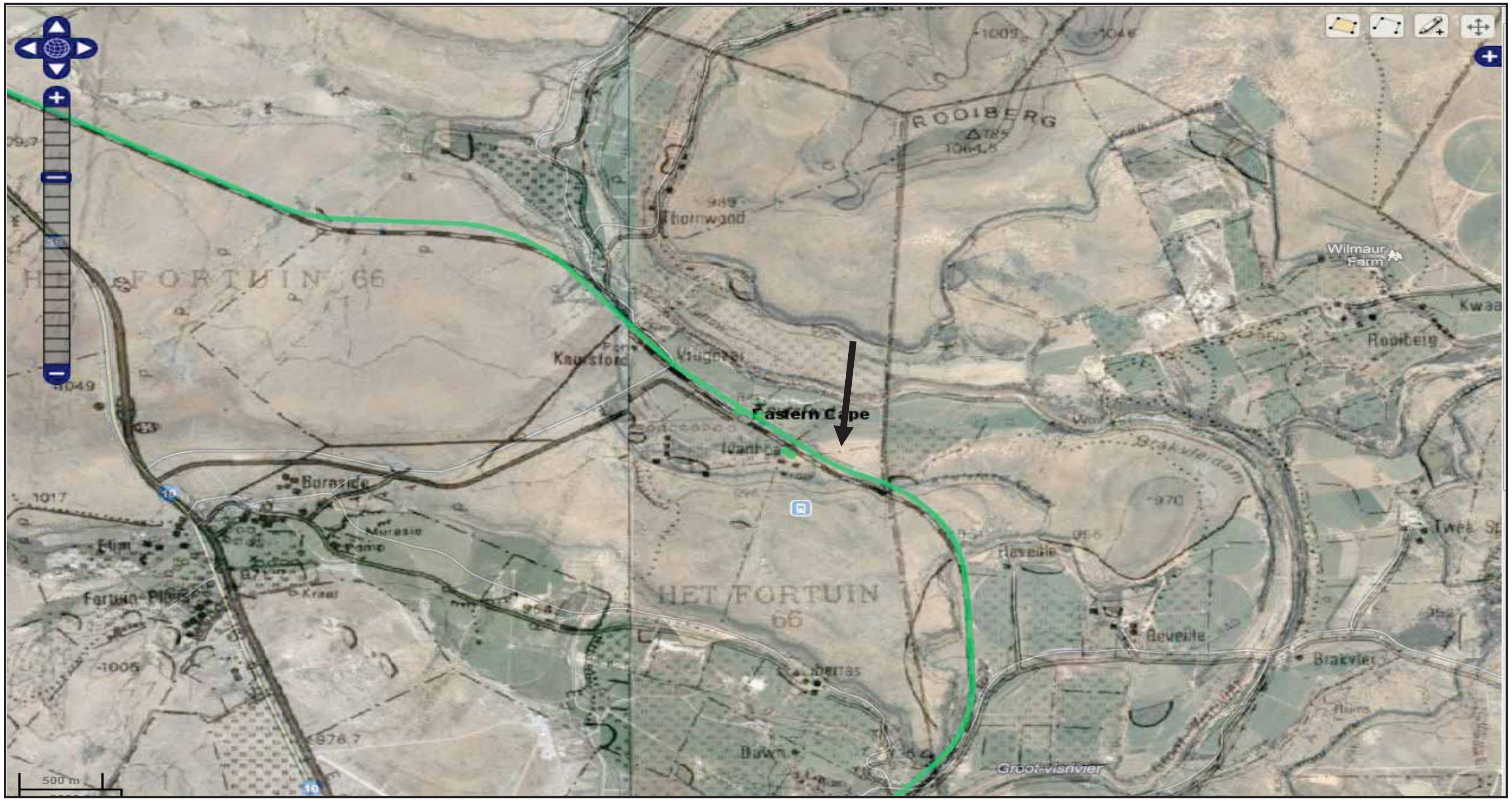


Figure 32: Location of the proposed Knutsford loop extension

Figure 33: Aerial view of the proposed Knutsford loop extension

4.2.6 Drennan Loop Extension

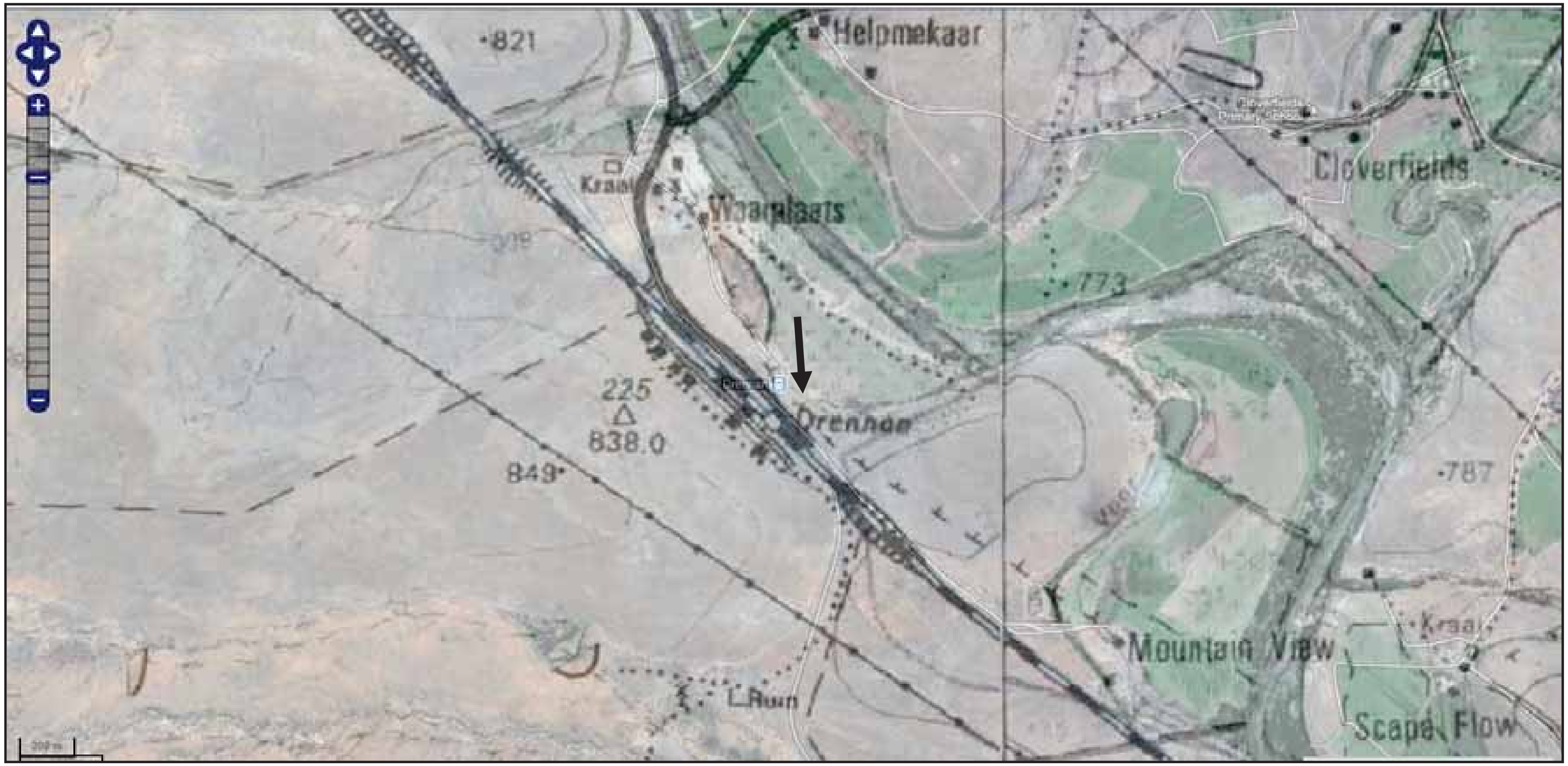


Figure 34: Location of the proposed Drennan loop extension (SAHRIS, 2013)

Figure 35: Aerial view of the proposed Drennan loop extension (SAHRIS, 2013)

4.2.7 Thorngrove Loop Extension

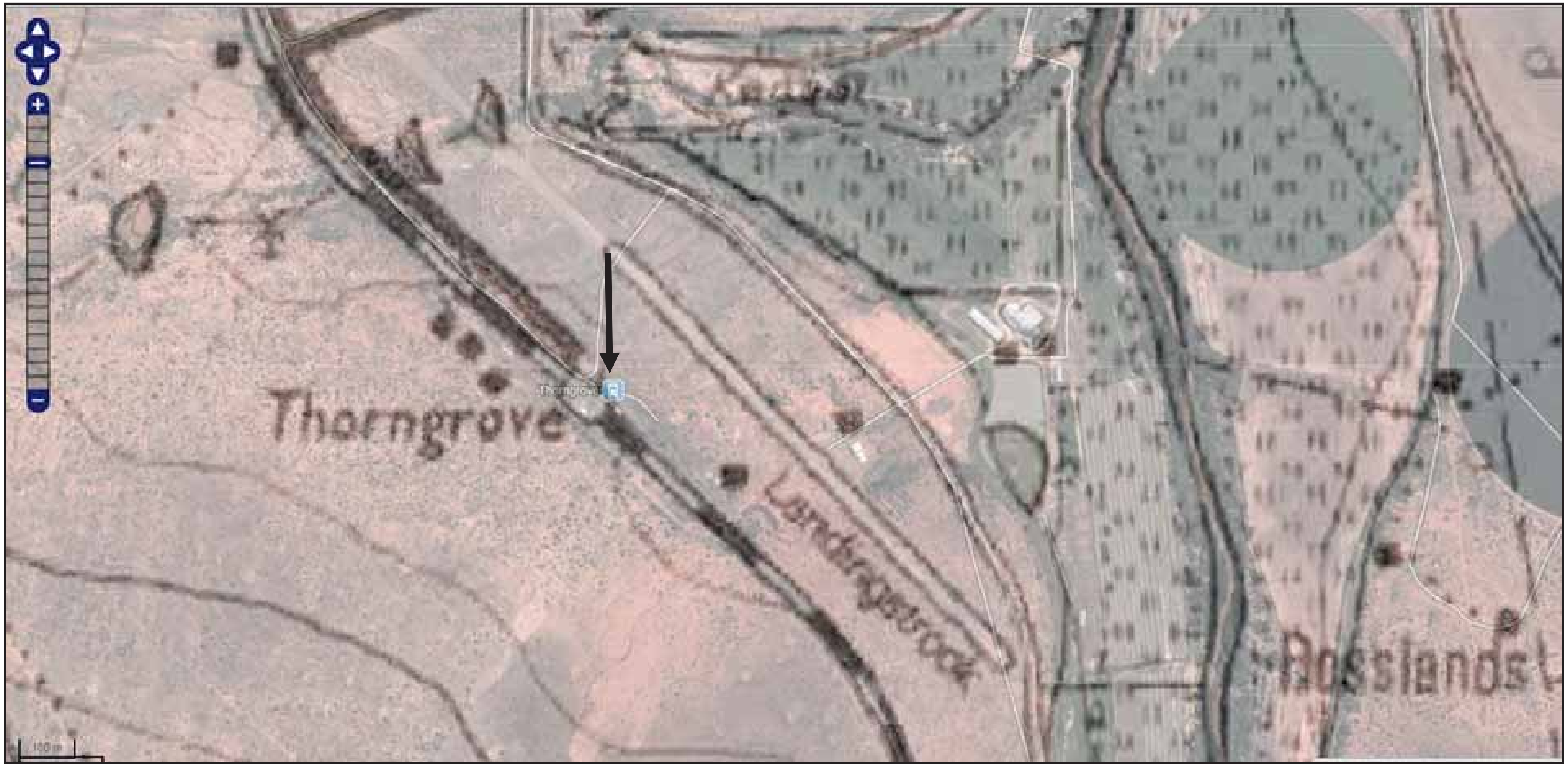


Figure 36: Location of the proposed Thorngrove loop extension (SAHRIS, 2013)

4.2.8 Cookhouse – Golden Valley Doubling

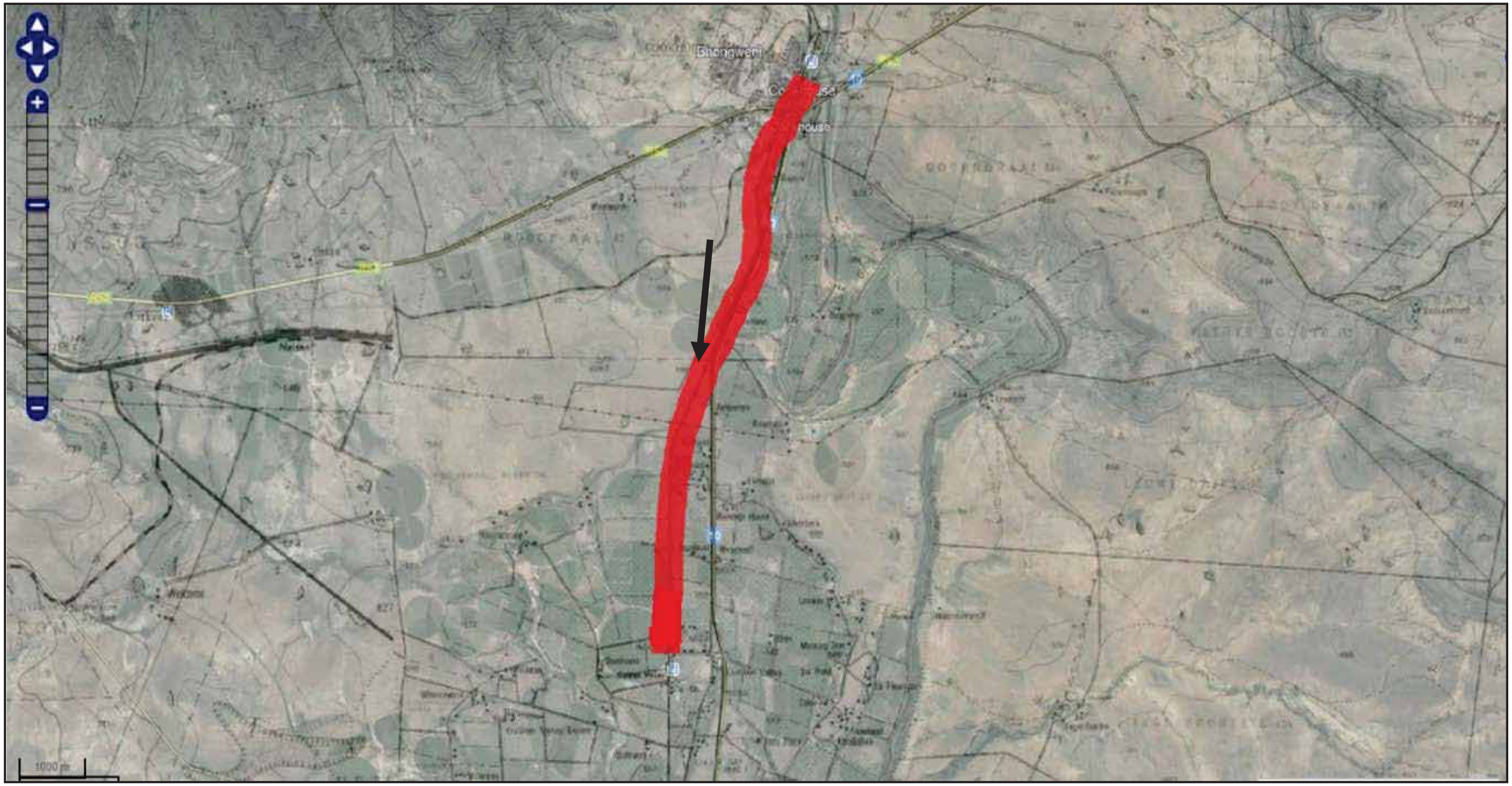


Figure 37: Location of the proposed Cookhouse – Golden Valley doubling of the railway line (SAHRIS, 2013)

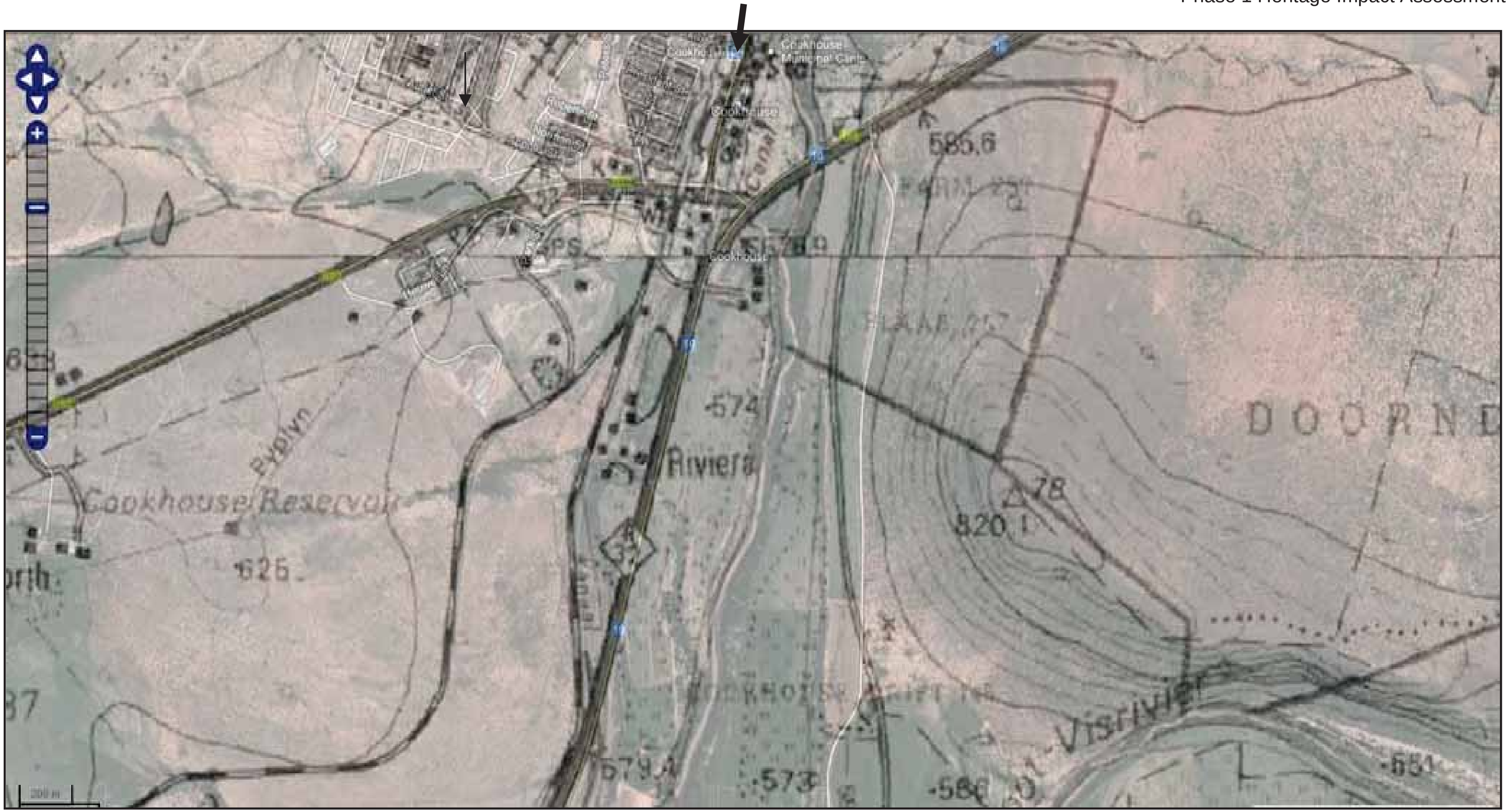


Figure 38: Location of Cookhouse Station and surrounding areas (SAHRIS, 2013)

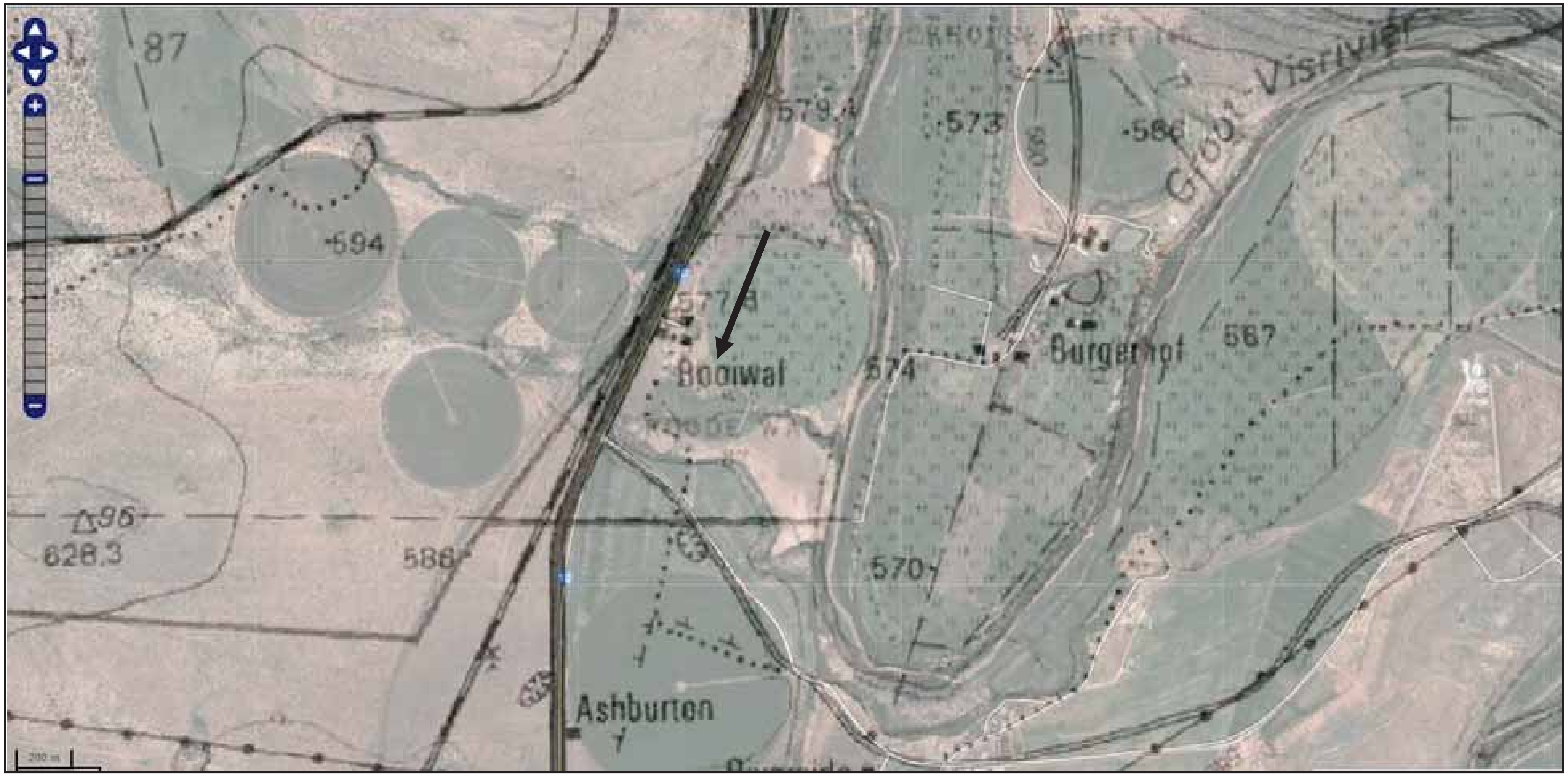


Figure 39: Rooiwal area that occurs south of Cookhouse Station. The Great Fish River is situated east from the railway line (SAHRIS, 2013)

Safety • Quality • Sustainability • Innovation

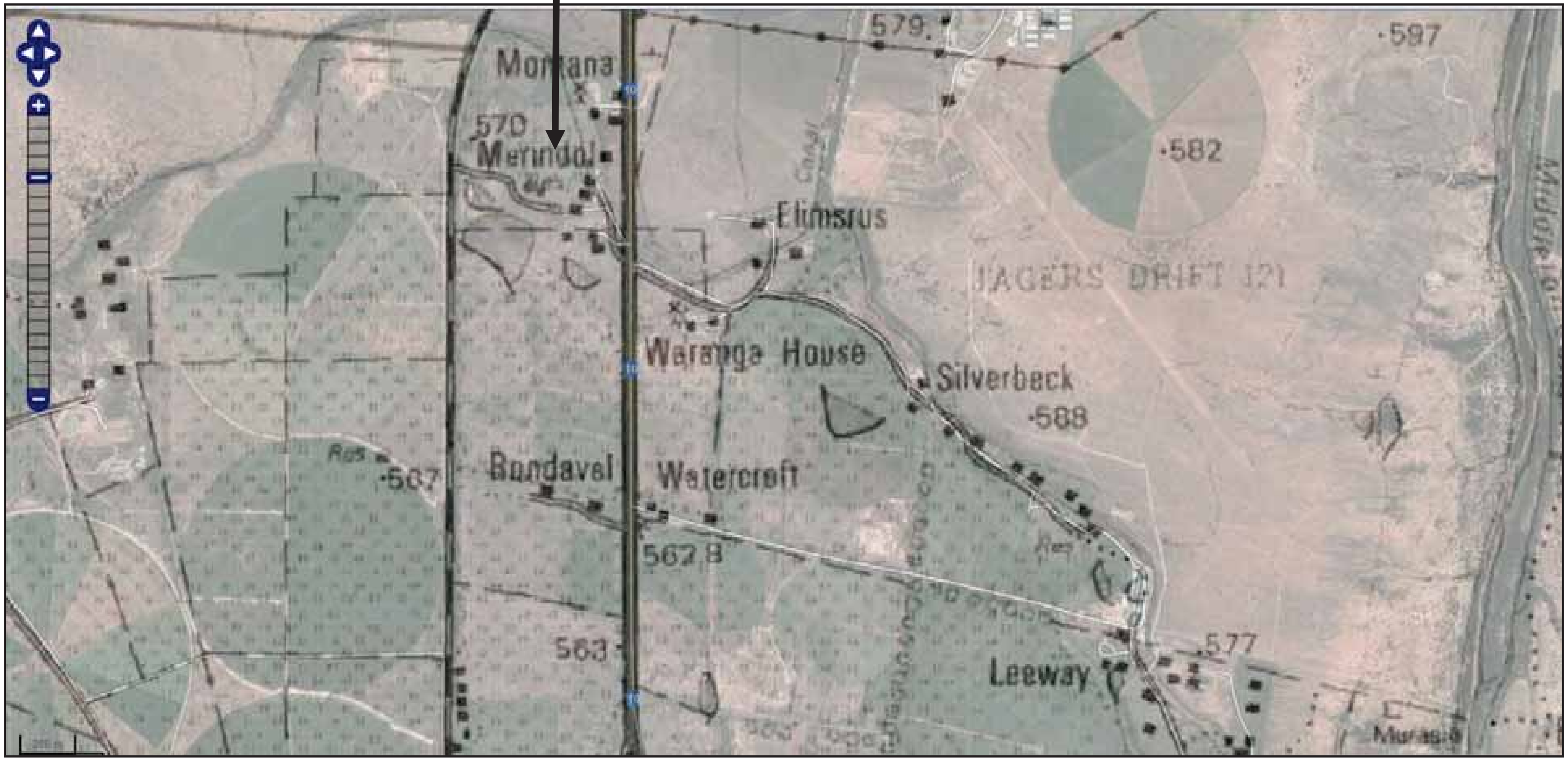


Figure 40: Farming areas at Montana, Merindal and Rondavel. This section is located north of Golden Valley Station (SAHRIS, 2013)

Figure 41: Golden Valley Station and surrounding farming areas (SAHRIS, 2013)

Safety • Quality • Sustainability • Innovation

4.2.9 *Sheldon Loop Extension*

A loop extension is proposed at Sheldon.

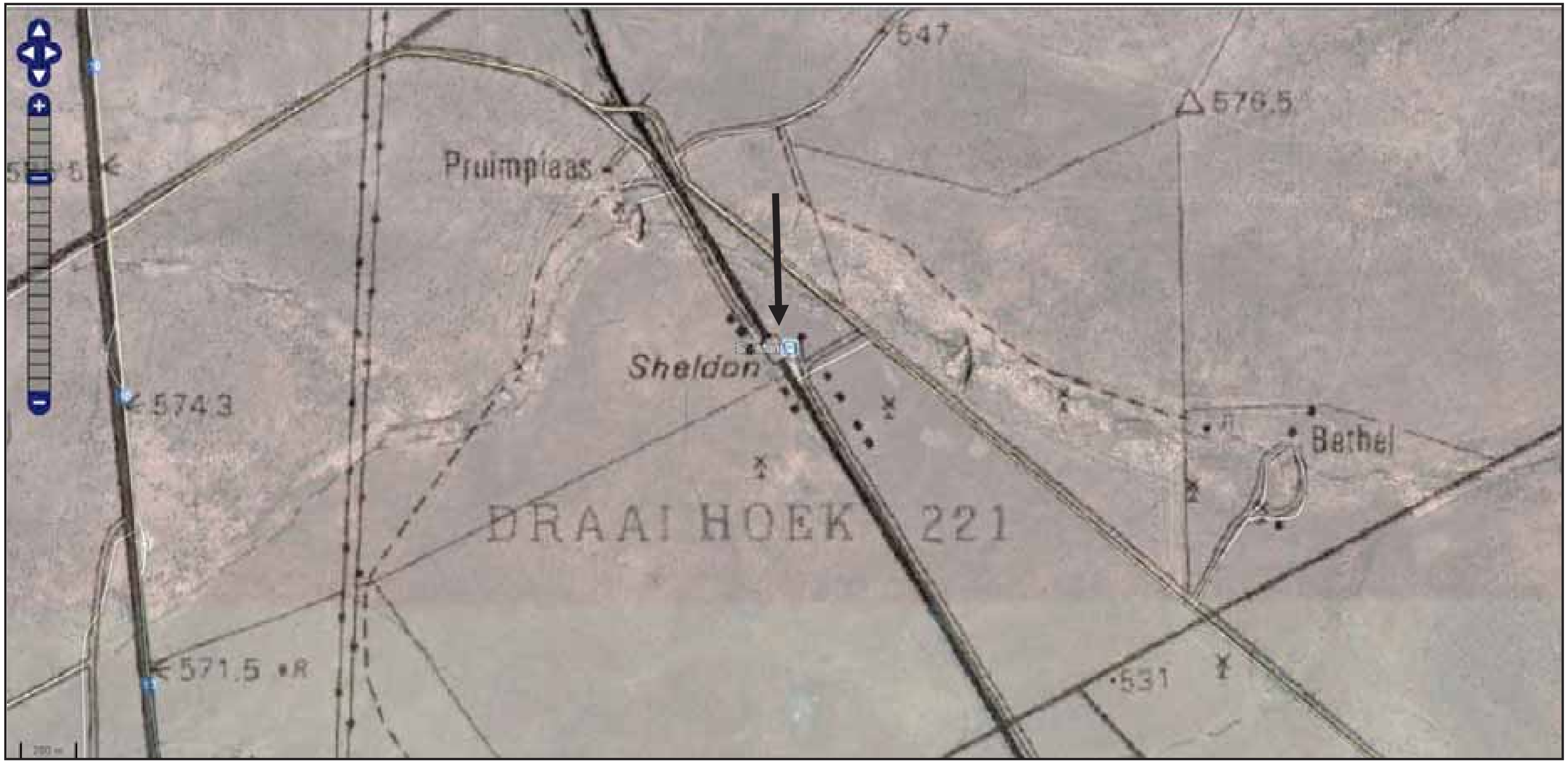


Figure 42: Location of the proposed Sheldon loop extension (SAHRIS, 2013)

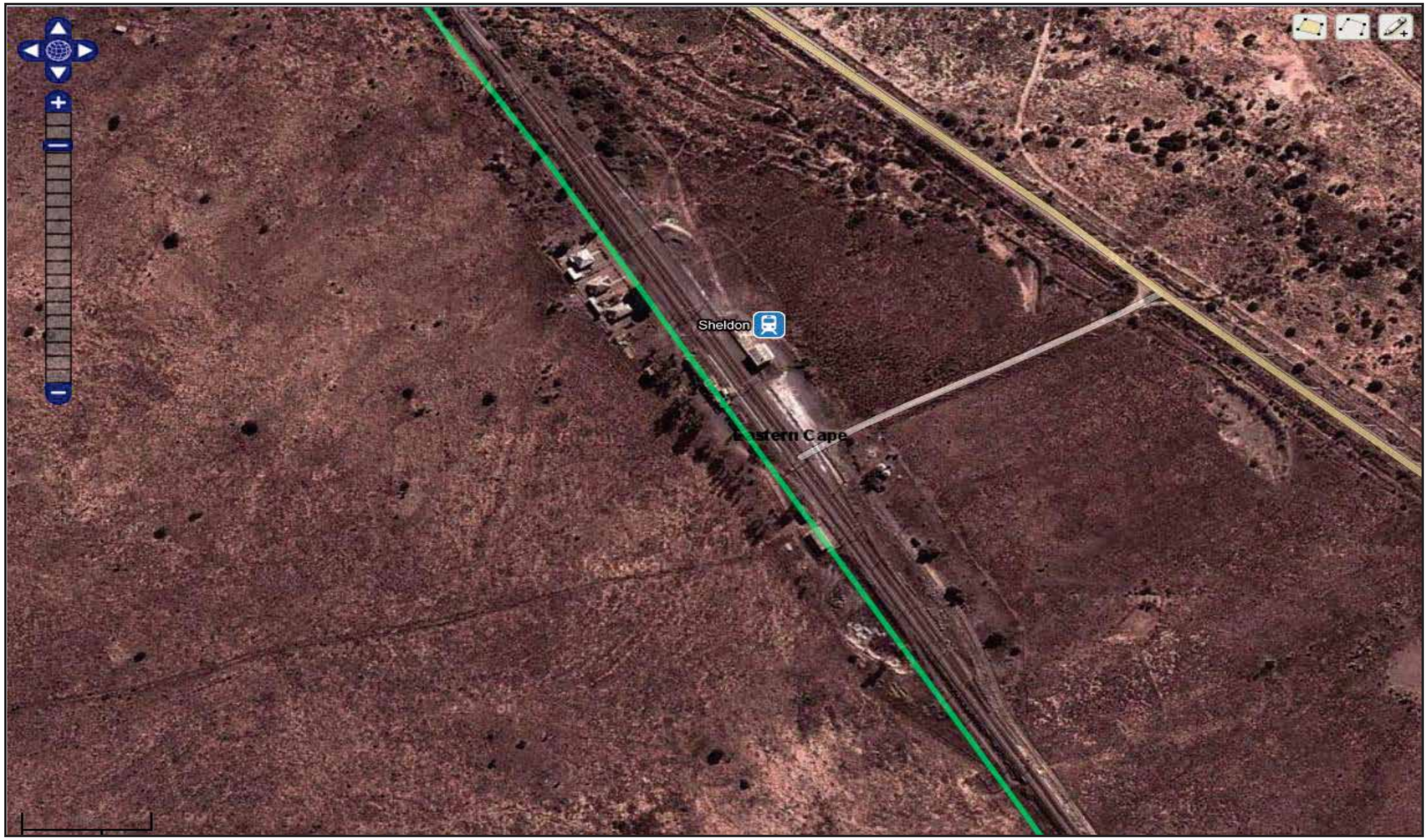


Figure 43: Aerial view of the proposed Sheldon loop extension

4.2.10 Ripon to Kommadagga

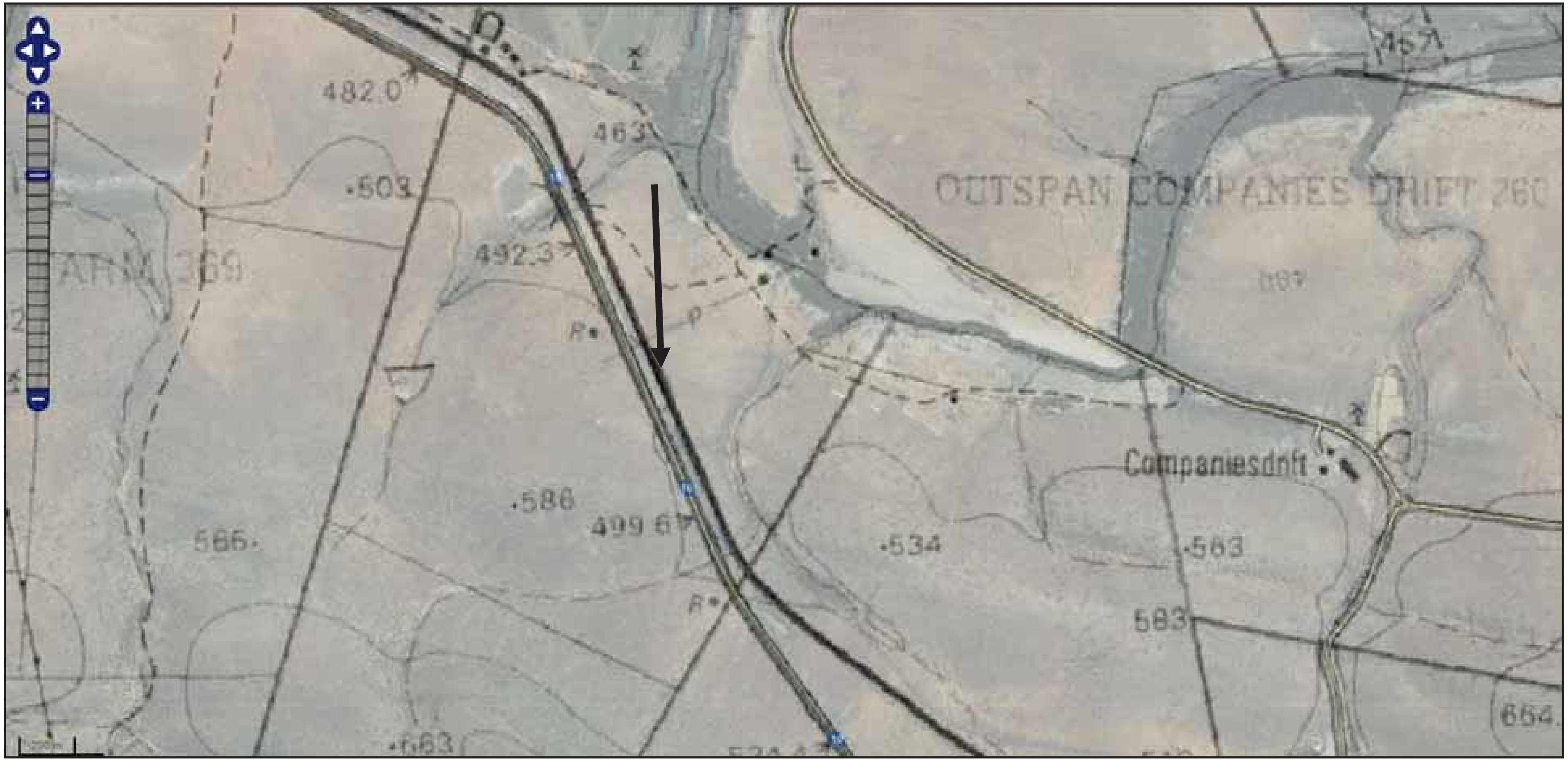


Figure 44: Downhill section between Ripon to Kommadagga Stations (SAHRIS, 2013)

Safety • Quality • Sustainability • Innovation

Figure 45: Aerial view of the downhill section south towards Kommadagga Station (SAHRIS, 2013)

Figure 46: Kommadagga Station (SAHRIS, 2013)

5. Approach

This section summarises the approach, identify concerns and propose mitigation measures focusing on the sections from Hotazel to Kimberley (Area 1) and De Aar to Port of Ngqura (Area 3).

The first step was to undertake a gap analysis to identify where further studies were required, following on from the assessment done by Archaic in 2008. Although a significant portion of the heritage resources identified during that assessment are situated outside of the development footprint, the results also showed that further heritage investigations were necessary to have a clear understanding of the range of heritage resources that exist alongside/within the proposed railway line development route and stations.

As such, the main focus of this heritage impact assessment was on identifying areas where construction activities may impact on potential heritage resources, building on and adding to those resources identified already. Furthermore a detailed heritage management plan was prepared that focuses on structures, cultural landscapes, archaeological sites, paleontological sites, indigenous groups and heritage objects.

The specific terms of reference for the Phase 1 Heritage Impact Assessment are as follows:

- Provide a description of the archaeology, and cultural heritage of the project development route and identify/map any sites of archaeological or cultural significance that may be impacted by the proposed project. **Note**: The palaeontology impact assessment has been completed as part of a separate specialist study
- Undertake an archaeological reconnaissance survey to locate, identify and record the distribution of archaeological sites on th**e su**rface and against the natural geographic as well as environmental background
- Assess the sensitivity and conservation significance of any sites of archaeological or cultural heritage significance affected by the proposed development
- Make practical recommendations for the protection and maintenance of any identified and significant archaeological or cultural heritage sites that may be affected
- Provide guidance for the requirement of any permits from SAHRA, Heritage Eastern Cape and Ngwao Boswa Kapa Bokoni (Heritage Northern Cape) that might be needed

5.1 Heritage Impact Assessment Objectives

The specific project objectives are as follows:

- Identify major heritage resources issues that may result in a risk to the project or may be a potential fatal flaw
- Heritage resources of significance will be preserved and managed according to an approved Heritage Management Plan (HMP)
- Minimise the adverse impacts on heritage resources that are positioned on the surface or placed in situ

- Identify the areas where permanent impact on tangible as well as intangible heritage resources needs to be undertaken within a controlled environment
- Avoid impacts on communities of Indigenous Peoples or minimise the impact as far as possible

5.2 Legislation and Guidelines

SAHRA is a statutory organisation established in terms of the National Heritage Resources Act (No. 25 of 1999) as the national body responsible for the protection of South Africa's cultural heritage resources. SAHRA manages the administration of permits for:

- Destruction, alteration or demolition of structures older than sixty years
- Needs and desirability permits linked to development activities
- Sampling permits that allow for the removal of heritage objects for research purposes or rescue archaeology
- Rock art documentation permits
- Grave exhumation and removal permits
- Archaeological excavation permits

The need for input with respect to heritage resources is primarily triggered through statutory requirements, the nature and degree of the potential impact's significance, and concerns raised during the stakeholder consultation process (Provincial Government Western Cape, 2005)

It is the legal responsibility of the developer to ensure that the cultural heritage, archaeological resources and paleontological sites that have been identified during the reconnaissance survey are protected and that the recommended mitigation procedures are implemented. It is also the responsibility of the developer to ensure that competent professionals are contracted to assist with the identification and protection of heritage resources.

6. Assumptions and Limitations

The following assumptions and limitations must be taken into consideration when reading this report.

6.1 Assumptions

The following assumptions are applicable based on the engineering scope of works:

- No structures older than sixty years will be demolished, disturbed or destroyed
- If such an activity is to take place a professional Archaeologist will need to be informed immediately and a permitting process will need to be initiated
- No grave sites will be affected, disturbed, altered or exhumed although if such a scenario is to take place a permitting procedure must be initiated with SAHRA's assistance and the input from a professional Archaeologist
- A HMP has been drafted to guide the management of heritage resources as part of the Environmental Management Plan

- Construction of site offices will be placed at the construction sites within the railway reserve areas

6.2 Limitations

The following limitations are applicable:

- The extent of the proposed development had logistical constraints that did not allow for a complete archaeological reconnaissance survey (fieldwork) at the full extent of the railway line which covers more than 1000 km. The study therefore focussed on the construction areas identified
- The development is of a linear nature which crosses several cultural landscape areas which range in terms of the heritage resources from high to low significance. The extent of this area limits the effectiveness of a detailed survey and therefore specific focus areas where development footprints are likely to result in destruction of potential sites were focused on

7. Project Methodology

The methodology includes the following:

- Provision of a sensitivity map that will indicate the tangible and intangible heritage resources positioned alongside and within the proposed development route, supported by the review of previous heritage impact assessment reports completed for previous archaeological survey projects
- Document, calculate and analyse the heritage resources identified during the reconnaissance survey to determine what constitutes a significant resource and how this can be managed
- List recommendations, alternatives as well as mitigation measures to inform the decision-making process
- Consult with local community members, authorities, museums, academic institutions and historical associations on a regular basis
- Ensure that public access to the identified heritage resources of national, provincial and local significance are not affected

8. What is Cultural Heritage

Cultural heritage resources are characterised by two different sub-disciplines which represent intangible and tangible heritage resources that define the field of heritage resources management. Tangible heritage resources can be documented using a quantitative method and intangible heritage resources are documented using a qualitative method.

The list of heritage resources that are protected in terms of the National Heritage Act (No. 25 of 1999) is inclusive of the following:

- Tangible moveable and immovable objects
- Property sites, structures, or groups of structures older than sixty years
- Palaeontological sites and objects
- Archaeological sites and objects
- Physical landscape features for example sacred rocks, lakes and waterfalls
- Places of historic, cultural, artistic and religious value

- Unique natural features
- Intangible forms of culture that are inclusive of cultural knowledge, innovations and traditional lifestyles

Cultural landscapes developed as a result of interactions between nature and man, are illustrative of the relationship that people/communities have with the natural environment (France_UNESCO cooperation agreement, 2006). Cultural landscapes are a combination of trees, forest, rocks, hilltops and associations with sacred natural features. Cultural landscapes are also associated with areas linked to events of bravery, survival and remarkable human events.

8.1 Archaeological Time Periods

Heritage resources and cultural landscapes are linked to specific time periods. In summary the various eras are as follows:

The Iron Age and farmer period occurred in southern Africa from Common Era (2000 years ago to 1950) to historical periods. The definition is divided between Early Iron Age (c. 200 CE to c. 1400 CE) and Late Iron Age (c. 1400 CE to 1800's (Archaic, 2008)). The historical period indicates dates from 1500s to present (Natalie Swanepoel, Amanda Esterhuysen and Phillip Bonner, 2007). The Iron Age is defined as a time period that occurred during c. 200 to c. 1000 Common Era, named as the early period, and c. 1000 to 1800's Common Era (Archaic, 2008).

The Stone Age time period is divided between three different time periods, namely:

- Early: c. 2 500 000 to 150 000 Before Common Era
- Middle: c. 150 000 to 30 000 Before Common Era
- Late: c. 30 000 Before Common Era until the historical time periods commenced

9. Archaeological and Historical Background

The Northern and Eastern Cape are evident of different types of human activities, settlement areas, cultural attributes and conflict time periods. The variety of cultural groups and communities has resulted in a unique cultural landscape that provides insight into the way people lived in the archaeological as well historical times.

9.1 Archaeological Background

The Northern Cape has traces of various types of archaeological sites inclusive of prehistorical and historical sites. A range of these sites are positioned next to the rivers, hilltops and pans. The Northern Cape is evident of rocky outcrops and river banks that were used by hunter gatherers to develop temporary camping areas to have access to water and hunting resources.

The Northern Cape is evident of the occurrence of a variety of rock art images, Stone Age sites and palaeontological significant areas. The historical sites are mostly related to the siege of Kimberley and the South African War. Stone Age sites have been identified in the past by archaeologists in the well known Wonderwerk Cave located in the Kuruman Hills, Postmasburg, Doornfontein, Beeshoek and Kathu. Specularite workings, Later Stone Age and Early Middle Stone Age have been identified in Lylyfeld, Demaneng, Mashwening, King, Rust & Vrede, Paling, Glucester and Mount Huxley to the northern side. According to archaeological records rock art sites have been identified at Beeshoek and Bruce.

Evidence of Later Iron Age (LIA) early farmers occur in the close vicinity of Kuruman. The early farmers came in contact with the Khoisan groups known as the Late Stone Age (LSA) peoples. Most of the LSA peoples were incorporated in the LIA communities and this period is represented at the Blinkklipkop specularite mine close to Postmasburg.

In terms of archaeological records and reports completed by heritage specialists various old mine works occur on the ridges to the west of the Glosam railway line siding (Pelser A J, 2012). The Glosam railway siding is positioned at the Tsantsabane Local Municipality in the Siyanda district of the Northern Cape.

The 18th century was defined as a conflict time period when the Griqua, Korana and white settlers were competing for the availability of land. This period is also known for the occurrence of the Mfecane or the so called Difaqane that resulted in a time period of instability that started in the middle 1820's. The conflict time period related to the Mfecane or Difaqane was the result of the influx of the then displaced people. The continuous conflict resulted in tribal groups migrating to hilltop areas in the need of finding safe environments.

The Platfontein area on the way to Barkley West is evident of the oldest indigenous group of people in Southern Africa. The San group is named the !Xun and Khwe that form part of a larger Khoi San category. In terms of historical records the !Xun is originally from South Angola and the Khwe from the West Caprivi in Namibia.

9.2 Historical Background

- The history of mining

North of Kimberley the Kamfersdam mine and dump are of historical value. Kamfersdam is associated with historical mining and diamond digging camp sites. The mine area was also used by the Boers during the South African War to position their ammunitions.

- South Africa's Railway History

South Africa's railway system dates back to the 1860's and is one of the largest on the African continent. The few lines that originated in the 1870's to 1880's were part of the historical time period associated with the finding of gold and diamonds. Various railway administrations and departments originated during the development of colonies as well as the Boer republics. These systems were combined in 1910 to develop one railway map (De Jong R. C., 2002). The discovery of minerals in the area between Hotazel and Kimberley has resulted in the need for the development of a railway line. Various sections were originally identified to be of urgent need in transportation of goods via the use of a railway line. The first section that received railway line infrastructure was Kimberley to Barkley West and thereafter the railway line was further developed between Barkley West to Koopmansfontein (Historical and Heritage Research Consultants, 2008). Afterwards the line was extended to Postmasburg and eventually reached Lohathla, Sishen and later Hotazel.

During 1922, Borrelskop featured as an area that needed a railway station and the section between Longlands as well as Delportshoop was identified for the development of a railway siding (Historical and Heritage Research Consultants, 2008). It is estimated that the railway line between Kimberley, Barkley West and Koopmansfontein was developed between 1922 and 1930.

In 1928, with the cooperation of the Forestry Department, the South African Railways decided to develop railway infrastructure between Postmasburg, Koopmansfontein and Danielskuil to the Maremane Native Reserve in Postmasburg (Historical and Heritage Research Consultants, 2008).

This route appeared to be the closest to the Kathu Forest Reserve that required goods transportation to the Postmasburg mines (Historical and Heritage Research Consultants, 2008).

The Groenwater area was managed by the Department of Native Affairs and they had to be consulted when land was needed for a railway siding. The affected local community members at Groenwater were compensated.

The railway line between Koopmansfontein and Postmasburg was approved for construction in 1929 and the infrastructure was in full operation during 1930. After the depression years that occurred between 1930 and 1936, the railway line was extended to Lohathla.

In 1953 the railway line was extended to Sishen because of an increase in manganese ore mining and the need of Kuruman miners to export their livestock to markets in the republic. Although farmers indicated their needs in terms of livestock transport, the decision was mostly based on the need of the manganese mines to export their material. Interest in manganese mining extended to Black Rock and Kathu, but as a result of cost implication the approval of such an infrastructure development was declined in 1952.

The South African Manganese Limited Company applied for a second time that a railway line should be developed between Sishen and Hotazel during 1959. A concern was that a lack of water existed between Hotazel and Kuruman that was needed for the locomotives. In the end the construction was approved by the South African government for development in 1959. The electrification of the railway line between Postmasburg and Hotazel occurred in 1966 (Historical and Heritage Research Consultants, 2008).

- Diamond Digging History

Diamond digging commenced in Kimberley during 1871 and ended by 1914 (The Big Hole Kimberley, 2012). The area was characterised historically and is still characterised today by the surroundings of original buildings occupied by the diamond diggers, diamond buyers and other business communities. De Beers has been mining in the area for the last 120 years and since the end of the underground mining activities the region has changed into a unique heritage landscape.

A decline of liberalism was experienced in the diamond fields of Kimberley during 1886. A well known parliamentarian from the Cape indicated that Cecil John Rhodes proposed to influence the vote by incorporating the mass working class in the political structures of democracy (Rob T., 1981). An opposition was present in the political arena that was adopted during the early Diamond Field days (Rob T., 1981) . The Kimberley area was dominated by merchants with interests in an expanding commodity market that was being challenged by a class of industrialists (Rob T., 1981). A clear population shift occurred in 1872 after an increase of diamond digging activities that is an estimate increase of 28 000 to 50 000 people (Rob T., 1981).

The Great Depression that occurred in 1873 resulted in the migration of diggers from Kimberley to the Gold Fields of Pilgrim's Rest (Rob T., 1981). During 1875 the population of the diamond fields was reduced and the majority of the people were concentrated around the richest diamond pipe named Kimberley mine (Rob T., 1981).The area had four mines, but the Kimberley pipe attracted most of the diggers and resulted in an average of 470 claims of ten hectares in extent that were further subdivided in smaller portions (Rob T., 1981).

- South African War 1899-1902

The South African War, also known as the Anglo - Boer War, has left a footprint of historical archaeological sites related to the siege of Kimberley between 1899 and 1900. A range of encampments and fortifications were developed in the area that is still visible today.

- Iron Age Groups in the Northern Cape

Archaeological evidence showed that Tswana speaking Iron Age groups have inhabited the areas north of Postmasburg. A variety of iron and copper artefacts of Tswana origin have been discovered. Traces of specularite which could have been from the Postmasburg area provide an indication of prehistorical trading activities in the area (Humphreys A. J., 2009 reproduced).

- Archaeological - Historical evidence from the Eastern Cape

It has been identified that from the late 17th century onwards, that an increasing number of European travellers entered the Eastern Cape. Contact between the European travellers and hunter-gatherers were limited. It seems that most of the historical contact occurred between the Colonial people and the pastoralists. In terms of historical records the section at the lower Fish River was a combination of Khoi and Xhosa pastoralists who struggled to maintain their social lifestyle in the light of an increase of landuse related to cattle grazing (Hall S.L., 1986).

- Colonial History Eastern Cape

Britain experienced an unemployment problem after the Napoleonic conflict years. The British government decided to support immigration of their citizens to the Cape Colony in 1820. The settlers first reached Table Bay and were then sent to Algoa Bay that is currently known as Port Elizabeth (Godlonton R., 2012).

A British governor in South Africa, named Lord Somerset, supported British citizens to settle at the frontier area positioned in the Eastern Cape. The request for settlement had a specific reason and that was to defend the eastern frontier against the Xhosa speaking people. The second agenda was to increase the quantity of English-speaking people (Godlonton R., 2012).

Life at the border was difficult and some of the settlers decided to rather move to Port Elizabeth, Grahamstown and East London. The few settlers that decided to stay on decided to contribute to agricultural activities, planting of maize, as well as rye and barley. Wool farming became popular in the area that resulted in the development of trading relationships between the border and Grahamstown as well as Port Elizabeth (Godlonton R., 2012).

- Rock Art Engravings Northern and Eastern Cape

Rock engravings are mostly found in the interior plateau for example in Kimberley and the Karoo (Lewis Williams D.; Dowson T., 1989). The Wonderwerk Cave (Northern Cape) archaeological excavations and research have indicated that rock engravings were evident more than 10 000 years ago (Lewis Williams D.; Dowson T., 1989). Evidence exists of rock art paintings occurring in caves and shelters at the Kuruman Hills, Ghaap Escarpment and scattered sites in the Karoo (Morris D., 1988).

Rock engravings have also been identified at Driekopseiland that is positioned in the close vicinity of Kimberley Town (Butzer K.W., Fock G.J., Scott L. and Stuckenrath R., 1979).

Driekopseiland is evident of more than ninety percent of geometric engraving sites (Morris D., 1988). Geometrics have been identified at the Kuruman valley and the middle Orange area (Morris D., 1988). Engravings tend to be found at rock walls, low outcrops, or clusters of surface stone (Butzer K.W., Fock G.J., Scott L. and Stuckenrath R., 1979).

10. Findings

Heritage resources of significance were identified during the reconnaissance survey during March 2012 to April 2012. The emphasis of the survey was placed on areas that may experience a direct impact or change. Additional information has been provided to highlight the occurrence of different types of heritage resources that occur in close vicinity of the proposed development areas and to ensure that those areas are protected if a change in scope occurs.

The screening of the proposed development area indicated that significant cultural landscapes, inclusive of the footprints of the San, the South African War, and historical diamond digging areas were within and around the development footprint. The historical railway lines, historical structures and foundations which are part of the rail industrial archaeology have also been identified and added to the significant heritage resources that are positioned alongside the existing railway line. Refer to the map book (Appendix A) indicating where heritage resources have been identified.

At Sishen a new loop is proposed. This area is highly disturbed because of the occurrence of intensive mining activities. Previous heritage impact assessment reports note a cluster of Stone Age sites close to Kathu and the Sishen areas. It is therefore advised that monitoring occurs before and after construction.

The proposed Mamathwane Rail Compilation Yard covers an area of 120 ha that is proposed to be placed next to the existing railway line. Although the area is already disturbed because of railway activities, it must be emphasized that in terms of previous archaeological impact assessment reports, a high density of stone tools were identified in the close vicinity. It is recommended that monitoring occurs before and during construction.

The criteria of impact were reliant on the following scenarios:

- Is the impact expected to be direct/indirect
- What is the cumulative aspect
- What is the duration and scale of the impact

- What is the significance of the impact?

10.1 Area 1 (Hotazel to Kimberley)

The table below lists the location where construction is proposed and the type of heritage resources that have been identified.

Table 10-1: Findings between Hotazel to Kimberley

Area	Coordinates		Description	Position in relation to the railway line	Mitigation	Nature of Impact before mitigation	Nature of Impact after mitigation
	South	East					
Ulco Station	28°21'52.75"	24°18'22.01"	Cultural landscape, historical buildings and old railway line	65 metres west	No construction should occur within 50 metres from the existing railway line	Medium	Low
Gong Gong Station	28°28'43.93"	24°26'30.39"	Old railway route and bridge Stone walling	7 metres west The historical structures are positioned relatively close to the railway reserve.	The historical structures are positioned relatively close to the railway reserve. Construction should be limited to the railway reserve area	Medium	Low
Fieldsview Station and surroundings	28° 35' 44.0"	24° 40' 27.9"	!Xun and Khwe cultural landscape	Borders both sides of the reserve	The area is known to be part of the !Xun and Khwe landscape and regular engagement with these communities should occur	Medium	Low
North of Fieldsview Station (6km)	28° 32' 16.0"	24° 37' 25.4"	Old railway structure foundation	5 metres east The historical structure is positioned relatively close to the railway reserve.	Construction should be limited to the railway reserve area	Medium - Low	Low

10.1.1 *Area 1 (Hotazel to Kimberley) Maps*

The following section provides maps and photographs that visually display the areas that are proposed to be developed (Please refer to subsection 2).

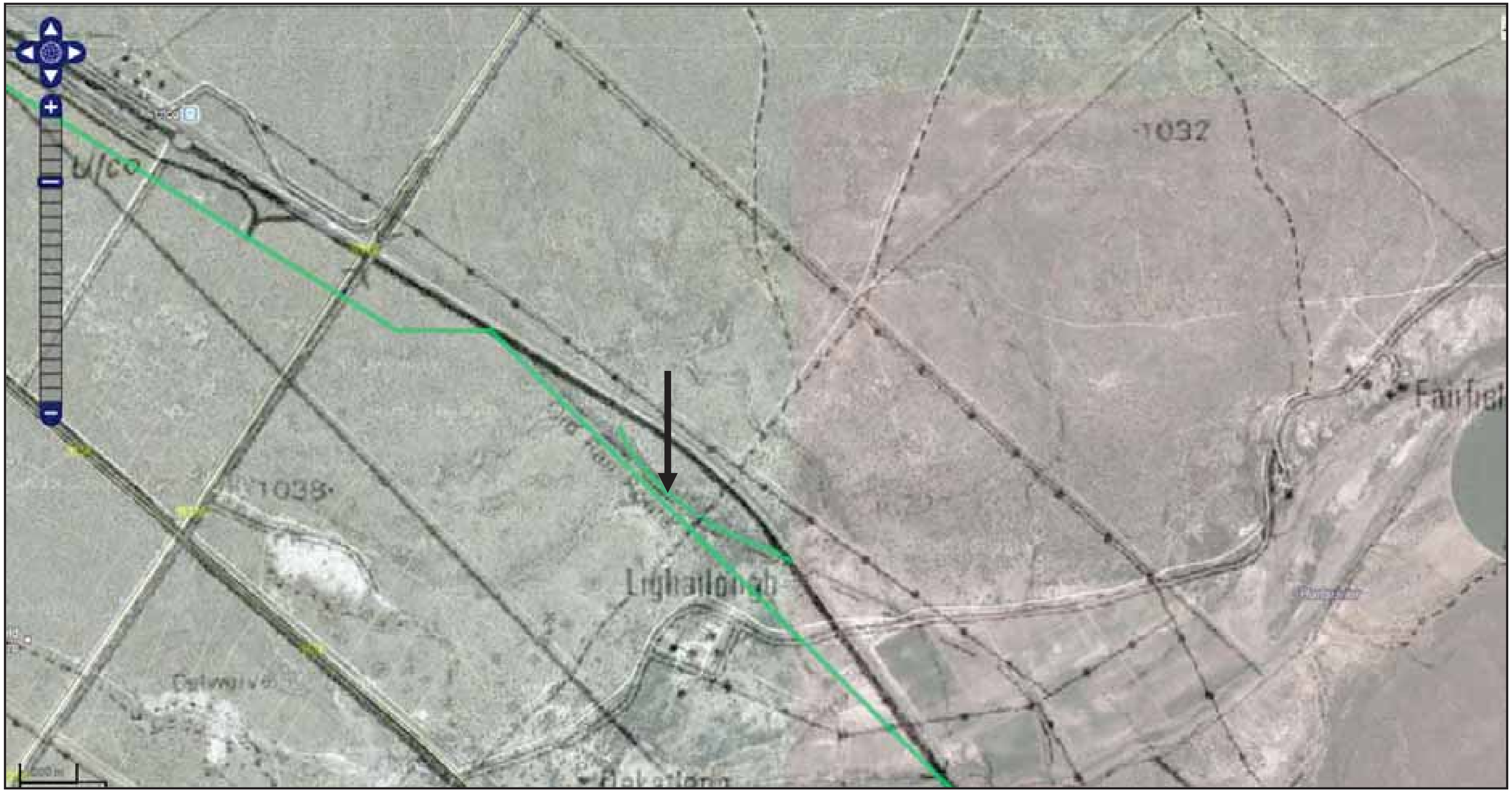


Figure 47: Ulco old railway line situated 65 metres west from the existing reserve area (SAHRIS, 2013)

Figure 48: Ulco loop extension (SAHRIS, 2013)

Figure 49: Ulco Station

Figure 50: Railway reserve at Ulco Station

Figure 51: Railway buildings at Ulco Station

Figure 52: Historical railway structures and railway within the reserve at Ulco Station

Figure 53: Old railway features at Ulco Station

Figure 54: Area south of Ulco Station, towards Ghaap

Figure 55: Gong Gong Station and the area marked in green is evident of an old railway line (SAHRIS, 2013)

Figure 56: Gong Gong Station (SAHRIS, 2013)

Figure 57: Gong Gong Station and old railway line indicated by the green section (SAHRIS, 2013)

Figure 58: Gong Gong Station

Figure 59: Landscape surrounding Gong Gong Station

Figure 60: Historical bridge positioned seven metres west of the existing railway line at Gong Gong Station

Figure 61: Old railway line between Gong Gong and Winter's Rush Stations

Figure 62: Stone walling situated west of the railway line and south of Gong Gong Station

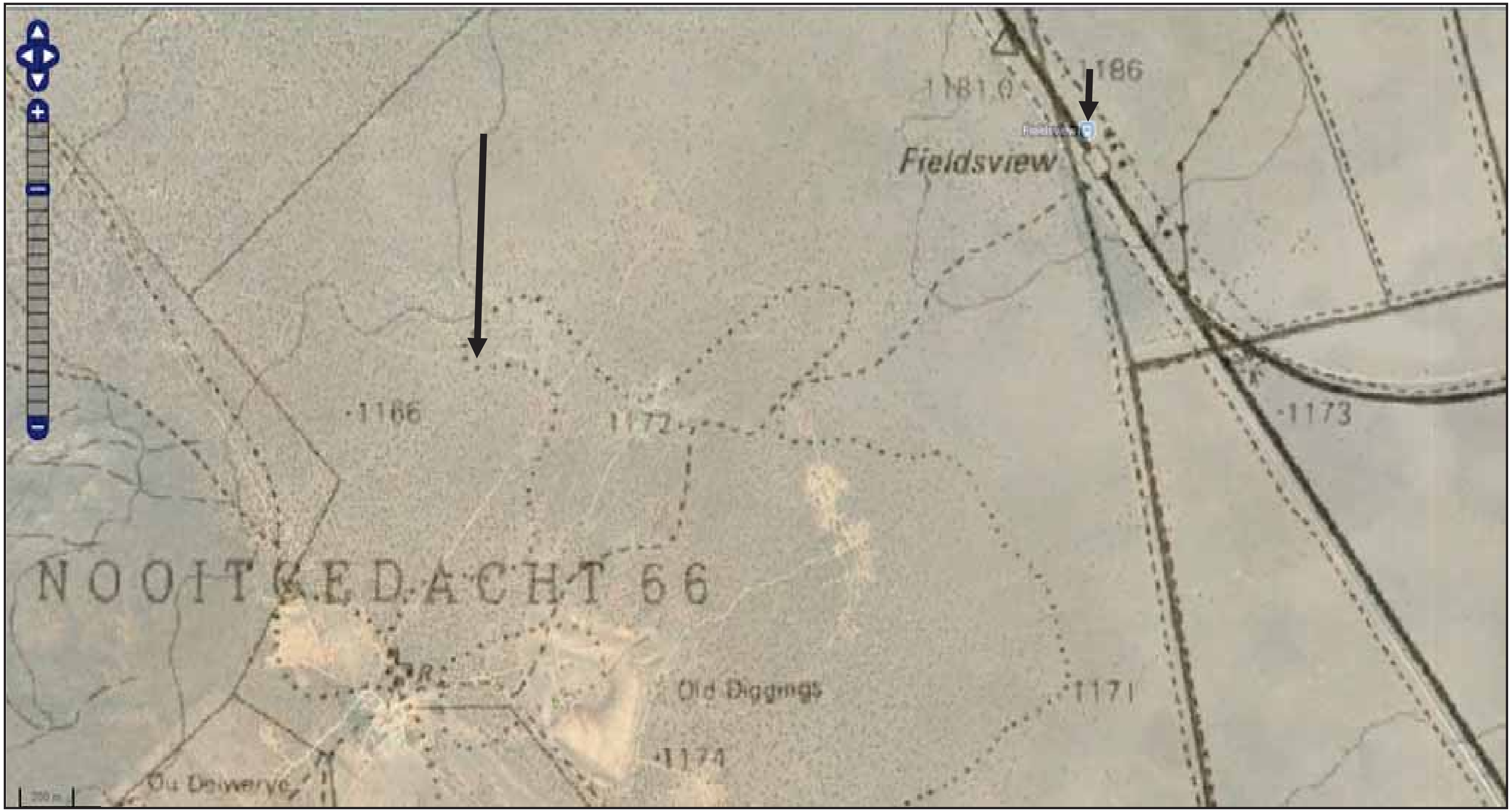


Figure 63: Fieldsview Station and surrounding area. The area is particularly known for the historical diamond digging history (indicated by the arrow) (SAHRIS, 2013)

Figure 64: Fieldsview Station

Figure 65: Fieldsview Station and associated railway infrastructure. No heritage resources have been identified within the railway reserve, but the area is bordered by the !Xun and Khwe cultural landscape

Figure 66: The !Xun and Khwe cultural landscape borders the existing railway reserve. This photograph has been taken with the area situated west of the existing fencing line

Figure 67: The !Xun and Khwe communities are living in an area called Platfontein. The actual position of the living area is located within 7km west of the railway reserve, but the surrounding area is part their cultural landscape.

Figure 68: Close up view of the area that borders the existing railway line south of Fieldsview Station and west of the fence line

Figure 69: The railway reserve south of Fieldsview Station

10.2 Area 2 (Kimberley to De Aar)

This area has been dealt with in a separate Phase 1 Heritage Impact Assessment report.

10.3 Area 3 (De Aar to Port of Ngqura)

The heritage resources identified at the proposed development areas are inclusive of old railway infrastructure (housing, old railway lines and foundations) at Burgervilleweg, Rosmead, Linde, Tafelberg, Knutsford, Drennan, Thorngrove, Cookhouse, Golden Valley, Sheldon, Ripon and Kommadagga.

Kommadagga is particularly sensitive towards the occurrence of Stone Age material. After a change in scope of work, Kommadagga Station and surrounding areas will not be impacted upon by the proposed development. The reconnaissance survey focused on areas located within the railway reserve and where the actual construction is proposed to occur.

Table 10-2: Directly impacted areas between De Aar and Port of Ngqura

Area	Coordinates		Description	Position in relation to the railway line	Mitigation	Nature of Impact before mitigation	Nature of Impact after mitigation
	South	East					
Burgervilleweg	30°49'26.29"S	24°17'31.31"E	Various old railway structures and an old homestead are situated at the crossing station	Historical railway structures are situated 50 metres west of the existing railway line. An old homestead is positioned 50 metres east of the reserve.	The railway structures and homestead should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	High	Medium
Rosmead	31°29'25.38"S	25° 7'9.29"E	Historical structures are located west and east of the station The area is occupied by local community members and schools are situated in the vicinity	The historical structures are situated within 20 to 100 metres from the existing railway line	The historical structures should not be impacted by the proposed development. If structures need to be demolished a permit application must be completed	High	Medium
Linde	30°59'26.03"S	24°38'21.88"E	Few historical structures are positioned north west of the existing railway line Scattered Middle Stone	The historical structures are situated within 50 metres of the reserve area Scattered Middle Stone	The historical structures should not be impacted by the proposed development. If structures need to be demolished a	Medium	Low

			Age Material	Age Material has been identified 130 metres west of the reserve area	permit application must be completed The Stone Age Material should not be impacted by the proposed development		
Tafelberg	31°37'3.92"S	25°14'26.04"E	Historical structures are located west and east of the station	The historical structures are situated within 50 to 100 metres from the existing railway line	The historical structures should not be impacted by the proposed development. If structures need to be demolished a permit application must be completed	High	Medium
Tafelberg Historical Church and other structures	31°36'55.37"S	25°14'25.87"E	Historical church	The historical structure is located north east of Tafelberg Station Historical structures have been identified 200 metres north west of the reserve	The historical structures should not be impacted by the proposed development. If structures need to be demolished a permit application must be completed	High	Medium
Knutsford	31°56'53.65"S	25°29'54.40"E	Knutsford is bordered by agricultural land Scattered stone tool material	Few structures are located west and east of the existing railway line. The features are positioned within 50 to 100 metres from the	The historical structures should not be impacted by the proposed development. If structures need to be demolished a permit application must	Medium	Low

				reserve South East of Knutsford Station, scattered stone tool material occur within a 130 metres of the reserve	be completed The Stone Age Material should not be impacted by the proposed development		
Drennan	32°26'29.52"S	25°44'29.74"E	Various old railway structures are situated at the crossing station	West and east of the existing railway line	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	High	Medium
Thorngrove	32°38'8.51"S	25°48'35.87"E	Few old railway structures	West and east of the existing railway line	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	High	Medium
Cookhouse	32°44'42.58"S	25°48'24.90"E	Old and contemporary railway structures	West and east of the existing railway line	The railway structures should not be impacted by the proposed development. If the	High	Medium

					structures need to be demolished a permit application must be completed		
Golden Valley Station and surroundings	32°48'38.13"S	25°47'20.36"E	Station that is evident of historical railway structures	The railway structures are situated west of the existing railway line	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	High	Medium
Sheldon	33° 0'50.28"S	25°50'21.68"E	Historical Station	Railway structures are positioned west and east from the existing railway line	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	High	Medium
Ripon	33° 5'36.27"S	25°52'14.65"E	Historical Station evident of contemporary and historical railway structures	Railway structures are positioned west and east from the existing railway line	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be	High	Medium

					completed		
Kommadagga Station and surroundings	33° 7'1.24"S	E25°53'46.28"E	The site is situated within 70 metres from the existing railway line	Medium density middle and late stone tool material located in the railway reserve and development area	Phase 2 removal of artefacts and detailed site recordings	High	Medium
Kommadagga Station and surroundings	33° 7'6.71"S	25°53'58.56"E	The site is situated east from the existing railway line within the reserve area	Medium density middle and late stone tool material located in the railway reserve and development area	Phase 2 removal of artefacts and detailed site recordings	High	Medium
Verby	33°26'26.82"S	26° 0'30.03"E	Verby Station is bordered by agricultural land	Few structures are located 50 to 100 metres west and east of the reserve	The railway structures should not be impacted by the proposed development. If the structures need to be demolished a permit application must be completed	Medium	Low

10.3.1 Burgervilleweg Loop Extension

Figure 70: Historical railway structures and an old homestead are located at Burgerville Station (SAHRIS, 2013)

10.3.2 *Rosmead Loop Extension*

Figure 71: Rosmead Historical Station (SAHRIS, 2013)

Figure 72: Rosmead Historical Station

Figure 73: Rosmead historical structures and railway line

10.3.3 Linde Loop Extension

Figure 74: Linde is evident of a few historical structures (SAHRIS, 2013)

10.3.4 Tafelberg Loop Extension

Figure 75: Tafelberg Station is evident of old railway structures and north of the station an old church is situated east of the existing railway line (SAHRIS, 2013)

10.3.5 *Knutsford Loop Extension*

Figure 76: Few historical structures are evident at Knutsford Station (SAHRIS, 2013)

10.3.6 Drennan Loop Extension

Figure 77: Drennan Station and various old railway structures (SAHRIS, 2013)

10.3.7 Thorngrove Loop Extension

Figure 78: Thorngrove Station evident of old railway buildings (SAHRIS, 2013)

10.3.8 Cookhouse to Golden Valley Doubling

Figure 79: Cookhouse Station. It is associated with contemporary and historical railway structures (SAHRIS, 2013)

Figure 80: Cookhouse to Drennan

Figure 81: Golden Valley Station and historical structures

Figure 82: Historical structures at Golden Valley Station

Figure 83: Railway infrastructure at Golden Valley Station

Figure 84: An access road towards Golden Valley Station

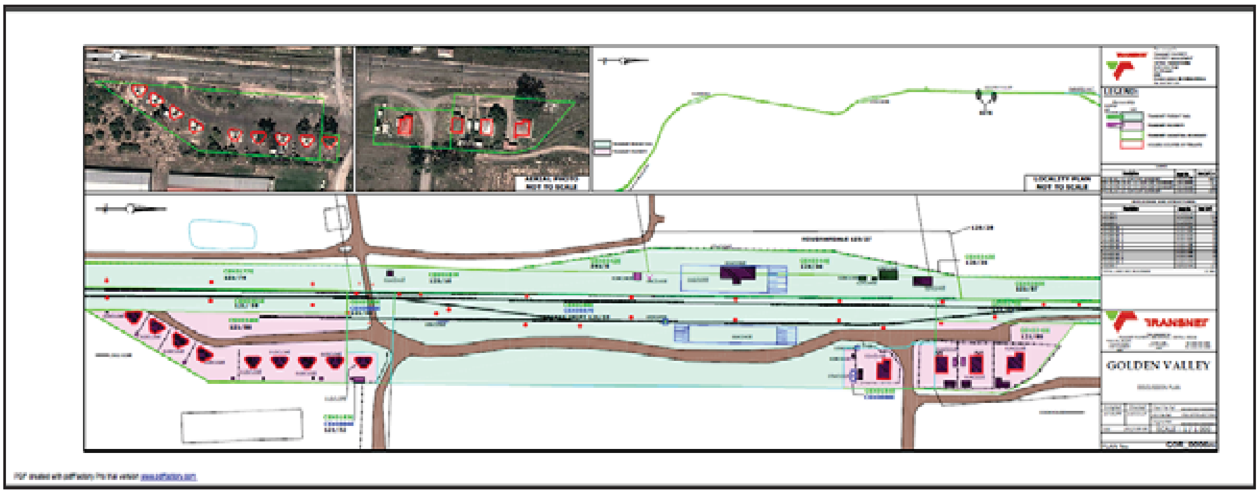


Figure 85: Golden Valley Plan displaying Transnet Properties (Transnet Properties, 2012)

Figure 86: Railway line south of Golden Valley Station. Historical and temporary structures are situated alongside the existing railway line

Figure 87: View of the railway line south of Golden Valley Station

10.3.9 Sheldon Loop Extension

Figure 88: Sheldon Station and doubling of the railway line

Figure 89: Sheldon Station evident of historical railway buildings

(SAHRIS, 2013)

Figure 90: Klein Vis Station situated 5 km south from Sheldon Station. The area is evident of historical station buildings (SAHRIS, 2013)

Figure 91: Sheldon Station historical buildings

Figure 92: Old railway buildings at Sheldon

Figure 93: The cultural landscape is particularly disturbed in the vicinity of the existing railway line

10.3.10 Ripon to Kommadagga Stations

The section between Ripon to Kommadagga will not be directly impacted upon, but an assessment was completed to confirm the significance of this area.

Figure 94: Ripon Station evident of historical railway structures (SAHRIS, 2013)

10.3.11 Kommadagga Station

Figure 95: View of the railway line heading towards Kommadagga Station

Figure 96: Railway reserve road heading towards Kommadagga Station

Figure 97: Station and line situated west from the existing railway line at Kommadagga Station

Figure 98: Historical water tank situated west of the existing railway line at Kommadagga Station

The water tank will not be destructed by the proposed development

Safety • Quality • Sustainability • Innovation

Figure 99: The surrounding environment at Kommadagga Station

The photograph indicates the area east from the existing railway line

Figure 100: School situated east from the railway reserve at Kommadagga Station

Figure 101: Various types of stone tool material were identified at the embankment displayed in the photograph

The embankment is situated west from the existing railway line at Kommadagga Station

Figure 102: Railway line positioned south of Kommadagga Station

Figure 103: Railway tracks and structure situated at Kommadagga Station

Figure 104: Stone tool material identified at embankment positioned west of Kommadagga railway reserve

Figure 105: Stone tool material identified at embankment situated west of Kommadagga railway reserve

Figure 106: Stone tool material at embankment situated west of Kommadagga railway reserve

Figure 107: Landscape photograph of Kommadagga Station and surrounds

11. Mitigation Measures and Recommendations

The following mitigation procedures and recommendations would assist in the protection of heritage resources at the identified cultural landscape areas:

- Construction activities should not impact on areas where historical railway buildings are positioned as indicated on the maps provided
- The historical railway structures (buildings, old railway lines, foundations) that are located at each station area, should be fenced and these areas must not be used for storing of construction material
- During construction if any heritage objects are discovered, the Environmental Officer (EO) must contact the professional Archaeologist that is on standby for project support. The Professional Archaeologist will visit the site and determine the significance of the heritage resources findings. If the findings are of importance, the Professional Archaeologist will inform SAHRA, Heritage Northern Cape (Ngwao Boswa Kapa Bokoni) and McGregor Museum (Provincial Site Recording Institute). A combined decision will be made on the way forward and work may only proceed after SAHRA has provided approval for construction activities to proceed at the area where the heritage objects were found
- Quarterly monitoring reports completed by the EO should be forwarded to SAHRA, Heritage Eastern Cape and Heritage Northern Cape (Ngwao Boswa Kapa Bokoni) to inform them of the conservation status at each historical station area
- A sampling and monitoring permit has been applied for that will allow for heritage resource rescue work if necessary. The permit will be used in the event that in situ archaeological material related to the South African War dumping sites, stone tool material or any other type of heritage objects are uncovered during earthmoving activities

12. The Way Forward

The section from Hotazel to Kimberley (Area 1) and De Aar to the Port of Ngqura (Area 3) consists of a variety of heritage resources sites that are mostly positioned outside of the railway line reserve areas. Stone walling and South African War fortifications that are positioned outside of the railway line reserve areas should not be impacted by the proposed development. The assumption is that a large section of the construction work will be limited to the railway reserve areas. If any type of work is proposed to commence outside of the railway reserve properties, SAHRA must be notified immediately. The reason for this is that fortifications, historical structures and archaeological sites could be destroyed when development is allowed outside of the mentioned boundaries.

13. Conclusion

A number of historical railway buildings, foundations and lines have been noted at several stations. These features should not be impacted upon without a permit from the heritage authority.

The proposed compilation yard has a larger impact related to the size of the proposed development than the new loops and loop extensions. The area is already disturbed as a result of past and existing mining activities. It is recommended that construction work stay within areas that have been developed in the past.

If any heritage resources are discovered during the earthmoving operations, it is advised that a professional Archaeologist is contacted immediately to guide the process.

In terms of the way forward the heritage impact assessment report will be externally reviewed and forwarded to SAHRA for review comment.

14. Bibliography

Butzer K.W., Fock G.J., Scott L. and Stuckenrath R. (1979). Dating and Context of Rock Engravings in Southern Africa. *Science, New Series, Vol. 203, No. 4386* , 1201 - 1214.
Hall S.L. (1986). Pastoral Adaptations and Forager Reactions in the Eastern Cape. *Goodwin Series, Vol. 5, Prehistoric Pastoralism in Southern Africa* , 42-49.
Archaic. (2008). *Final Report Heritage Resources Survey and Preliminary Assessment, Transnet Freight Line EIA, Eastern Cape and Northern Cape.* Pretoria: ERM.
De Jong R. C. (2002). *Railway Heritage at Risk.* Queenswood South Africa: Cultmatrix.
France_UNESCO cooperation agreement. (2006). *A Guide for African Local Governments, Cultural Heritage and Local Development.* Convention France_UNESCO.
Godlonton R. (2012). *South African History Online*. Retrieved from The first 1820 British Settlers arrive in South Africa.
Historical and Heritage Research Consultants. (2008). *Archival research final report.*
Humphreys A. J. (2009 reproduced). *A Prehistoric Frontier in the Northern Cape and the Western Orange Free State Archaeological Evidence in Interaction and Ideological Change.*
Lewis Williams D.; Dowson T. (1989). *Images of Power, Understanding Bushman Rock Art.* Johannesburg: Southern Book Publishers.
Morris D. (1988). Engraved in Place and Time: A Review of Variability in the Rock Art of the Northern Cape and Karoo. *The South African Archaeological Bulletin, Vol. 43, No. 148,* , 109-120.
Natalie Swanepoel, Amanda Esterhuysen and Phillip Bonner. (2007). *Five Hundred Years Rediscovered, Southern African Precedents and Prospects.* Johannesburg: Wits University Press.
Pelser A J. (2012). *A 2nd report on a Heritage Impact Assessment for the upgrade of Transnet's Glosam Siding.* Archaetnos Culture and Cultural Resource Consultants.
Provincial Government Western Cape. (2005). *Guidelines for Involving Heritage Specialists in EIA Processes.*
Rob T. (1981). The 1875 Black Flag Revolt on the Kimberley Diamond Fields. *Journal fo Southern African Studies, Vol. 7, No.2* , 194-235.
SAHRIS. (2013). SAHRIS.
South African Heritage Agency. (2012). *http://www.sahra.org.za/LivingHeritage.htm*. Retrieved from www.sahra.org.za.
Transnet Properties. (2012). Golden Valley Discussion Plan.
Transnet Properties. (2012). Plan showing Transnet Property Residential Assets Ripon.

Elize Becker
EB:EB

Appendix A : Heritage Map Book

Appendix B : Additional Site Photos and Descriptions

Site Photo	Description
	**Barkley West** railway reserve. The reserve areas are highly disturbed and heritage resources located in these areas tend to be out of context
	Commercial buildings that border the **Barkley West** reserve areas. The photograph is an indication of the disturbed cultural environment

	**Borrelskop** station featured during the start of the railway development in 1922 Traces of the old station foundations are visible No construction is scheduled to take place in this area
	Traces of fortifications are evident alongside the existing railway line. The density of these features increases when entering **Bad Hope** Station and surroundings

	Collapsed stone walling evident next to the existing railway line in the close vicinity of **Bad Hope** Station The area will not be affected by the proposed development
	Further traces of collapsed stone walling in **the Bad Hope** area

	**Fieldsview** cultural landscape The cultural landscape is an extension of the Footprints of the San that occurs on the opposite site of road between Kimberley and Barkley West
	Old railway lines, structures and foundations occur in the **Fieldsview** reserve areas

	Example of access roads used to reach reserve areas between Gong Gong and Fieldsview
	Service roads are located in the reserve areas and as a result archaeological features have been disturbed or are out of context

	The railway reserves are mostly entered via crossing farming properties. These areas are highly disturbed and archaeological features are destroyed because of historical developments. The type of developments refer to are access roads, service roads, the railway line and fencing
	The existing reserve area at **Groenwater** Station and surrounds are a combination of the railway line, the reserve area and scattered traces of old pieces of railway building material

	**Ghaap** cultural landscape is known for the occurrence of significant palaeontological resources. Secondly various types of significant information regarding the Diamond Digging history occur in this area. The heritage resources are not positioned in the reserve areas
	**Kneukel** occurs close the Ghaap Station and is evident of relatively new structures

	**Groenwater** and surroundings. The service road has recently been upgraded and as a result archaeological material are out of context
	A large traditional grave yard is positioned within 130 metres from the existing railway line at the **Groenwater** area. The burial ground belongs the Metsimetala Tswana speaking community

	An average of a hundred graves occur in the open field that belongs to the descendents of the Metsimetala community from **Groenwater**
	The grave of Kgosi Kweetsane is positioned in the **Metsimetala** traditional grave yard area. This area is of high heritage significance

	A distant picture displaying **Kgosi Kweetsane's** grave
	Approximately 10 unmarked graves are positioned within 50 metres from the current reserve area at **Groenwater**. No fencing occur at the grave or railway reserve area

	The environmental landscape that surrounds the graves mentioned above
	Large graves occur in the area positioned within 50 metres from the **Groenwater** reserve areas. The graves could belong to previous traditional leaders and they are of high sensitivity

	A 1931 grave that occur within 50 metres from the existing reserve area in **Groenwater**
	A new grave yard is positioned at the Groenwater area. The new burial ground is approximately 700 metres from the existing railway line

Safety ● Quality ● Sustainability ● Innovation

	This is the environment that borders the **Winterton** reserve areas
	Example of a railway crossing at **Winter's Rush**

	Old station foundations occur at **Winter's Rush** Station No construction is scheduled to take place in this area
	**Winter's Rush** bridge. No construction is proposed at this area

Safety ● Quality ● Sustainability ● Innovation

	Road on the way to **Silver Streams** and surroundings. No heritage resources of significance were identified within the railway reserve area
	Cultural landscape north of **Postmasburg** in the close vicinity of Sishen

	Cultural landscape north of **Postmasburg** in the close vicinity of Sishen
	**Canteen Kopje** archaeological site located within 300 metres of the railway line

	**Canteen Kopje** archaeological site located within 300 metres of the railway line
	**Diamantoord** Station. The cultural landscape is evident of South African War and Diamond Digging historical resources. No heritage resources are positioned in the reserve area

	Railway line north of **Sishen** on the way to Hotazel
	**Gong Gong** Station and relatively modern buildings

	**Gong Gong** historical bridge that is position within 50 metres of the reserve
	Railway line north of **Sishen** on the way to Hotazel

	Railway crossings at Kommadagga
	Railway crossings at Kommadagga

	Existing borrow pit area in close vicinity of Golden Valley. Borrow pit areas have displayed valuable evidence of middle and late Stone Age material
	Existing borrow pit area in close vicinity of Golden Valley. Borrow pit areas have displayed valuable evidence of middle and late Stone Age material

	Sections between Conway and Cypress Grove are evident of local community members living in historical houses. The structures will not be demolished, altered or destructed
	The railway line is part of the cultural landscape in the Eastern Cape area

	An example of a culvert that occurs in the Eastern Cape section
	Kommadagga is one of the areas that was identified to be of high significance in terms of the occurrence of Stone Age material

Safety ● Quality ● Sustainability ● Innovation

	The type of cultural landscape that borders the existing railway line reserve is typical of a Stone Age time period environment
	A culvert that occurs in the Kommadagga area

	Hilltop areas are positioned in close vicinity of the railway line that could display valuable archaeological material
	River banks have the potential to contain valuable archaeological material

	The Fish River railway bridge
	Golden Valley Station
	Golden Valley Station

	Scattered middle to late Stone Age material occur in Knutsford and surrounds
	High density middle to late Stone Age material occur within the railway reserve at Kommadagga Station

	Service road positioned next to the railway line at Kommadagga Station
	Slagtersnek Memorial

	Golden Valley cultural landscape
	In terms of previous heritage reports rock art engraving sites have been identified within 500 metres from the existing railway line at Golden Valley

	The area has the potential to display archaeological material and possible rock art sites.
	Local community members are living in the close vicinity of the Kommadagga railway line

Safety ● Quality ● Sustainability ● Innovation

	A single middle age hand axe identified at Kommadagga
	Stone tool material have been identified at the sand banks that occur next to the railway line

	Medium density Stone Age material identified within the Golden Valley Station reserve areas
	Various photovoltaic type developments have been proposed at the Golden Valley, Ripon and Kommadagga areas

	Stone structure positioned south of Visrivier area
	Blockhouse positioned next to the existing railway line at Visrivier area

Safety • Quality • Sustainability • Innovation

	Historical water towers positioned next to the existing railway line at Visrivier area
	The historical town of Visrivier

	Historical houses are positioned next to the existing railway line at the Visrivier area
	Historical stone wall or retaining wall is evident at the section south of Knutsford. Knutsford is also known for the occurrence of low to medium density stone tool material and evidence of the colonial historical resources

	River banks have the potential to contain valuable archaeological material
	Historical housing south of Kommadagga

	Irrigation farms that occur at Kommadagga area and surrounds
	Klipfontein graves (Archaic, 2008)

	Rosmead historical houses (Archaic, 2008)

Appendix D4

Noise Specialist Study

Noise and Vibration Impact Assessment for the Proposed Expansion of Transnet's Manganese Ore Export Railway Line: Northern Cape Component

Commissioned by:

ERM South Africa

Prepared by:

Demos Dracoulides

Ebot Arrey

CAPE TOWN

PO Box 60034, Table View 7439

Tel: +2721 551 1836

Fax: +2721 557 1078

DemosD@xsinet.co.za

Report No TRN-NVI-R01
June 2013

Table of Contents

List of Figures page

List of Tables page

Terminology, Acronyms and Definitions

Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
A-weighted sound level	A frequency weighting filter used to measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.
dB(A)	Unit of sound level. The weighted sound pressure level by the use of the A metering characteristic and weighting.
dBV	Vibration velocity level
deciBel (dB)	A measure of sound. It is equal to 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference sound pressure. The reference sound pressure used is 20 micropascals, which is the lowest audible sound.
Equivalent A-weighted sound level (L_{Aeq})	A-weighted sound pressure level in decibels of continuous steady sound that within a specified interval has the same sound pressure as a sound that varies with time.
Equivalent continuous day/night rating level	Equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) during a reference time interval of 24 h, including adjustments for tonal character, impulsiveness of the sound and the time of day.
GPS	Global Positioning System
IEC	Independent Electoral Commission
IFC	International Finance Corporation
Impulse time weighting	A standard time constant weighting applied by the Sound Level Meter.
ISO	International Organisation Standardisation
L_{A10}	The noise level exceeded 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis.
L_{A90}	The noise level exceeded 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis. It is generally utilized for the determination of background noise, i.e. the noise levels without the influence of the main sources.
L_{WA}	Sound power level in dB(A), re 10^{-12} W.
WS	Wind speed
Mtpa	Million tonnes per annum
OECD	Organisation for Economic Co-ordination and Development
PPE	Personal Protective Equipment
PPV	Peak Particle Velocity. The peak signal value of an oscillating vibration velocity waveform, usually expressed in mm/second.
PWL	Power level in dB(A).
Residual noise	Sound in a given situation at a given time that excludes the noise under investigation but encompasses all other sound sources, both

	near and far.
SA	South Africa
SANS	South African National Standard.
SLM	Sound Level Meter
WBG	World Bank Group
WHO	World Health Organisation

1 INTRODUCTION

In 2009, authorisation was granted for the upgrading of the manganese ore railway line between Hotazel in the Northern Cape Province and the Port of Ngqura in the Eastern Cape, in order to accommodate for an increase in the transportation capacity of Manganese from 5 million tons per annum (Mtpa) to 12 Mtpa.

Transnet SOC Limited, together with the manganese mining industry, identified the need to increase the export capacity further to 16 Mtpa. Therefore, it is proposed that the existing railway line be expanded to allow for the transportation of 16 Mtpa of manganese ore. As such, the changes to the original development proposal necessitate an additional environmental assessment.

The following has been proposed in order to facilitate the 16 Mtpa export capacity:

- Extension of several existing rail loops in both the Eastern and Northern Cape.
- The installation of two new rail loops in the Northern Cape.
- The construction of a new compilation yard at Mamatwane, situated approximately 22 km south of Hotazel in the Northern Cape.

DDA Environmental Engineers (DDA) has been appointed by ERM (South Africa) (Pty) Ltd to determine the baseline noise levels, and undertake the noise and vibration impact assessment for the proposed expansion.

The assessment for the proposed project has been divided into two reports, namely one for the Northern Cape and one for the Eastern Cape, based on geographic demarcation. The present report describes the noise and vibration impact assessment of the proposed upgrade of the railway line in the Northern Cape.

1.1 Terms of Reference

The proposed terms of reference for the baseline and noise and vibration impact assessment were:

- Establish the baseline noise levels around each loop.
- Determine thresholds of acceptable change and relevant noise standards to be complied with.
- Identify sensitive receptors at each loop that may potentially be impacted upon by the proposed loop extensions and compilation yard.

- Build a 3-dimensional noise impact model, in order to predict the future noise levels due to the construction and operation of each loop for comparison against regulatory and contractual limits.
- Identify and predict the noise impact of the proposed rail loop extensions and compilation yard during the construction and operation phases, as well as the assessment of significance before and after mitigation, if necessary.
- Assess potential vibrational risks associated with the proposed loop extensions and compilation yard.
- Propose mitigation measures, where necessary.

1.2 Study Area – Northern Cape

This report focuses on the portion of the proposed railway line to be upgraded, which is located in the Northern Cape between the towns of Hotazel and Kimberly. New loops are to be established at Witloop and Sishen, a new compilation yard at Mamatwane and the extension of the following loops:

- Fieldsview
- Gong-Gong
- Ulco
- Trewil
- Tsantsabane
- Postmasburg
- Glosam
- Wincanton.

The locations of these loops are shown in Figure 1-1 below.

- The proposed loop at Witloop is located approximately 11 km south of Hotazel, along the R380. The Mamatwane compilation yard is situated 11 km south-east of Witloop and lies adjacent to the Mamatwane Manganese Mine to the east.
- The Fieldsview loop lies approximately 7 km south-east of the town of Barkly West, and 11km north-west of Kimberley.
- The Gong-Gong loop is further away from Barkly West, 10 km to the north-west, along the R31. The Gong-Gong local community is located approximately 1.6 km south-west of the loop.
- The Ulco loop is situated 6.5 km north of Delportshoop town along the R31.

- The Trewil loop is within a remote area, approximately 61 km east of Postmasburg town and 7 km south of the R31.
- The Tsantsabane and Postmasburg loops are both located near the town of Postmasburg. The Tsantsabane is about 6 km north-east of the town, and the Postmasburg loop is situated just north of the town, about 600 m north of the R385, which traverses through the town. The area around these two loops is considered urban.
- The Glosam loop lies along the R325 road, 25 km north of Postmasburg town. The Glosam residential area is about 500 m north-west of the loop.
- The Sishen loop is north of the Glosam loop, about 30 km away. The Dingle residential area and an iron mine are approximately 3 km north-east of the loop.

All the loops are located in remote areas, except the Postmasburg loop, as it is located within close proximity of Postmasburg town. The sensitive receptors around the loops in the study area include residential areas, farm houses and farmland.

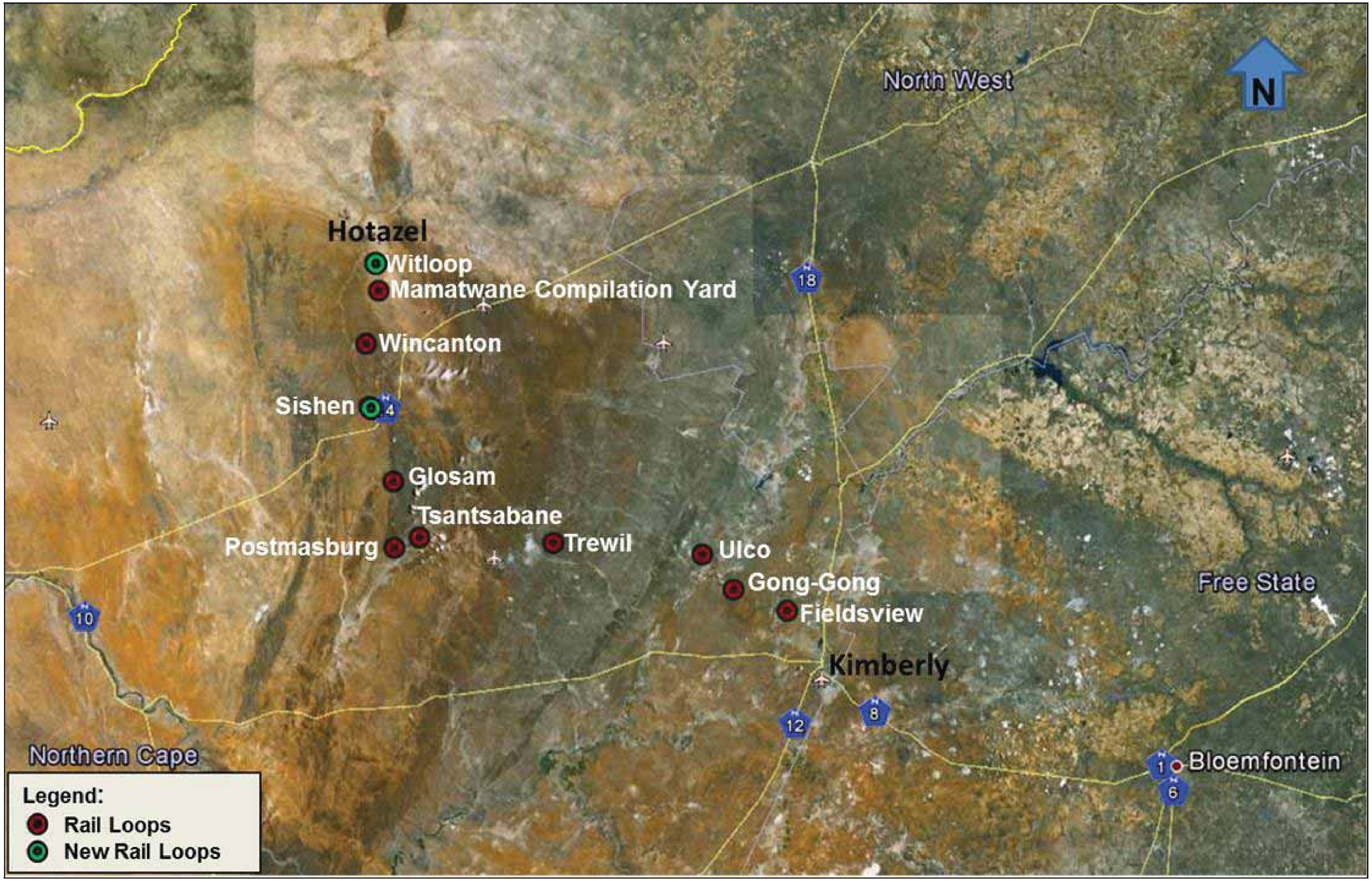


Figure 1-1. Northern Cape Railway Expansion Locality Map

2 NOISE AND VIBRATION BASICS, GUIDELINES AND LEGAL REQUIREMENTS

2.1 Noise Basics

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure or waves through a medium, such as air, water or a solid. Sound and noise are measured in units of decibels (dB). The dB scale is not linear but logarithmic. This means, for example, that if two identical noise sources, each producing 60 dB, operate simultaneously they will generate 63 dB. Similarly, a 10-decibel increase in sound levels represents ten times as much sound energy.

The human ear can accommodate a wide range of sound energy levels, including pressure fluctuations that increase by more than a million times. The human ear is not equally receptive to all frequencies of sound. The A-weighting of sound levels is a method used to approximate how the human ear would perceive a sound, mostly by reducing the contribution from lower frequencies by a specified amount. The unit for the A-weighted sound levels is dB(A).

Small changes in ambient sound levels will not be able to be detected by the human ear. Most people will not notice a difference in loudness of sound levels of less than 3 dB(A), which is a two-fold change in the sound energy. A 10-dB(A) change in sound levels would be perceived as doubling of sound loudness.

The level of ambient sound usually varies continuously with time. A human's subjective response to varying sounds is primarily governed by the total sound energy received. The total sound energy is the average level of the fluctuating sound, occurring over a period of time, multiplied by the total time period.

In order to compare the effects of different fluctuating sounds, one compares the average sound level over the time period with the constant level of a steady, non-varying sound that will produce the same energy during the same time period. The average of the fluctuating noise levels over the time period is termed L_{eq}, and it represents the constant noise level that would produce the same sound energy over the time period as the fluctuating noise level.

Percentile parameters (L_n) are also useful descriptors of noise. The L_n value is the noise level exceeded for "n" per cent of the measurement period. The L_n value can be anywhere between 0 and 100. The two most common ones are L_{10} and the L_{90}, which are the levels exceeded for 10 and 90 per cent of the time respectively. The L_{90} has been adopted as a good indicator of the "background" noise level. The L_{10} has been shown to give a good indication of people's subjective response to noise.

Sound levels diminish with distance from the source because of dispersion, and for point noise sources the calculated sound pressure is:

$L_{p2} = L_{p1} - 20 \log(r_2/r_1)$

Where: L_{p2} = sound pressure level in dB at distance r_2 in meters, and L_{p1} = sound pressure level in dB at distance r_1 in meters

In the case of a line source the sound pressure is:

$L_{p2} = L_{p1} - 10 \log(r_2/r_1)$

In simple terms, for point sources, the distance attenuation would be approximately 6 dB(A) per doubling of distance from the source. For line sources the same attenuation is approximately 3 dB(A).

The atmospheric conditions, interference from other objects and ground effects also play an important role in the resulting noise levels. For example, "hard" ground, such as asphalt or cement transmits sound differently than "soft" ground, such as grass. The first ground type promotes transmission of sound, thus producing louder sound levels farther from the source. In general terms, the above effects increase with distance, and the magnitude of the effect depends upon the frequency of the sound. The effects tend to be greater at high frequencies and less at low frequencies.

Typical noise levels for various environments are shown in the following figure.

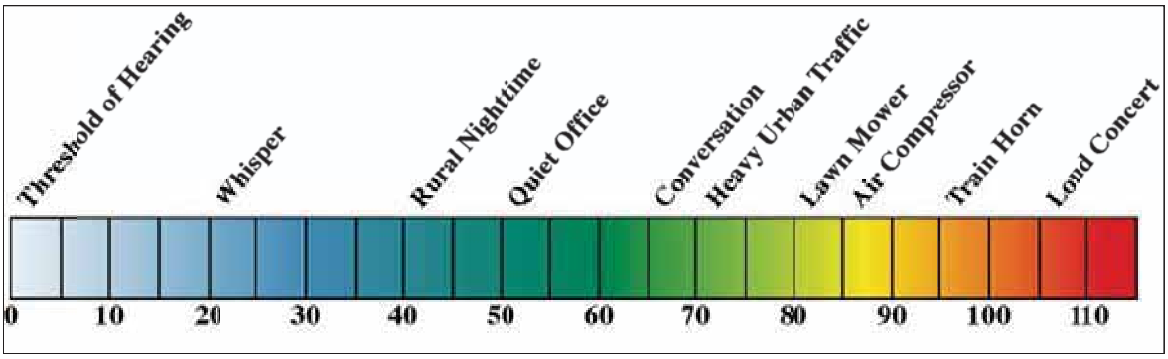


Figure 2-1. Typical Sound Levels (dB(A))

2.2 Noise Standards and Guidelines

In general, the standards applied by the international community are similar for different countries. Internationally, the current trends are to apply more stringent criteria due to the deteriorating noise climate.

The noise impacts due to a proposed project are generally based on the difference between the expected noise level increase and the existing noise levels in the area, as well as on comparisons against area-specific noise guidelines.

The available international guidelines are presented in the sections below and have taken into consideration the following adverse effects of noise:

- Annoyance.
- Speech intelligibility and communication interference.
- Disturbance of information extraction.
- Sleep disturbance.
- Hearing impairment.

The World Health Organisation (WHO) together with the Organisation for Economic Co-ordination and Development (OECD) have developed their own guidelines based on the effects of the exposure to environmental noise. These provide recommended noise levels for different area types and time periods.

The World Health Organisation has recommended that a standard guideline value for average outdoor noise levels of 55 dB(A) be applied during normal daytime, in order to prevent significant interference with the normal activities of local communities. The relevant night-time noise level is 45 dB(A). The WHO further recommends that, during the night, the maximum level of any single event should not exceed 60 dB(A). This limit is to protect against sleep disruption. In addition, ambient noise levels have been specified for various environments. These levels are presented in the table below.

Table 2-1. WHO Guidelines for Ambient Sound Levels

Environments	Ambient Sound Level L_{Aeq} (dB(A))			
	Daytime		Night-time	
	Indoor	Outdoor	Indoor	Outdoor
Dwellings	50	55	-	-
Bedrooms	-	-	30	45
Schools	35	55	-	-

The WHO specifies that an environmental noise impact analysis is required before implementing any project that would significantly increase the level of environmental noise in a community (WHO, 1999). Significant increase is considered a noise level increase of greater than 5 dB.

World Bank Group (WBG) International Finance Corporation (IFC) has developed a program in pollution management so as to ensure that the projects they finance in developing countries are environmentally sound. Noise is one of the pollutants covered by their policy. It specifies that noise levels measured at noise receptors, located outside the project's property boundary, should not be 3 dB(A) greater than the background noise levels, or exceed the noise levels depicted in Table 2-2.

The Standard also refers to the WHO Guidelines for Community Noise (WHO, 1999) for the provision of guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

Table 2-2. World Bank/IFC Ambient Noise Guidelines

Receptor	Maximum Allowable Ambient Noise Levels 1-hour L_{Aeq} (dB(A))	
	Daytime 07:00 – 22:00	Night-time 22:00 – 07:00
Residential, institutional, educational	55	45
Industrial, commercial	70	70
Note: No L_{Aeq} values are stipulated for rural areas.		

2.2.1 SANS Codes of Practice and Guidelines

The SANS 10103 Code of Practice provides typical ambient noise rating levels ($L_{Req,T}$) in various districts. The outdoor ambient noise levels recommended for the districts are shown in Table 2-3 below.

It is probable that the noise is annoying or otherwise intrusive to the community or to a group of persons if the rating level of the ambient noise under investigation exceeds the applicable rating level of the residual noise (determined in the absence of the specific noise under investigation), or the typical rating level for the ambient noise for the applicable environment given in Table 2-3 (Table 2 of SANS 10103).

The expected response from the local community to the noise impact, i.e. the exceedance of the noise over the acceptable rating level for the appropriate district, is primarily based on Table 5 of SANS Code of Practice 10103 (SANS 10103, 2008), but expressed in terms of the effects of impact, on a scale of NONE to VERY HIGH (see Table 2-4 below).

The noise monitoring of the baseline conditions within and around the site will provide the rating level of the residual noise. The noise impact during construction and the noise emission requirements will be determined by comparing:

- the ambient noise under investigation with the measured rating level of the residual noise (background noise levels); and
- the ambient noise under investigation with the typical rating level for the ambient noise for the applicable environment given in Table 2-3.

Table 2-3. Typical Rating Levels for Ambient Noise

Type of district	Equivalent continuous rating level ($L_{Req.T}$) for noise (dB(A))					
	Outdoors			Indoors, with open windows		
	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Table 2-4. Response Intensity and Noise Impact for Increases of the Ambient Noise

Increase (dB)	Response Intensity	Remarks	Noise Impact
0	None	Change not discernible by a person	None
3	None to little	Change just discernible	Very low
$3 \leq 5$	Little	Change easily discernible	Low
$5 \leq 7$	Little	Sporadic complaints	Moderate
7	Little	Defined by South African National Noise Regulations as being 'disturbing'	Moderate
$7 \leq 10$	Little - medium	Sporadic complaints	High
$10 \leq 15$	Medium	Change of 10dB perceived as 'twice as loud', leading to widespread complaints	Very high
$15 \leq 20$	Strong	Threats of community/group action	Very high

2.2.2 Recommended Noise Limits for Train Operations

The ambient noise level guidelines, which the train transport should adhere to, are summarised in the following table.

Table 2-5. Ambient Noise Guideline Limits

Receptor	Permissible Ambient Noise Limits L_{Aeq} (dB(A))		Maximum Noise Limit of any Single Event L_{Amax} (dB(A))
	Daytime [1]	Night-time [2]	Night-time
Residential, institutional, educational	55	45	60
Industrial, commercial	70	70	

[1] Daytime: 07:00 – 22:00
[2] Night-time: 22:00 – 07:00

In addition, noise levels measured at noise receptors located outside the project's property boundary should not be 3 dB(A) greater than the background noise levels or exceed the noise levels depicted in Table 2-5.

In order to establish a uniform approach regarding the assessment of impacts, ERM has issued a procedure in terms of a rating matrix for the determination of the overall noise impact due to the project. In accordance with this procedure, several aspects of the impact, such as its nature, scale, duration, intensity and probability were taken into account. A detailed description of the methodology is provided in Appendix A.

2.2.3 Health and Safety

In South Africa, any operation that has the potential to generate noise should have a noise survey done, in terms of the Noise Induced Hearing Loss Regulations of the Occupational Health and Safety Act 85 of 1993 (SA).

The regulations require an Approved Inspection Authority to conduct the surveys in accordance with SANS 10083 and submit a report. All people exposed to an equivalent noise level of 85 dB(A) or more must be subjected to audiometric testing. It is required that all records of surveys and audiometric testing must be kept for 40 years.

The sound pressure threshold limits within workshops and plants that could affect employees' health, quality of life and quality of work are:

- Alert threshold 80 dB(A).
- Danger threshold 85 dB(A).

Site locations are required to meet the following levels of performance at all points accessible by the employees on a regular basis:

- For workshop circulated areas, the maximum levels must not exceed 85 dB(A).
- For work equipment, the maximum levels must not exceed 80 dB(A) at one meter from the equipment and at 1.60 m high.

Exceptions may be considered for areas that should not be accessed on a regular basis. Personal Protective Equipment (PPE) will be required to access those areas, and the noise levels outside should comply with the above-mentioned thresholds.

The employer has a legal duty under the current Occupational Health Regulations (SA) to reduce the risk of damage to his/her employees' hearing. The main requirements apply, where employees' noise exposure is likely to be at or above the danger threshold limit of 85 dB(A). It should be noted that there is an international tendency to regard 80 dB(A) as an informal warning level.

The action level is the value of 'daily personal exposure to noise' ($L_{EP,d}$). This depends on the noise level in the working area and how long people are exposed to the noise. The values take account of an 8-hour noise exposure over the whole working day or shift.

2.3 Rail Vibration Basics

The main source of ground-borne vibration for rail transportation systems is the interaction between the track and the wheels of the locomotives and wagons. The amount of vibration that is transmitted depends strongly on factors such as the smoothness of the wheels and rails, as well as the resonance frequencies of the vehicle suspension system and the track support system. Poorly maintained tracks and/or flat spots on the wheels can increase the level of vibration.

This energy is transmitted through the support to the ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. Once the vibration reaches a building, it is transferred through the foundations into the structure. Any structural resonances that may be excited will increase the effect of the vibration.

Vibration can be described in terms of displacement, velocity or acceleration. For a vibrating floor, the displacement is defined as the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement, and acceleration is the rate of change of that speed.

The most commonly used measures of vibration are the peak particle velocity (PPV) in millimetres (mm), the velocity in metres per second (m/s) and acceleration in metres per second squared (m/s^2). The PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal and is often used in monitoring the stresses that are experienced by buildings.

The vibration levels can also be expressed as a logarithmic scale in decibels, similar to the sound pressure levels for expressing noise. The relevant calculations for the velocity (L_v) and the acceleration (L_a) levels are:

$L_v = 20 \log_{10}(V/V_r)$, and

$L_a = 20 \log_{10}(A/A_r)$

where: $V_r = 10^{-9}$ m/s and $A_r = 10^{-6}$ m/s^2 are the velocity and acceleration reference levels as specified in ISO 1683.

In this report, when the vibration velocity levels are expressed in decibels, the reference level defined above applies, and the unit is specified as dBV, in order to distinguish it from dB(A), which is used for A-weighted noise levels.

2.4 Effects of Vibration on Humans and Structures

Humans are extremely sensitive to low levels of vibration and can detect levels of ground vibration of less than 0.1 mm/s, which is less than one hundredth of the levels which could cause even minor cosmetic damage to a normal building. Complaints and annoyance regarding ground vibration are therefore much more likely to be determined by human perception than by noticing minor structural damage. However, these effects, and the startling effect of sudden impulses of both sound and vibration are often perceived as intrusion of privacy and could be a source of considerable annoyance to the local community.

There is widespread agreement in the industry that the peak particle velocity (PPV) is the parameter which best correlates with observed damage to structures caused by vibration, and is widely applied in assessments. The first observable damage to structures, i.e. the forming of hairline cracks in plaster, begins at a PPV of about 25 mm/s. The US Bureau of Mines recommends twice this value, i.e. 50 mm/s, as a "safe blasting limit" for residential properties. Minor structural damage can occur at values in excess of 100 mm/s, and serious damage occurs at values in excess of 200 mm/s, according to a range of authors (Lear, 1992). Effects on temporary structures are likely to occur at values which are lower than those for masonry structures, even though the high variability in the type and construction quality of such structures renders reliable prediction of these values difficult.

2.5 Vibration Criteria and Guidelines

As indicated previously, to date, there is no a specific standard or guideline pertaining to the impact of ground-borne vibration in South Africa. As such, international standards and guidelines will be applied for the assessment of the vibration impact on humans and structures.

A considerable amount of research has been done to correlate vibrations from single events such as dynamite blasts with architectural and structural damage. The U.S. Bureau of Mines has set a "safe blasting limit" of 50 mm/s. Below this level there is virtually no risk of building damage. However, since some of the structures in the extended area were in poor condition, the adopted limit utilised in this study was selected to be 12.5 mm/s.

The Transport and Road Research Laboratory in England has researched continuous vibrations to some extent and developed a summary of vibration levels and reactions of people and the effects on buildings (Whiffen and Leonard, 1971). These criteria have been adopted in the present study for the evaluation of the severity of vibration caused by the current railway operations and are presented in Table 2-6.

Traffic, train and most construction vibrations (with the exception of pile driving, blasting, and some other types of construction/demolition) are considered continuous. The "architectural damage risk level" for continuous vibrations (peak vertical particle velocity of 5 mm/sec) shown in Table 2-6 is one tenth of the maximum "safe" level of 50 mm/sec for single events. The recommended level for historical buildings or buildings that are in poor condition is 2.0 mm/s.

Table 2-6. Vibration Levels for Reactions of People and Effects on Buildings

Vibration Level PPV* (mm/s)	Human Reaction	Effect on Buildings
0.15-0.30	Threshold of perception; possibility of intrusion.	Vibrations unlikely to cause damage of any type.
2.0	Vibrations readily perceptible.	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected.
2.5	Level at which continuous vibrations begin to annoy people.	Virtually no risk of "architectural" damage to normal buildings.

Vibration Level PPV* (mm/s)	Human Reaction	Effect on Buildings
5.0	Vibrations annoying to people in buildings (for relatively short periods of vibration).	Threshold at which there is a risk of "architectural" damage to normal dwellings, i.e. houses with plastered walls and ceilings.
10-15	Vibrations considered unpleasant by people subjected to continuous vibration.	Vibrations at a greater level than normally expected from traffic, but which would cause "architectural" damage and possibly minor structural damage.
* The vibration levels are based on the peak particle velocity in vertical direction. No allowance is made for the potential amplifying effects of structural components.		

3 AMBIENT NOISE MEASUREMENTS

3.1 Methodology

The ambient noise measurements was carried out with the use of a Type 1 Precision Impulse Integrating Sound Level Meter, in accordance with international standards for sound level meter specifications IEC 61672:1999, IEC 61260:1995 and IEC 60651., as well as ISO 19961:2003 and ISO 3095:2001 for the measurement and assessment of environmental noise.

An assessment of each loop was performed during an initial site visit, and monitoring points were selected for the noise measurements. One or two monitoring points were selected at each loop for the determination of the existing background noise levels and the noise comparisons between the modelling and the measurements.

The noise measurements were performed intermittently over a twenty-four hour period and were categorised in terms of daytime (07:00-22:00) and night-time (22:00-07:00), in order to generate results suitable for comparison to international guidelines.

At each location at least two measurements were performed for both daytime and night-time periods. In each period the continuous A-weighted equivalent sound pressure level (L_{Aeq}) of at least a 10-minute duration was taken. Abnormal disturbances, such as loud noise generation in close proximity or sudden noise bursts that affect the measurement, were discarded.

In addition to the L_{eq}, L_{10}, L_{50}, and L_{90}, the occurring maximum (L_{max}) and minimum levels (L_{min}) during the measurement period were also recorded. These measurements were appropriate for the determination of:

a) The noise levels with existing and future operations in progress.

b) The background noise, i.e. when no activities are contributing to the ambient noise levels.

c) The nature and extent of the noise.

All the noise measurements were performed in compliance with the weather condition requirements specified by the SANS and ISO codes. Therefore, measurements were not performed when the steady wind speed exceeded $5ms^{-1}$ or wind gusts exceeded $10\ ms^{-1}$. The wind speed was measured at each location with a portable meter capable of measuring the wind speed and gusts in meters per second.

3.2 Monitoring Equipment

The measurements were performed via a 01dB DUO, which is a Type 1 Data-logging Precision Impulse Integrating Sound Level Meter (see Table 3-1). The Sound Level Meter was calibrated before and after the measurement session with a 01dB Type 1, 94dB, 1 kHz field calibrator. The above-mentioned equipment, i.e. sound level meter and calibrator, have valid calibration certificates from the testing laboratories of the De Beer Calibration Services and the manufacturer, and comply with the following international standards:

- IEC 651 & 804 – Integrating sound level meters.
- IEC 942 – Sound calibrators.

The calibration certificates are available on request.

Table 3-1. Sound Level Measurement Instrumentation

Instrument	Type	Serial No.
1. Precision Integrating Sound Level Meter	01dB DUO	10372
1a. Microphone	01dB 40 CD	144888
2. Field Calibrator 01dB Cal01	CAL01	11243

All the noise measurements complied with the weather condition requirements, as specified by the SANS Codes and the Noise Control Regulations:

- The South African National Standard - Code of Practice, SANS 10103:2008, *The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication*;
- Department of Environmental Affairs And Tourism. NO. R. 154. *Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989)*. Govt. Gaz. No. 13717, 10 January 1992.

The coordinates of each monitoring point were recorded with the GARMIN iQue 3600, and the local weather parameters were measured with an AZ 8910 portable weather meter.

3.3 Noise Monitoring Locations and Noise Sensitive Receptors

The noise measurements were carried out over 3 days, i.e. from the 15th to the 18th of October 2012, at seven locations around the following loops:

1) Fieldsview
2) Gong-Gong
3) Ulco
4) Trewil
5) Tsantsabane
6) Postmasburg
7) Glosam
8) Sishen
9) Wincanton
10) Witloop
11) Mamatwane Yard

The measurement points were chosen based on the following criteria:

- Representative of the current noise levels in the various areas where noise-sensitive receptors are located.
- Areas in close proximity to the rail loops.
- Easy accessibility under the current conditions.
- Safety in terms of demining operations and possible night-time measurements.
- Likelihood of continuing to exist after the development of the site and therefore to be used for future comparison purposes.

Table 3-2 shows the averaged values of the L_{Aeq} for each monitoring location and period of the day and night. The additional parameters recorded during the measurements, such as the L_{max}, L_{min}, L_{90}, L_{50} and L_{10}, can be found in Table B-1of Appendix B. The coordinates of the measurement points and noise sensitive receptors identified around each site can be seen in Table B-2 of Appendix B.

Table 3-2. Noise Measurement Results

Loops	Measurement Points	Area Type	Noise Level (dB(A))	
			Daytime	Night-time
Fieldsview	MP01	Rural	41.2	*
Gong-Gong	MP02	Rural	48.8	42.9
Ulco	MP03	Rural	47.1	34.8
Trewil	MP04	Rural	38.1	*
Tsantsabane	MP05	Rural	38.5	30.0
Postmasburg	MP06	Urban	53.7	51.3
Glosam	MP07	Rural	44.7	34.4
Sishen	MP08	Rural	43.0	36.9
Wincanton	MP09	Rural	45.7	*
Witloop	MP10	Rural	38.9	43.2
Mamatwane Yard	MP11	Rural/Industrial	53.0	50.3
SANS guidelines: Rural districts: Daytime: 45 dB(A), Night-time:35 dB(A) Industrial: Daytime: 70 dB(A), Night-time:60 dB(A) Urban areas with main roads: Daytime: 60 dB(A), Night-time:50 dB(A)				
World Bank guidelines: Residential: Daytime: 55 dB(A), Night-time:45 dB(A) Industrial: Daytime: 70 dB(A), Night-time:70 dB(A)				
* No measurement				

3.3.1 Fieldsview Loop

The Fieldsview loop is located approximately 13 km north-west of Kimberley. The measurement point (MP01) positioned about 800 m west of the loop. The location of this measurement point, together with the noise-sensitive receptors identified in the area, can be seen in Figure 3-1 below.

The noise environment at this loop, around which are situated seven farm houses, is that of a typical rural area.

Based on the noise measurement results (see Table 3-2), the average noise level at MP01 was 41.2 dB(A) during daytime, which is within the SANS daytime guideline of 45 dB(A) for rural areas. No night-time measurement was performed at this loop due to difficult accessibility. However, due to the remoteness of the area, the night-time levels are expected to be similar to Glosam and Sishen, at around 35 dB(A).

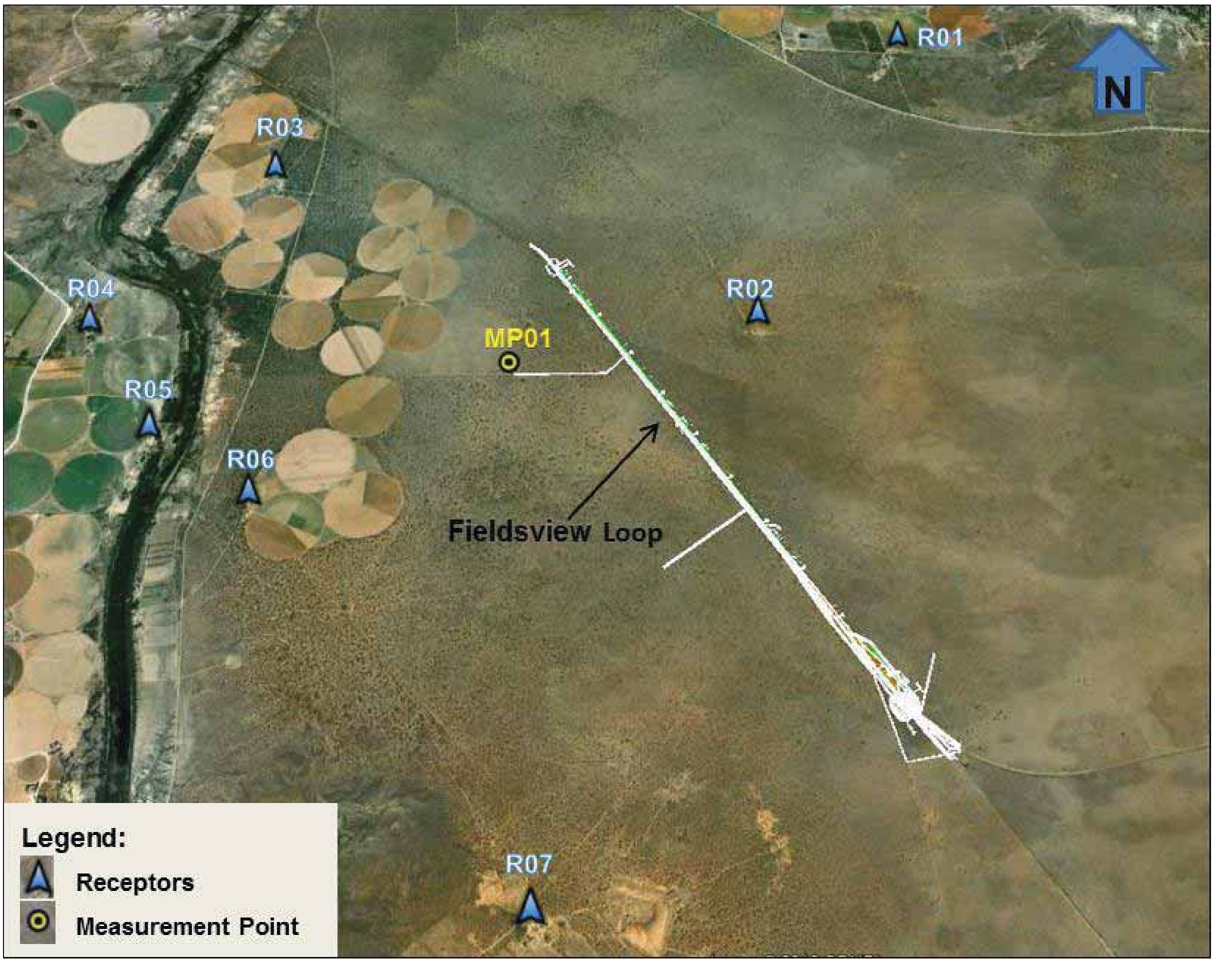


Figure 3-1. Fieldsview Loop Noise Measurement Point and Receptors

3.3.2 Gong-Gong Loop

The Gong-Gong loop is located about 9 km south-east of the town of Delportshoop and 10km north-west of the town of Barkly West. The loop lies 800 m from the R31. The measurement point (MP02) at this loop was located at the border of Gong- Gong village, 1.5 km west of the loop. The measurement point MP02 is shown in Figure 3-2 below, together with the Gong-Gong loop and the sensitive receptors within a 2 km radius. The sensitive receptors in this area are mainly farm houses and the Gong-Gong community.

The noise environment around this loop and away from the R31 is typical of a rural area. Some farm houses are situated within close proximity to the loop.

As can be seen in Table 3-2 above, the average measured noise levels at MP02 was 48.8 dB(A) during daytime, which is marginally above the SANS daytime guideline of 45 dB(A) for rural districts. The average night-time noise level was 42.9 dB(A), exceeding the SANS night-time guideline of 35 dB(A). The predominant noise sources were human activities and vehicular traffic noise from the R31 during the day and night.

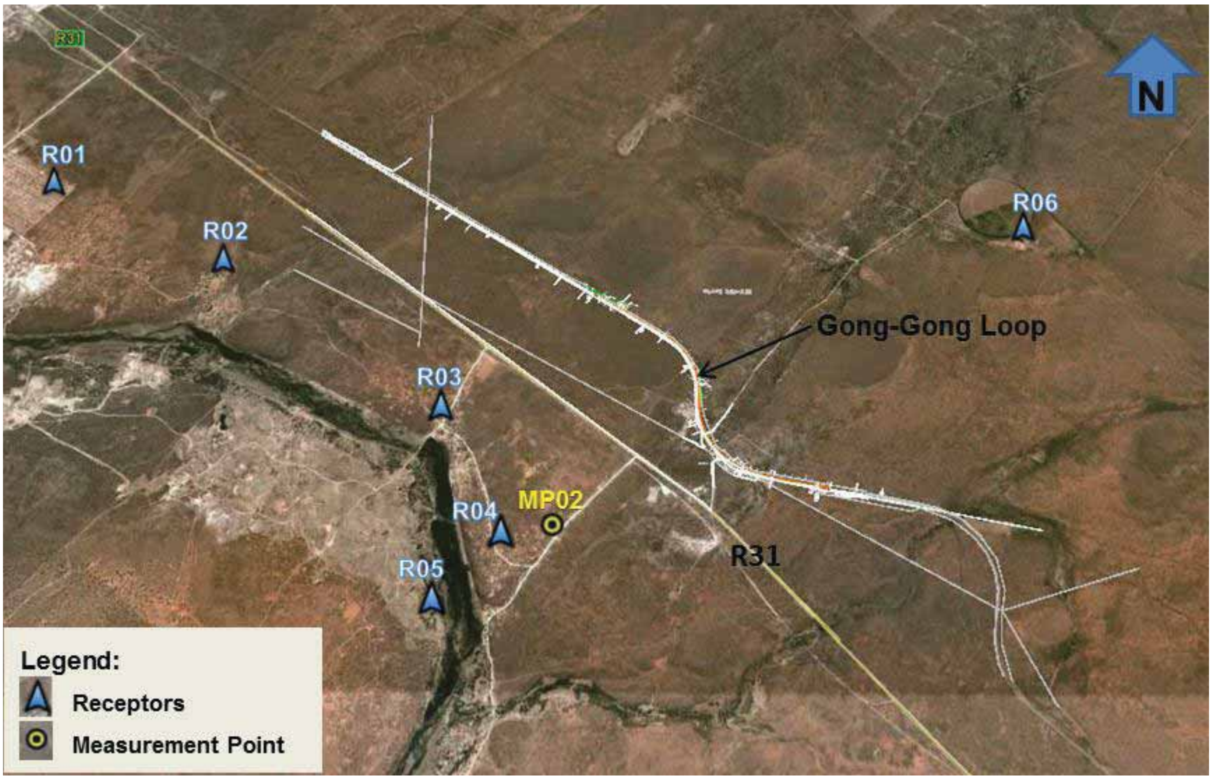


Figure 3-2. The Gong-Gong Loop Noise Measurement Point and Receptors

3.3.3 Ulco Loop

The Ulco loop lies along the R31, is approximately 4 km north-west of Delportshoop town. The measurement point (MP03) for this loop was positioned next to the railway line, north of the R370. This point, as well as the sensitive receptors within a 3 km radius of the Ulco loop can be seen in Figure 3-3 below.

The noise environment in the area, away from the R31 and R370, is typical of a rural area, with some unoccupied farm houses in close proximity to the loop.

As can be seen in Table 3-2 above, the average measured daytime noise level at MP03 was 47.1 dB(A), which exceeds the SANS daytime guideline of 45 dB(A) for rural districts. The average night-time noise level was 34.8 dB(A),which is within the SANS night-time guideline of 35 dB(A). The predominant noise sources were vehicular traffic on the R31 and the nearby Afrisam-Ulco Cement Plant and mine, located 7km north-west of the loop.

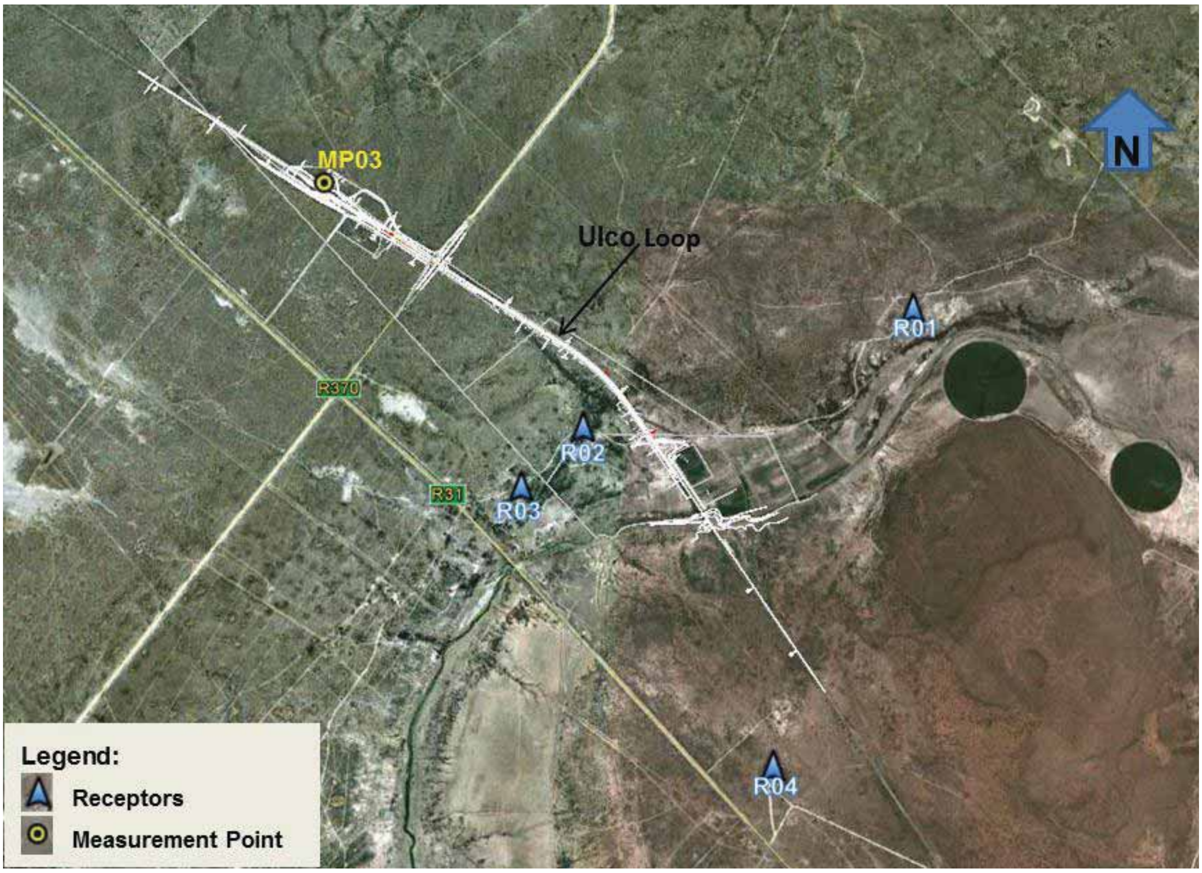


Figure 3-3. Ulco Loop Noise Monitoring Point and Receptors

3.3.4 Trewil Loop

The Trewil loop is located approximately 60 km east of Postmasburg town and 7.5 km south of the R31. The measurement point (MP04) was positioned next to the loop, 10 m from the railway alignment. The loop, measurement point and sensitive receptors within a 3 km radius are shown in Figure 3-4 below.

The noise environment around this loop is typical of a rural area.

The average measured daytime noise levels at MP03 was 38.1 dB(A) (see Table 3-2), which is well within the SANS daytime guideline of 45 dB(A) for rural areas. No night-time measurement was performed at this loop due to difficult accessibility. However, due to the remoteness of the area, the night-time levels are expected to be similar to Glosam and Sishen, at around 35 dB(A).

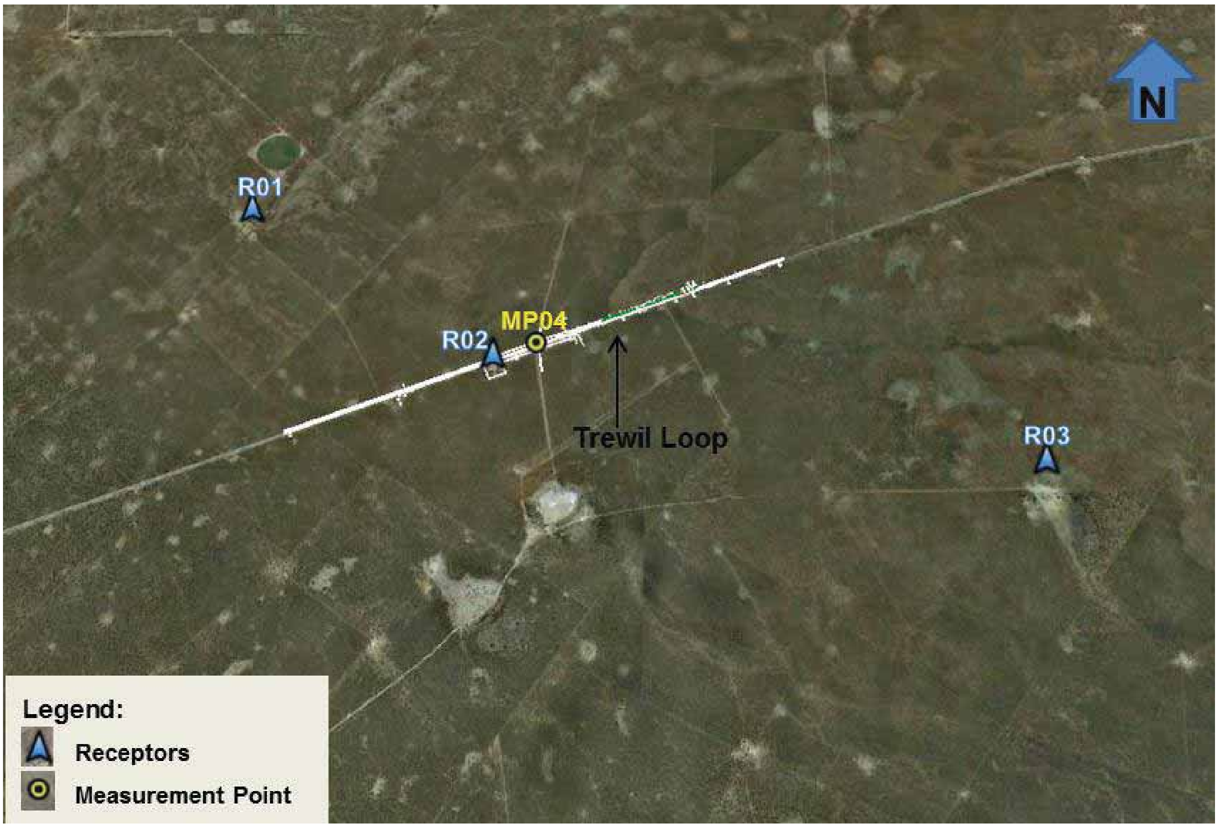


Figure 3-4. Map Trewil Loop Showing Noise Monitoring Point and Receptors

3.3.5 Tsantsabane Loop

The Tsantsabane loop is located approximately 6 km north-east of Postmasburg town. The area around the loop is considered rural. There are several farm houses located primarily south of the loop, as well as the Postdene community (R01) 3.7 km to the east.

The measurement point (MP05) was positioned along the gravel road parallel to the loop, approximately 50 m south of the railway line. This point, together with the sensitive receptors within a 3 km radius from loop are shown in Figure 3-5 below.

The average measured noise levels at MP05 were 38.5 dB(A) and 30 dB(A) during daytime and night-time respectively (see Table 3-2). These noise levels are well within the SANS guidelines for rural districts.

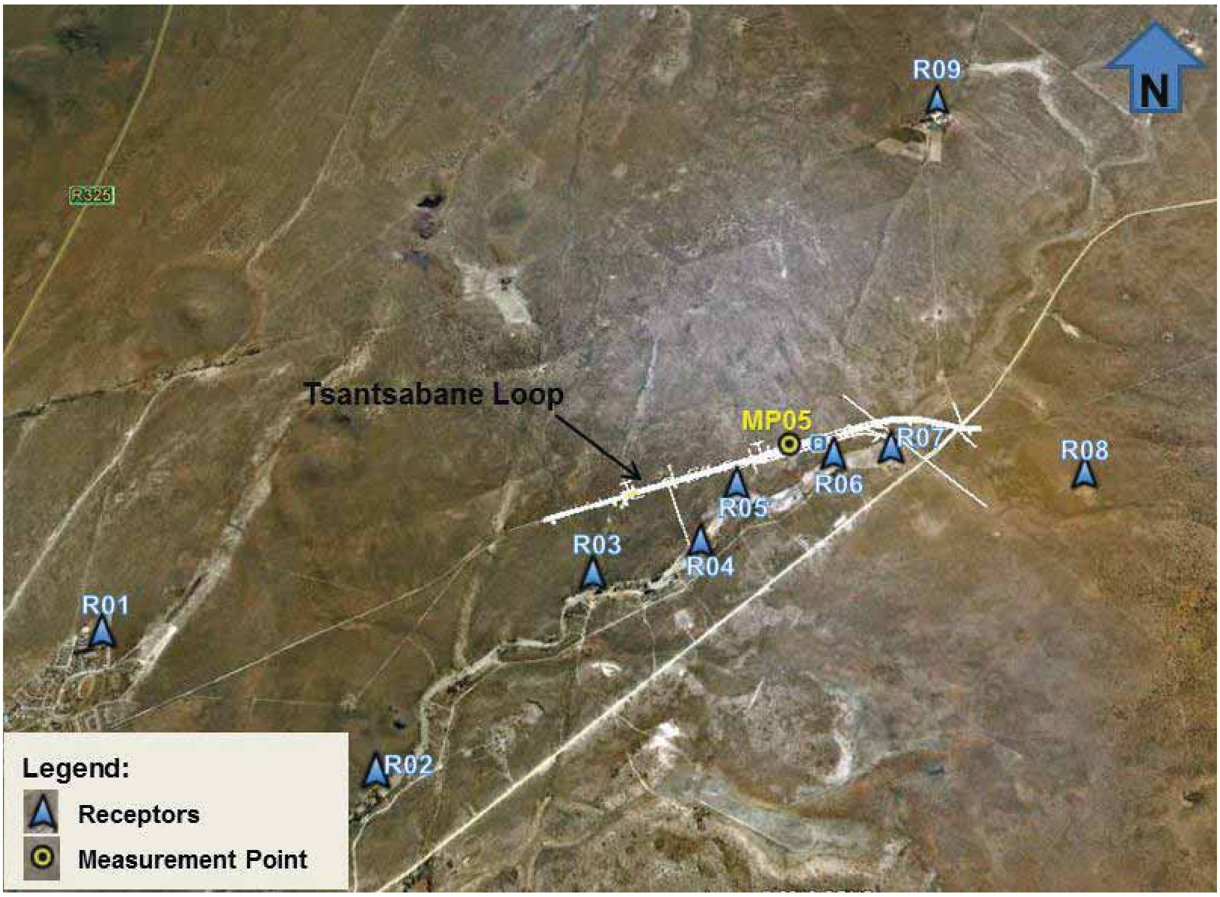


Figure 3-5. Tsantsabane Loop Noise Monitoring Point and Receptors

3.3.6 Postmasburg Loop

The Postmasburg loop is located immediately north of the town of Postmasburg, 600 m north from the R385. The area around the loop is considered urban residential and a school situated in close proximity of the loop. The noise environment is that of a typical urban district with main roads and is dominated by vehicular traffic and human activities.

The measurement point (MP06) was positioned in the Boichoko community, 1.2 km south of the loop. This point is shown Figure 3-6 below, together with the Postmasburg loop and the residential areas within a 2 km radius.

As can be seen in Table 3-2 above, the average measured daytime noise levels at MP06 was 53.7 dB(A), which is below the SANS daytime guideline for urban districts. The night-time noise level was 50.3 dB(A) and it exceeds the SANS night-time guideline of 45 dB(A). The predominant noise sources during the daytime and night-time were human activities and vehicular traffic on the local road network.

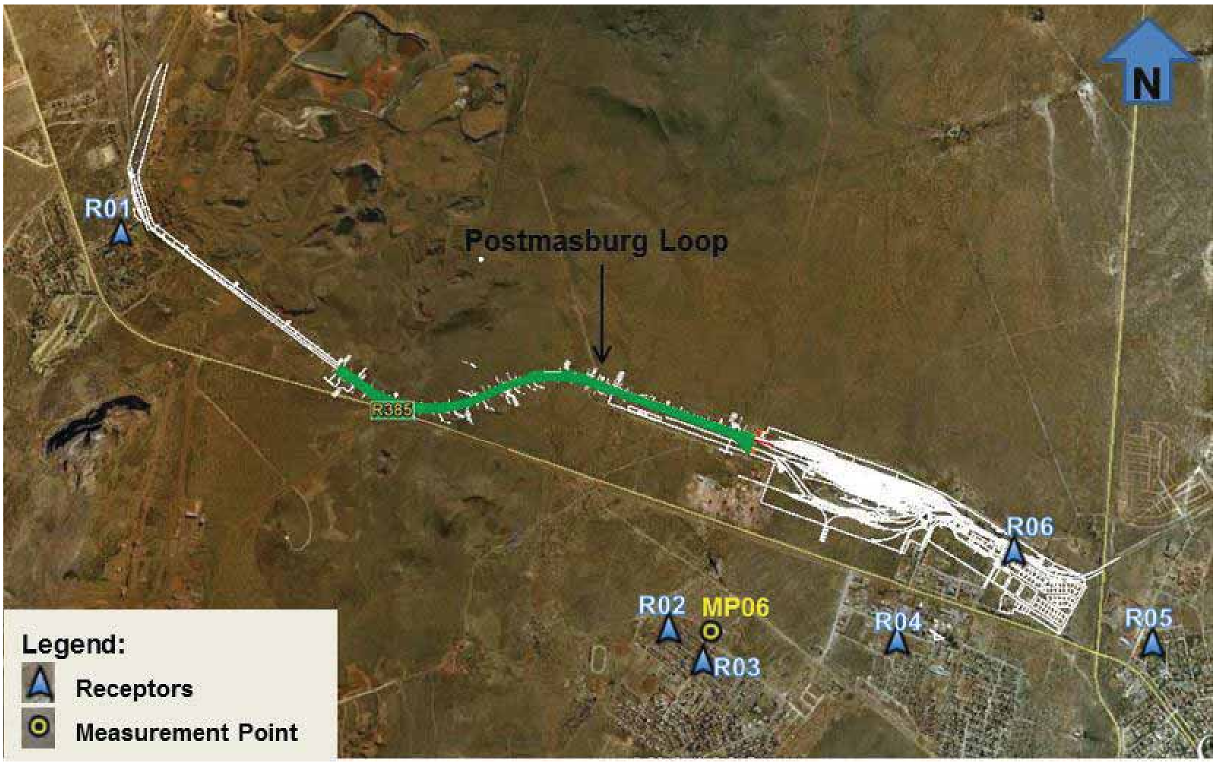


Figure 3-6. Postmasburg Loop Noise Monitoring Point and Receptors

3.3.7 Glosam Loop

The Glosam loop is located approximately 22 km north of Postmasburg Town and 2 km west of the R325. The area around the loop is rural. The Closam (R01) community and two farm houses are situated west of the loop.

The measurement point (MP07) was located about 20 m east of the residential area and 150 m west of the loop. Figure 3-7 below shows the measurement location and the sensitive receptors within a 3 km radius of the Glosam loop.

The average measured daytime and night-time noise levels at MP07 were 44.1 dB(A) and 34.4 dB(A) respectively (see Table 3-2), which are within the SANS guidelines for rural districts.

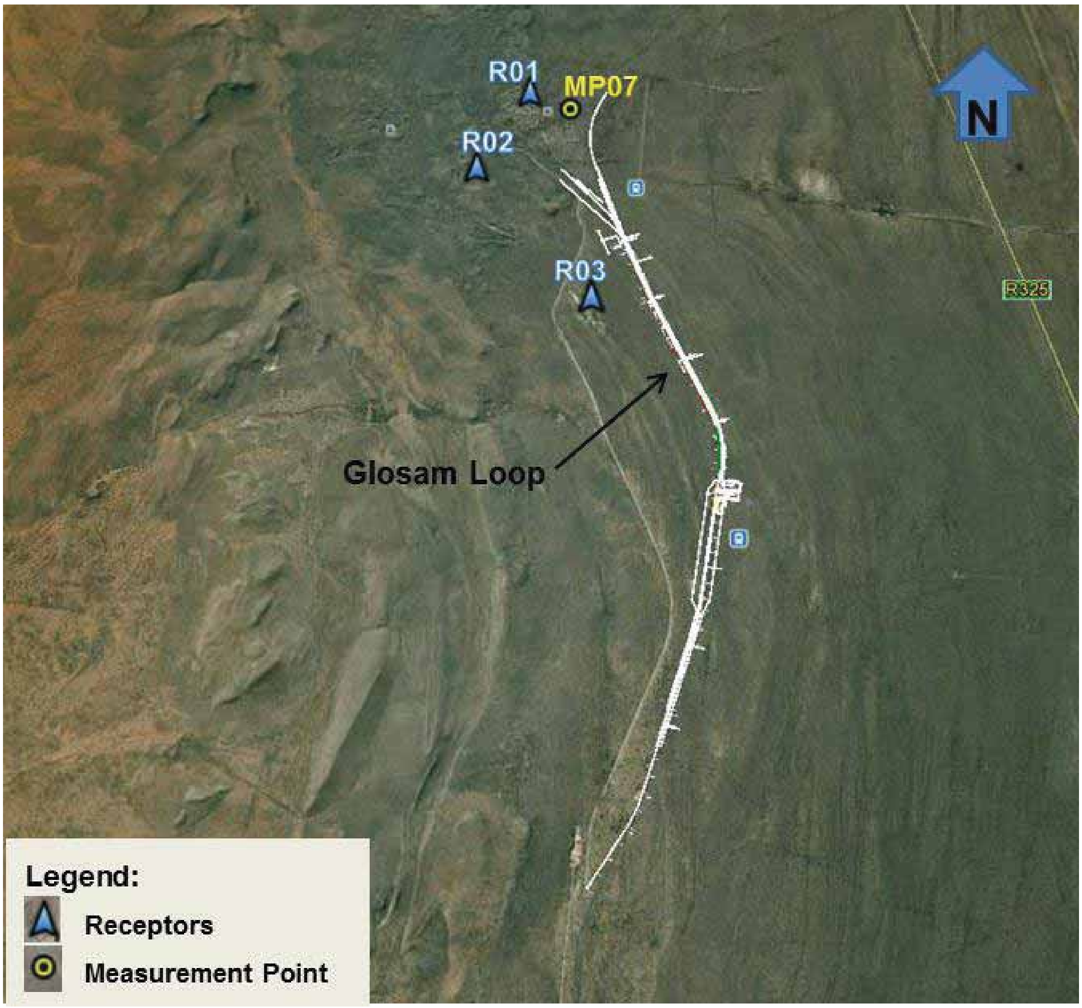


Figure 3-7. Glosam Loop Noise Monitoring Point and Receptors

3.3.8 Sishen Loop

The Sishen loop is located approximately 20 km south-west of Kathu town and 5 km north-west of the N14. The area around the loop is rural, with a few scattered farm houses west of it. The Dingle residential area and Kumba Iron Ore mine are situated about 2.5 km north-east of the loop.

The measurement point (MP08) was positioned next to Tiptol Avenue, 900 m west of the loop. The Sishen loop, together with the monitoring point and sensitive receptors in the area are shown in Figure 3-8 below.

As can be seen in Table 3-2 above, the average measured daytime noise level at MP08 was 43.0 dB(A), which is below the SANS daytime guideline of 45 dB(A) for rural districts. The average measured night-time noise level was 36.9 dB(A), marginally exceeding the night-time noise guideline for rural districts.

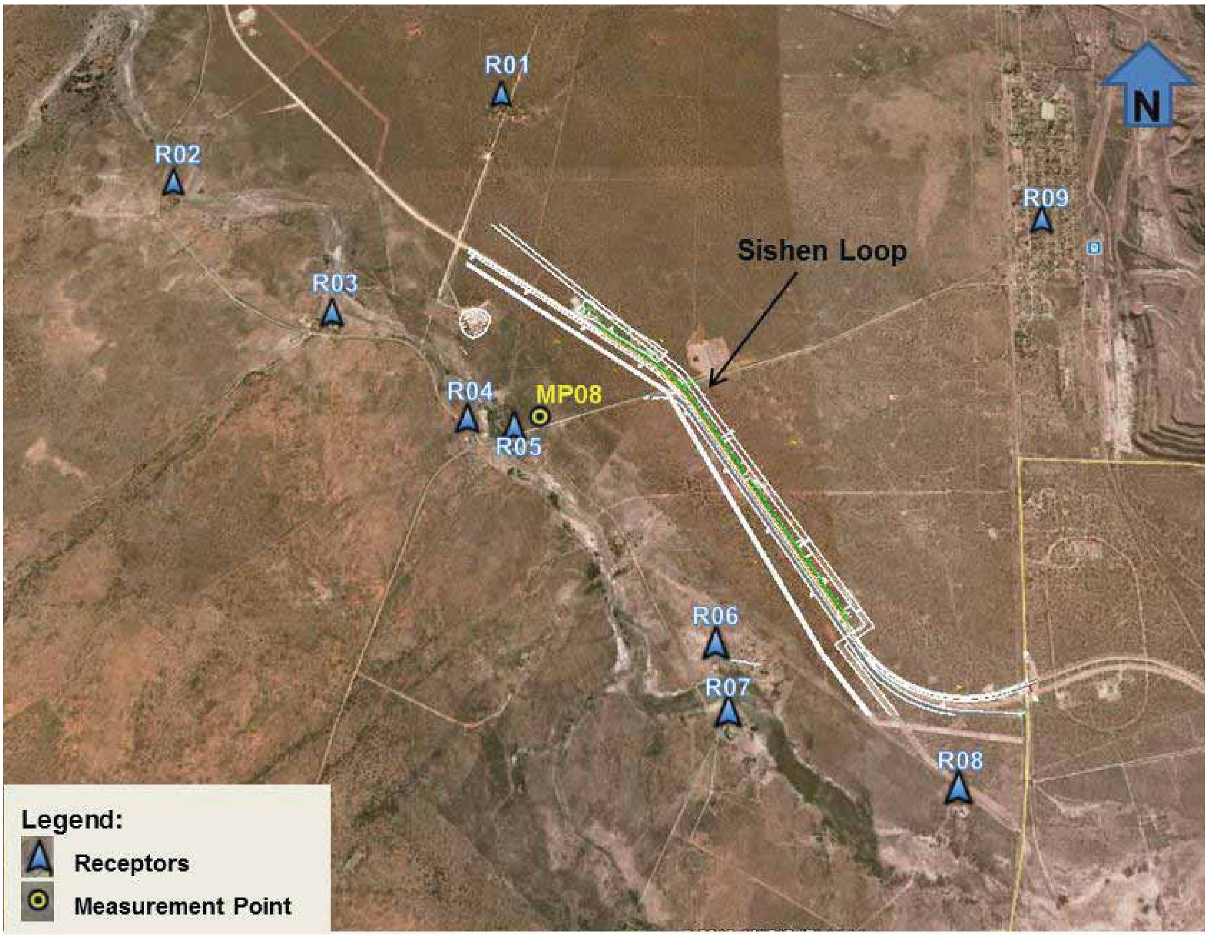


Figure 3-8. Sishen Loop Noise Monitoring Point and Receptors

3.3.9 Wincanton Loop

The Wincanton loop is located approximately 6.5 km east of the town of Deben, and 16 km north-west of Kathu. The noise environment around this loop and away from the R380 is typical of a rural area. Some unoccupied farm houses are situated adjacent, on the western side of the loop, and another farm house approximately 2.6 km to the west.

The measurement point (MP09) was positioned along the gravel road, east of the railway line. The Wincanton loop, together with the sensitive receptors within a 3 km radius and the monitoring point are shown in Figure 3-9.

The average measured daytime noise level at MP07 was 45.7 dB(A), which marginally exceeds the SANS daytime guideline of 45 dB(A) for rural districts. The noise environment was dominated by the vehicular traffic on the R380. No night-time measurement was performed at this loop due to difficult accessibility. However, due to the remoteness of the area, the night-time levels are expected to be similar to Glosam and Sishen, at around 35 dB(A).

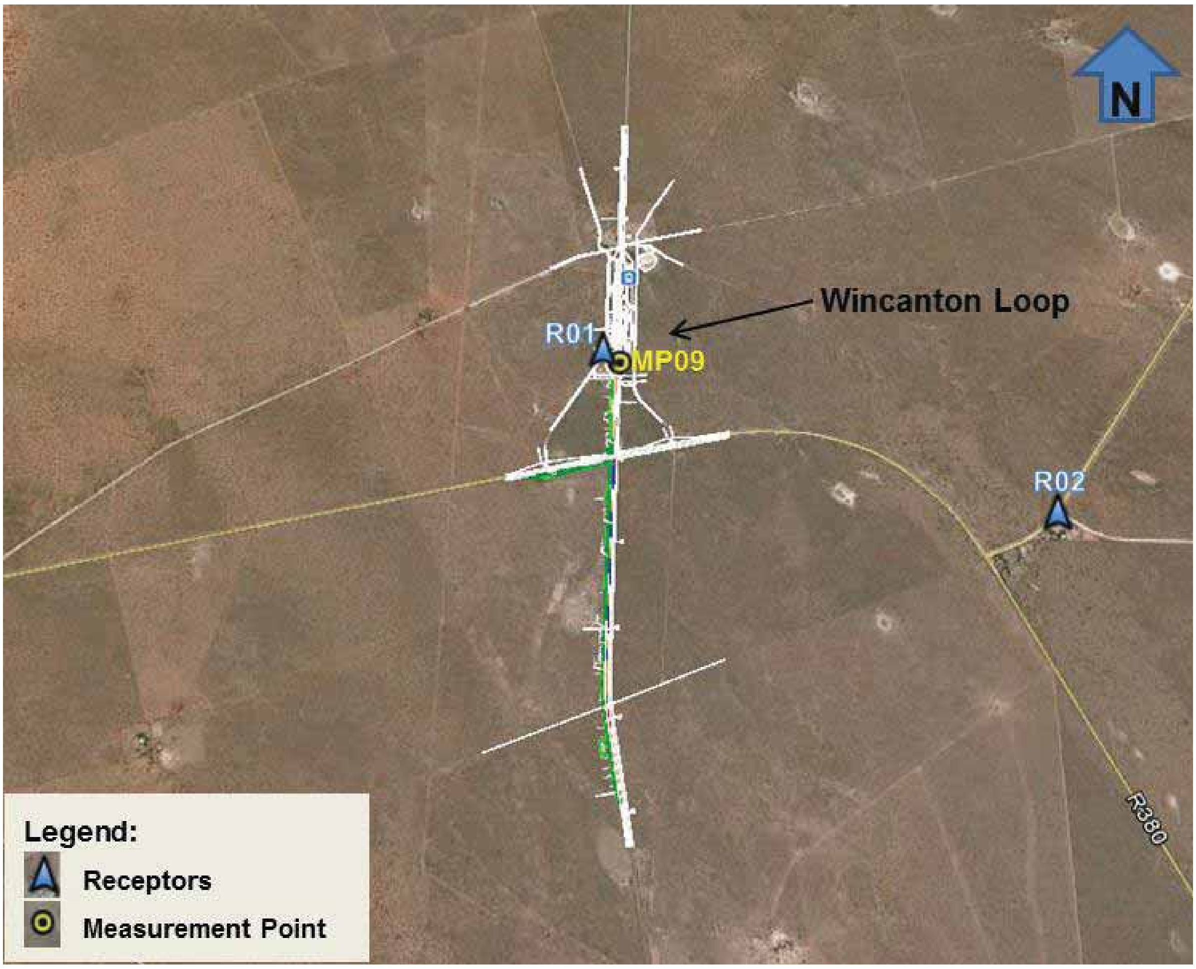


Figure 3-9. Wincanton Loop Noise Monitoring Point and Receptors

3.3.10 Witloop

The Witloop loop is located approximately 8 km south of Hotazel, along the R380. The area around the loop and away from the R380 and the Mamatwane mining area is that of a typical rural environment. There were no sensitive receptors close to the loop, other than a temporary office block 400 m west of it (R01).

Noise measurements were performed at the gravel road west of the railway line. The Witloop loop, together with the measurement point and office block, are shown in Figure 3-10.

As is evident from Table 3-2 further above, the average measured daytime noise level was 38.9 dB(A), which is well within the SANS daytime guideline of 45 dB(A) for rural districts. The measured night-time noise level was 43.2 dB(A), primarily due to train operations and vehicular traffic, thus exceeding the SANS guideline of 35 dB(A). The noise environment was dominated during the day and night by the vehicular traffic on the R380, as well as by the mining and train operations in the area.

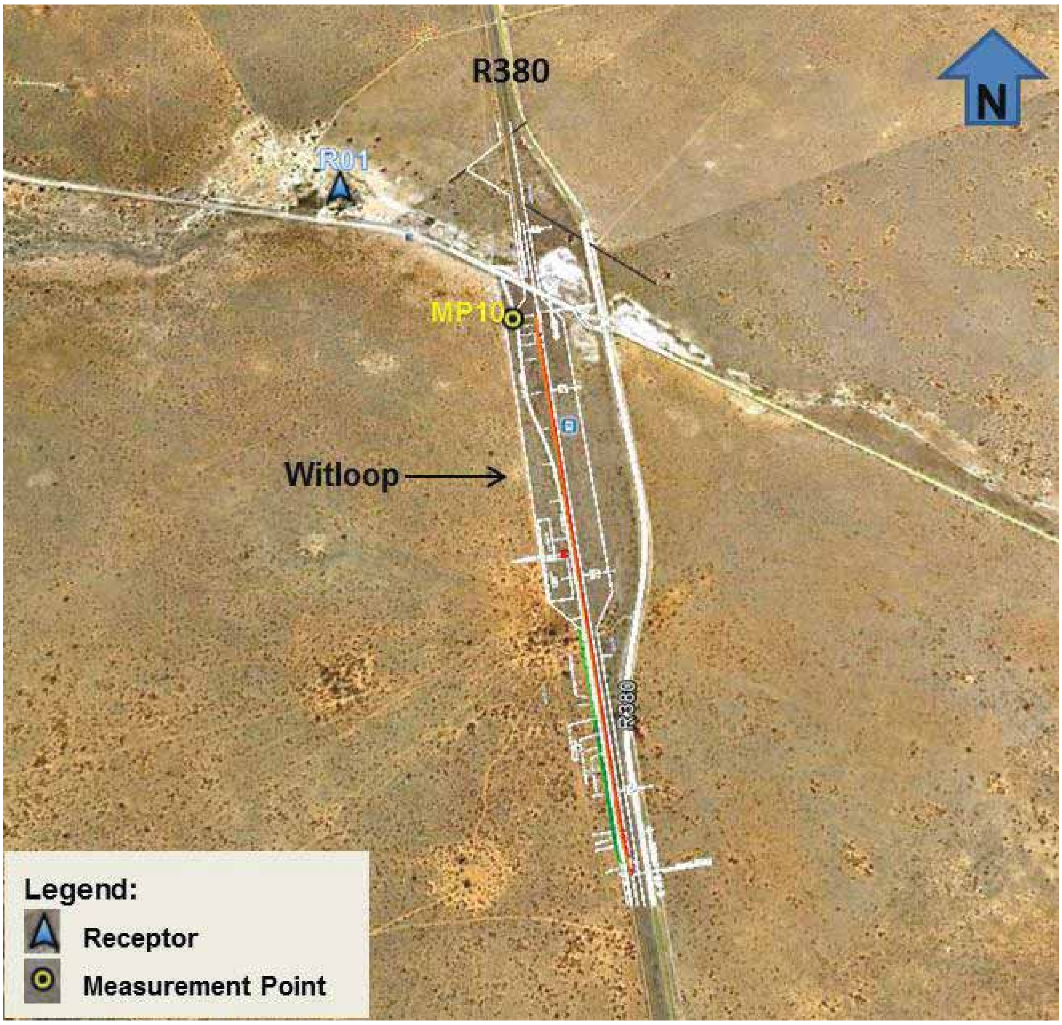


Figure 3-10. Witloop Noise Monitoring Point and Receptor

3.3.11 Mamatwane Compilation Yard

The Mamatwane compilation yard is located adjacent to the Mamatwane Manganese mine and processing plant, approximately 15km south of Hotazel. The noise environment around the site is considered industrial, with high constant noise levels due to the existing Manganese plant, which operates on a continuous basis. The noise environment further away from the R380 and the Manganese plant and mine is that of a typical rural area. Two farm houses, which belong to Transnet are situated next to the alignment, on the western side, and two farm houses approximately 4 km south of the yard.

The measurement point (PM11) and the sensitive receptors in the area are shown in Figure 4-1.

The average measured daytime and night-time noise levels were 53.0 dB(A) and 50.3 dB(A) respectively, and fell well within the SANS guidelines for industrial districts of 70 dB(A) and 60 dB(A) (see Table 3-2). The noise environment was dominated by vehicular traffic on the R380, the mining operations, as well as the train operations to and from the manganese plant and mine.

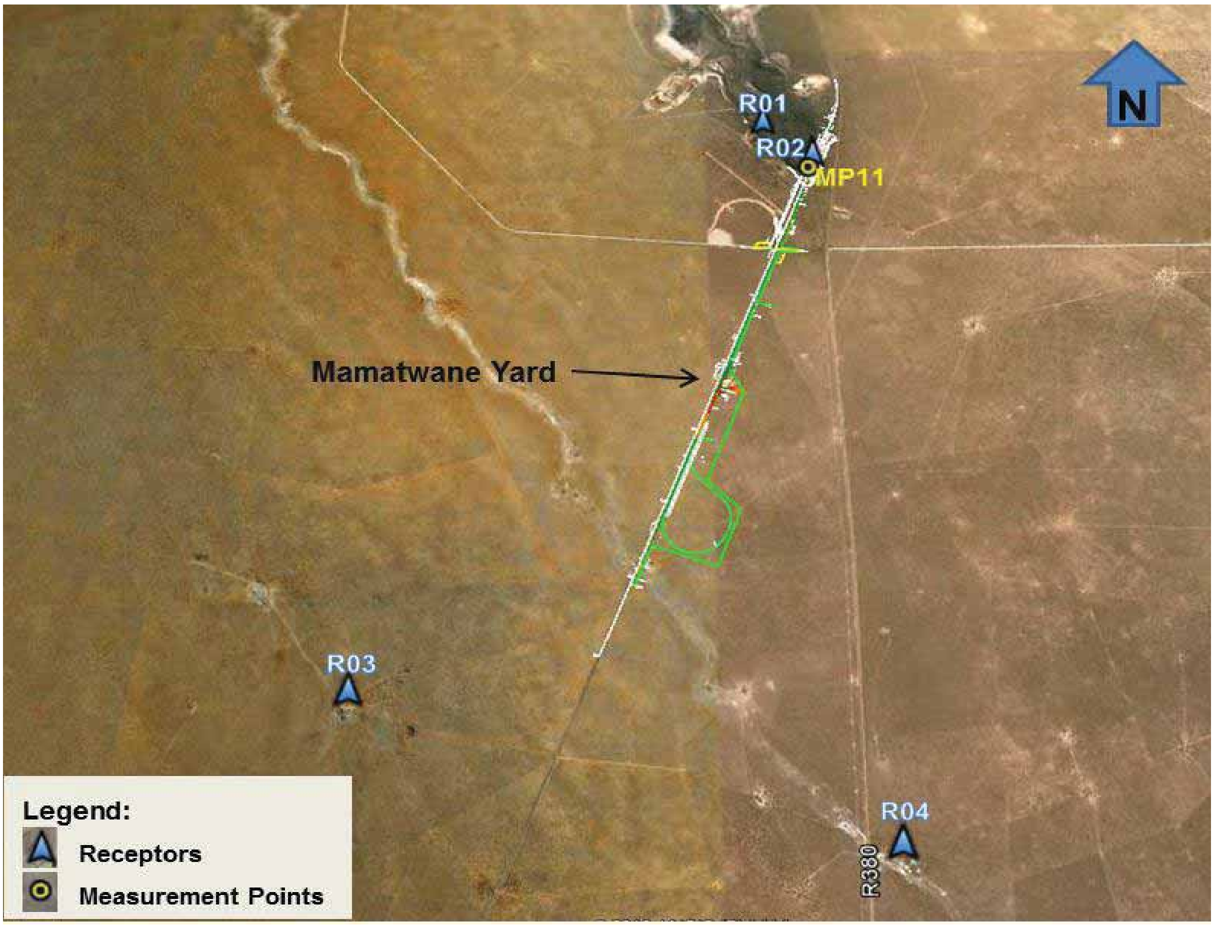


Figure 4-1. Mamatwane Yard Noise Monitoring Point and Receptors

4 VIBRATION MONITORING

Vibration measurements were performed at the Gong-Gong village, the Ulco loop and the Witloop loop on the 15th and 18th of October 2012. The locations of the measurement points are shown in the Figure 4-1 below. The coordinates of the measurement points can be seen in Table 4-1. The monitoring record sheets and vibration graphs are can be found in Appendix C.

Table 4-1. Vibration Monitoring Points

Measurement Points	Location	GPS Position (hdd°mm'ss.s'')
MPV01	Gong-Gong Community	S28°28'47.94" E24°24'50.22"
MPV02	Ulco Loop	S28°21'13.02" E24°17'18.72"
MPV03	Witloop	S 27°17'50.88" E22°58'49.86"

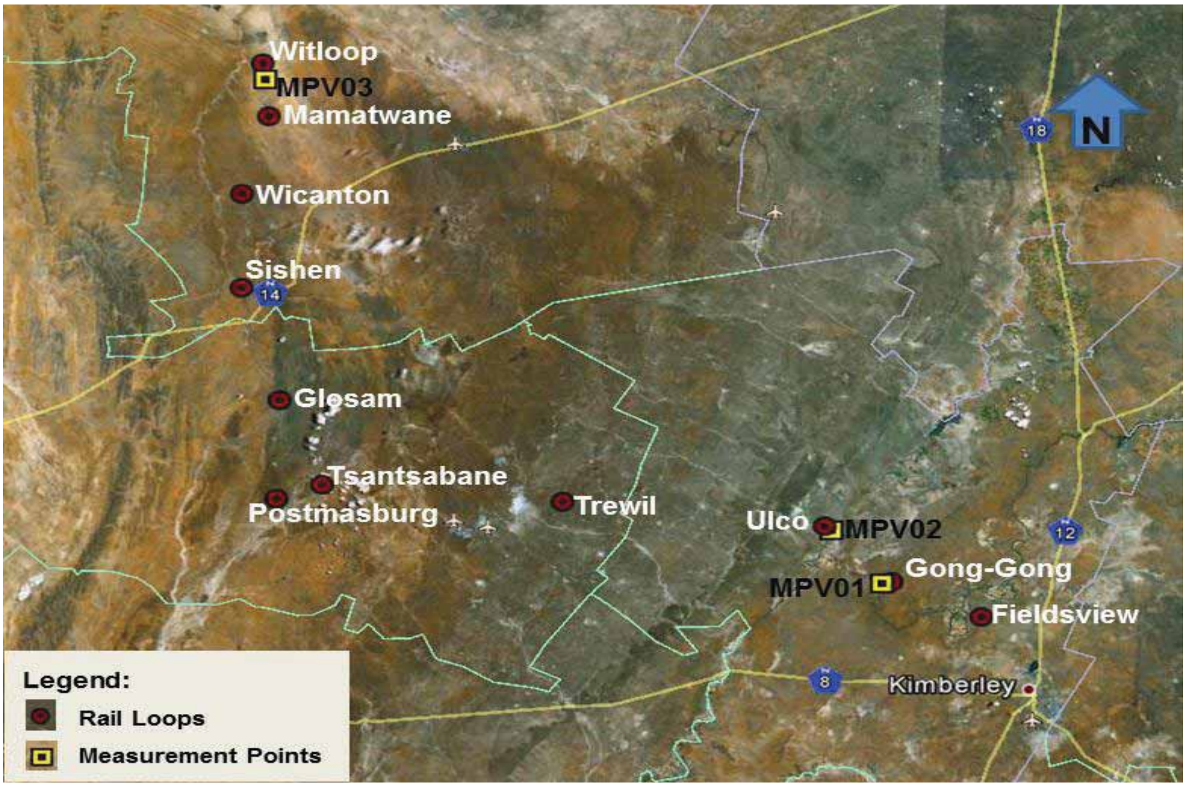


Figure 4-1. Vibration Monitoring Locations

4.1 Vibration Monitoring Procedure

The vibration measurements were performed with the use of the OneproD MVP-2C vibration analyser by 01dB-Metravib, with serial number 15134. This instrument is capable of recording the time series of the signals from a tri-axial or from individual one-directional accelerometers. The time series can then be downloaded to a computer for the determination of the relevant vibration parameters, such as the PPV and the RMS.

The vibration measurements in the present study were performed with an accelerometer, positioned in a direction vertical to the ground. The distances from the track were 1.2 km for MPV01 (Background), 8 m for MPV02 and MPV03.

4.2 Vibration Monitoring Data

The background vibration levels (MPV01), and the levels at two measurement locations with a train passing, are presented in Table 4-2 below.

Table 4-2. Vibration Measurement Results

Measurement Points	Measurement Description	Distance from Track (m)	PPV * (mm/s)	Train Speed (km/hr)
MPV01	Baseline Measurement at Gong-Gong village, with no train pass by	1200	0.134	-
MPV02	Train to Gong-Gong: 2 locomotive and 50 wagons	8	0.155	20
MPV03	Train from Hotazel : 1 locomotive and 34 wagons	8	2.94	50

* Peak Particle Velocity (PPV) guidelines:

- Human perception: 0.15 mm/s
- Buildings with poor construction: 2.0 mm/s
- Architectural damage risk level: 5.0 mm/s

5 NOISE AND VIBRATION MODELLING METHODOLOGY AND INPUT

5.1 Noise During Construction and Decommissioning

The construction activities of the proposed loops and compilation yard are likely to increase the local noise levels temporarily during the construction period. The basis for the modelling methodology for construction noise was the BS 5228-1: 2009, "Code of practice for noise and vibration control on construction and open sites – Part 1: Noise"

This standard was utilised for the calculation of noise from construction and the determination of the sound level data from on-site equipment and site activities. The typical sound power levels utilised in that standard were taken from measurements at various sites, percentage on-times and power ratings for a wide range of construction activities. The expected worst-case mix of excavators, bulldozers, front-end loaders, graders, compressors and trucks utilised for the noise modelling was assumed by similar operations.

The following parameters and assumptions were used in the calculations:

- Average height of noise sources: 2 m.
- Construction operating hours: 8 hr.
- No noise barriers in place.
- Construction site equipment:
  - ⇒ Excavator
  - ⇒ 2 Front end loaders
  - ⇒ 20t bulldozer
  - ⇒ 10m^3 tip trucks
  - ⇒ Grader
  - ⇒ Vibratory roller
  - ⇒ Compressor
  - ⇒ Generator
  - ⇒ Water pumps

It was also assumed, as a worst-case scenario, that all the equipment would be operated simultaneously at the construction site. The sound power levels of the construction equipment are shown in Table D-1 of Appendix D.

The equipment to be used for the decommissioning of the loop is expected to be similar to the construction equipment. As such, the noise levels during the decommissioning operations will be the same or similar to the construction related noise levels.

5.2 Operational Noise Prediction Methodology

Noise modelling was utilised for the sound propagation calculations and the prediction of the sound pressure levels around the loops. A modelling receptor grid was utilised for the determination of the expected noise contours, as a result of the increased train operations at the loops. In addition, the noise levels were estimated at several discrete receptors placed along the railway line and at various residential areas and farm houses around each loop.

The noise modelling was performed via the CADNA (Computer Aided Noise Abatement) noise model. The latter was selected for the following reasons:

- It incorporates the ISO 9613 in conjunction with the CONCAWE noise propagation calculation methodology.
- It provides an integrated environment for noise predictions under varying scenarios of operation.
- The ground elevations around the entire site can be entered into the model and their screening effects be taken into consideration.
- The noise propagation influences of the meteorological parameters can also be accounted for.

The main assumptions adopted in the noise modelling were:

Acoustically semi-hard ground conditions:

This assumes that partial attenuation due to absorption at the ground surface takes place. This assumption represents a somewhat pessimistic evaluation of the potential noise impact.

Meteorological conditions:

For the noise propagation in the extended area, the temperature and humidity for daytime was set in the model to 35^{o}C and 50% respectively, and for night-time 25^{o}C and 70% respectively. The model was set up to favourable atmospheric conditions for the noise propagation towards each receptor.

Screening effect of buildings and other barriers:

The effect of these structures on the noise climate has been ignored, representing a pessimistic evaluation of the potential noise impact. However, the ground elevations of the entire area were utilised in the modelling set-up.

5.2.1 Model Input

Due to the fact that authorisation has been granted for the loops, in order to accommodate the transportation of 12 Mtpa of Manganese, it was decided to use two scenarios for the noise modelling set-up and the impact assessment. The first scenario was based on the previously approved 12 Mtpa Manganese transport and the second on the 16 Mtpa transport, which is the amount of Manganese that will be accommodated due to the loop extensions. Therefore, the following two scenarios were utilised in the model set-up:

Scenario 1: 12 Mtpa (approved situation)

Scenario 2: 16 Mtpa (with loop extensions)

The train characteristics for the model input are presented in Table 5-1 below. The cumulative impact of the general freight trains utilising the railway line were also taken into consideration for each scenario.

Table 5-1. Operational Details for the Railway Line Loops

Description	Details
Scenario 1 (approved situation)	
Manganese transport capacity	12 Mtpa
Type of rail line	1065 mm gauge, electrified (3 kV DC) line.
Locomotive types:	Electric locomotives (10Es & 18Es).
No. of trains per day	Manganese: 6 per direction General Container: 3 per direction
No. of locomotives per train	Manganese: Four locomotives to be required for the 104 wagon trains. Container: Two locomotives will be required for the 50 general container trains.
Total rail traffic per day	Manganese: 624 wagons + 24 locomotives (one way) Container: 150 wagons + 6 locomotives (one way)
Operating hours	Trains will run both day and night.
Train speed	A speed of 60 km/hr was assumed for the trains passing the loops.
Scenario 2 (with loop extensions)	
Manganese transport capacity	16 Mtpa
Type of rail line	1065 mm gauge, electrified (3 kV DC) line.
Locomotive types:	Electric locomotives (New generation dual voltage locomotives).
No. of trains per day	Manganese: 5 per direction General Container: 4 per direction
No. of locomotives per train	Manganese: Nine locomotives to be required for the 200 wagon trains. Container: Two locomotives will be required for the 50 general container trains.

Description	Details
Total rail traffic per day	Manganese: 1000 wagons + 45 locomotives (one way) Container: 200 wagons + 8 locomotives (one way)
Operating hours	Trains will run both day and night.
Train speed	A speed of 60 km/hr was assumed for the trains passing the loops.

5.3 Vibration During Construction and Operation

With respect to construction vibration, there are no standards that provide a methodology to predict levels of vibration from construction activities, other than those contained within BS 5228: Part 2, which relates to piling and other construction activities.

It is generally accepted that for the majority of people vibration levels of between 0.15 and 0.3 mm/s peak particle velocity are just perceptible. Table 5-2 below details the distances at which certain construction activities give rise to a just perceptible level of vibration. This data is based on historical field measurements and BS 5228-2: 2009, "Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration".

The activities and equipment listed below are the ones that typically generate the highest levels of vibration at construction sites.

Table 5-2. Vibration Levels of Construction Sources

Construction activity	Distance from activity when vibration may just be perceptible (m)
Excavation	10 - 20
Hydraulic breaker	15 - 20
Vibratory rollers	15 - 25

None of the above-mentioned activities during construction will take place outside the loop extension sites or closer than 10 m from the boundaries. The Threshold of Perception for Human Reaction level of 0.3 mm/s is not expected to be exceeded outside the site. However, the train operations are expected to generate vibrations at close distances from the rail tracks.

The surface waves generated by traffic, trains and most construction operations attenuate with distance according to the following equation:

$$PPV = PPV_0 (D_0/D)^{0.5} * e^{\alpha(Do-D)} \quad \textbf{Eq. 5-1}$$

Where:

PPV = Peak particle velocity.

PPV_0 = Peak particle velocity at reference distance D0.

D0 = Reference distance.

D = Distance for which vibration level is to be calculated.

α = Soil parameter (0.017 for clayey soil).

Vibration measurements were undertaken along the existing railway loops in Northern Cape as well as the Eastern Cape, in order to determine the reference PPV_0. As a worst-case scenario, the highest measured PPV value of 5.87 mm/s was used as the reference PPV_0 for the calculation of the vibration levels at various distances from the track.

It should be noted that these levels represent an indication of the conditions at the time of the measurement and the specific location.

The calculated vibration levels at various distances from the rail tracks can be found in the modelling section further below.

6 PREDICTED NOISE AND VIRATION LEVELS

6.1 Construction Noise Modelling Results

The noise levels due to the construction operations at the loops, taking into consideration the expected equipment mix as outlined in Section 5.1, were calculated. As a worst-case scenario, it was assumed that all of the equipment operates at the working face simultaneously.

Table 6-1 below shows the noise levels at various distances from the construction working face. The noise levels further than 500 m from the working face were found to be around 45 dB(A). Therefore, the construction activities at receptors outside the 500 m zone from the main working area will be noticeable but will not constitute a disturbing noise. For receptors located at greater distances than a 1.0 km radius, the construction noise will be barely audible.

There are several isolated farm houses along the loop alignments that are situated within the 500 m zone around the railway line. The noise impact within this zone is expected to be Medium, and as the construction activities move further away, the impact is estimated to be Low.

It should also be noted that the screening effects of the existing ground elevations may have a small reduction effect on the actual noise levels generated during the construction phase. The noise levels in Table 6-1 were estimated without any barrier effects and can thus be considered a worst-case scenario.

Table 6-1: Modelled Noise Levels at Various Distances from the Loops: Construction Working Face

Receptor Distance (m)	Noise Level (dB(A))
100	62.2
200	56.6
400	50.1
500	47.8
700	44.2
1000	40.1

Similar noise levels are expected to be generated by the decommissioning operations at the loops. In addition, this impact is likely to be of shorter duration. As such, no significant noise impacts are expected during the decommissioning phase of the loops.

6.2 Operational Noise Modelling Results

Based on the noise modelling methodology and input data outlined in Section 5, the resulting noise levels around each rail loop were estimated for day- and night-time conditions. The modelling results for each loop are presented in the sections below.

It should be noted that the noise contours were calculated for the proposed expansion, which will allow for the 16 Mtpa Manganese transport (Scenario 2). Noise contours were not generated for the previously approved scenario of 12 Mtpa transport (Scenario 1).

However, for comparison purposes, the modelling noise levels for both scenarios were calculated for the discrete receptors around the loops, and are presented for each loop.

6.2.1 Fieldsview Loop

The modelled noise contours around the Fieldsview loop can be seen in Figure 6-1 and Figure 6-2 for day- and night-time respectively. The area around this loop is considered to be rural and the noise levels are within the guideline for rural areas, i.e. 45 dB(A) during daytime and 35 dB(A) during the night.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop reached 600 m on either side of the loop, with small variations due to the local topography (see Figure 6-1). During night-time, the 35 dB(A) zone extended approximately 1.7 km away from the loop (see Figure 6-2).

The modelled noise levels at receptors around the loop for both scenarios are shown in Table 6-2. As can be seen, there are no receptors within the zone exceeding the daytime SANS guideline of 45 dB(A) for rural district. However, as for night-time, the predicted noise levels at receptors R02 and R03 exceeded the guideline of 35 dB(A) both scenarios.

It should be noted that these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. The expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa Scenario was estimated to be 2 dB(A) (see Table 6-2), which is considered very low, since the levels at both receptors will be below the WHO night-time guideline for dwellings of 45 dB(A).

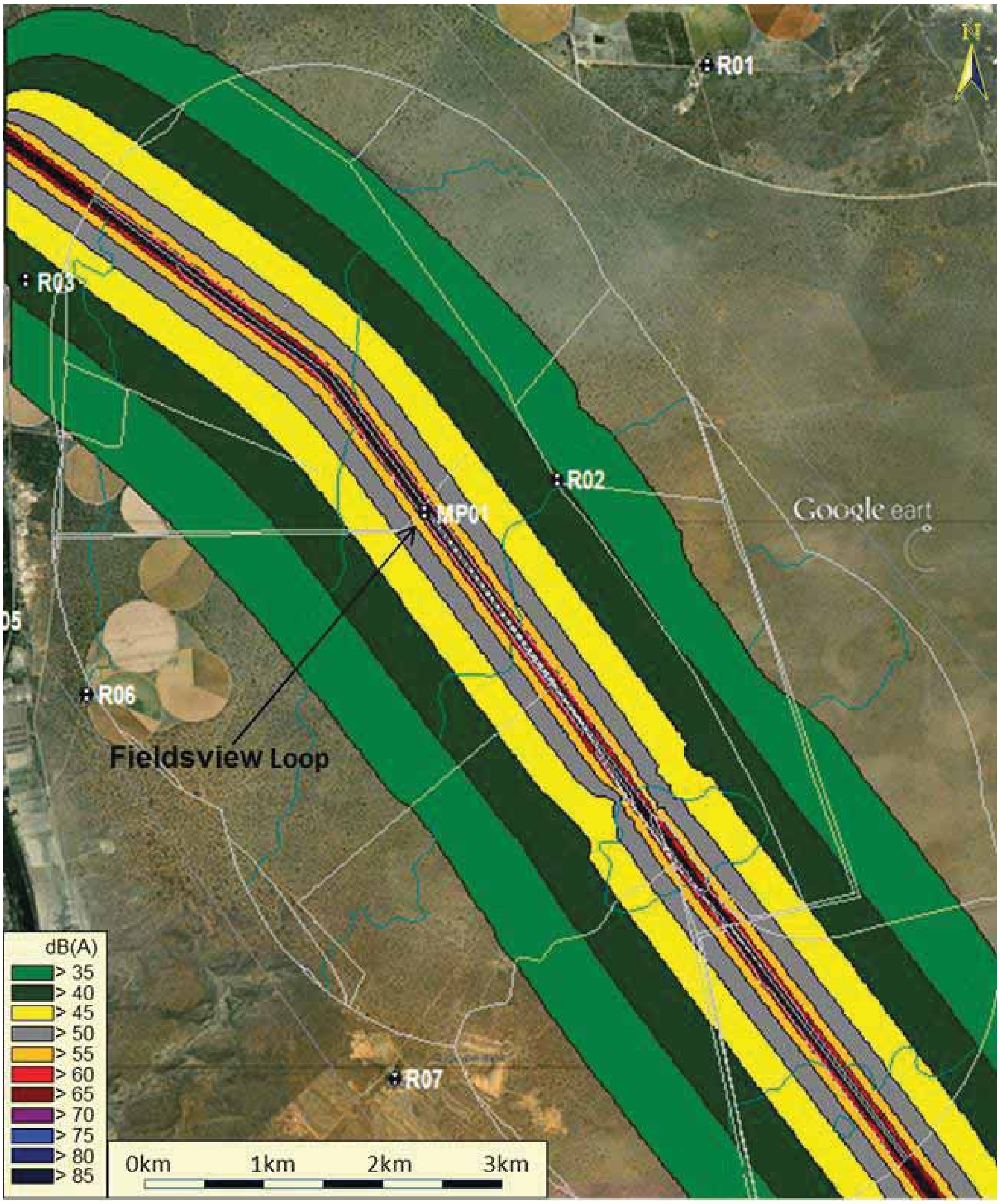


Figure 6-1. Daytime Noise Contours: Fieldsview Loop

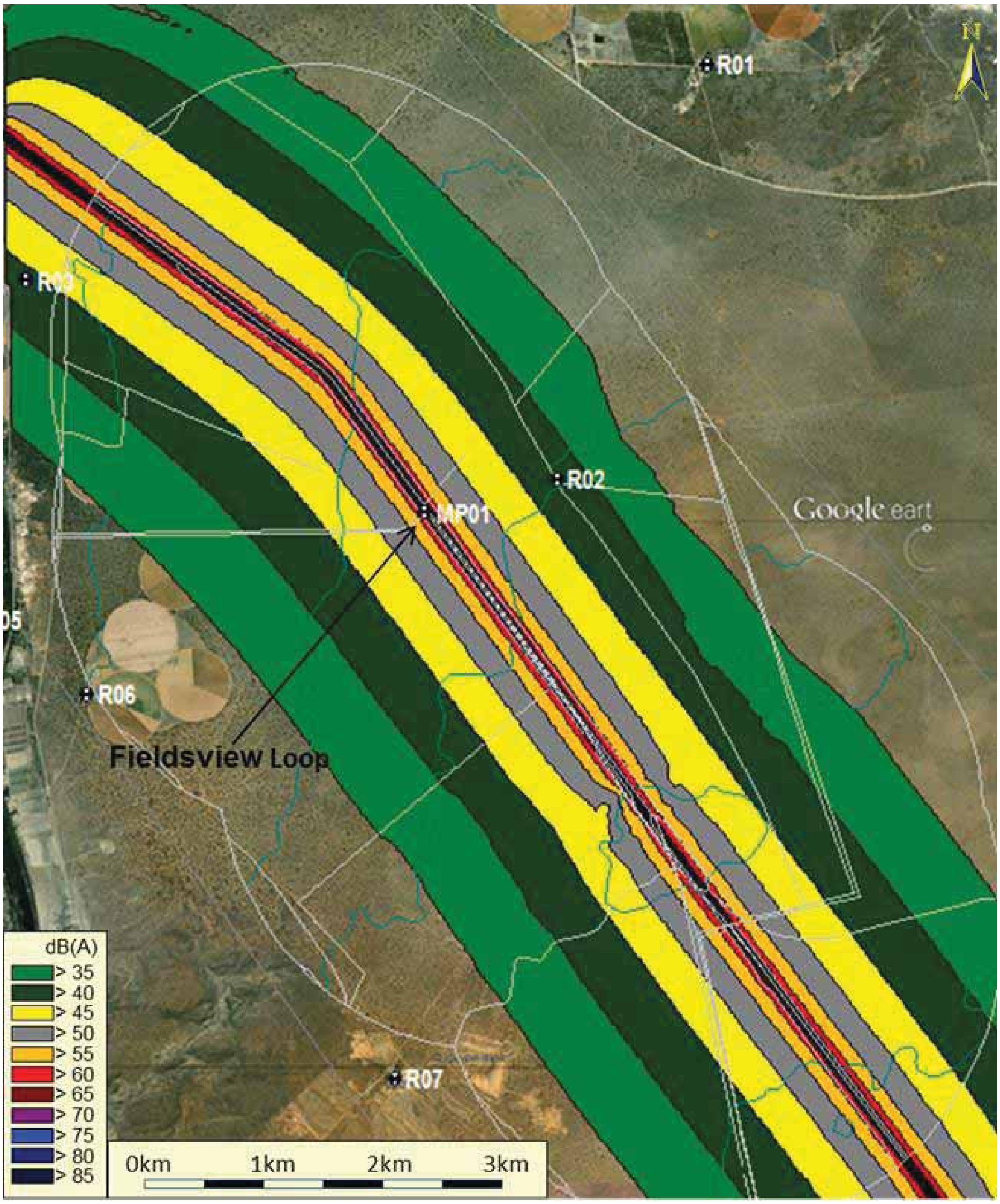


Figure 6-2. Night-time Noise Contours: Fieldsview Loop

Table 6-2. Modelled Noise Levels around Fieldsview Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP01	Measurement Point	66.2	66.5	68.1	68.4
R01	Farm House	< 25	< 25	< 25	< 25
R02	Farm House	38.3	40.2	40.2	42.2
R03	Farm House	40.0	41.9	41.9	43.9
R04	Farm House	24.2	26.1	26.1	28.1

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
R05	Farm House	23.4	25.4	25.4	27.4
R06	Farm House	24.5	26.5	26.5	28.5
R07	Farm House	24.6	26.6	26.6	28.5

[a] Scenario 1: 12 Mtpa (Approved in previous EIA)

[b] Scenario 2: 16 Mtpa

6.2.2 Gong-Gong Loop

The modelled noise contours around the Gong-Gong loop can be seen in Figure 6-3 and Figure 6-4 for daytime and night-time respectively. The modelled noise levels at sensitive receptors around the loop are shown in Table 6-3.

As can be seen from Figure 6-3, with the loop extension, the 45 dB(A) zone reached 600 m on both sides of the loop. The modelled daytime noise levels at all sensitive receptors were below the guideline of 45 dB(A).

During night-time, the guideline 35 dB(A) zone extended approximately 1.8 km away from the loop (see Figure 6-4). The modelled noise levels at the community north west and west of the loop (R01-R04), marginally exceeded the guideline of 35 dB(A).

It should be noted that the night-time noise level, measured on the border of these communities, was around 43 dB(A), primarily due to traffic on the R31 and human activity. As such, the cumulative noise level in these communities is not expected to exceed the WHO and SANS guideline for urban residential areas of 45 dB(A). The contribution of the increased railway activity is expected to be low.

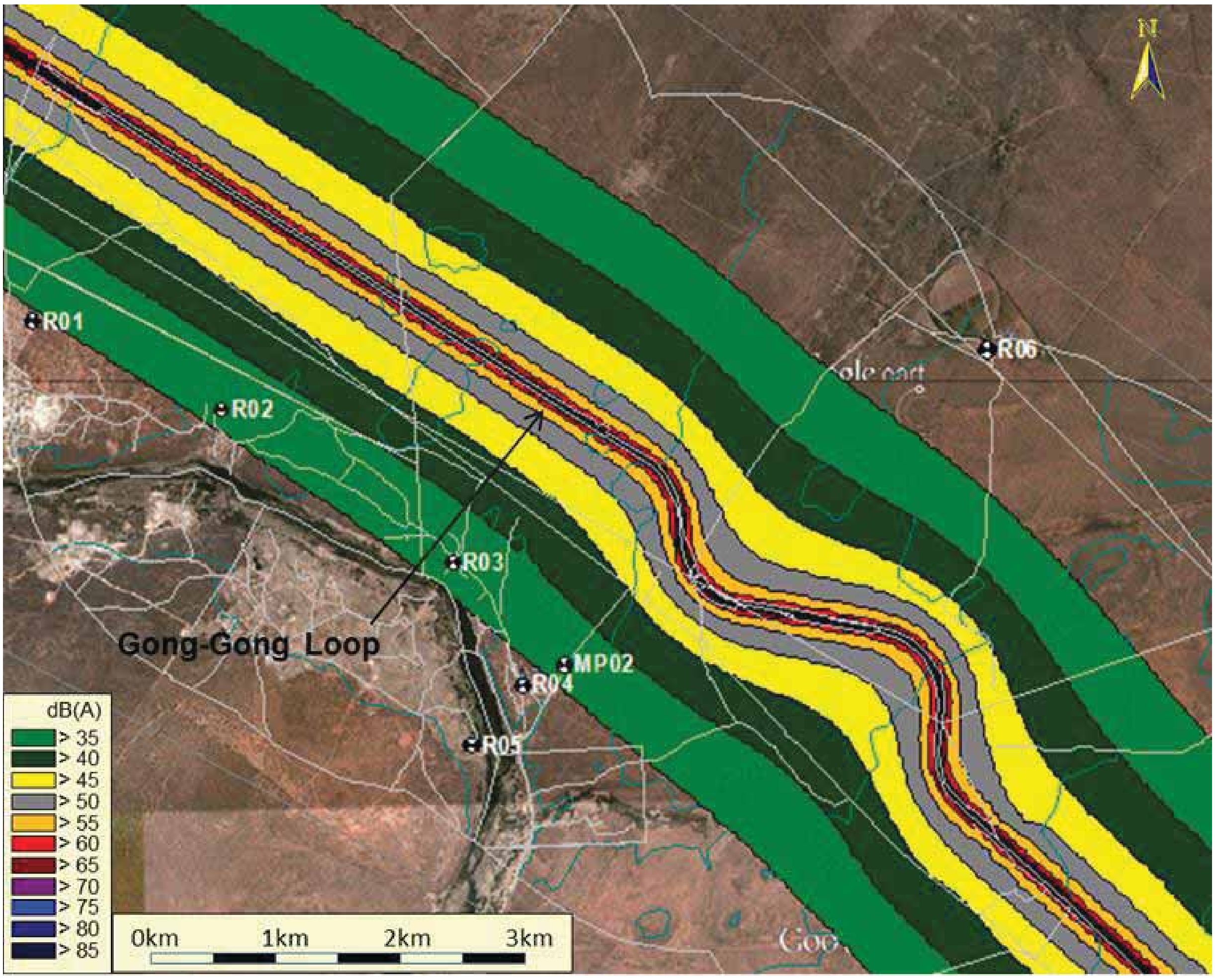


Figure 6-3. Daytime Noise Contours: Gong-Gong Loop

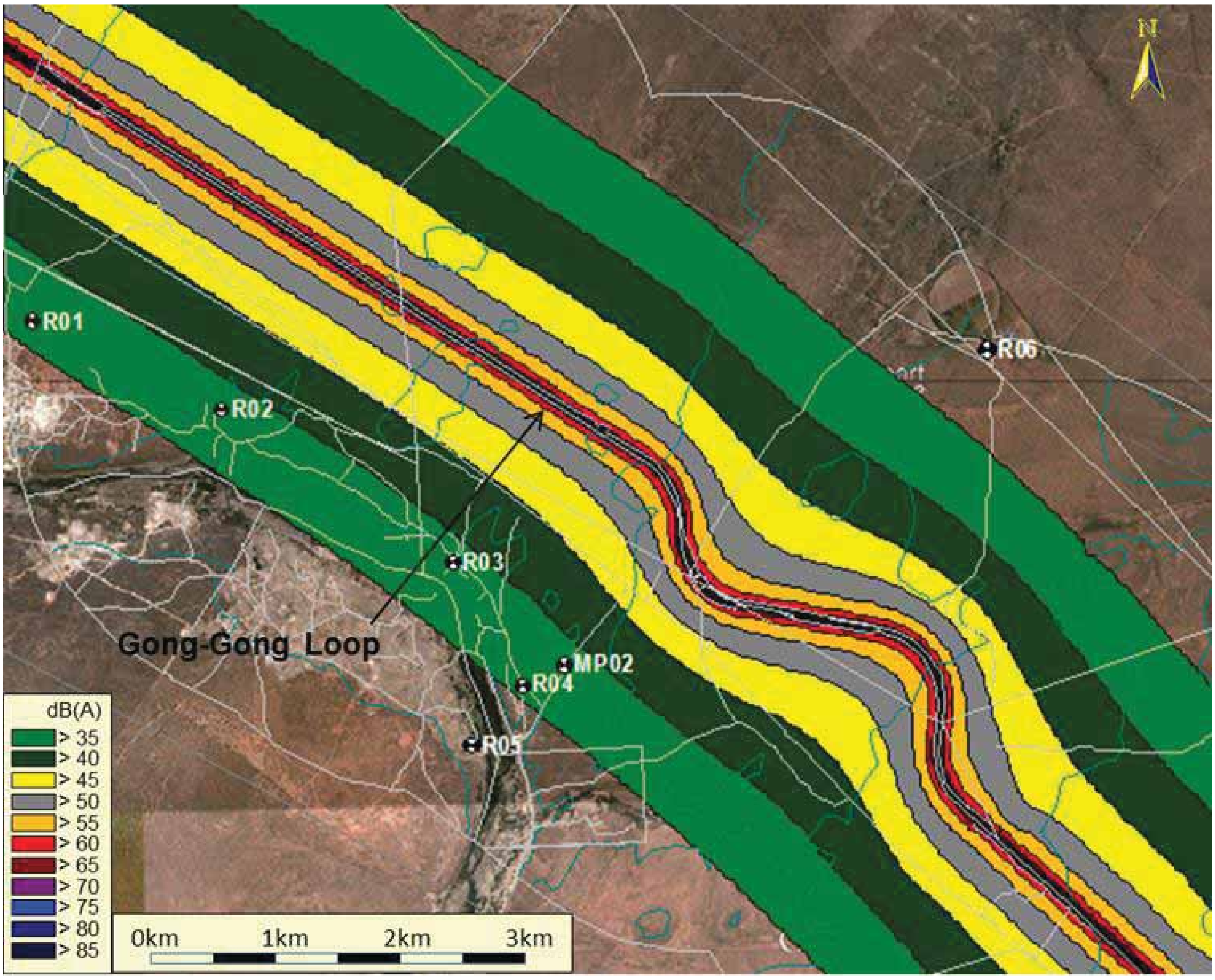


Figure 6-4. Night-time Noise Contours: Gong-Gong Loop

Table 6-3. Modelled Noise Levels around Gong-Gong Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP02	Measurement Point	34.4	36.4	36.3	38.3
R01	Community north west of loop	32.5	34.4	34.4	36.4
R02	Communities west of loop	34.3	36.2	36.2	38.2
R03		34.6	36.6	36.6	38.5
R04		31.7	33.7	33.7	35.6
R05	Farm House	27.7	29.7	29.7	31.7
R06	Farm House	27.1	29.1	29.0	31.0

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.3 Ulco Loop

The modelled noise contours for the Ulco loop are shown in Figure 6-5 and Figure 6-6 below for daytime and night-time respectively. The area around the Ulco loop is considered to be rural. The predicted railway noise contribution up to 600 m and 1.7 km around the loop is expected to be above the 45 dB(A) during daytime and above 35 dB(A) during night-time respectively.

The modelled noise levels at receptors around the loop for the two scenarios are shown in Table 6-4. As can be seen, out of the three receptors in the area, only receptor R02 is situated within the zone exceeding the daytime rural guideline of 45 dB(A) for both scenarios.

The night-time noise levels exceeded the night-time rural guideline at receptors R02, R03 and R04. From Table 6-4 it is also evident that the exceedances at these receptors are expected to be present around the loops, due to the approved 12 Mtpa Manganese transport (Scenario 1). The noise level increase due to the proposed loop extension, in order to allow for a 16 Mtpa transport, is expected to be approximately 2 dB(A), which is considered low.

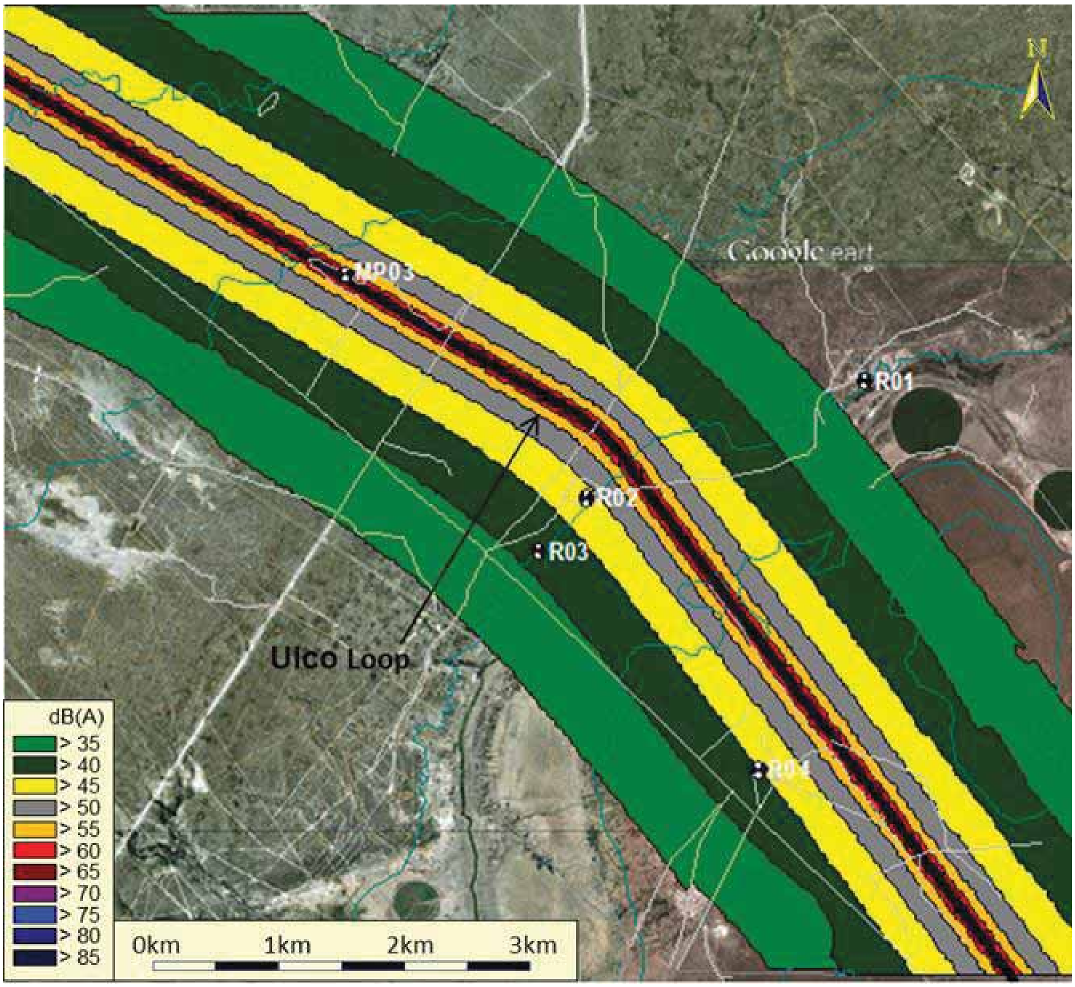


Figure 6-5. Daytime Noise Contours: Ulco Loop

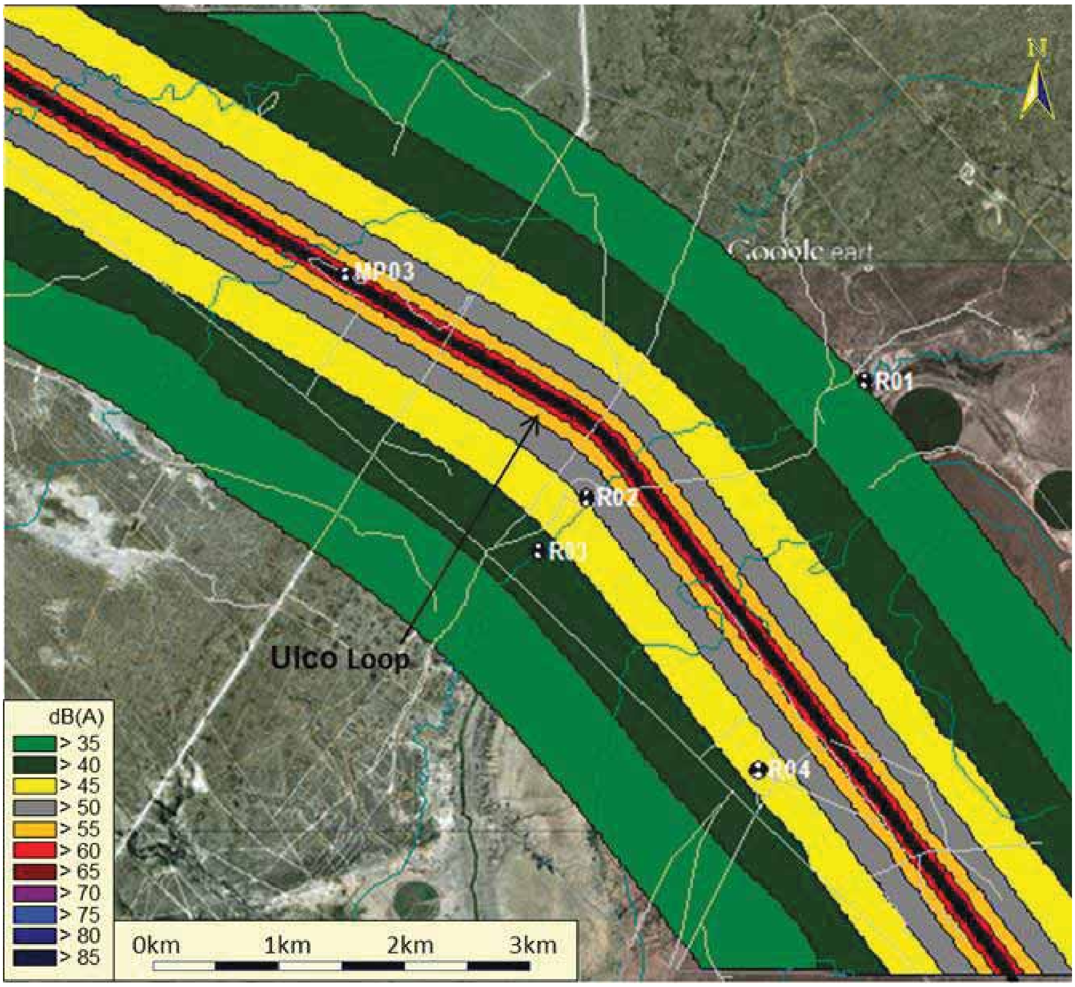


Figure 6-6. Night-time Noise Contours: Ulco Loop

Table 6-4. Modelled Noise Levels around Ulco Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP03	Measurement Point	62.8	63.7	64.8	65.6
R01	Farm House	30.9	32.9	32.9	34.8
R02	Farm House	46.6	48.5	48.5	50.4
R03	Farm House	39.5	41.5	41.5	43.4
R04	Farm House	42.9	44.9	44.9	46.8

[a] Scenario 1: 12Mtpa (Approved in previous EIA)

[b] Scenario 2: 16Mtpa

6.2.4 Trewil Loop

Figure 6-7 and Figure 6-8 below depict the daytime and night-time noise contours around the Trewil loop respectively. The loop is located in a remote rural area with low ambient noise levels.

With the rail capacity increase due to the loop extension, the 45 dB(A) zone around the loop reached 700 m on either side of the loop during the day (see Figure 6-7). At night-time, the 35 dB(A) zone extended approximately 1.8 km away from the loop (see Figure 6-8).

The modelled noise levels for the two scenarios at receptors around the loop are shown in Table 6-5. As can be seen, at receptor R02, which is a Transnet building, the predicted noise levels exceeded the SANS guidelines for rural areas, i.e. 45 dB(A) and 35 dB(A) for daytime and night-time respectively.

The farm houses R01 and R03 were outside of the zones of guideline exceedances and for both scenarios. The expected noise contribution due to the loop expansion is considered very low.

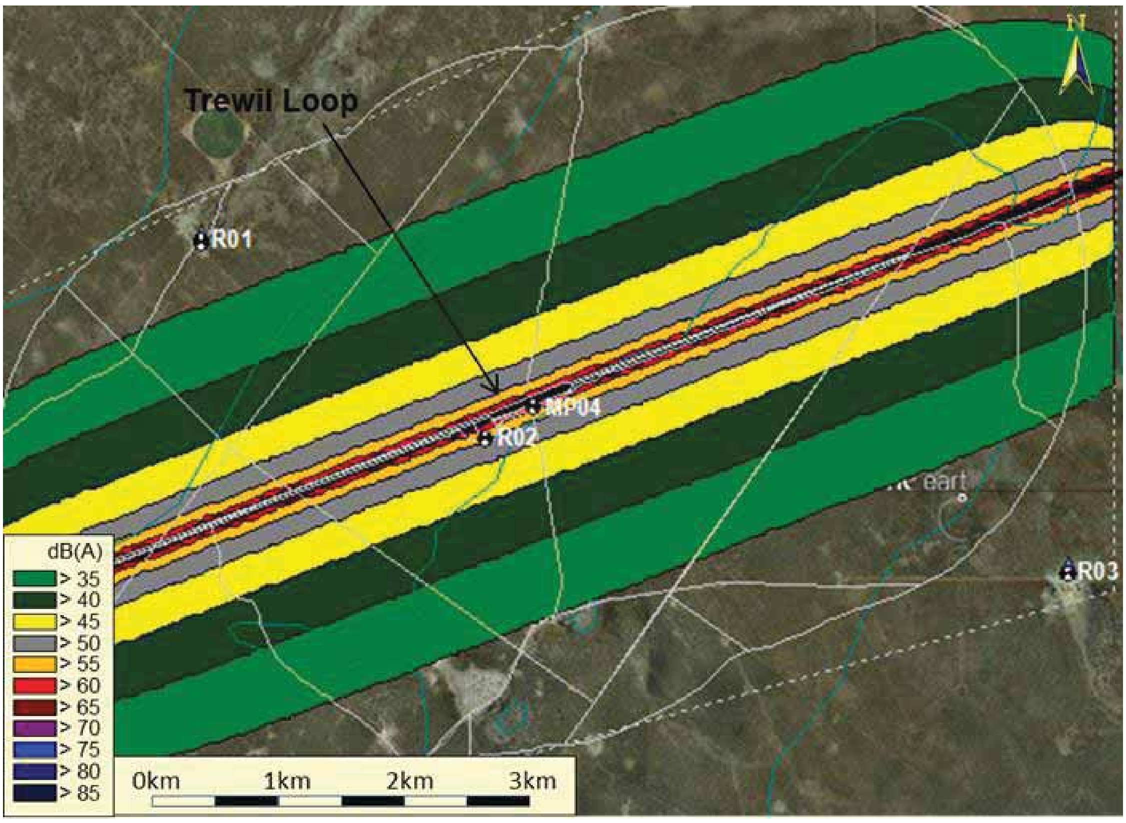


Figure 6-7. Daytime Noise Contours: Trewil Loop

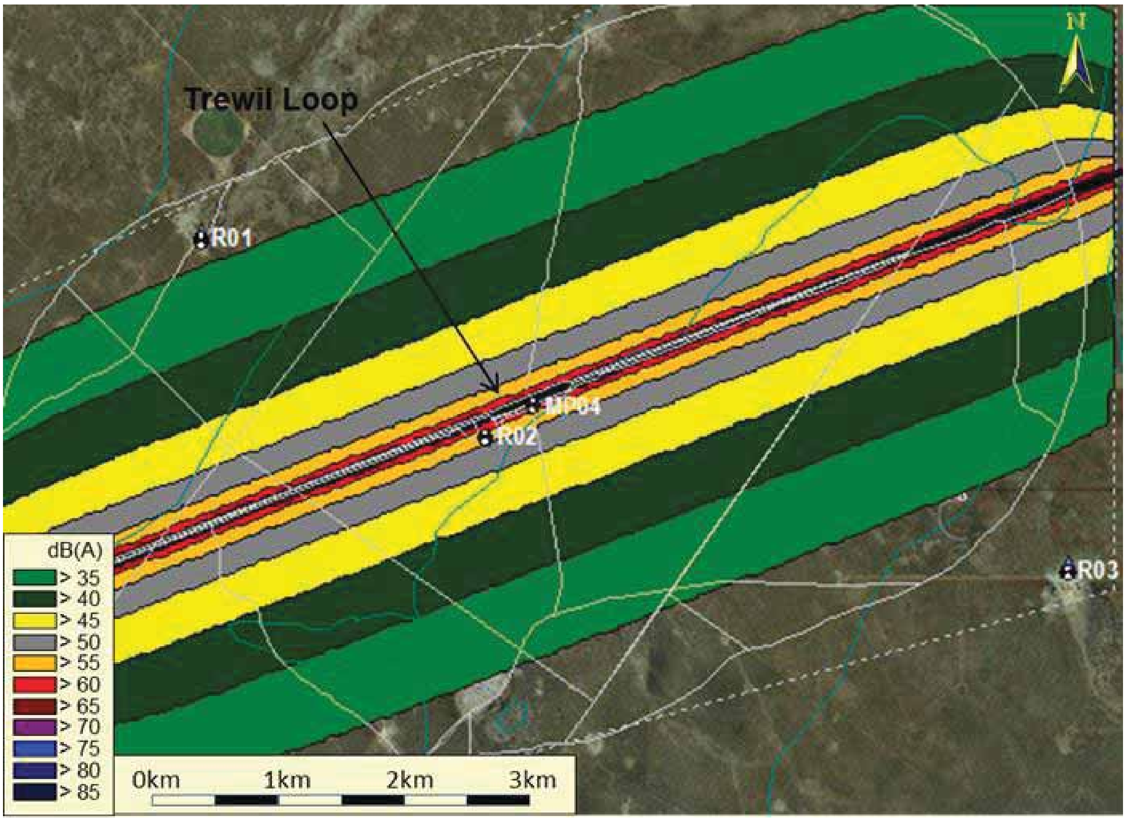


Figure 6-8. Night-time Noise Contours: Trewil Loop

Table 6-5. Modelled Noise Levels around Trewil Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP04	Measurement Point	60.8	62.0	62.8	63.9
R01	Farm House	29.7	31.7	31.7	33.6
R02	Farm House	53.7	55.4	55.6	57.3
R03	Farm House	25.3	27.3	27.3	29.3

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.5 Tsantsabane Loop

The noise contours around the Tsantsabane loop are shown in Figure 6-9 and Figure 6-10 for daytime and night-time respectively. The noise environment around the loop is that of a typical rural area with low noise levels. The predicted noise level contribution of the railway loops up to 500 m and 1.8 km from the alignment exceeded the SANS guideline for daytime (45 dB(A) and night-time (35 dB(A)) respectively.

The modelled noise levels at receptors around the loop for the two scenarios are shown in Table 6-6. As can be seen, there are three receptors with the zone exceeding the daytime guideline of 45 dB(A) for rural districts for both scenarios, i.e. R05, R07 and R08. The night-time rural guideline was exceeded at all of the receptors except for R09, which is situated more than 3 km north of the loop.

The noise impact at the above-mentioned receptors is considered significant. However, these exceedances are expected to be present with the implementation of the 12 Mtpa Manganese transport scenario, which was authorised in the previous EIA. The expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa scenario was estimated to be 2 dB(A), which is considered low.

It should be noted that the Postdene community, situated 3.5 km south-east from the loop, due to its close proximity to the railway line, lies primarily within the 45 dB(A) zone and will be significantly affected by the railway traffic for the 12 Mtpa transport (Scenario 1) and the loop extension.

During daytime, the first rows of houses closer to the railway line will also experience noise levels greater than the daytime guideline for urban areas of 55 dB(A). Within this zone, in addition to the dwellings, are also situated noise-sensitive receptors such as the Asmandia Primary School and two Churches.

As mentioned above, the noise impact on the Postdene community will be present already with the 12 Mtpa transport scenario, which has been previously approved. As such, mitigation measures should be investigated and implemented as soon as possible.

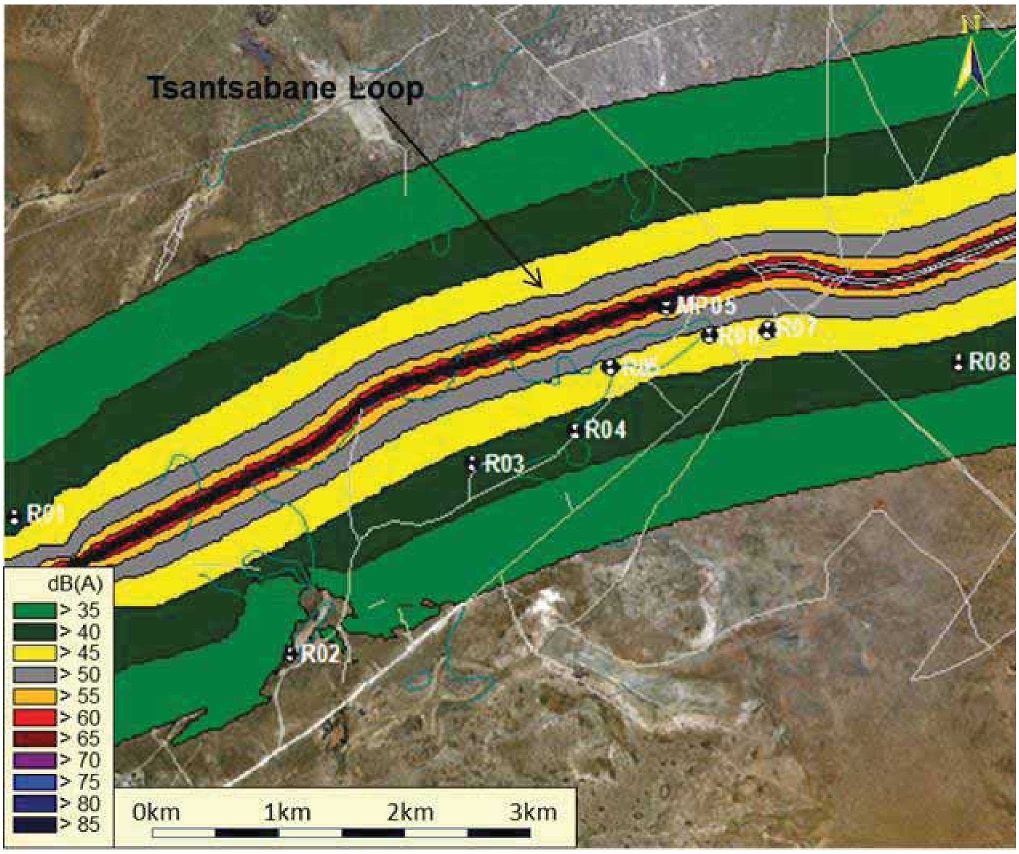


Figure 6-9. Daytime Noise Contours: Tsantsabane Loop

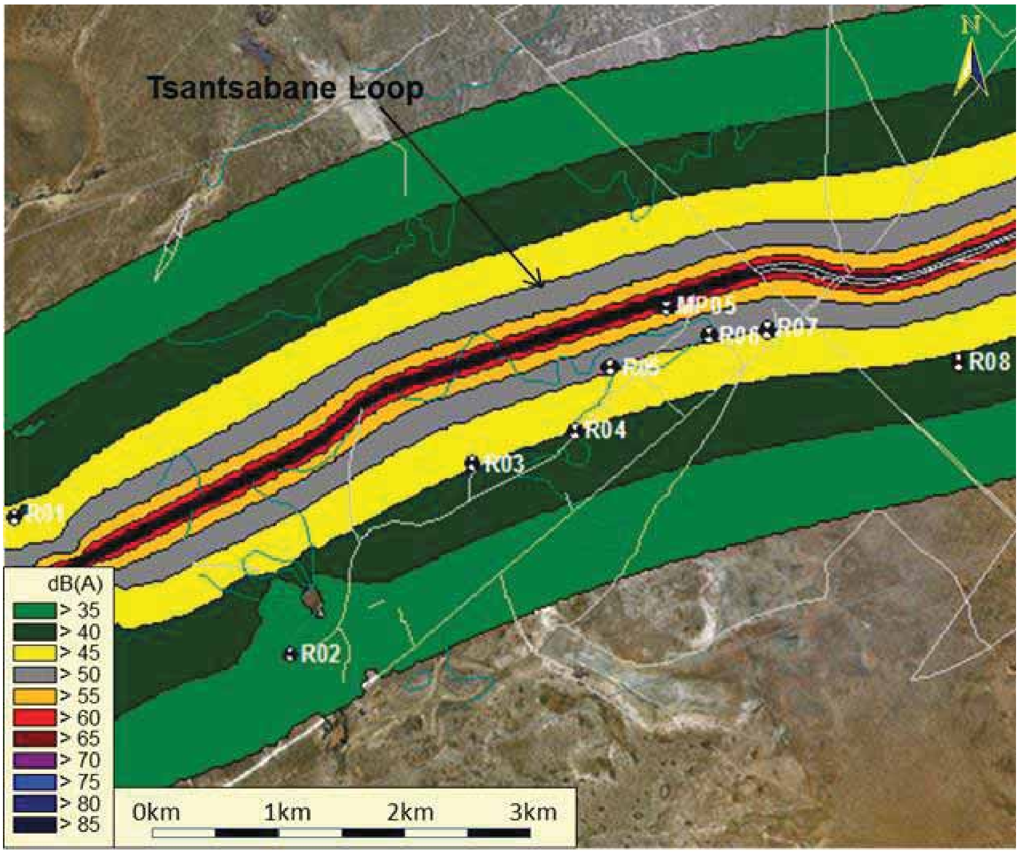


Figure 6-10. Night-time Noise Contours: Tsantsabane Loop

Table 6-6. Modelled Noise Levels around Tsantsabane Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP05	Measurement Point	59.7	61.0	61.7	62.9
R01	Postdene community west of loop	41.0	43.0	43.0	44.9
R02	Farm House	33.5	35.5	35.5	37.4
R03	Farm House	41.6	43.5	43.5	45.5
R04	Farm House	41.2	43.1	43.1	45.1
R05	Farm House	46.9	48.8	48.8	50.7
R06	Farm House	47.1	49.0	49.1	51.0
R07	Farm House	46.3	48.2	48.2	50.1
R08	Farm House	40.3	42.2	42.2	44.1
R09	Farm House	23.6	25.6	25.6	27.6

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.6 Postmasburg Loop

The noise contours around the Postmasburg loop can be seen in Figure 6-11 and Figure 6-12 for the daytime and night-time respectively.

The noise contribution due to the railway loop extension will exceed the SANS daytime guideline for urban residential areas in very close proximity around the loop, i.e. within 150 m from the line.

The night-time noise levels due to the Postmasburg loop will exceed the 45 dB(A) guideline for urban areas within 620 m from the loop (see Figure 6-12).

The modelled noise levels for the two scenarios at receptors around the loop are shown in Table 6-7. As can be seen, the noise levels at the community southeast of the loop (R06), which is situated adjacent to the railway line, exceeded the night-time guideline for both scenarios. The night-time guideline of 45 dB(A) was also exceeded at the Beeshoek community (R01) for both scenarios.

It should be noted that these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. The expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa Scenario was estimated to be 2 dB(A), which is considered low.

Noise-sensitive receptors such as the Newtown Primary School, the Bidi Memorial Primary School, the Ratang Thuto Senior Secondary School and the Boishoko Methodist Church were outside the 45 dB(A) noise contour and are not expected to be affected by the loop extension.

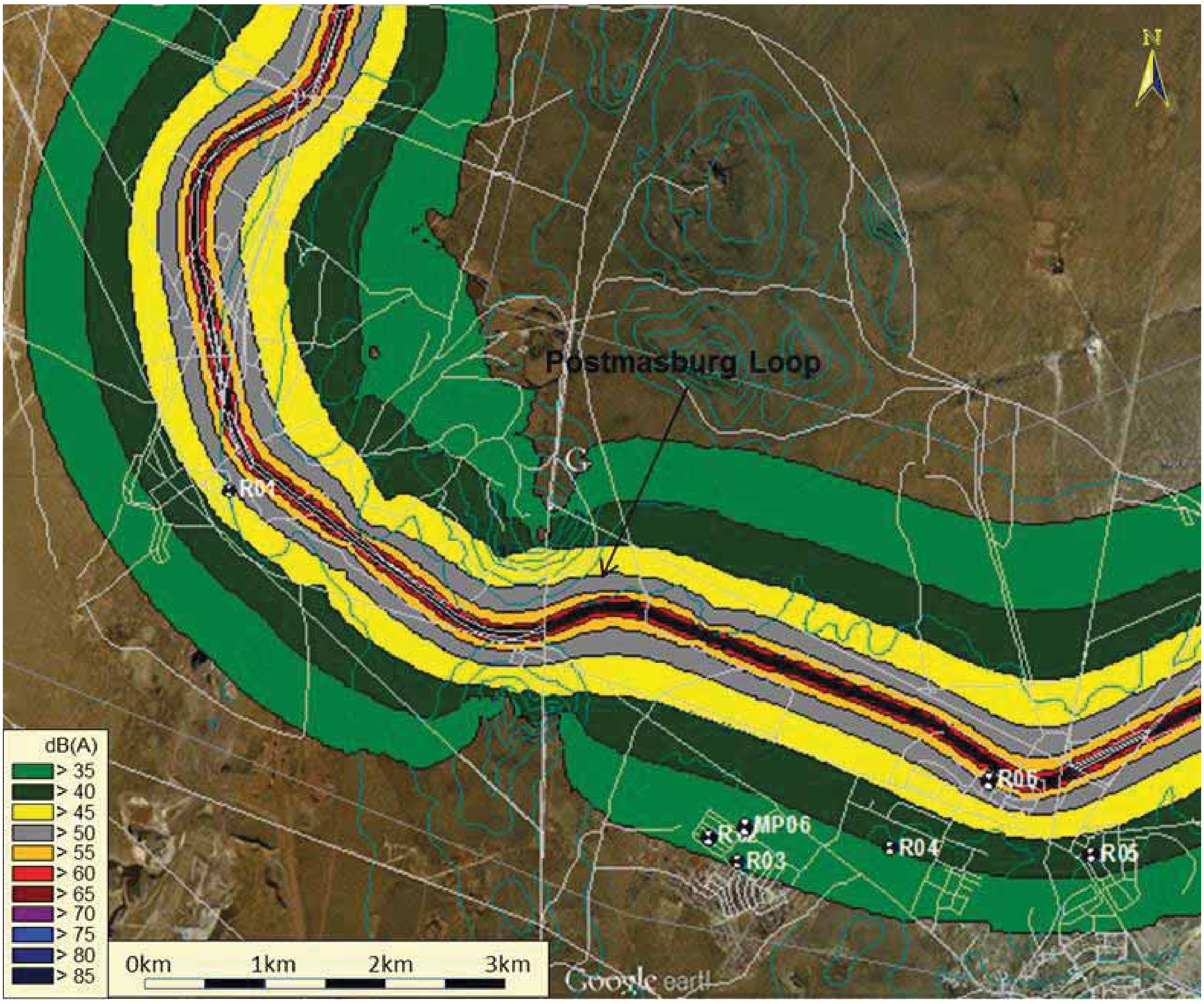


Figure 6-11. Daytime Noise Contours: Postmasburg Loop

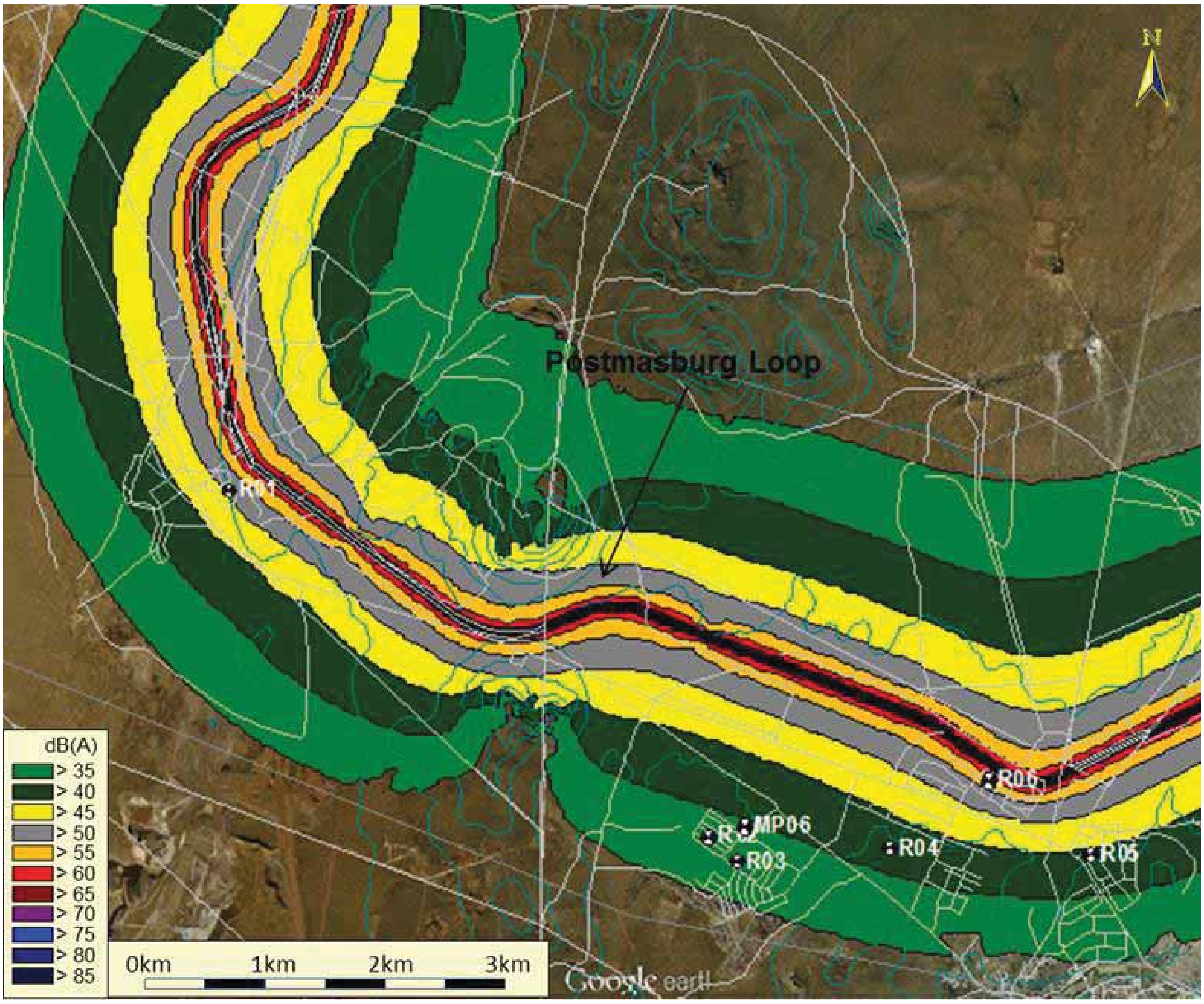


Figure 6-12. Night-time Noise Contours: Postmasburg Loop

Table 6-7. Modelled Noise Levels around Postmasburg Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP06	Measurement Point	35.6	37.6	37.6	39.6
R01	Beeshoek community northwest of loop	47.1	48.9	49.0	50.9
R02	Boichoko Community	34.3	36.2	36.2	38.2
R03	HTT Bidi Memorial Primary School	33.4	35.3	35.3	37.3
R04	Newtown community south of R385	38.1	40.0	40.0	42.5
R05	Postmasburg community east of R325	40.5	42.4	42.4	44.3
R06	Newtown community south east of the loop	54.1	55.8	56.1	57.8

[a] Scenario 1: 12Mtpa (Approved in previous EIA)

[b] Scenario 2: 16Mtpa

6.2.7 Glosam Loop

The noise contours around the Glosam loop can be seen in Figure 6-13 and Figure 6-14 for the daytime and night-time respectively.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop reached 600 m on either side of the loop, with small variations due to the local topography (see Figure 6-13). During night-time, the 35 dB(A) zone extended approximately 1.6 km away from the loop (Figure 6-14).

The predicted noise levels at receptors around the loop for the two examined scenarios, i.e. the 12 Mtpa and 16 Mtpa of Manganese transport, are shown in Table 6-8. For Scenario 2 (16 Mtpa), the noise levels at the Glosam community (R01) and receptor R03 marginally exceeded the daytime guideline of 45 dB(A) for rural districts.

The expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa Scenario was estimated to be 2 dB(A), which is considered low. However, the night-time guideline for rural districts was exceeded at all receptors by more than 10 dB, which is considered significant, since the existing night-time noise level is below 35 dB(A).

As can be seen from Table 6-8, these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. As such, mitigation measures should be investigated and implemented as soon as possible.

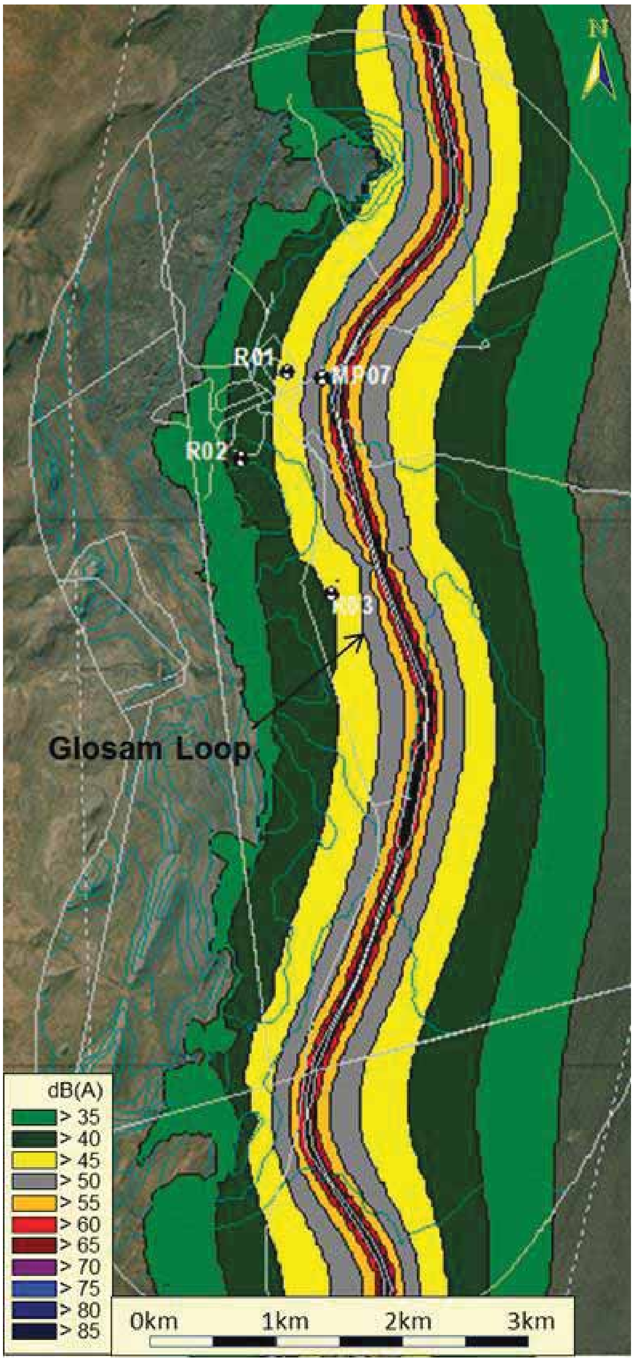


Figure 6-13. Daytime Noise Contours: Glosam Loop

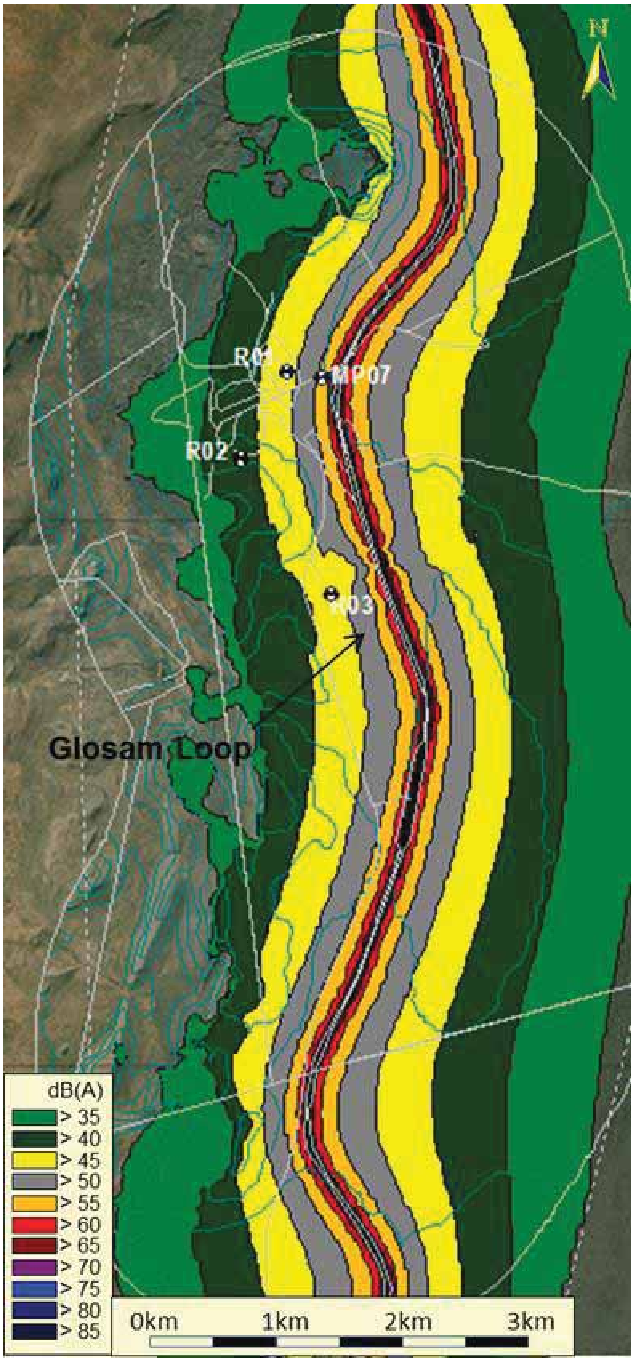


Figure 6-14. Night-time Noise Contours: Glosam Loop

Table 6-8. Modelled Noise Levels around Glosam Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP07	Measurement Point	52.7	54.4	54.6	56.3
R01	Glosam community	44.5	46.4	46.4	48.3
R02	Farm House	39.3	41.2	41.2	43.2
R03	Farm House	43.8	45.7	45.7	47.6

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.8 Sishen Loop

The daytime and night-time noise contours around the Sishen loop are shown in Figure 6-15 and Figure 6-16 respectively.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop reached 600 m on either side of the loop, with small variations due to the local topography (see Figure 6-15). During night-time, the 35 dB(A) zone extended approximately 1.7 km away from the loop (see Figure 6-16). This zone included all of the identified scattered farm houses east and west of the loop.

The modelled noise levels for the two scenarios at receptors around the loop are shown in Table 6-9. The noise levels at all receptors were below the daytime guideline of 45 dB(A) for both scenarios.

The night-time rural guideline was exceeded for both scenarios at all receptor except for Sishen (R09), which is situated more than 2 km east of the alignment.

It can also be seen from Table 6-9 that the expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa scenario was estimated to be 2 dB(A), which is considered low.

However, the night-time guideline for rural districts was exceeded at most receptors by between 5 dB and 8 dB, which is considered of medium significance, since the existing night-time noise level is around 35 dB(A).

Based on the modelled noise levels, the night-time exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. As such, mitigation measures should be investigated and implemented as soon as possible.

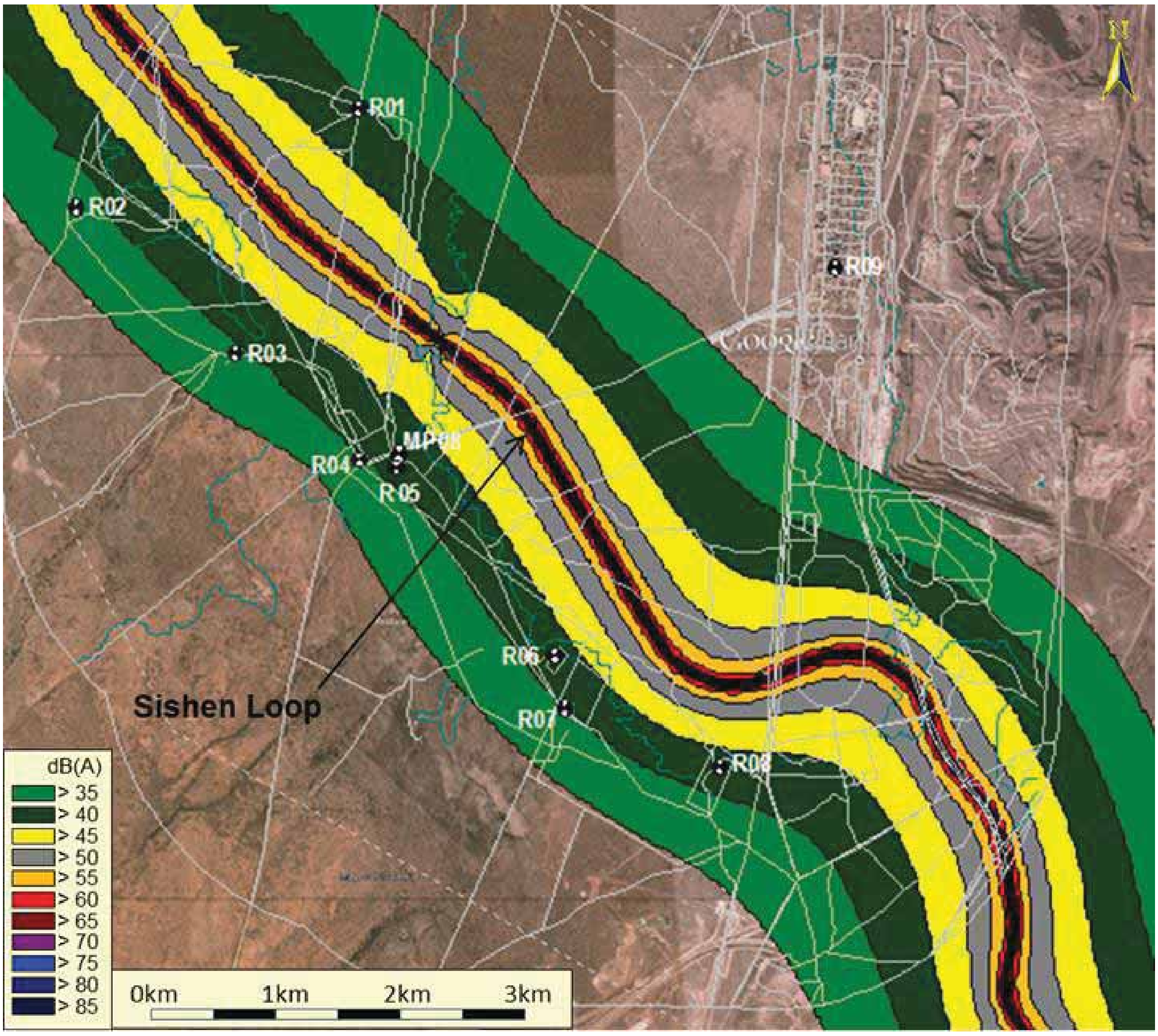


Figure 6-15. Daytime Noise Contours: Sishen Loop

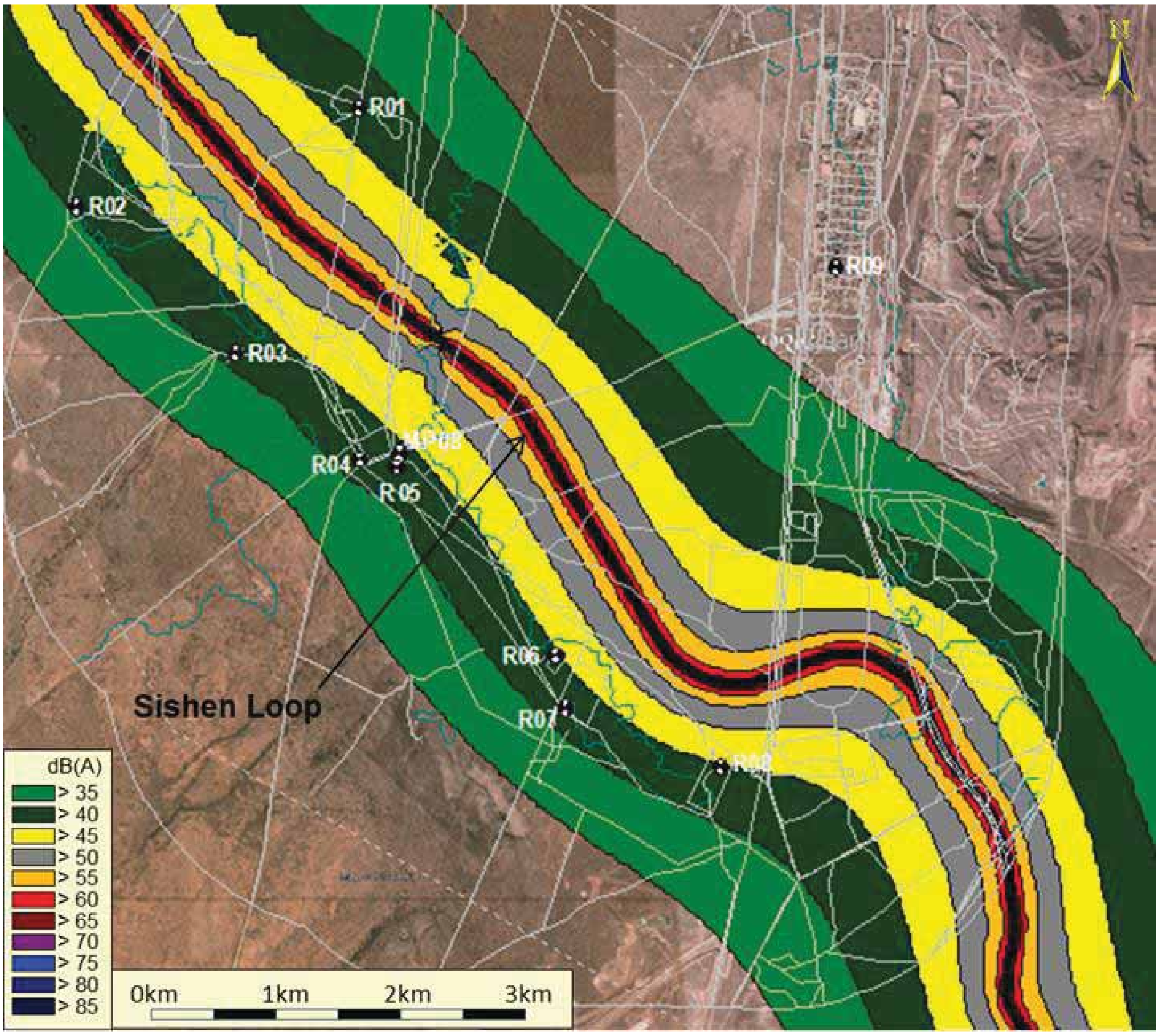


Figure 6-16. Night-time Noise Contours: Sishen Loop

Table 6-9. Modelled Noise Levels around Sishen Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP08	Measurement Point	40.2	42.2	42.2	44.1
R01	Farm House	38.8	40.8	40.7	42.7
R02	Farm House	36.6	38.6	38.5	40.5
R03	Farm House	37.4	39.4	39.3	41.3
R04	Farm House	37.5	39.4	39.4	41.4
R05	Farm House	39.1	41.0	41.0	43.0
R06	Farm House	40.7	42.6	42.6	44.6
R07	Farm House	37.9	39.9	39.9	41.8
R08	Farm House	40.9	42.8	42.8	44.8
R09	Dingle Community	26.1	28.1	28.0	30.0
[a] Scenario 1: 12Mtpa (Approved in previous EIA) [b] Scenario 2: 16Mtpa					

6.2.9 Wincanton Loop

The daytime and night-time noise contours around the Wincanton loop can be seen in Figure 6-17 and Figure 6-18 respectively. With the loop extension, the 45 dB(A) noise guideline zone for rural areas reached 630 m on either side of the loop (see Figure 6-17). During night-time, the 35 dB(A) guideline zone extended approximately 1.6 km away from the loop (see Figure 6-18).

The modelled noise levels for the two scenarios at receptors around the loop are shown in Table 6-10. As can be seen, the noise levels at one of the two receptors in the area, i.e. farm house (R01) is in very close proximity to the loop, and the noise levels due to the railway operations exceeded the SANS daytime and night-time guidelines of 45 dB(A) and 35 dB(A) by more than 10 dB and 25 dB respectively.

Based on the modelled noise levels for Scenario 1, these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport, which had been approved in the previous EIA.

The farm house R02 is more than 2.4 km from the alignment and is not expected to be affected by the railway traffic and the loop extension.

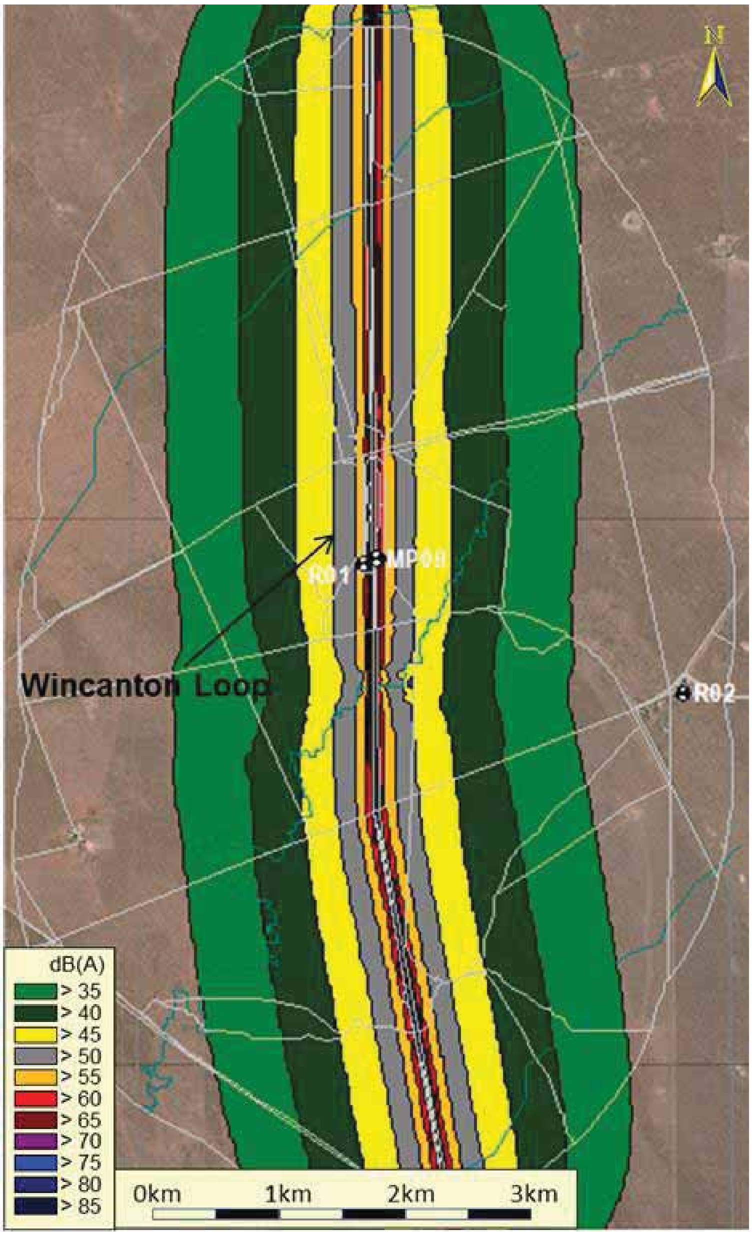


Figure 6-17. Daytime Noise Contours: Wincanton Loop

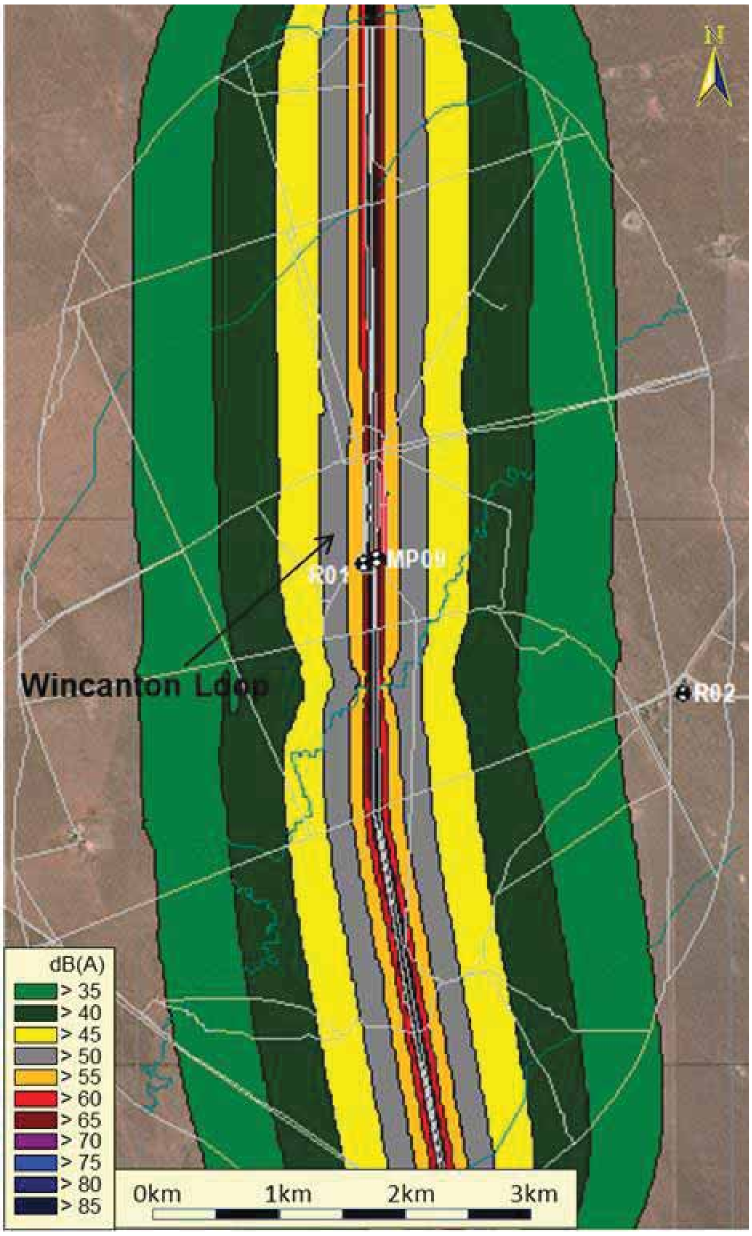


Figure 6-18. Night-time Noise Contours: Wincanton Loop

Table 6-10. Modelled Noise Levels around Wincanton Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP09	Measurement Point	68.3	68.4	70.3	70.3
R01	Farm House	56.6	58.2	58.6	60.1
R02	Farm House	28.3	30.3	30.3	32.3

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.10 Witloop

Even though the extended area at Witloop is considered rural, the noise levels around the loop are higher than those of a typical rural environment, primarily due to the existing vehicular traffic on the R380, as well as the current railway activity and the mining operations in the area.

There are no noise-sensitive receptors within 3km radius of the loop, except for a site office, situated 400 m west of the loop. The daytime and night-time noise contours around the Witloop can be seen in Figure 6-19 and Figure 6-20 respectively.

As shown in Figure 6-19, the daytime guideline noise level (45 dB(A)) reached 620 m around the loop. As for night-time, the 35 dB(A) guideline zone extended approximately 1.6 km away from the loop (see Figure 6-20).

The modelled noise levels for the two scenarios at the site office are expected to reach 47 dB(A), which is considered acceptable for an office use.

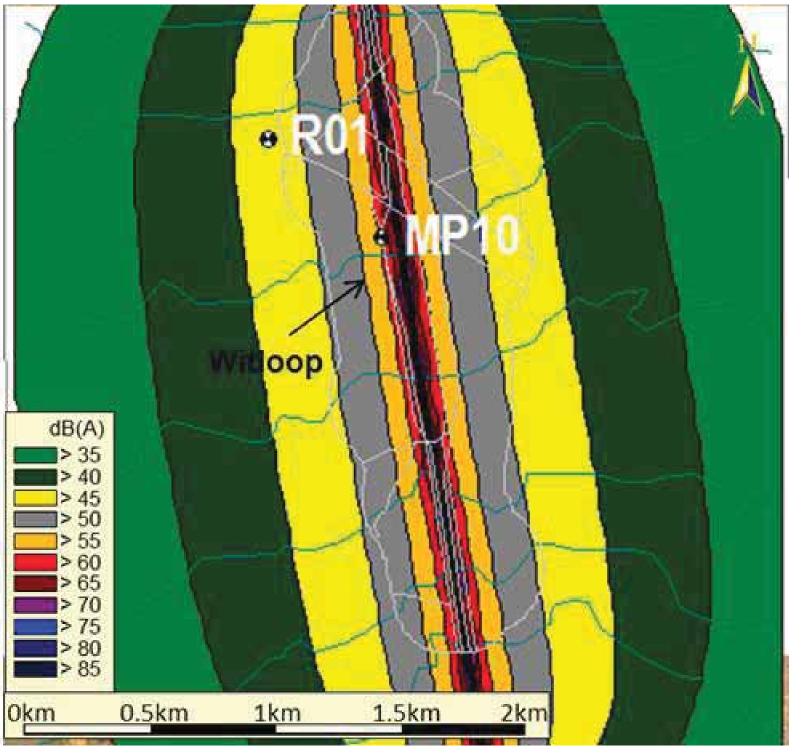


Figure 6-19. Daytime Noise Contours: Witloop

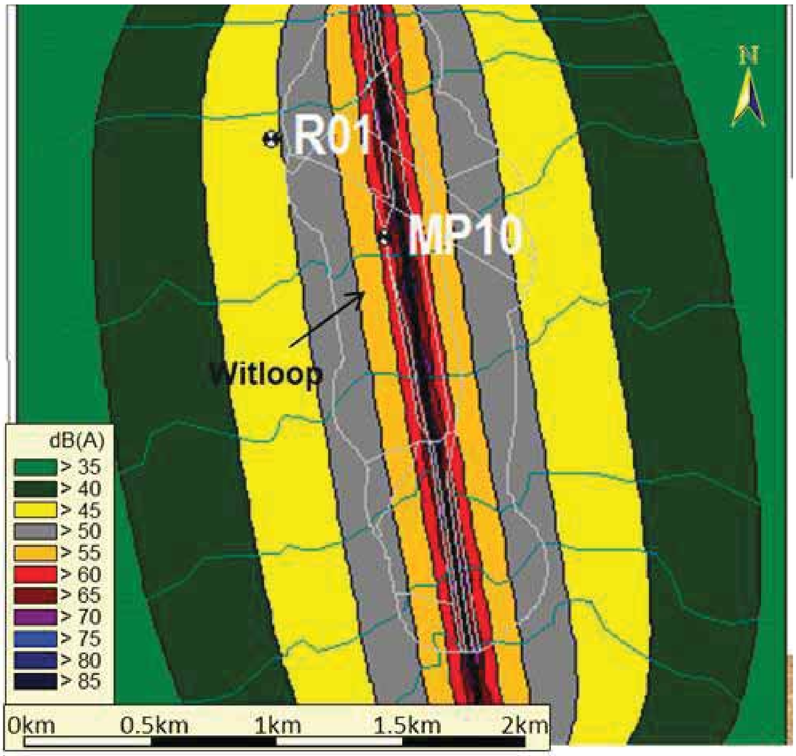


Figure 6-20. Night-time Noise Contours: Witloop

Table 6-11. Modelled Noise Levels around Witloop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP10	Measurement Point	58.3	59.7	60.3	61.7
R01	Offices	45.4	47.3	47.3	49.2

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.11 Mamatwane Compilation Yard

The daytime and night-time noise contours around the Mamatwane compilation yard are shown in Figure 6-21 and Figure 6-22 respectively. The extended area around the loop is rural. However, the existing noise environment has higher noise levels that that of a typical rural area, primarily due to the current Mamatwane mining activities and processing plant, as well as the existing rail operations and vehicular traffic on the R380. The noise levels further away from the yard and the above-mentioned sources are expected to be within the guidelines for rural areas.

With the establishment of the compilation yard, the 45 dB(A) zone around the loop reached 650 m on either side of the yard during daytime (see Figure 6-21).

As can be seen, the only receptors that the 45 dB(A) noise level is going to be exceeded due to the increased railway activity are the two Transnet farm houses next to the loop (R02), since they are situated very close to the railway alignment, i.e. within 40 m. The current daytime noise level there is 53 dB(A), due to the Manganese plant, railway activity to the mine and traffic on the R380. With the extension, the level will reach more than 64 dB(A), which is within the industrial zone guideline, but well above the one for dwellings. Similar levels are expected for night-time at that location. Therefore relocation of the occupants would be recommended.

During night-time, the 35 dB(A) zone extended approximately 1.7 km away from the yard (see Figure 6-22). This zone is not expected to reach any of the two farm houses (R03 and R04) situated south from the yard. As such the impact there is considered to be minor.

The modelled noise levels for the two scenarios at the receptors around the yard can be seen in Table 6-12. It is clear that the noise levels at R02 will be above 60 dB(A) for the 12 Mtpa Manganese transport, which have been approved in the previous EIA.

The night-time noise levels at receptors R03 and R04 will reach for Scenario 2 33 dB(A) and 25 dB(A) respectively, which is below the SANS rural guide line of 35 dB(A).

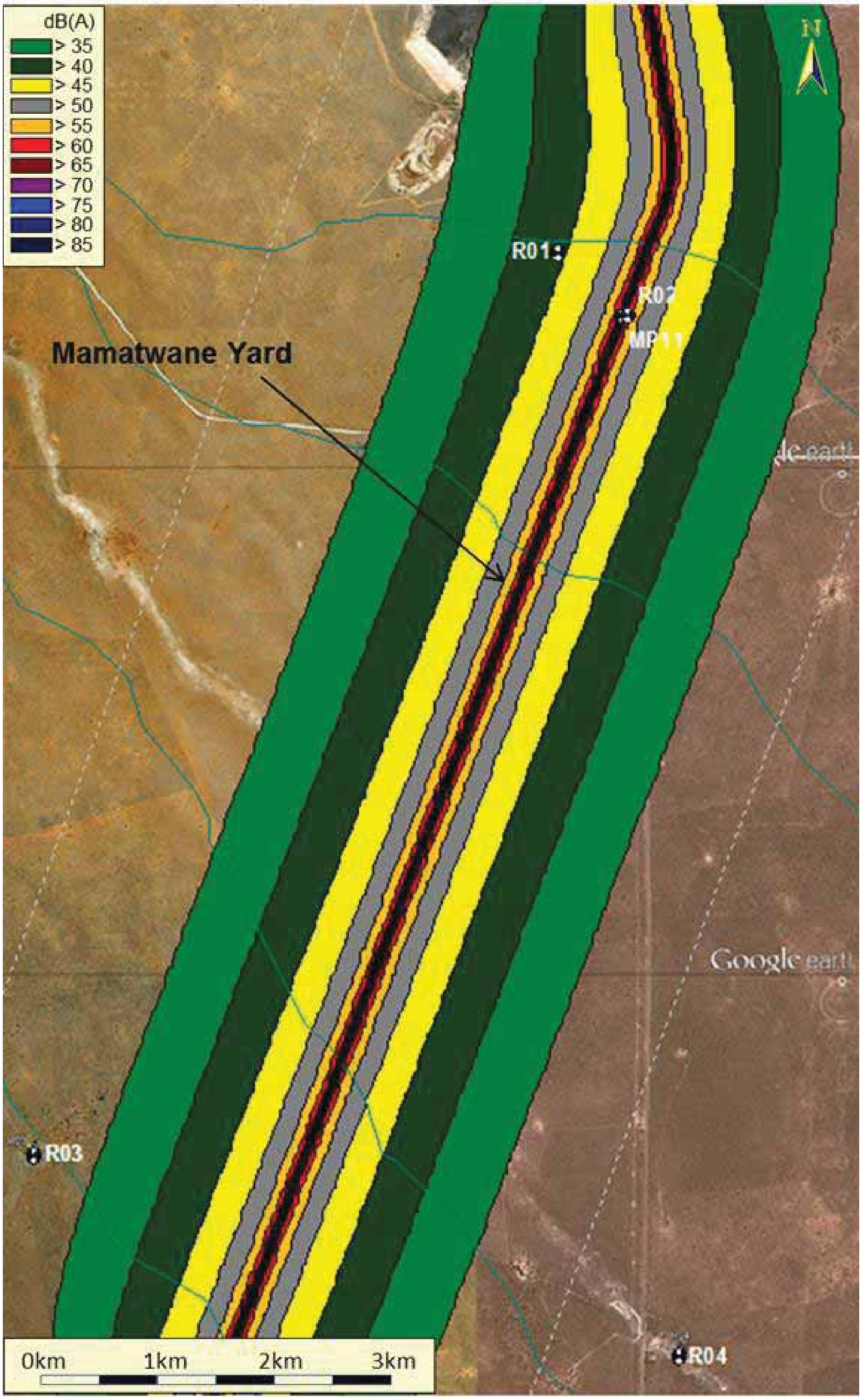


Figure 6-21. Daytime Noise Contours: Mamatwane Compilation Yard

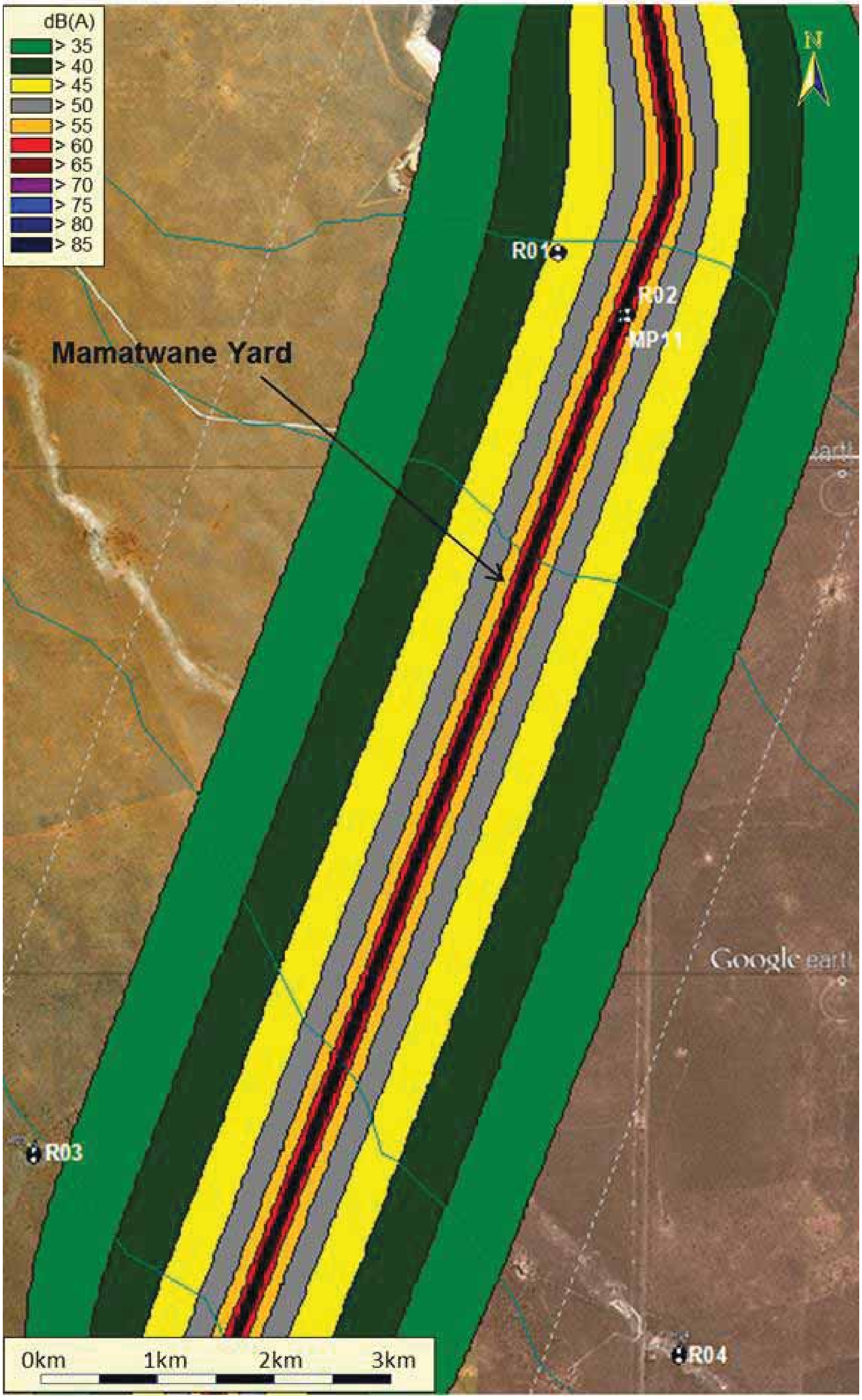


Figure 6-22. Night-time Noise Contours: Mamatwane Compilation Yard

Table 6-12. Modelled Noise Levels around Mamatwane Compilation Yard

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP11	Measurement Point	72.0	72.0	73.9	74.0
R01	Mamatwane Mine Offices	42.2	44.1	44.1	46.1
R02	Transnet Farm Houses	62.9	63.7	64.8	65.7
R03	Farm House	29.4	31.4	31.3	33.3
R04	Farm House	21.3	23.3	23.3	25.2

[a] Scenario 1: 12Mtpa (Approved in previous EIA)

[b] Scenario 2: 16Mtpa

6.3 Predicted Rail Vibration Levels

Based on the vibration propagation method outlined in Section 5.3, the vibration levels at various distances from the track centreline were estimated. It should be noted that these calculations were based on vibration measurements of existing cargo trains. As a worst-case scenario, the highest measured value was used in the vibration propagation calculations.

The calculated vibration levels at increasing distances from the line, together with the limits for structural damage, damage to sensitive or historical structures, as well as the human perception level, are shown in Figure 6-23 below. It can be seen that the vibration levels are lower than the recommended limit for structural damage at distances greater than 5 m.

Sensitive or historical buildings within a 14 m zone may experience vibration levels above the 2 mm/s limit for such structures. Any dwellings within this zone from the track should be inspected for their structural integrity. The human perception level is expected to be exceeded within 85 m from the line.

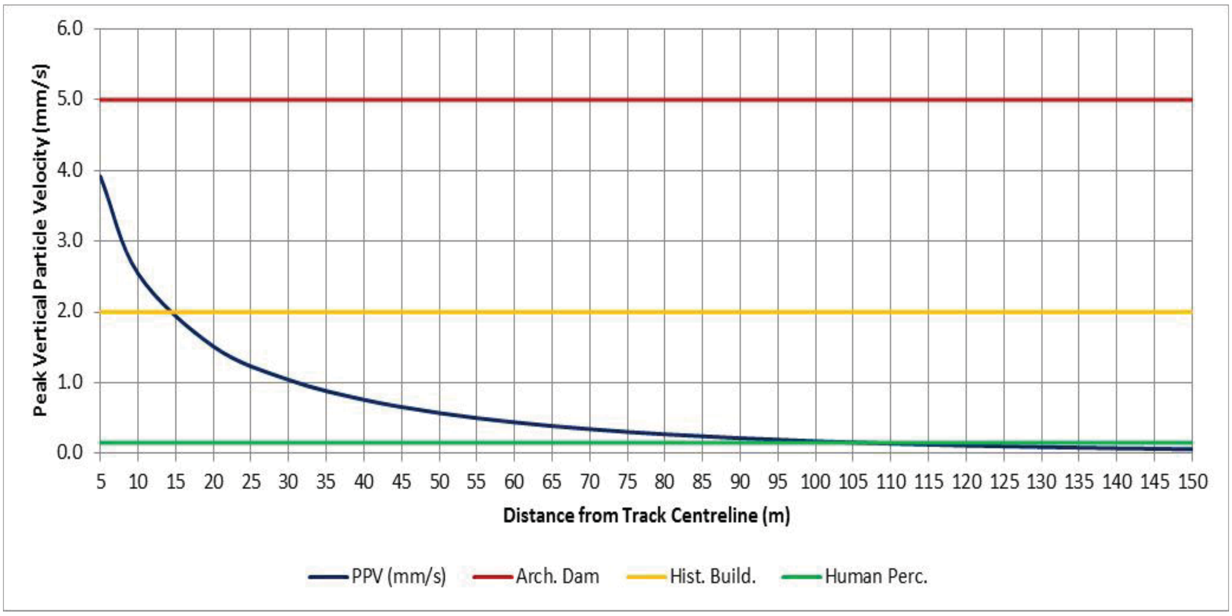


Figure 6-23. Vibration Levels per Distance from the Track

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Baseline Noise Environment:

i. The project components are situated in rural areas, except for the Postmasburg loop, which is located close to the town of Postmasburg. The Witloop loop and Mamatwane compilation yard are located near existing operational mines. The Gong-Gong and Ulco loops are located close to the R31 (less than 1 km away), while the Wincanton, Witloop and the Mamatwane loops are located close to the R380.

ii. The existing noise environment around the loops located in rural areas (Fieldsview, Trewil, Tsantsabane, Glosam and Sishen) without main roads or other industrial sources is that of a typical rural area with low noise levels. The measured baseline noise levels there were within the SANS guidelines for rural districts, and the main noise sources were natural sounds, bird and insect activity.

iii. For those loops located near the main roads (Gong-Gong and Ulco), the noise environment is affected by the existing vehicular traffic, and the measured noise levels there exceeded or were very close to the guidelines for rural areas.

iv. The noise environment around Mamatwane and Witloop was dominated by the existing train and mining operations, as well as the vehicular traffic on the R380. The average daytime noise level at Mamatwane was 53 dB(A), while the night-time noise level was 50 dB(A).

v. The existing noise environment around the Postmasburg loop is that of an urban area. The daytime noise levels measured were within the SANS and WHO daytime guideline of 55 dB(A) for urban residential areas. The night-time noise levels exceeded the SANS and WHO night-time guideline of 45 dB(A). The main noise contributors were vehicular traffic on local roads and human activities.

Based on the modelling of the noise and vibration levels due to the proposed loop extensions, the main findings of the noise and vibration impact study were:

Construction:

i. The construction activities at receptors outside a 500 m zone from the main working area will be noticeable but will not constitute a disturbing noise. For receptors located at greater distances than a 1 km radius, the construction noise will be barely audible.

ii. For a short duration the noise levels in the Postmasburg residential area may exceed 55 dB(A) within a zone of 200 m from the alignment, which is considered to be of Moderate significance but of short duration. As the working face moves further towards the north-west, the impact is expected to be Low.

iii. The vibration impact during construction is considered to be insignificant, since the majority of the surrounding communities or local dwellings are located more than 100 m from the construction sites. The only community which is in close proximity is the Newtown community, immediately south of the Postmasburg loop. However, the closest houses are located approximately 40- 50 m away from the loop, which is outside of the 5 m zone in which structural damage can occur (see Section 6.3).

Operation:

i. With the capacity increase, the zone exceeding the SANS daytime guideline of 45 dB(A) for rural districts will reach between 600 m to 700 m on either side of the Fieldsview, Gong-Gong, Ulco, Trewil, Tsantsabane, Glosam, Sishen, Wincanton and Witloop loops and the Mamatwane compilation yard.

ii. During night-time, the SANS night-time guideline zone of 35 dB(A) for rural districts will be exceeded within 1.6 km to 1.8 km from the loops, with small variations due to the local topographies.

iii. The noise impact from the above-mentioned loops is expected to be of Low significance, as most of the isolated dwellings lie outside the 45 dB(A) night-time contour, which is the SANS and WHO guideline for residential areas and dwellings. In addition, the loop extensions are expected to increase the noise levels at these receptors from the previously approved 12 Mtpa transport scenario by approximately 2 dB, which is considered to be very low.

iv. At Postmasburg, the loop is situated on the border of the urban residential area, and based on the modelling results, the SANS daytime guideline for urban areas of 55 dB(A) will be exceeded in very close proximity around the loop, i.e. within 150 m from the line. The night-time noise levels due to the Postmasburg loop will exceed the 45 dB(A) guideline for urban areas within 620 m from the loop.

v. The noise impact due to the Postmasburg loop extension is considered to be High, as several dwellings are in close proximity to the railway line, i.e. within 200 m from the tracks. Mitigation measures by way of a 3 m noise barrier need to be introduced, in order to reduce the resulting noise levels. The mitigated noise impact of the train operation is expected to be Low. It should, however, be noted that this mitigation measure ought to have been proposed and implemented for the approved 12 Mtpa Manganese transport.

vi. The operational vibration levels are not expected to exceed the limit for structural damage beyond a 10 m zone around the track, or the limit for sensitive or historical buildings beyond a 25 m zone.

vii. The vibration impact due to the railway loop extensions is considered to be Very Low.

7.2 Recommendations

Based on this noise and vibration study, the noise performance indicator to be adopted for the residential areas around the rail loops should be that the noise levels in these areas and single dwellings do not exceed 55 dB(A) and 45 dB(A) during day- and night-time respectively, due to the train operations.

The performance indicator for vibration should be that the vibration level at dwellings around the loops should not exceed the PPV limit for structural damage of 5 mm/s, and at sensitive or historical buildings should not exceed 2 mm/s. The vibration levels due to the train operations should not exceed the PPV limit of 0.15 mm/s in urban residential areas.

The main recommendations of the noise and vibration study are outlined below. The essential mitigation measures are included in the impact tables.

Construction:

i. Utilise temporary noise screens for the construction of the loop within the Postmasburg residential area.

ii. Construction noise and vibration monitoring should be performed at selected dwellings along the loops and within residential areas closest to the construction site boundaries. This monitoring should commence prior to and continue on a biannual basis during construction.

iii. Construction should take place during normal daytime working hours and should not be permitted during night-time, on Saturdays after midday and on Sundays.

Operation:

i. Introduce a 3 m high noise barrier along the railway loops, where communities or large clusters of dwellings are in close proximity, i.e. within 200 m and 400 m from the tracks. It should be noted that the implementation of such measures should have been incorporated in the authorisation of the 12 Mtpa transport.

ii. The accurate determination of the length and height of the specific sound barriers for each loop should be determined during the detailed design study when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loops are available.

iii. Reduce the speed of the train along the loops to 40 km /hr or as close to this limit as possible, that is allowable in terms of safety. With the implementation of this measure, the barrier requirement should be examined in conjunction with the detailed information described above.

iv. Perform appropriate and timeous maintenance of rolling stock and locomotive engines.

v. Train personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.

vi. Perform noise and vibration monitoring on an annual basis at two locations within the Postmasburg community and for the other loops at two selected dwellings, one of which should be the closest to the alignment. The noise monitoring should incorporate noise measurements over a 24-hour period, in order to capture the train passes, as well as quantify the overall daytime and night-time levels. Similar monitoring should be performed at two additional loops, with preference to the Glosam and Tsantsabane loop (Postdene community).

vii. Ensure proper maintenance of wheel and rail surfaces, in order to reduce operational vibrations.

General recommendations for noise minimization and management during construction and operation:

- Maintenance of equipment and operational procedures: Proper design and maintenance of silencers on diesel-powered equipment, systematic maintenance of all forms of equipment, training of personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.

- Equipment noise audits: Standardised noise measurements should be carried out on individual equipment on delivery to site or at commissioning, in order to construct a reference data-base. Regular checks should be carried out to ensure that equipment is not deteriorating and to detect sound generation increases, which could lead to an increase in the noise impact over time and increased complaints.
- Public complaints and actions registry: A formal recording system should be introduced, in order to capture public perceptions and complaints with regard to noise impacts, track investigation actions and introduce corrective measures for continuous improvement.

8 IMPACTS RATING

Based on the modelling results for the proposed development, the impacts of construction and operation are summarised in the tables below.

The noise and vibration impact during construction is presented for all loops in Table 8-1 and is considered to be without mitigation *MODERATE*, and with mitigation measures *MINOR*.

For the operational phase, the vibration impact can be seen in Table 8-2 for all the loops, and the noise impact is presented for each loop separately in the tables further below.

Table 8-1. Noise and Vibration Impact Rating During Loop Construction

Nature: Construction activities would result in a **negative direct** impact on the vibration levels and noise environment around the loops.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise and vibration levels at receptors in close proximity to the loops. However, these receptors are sparsely distributed around the loops and most of them at distances greater than 200 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **short-term** (i.e. for the duration of construction).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 500 m from the alignment. For receptors within the above-mentioned zone, there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The noise levels during construction are **likely** to increase during the construction period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:
i. Utilise temporary noise screens for the construction of the loop within the Postmasburg residential area and along the other loops, where local isolated dwellings are situated within a 200 m zone from the loop.
ii. Construction should take place during normal daytime working hours and should not be permitted during night-time, on Saturdays after midday or on Sundays.

WITH MITIGATION
Impact Magnitude – Low
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **short-term** (i.e. for the duration of construction).
- Scale: The impact will **not** result in **notable changes** to the noise levels at existing receptors.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The noise levels during construction are **likely** to increase during the construction period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-2. Vibration Impact Rating During Loop Operation

Nature: The operation of the loops will increase the number of trains along the line and will result in a **negative direct** impact on the vibration levels around the loops.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The sensitivity is considered to be **low**, since the activity will increase the vibration levels only at receptors in very close proximity to the loops. In addition, there are only a small number of dwellings and structures around each loop, with the majority of them situated further than 50 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. for the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the existing vibration levels due to the existing operations.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The vibration levels in close proximity to the loops are **possible** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:
No specific mitigation measures are necessary during the operational phase, other than "good practice" maintenance of the train wheels and rail surfaces.

WITH MITIGATION
Same as above

Table 8-3. Operational Noise Impact Rating: Fieldsview Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The loop is located in a rural area, with very few sensitive receptors around the loop.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-4. Operational Noise Impact Rating: Gong-Gong Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: Local dwellings are located more than 1.0 km away from the loop. The noise environment at the receptors may be affected during night-time; however, the magnitude is expected to be low.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local.**
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-5. Operational Noise Impact Rating: Ulco Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The loop extension will likely increase the noise levels at receptors close to the loop.

PRE-MITIGATION

Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

`

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the Ulco loop, where dwellings are in close proximity to the railway, i.e. within 400 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Ulco loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop is available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION

Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 300 m from the alignment.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-6. Operational Noise Impact Rating: Trewil Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The loop is located in a remote rural area. There are very few noise-sensitive receptors around the loop.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptor R02, there will be some **notable changes** to the existing noise level.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-7. Operational Noise Impact Rating: Tsantsabane Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The development will increase the noise levels at receptors in close proximity to the loop. There are several dwellings south of the loop. In addition, the Postdene community lies immediately north, adjacent to the railway line.

PRE-MITIGATION

Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the Tsantsabane loop, where dwellings are in close proximity to the railway, i.e. within 400 m from the tracks. In addition, a similar barrier should be considered for the length of the track along Postdene community. These measures should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Tsantsabane loop and the Postdene community can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION

Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 200 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-8. Operational Noise Impact Rating: Postmasburg Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – High
Sensitivity: The activity will increase the noise levels at receptors around the loop. Local residential areas are just south of the loop, within close proximity.

PRE-MITIGATION

Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 200 m zone there will be **notable changes** to the existing noise levels. It should be considered, however, that the noise increase due to the loop extensions from the approved loop, which allows for the transport of 12 Mtpa Manganese, will be within 2 dB, which is considered very low.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MAJOR
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the loop, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION

Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Table 8-9. Operational Noise Impact Rating: Glosam Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The loop is located in a remote rural area with low noise levels. There are two farm houses in the area and the Glosam community north of the loop, within 500 m from the railway alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 600 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:
iv. Introduce a 3 m high noise barrier along the alignment, close to the Closam community. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
v. The accurate determination of the length and height-specific sound barriers for the loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
vi. Reduce the speed of the train close and along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 400 m from the alignment.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-10. Operational Noise Impact Rating: Sishen Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: : The loop is located in a rural area with low noise levels. There are receptors sparsely distributed around the loop and most of them at distances greater than 700 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors closer to the loop, there may be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:
i. Introduce a 3 m high noise barrier on the western side of the Sishen loop, where dwellings are within 700 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Sishen loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 400 m from the alignment.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-11. Operational Noise Impact Rating: Wincanton Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The loop is located in a remote rural area. There are very few receptors in the area around the loop.

PRE-MITIGATION
Impact Magnitude – Medium
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will result in **no notable changes** to the noise levels at receptors situated further than 1 km of the loop.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-12. Operational Noise Impact Rating: Witloop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The loop is located in a rural area. There are very few receptors in the area around the loop.

PRE-MITIGATION
Impact Magnitude – Medium
- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will result in some **notable changes** to the noise levels at receptors situated within 500 m of the loop.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-13. Operational Noise Impact Rating: Mamatwane Compilation Yard

Nature: The compilation yard and loop operation will result in a **negative direct** impact on the noise environment around the railway alignment.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The loop is located in a rural area, adjacent to Mamatwane mine and processing plant. There are very few receptors around the loop, i.e. two Transnet farm houses immediately next to the railway line and two farm houses further south, 2 km from the railway alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will result in **notable changes** to the noise levels at receptors situated within 100 m from the alignment. For receptors outside a 2 km zone there will be **no notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

REFERENCES

British Standard 4142, (1997). Method for rating industrial noise affecting mixed residential and industrial areas.

Feasibility (FEL) Report (2010). Chapters 3 and 4: Risk analysis and affected environment; Chapter 26: Health safety environment and communities.

IFC, (2007). General Environmental, Health and Safety Guidelines.

ISO 1996-1, (2003). Acoustics – Description, assessment and measurement of environmental noise – Part 1: Basic quantities and assessment procedures. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1996-2, (2000). Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1996-3, (1987). Acoustics – Description and measurement of environmental noise -- Part 3: Application to noise limits. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1999, (1990). Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment. Geneva, Switzerland: International Organization for Standardization, International Standard.

OECD, (1996). Environmental Criteria for Sustainable Transport, Report on Phase 1 of the Project on Environmentally Sustainable Transport (EST), Organization for Economic Co-Operation and Development, OCDE/GD(96)136. Paris, 1996.

South African National Standard SANS10103, (2003). The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication.

Whiffin, A.C., and Leonard, D.R. (1971). A survey of Traffic-Induced Vibrations, Research Report LR 418, Road Research Laboratory, Department of Transport, Crowthorne, UK.

WHO, (1999). Guidelines for Community Noise, Edited by Birgitta Berglund, World Health Organization, Thomas Lindvall, and Dietrich Schwela. Geneva, April 1999.

World Bank Group, (1998). Pollution Prevention and Abatement Handbook, General Environmental Guidelines. July 1998.

Appendix A Impact Assessment Methodology for EIAs - Instructions to Specialists

A definition of each impact characteristic is provided to contextualise the requirements. The designations for each of the characteristics are defined below.

Table 1.1 Defining Impact Characteristics

Characteristic	Definition	Designation
Type	A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).	**Direct -** Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between occupation of a plot of land and the habitats which are affected). **Indirect -** Impacts that follow on from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land). **Induced -** Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the importation of a large Project workforce).
Duration	The time period over which a resource / receptor is affected.	**Temporary** (negligible/ pre-construction) **Short-term** (period of less than 5 years i.e. production ramp up period) **Long-term** (period of more than 5 years and less than 19 years i.e. life of project) **Permanent** (a period that exceeds the life of the project – i.e. irreversible.)
Extent	The reach of the impact (i.e. physical distance an impact will extend to)	**On-site** – impacts that are limited to the project site. **Local** – impacts that are limited to the project site and adjacent properties. **Regional** – impacts that are experienced at a regional scale, e.g. District or Province. **National** – impacts that are experienced at a national scale. **Trans-boundary/International** – impacts that are experienced at an international scale, e.g. extinction of species resulting in global loss.
Scale	The size of the impact (e.g. the size of the area damaged or impacted the fraction of a resource that is lost or affected).	1 - functions and/ or processes remain ***unaltered*** 2 - functions and/ or processes are ***notably altered*** 3 - functions and/ or processes are ***severely altered***
Frequency	Measure of the constancy or periodicity of the impact.	1 - Periodic 2 - **Once off**

The terminology and designations are provided to ensure consistency when these characteristics are described in an Impact Assessment deliverable.

An additional characteristic that pertains only to unplanned events (e.g., traffic accident, accidental release of toxic gas, community riot, etc.) is likelihood. The likelihood of an unplanned event occurring is designated using a qualitative (or semi-quantitative, where appropriate data are available) scale.

Table 1.2 Definitions of likelihood

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely/ Certain	The event will occur during normal operating conditions (i.e., it is essentially inevitable).

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred. It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, not the degree to which an impact or effect is expected to occur as a result of the unplanned event. The latter concept is referred to as uncertainty, and this is typically dealt with in a contextual discussion in the Impact Assessment deliverable, rather than in the impact significance assignment process.

Assessing Significance

Once the impact characteristics are understood, these characteristics are used (in a manner specific to the resource/receptor in question) to assign each impact a magnitude. Magnitude is a function of the following impact characteristics:

- Extent [(a)]
- Duration [(b)]
- Scale
- Frequency
- Likelihood

Magnitude essentially describes the degree of change that the impact is likely to impart upon the resource/receptor. The magnitude designations are as follows:

- Positive
- Negligible
- Small
- Medium
- Large

The methodology incorporates likelihood into the magnitude designation (i.e., in parallel with consideration of the other impact characteristics), so that the "likelihood-factored" magnitude

---

(a) Important in defining 'extent' is the differentiation between the spatial extent of impact (i.e. the physical distance of the impact in terms of on-site, *local, regional, national* or *international*) and the temporal extent/ effect of an impact may have (i.e. a localised impact on restricted species may lead to its extinction and therefore the impact would have global ramifications).

(b) Duration must consider irreversible impacts (i.e. permanent).

can then be considered with the resource/receptor sensitivity/vulnerability/irreplaceability in order to assign impact significance.

The magnitude of impacts takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum from negligible to large. Some impacts will result in changes to the environment that may be immeasurable, undetectable or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and should be characterised as having a negligible magnitude.

In addition to characterising the magnitude of impact, the other principal step necessary to assign significance for a given impact is to define the sensitivity/vulnerability/ irreplaceability of the resource/receptor. There are a range of factors to be taken into account when defining the sensitivity/vulnerability/ irreplaceability of the resource/receptor, which may be physical, biological, cultural or human. Where the resource is *physical* (for example, a water body) its quality, sensitivity to change and importance (on a local, national and international scale) are considered. Where the resource/receptor is *biological or cultural* (for example, the marine environment or a coral reef), its importance (for example, its local, regional, national or international importance) and its sensitivity to the specific type of impact are considered. Where the receptor is *human*, the vulnerability of the individual, community or wider societal group is considered.

As in the case of magnitude, the sensitivity/vulnerability/ irreplaceability designations themselves are universally consistent, but the definitions for these designations will vary on a resource/receptor basis. The universal sensitivity/vulnerability/irreplaceability [(c)] of resource/receptor is:

- Low
- Medium
- High

Once magnitude of impact and sensitivity/vulnerability/irreplaceability of resource/receptor have been characterised, the significance can be assigned for each impact. The following provides a context for defining significance.

Table 1.3 Context for Defining Significance

• An impact of ***negligible*** significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.

(c) Irreplaceable (SANBI, 2013): "In terms of biodiversity, irreplaceable areas are those of highest biodiversity value outside the formal protected area network. They support unique biodiversity features, such as endangered species or rare habitat patches that do not occur anywhere else in the province. These features have already been so reduced by loss of natural habitat, that 100% of what remains must be protected to achieve biodiversity targets."

- An impact of ***minor*** significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.
- An impact of ***moderate*** significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.
- An impact of ***major*** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts remaining even after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

Based on the context for defining significance, the impact significance rating will be determined, using the matrix below.

Table 1.4 Impact Significance Rating Matrix

		Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Once the significance of the impact has been determined, it is important to qualify the **degree of confidence** in the assessment. Confidence in the prediction is associated with any uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence can be expressed as low, medium or high.

Appendix B Noise Monitoring Record Sheets

- **Position MP01**

It is located about 10 m from Fieldsview loop.

GPS coordinates – S 28°33'17.10" E 24°38'29.22"

View north

View east

Figure B-1. MP01 Images

- **Position MP02**

This point is located at the Gong-Gong community, about 1.2 m west of the Gong-Gong loop.

GPS coordinates – S 28°28'47.94" E 24°24'50.22"

view west towards Gong-Gong

View east towards the loop

Figure B-2. MP02 Images

- **Position MP03**

This point was located about 40 m from the Ulco loop.

GPS coordinates –S 28°21'13.02" E 24°17'18.72"

View north

View east towards abandoned farm houses

Figure B-3. MP03 Images

- **Position MP04**

At the Trewil loop, about 10 m from the loop

GPS coordinates – 28°18'26.88" E 23°41'11.22"

View south

View North toward existing loop

Figure B-4. MP04 Images

- **Position MP05**

At the Tsantsabane Loop, about 10 m from the railway line.

GPS coordinates – S 28°16'51.30" E 23° 8'37.80"

View south toward farm houses

View west

Figure B-5. MP05 Images

- **Position MP06**

This point was located about 1.2 km south of the existing Postmasburg loop, approximately 30m from the Boichoko community.

GPS coordinates –S28°19'1.38" E23° 2'30.54"

View north toward the loop

View north south the loop

Figure B-6. MP06 Images

- **Position MP07**

This point was located about 130 m west of the Glosam loop and about 2.5 km from R325 road.

GPS coordinates – S28° 4'49.08" E 23° 2'30.54"

View south

View north

Figure B-7. MP07 Images

- **Position MP08**

This point was located approximately 1.0 km west of the Sishen loop, and 100 m from Receptor R05.

GPS coordinates –S 27°48'43.08" E 22°56'51.30"

View east towards Loop

View south

Figure B-8. MP08 Images

- **Position MP09**

This point was located south of the existing Wincanton loop and about 520 m from R380 road. GPS coordinates –S 27°35'7.74" E22°56'25.50"

View west

View west north

Figure B-9. MP09 Images

- **Position MP10**

This point was located west of the Witloop, about 200 m from the R380 road.

GPS coordinates –S 27°17'50.88" E 22°58'49.86"

View north towards Hotazel

View east towards R380 road

Figure B-10. MP10 Images

- **Position MP11**

This point was located 20 m south of Mamatwane train station and about 400 m from R380 road.

GPS coordinates –S 27°23'47.46" E 22°59'38.76"

View north towards Mamatwane mine

View south

Figure B-11. MP11 Images

Table B-1. Baseline Noise Measurements Results

Date - Time	Loop	Measurement Position	Location	WS (m/s)	$L_{Aeq,I}$ (dB(A))	L_{Amin} (dB(A))	L_{Amax} (dB(A))	L_{90} (dB(A))	L_{50} (dB(A))	L_{10} (dB(A))	Comments
15-10-12 11:19	Fieldsview	MP01	Rural	1.7	43.5	29.1	55.5	34.2	40.4	46.8	Bird activity audible
15-10-12 11:51		MP01	Rural	2.9	38.9	26.1	51.8	28.6	34	42.4	
15-10-12 16:07	Gong-Gong	MP02	Rural	2.3	60.8	37.4	85.1	41.6	46.3	50.3	Traffic from R31 road, human activities, very audible
15-10-12 16:22		MP02	Rural	1.7	46.4	35.1	56	40.2	45.2	49.4	
16-10-12 0:15		MP02	Rural	1.4	43.7	24.4	59.2	28.7	37.5	45.9	
16-10-12 0:28		MP02	Rural	0.4	42.1	25.1	54.9	28.6	37.1	45.7	
16-10-12 9:25		MP02	Rural	0.2	44.4	30.9	59.4	35.6	39.4	46.3	
16-10-12 9:35		MP02	Rural	0	43.7	28.8	62	32.7	39.1	45	
15-10-12 17:19	Ulco	MP03	Rural	0.9	43.5	33.5	57.4	36.9	41.3	45.2	Bird activity and noise from nearby industries clearly audible
15-10-12 17:39		MP03	Rural	0.8	44.7	32.6	58.1	37	41	47.5	
16-10-12 1:13		MP03	Rural	0.4	36	21.7	56.2	23	27.1	35.8	Traffic from R31 road very audible
16-10-12 1:25		MP03	Rural	0	33.6	20.9	51	21.6	24.1	36.8	
16-10-12 10:19		MP03	Rural	0.6	48	34.8	60.5	40.4	46.2	50.6	Noise existing loop operations audible
16-10-12 10:31		MP03	Rural	0.7	52.3	36.5	68.9	39.7	48.3	54.5	Noise from existing loop operation audible
16-10-12 12:07	Trewil	MP04	Rural	2.9	38.6	46.3	53.4	47.5	48.4	49.3	Bird activity audible
16-10-12 12:23		MP04	Rural	1.9	37.5	24.5	52.1	27.5	32.7	40.6	
16-10-12 14:42	Tsantsabane	MP05	Rural	3.5	38.5	20.8	55.8	24.8	32.7	41.4	
16-10-12 14:54		MP05	Rural	2.5	40.1	22.8	58.2	28.2	34.8	43.4	
16-10-12 15:06		MP05	Rural	2.9	36.8	24	49.2	28.9	33.3	40.1	

Date - Time	Loop	Measurement Position	Location	WS	$L_{Aeq,I}$	L_{Amin}	L_{Amax}	L_{90}	L_{50}	L_{10}	Comments
				(m/s)	(dB(A))	(dB(A))	(dB(A))	(dB(A))	(dB(A))	(dB(A))	
17-10-12 0:43		MP05	Rural	0.4	32.1	24.8	48	25.5	27	33.6	
17-10-12 0:56		MP05	Rural	0	27.9	24.6	44.3	25.5	26.7	28.4	
16-10-12 17:48	Postmasburg	MP06	Urban	0.8	57.2	42.5	72.6	45.7	50.6	58	Traffic from nearby roads, human activities very audible
16-10-12 18:10		MP06	Urban	0	53.3	37.5	70.2	39.7	46.1	53.9	
16-10-12 18:21		MP06	Urban	0.2	55.2	36.3	74	39.8	44.6	56.1	
16-10-12 18:33		MP06	Urban	0	55.3	40.6	70.3	43.5	47.9	58.3	
16-10-12 23:51		MP06	Urban	0.2	52.4	46.2	67.2	46.7	48.7	55.1	
17-10-12 0:00		MP06	Urban	0.2	51.5	45.2	65.3	46.8	48.6	53.6	
17-10-12 0:11		MP06	Urban	0	50.1	42.8	58	45.9	48.7	53.1	
17-10-12 9:56		MP06	Urban	3.4	53	41.4	70.8	43.9	45.9	52.8	
17-10-12 10:08		MP06	Urban	3.5	50.4	41.2	65.2	44.4	47.6	52	
17-10-12 10:20		MP06	Urban	3.7	51	42.5	66.1	44.7	47.5	54	
17-10-12 10:34		MP06	Urban	3.2	54.2	43.2	71.6	44.8	47.3	55	
17-10-12 11:48	Glosam	MP07	Rural	3.4	46.9	33.6	63.7	36.9	41.4	48.2	Bird activity audible
17-10-12 12:02		MP07	Rural	3.5	46.4	32.7	63.6	36.8	41.3	48.8	
17-10-12 12:13		MP07	Rural	3.6	47.8	34.3	63.5	37.2	43.3	50.4	
17-10-12 23:15		MP07	Rural	0	35.8	23.7	51.9	28.5	32.4	37.7	Insect activity audible
17-10-12 23:27		MP07	Rural	0	35.5	22.7	54.9	25.7	29.4	37.3	
18-10-12 10:13		MP07	Rural	1.9	42.5	27.5	56.4	31.4	35.6	44.8	Bird activity audible
18-10-12 10:25		MP07	Rural	0.8	40	28	57.1	30.9	34.7	42.9	
18-10-12 22:10		MP07	Rural	0	32.3	22	47.3	23.8	27	35.5	Dogs barking audible
18-10-12 22:21		MP07	Rural	0	33.8	20.1	50.7	21.1	23.5	31.2	

Date - Time	Loop	Measurement Position	Location	WS (m/s)	$L_{Aeq,I}$ (dB(A))	L_{Amin} (dB(A))	L_{Amax} (dB(A))	L_{90} (dB(A))	L_{50} (dB(A))	L_{10} (dB(A))	Comments
17-10-12 13:15	Sishen	MP08	Rural	3.5	45.5	34.8	61.1	36.8	41.3	48.4	Human activities audible
17-10-12 13:27		MP08	Rural	3.8	47.6	32.8	65.5	36.6	42.1	48.1	
17-10-12 13:38		MP08	Rural	3.6	39.5	30.3	52.9	33.2	37.1	41.3	
18-10-12 0:28		MP08	Rural	0	38.5	28.7	56.5	29.4	30.6	38.5	Insect activity audible
18-10-12 0:40		MP08	Rural	0	35.4	29.7	52.1	30.5	31.6	34.2	
18-10-12 11:12		MP08	Rural	0.9	43.4	25.1	64.6	28.3	34.9	44.7	Human and farming activities audible
18-10-12 11:28		MP08	Rural	0.2	39	23	57.6	25	28.8	40.6	
18-10-12 23:18		MP08	Rural	0.6	37.5	22.6	56.3	23.9	25.6	33.3	Insect activity audible
18-10-12 23:32		MP08	Rural	0.06	36.3	23.8	58.5	24.6	26	30	
17-10-12 16:39	Wincanton	MP09	Rural	3.3	46.5	32.6	57.4	36.7	44.2	49.6	Nearby traffic audible
17-10-12 16:52		MP09	Rural	3.8	47.1	29.3	65.7	35.1	41.7	49.6	
17-10-12 17:01		MP09	Rural	3.2	43.5	30.9	55.3	34.1	39.5	47.1	
17-10-12 18:06	Witloop	MP10	Rural	2.5	40.9	28.5	53.6	30.7	36.3	44.6	
17-10-12 18:17		MP10	Rural	2.8	39.5	30.4	51.9	32.9	35.9	42.2	
18-10-12 2:36		MP10	Rural	1.8	42.6	31.5	59.2	32.9	34.4	41.1	Train operations audible
18-10-12 2:52		MP10	Rural	1.8	43.8	29.3	57.7	31.3	33	45.2	
18-10-12 13:22		MP10	Rural	1.1	38.5	29.4	52.3	30.8	34.6	41.3	
18-10-12 13:35		MP10	Rural	0.8	36.5	29.1	54.9	30.4	32.2	37.1	
17-10-12 18:54	Mamatwane Yard	MP11	Rural	2.8	54.1	44.7	76.7	47.3	50.3	52.8	Noise from Mamatwane mine and plant clearly audible
17-10-12 19:06		MP11	Rural	2	51.6	45	57.9	47.9	51	53.9	
18-10-12 1:50		MP11	Rural	0.8	54	46.2	64	47.7	50.3	58.4	
18-10-12 2:00		MP11	Rural	0	48.8	41.7	61.2	43.3	46	50.4	Noise from Mamatwane mine, plant and train

Date - Time	Loop	Measurement Position	Location	WS	$L_{Aeq,I}$	L_{Amin}	L_{Amax}	L_{90}	L_{50}	L_{10}	Comments
				(m/s)	(dB(A))	(dB(A))	(dB(A))	(dB(A))	(dB(A))	(dB(A))	
18-10-12 2:11		MP11	Rural	0.2	48	42.8	58.9	44.2	46.4	49.2	operations clearly audible
18-10-12 12:34		MP11	Rural	1.6	53.3	43.5	59.1	48.9	52.7	55.7	Noise from Mamatwane mine and plant, as well as human activities clearly audible
18-10-12 12:45		MP11	Rural	1.2	53.1	45.1	60.1	48.9	52.1	55.5	

Table B-2. Coordinates of Noise Measurement Points and Sensitive Receptors

Receptor	Description	Coordinates			
		UTM (m)		Lad/Lon (DD MM)	
		X	Y	South	East
Fieldsview Loop					
MP01	Measurement Point	269264.00	6839071.00	28° 33.285'	24° 38.487'
R01	Farm House	271623.37	6842805.78	28° 31.290'	24° 39.977'
R02	Farm House	270367.49	6839350.57	28° 33.146'	24° 39.166'
R03	Farm House	265931.16	6841009.33	28° 32.201'	24° 36.468'
R04	Farm House	264713.33	6839232.89	28° 33.149'	24° 35.700'
R05	Farm House	265485.13	6838171.12	28° 33.732'	24° 36.160'
R06	Farm House	266431.46	6837551.18	28° 34.078'	24° 36.732'
R07	Farm House	269012.51	6834332.12	28° 35.847'	24° 38.275'
Gong-Gong Loop					
MP02	Measurement Point	246822.00	6846899.00	28° 28.799'	24° 24.837'
R01	Community north west of loop	242575.58	6849645.74	28° 27.264'	24° 22.274'
R02	Community west of loop	244084.56	6848941.46	28° 27.663'	24° 23.188'
R03		245930.84	6847708.06	28° 28.351'	24° 24.302'
R04		246479.34	6846736.82	28° 28.884'	24° 24.625'
R05	Farm House	246081.47	6846247.32	28° 29.144'	24° 24.375'
R06	Farm House	250191.19	6849410.68	28° 27.480'	24° 26.933'
Ulco Loop					
MP03	Measurement Point	234223.00	6860636	28° 21.217'	24° 17.312'
R01	Farm House	238344.27	6859770.65	28° 21.736'	24° 19.821'
R02	Farm House	236143.81	6858841.07	28° 22.212'	24° 18.462'
R03	Farm House	235757.44	6858419.14	28° 22.435'	24° 18.220'
R04	Farm House	237505.59	6856682.27	28° 23.396'	24° 19.266'
Trewil Loop					
MP04	Measurement Point	763439.00	6865807.00	28° 18.448'	23° 41.187'
R01	Farm House	760799.22	6867125.41	28° 17.767'	23° 39.556'
R02	Farm House	763064.16	6865561.44	28° 18.586'	23° 40.961'
R03	Farm House	767683.27	6864491.87	28° 19.109'	23° 43.800'
Tsantsabane Loop					
MP05	Measurement Point	710265.00	6869814.00	28° 16.855'	23° 8.630'
R01	Community west of loop	705095.34	6868153.93	28° 17.803'	23° 5.486'
R02	Farm House	707273.04	6867058.8	28° 18.375'	23° 6.830'
R03	Farm House	708731.81	6868570.99	28° 17.543'	23° 7.705'
R04	Farm House	709547.76	6868830.21	28° 17.394'	23° 8.202'
R05	Farm House	709828.30	6869332.41	28° 17.120'	23° 8.368'
R06	Farm House	710602.78	6869587.21	28° 16.975'	23° 8.838'
R07	Farm House	711067.33	6869634.86	28° 16.945'	23° 9.122'
R08	Farm House	712590.46	6869372.79	28° 17.072'	23° 10.056'
R09	Farm House	711691.30	6873358.03	28° 14.923'	23° 9.463'
Postmasburg Loop					
MP06	Measurement Point	700189.00	6865983.00	28° 19.023'	23° 2.509'
R01	Community northwest of	695903.00	6868782.00	28° 17.547'	22° 59.859'

Receptor	Description	Coordinates			
		UTM (m)		Lad/Lon (DD MM)	
		X	Y	South	East
	loop				
R02	Boichoko Community	699901.00	6865894.00	28° 19.074'	23° 2.334'
R03	HTT Bidi Memorial Primary School	700124.09	6865686.66	28° 19.184'	23° 2.472'
R04	Community south of the loop	701401.00	6865796.00	28° 19.113'	23° 3.252'
R05	Community further south west of the loop	703076.00	6865747.00	28° 19.124'	23° 4.277'
R06	Community south west of the loop	702221.45	6866360.76	28° 18.800'	23° 3.748'
Glosam Loop					
MP07	Measurement Point	700632.00	6892219.00	28° 4.818'	23° 2.509'
R01	Community west of the loop	700348.19	6892255.09	28° 4.801'	23° 2.336'
R02	Farm House	699987.10	6891573.51	28° 5.174'	23° 2.122'
R03	Farm House	700713.19	6890499.08	28° 5.748'	23° 2.576'
Sishen Loop					
MP08	Measurement Point	691844.00	6922106.00	27° 48.718'	22° 56.855'
R01	Farm House	691510.51	6924863.86	27° 47.228'	22° 56.625'
R02	Farm House	689266.17	6924072.65	27° 47.675'	22° 55.267'
R03	Farm House	690542.83	6922910.08	27° 48.293'	22° 56.055'
R04	Farm House	691520.11	6922052.86	27° 48.750'	22° 56.658'
R05	Farm House	691819.01	6921985.13	27° 48.783'	22° 56.841'
R06	Farm House	693091.00	6920491.42	27° 49.581'	22° 57.630'
R07	Farm House	693163.24	6920073.03	27° 49.807'	22° 57.678'
R08	Farm House	694416.43	6919609.52	27° 50.047'	22° 58.446'
R09	Dingle Community	695324.09	6923588.57	27° 47.885'	22° 58.959'
Wincanton Loop					
MP09	Measurement Point	691532.00	6947213.00	27° 35.129'	22° 56.425'
R01	Farm House	691425.00	6947186.00	27° 35.144'	22° 56.360'
R02	Farm House	693959.00	6946149.00	27° 35.684'	22° 57.909'
Witloop					
MP10	Measurement Point	696001.00	6979063.00	27° 17.848'	22° 58.831'
R01	Offices	695551.00	6979453.00	27° 17.641'	22° 58.555'
Mamatwane Loop					
MP11	Measurement Point	697169.00	6968066.00	27° 23.791'	22° 59.646'
R01	Mamatwane mine	696616.00	6968612.00	27° 23.500'	22° 59.305'
R02	Farm House	697203.00	6968080.00	27° 23.783'	22° 59.666'
R03	Farm House	692136.00	6960902.00	27° 27.713'	22° 56.661'
R04	Farm House	697644.24	6959182.32	27° 28.596'	23° 0.021'

Appendix C Vibration Monitoring

C.1 Vibration Monitoring Record Sheets

- **Position MPV01**

This point is located at the Gong -Gong community about 1.2 m from Gong-Gong Loop

GPS coordinates- S 28°28'47.94" E 24°24'50.22"

View east towards Loop

View west

Figure C-1. MPV01 Images

- **Position MPV02**

This point is located about 8 m from the existing Ulco loop.

GPS coordinates –S 28°21'13.02" E 24°17'18.72"

View west towards Loop

View north

Figure C-2. MPV02 Images

- **Position MPV03**

This point is located west of the Witloop about 8 m from the rail line and 209m from the R380 road.

GPS coordinates –S 27°17'50.88" E 22°58'49.86"

View north towards Hotazel

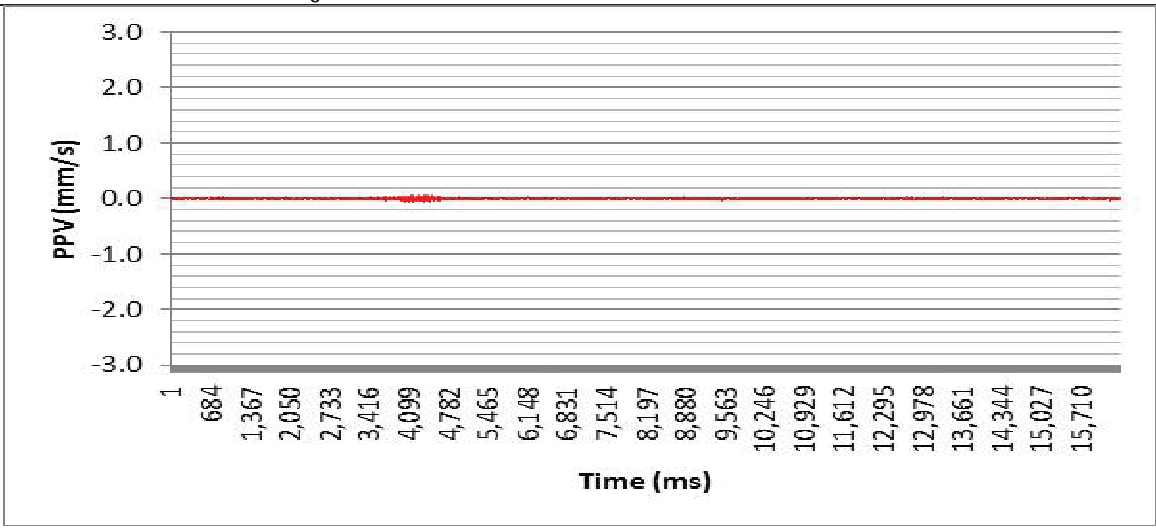
View east towards R380 road

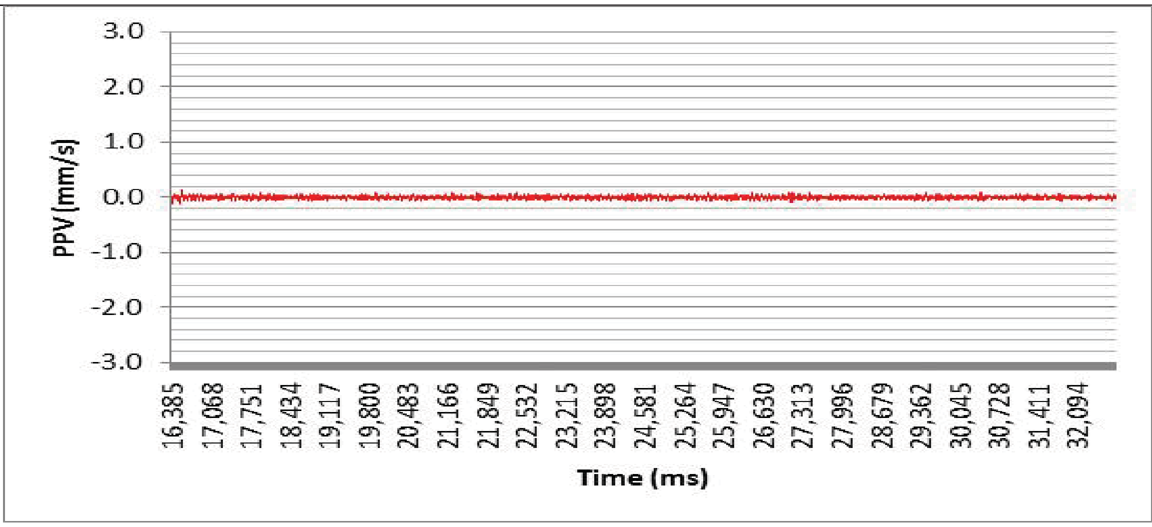
Figure C-3. MPV03 Images

C.2 Vibration Graphs

Point: MPV01	Date: 15/10/2012	Distance from Track: 1200 m
	Location: Gong-Gong Community	**Notes:** Background measurements with no train pass by.
	GPS: S28° 28.799' E24°24.837'	

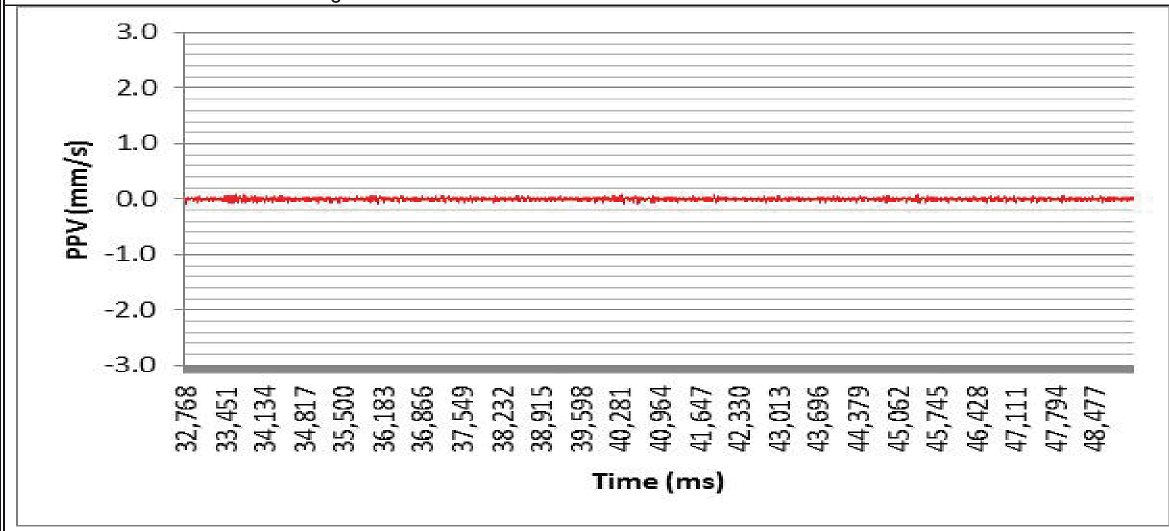
Red Line: Vertical relative to ground.

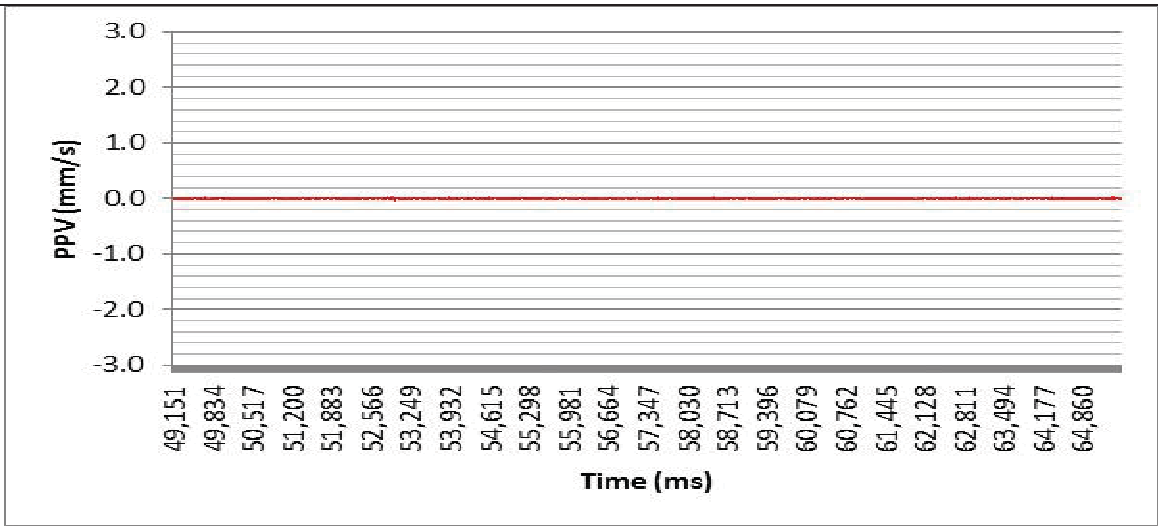




Point: MPV01	**Date: 15/10/2012**	**Distance from Track:** 1200 m
	Location: Gong-Gong Community	**Notes:** Background measurements with no train pass by.
	GPS: S28° 28.799' E24°24.837'	

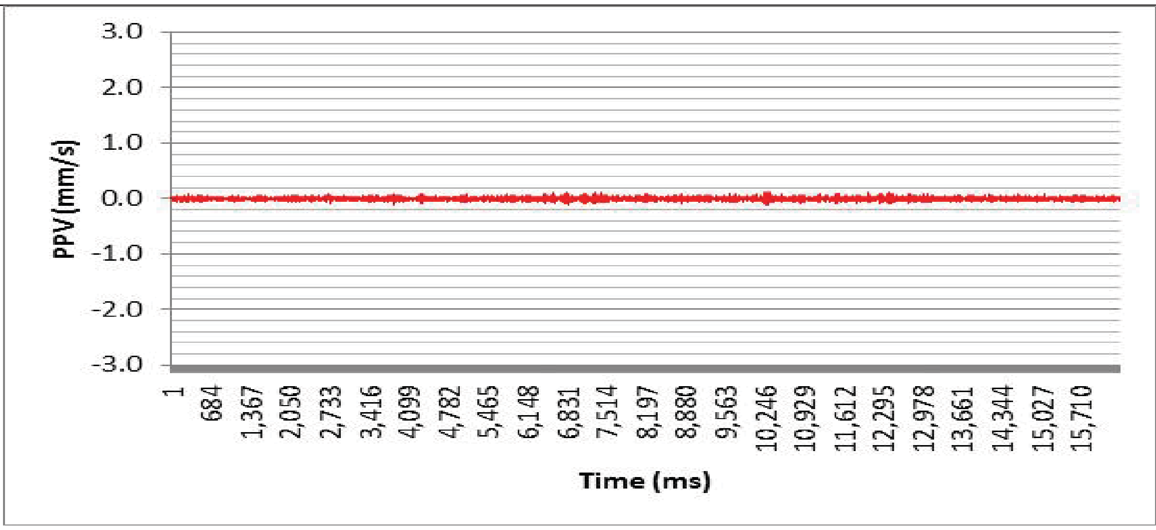
Red Line: Vertical relative to ground.

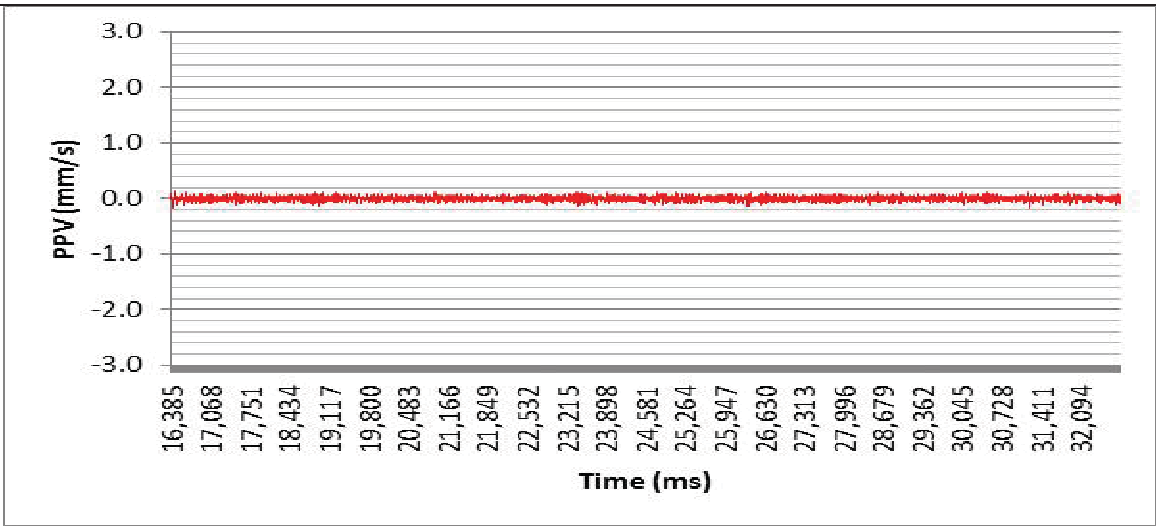




Point: MPV02	**Date: 18/10/2012**	**Distance from Track:** 8m
	Location: Ulco Loop GPS: S28° 18.448' E24°17.312'	**Notes: :** Train to Gong-Gong: 2 Locomotive and 50 Wagons **Train Speed:** 20km/hr

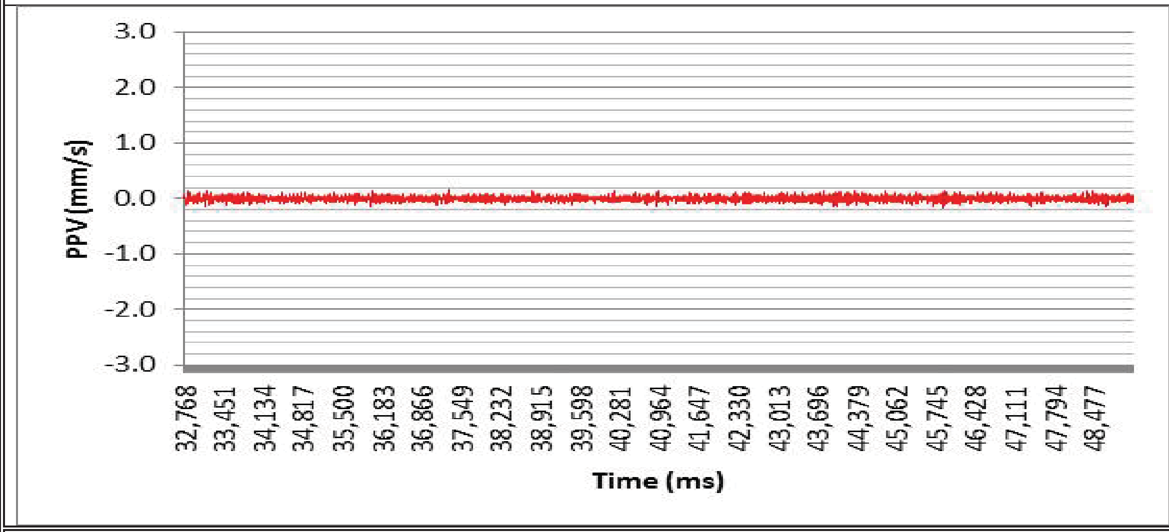
Red Line: Vertical relative to ground.

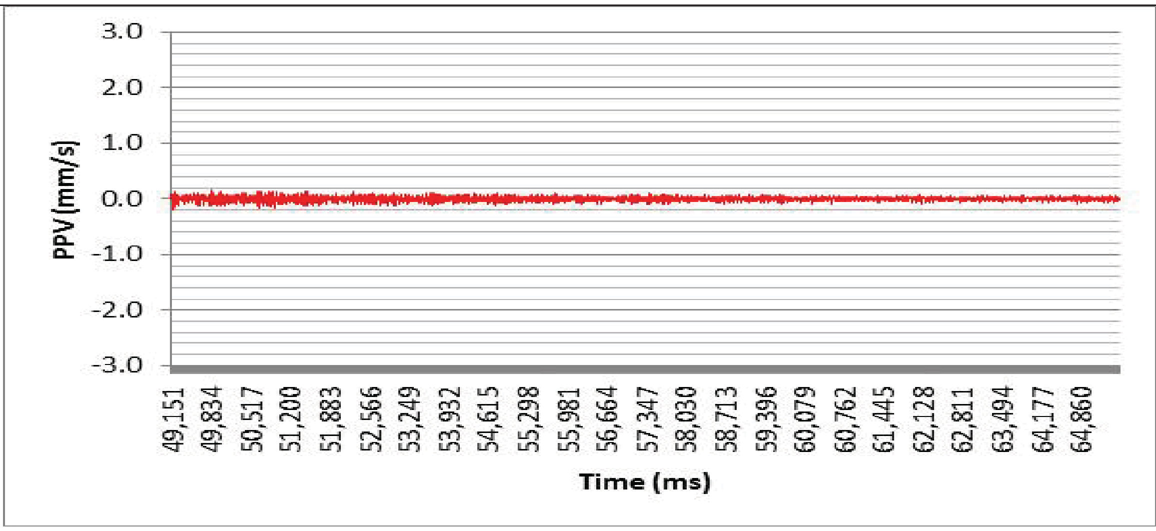




Point: MPV02	Date: 18/10/2012	Distance from Track: 8m
	Location: Ulco Loop	Notes: : Train to Gong-Gong: 2 Locomotive and 50 Wagons
	GPS: S28° 18.448' E24°17.312'	Train Speed: 20km/hr

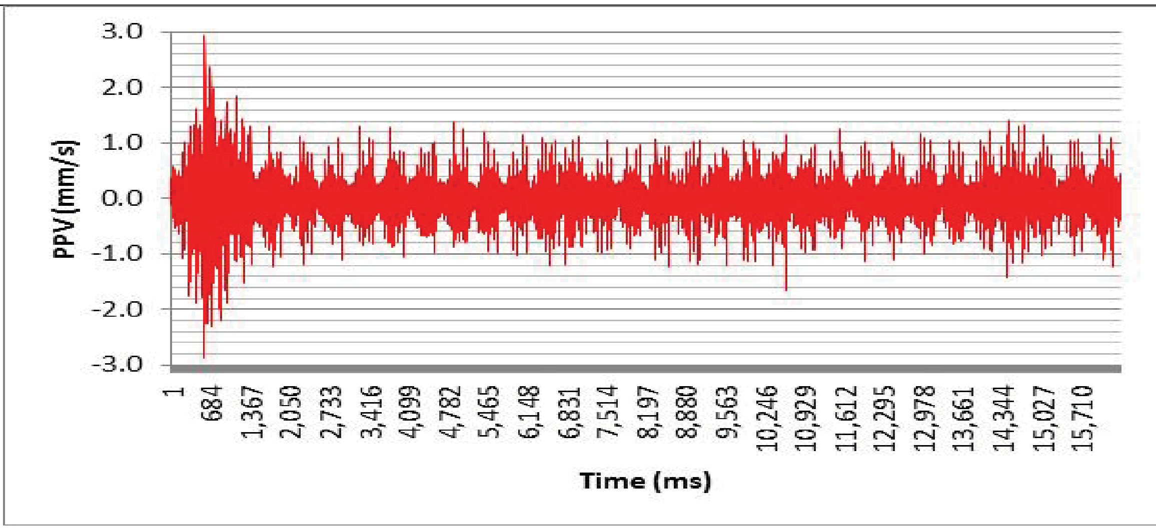
Red Line: Vertical relative to ground.

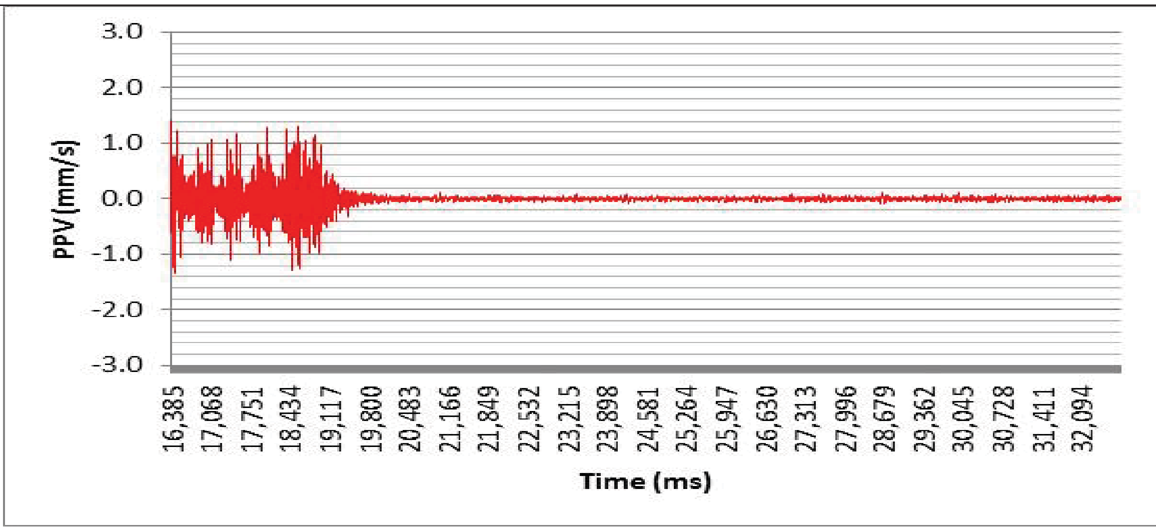




Point: MPV03	**Date: 18/10/2012**	**Distance from Track:** 8m
	Location: Witloop	**Notes: :** Train from Hotazel: 1 Locomotive and 34 Wagons **Train Speed:** 50km/hr
	GPS: S27° 17.641' E22° 58.555'	

Red Line: Vertical relative to ground.





Appendix D Construction and Operation Noise Model Sound Power Input Data

Table D-1. Construction Equipment Sound Power Emission Levels

Equipment	Octave Band (Hz)							
	63	125	250	500	1000	2000	4000	8000
	Sound Power Level (dB), re 1 pW							
Bulldozer	88.0	118.0	111.0	109.0	107.0	103.0	97.0	67.0
Excavator	82.0	112.0	118.0	105.0	106.0	99.0	95.0	65.0
Grader	81.0	111.0	108.0	108.0	106.0	104.0	98.0	68.0
Truck	83.0	113.2	116.9	114.4	110.6	106.8	100.2	70.0
Front end loader	86.0	116.0	107.0	108.0	105.0	99.0	95.0	65.0
Generator	90.0	90.0	97.0	103.0	103.0	99.0	92.0	92.0
Compressor	71.1	101.1	103.9	104.1	103.4	112.4	113.1	83.1

Noise and Vibration Impact Assessment for the Proposed Expansion of Transnet's Manganese Ore Export Railway Line: Eastern Cape Component

Commissioned by:

ERM South Africa

Prepared by:

Demos Dracoulides

Ebot Arrey

CAPE TOWN

PO Box 60034, Table View 7439

Tel: +2721 551 1836

Fax: +2721 557 1078

DemosD@xsinet.co.za

Report No TRN-NVI-R02
June 2013

Table of Contents

List of Figures page

List of Tables **page**

Terminology, Acronyms and Definitions

Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
A-weighted sound level	A frequency weighting filter used to measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies.
dB(A)	Unit of sound level. The weighted sound pressure level by the use of the A metering characteristic and weighting.
deciBel (dB)	A measure of sound. It is equal to 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference sound pressure. The reference sound pressure used is 20 micropascals, which is the lowest audible sound.
Equivalent A-weighted sound level (L_{Aeq})	A-weighted sound pressure level in decibels of continuous steady sound that within a specified interval has the same sound pressure as a sound that varies with time.
Equivalent continuous day/night rating level	Equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) during a reference time interval of 24 h, including adjustments for tonal character, impulsiveness of the sound and the time of day.
GPS	Global Positioning System
IEC	Independent Electoral Commission
IFC	International Finance Corporation
Impulse time weighting	A standard time constant weighting applied by the Sound Level Meter.
ISO	International Organisation Standardisation
LA_{10}	The noise level exceeded 10% of the measurement period with 'A' frequency weighting calculated by statistical analysis.
LA_{90}	The noise level exceeded 90% of the measurement period with 'A' frequency weighting calculated by statistical analysis. It is generally utilized for the determination of background noise, i.e. the noise levels without the influence of the main sources.
L_{WA}	Sound power level in dB(A), re 10^{-12} W.
Mtpa	Million tonnes per annum
NSR	Noise Sensitive Receivers.
OECD	Organisation for Economic Co-ordination and Development

PPE	Personal Protective Equipment
PPV	Peak Particle Velocity. The peak signal value of an oscillating vibration velocity waveform, usually expressed in mm/second.
PWL	Power level in dB(A).
Residual noise	Sound in a given situation at a given time that excludes the noise under investigation but encompasses all other sound sources, both near and far.
SA	South Africa
SANS	South African National Standard.
SLM	Sound Level Meter
WBG	World Bank Group
WHO	World Health Organisation

1 INTRODUCTION

In 2009 an authorisation was granted for the upgrading of the manganese ore railway line between Hotazel in the Northern Cape to the Port of Ngqura in the Eastern Cape, in order to accommodate an increase in the transportation capacity of Manganese from 5 million tons per annum (Mtpa) to12 Mtpa.

Transnet SOC Limited, together with the manganese mining industry, identified the need to increase the export capacity to 16 Mtpa. As such, it is intended that the existing railway line be expanded, to allow for the transportation of 16 Mtpa of manganese ore. As such, the changes to the original development proposal necessitate an additional environmental assessment.

The proposed rail expansion for the 16 Mtpa includes:

- Extension of several existing rail loops in both the Eastern and Northern Cape.
- The installation of two new rail loops in the Northern Cape.
- The construction of a new compilation yard at Mamathwane, situated approximately 22 km south of Hotazel in the Northern Cape.

DDA Environmental Engineers (DDA) has been appointed by ERM (South Africa) (Pty) Ltd to determine the baseline noise levels, and undertake the noise and vibration impact assessment for the proposed expansion.

The assessment for the proposed project has been divided into two sections, namely Northern Cape and Eastern Cape, based on geographic demarcation. The present report describes the noise and vibration impact assessment of the proposed extension of the existing loops in the Eastern Cape.

1.1 Terms of Reference

The proposed terms of reference for the baseline and noise and vibration impact assessment were:

- Establish the baseline noise levels around each loop.
- Determine thresholds of acceptable change and relevant noise standards to be complied with.
- Identify sensitive receptors at each loop that may potentially be impacted upon by the proposed loop extension.

- Build a 3-dimensional noise impact model, in order to predict the future noise levels due to the construction and operation of each loop for comparison against regulatory and contractual limits.
- Identify and predict the noise impact of the proposed rail loop extensions during the construction and operation phases, as well as the assessment of significance before and after mitigation, if necessary.
- Assess potential vibrational risks associated with the proposed loop extensions.
- Propose mitigation measures, where necessary.

1.2 Study Area - Eastern Cape

This report focuses on the portion of the proposed railway line to be upgraded which is located in the Eastern Cape. The loops that are proposed to be extended in the Eastern Cape are the Drennan loop, the Thorngrove loop, the Cookhouse-Golden Valley doubling, the Sheldon loop, and the Ripon-Kommadagga doubling.

- The Drennan loop is located just west of the N10 road, about 35 km south of the town of Cradock.
- The Thorngrove loop is about 25 km south of the Drennan loop.
- The Cookhouse-Golden Valley doubling is located further south of the Drennan loop, on the eastern border of Cookhouse. This loop consists of a complete extension between the two stations (i.e. Cookhouse Station and Golden Valley Station) and therefore is also referred to as a doubling instead of a loop extension.
- The Sheldon loop is located about 2km from the N10, and about 28km south of Cookhouse.
- Lastly, the Ripon-Kommadagga doubling is located 83 km north-east of the Port of Ngqura and is also a doubling between Ripon Station and Kommadagga Station. Their locations are shown in Figure 1-1 below.

All the loops/doublings are situated in remote areas, except for the Cookhouse-Golden Valley doubling, which is on the eastern border of Cookhouse. The sensitive receptors in the study area include sparsely situated farm houses, as well as the residential area of Cookhouse, which includes a school and a church.

Figure 1-1. Eastern Cape Loops Locality Map

2 NOISE AND VIBRATION BASICS, GUIDELINES AND LEGAL REQUIREMENTS

2.1 Noise Basics

Sound is created when an object vibrates and radiates part of that energy as acoustic pressure or waves through a medium, such as air, water or a solid. Sound and noise are measured in units of decibels (dB). The dB scale is not linear but logarithmic. This means, for example, that if two identical noise sources, each producing 60 dB, operate simultaneously they will generate 63 dB. Similarly, a 10-decibel increase in sound levels represents ten times as much sound energy.

The human ear can accommodate a wide range of sound energy levels, including pressure fluctuations that increase by more than a million times. The human ear is not equally receptive to all frequencies of sound. The A-weighting of sound levels is a method used to approximate how the human ear would perceive a sound, mostly by reducing the contribution from lower frequencies by a specified amount. The unit for the A-weighted sound levels is dB(A).

Small changes in ambient sound levels will not be able to be detected by the human ear. Most people will not notice a difference in loudness of sound levels of less than 3 dB(A), which is a two-fold change in the sound energy. A 10-dB(A) change in sound levels would be perceived as doubling of sound loudness.

The level of ambient sound usually varies continuously with time. A human's subjective response to varying sounds is primarily governed by the total sound energy received. The total sound energy is the average level of the fluctuating sound, occurring over a period of time, multiplied by the total time period.

In order to compare the effects of different fluctuating sounds, one compares the average sound level over the time period with the constant level of a steady, non-varying sound that will produce the same energy during the same time period. The average of the fluctuating noise levels over the time period is termed L_{eq}, and it represents the constant noise level that would produce the same sound energy over the time period as the fluctuating noise level.

Percentile parameters (L_n) are also useful descriptors of noise. The L_n value is the noise level exceeded for "n" percent of the measurement period. The L_n value can be anywhere between 0 and 100. The two most common ones are L_{10} and the L_{90}, which are the levels exceeded for 10 and 90 percent of the time respectively. The L_{90} has been adopted as a good indicator of the "background" noise level. The L_{10} has been shown to give a good indication of people's subjective response to noise.

Sound levels diminish with distance from the source because of dispersion, and for point noise sources the calculated sound pressure is:

$L_{p2} = L_{p1} - 20 \log(r_2/r_1)$

Where: L_{p2} = sound pressure level in dB at distance r_2 in meters, and L_{p1} = sound pressure level in dB at distance r_1 in meters

In the case of a line source the sound pressure is:

$L_{p2} = L_{p1} - 10 \log(r_2/r_1)$

In simple terms, for point sources, the distance attenuation would be approximately 6 dB(A) per doubling of distance from the source. For line sources the same attenuation is approximately 3 dB(A).

The atmospheric conditions, interference from other objects and ground effects also play an important role in the resulting noise levels. For example, "hard" ground, such as asphalt or cement transmits sound differently than "soft" ground, such as grass. The first ground type promotes transmission of sound, thus producing louder sound levels farther from the source. In general terms, the above effects increase with distance, and the magnitude of the effect depends upon the frequency of the sound. The effects tend to be greater at high frequencies and less at low frequencies.

Typical noise levels for various environments are shown in the following figure.

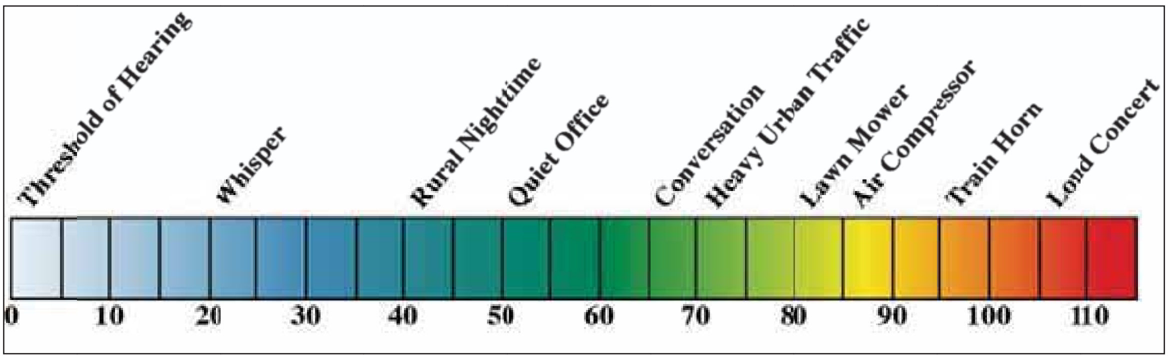


Figure 2-1. Typical Sound Levels (dB(A))

2.2 Noise Standards and Guidelines

In general, the standards applied by the international community are similar for different countries. Internationally, the current trends are to apply more stringent criteria due to the deteriorating noise climate.

The noise impacts due to a proposed project are generally based on the difference between the expected noise level increase and the existing noise levels in the area, as well as on comparisons against area-specific noise guidelines.

The available international guidelines are presented in the sections below and have taken into consideration the following adverse effects of noise:

- Annoyance.
- Speech intelligibility and communication interference.
- Disturbance of information extraction.
- Sleep disturbance.
- Hearing impairment.

The World Health Organisation (WHO) together with the Organisation for Economic Co-ordination and Development (OECD) have developed their own guidelines based on the effects of the exposure to environmental noise. These provide recommended noise levels for different area types and time periods.

The World Health Organisation has recommended that a standard guideline value for average outdoor noise levels of 55 dB(A) be applied during normal daytime, in order to prevent significant interference with the normal activities of local communities. The relevant night-time noise level is 45 dB(A). The WHO further recommends that, during the night, the maximum level of any single event should not exceed 60 dB(A). This limit is to protect against sleep disruption. In addition, ambient noise levels have been specified for various environments. These levels are presented in the table below.

Table 2-1. WHO Guidelines for Ambient Sound Levels

Environments	Ambient Sound Level L_{Aeq} (dB(A))			
	Daytime		Night-time	
	Indoor	Outdoor	Indoor	Outdoor
Dwellings	50	55	-	-
Bedrooms	-	-	30	45
Schools	35	55	-	-

The WHO specifies that an environmental noise impact analysis is required before implementing any project that would significantly increase the level of environmental noise in a community (WHO, 1999). Significant increase is considered a noise level increase of greater than 5 dB.

World Bank Group (WBG) International Finance Corporation (IFC) has developed a program in pollution management so as to ensure that the projects they finance in developing countries are environmentally sound. Noise is one of the pollutants covered by their policy. It specifies that noise levels measured at noise receptors, located outside the project's property boundary, should not be 3 dB(A) greater than the background noise levels, or exceed the noise levels depicted in Table 2-2.

The Standard also refers to the WHO Guidelines for Community Noise (WHO, 1999) for the provision of guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

Table 2-2. World Bank/IFC Ambient Noise Guidelines

Receptor	Maximum Allowable Ambient Noise Levels 1-hour L_{Aeq} (dB(A))	
	Daytime 07:00 – 22:00	Night-time 22:00 – 07:00
Residential, institutional, educational	55	45
Industrial, commercial	70	70
Note: No L_{Aeq} values are stipulated for rural areas.		

2.2.1 SANS Codes of Practice and Guidelines

The SANS 10103 Code of Practice provides typical ambient noise rating levels ($L_{Req,T}$) in various districts. The outdoor ambient noise levels recommended for the districts are shown in Table 2-3 below.

It is probable that the noise is annoying or otherwise intrusive to the community or to a group of persons if the rating level of the ambient noise under investigation exceeds the applicable rating level of the residual noise (determined in the absence of the specific noise under investigation), or the typical rating level for the ambient noise for the applicable environment given in Table 2-3 (Table 2 of SANS 10103)

The expected response from the local community to the noise impact, i.e. the exceedance of the noise over the acceptable rating level for the appropriate district, is primarily based on Table 5 of SANS Code of Practice 10103 (SANS 10103, 2008), but expressed in terms of the effects of impact, on a scale of NONE to VERY HIGH (see Table 2-4 below).

The noise monitoring of the baseline conditions within and around the site will provide the rating level of the residual noise. The noise impact during construction and the noise emission requirements will be determined by comparing:

- the ambient noise under investigation with the measured rating level of the residual noise (background noise levels); and
- the ambient noise under investigation with the typical rating level for the ambient noise for the applicable environment given in Table 2-3.

Table 2-3. Typical Rating Levels for Ambient Noise

Type of district	Equivalent continuous rating level ($L_{Req.T}$) for noise (dB(A))					
	Outdoors			Indoors, with open windows		
	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)	Day-night $L_{R,dn}$ 1)	Day-time $L_{Req,d}$ 2)	Night-time $L_{Req,n}$ 2)
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

Table 2-4. Response Intensity and Noise Impact for Increases of the Ambient Noise

Increase (dB)	Response Intensity	Remarks	Noise Impact
0	None	Change not discernible by a person	None
3	None to little	Change just discernible	Very low
$3 \leq 5$	Little	Change easily discernible	Low
$5 \leq 7$	Little	Sporadic complaints	Moderate
7	Little	Defined by South African National Noise Regulations as being 'disturbing'	Moderate
$7 \leq 10$	Little - medium	Sporadic complaints	High
$10 \leq 15$	Medium	Change of 10dB perceived as 'twice as loud', leading to widespread complaints	Very high
$15 \leq 20$	Strong	Threats of community/group action	Very high

2.2.2 Recommended Noise Limits for Train Operations

The ambient noise level guidelines, which the train transport should adhere to, are summarised in the following table.

Table 2-5. Ambient Noise Guideline Limits

Receptor	Allowable Ambient Noise Limits L_{Aeq} (dB(A))		Maximum Noise Limit of any Single Event L_{Amax} (dB(A))
	Daytime [1]	Night-time [2]	Night-time
Residential, institutional, educational	55	45	60
Industrial, commercial	70	70	

[1] Daytime: 07:00 – 22:00

[2] Night-time: 22:00 – 07:00

In addition, noise levels measured at noise receptors located outside the project's property boundary should not be 3 dBA greater than the background noise levels or exceed the noise levels depicted in Table 2-5.

In order to establish a uniform approach regarding the assessment of impacts, ERM has issued a procedure in terms of a rating matrix for the determination of the overall noise impact due to the project. In accordance with this procedure, several aspects of the impact, such as its nature, scale, duration, intensity and probability were taken into account. A detailed description of the methodology is provided in Appendix A.

2.2.3 Health and Safety

In South Africa, any operation that has the potential to generate noise should have a noise survey done, in terms of the Noise Induced Hearing Loss Regulations of the Occupational Health and Safety Act 85 of 1993 (SA).

The regulations require an Approved Inspection Authority to conduct the surveys in accordance with SANS 10083 and submit a report. All people exposed to an equivalent noise level of 85 dB(A) or more must be subjected to audiometric testing. It is required that all records of surveys and audiometric testing must be kept for 40 years.

The sound pressure threshold limits within workshops and plants that could affect employees' health, quality of life and quality of work are:

- Alert threshold 80 dB(A).
- Danger threshold 85 dB(A).

Site locations are required to meet the following levels of performance at all points accessible by the employees on a regular basis:

- For workshop circulated areas, the maximum levels must not exceed 85 dB(A).
- For work equipment, the maximum levels must not exceed 80 dB(A) at one meter from the equipment and at 1.60 m high.

Exceptions may be considered for areas that should not be accessed on a regular basis. Personal Protective Equipment (PPE) will be required to access those areas, and the noise levels outside should comply with the above-mentioned thresholds.

The employer has a legal duty under the current Occupational Health Regulations (SA) to reduce the risk of damage to his/her employees' hearing. The main requirements apply, where employees' noise exposure is likely to be at or above the danger threshold limit of 85 dB(A). It should be noted that there is an international tendency to regard 80 dB(A) as an informal warning level.

The action level is the value of 'daily personal exposure to noise' ($L_{EP,d}$). This depends on the noise level in the working area and how long people are exposed to the noise. The values take account of an 8-hour noise exposure over the whole working day or shift.

2.3 Rail Vibration Basics

The main source of ground-borne vibration for rail transportation systems is the interaction between the track and the wheels of the locomotives and wagons. The amount of vibration that is transmitted depends strongly on factors such as the smoothness of the wheels and rails, as well as the resonance frequencies of the vehicle suspension system and the track support system. Poorly maintained tracks and/or flat spots on the wheels can increase the level of vibration.

This energy is transmitted through the support to the ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. Once the vibration reaches a building, it is transferred through the foundations into the structure. Any structural resonances that may be excited will increase the effect of the vibration.

Vibration can be described in terms of displacement, velocity or acceleration. For a vibrating floor, the displacement is defined as the distance that a point on the floor moves away from its static position. The velocity represents the instantaneous speed of the floor movement, and acceleration is the rate of change of that speed.

The most commonly used measures of vibration are the peak particle velocity (PPV) in millimetres (mm), the velocity in metres per second (m/s) and acceleration in metres per second squared (m/s^2). The PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal and is often used in monitoring the stresses that are experienced by buildings.

The vibration levels can also be expressed as a logarithmic scale in decibels, similar to the sound pressure levels for expressing noise. The relevant calculations for the velocity (L_v) and the acceleration (L_a) levels are:

$$L_v = 20 \log_{10}(V/V_r), \text{ and}$$

$$L_a = 20 \log_{10}(A/A_r)$$

where: $V_r = 10^{-9}$ m/s and $A_r = 10^{-6}$ m/s^2 are the velocity and acceleration reference levels as specified in ISO 1683.

In this report, when the vibration velocity levels are expressed in decibels, the reference level defined above applies, and the unit is specified as dBV, in order to distinguish it from dB(A), which is used for A-weighted noise levels.

2.4 Effects of Vibration on Humans and Structures

Humans are extremely sensitive to low levels of vibration and can detect levels of ground vibration of less than 0.1 mm/s, which is less than one hundredth of the levels which could cause even minor cosmetic damage to a normal building. Complaints and annoyance regarding ground vibration are therefore much more likely to be determined by human perception than by noticing minor structural damage. However, these effects, and the startling effect of sudden impulses of both sound and vibration are often perceived as intrusion of privacy and could be a source of considerable annoyance to the local community.

There is widespread agreement in the industry that the peak particle velocity (PPV) is the parameter which best correlates with observed damage to structures caused by vibration, and is widely applied in assessments. The first observable damage to structures, i.e. the forming of hairline cracks in plaster, begins at a PPV of about 25 mm/s. The US Bureau of Mines recommends twice this value, i.e. 50 mm/s, as a "safe blasting limit" for residential properties. Minor structural damage can occur at values in excess of 100 mm/s, and serious damage occurs at values in excess of 200 mm/s, according to a range of authors (Lear, 1992). Effects on temporary structures are likely to occur at values which are lower than those for masonry structures, even though the high variability in the type and construction quality of such structures renders reliable prediction of these values difficult.

2.5 Vibration Criteria and Guidelines

As indicated previously, to date, there is no a specific standard or guideline pertaining to the impact of ground-borne vibration in South Africa. As such, international standards and guidelines will be applied for the assessment of the vibration impact on humans and structures.

A considerable amount of research has been done to correlate vibrations from single events such as dynamite blasts with architectural and structural damage. The U.S. Bureau of Mines has set a "safe blasting limit" of 50 mm/s. Below this level there is virtually no risk of building damage. However, since some of the structures in the extended area were in poor condition, the adopted limit utilised in this study was selected to be 12.5 mm/s.

The Transport and Road Research Laboratory in England has researched continuous vibrations to some extent and developed a summary of vibration levels and reactions of people and the effects on buildings (Whiffen and Leonard, 1971). These criteria have been adopted in the present study for the evaluation of the severity of vibration caused by the current railway operations and are presented in Table 2-6.

Traffic, train and most construction vibrations (with the exception of pile driving, blasting, and some other types of construction/demolition) are considered continuous. The "architectural damage risk level" for continuous vibrations (peak vertical particle velocity of 5 mm/sec) shown in Table 2-6 is one tenth of the maximum "safe" level of 50 mm/sec for single events. The recommended level for historical buildings or buildings that are in poor condition is 2.0 mm/s.

Table 2-6. Vibration Levels for Reactions of People and Effects on Buildings

Vibration Level PPV* (mm/s)	Human Reaction	Effect on Buildings
0.15 - 0.30	Threshold of perception; possibility of intrusion.	Vibrations unlikely to cause damage of any type.
2.0	Vibrations readily perceptible.	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected.
2.5	Level at which continuous vibrations begin to annoy people.	Virtually no risk of "architectural" damage to normal buildings.

Vibration Level PPV* (mm/s)	Human Reaction	Effect on Buildings
5.0	Vibrations annoying to people in buildings (for relatively short periods of vibration).	Threshold at which there is a risk of "architectural" damage to normal dwellings, i.e. houses with plastered walls and ceilings.
10 - 15	Vibrations considered unpleasant by people subjected to continuous vibration.	Vibrations at a greater level than normally expected from traffic, but which would cause "architectural" damage and possibly minor structural damage.
The vibration levels are based on the peak particle velocity in vertical direction. No allowance is made for the potential amplifying effects of structural components.		

3 AMBIENT NOISE MEASUREMENTS

3.1 Methodology

The ambient noise measurements were carried out with the use of a Type 1 Precision Impulse Integrating Sound Level Meter, in accordance with international standards for sound level meter specifications IEC 61672:1999, IEC 61260:1995 and IEC 60651, as well as ISO 19961:2003 and ISO 3095:2001 for the measurement and assessment of environmental noise.

An assessment of each loop was performed during an initial site visit, and monitoring points were selected for the noise measurements. One or two monitoring points were selected at each loop for the determination of the existing background noise levels and the noise comparisons between the modelling and the measurements.

The noise measurements were performed intermittently over a twenty-four hour period and were categorised in terms of daytime (07:00-22:00) and night-time (22:00-07:00), in order to generate results suitable for comparison to international guidelines.

At each location at least two measurements were performed for both daytime and night-time periods. In each period the continuous A-weighted equivalent sound pressure level (L_{Aeq}) of at least a 10-minute duration was taken. Abnormal disturbances, such as loud noise generation in close proximity or sudden noise bursts that affect the measurement, were discarded.

In addition to the L_{eq}, L_{10}, L_{50}, and L_{90}, the occurring maximum (L_{max}) and minimum levels (L_{min}) during the measurement period were also recorded. These measurements were appropriate for the determination of:

a) The noise levels with existing and future operations in progress.

b) The background noise, i.e. when no activities are contributing to the ambient noise levels.

c) The nature and extent of the noise.

All the noise measurements were performed in compliance with the weather condition requirements specified by the SANS and ISO codes. Therefore, measurements were not performed when the steady wind speed exceeded 5 ms^{-1} or wind gusts exceeded 10 ms^{-1}. The wind speed was measured at each location with a portable meter capable of measuring the wind speed and gusts in meters per second.

3.2 Measurement Equipment

The measurements were performed via a 01dB DUO, which is a Type 1 Data-logging Precision Impulse Integrating Sound Level Meter (see Table 3-1). The Sound Level Meter was calibrated before and after the measurement session with a 01dB Type 1, 94dB, 1 kHz field calibrator. The above-mentioned equipment, i.e. sound level meter and calibrator, have valid calibration certificates from the testing laboratories of the De Beer Calibration Services and the manufacturer, and comply with the following international standards:

- IEC 651 & 804 – Integrating sound level meters.
- IEC 942 – Sound calibrators.

The calibration certificates are available on request.

Table 3-1. Sound Level Measurement Instrumentation

Instrument	Type	Serial No.
1. Precision Integrating Sound Level Meter	01dB DUO	10372
1a. Microphone	01dB 40 CD	144888
2. Field Calibrator 01dB Cal01	CAL01	11243

All the noise measurements complied with the weather condition requirements, as specified by the SANS Codes and the Noise Control Regulations:

- The South African National Standard - Code of Practice, SANS 10103:2008, *The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication*;
- DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM. NO. R. 154. *Noise Control Regulations in Terms of Section 25 of the Environmental Conservation Act, 1989 (Act No. 73 of 1989)*. Govt. Gaz. No. 13717, 10 January 1992.

The coordinates of each monitoring point were recorded with the GARMIN iQue M5, and the local weather parameters were measured with an AZ 8910 portable weather meter.

3.3 Measurement Location and Noise-Sensitive Receptors

Ambient noise measurements were carried out over 3 days, i.e. from the 23rd to the 25th of October 2012, at seven locations around the following loops:

1) Drennan loop
2) Thorngrove loop
3) Cookhouse-Golden Valley doubling
4) Ripon-Kommadagga doubling

The measurement points were chosen based on the following criteria:

- Representative of the current noise levels in the various areas where noise-sensitive receptors are located.
- Areas in close proximity to the rail loops.
- Easy accessibility under the current conditions.
- Safety in terms of demining operations and possible night-time measurements.
- Likelihood of continuing to exist after the development of the site and therefore to be used for future comparison purposes.

The monitoring results are shown in Table 3-2 below, as the averaged values of the L_{Aeq} for each monitoring location and for daytime and night-time. The additional parameters recorded during the measurements, such as the L_{max}, L_{min}, L_{90}, L_{50} and L_{10}, can be found in Table B-1 of Appendix B. The coordinates of the noise-sensitive receptors and measurement points can also be found in Table B-2.

Table 3-2. Noise Guidelines and Noise Levels per Location

Loops	Measurement Points	Type of Area	Noise Level (dB(A))	
			Daytime	Night-time
Drennan	MP01	Rural	48.7	36.8
Thorngrove	MP02	Rural	41.8	39.3
Cookhouse-Golden Valley	MP03	Urban	53.3	43.8
	MP04	Urban	59.0	46.0
	MP05	Rural	48.2	-
Ripon-Kommadagga	MP06	Rural	41.5	39.6
	MP07	Rural	61.4	40.5

- No measurement.

SANS guidelines:
Rural districts: Daytime: 45 dB(A), Night-time:35 dB(A)
Urban districts: Daytime: 55 dB(A), Night-time:45 dB(A)
World Bank guidelines:
Residential: Daytime: 55 dB(A), Night-time:45 dB(A)

3.3.1 Drennan Loop

The Drennan loop lies about 32 km south of the town of Cradock, and approximately 3km from the N10 Road. This loop is easily accessible via the R390 Road. The selected measurement point (MP01) was located about 90 m north-east of the loop, close to the R390.

The noise environment around this loop is typical of a rural area. Some farm houses are situated within close proximity to the loop.

As can be seen in Table 3-2, the average noise level at MP01 was 48.7 dB(A) during daytime, which is above the SANS daytime rural guideline of 45 dB(A). The average noise level at night time was 36.8 dB(A), which marginally exceeded the rural guideline of 35 dB(A). The main noise sources at this point were bird activities, people conversing and vehicular traffic from the R390.

The location of the measurement point MP01 is shown Figure 3-1 below, together with the Drennan loop and the sensitive receptors within a 2 km radius.

Figure 3-1. Map of Drennan Loop Showing Noise Measurement Point and Receptors

3.3.2 Thorngrove Loop

The Thorngrove loop is located about 20 km south of the Drennan loop, and about 6km from the N10. The noise environment around this loop is typical of a rural area. Some farm houses are situated within close proximity of the loop. There is a small private runway approximately 100 m to the north, between the loop and farmhouse R04. The measurement point (MP02) was located approximately 300 m north-east of the loop.

The average measured daytime noise level at MP02 was 41.8 dB(A), which is below the SANS daytime guideline of 45 dB(A). The average night-time noise level, primarily due to insert activity, was 39.3 dB(A), which is above the SANS night time guideline of 35 dB(A).

The predominant noise sources were human activities during the day and frogs and insects at night.

The measurement point MP02 is shown Figure 3-2 below, together with the Thorngrove loop and the sensitive receptors within a 2 km radius.

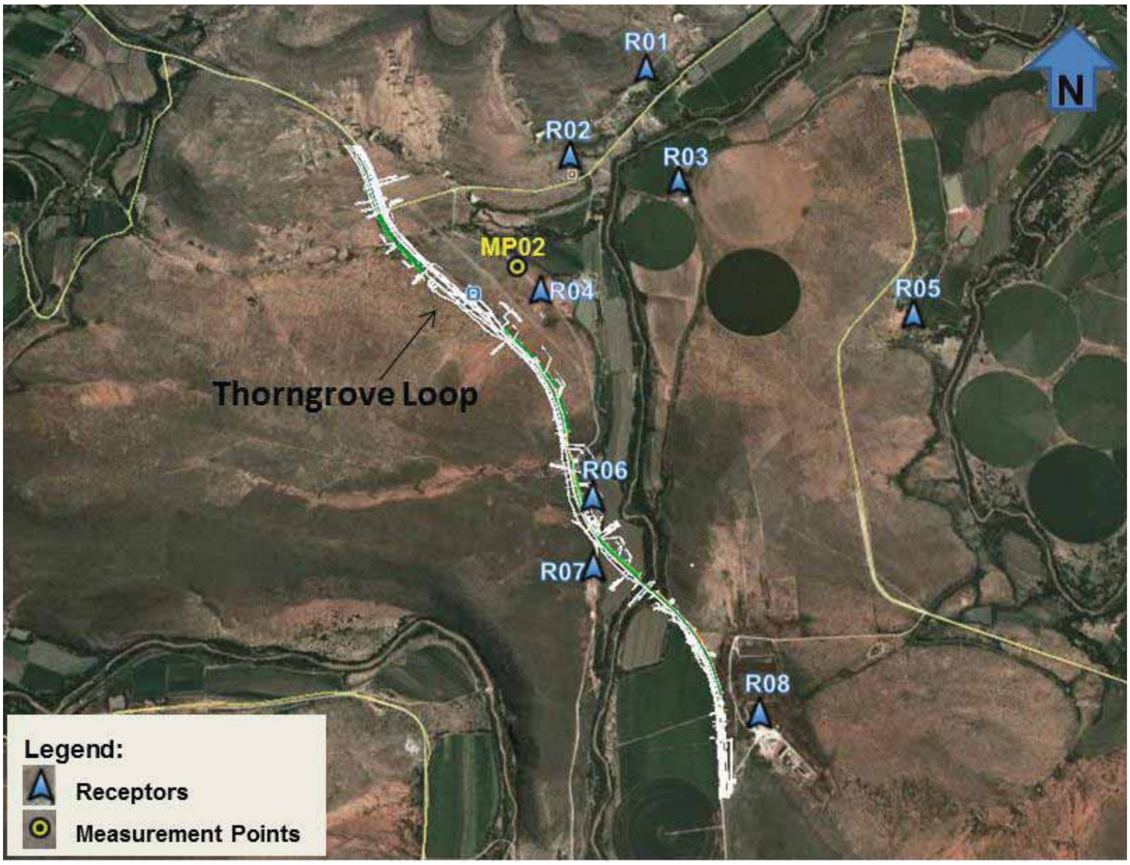


Figure 3-2. Map of Thorngrove Loop showing Noise Measurement Point and Receptors

3.3.3 Cookhouse-Golden Valley Doubling

The Cookhouse-Golden Valley doubling consists of extensions between two stations, namely, the Cookhouse Station and the Golden Valley Station.

The northern section of the loop is adjacent to the urban area of Cookhouse and Bongweni, with a church and three schools, i.e. Msobomvu Primary, Cookhouse Primary and Fish River Primary, within 1 km from the alignment. The closest school to the loop is Fish River Primary (R02) at approximately 250 m from the alignment.

The southern section of the loop is located in a rural area, and lies about 600 m west of the N10, with a few farm houses in close proximity.

Three measurement points were chosen around the loop, the first (MP03), was positioned in front of the first row of houses, in close proximity to the Cookhouse Train Station.

The second point (MP04) was situated at the centre of the Bongweni community, north-west of the loop, and the third point (MP05) east of the southern section of the loop, in a rural area.

The measured average daytime noise levels at MP03 and MP04 were 53.3 dB(A) and 59 dB(A) respectively. The average daytime noise level at MP05 was 48.2 dB(A) (see Table 3-2). The noise sources during daytime were mainly human activities and vehicular traffic from the N10 for MP03 and MP04, while the predominant noise source at MP05 was the vehicular traffic from the N10.

The average noise levels at night time were 43.8 dB(A) and 46.0 dB(A) at MP03 and MP04 respectively. No night time noise measurement was performed at MP05. The predominant noise sources at MP04 during night time were dogs barking and the vehicular traffic from the N10. Figure 3-3 below shows the measurement locations and the sensitive receptors within a 2 km radius.

Figure 3-3. Map of Cookhouse-Golden Valley Doubling Showing Noise Monitoring Points and Receptors

3.3.4 Ripon-Kommadagga Doubling

The Ripon-Kommadagga doubling is situated about 40 km south of the town of Cookhouse and runs parallel to the N10 at a distance of 20m.

Two measurement points were selected for the Ripon-Kommadagga doubling, the first one (MP06) was positioned about 650 m north-east of the loop, the other (MP07) was located in close proximity to the loop and the N10. The loop is located in a rural area with some occupied houses belonging to Transnet, in close proximity.

The average daytime noise levels at MP06 and MP07 were 41.5 dB(A) and 61.4 dB(A) respectively. The high noise level at MP07 was due to the traffic from the N10. The night-time noise levels at these two points were 39.6 dB(A) and 40.5 dB(A) respectively (see Table 3-2). The measurement points, the Ripon-Kommadagga doubling, together with the sensitive receptors within a 2 km radius are shown in Figure 3-4 below.

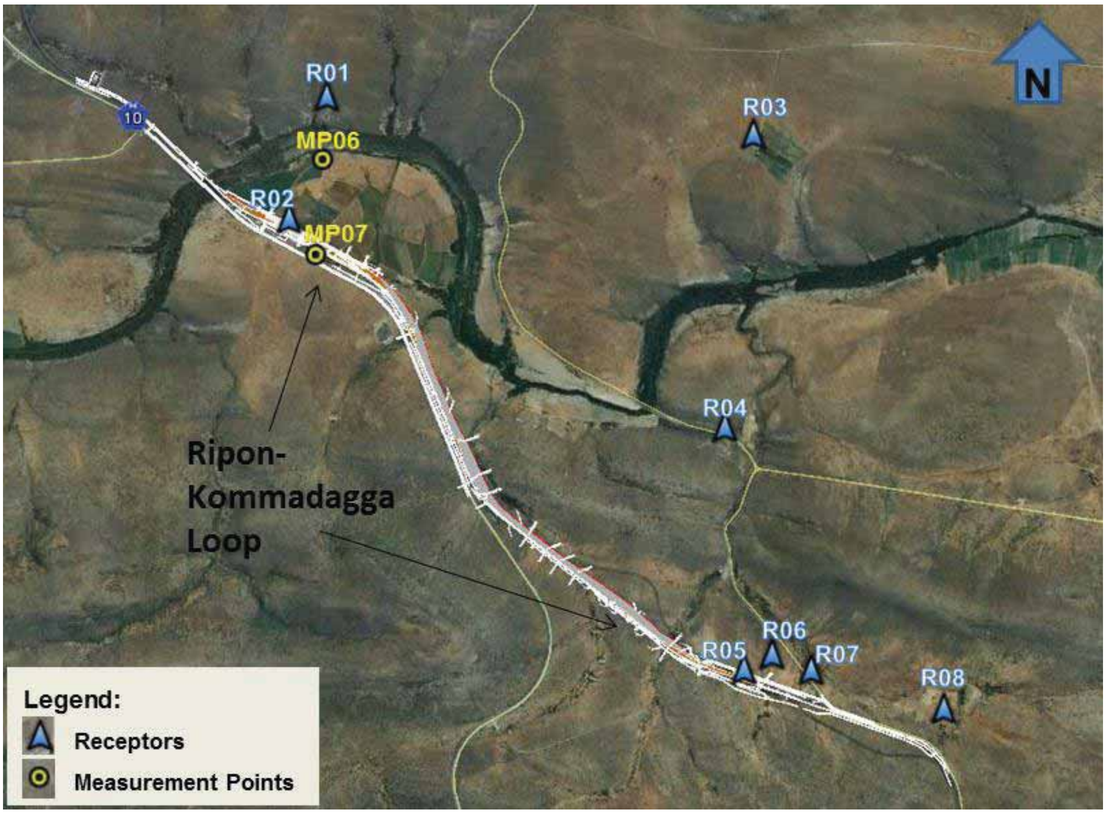


Figure 3-4. Map of Ripon-Kommadagga Doubling Showing Noise Monitoring Points and Receptors

3.3.5 Sheldon Loop

The Sheldon loop is located approximately 2.6 km north of the Ripon-Kommadagga doubling, and about 2.3km east of the N10. The noise environment around the loop is typical of a rural area. Some farm houses are situated within close proximity of the loop.

Even though the ambient noise level around this loop was not measured, the Sheldon loop and the Ripon-Kommadagga doubling are in similar rural environments, such that noise levels measured at the latter loop (MP06) are considered representative of the Sheldon loop.

The measurement points at the Sheldon loop, together with the sensitive receptors within a 2 km radius are shown in Figure 3-5 below.

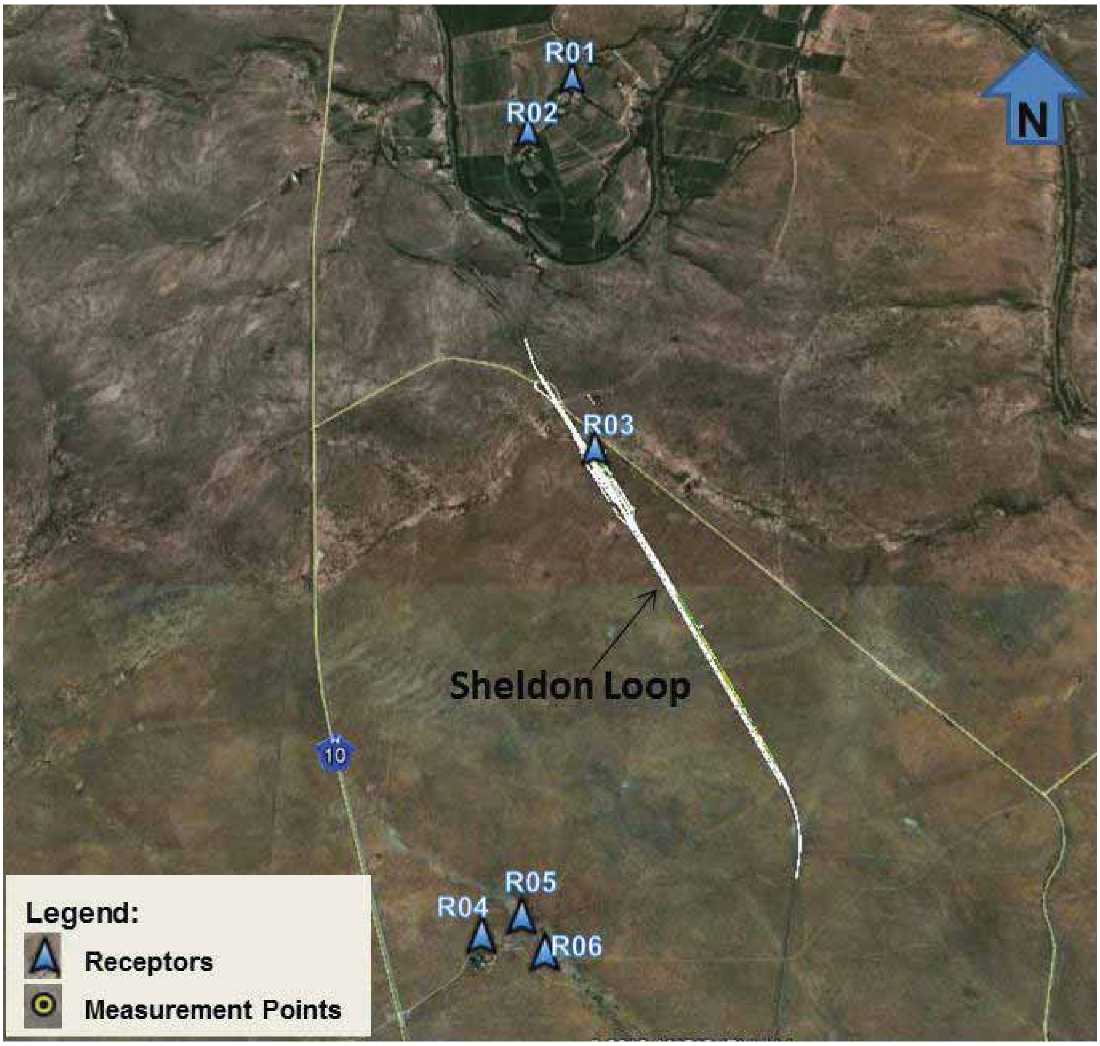


Figure 3-5. Map of Sheldon Loop Showing Sensitive Receptors

4 VIBRATION MONITORING

Vibration measurements were performed at the Thorngrove loop and the Ripon-Kommadagga loop. The locations of the measurement points are shown in Figure 4-1 below. The coordinates of the vibration measurement positions can be seen in Table 4-1. The vibration graphs from each measurement can be found in Appendix C.

Figure 4-1. Locations of the Vibration Measurement Points

Table 4-1. Vibration Measurement Points

Measurement Points	Location	GPS Position (hdd°mm'ss.s'')
MPV01	Adjacent to Thorngrove loop	S32°38'5.22" E25°48'34.00"
MPV02	Adjacent to Ripon-Kommadagga doubling	S33° 5'21.25" E25°51'47.41"

4.1 Vibration Monitoring Procedure

The vibration measurements were performed with the use of the OneproD MVP-2C vibration analyser by 01dB-Metravib, with Serial Number 15134. This instrument is capable of recording the time series of the signals from a triaxial or from individual one-directional accelerometers. The time series can then be downloaded to a computer for the determination of the relevant vibration parameters, such as the PPV and the RMS.

The vibration measurements in the present study were performed with an accelerometer, positioned in a direction vertical to the ground. The distances from the track were 8 m for MPV01 and 3 m for MPV02. The measurement duration covered the entire train passby for MPV01 and half the train passby for MPV02.

4.2 Vibration Monitoring Data

The vibration levels at the two measurement locations with a train passing are presented in Table 4-2 below.

Table 4-2. Vibration Measurement Results

Measurement Point	Measurement Description	Distance from Track	PPV *	Train Speed
		(m)	(mm/s)	(km/hr)
MPV01	Train to Drennan: 2 locomotive and 50 wagons	8	1.45	50
MPV02	Train from Cookhouse : 1 locomotive and 33 wagons	3	2.47	70

* Peak Particle Velocity (PPV) guidelines:
- Human perception: 0.15 mm/s
- Buildings with poor construction: 2.0 mm/s
- Architectural damage risk level: 5.0 mm/s

5 NOISE AND VIBRATION MODELLING METHODOLOGY AND INPUT

5.1 Noise During Construction and Decommissioning

The construction activities of the proposed loops are likely to increase the local noise levels temporarily during the construction period. The basis for the modelling methodology for construction noise was the BS 5228-1: 2009, "Code of practice for noise and vibration control on construction and open sites – Part 1: Noise"

This standard was utilised for the calculation of noise from construction and the determination of the sound level data from on-site equipment and site activities. The typical sound power levels utilised in that standard were taken from measurements at various sites, percentage on-times and power ratings for a wide range of construction activities. The expected worst-case mix of excavators, bulldozers, front-end loaders, graders, compressors and trucks utilised for the noise modelling was assumed by similar operations.

The following parameters and assumptions were used in the calculations:

- Average height of noise sources: 2 m.
- Construction operating hours: 8 hr.
- No noise barriers in place.
- Construction site equipment:
  - ⇒ Excavator
  - ⇒ 2 Front end loaders
  - ⇒ 20t bulldozer
  - ⇒ $10m^3$ tip trucks
  - ⇒ Grader
  - ⇒ Vibratory roller
  - ⇒ Compressor
  - ⇒ Generator
  - ⇒ Water pumps

It was also assumed, as a worst-case scenario, that all the equipment would be operated simultaneously at the construction site. The sound power levels of the construction equipment are shown in Table D-1 of Appendix D.

The equipment to be used for the decommissioning of the loop is expected to be similar to the construction equipment. As such, the noise levels during the decommissioning operations will be the same or similar to the construction related noise levels.

5.2 Operational Noise Prediction Methodology

Noise modelling was utilised for the sound propagation calculations and the prediction of the sound pressure levels around the loops. A modelling receptor grid was utilised for the determination of the expected noise contours, as a result of the increased train operations at the loops. In addition, the noise levels were estimated at several discrete receptors placed along the railway line and the various residential areas and farm houses around each loop.

The noise modelling was performed via the CADNA (Computer Aided Noise Abatement) noise model. The latter was selected for the following reasons:

- It incorporates the ISO 9613 in conjunction with the CONCAWE noise propagation calculation methodology.
- It provides an integrated environment for noise predictions under varying scenarios of operation.
- The ground elevations around the entire site can be entered into the model, and their screening effects be taken into consideration.
- The noise propagation influences of the meteorological parameters can also be accounted for.

The main assumptions adopted in the noise modelling were:

<u>Acoustically semi-hard ground conditions</u>:

This assumes that partial attenuation due to absorption at the ground surface takes place. This assumption represents a somewhat pessimistic evaluation of the potential noise impact.

<u>Meteorological conditions:</u>

For the noise propagation in the extended area, the temperature and humidity for daytime was set in the model to 35^{o}C and 50% respectively, and for night-time 25^{o}C and 70% respectively. The model was set up to favourable atmospheric conditions for the noise propagation towards each receptor.

<u>Screening effect of buildings and other barriers</u>:

The effect of these structures on the noise climate has been ignored, representing a pessimistic evaluation of the potential noise impact. However, the ground elevations of the entire area were utilised in the modelling set-up.

5.2.1 Model Input

Due to the fact that authorisation has been granted for the loops, in order to accommodate the transportation of 12 Mtpa of Manganese, it was decided to use two scenarios for the noise modelling set-up and the impact assessment. The first scenario was based on the previously approved 12 Mtpa Manganese transport and the second on the 16 Mtpa transport, which is the amount of Manganese that will be accommodated due to the loop extensions. Therefore, the following two scenarios were utilised in the model set-up:

Scenario 1: 12 Mtpa (approved situation)

Scenario 2: 16 Mtpa (with loop extensions)

The train characteristics for the model input are presented in Table 5-1 below. The cumulative impact of the general freight trains utilising the railway line were also taken into consideration for each scenario. .

Table 5-1. Operational Details for the Railway Line Loops

Description	Details
Scenario 1 (approved situation)	
Manganese transport capacity	12 Mtpa
Type of rail line	1065 mm gauge, electrified (25 kV) line.
Locomotive types:	Electric locomotives (7Es).
No. of trains per day	Manganese: 6 per direction General Container: 3 per direction
No. of locomotives per train	Manganese: Four locomotives to be required for the 104 wagon trains. Container: Two locomotives will be required for the 50 general container trains.
Total rail traffic per day	Manganese: 624 wagons + 24 locomotives (one way) Container: 150 wagons + 6 locomotives (one way)
Operating hours	Trains will run both day and night.
Train speed	A speed of 60 km/hr was assumed for the trains passing the loops.
Scenario 2 (with loop extensions)	
Manganese transport capacity	16 Mtpa
Type of rail line	1065 mm gauge, electrified (25 kV) line.
Locomotive types:	Electric locomotives (7Es).
No. of trains per day	Manganese: 5 per direction General Container: 4 per direction
No. of locomotives per train	Manganese: Nine locomotives to be required for the 200 wagon trains. Container: Two locomotives will be required for the 50 general container trains.

Description	Details
Total rail traffic per day	Manganese: 1000 wagons + 45 locomotives (one way) Container: 200 wagons + 8 locomotives (one way)
Operating hours	Trains will run both day and night.
Train speed	A speed of 60 km/hr was assumed for the trains passing the loops.

5.3 Vibration During Construction and Operation

With respect to construction vibration, there are no standards that provide a methodology to predict levels of vibration from construction activities, other than those contained within BS 5228: Part 2, which relates to piling and other construction activities.

It is generally accepted that for the majority of people, vibration levels of between 0.15 and 0.3 mm/s peak particle velocity are just perceptible. Table 5-2 below details the distances at which certain construction activities give rise to a just perceptible level of vibration. This data is based on historical field measurements and BS 5228-2: 2009, "Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration".

The activities and equipment listed below are the ones that typically generate the highest levels of vibration at construction sites.

Table 5-2. Construction Source Vibration Levels

Construction activity	Distance from activity when vibration may just be perceptible (m)
Excavation	10 - 20
Hydraulic breaker	15 - 20
Vibratory rollers	15 - 25

None of the above-mentioned activities during construction will take place outside the loop extension sites or closer than 10 m from the boundaries. The Threshold of Perception for Human Reaction level of 0.3 mm/s is not expected to be exceeded outside the site. However, the train operations are expected to generate vibrations at close distances from the rail tracks.

The surface waves generated by traffic, trains and most construction operations attenuate with distance according to the following equation:

$$PPV = PPV_0(D_0/D)^{0.5} * e^{\alpha(Do-D)} \quad \textbf{Eq. 5-1}$$

Where:

PPV = Peak particle velocity.

PPV_0 = Peak particle velocity at reference distance D0.

D0 = Reference distance.

D = Distance for which vibration level is to be calculated.

α = Soil parameter (0.017 for clayey soil).

For the determination of the reference PPV_0, the data from vibration measurements of cargo train passbys along the existing railway loops of Thorngrove and Ripon-Kommadagga were utilised. It should be noted that these levels represent an indication of the conditions at the time of the measurement and the specific location.

As a worst-case scenario, the highest measured PPV value of 5.87 mm/s was used as the reference PPV_0 for the determination of the vibration levels at various distances from the track.

The calculated vibration levels at various distances from the rail tracks can be found in the modelling section further below.

6 PREDICTED NOISE AND VIBRATION LEVELS

6.1 Construction Noise Modelling Results

The noise levels due to the construction operations at the loops, taking into consideration the expected equipment mix as outlined in Section 5.1, were calculated. As a worst-case scenario, it was assumed that all of the equipment operates at the working face simultaneously.

Table 6-1 below shows the noise levels at various distances from the construction working face. The noise levels further than 500 m from the working face were found to be around 45 dB(A). Therefore, the construction activities at receptors outside the 500 m zone from the main working area will be noticeable but will not constitute a disturbing noise. For receptors located at greater distances than a 1 km radius, the construction noise will be barely audible.

There are several isolated farm houses along the loop alignments that are situated within the 500 m zone around the railway line. The noise impact within this zone is expected to be Medium, and as the construction activities move further away, the impact is estimated to be Low.

It should also be noted that the screening effects of the existing ground elevations may have a small reduction effect on the actual noise levels generated during the construction phase. The noise levels in Table 6-1 were estimated without any barrier effects and can thus be considered a worst-case scenario.

Table 6-1. Modelled Noise at Various Distances from the Loop Construction Working Face

Receptor Distance (m)	Noise Level (dB(A))
100	62.2
200	56.6
400	50.1
500	47.8
700	44.2
1000	40.1

Similar noise levels are expected to be generated by the decommissioning operations at the loops. In addition, this impact is likely to be of shorter duration. As such, no significant noise impacts are expected during the decommissioning phase of the loops.

6.2 Operational Noise Modelling Results

Based on the noise modelling methodology and input data outlined in Section 5, the noise contours around each rail loop were estimated for day- and night-time conditions. The modelling results for each loop are presented in the sections below.

6.2.1 Drennan Loop

The noise contours around the Drennan loop can be seen in Figure 6-1 and Figure 6-2 for day- and night-time respectively. The area is considered to be rural and the noise levels further away from the R390 are within the guideline for rural areas, i.e. 45 dB(A) during daytime and 35 dB(A) during the night.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop will reach 600 m on either side of the loop, with small variations due to the local topography (see Figure 6-1). During night-time, the 35 dB(A) zone will extend approximately 1.6 km away from the loop (see Figure 6-2).

The modelled noise levels for the two scenarios at receptors around the loop are shown in Table 6-2. As can be seen, there are three receptors with the zone exceeding the daytime guideline of 45 dB(A) for rural districts for both scenarios, i.e. R05, R07 and R08. The night-time rural guideline was exceeded for both scenarios at most of the receptors, except for R04 and R06, which are situated more than 2 km away.

It should be noted that these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. The expected increase of the noise levels at all receptors due to the increase of the 12 Mtpa Manganese to the 16 Mtpa Scenario was estimated to be 2 dB(A), which is considered very low.

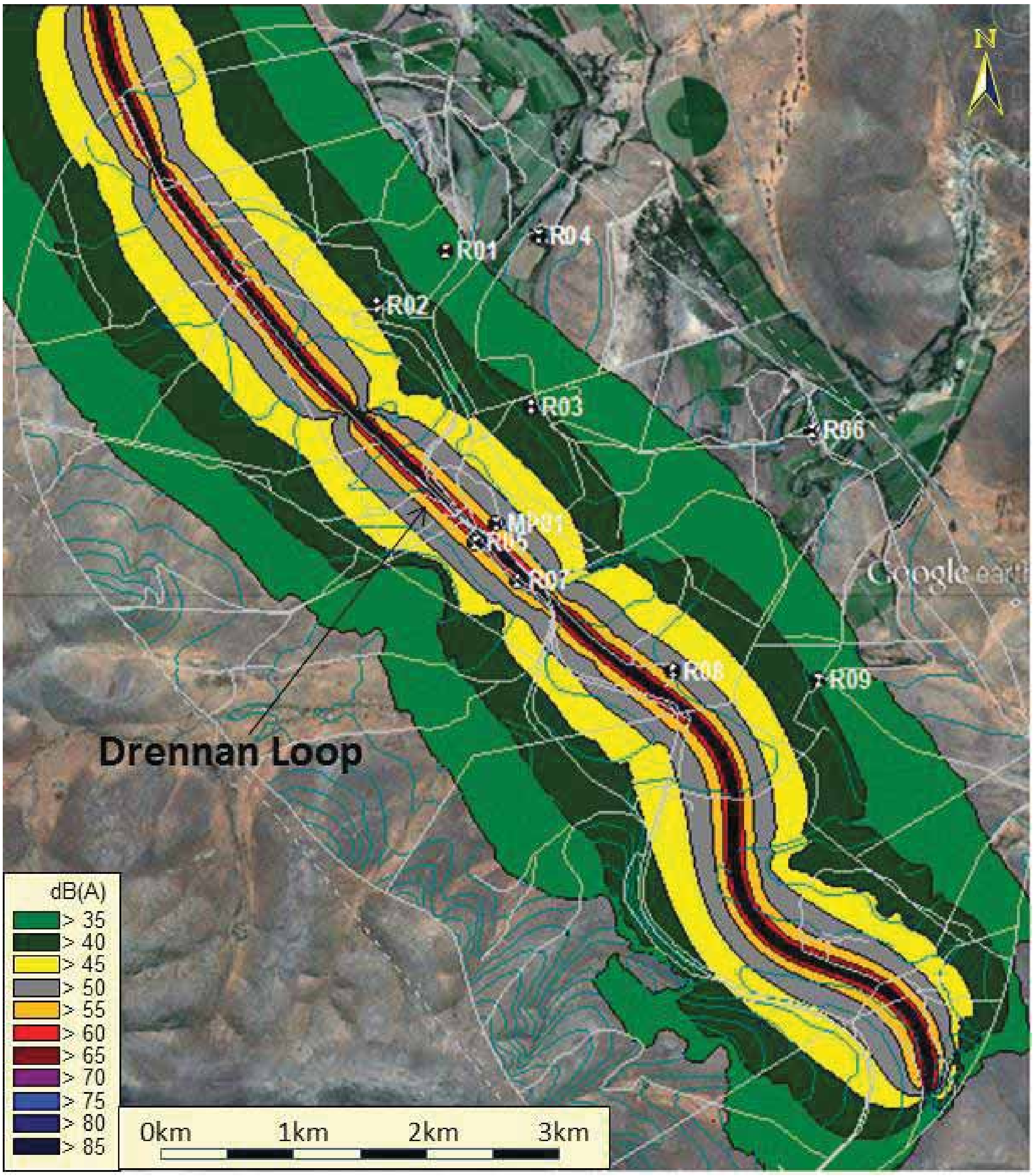


Figure 6-1. Daytime Noise Contours: Drennan Loop

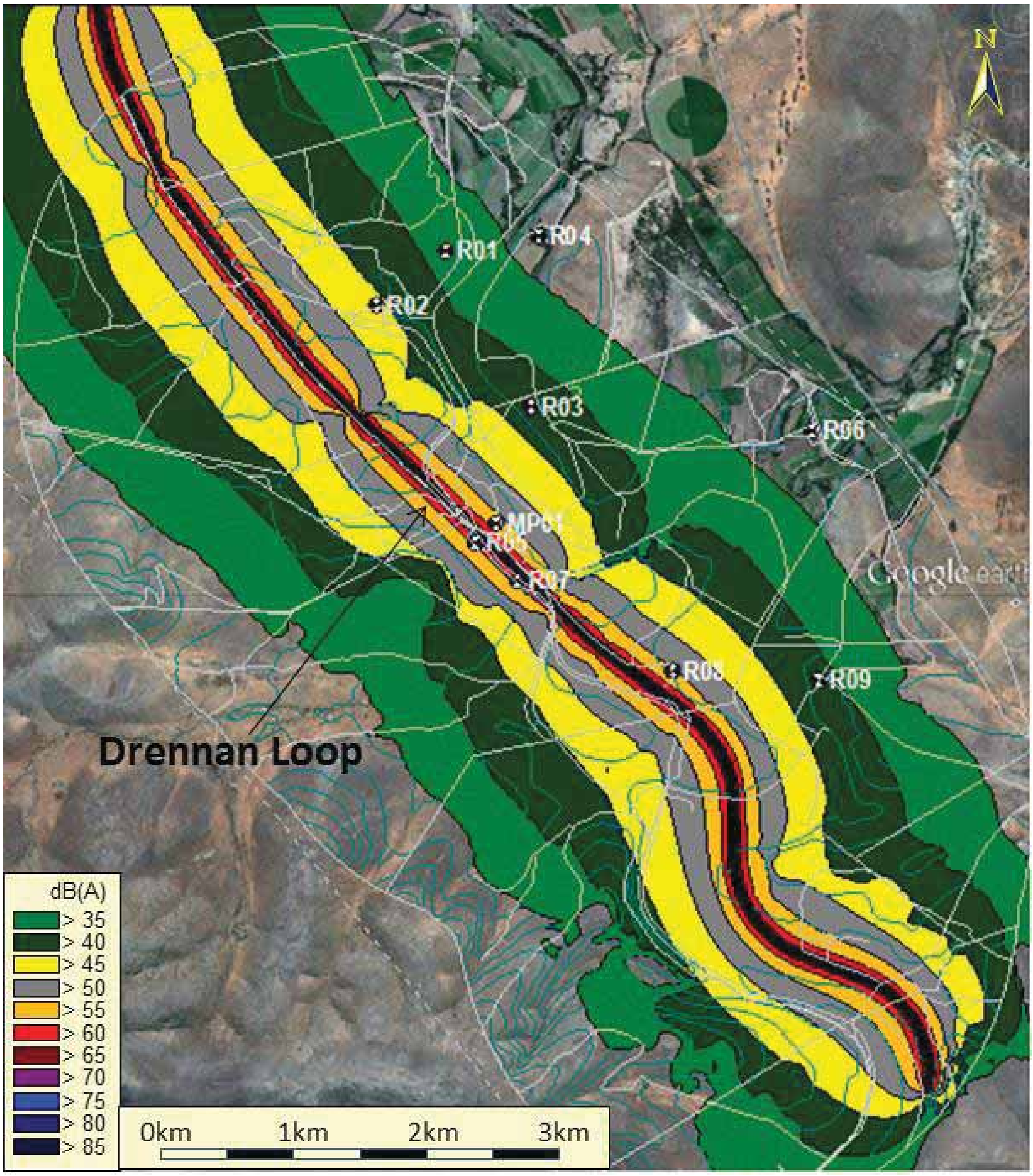


Figure 6-2. Night-time Noise Contours: Drennan Loop

Table 6-2. Calculated Noise Levels at Discrete Receptors and Monitoring Points: Drennan Loop

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP01	Measurement Point	53.6	55.3	55.6	57.3
R01	Farm House	34.7	36.7	36.7	38.6
R02	Farm House	42.0	44.0	44.0	45.9

Receptor	Description	Noise Level (dB(A))			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
R03	Farm House	38.9	40.9	40.9	42.8
R04	Farm House	30.6	32.6	32.5	34.5
R05	Farm House	58.0	59.4	59.9	61.4
R06	Farm House	28.8	30.7	30.7	32.7
R07	Farm House	58.8	60.1	60.7	62.0
R08	Farm House	51.7	53.5	53.7	55.5
R09	Farm House	37.7	39.7	39.7	41.6

[a] Scenario 1: 12Mtpa (Approved in previous EIA)

[b] Scenario 2: 16Mtpa

6.2.2 Thorngrove Loop

The noise contours around the Thorngrove loop can be seen in Figure 6-3 and Figure 6-4 for day- and night-time respectively. The area is considered to be rural, and the noise levels further away from the loop are within the guideline for rural areas, i.e. 45 dB(A) during daytime and 35 dB(A) during the night.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop will reach 600 m on either side, with small variations due to the local topography (see Figure 6-3). During night-time, the 35 dB(A) zone will extend approximately 1.6 km (see Figure 6-4).

The modelled noise levels for the two scenarios at the receptors around the loop are shown in Table 6-3. As can be seen, there are four receptors within the zone exceeding the daytime guideline of 45 dB(A) for rural districts, i.e. R04, R06, R07 and R08. The night-time rural guideline was exceeded at most of the receptors except for R05, which is situated more than 2 km away from the loop.

From Table 6-3 it can also be seen that most of these exceedances are expected to be present around the loop, due to the 12 Mtpa Manganese transport (Scenario 1), which had been approved in the previous EIA. The only exception is receptor R01, for which the 12 Mtpa scenario generated a night-time level of 33 dB(A) and the 16 Mtpa scenario increased it to 35 dB(A). It should further be noted that the existing night-time noise levels in the area were measured to be around 39 dB(A) due to frog and insect activity.

The expected increase of the noise levels at all receptors due to the loop extension was estimated to be 2 dB(A), which is considered very low.

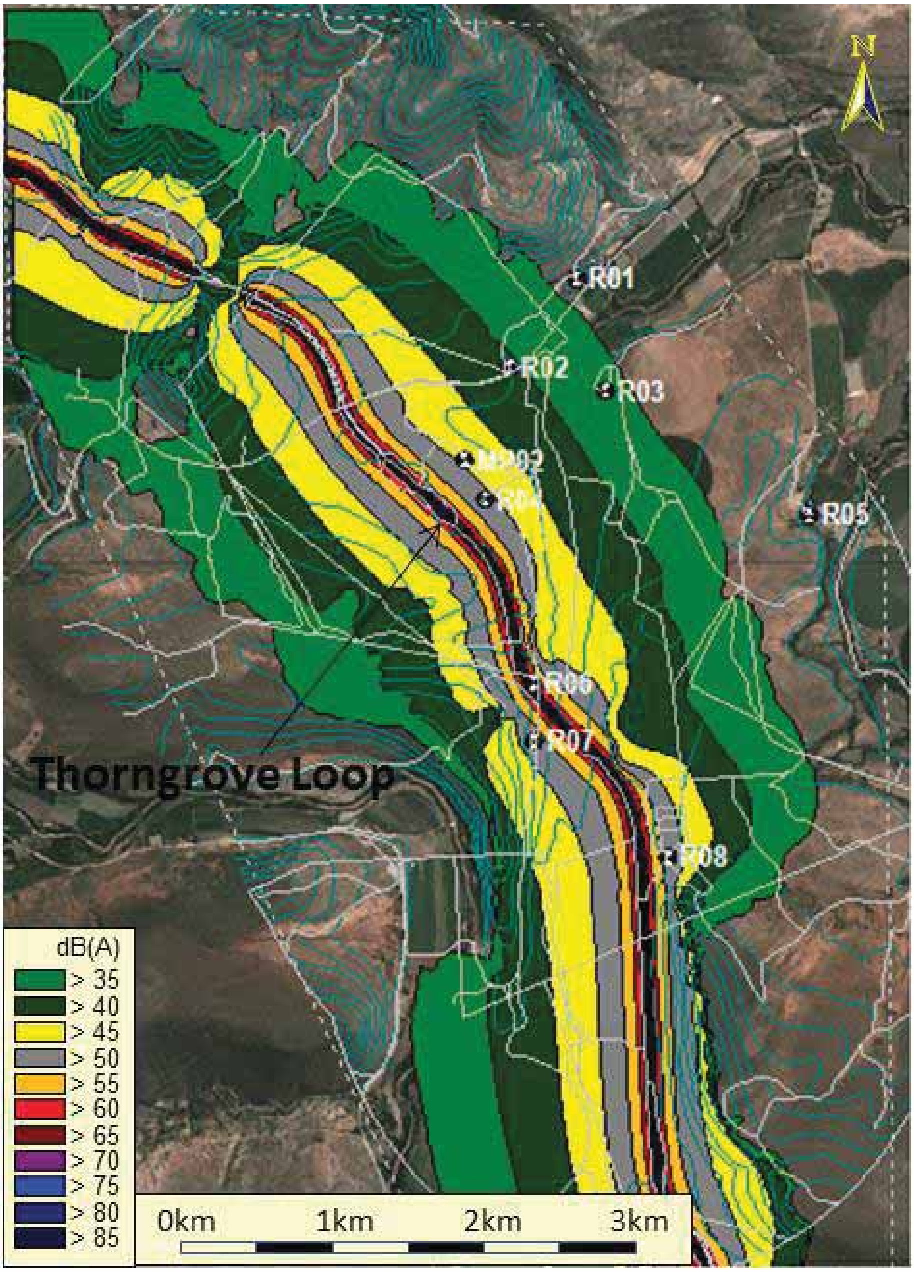


Figure 6-3. Daytime Noise Contours: Thorngrove Loop

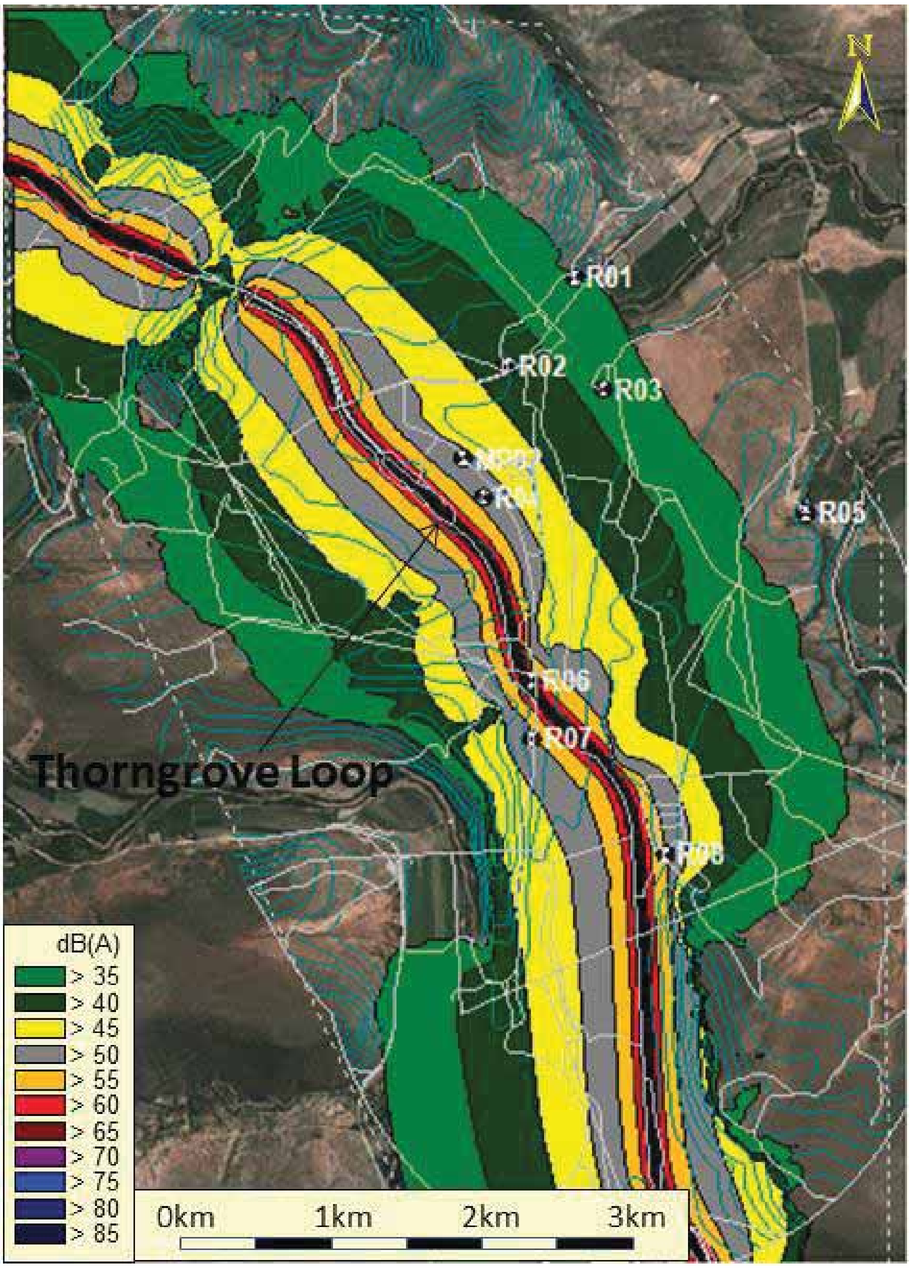


Figure 6-4. Night-time Noise Contours: Thorngrove Loop

Table 6-3. Calculated Noise Levels at Discrete Receptors and Monitoring Points: Thorngrove Loop

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP02	Measurement Point	47.4	49.3	49.3	51.2
R01	Farm House	31.4	33.4	33.4	35.3
R02	Farm House	38.9	40.8	40.8	42.8
R03	Farm House	34.7	36.7	36.7	38.6
R04	Farm House	49.3	51.2	51.3	53.1
R05	Farm House	26.4	28.3	28.3	30.3

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
R06	Farm House	65.3	65.7	67.3	67.6
R07	Farm House	50.4	52.2	52.4	54.2
R08	Farm House	51.4	53.1	53.3	55.1

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.3 Cookhouse-Golden Valley Doubling

The noise contours around the Cookhouse-Golden Valley doubling can be seen in Figure 6-5 and Figure 6-6 for daytime and night-time respectively. The northern section of the doubling is situated near a residential area. The Cookhouse (MP03) and Bongweni (R01) communities, as well as three schools (R02 (closest)) and a church (R03) are in close proximity to the doubling. The calculated day time noise levels at R01, R02 and R03 were estimated to be 40.9 dB(A), 55.1 dB(A) and 52.1 dB(A) respectively. These noise levels are within the SANS daytime guideline of 55 dB(A) for urban residential districts, and the WHO Guidelines for Ambient Sound Levels for schools and dwellings (see Table 2-3 and Table 2-1).

The 55 dB(A) zone around the doubling reached 125 m on either side of the railway line, with small variations due to the local topography (see Figure 6-5). During night-time the 45 dB(A) zone extended approximately 500 m (see Figure 6-6).

The modelled noise levels for the two scenarios at the identified receptors around the Cookhouse-Golden Valley doubling are included in Table 6-4. As can be seen, the predicted noise level at receptor R08 and R11 exceeded the daytime guideline of 55 dB(A) for residential districts. The night-time guideline was exceeded at most of the receptors close to the railway line, except for R01, R04, R05 and R07, which are situated further away.

From Table 6-4 it is also evident that the exceedances are expected to be present around the doubling, due to the approved 12 Mtpa Manganese transport (Scenario 1). The proposed extension of the doubling, in order to allow for a 16 Mtpa transport, is expected to increase the noise levels at all receptors by approximately 2 dB(A), which is considered very low.

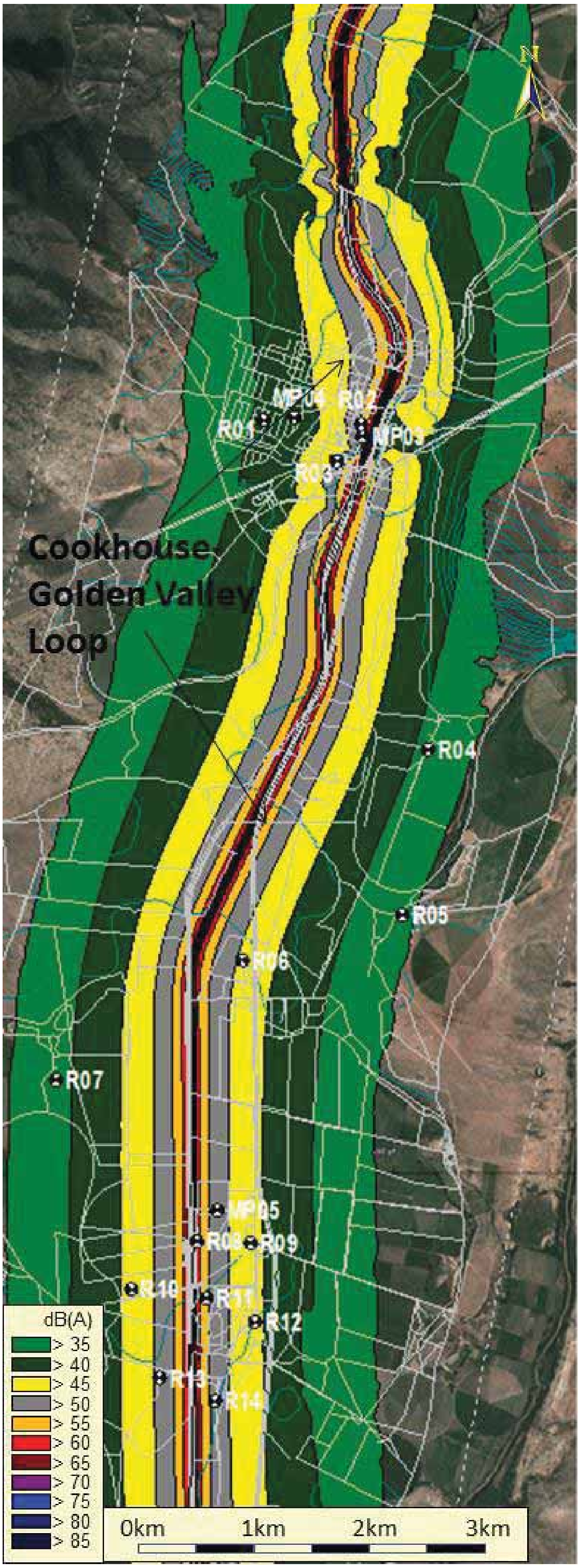


Figure 6-5. Daytime Noise Contours: Cookhouse-Golden Valley Doubling

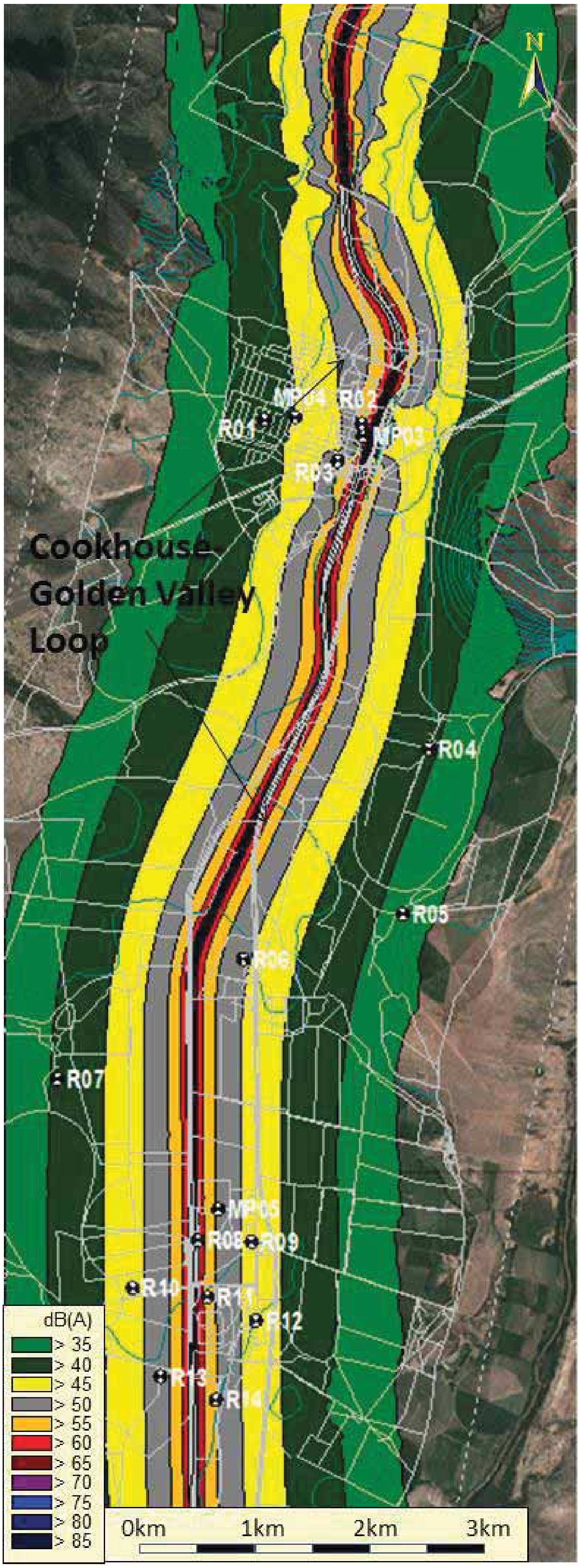


Figure 6-6. Night-time Noise Contours: Cookhouse-Golden Valley Doubling

Table 6-4. Calculated Noise Levels at Discrete Receptors and Monitoring Points: Cookhouse-Golden Valley Doubling

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP03	Measurement Point	51.6	53.1	53.6	55.1
MP04	Measurement Point	41.3	43.3	43.3	45.2
MP05	Measurement Point	50.7	52.5	52.6	54.5
R01	Bongweni Community	39.0	41.0	40.9	42.9
R02	Fish River Primary School	53.1	54.8	55.1	56.7
R03	Church	50.2	52.0	52.1	53.9
R04	Farm House	36.9	38.9	38.9	40.8
R05	Farm House	34.6	36.5	36.5	38.5
R06	Farm House	47.2	49.1	49.1	51.0
R07	Farm House	36.8	38.7	38.7	40.7
R08	Farm House	61.5	62.5	63.4	64.5
R09	Farm House	44.6	46.6	46.6	48.5
R10	Farm House	44.4	46.4	46.4	48.3
R11	Farm House	54.2	55.9	56.1	57.8
R12	Farm House	44.1	46.0	46.0	47.9
R13	Farm House	49.0	50.8	50.9	52.8
R14	Farm House	51.5	53.2	53.4	55.2

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.4 Ripon-Kommadagga Doubling

The noise contours around the Ripon-Kommadagga doubling can be seen in Figure 6-7 and Figure 6-8 for day- and night-time respectively. The 45 dB(A) zone around the doubling reached 700 m on either side, with small variations due to the local topography (Figure 6-7). During night-time the 35 dB(A) extended approximately 1.6 km (Figure 6-8).

The measured daytime noise level further away from the railway alignment and the N10 was within the guideline for rural areas, i.e. 45 dB(A) and marginally above the night-time one at 39 dB(A).

As can be seen from Table 6-5 there are five receptors within the zone that exceeded the daytime guideline of 45 dB(A) for rural districts, i.e. R02, R05, R06, R07 and R08. The night-time rural guideline was exceeded at most of the receptors except for R03. However, it should be noted that the exceedances are expected to be already present around the doubling, due to the approved 12 Mtpa Manganese transport scenario and therefore the impact due to the further increase is considered low.

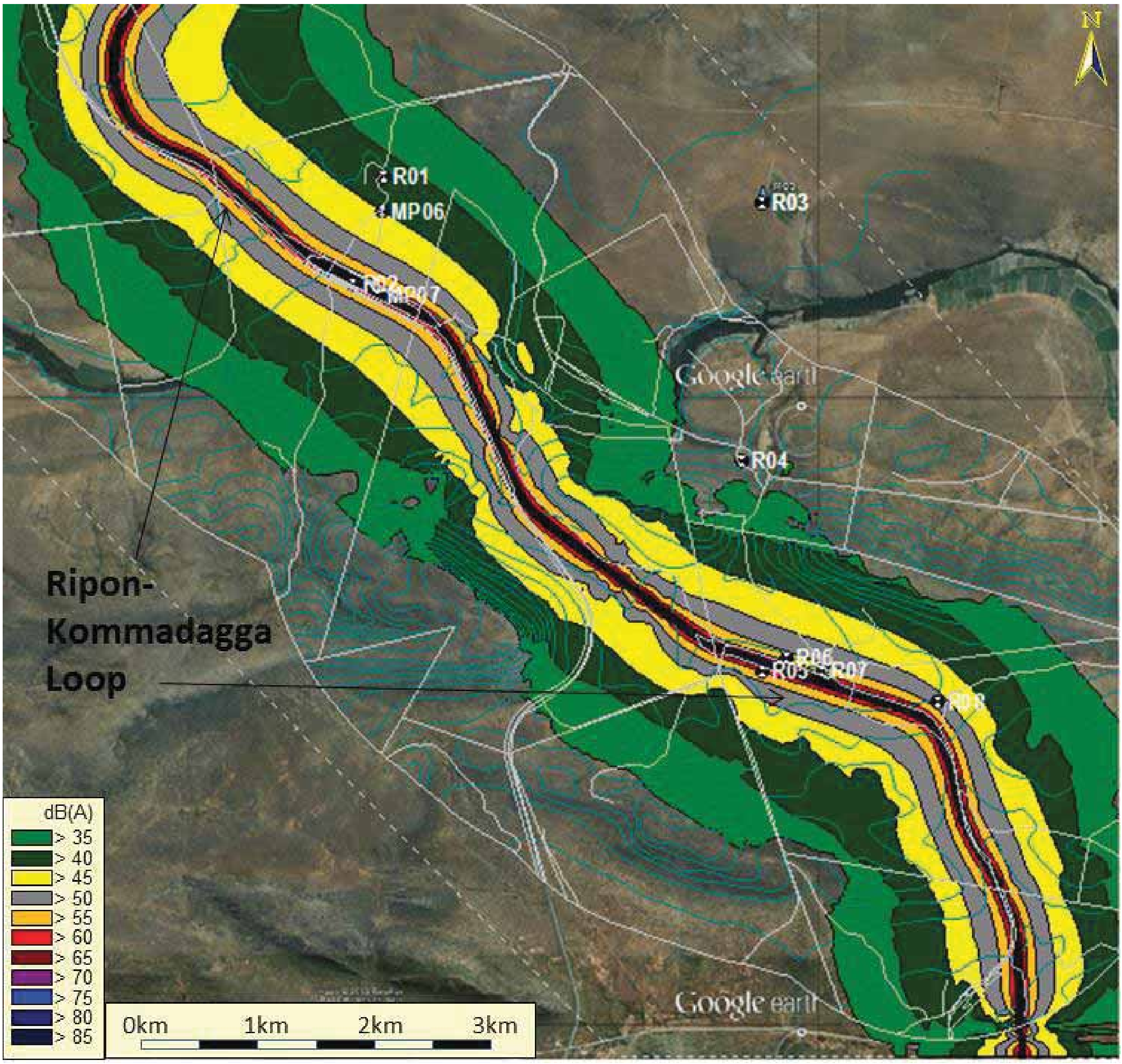


Figure 6-7. Daytime Noise Contours: Ripon-Kommadagga Doubling

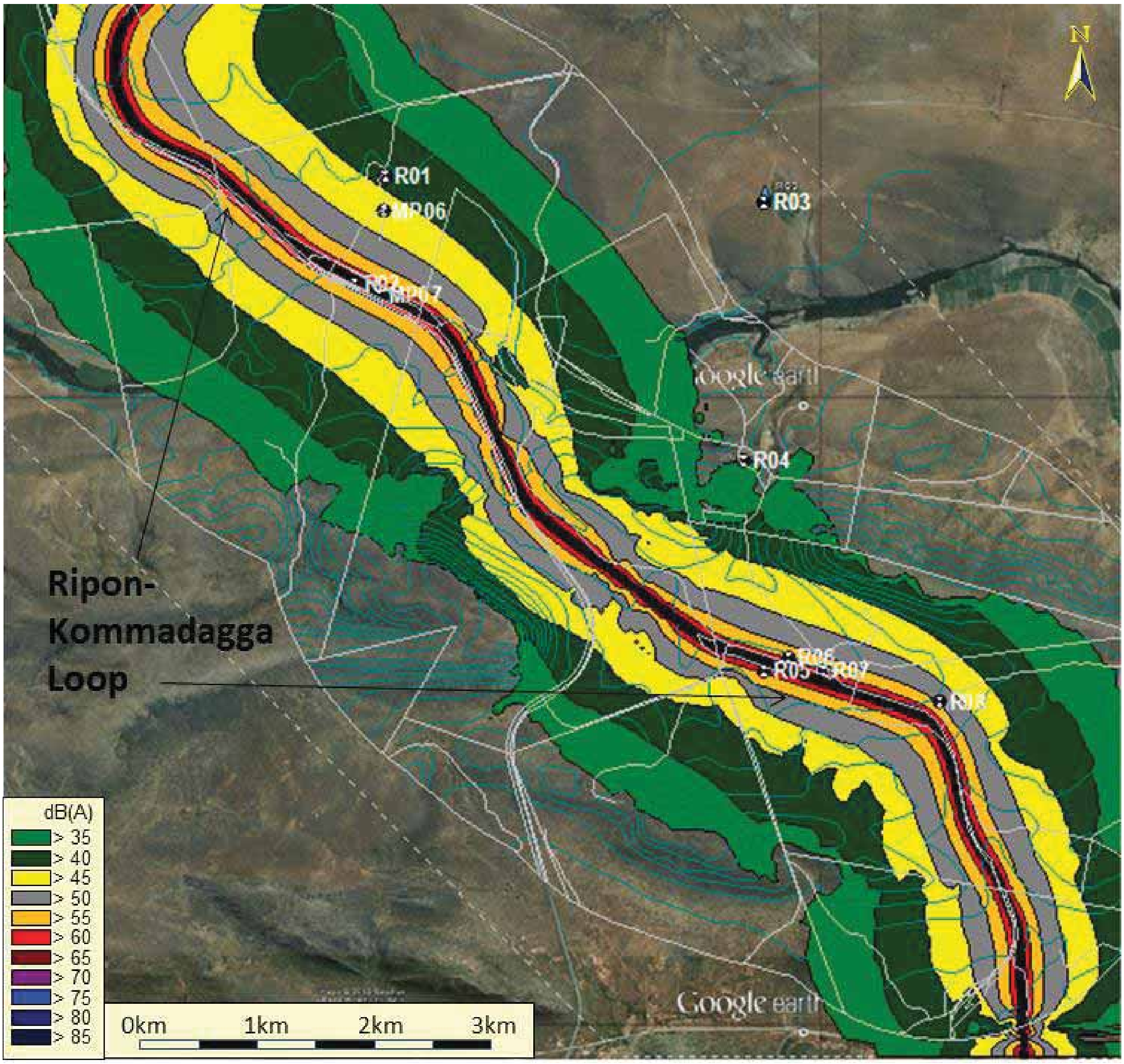


Figure 6-8. Night-time Noise Contours: Ripon-Kommadagga Doubling

Table 6-5. Calculated Noise Levels at Discrete Receptors and Monitoring Points: Ripon-Kommadagga Doubling

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
MP06	Measurement Point	43.1	45.1	45.1	47.0
MP07	Measurement Point	65.7	66.1	67.7	68.0
R01	Farm House	40.2	42.1	42.1	44.1
R02	Farm House	61.9	62.9	63.8	64.8
R03	Farm House	24.4	26.4	26.3	28.3
R04	Farm House	31.8	33.7	33.7	35.7
R05	Farm House	57.9	59.3	59.8	61.3

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
R06	Farm House	55.9	57.5	57.9	59.4
R07	Farm House	56.7	58.2	58.6	60.2
R08	Farm House	50.5	52.3	52.5	54.2

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.2.5 Sheldon Loop

The noise contours around the Sheldon loop can be seen in Figure 6-9 and Figure 6-10 for day- and night-time respectively. The area around this loop is considered to be rural.

Apart from the R03, which is very close to the loop, the calculated noise levels at the remaining receptors are within the daytime guideline for rural areas, i.e. 45 dB(A). The night-time guideline of 35 dB(A) was exceeded for all receptors, except for R07, which is situated more than 3 km from the railway alignment.

With the capacity increase due to the loop extension, the 45 dB(A) zone around the loop will reach 500 m on either side, with small variations due to the local topography (Figure 6-9). During night-time the 35 dB(A) will extend approximately 1.6 km (Figure 6-10).

The predicted noise levels for both scenarios at the Sheldon loop are shown in Table 6-6. As can be seen, the calculated noise level at R03 exceeds the daytime guideline of 45 dB(A) for rural districts. The night-time rural guideline was exceeded at most of the receptors except for R07 for both scenarios. However, the exceedances are expected to be already present around the loop, due to the approved 12 Mtpa Manganese transport scenario and therefore the impact due to the further increase is considered low.

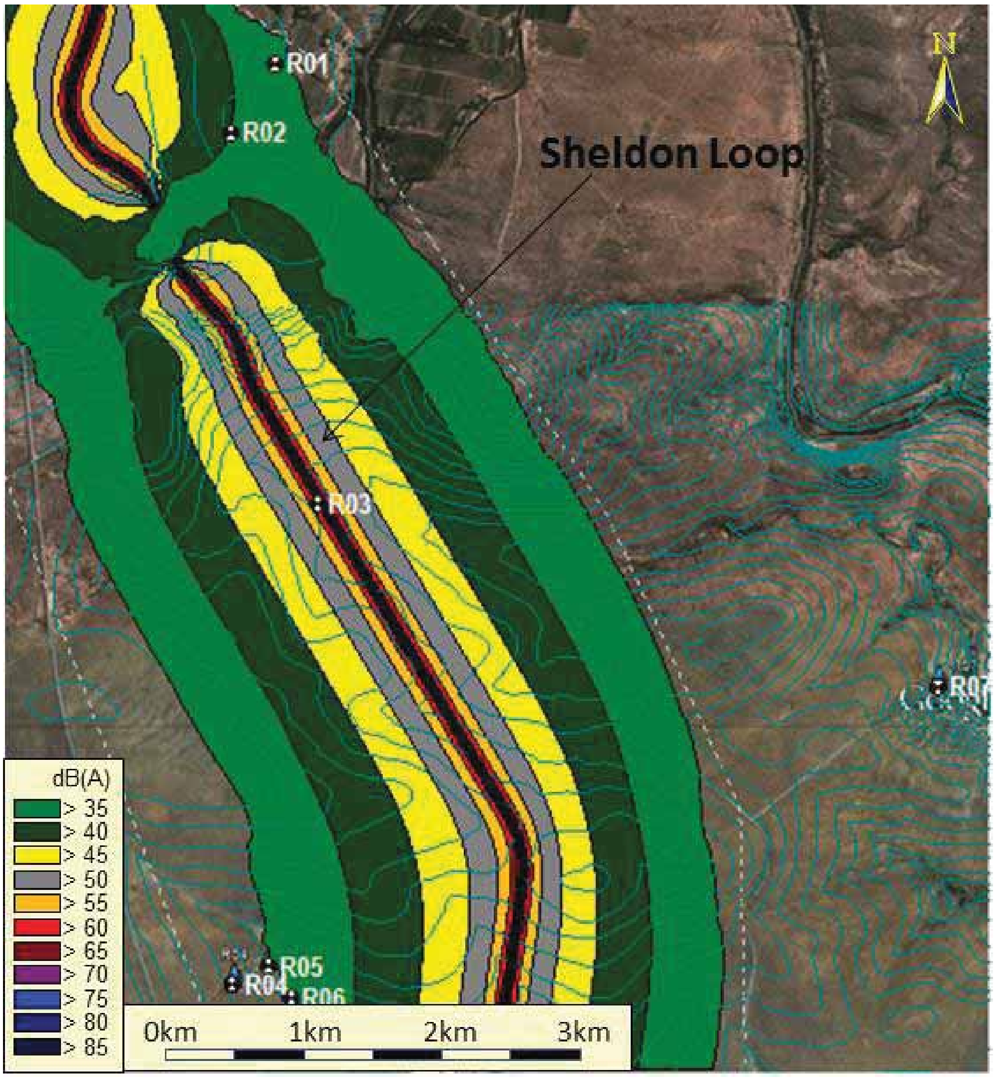


Figure 6-9. Daytime Noise Contours: Sheldon Loop

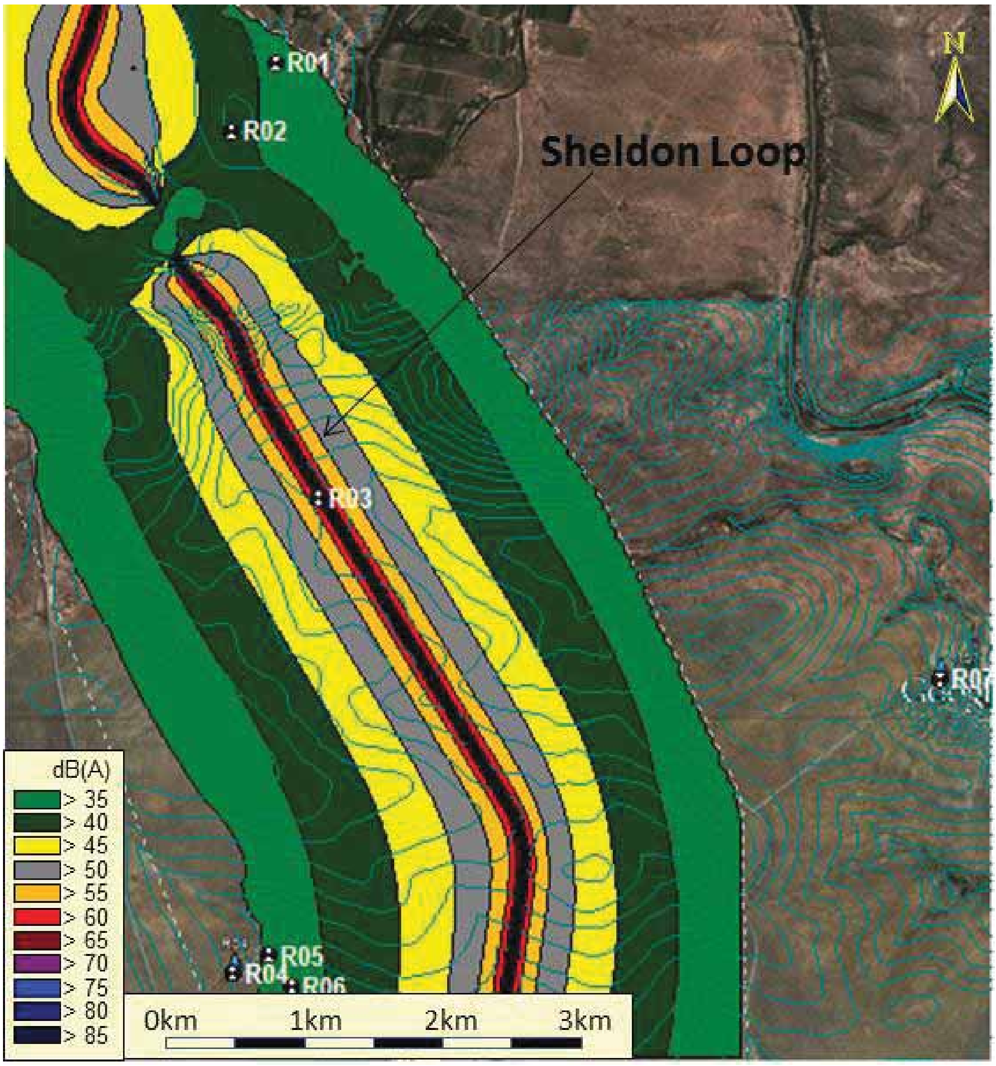


Figure 6-10. Night-time Noise Contours: Sheldon Loop

Table 6-6. Calculated Noise Levels at Discrete Receptors and Monitoring Points: Sheldon Loop

Receptor	Description	Noise Level (dBA)			
		Scenario 1[a]		Scenario 2[b]	
		Day	Night	Day	Night
R01	Farm House	34.7	36.7	36.7	38.6
R02	Farm House	38.0	39.9	39.9	41.9
R03	Farm House	64.2	64.8	66.2	66.8
R04	Farm House	32.0	34.0	33.9	35.9
R05	Farm House	33.6	35.6	35.5	37.5
R06	Farm House	34.7	36.6	36.6	38.6
R07	Farm House	21.0	23.0	22.9	24.9

[a] Scenario 1: 12Mtpa (Approved in previous EIA)
[b] Scenario 2: 16Mtpa

6.3 Predicted Rail Vibration Levels

Based on the vibration propagation method outlined in Section 5.3, the vibration levels at various distances from the track centreline were estimated. It should be noted that these calculations were based on vibration measurements of existing cargo trains. As a worst-case scenario, the highest measured value was used in the vibration propagation calculations.

The calculated vibration levels at increasing distances from the line, together with the limits for structural damage, damage to sensitive or historical structures, as well as the human perception level, are shown in Figure 6-11 below. It can be seen that the vibration levels are lower than the recommended limit for structural damage at distances greater than 5 m.

Sensitive or historical buildings within a 14 m zone may experience vibration levels above the 2 mm/s limit for such structures. Any dwellings within this zone from the track should be inspected for their structural integrity. The human perception level is expected to be exceeded within 85 m from the line.

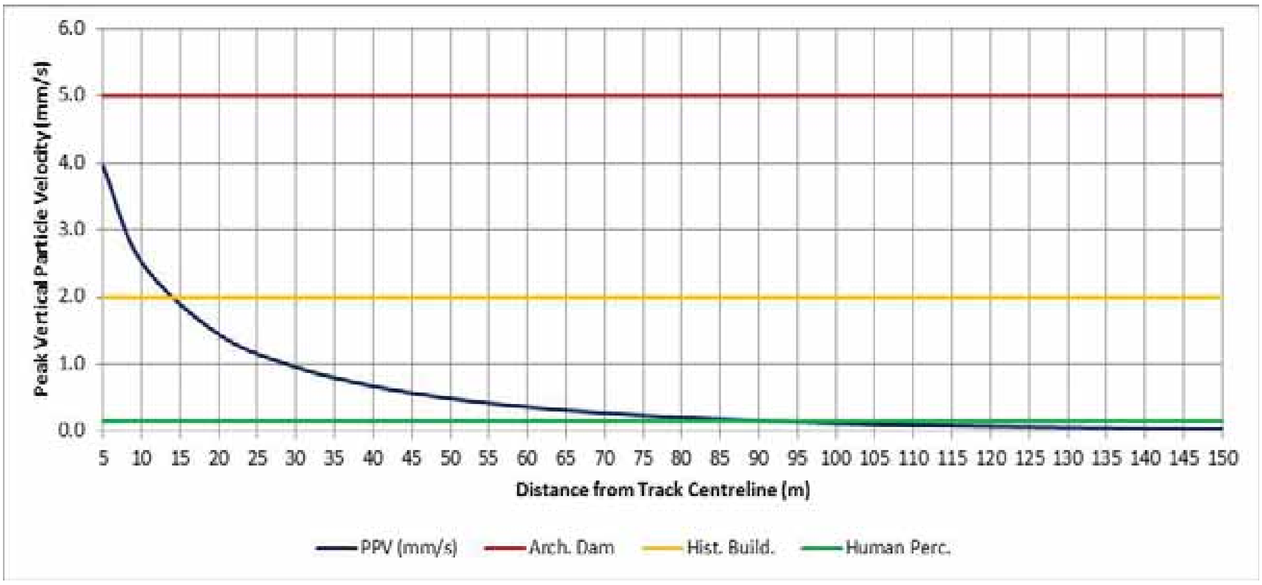


Figure 6-11. Vibration Levels per Distance from the Track

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Baseline Noise Environment:

i. The main noise contributors within the extended area of the project were the traffic on the N10 and local roads, the train activity along the railway line and human activities within the residential area of Cookhouse and Bongweni. During night-time, most of these sources were still the main contributors, however at certain locations the frog and insect activity also contributed significantly to the local noise levels.

ii. The noise environment in close proximity to the N10 and Cookhouse reached between 53 dB(A) and 61 dB(A), which is within the SANS guideline for Urban Districts with main roads and very close to the WHO daytime guideline of 55 dB(A). During night-time the noise levels reached between 40 and 45 dB(A), which is within the WHO night-time guideline of 45 dB(A) for dwellings.

iii. For the areas further away from the N10 and the railway line, the noise environment was that of a typical rural area with the daytime noise levels around 45 dB(A) and the night-time levels between 35 dB(A) and 40 dB(A), primarily due to frog and insect activity.

Based on the modelling of the noise and vibration levels due to the proposed loop extensions/ doublings, the main findings of the noise and vibration impact study were:

Construction:

i. The construction activities at receptors outside a 500 m zone from the main working area will be noticeable but will not constitute a disturbing noise. For receptors located at greater distances than a 1 km radius, the construction noise will be barely audible.

ii. For a short duration the noise levels in the Cookhouse residential area may exceed 55 dB(A) within a zone of 200 m from the alignment, which is considered to be of Moderate significance but of short duration. As the working face moves further towards the south, the impact is expected to be Low.

iii. The vibration during construction is not considered to have a significant impact on the surrounding communities or local dwellings, as for the majority of them there is a separation distance from the site of more than 50 m.

Operation:

i. With the capacity increase due to the loop extension/doublings, under daytime conditions the 55 dB(A) contour extended approximately 125 m from the loop alignment. Under night-time conditions, the 45 dB(A) extended to a maximum of 500 m from the line. At Cookhouse this impact is considered to be moderate to high, as there are several local dwellings within a 200 m zone around the loop, with the night-time noise levels there reaching more than 55 dB(A).

ii. For the Cookhouse loop, where dwellings are in close proximity to the railway line, i.e. within 200 m from the tracks, mitigation measures in terms of a 2 m barrier will reduce the noise levels. The mitigated noise impact of the train operation is considered to be Low. It should be noted, however, that this mitigation measure should have been proposed and implemented for the approved 12 Mtpa Manganese transport.

iii. With the capacity increase due to the loop extension, the 45 dB(A) zone around the loops will reach 600 m on either side, with small variations due to the local topographies. During night-time, the 35 dB(A) zone will extend approximately 1.6 km from the loops.

iv. The noise impact around the other loops, i.e. Drennan, Thorngrove, and Ripon-Kommadagga is expected to be of Low significance, as most of the isolated dwellings lie outside the 45 dB(A) night-time contour. In addition, the loop extensions are expected to increase the noise levels at these receptors from the previously approved 12 Mtpa transport scenario by approximately 2 dB, which is considered to be very low.

v. The vibration levels are not expected to exceed the limit for structural damage beyond a 10 m zone around the track, or the limit for sensitive or historical buildings beyond a 25 m zone.

vi. The vibration impact due to the railway loop extensions is considered to be Very Low.

7.2 Recommendations

Based on this noise and vibration study, the noise performance indicator to be adopted for the residential areas around the rail loops should be that the noise levels in these areas and single dwellings do not exceed 55 dB(A) and 45 dB(A) during day- and night-time respectively, due to the train operations.

The performance indicator for vibration should be that the vibration level at dwellings around the loops should not exceed the PPV limit for structural damage of 5 mm/s, and at sensitive or historical buildings should not exceed 2 mm/s. The vibration levels due to the train operations should not exceed the PPV limit of 0.15 mm/s in urban residential areas.

The main recommendations of the noise and vibration study are outlined below. The essential mitigation measures are included in the impact tables.

Construction:

i. Utilise temporary noise screens for the construction of the loop within the Cookhouse residential area and along the other loops, where local isolated dwellings are situated within a 200 m zone from the loop.

ii. Construction noise and vibration monitoring should be performed at selected dwellings along the loops and within residential areas closest to the construction site boundaries. This monitoring should commence prior to and continue on a biannual basis during construction.

iii. Construction should take place during normal daytime working hours and should not be permitted during night-time, on Saturdays after midday and on Sundays.

Operation:

i. Introduce a 3 m high noise barrier along the railway loops, where communities or large clusters of dwellings are in close proximity to these railway loops, i.e. within 200 m from the tracks. It should be noted that the implementation of such measures should have been incorporated in the authorisation of the 12 Mtpa transport.

ii. The accurate determination of the length and height of the specific sound barriers for each loop should be determined during the detailed design study when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loops are available.

iii. Reduce the speed of the train along the loops to 40 km /hr or as close to this limit as possible that is allowable in terms of safety. With the implementation of this measure, the barrier requirement should be examined in conjunction with the detailed information described above.

iv. Perform appropriate and timeous maintenance of rolling stock and locomotive engines.

v. Train personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.

vi. Perform noise and vibration monitoring on an annual basis at two locations within the Cookhouse community and for the other loops at two selected dwellings, one of which should be the closest to the alignment. The noise monitoring should incorporate noise measurements over a 24-hour period, in order to capture the train passes, as well as quantify overall daytime and night-time levels.

vii. Ensure proper maintenance of wheel and rail surfaces, in order to reduce operational vibrations.

General recommendations for noise minimization and management during construction and operation:

- Maintenance of equipment and operational procedures: Proper design and maintenance of silencers on diesel-powered equipment, systematic maintenance of all forms of equipment, training of personnel to adhere to operational procedures that reduce the occurrence and magnitude of individual noisy events.
- Equipment noise audits: Standardised noise measurements should be carried out on individual equipment on delivery to site or at commissioning, in order to construct a reference data-base. Regular checks should be carried out to ensure that equipment is not deteriorating and to detect sound generation increases, which could lead to an increase in the noise impact over time and increased complaints.
- Public complaints and actions registry: A formal recording system should be introduced, in order to capture public perceptions and complaints with regard to noise impacts, track investigation actions and introduce corrective measures for continuous improvement.

8 IMPACTS RATING

Based on the modelling results for the proposed development, the impacts of construction and operation are summarised in the tables below.

The noise and vibration impact during construction is presented for all four loops in Table 8-1 and is considered to be without mitigation *MODERATE*, and with mitigation measures *MINOR*.

For the operational phase, the vibration impact can be seen in Table 8-2 for all the loops, and the noise impact is presented for each loop separately in the tables further below.

Table 8-1. Noise and Vibration Impact Rating During Loop Construction

Nature: Construction activities would result in a **negative direct** impact on the vibration levels and noise environment around the loops.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise and vibration levels at receptors in close proximity to the loops. However, these receptors are sparsely distributed around the loops and most of them at distances greater than 200 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **short-term** (i.e. for the duration of construction).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 500 m from the alignment. For receptors within the above-mentioned zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The noise levels during construction are **likely** to increase during the construction period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Utilise temporary noise screens for the construction of the loop within the Cookhouse residential area and along the other loops, where local isolated dwellings are situated within a 200 m zone from the loop.
ii. Construction should take place during normal daytime working hours and should not be permitted during night-time, on Saturdays after midday or on Sundays.

WITH MITIGATION
Impact Magnitude – Low

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **short-term** (i.e. for the duration of construction).
- Scale: The impact will **not** result in **notable changes** to the noise levels at existing receptors.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The noise levels during construction are **likely** to increase during the construction period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-2. Vibration Impact Rating During Loop Operation

Nature: The operation of the loops will increase of the number of trains along the line and will result in a **negative direct** impact on the vibration levels around the loops.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Low
Sensitivity: The sensitivity is considered to be **low**, since the activity will increase the vibration levels only at receptors in very close proximity to the loops. In addition, there are only a small number of dwellings and structures around each loop, with the majority of them situated further than 50 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. for the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the existing vibration levels due to the existing operations.
- Frequency: The frequency of the impact will be **periodic**.
- Likelihood: The vibration levels in close proximity to the loops are **possible** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – NEGLIGIBLE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:
No specific mitigation measures are necessary during the operational phase, other than "good practice" maintenance of the train wheels and rail surfaces.

WITH MITIGATION
Same as above

Table 8-3. Operational Noise Impact Rating for Drennan Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise levels at receptors in close proximity to the loop. However, these receptors are sparsely distributed around the loop and most of them at distances greater than 500 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the Drennan loop, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Drennan loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-4. Operational Noise Impact Rating for Thorngrove Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise levels at receptors in close proximity to the loop. However, these receptors are sparsely distributed around the loop and most of them at distances greater than 500 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the Thorngrove loop, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Thorngrove loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-5. Operational Noise Impact Rating for Cookhouse-Golden Valley Doubling

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – High
Sensitivity: The activity will increase the noise levels at receptors around the loop. There are several dwellings, three schools and a church close to the alignment.

PRE-MITIGATION

Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 200 m zone there will be **notable changes** to the existing noise levels. It should be considered, however, that the noise increase due to the loop extensions from the approved loop, which allows for the transport of 12 Mtpa Manganese, will be within 2 dB, which is considered very low.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MAJOR
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

iv. Introduce a 3 m high noise barrier along the Cookhouse doubling, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
v. The accurate determination of the length and height-specific sound barriers for the Cookhouse doubling can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
vi. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION

Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Table 8-6. Operational Noise Impact Rating for Ripon-Kommadagga Doubling

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise levels at receptors in close proximity to the loop. However, these receptors are sparsely distributed around the loop and most of them at distances greater than 500 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

i. Introduce a 3 m high noise barrier along the Ripon-Kommadagga doubling, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.
ii. The accurate determination of the length and height-specific sound barriers for the Ripon-Kommadagga doubling can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.
iii. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

Table 8-7. Operational Noise Impact Rating for Sheldon Loop

Nature: The loop operation will result in a **negative direct** impact on the noise environment around the loop.

Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor – Medium
Sensitivity: The activity will increase the noise levels at receptors in close proximity to the loop. However, these receptors are sparsely distributed around the loop and most of them at distances greater than 500 m from the alignment.

PRE-MITIGATION
Impact Magnitude – Medium

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 1 km from the alignment. For receptors within a 400 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (PRE-MITIGATION) – MODERATE
Degree of Confidence: The degree of confidence is **high**.

Essential Mitigation Measures:

iv. Introduce a 3 m high noise barrier along the Sheldon loop, where dwellings are in close proximity to the railway, i.e. within 200 m from the tracks. This measure should have been incorporated into the authorisation of the loop for the 12 Mtpa transport.

v. The accurate determination of the length and height-specific sound barriers for the Sheldon loop can be determined during the detailed design, when higher ground level resolutions (1 to 3 m), as well as the final vertical alignment of the loop are available.

vi. Reduce the speed of the train along the loop to 40 km/hr or as close to this limit as possible, allowable in terms of safety. With the implementation of this measure, the barrier requirement should be re-examined, in conjunction with the detailed information described above.

WITH MITIGATION
Impact Magnitude – Small

- Extent: The extent of the impact is **local**.
- Duration: The expected impact will be **long-term** (i.e. the duration of the operation).
- Scale: The impact will **not** result in **notable changes** to the noise levels at receptors situated more than 700 m from the alignment. For receptors within a 100 m zone there will be some **notable changes** to the existing noise levels.
- Frequency: The frequency of the impact will be **periodic.**
- Likelihood: The noise levels during operation are **likely** to increase during the operational period.

IMPACT SIGNIFICANCE (WITH MITIGATION) – MINOR
Degree of Confidence: The degree of confidence is **high**.

REFERENCES

British Standard 4142, (1997). Method for rating industrial noise affecting mixed residential and industrial areas.

Feasibility (FEL) Report (2010). Chapters 3 and 4: Risk analysis and affected environment; Chapter 26: Health safety environment and communities.

IFC, (2007). General Environmental, Health and Safety Guidelines.

ISO 1996-1, (2003). Acoustics – Description, assessment and measurement of environmental noise – Part 1: Basic quantities and assessment procedures. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1996-2, (2000). Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1996-3, (1987). Acoustics – Description and measurement of environmental noise -- Part 3: Application to noise limits. Geneva, Switzerland: International Organization for Standardization, International Standard.

ISO 1999, (1990). Acoustics – Determination of occupational noise exposure and estimation of noise-induced hearing impairment. Geneva, Switzerland: International Organization for Standardization, International Standard.

OECD, (1996). Environmental Criteria for Sustainable Transport, Report on Phase 1 of the Project on Environmentally Sustainable Transport (EST), Organization for Economic Co-Operation and Development, OCDE/GD(96)136. Paris, 1996.

South African National Standard SANS10103, (2003). The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication.

WHO, (1999). Guidelines for Community Noise, Edited by Birgitta Berglund, World Heath Organization, Thomas Lindvall, and Dietrich Schwela. Geneva, April 1999.

World Bank Group, (1998). Pollution Prevention and Abatement Handbook, General Environmental Guidelines. July 1998.

Appendix A

A.1 Impact Assessment Methodology for EIAs - Instructions to Specialists

A definition of each impact characteristic is provided to contextualise the requirements. The designations for each of the characteristics are defined below.

Table 1.1 Defining Impact Characteristics

Characteristic	Definition	Designation
Type	A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).	**Direct -** Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between occupation of a plot of land and the habitats which are affected). **Indirect -** Impacts that follow on from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land). **Induced -** Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the importation of a large Project workforce).
Duration	The time period over which a resource / receptor is affected.	**Temporary** (negligible/ pre-construction) **Short-term** (period of less than 5 years i.e. production ramp up period) **Long-term** (period of more than 5 years and less than 19 years i.e. life of project) **Permanent** (a period that exceeds the life of the project – i.e. irreversible.)
Extent	The reach of the impact (i.e. physical distance an impact will extend to)	**On-site** – impacts that are limited to the project site. **Local** – impacts that are limited to the project site and adjacent properties. **Regional** – impacts that are experienced at a regional scale, e.g. District or Province. **National** – impacts that are experienced at a national scale. **Trans-boundary/International** – impacts that are experienced at an international scale, e.g. extinction of species resulting in global loss.
Scale	The size of the impact (e.g. the size of the area damaged or impacted the fraction of a resource that is lost or affected).	1 - functions and/ or processes remain ***unaltered*** 2 - functions and/ or processes are ***notably altered*** 3 - functions and/ or processes are ***severely altered***
Frequency	Measure of the constancy or periodicity of the impact.	1 - Periodic 2 - **Once off**

The terminology and designations are provided to ensure consistency when these characteristics are described in an Impact Assessment deliverable.

An additional characteristic that pertains only to unplanned events (e.g., traffic accident, accidental release of toxic gas, community riot, etc.) is likelihood. The likelihood of an unplanned event occurring is designated using a qualitative (or semi-quantitative, where appropriate data are available) scale.

Table 1.3 Definitions of likelihood

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely/ Certain	The event will occur during normal operating conditions (i.e., it is essentially inevitable).

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred. It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, not the degree to which an impact or effect is expected to occur as a result of the unplanned event. The latter concept is referred to as uncertainty, and this is typically dealt with in a contextual discussion in the Impact Assessment deliverable, rather than in the impact significance assignment process.

Assessing Significance

Once the impact characteristics are understood, these characteristics are used (in a manner specific to the resource/receptor in question) to assign each impact a magnitude. Magnitude is a function of the following impact characteristics:

- Extent [(a)]
- Duration [(b)]
- Scale
- Frequency
- Likelihood

Magnitude essentially describes the degree of change that the impact is likely to impart upon the resource/receptor. The magnitude designations are as follows:

- Positive
- Negligible
- Small
- Medium
- Large

The methodology incorporates likelihood into the magnitude designation (i.e., in parallel with consideration of the other impact characteristics), so that the "likelihood-factored" magnitude

(a) Important in defining 'extent' is the differentiation between the spatial extent of impact (i.e. the physical distance of the impact in terms of on-site, *local*, *regional*, *national* or *international*) and the temporal extent / effect of an impact may have (i.e. a localised impact on restricted species may lead to its extinction and therefore the impact would have global ramifications).

(b) Duration must consider irreversible impacts (i.e. permanent).

can then be considered with the resource/receptor sensitivity/vulnerability/irreplaceability in order to assign impact significance.

The magnitude of impacts takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum from negligible to large. Some impacts will result in changes to the environment that may be immeasurable, undetectable or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and should be characterised as having a negligible magnitude.

In addition to characterising the magnitude of impact, the other principal step necessary to assign significance for a given impact is to define the sensitivity/vulnerability/ irreplaceability of the resource/receptor. There are a range of factors to be taken into account when defining the sensitivity/vulnerability/ irreplaceability of the resource/receptor, which may be physical, biological, cultural or human. Where the resource is *physical* (for example, a water body) its quality, sensitivity to change and importance (on a local, national and international scale) are considered. Where the resource/receptor is *biological or cultural* (for example, the marine environment or a coral reef), its importance (for example, its local, regional, national or international importance) and its sensitivity to the specific type of impact are considered. Where the receptor is *human*, the vulnerability of the individual, community or wider societal group is considered.

As in the case of magnitude, the sensitivity/vulnerability/ irreplaceability designations themselves are universally consistent, but the definitions for these designations will vary on a resource/receptor basis. The universal sensitivity/vulnerability/irreplaceability [(c)] of resource/receptor is:

- Low
- Medium
- High

Once magnitude of impact and sensitivity/vulnerability/irreplaceability of resource/receptor have been characterised, the significance can be assigned for each impact. The following provides a context for defining significance.

Table 1.4 Context for Defining Significance

• An impact of ***negligible*** significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.
• An impact of ***minor*** significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

(c) Irreplaceable (SANBI, 2013): "*In terms of biodiversity, irreplaceable areas are those of highest biodiversity value outside the formal protected area network. They support unique biodiversity features, such as endangered species or rare habitat patches that do not occur anywhere else in the province. These features have already been so reduced by loss of natural habitat, that 100% of what remains must be protected to achieve biodiversity targets.*"

- An impact of ***moderate*** significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.
- An impact of ***major*** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long-term or extend over a large area. However, for some aspects there may be major residual impacts remaining even after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

Based on the context for defining significance, the impact significance rating will be determined, using the matrix below.

Table 1.5 Impact Significance Rating Matrix

		Sensitivity/Vulnerability/Irreplaceability of Resource/Receptor		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Once the significance of the impact has been determined, it is important to qualify the **degree of confidence** in the assessment. Confidence in the prediction is associated with any uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence can be expressed as low, medium or high.

Appendix B

B.1 Noise Monitoring Record Sheets

- **Position MP01**

Point located near the R390 road, about 100m north-east of the Drennan loop.

GPS coordinates – S32°26'10.56" E25°44'13.69"

View west towards the loop

View south-east towards R390

Figure B-1. Monitoring Point MP01 Images

- **Position MP02**

Point is located about 270m north of the Thorngrove loop.

GPS coordinates – S32°38'18.90" E25°49'7.47"

View north towards the loop

View north-west

Figure B-2. Monitoring Point MP02 Images

- **Position MP03**

Point located north of Cookhouse loop, about 65m from the loop.

GPS coordinates – S32°44'43.69" E25°48'20.53"

View east toward the loop

View north towards community

Figure B-3. Monitoring Point MP03 Images

- **Position MP04**

At the Bongweni community, about 780m east of the Cookhouse loop.

GPS coordinates – S32°44'48.32" E25°47'58.60"

View north-west

View east toward the loop

Figure B-4. Monitoring Point MP04 Images

- **Position MP05**

Point situated south of Cookhouse loop, about 200m from the loop and 300 m from farm house R04.

GPS coordinates – S32°48'22.09" E25°47'29.48"

View north

View south

Figure B-5. Monitoring Point MP05 Images

- **Position MP06**

Point located about 722 m north of the Ripon-Kommadagga doubling and 223 m from farm house R01.

GPS coordinates –S33°4'59.96" E25°51'52.72"

View north

View north west

Figure B-6. Monitoring Point MP06 Images

- **Position MP07**

Point is located between the Ripon-Kommadagga doubling and the N10. It is situated approximately 30 m south of the loop and 78 m north of the N10.

GPS coordinates –S33°5'23.21″ E25°51'51.07"

View east towards loop

View west toward N10 road

Figure B-7. Monitoring Point MP07 Images

Table B-1. Noise Measurements Results

Date - Time	Measurement Position	Location	WS (m/s)	$L_{Aeq,I}$ (dBA)	L_{Amin} (dBA)	L_{Amax} (dBA)	L_{90} (dBA)	L_{50} (dBA)	L_{10} (dBA)	Comments
24-10-12 10:51	MP01	Rural	1.30	42.70	25.40	51.90	26.90	38.80	47.30	Bird activity audible. People conversing, traffic from R390 road audible
24-10-12 11:02	MP01	Rural	2.40	48.40	23.60	65.20	23.90	33.80	49.40	Bird activity audible. People conversing, traffic from R390 road audible
24-10-12 11:22	MP01	Rural	2.00	53.20	28.70	75.60	30.00	40.00	46.50	Bird activity audible. People conversing, traffic from R390 road audible
24-10-12 11:32	MP01	Rural	2.00	40.00	25.30	55.20	26.10	36.00	43.80	Bird activity audible. People conversing, traffic from R390 road audible
25-10-12 3:26	MP01	Rural	0.60	35.90	28.30	53.50	28.60	31.40	35.10	
25-10-12 3:38	MP01	Rural	1.20	37.70	29.50	54.20	30.30	32.80	34.90	
25-10-12 18:50	MP01	Rural	1.10	59.80	36.80	73.70	37.80	50.40	61.50	Bird activity very audible, traffic from the R390
25-10-12 19:03	MP01	Rural	1.20	48.10	43.80	56.70	44.40	47.70	49.30	Bird activity very audible, traffic from the R391
23-10-12 17:12	MP02	Rural	2.70	41.00	28.20	59.30	28.70	36.90	43.60	Noise from farming activities
23-10-12 17:23	MP02	Rural	3.00	42.50	27.70	58.30	28.90	37.70	44.80	Noise from farming activities
24-10-12 2:43	MP02	Rural	2.20	32.90	19.40	49.70	19.90	24.00	33.90	Insect and bird activity audible
24-10-12 2:55	MP02	Rural	3.20	36.40	22.40	51.20	23.00	30.70	39.70	Insect and bird activity audible
25-10-12 2:14	MP02	Rural	3.60	44.00	39.40	50.10	40.60	43.70	45.40	Bird and insect activity very audible
25-10-12 2:25	MP02	Rural	1.80	44.00	38.90	53.40	39.30	42.90	46.00	Bird and insect activity very audible
24-10-12 15:37	MP03	Rural Residential	3.40	53.50	45.00	64.30	46.00	52.00	56.00	Next to station, dogs barking, people talking, music, and nearby traffic
24-10-12 15:49	MP03	Rural Residential	2.00	53.10	44.60	62.80	45.70	51.80	55.50	Next to station, dogs barking, people talking, music, and nearby traffic audible

Date - Time	Measurement Position	Location	WS	$L_{Aeq,I}$	L_{Amin}	L_{Amax}	L_{90}	L_{50}	L_{10}	Comments
			(m/s)	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	
25-10-12 1:17	MP03	Rural Residential	2.80	42.80	35.80	57.80	36.20	39.30	43.90	Dogs Barking, traffic from N10, insect and bird noise audible
25-10-12 1:30	MP03	Rural Residential	3.80	44.80	35.60	62.20	36.10	40.80	46.20	Dogs Barking, traffic from N10, insect and bird noise audible
23-10-12 15:23	MP04	Rural Residential	1.70	61.00	45.80	80.60	46.30	52.40	59.60	Middle of community, dogs barking, people talking, music, and nearby traffic audible
23-10-12 15:35	MP04	Rural Residential	1.80	59.80	44.90	82.30	45.10	51.00	57.40	Middle of community, dogs barking, people talking, music, and nearby traffic audible
24-10-12 1:37	MP04	Rural Residential	1.00	47.40	34.40	60.40	34.90	40.50	49.90	Dogs barking, traffic from N10, insect and bird noise audible
24-10-12 1:51	MP04	Rural Residential	0.80	44.30	34.60	60.40	35.90	40.80	47.30	Dogs Barking, traffic from N10, insect and bird noise audible
24-10-12 2:02	MP04	Rural Residential	1.40	46.40	33.40	64.00	34.70	37.70	44.90	Dogs Barking, traffic from N10, insect and bird noise audible
24-10-12 15:09	MP04	Rural Residential	4.00	57.10	47.50	73.00	47.90	53.10	59.50	Middle of community, dogs barking, people talking, music, and nearby traffic audible
24-10-12 15:19	MP04	Rural Residential	3.80	57.90	45.80	70.20	47.00	53.90	61.60	Middle of community, dogs barking, people talking, music, and nearby traffic audible
25-10-12 14:58	MP05	Rural	2.10	49.20	38.70	62.80	41.00	47.90	51.70	Dogs barking, traffic from N10 audible
25-10-12 15:10	MP05	Rural	1.00	48.80	39.00	61.00	40.30	45.60	51.40	Dogs barking, traffic from N10 audible
25-10-12 15:22	MP05	Rural	0.80	48.20	39.10	63.90	39.70	45.60	50.80	Dogs barking, traffic from N10 audible
25-10-12 15:32	MP05	Rural	0.80	46.50	37.10	56.80	38.60	45.00	49.10	Dogs barking, traffic from N10 audible
25-10-12 0:13	MP06	Rural	3.40	39.30	28.60	49.70	29.60	36.90	42.70	Bird sounds audible
25-10-12 0:26	MP06	Rural	3.70	39.90	31.70	52.30	33.00	38.10	42.60	Bird sounds audible
23-10-12 11:52	MP06	Rural	2.40	40.60	27.80	51.80	28.90	38.00	43.90	Traffic noise audible, noise from sheep audible
24-10-12 0:32	MP07	Rural	2.70	43.40	25.00	54.40	26.20	34.90	49.60	Traffic noise audible, noise from sheep audible

Date - Time	Measurement Position	Location	WS	$L_{Aeq,I}$	L_{Amin}	L_{Amax}	L_{90}	L_{50}	L_{10}	Comments
			(m/s)	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	(dBA)	
24-10-12 0:44	MP07	Rural	3.20	37.50	24.60	52.40	26.80	34.50	39.80	Traffic noise audible, noise from sheep
25-10-12 13:11	MP06	Rural	1.20	40.00	29.80	54.60	31.50	38.60	42.40	Traffic noise audible, noise from sheep audible
25-10-12 13:22	MP06	Rural	1.40	40.40	30.50	52.00	31.50	38.50	43.10	Traffic noise audible, noise from sheep
23-10-12 12:19	MP06	Rural	1.40	45.10	32.60	54.50	34.30	43.00	48.30	Traffic noise audible, noise from sheep
23-10-12 12:37	MP06	Rural	2.20	58.30	44.00	71.50	45.00	54.00	62.00	Traffic noise audible, noise from sheep very audible
23-10-12 12:49	MP07	Rural	3.20	58.70	38.30	71.80	39.80	50.90	63.50	Point next to N10 road, traffic noise very audible
23-10-12 13:05	MP07	Rural	3.00	71.80	40.00	86.10	40.40	59.20	77.10	Point next to N10 road, traffic noise very audible
23-10-12 13:14	MP07	Rural	1.80	59.70	42.00	72.80	43.00	53.30	64.10	Point next to N10 road. traffic noise very audible
25-10-12 13:44	MP07	Rural	3.20	58.60	34.10	71.00	35.30	54.60	62.40	Point next to N10 road, traffic noise very audible
25-10-12 13:55	MP07	Rural	4.60	58.10	31.80	67.10	33.90	52.20	63.10	Point next to N10 road, traffic noise very audible

Table B-2. Coordinates for Noise Sensitive Receptors and Measurement Points

Receptor	Description	Coordinates			
		UTM (m)		Lad/Lon (DD MM)	
		X	Y	South	East
Drennan Loop					
MP01	Measurement Point	381513.00	6410298.00	32° 26.289'	25° 44.375'
R01	Farm House	381134.00	6412346.00	32° 25.178'	25° 44.149'
R02	Farm House	380613.00	6411944.00	32° 25.392'	25° 43.814'
R03	Farm House	381774.00	6411178.00	32° 25.814'	25° 44.549'
R04	Farm House	381828.00	6412464.00	32° 25.119'	25° 44.593'
R05	Farm House	381355.00	6410151.00	32° 26.367'	25° 44.273'
R06	Farm House	383886.00	6410992.00	32° 25.928'	25° 45.895'
R07	Farm House	381672.12	6409862.99	32° 26.526'	25° 44.474'
R08	Farm House	382838.00	6409187.00	32° 26.899'	25° 45.213'
R09	Farm House	383938.76	6409116.82	32° 26.944'	25° 45.914'
Thorngrove Loop					
MP02	Measurement Point	389131.81	6388216.54	32° 38.286'	25° 49.080'
R01	Farm House	389871.13	6389418.04	32° 37.640'	25° 49.562'
R02	Farm House	389419.00	6388827.00	32° 37.957'	25° 49.269'
R03	Farm House	390065.00	6388677.00	32° 38.042'	25° 49.681'
R04	Farm House	389267.00	6387960.00	32° 38.425'	25° 49.165'
R05	Farm House	391409.54	6387853.55	32° 38.496'	25° 50.535'
R06	Farm House	389584.00	6386740.00	32° 39.087'	25° 49.360'
R07	Farm House	389594.00	6386355.00	32° 39.295'	25° 49.363'
R08	Farm House	390477.00	6385588.00	32° 39.716'	25° 49.923'
Cookhouse-Golden Valley					
MP03	Measurement Point	388117.54	6376258.66	32° 44.750'	25° 48.346'
MP04	Measurement Point	387530.02	6376423.88	32° 44.657'	25° 47.971'
MP05	Measurement Point	386858.79	6369558.27	32° 48.368'	25° 47.491'
R01	Bongweni Community	387260.11	6376400.49	32° 44.668'	25° 47.798'
R02	School	388108.51	6376367.00	32° 44.691'	25° 48.341'
R03	Church	387901.33	6376043.70	32° 44.865'	25° 48.206'
R04	Farm House	388691.40	6373552.26	32° 46.218'	25° 48.694'
R05	Farm House	388467.11	6372117.54	32° 46.993'	25° 48.540
R06	Farm House	387077.53	6371726.65	32° 47.196'	25° 47.647'
R07	Farm House	385458.30	6370686.10	32° 47.749'	25° 46.602'
R08	Farm House	386680.84	6369288.27	32° 48.513'	25° 47.375'
R09	Farm House	387147.58	6369278.82	32° 48.521'	25° 47.674'
R10	Farm House	386114.40	6368874.99	32° 48.733'	25° 47.009'
R11	Farm House	386766.05	6368797.64	32° 48.893'	25° 47.426'
R12	Farm House	387186.62	6368591.80	32° 48.893'	25° 47.694'
R13	Farm House	386355.76	6368105.51	32° 49.151'	25° 47.158'
R14	Farm House	386838.67	6367905.91	32° 49.262'	25° 47.466'
Ripon- Kommadagga					
MP06	Measurment Point	394036.79	6338902.76	33° 5.000'	25° 51.878'
MP07	Measurment Point	393999.76	6338182.71	33° 5.389'	25° 51.849'
R01	Farm House	394052.00	6339201.00	33° 4.838'	25° 51.891'

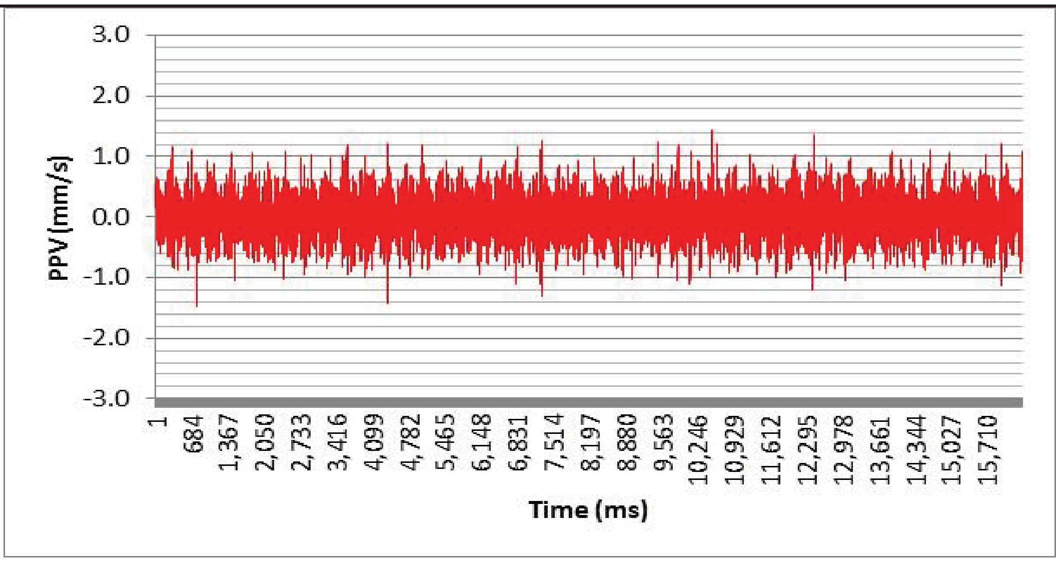
Receptor	Description	Coordinates			
		UTM (m)		Lad/Lon (DD MM)	
		X	Y	South	East
R02	Farm House	393785.02	6338273.25	33° 5.339'	25° 51.712'
R03	Farm House	397289.03	6338973.18	33° 4.980'	25° 53.970'
R04	Farm House	397115.76	6336762.69	33° 6.175'	25° 53.843'
R05	Farm House	397289.00	6334951.00	33° 7.156'	25° 53.942'
R06	Farm House	397499.14	6335064.33	33° 7.096'	25° 54.078'
R07	Farm House	397796.01	6334954.45	33° 7.158'	25° 54.268'
R08	Farm House	398792.44	6334688.95	33° 7.307'	25° 54.907'
Sheldon					
R01	Farm House	391182.65	6349834.79	32° 59.067'	25° 50.122'
R02	Farm House	390859.49	6349341.47	32°59.332'	25° 49.911'
R03	Farm House	391486.80	6346692.77	33° 0.769'	25° 50.295'
R04	Farm House	390874.22	6343252.28	33° 2.627'	25° 49.877'
R05	Farm House	391131.17	6343380.81	33° 2.559'	25° 50.043'
R06	Farm House	391294.01	6343153.45	33° 2.683'	25° 50.146'
R07	Farm House	395987.98	6345383.17	33° 1.504'	25° 53.177'

Appendix C

C.1 Vibration Measurement Graphs

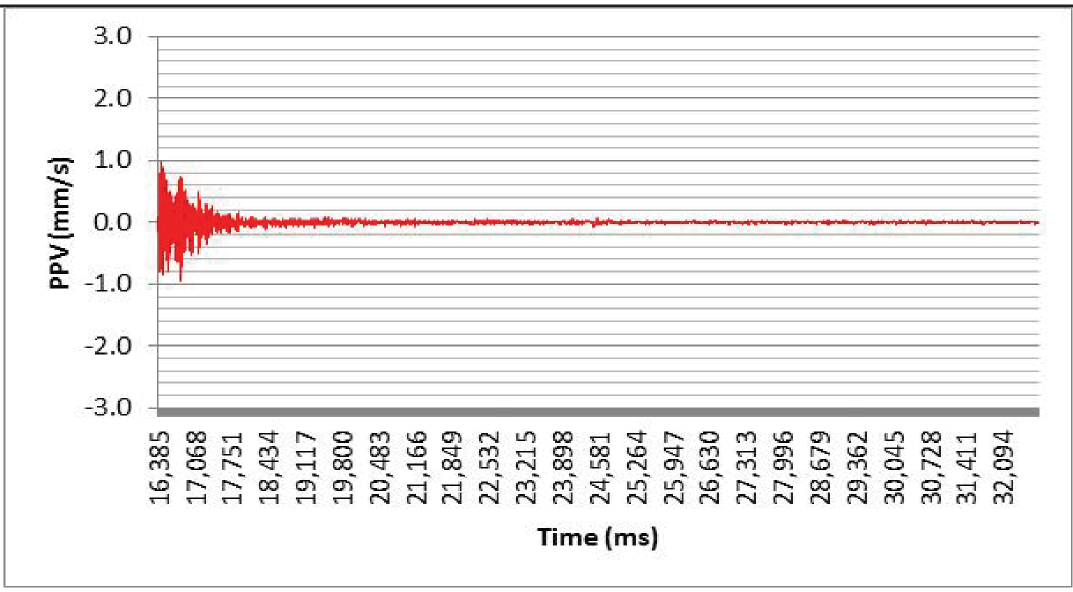
Point: MPV01	**Date: 23/10/2012** **Location:** Thorngrove loop, adjacent to railway line. GPS: S32°38'5.22" E25°48'34.00"	**Distance from Track:** 8 m **Notes: :** Train to Drennan: 2 locomotives and 50 wagons **Train Speed:** 50km/hr

Red Line: Vertical relative to ground.

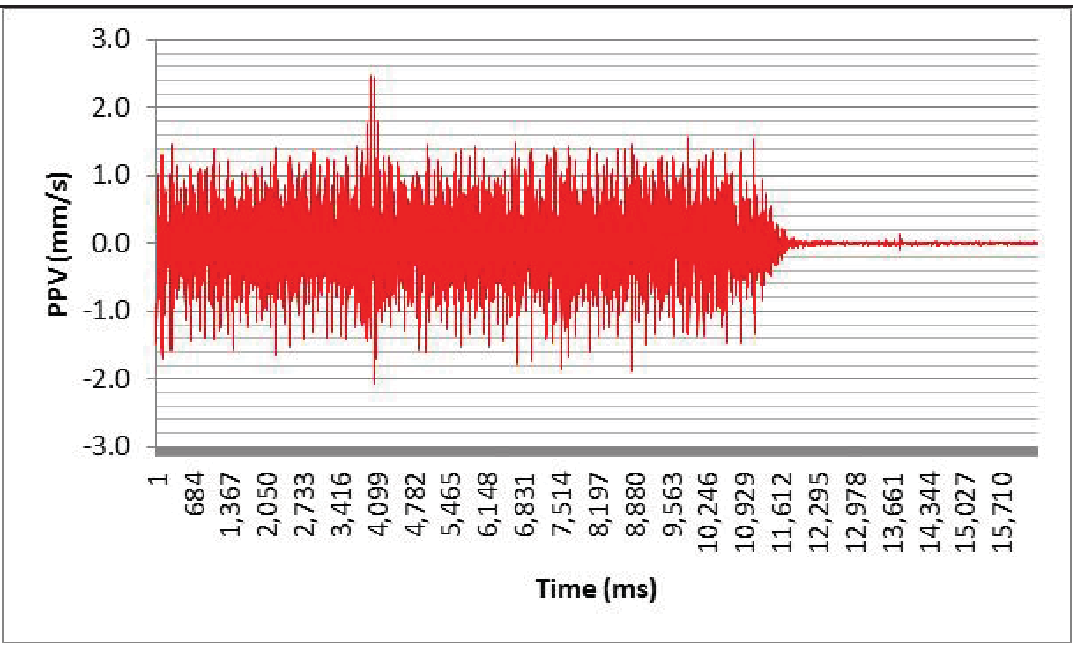


Point: MPV01	**Date: 23/10/2012** **Location:** Thorngrove loop, adjacent to railway line. **GPS:** S32°38'5.22" E25°48'34.00"	**Distance from Track:** 8 m **Notes:** Train to Drennan: 2 locomotives and 50 wagons **Train Speed:** 50km/hr

Red Line: Vertical relative to ground.



Point: MPV02	**Date: 24/10/2012** **Location:** Ripon- Kommadagga loop, adjacent to railway line. **GPS**: S33° 5'21.25" E25°51'47.41"	**Distance from Track:** 3m **Notes:** Train From CookHouse : 2 locomotives and 33 wagons **Train Speed:** 70 km/hr
Red Line: Vertical relative to ground.		



Appendix D

D.1 Construction and Operation Noise Model Sound Power Input Data

Table D-1. Construction Equipment Sound Power Emission Levels

Equipment	Octave Band (Hz)							
	63	125	250	500	1000	2000	4000	8000
	Sound Power Level (dB), re 1 pW							
Bulldozer	88.0	118.0	111.0	109.0	107.0	103.0	97.0	67.0
Excavator	82.0	112.0	118.0	105.0	106.0	99.0	95.0	65.0
Grader	81.0	111.0	108.0	108.0	106.0	104.0	98.0	68.0
Truck	83.0	113.2	116.9	114.4	110.6	106.8	100.2	70.0
Front end loader	86.0	116.0	107.0	108.0	105.0	99.0	95.0	65.0
Generator	90.0	90.0	97.0	103.0	103.0	99.0	92.0	92.0
Compressor	71.1	101.1	103.9	104.1	103.4	112.4	113.1	83.1

Appendix D5

Social Specialist Study

1 SOCIO-ECONOMIC BASELINE

1.1 INTRODUCTION

The purpose of this section is to describe the socio-economic environment within which the proposed Project is located. The description provided is based on publically available and high level secondary information as well as primary data gathered from the affected landowners and Community Development Workers (CDWs). The potential socio-economic impacts resulting from the proposed project will primarily be experienced at the local and on-site levels; therefore, the socio-economic baseline description is focused on the local municipality and site level information.

The proposed Project will occur in several Local Municipalities within the Eastern and Northern Cape. *Table 1.1* provides a list of all the affected Local Municipalities as well as the train stations where the proposed Project will occur by Province and District Municipalities.

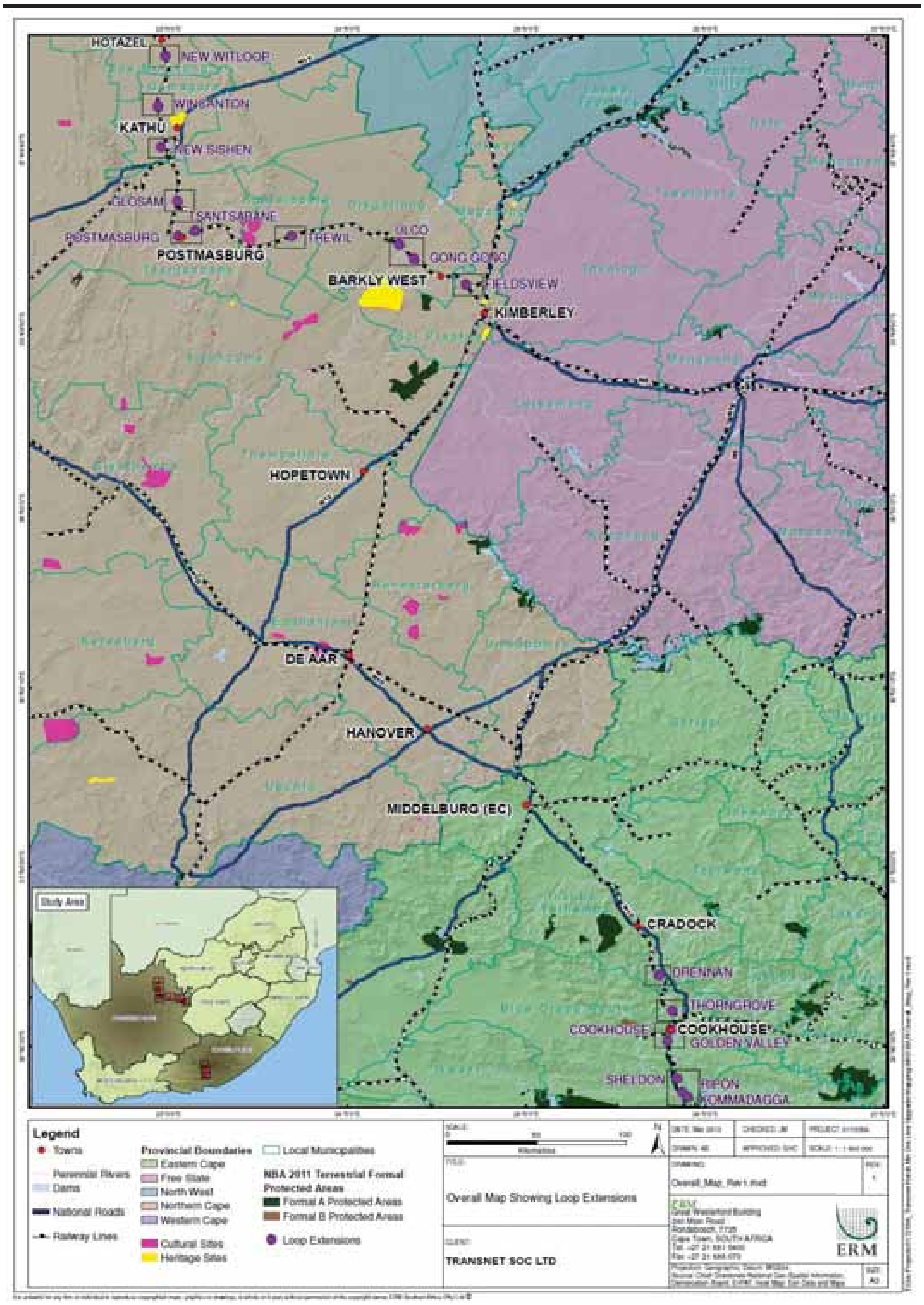
It is important to note that not all Project affected landowners have been interviewed for this report, especially in the Northern Cape. This gap will be filled in the Final Basic Assessment Report.

Table 1.1 Project Affected Municipalities per Province

Province	District	Local	Train Station/ Loops
Eastern Cape	Cacadu	Blue Crane	Ripon
			Kommadagga
			Sheldon
			Golden Valley
			Cookhouse
	Chris Hani	Inxuba Yethemba	Drennan
Northern Cape	Frances Baard	Sol Plaatje	Fieldview
		Dikgatlong	Gong-Gong
			Ulco
	Siyanda	Kgatelopele	Trewil
		Tsantsabane	Postmasburg
			Tsantsabane
			Glosam
	John Taolo Gaetswele	Gamagara	Sishen
			Wincanton
		Joe Morolong	Witloop

Figure 1.1 below shows the locations of the Project Sites.

Figure 1.1 Socio-economic Project Sites (from the Eastern Cape to the Northern Cape)



1.2 *EASTERN CAPE*

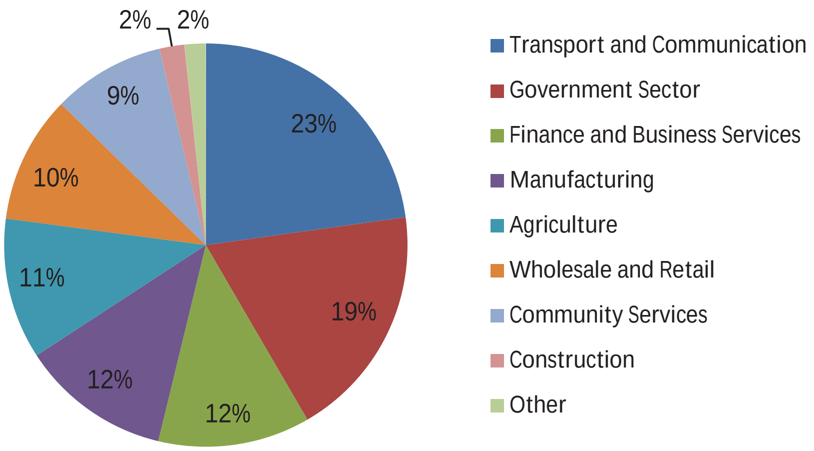
This section provides the socio-economic data for the Project affected Local Municipalities as well as the socio-economic data for each Project Site within the Eastern Cape Province.

1.2.1 *Blue Crane Route Local Municipality*

There are five proposed Project Sites that fall with the Blue Crane Route Local Municipality, namely Ripon, Kommadagga, Sheldon, Golden Valley, and Cookhouse. *Table 1.2* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.2 Blue Crane Route Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	25,573	
Annual growth rate	- 5.4	Estimated from a decline in population of 27% over a five year period
Racial Composition:		
African / Black	47	
Coloured	41	
White	12	
Indian / Asian	0	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	11	the majority of the population (64%)has primary and secondary schooling.
Primary Schooling	34	
Secondary Schooling	30	
Grade 12	19	
Tertiary	6	
Employment rate	40	
Unemployment rate	15	
Economically Inactive	45	
ECONOMIC INDICATORS *(highest sector contributions)*		



Box 1.1 and *Box 1.2* provide brief descriptions of the Project affected farm / s, and provide information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

The closest settlement to the Project Sites is Cookhouse (500m), which has a population of 7,000 people. The area is classified as rural. Most community members have completed Grade 12. The community's livelihoods are based on agricultural activities and many of the community members work on the Dairy Bell farms. The other main employment sources for the members of the community include civil employment as well as seasonal work on the surrounding farms. Unemployment levels are 80-90 percent due to low skill levels as well as a lack of opportunities.

Box 1.1 Socio-economic Description of the Project Sites: Kommadagga and Ripon

Ripon- Kommadagga

There are two Project affected farms, namely portion of Farm No 369 and portion of Farm No 447.

- Farm No 369 is privately owned, while Farm No 447 is owned by a Trust and it is currently being leased to another farmer.
- The combined size of the farms is currently unknown; however portion of Farm No 369 is approximately 2,200ha.
- An estimated 18.57 ha of land will be acquired for the Project. Additional land may be required during the construction phase for the laydown area.
- The farms are currently used for livestock farming (cattle) and irrigated crop farming (maize and peppers).
- Infrastructure currently found on the farms includes warehouses, sheds, farm houses, a National Road (N10) as well as Eskom power-lines.
- Currently, there are 28 employees residing permanently on Farm No 369 along with their families. The number of people residing on other portions of the Project affected farms is unkown.
- There are two planned renewable energy projects on Farm No 447. One is for a hydro-electric facility, which is being proposed by the Blue Crane Route Local Municipality. The second project is a proposed wind farm by a private renewable energy developer.

Sheldon

- There are three Project affected farms, namely the remainder, remainder of portion four, remainder of portion five, portion 18 and portion 26 of Farm No 221, Kraaifontein; remainder of Farm 223, Drie Kuilen; and Farm No 224 Zebraskop.
- Farm Kraaifontein is privately owned, Farm Zebraskop and the Remainder of Drie Kuilen is owned by National Government.
- The combined size of the farms is currently unknown, however Kraaifontein is approximately 1,000ha.
- An estimated 3ha of land will be acquired for the Project. An estimated 3,000m^2 of land is needed for laydown areas in the construction phase.
- The farms are currently used for livestock farming including sheep, goats and cattle.
- Infrastructure currently found on the farms includes a shed (used as a store room and for shearing purposes), boreholes, four wind mills, two rondawels and three Transnet houses.
- Currently, there is one employee and his family living on the farm as well as the employees father in law who lives in a seprate house on the farm on Farm Kraaifontein.
- There are two planned renewable energy facilities planned for Farm Kraaifontein including wind and solar which are both being proposed by Terra Power Solutions.

Figure 1.2 Photolog of the Ripon –Kommadagga Project Sites


Ripon


Kommadagga

Box 1.2 *Socio-economic Description of the Project Site: Cookhouse-Golden Valley and Thorngrove*

Golden Valley-Cookhouse

There are three Project affected farms, namely portion 2 of portion 4 of the farm Jagers Drift No 121, portion of Portion 28 of the farm Roode Wal No 87, , and portions (2) of Portion 1 of the farm Houghamdale North No 341.

- The land is owned under the Close Corporation called Number Two Piggeries.
- The combined size of the farms is 150 ha.
- The land that will be acquired for the Project is 18.57 ha. Additional land may be required during the construction phase for the laydown area.
- The farms are used for livestock (pigs), dairy farming, and cattle fodder production.
- Infrastructure on the farm includes, buildings, underground water pipelines (used for irrigation of fodder fields), and water switches.
- Approximately 85 people reside permanently on the farms.

Thorngrove

- There are four Project affected farms, namely portion of portion 14 of the farm Kokskraal no. 63, portion 4 of portion 12 of the farm Kokskraal no. 63, portion 2 of ERF 31 of Great Fish River Settlement, and portion 3 of ERF 146 of Great Fish River Settlement.
- The combined size of the farms is 4,740 ha.
- The land to be acquired for the Project is an estimated 0.807 ha. Additional land may be required during the construction phase for the laydown area.
- The farms are used for dairy production, irrigation farming (fodder, maize, and Lucerne), and grazing pastures.
- Infrastructure currently found on the farm includes irrigation systems, workshops, three houses, irrigation dams, and infrastructure associated with dairy farming.
- The irrigation system is found on the western side of the railway line on portion 3 of ERF 146.
- Overall, an estimated 450 people reside permanently on the Project affected farms (landowners, farm managers, as well as farm workers).
- Currently, there are no planned renewable energy facilities on the farms; however, portion 3 of ERF 146 is currently powered by hydro-power.

Figure 1.3 Photolog of the Cookhouse-Golden Valley and Thorngrove Project Sites

Cookhouse

Golden Valley

Thorngrove –Pivot Irrigation System

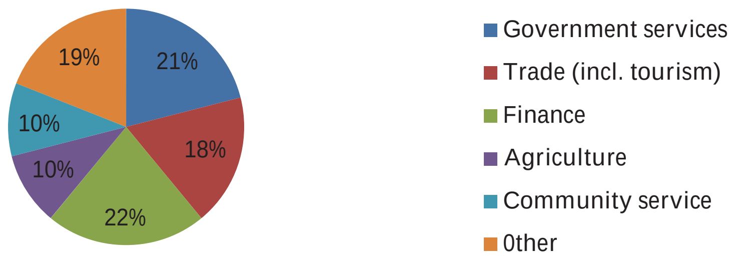
1.2.2 Inxuba Yethemba Local Municipality

There is one proposed Project Site that falls within the Inxuba Yethemba Local Municipality, namely Drennan. *Table 1.3* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.3 Inxuba Yethemba Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	48,899	
Annual growth rate	-3.8	Based on a decline of 19% in a five year period
Racial Composition:		

	Community Survey 2007 Data (in %)	Additional Comments
African / Black	48	
Coloured	36	
White	16	
Indian / Asian	0	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	17	
Primary Schooling	23	
Secondary Schooling	27	
Grade 12	22	
Tertiary	11	
Employment rate	38	
Unemployment rate	23	
Economically Inactive	39	
ECONOMIC INDICATORS (*highest sector contributions)*		



Box 1.3 provides a brief description of the Project affected farm / s, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

Cradock is the closest town to the Project Site (35km), and it has a population of 28,689 people with the majority of the population being Xhosa. The economy of Cradock is chiefly based on livestock and crop farming. The town is well known for its wool industry, along with the production of beef, dairy, fruit, Lucerne, and mohair. Tourism is also a significant activity in the area due to the hot sulphur springs which attracts a large number of tourists.

Box 1.3 Socio-economic Description of the Project Site: Drennan

Drennan

There are four Project affected farms, namely portion of the Remainder of the farm Alle Hoop No 551, portion of the Remainder of the farm Das En Door No 563, portion of Farm No 600, and portion of portion 4 of the farm Waai Plaats No 550.

- Three of the farms are privately owned, with the exception of portion of FARM No 600 which is owned by the National Government. Farm Waai Plaats is owned and managed by the Waterfall Trust.
- The land to be acquired for the Project is 0.57ha.
- The combined size of the farms is unknown. Additional land may be required during the construction phase for the laydown area.
- Government land is currently not used or occupied.
- On farm Alle Hoop, farming activities include crop farming (maize and lucerne) and livestock farming (sheep).
- Farm Das en Door is used for crop farming, specifically maize and lucerne.
- Farms Alle Hoop and Das en Door have been earmarked for pivot irrigation, on the land adjacent to the railway line.
- Waai Plaats is used for cattle and sheep farming.
- Infrastructure currently found on the farms includes a windmill, power-lines, Transnet substation and houses.
- Currently, there are ten permanent workers living permanently on the farms.
- No renewable energy facilities planned for farms Alle Hoop and Das en Door. However, a solar power facility is planned for farm Waai Plaats.

Figure 1.4 Photolog of the Drennan Project Site

1.3 NORTHERN CAPE

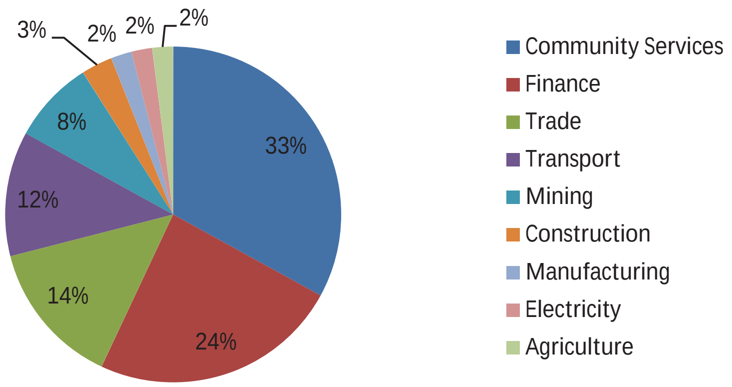
This section provides the socio-economic data of the Project affected Local Municipalities as well as the socio-economic data for each Project Site within the Northern Cape Province.

1.3.1 *Sol Plaatje Local Municipality*

There is one proposed Project Site that falls within the Sol Plaatje Local Municipality, namely Fieldsview. *Table 1.4* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.4 *Sol Plaatje Local Municipality*

	Community Survey 2007 Data (in %)	Additional Comments
DEMOGRAPHIC INDICATORS		
Population Size	243,018	
Annual growth rate	4.2	Based on an increase of 21% over a five year period. The increase may be related to the in-migration due to mining activities.
Racial Composition:		
African / Black	46	
Coloured	40	
White	14	
Indian / Asian	0	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	5	the majority of the population approx. 60% has primary and secondary schooling.
Primary Schooling	10	
Secondary Schooling	50	
Grade 12	25	
Tertiary	10	
Employment rate	38	
Unemployment rate	18	
Economically Inactive	44	
ECONOMIC INDICATORS *(highest sector contributions)*		



Box 1.4 provides a brief description of the Project affected farm, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

Box 1.4 Socio-economic Description of the Project Site: Fieldsview

Fieldsview

- The closest settlement to the Project Site is Droogfontein Communal Property Association (CPA), who are also the Project Affected landowners.
- The CPA land lies immediately adjacent to the railway station in Fieldsview.
- The CPA is comprised of 120 families who were resettled into the area in 2006 as part of the lands claim process.
- Between 20 and 30 families reside on the land, the majority reside in the surrounding towns closest to the area (Kimberley and Barkely West) but keep their livestock on the land.
- The CPA comprises of coloured and African / Black (Sothos, Tswanas, and Xhosas) ethnic groups.
- The land owned by the CPA is approximately 12,500 ha and it is used for livestock grazing and irrigation farming.
- The land that will be acquired for the Project is an estimated four hectars, from portion of Remainder of Farm No 193.
- Additional land may be required during the construction phase for the laydown area.
- The portion of land that will be affected by the Project is used primarily for grazing, with irrigated land located on another portion.
- The CPA owns only 600 cattle and it is planning to expand its herd in the future.
- The CPA is regarded as part of the emerging farmers and have in the past received government subsidies.
- The infrastructure on the land consists of three boreholes, one of which is not working, houses, and a fully functional primary school.
- The CPA has not received any basic services from the local government such as housing, sanitation and water. This has been the contributing factor to the limited number of families living on the land.
- There are two farms located within the CPA land which are privately owned. The CPA Chairperson stated that they don't understand why those two individual farms were not relocated when they were given back their land.
- The CPA has signed a lease agreement with Mainstream SA, a renewable energy developer, for the construction of a solar power facility (50MW) on another portion of its land; in addition they are in negotiations with another developer for a 275MW solar facility on another portion of the farm.

Figure 1.5 Photolog of the Fieldsview Project Site

Game farming opposite the Project Site

People from Droogfontein Community travelling on local road on horses

Grazing land opposite the Project Site

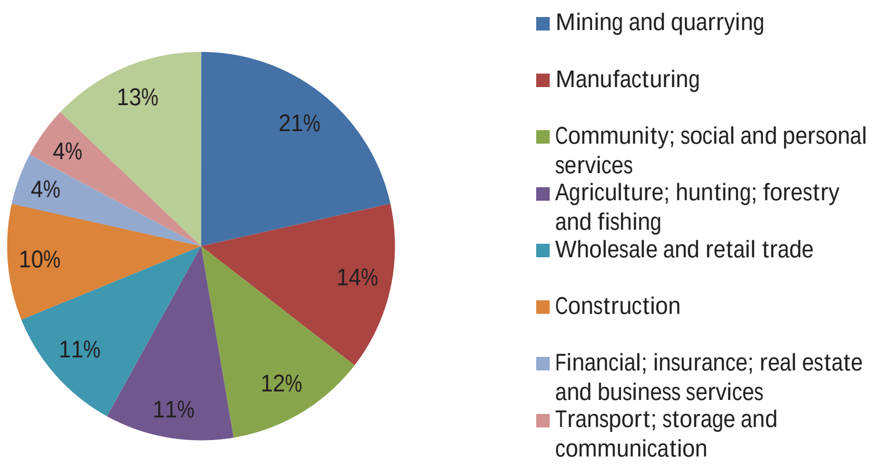
Irrigation Farming opposite the Project Site

1.3.2 *Dikgatlong Local Municipality*

There are two proposed Project Sites that fall within the Dikgatlong Local Municipality, namely Gong-gong and Ulco. *Table 1.5* provides a statistical summary of key socioeconomic indicators for the Local Municipality.

Table 1.5 Dikgatlong Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	40,748	
Annual growth rate	2.8	Based on a 14% increase over a five year period
Racial Composition:		
African / Black	54	
Coloured	41	
White	0	
Indian / Asian	5	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	22	the majority of the population (67%) primary and secondary schooling
Primary Schooling	37	
Secondary Schooling	30	
Grade 12	8	
Tertiary	3	
Employment rate	34	
Unemployment rate	22	
Economically Inactive	44	
ECONOMIC INDICATORS *(highest sector contributions)*		

	Community Survey 2007 Data (in %)	Additional Comments
		

Box 1.5 provides a brief description of the Project affected farm/s, and provides information about the size of the farms, the type of agricultural activities undertaken, as well as summary of infrastructure found on the farms.

The closest town to the Project site (Gong-gong) is Barkely West (15km);it has a population of 32,201 people. The population is comprised of African/Black, Coloureds and Whites. The main economic activities undertaken in the town include large-scale dairy farming and irrigation farming (from the Vaal-Harts irrigation scheme). Tourism is also an important part of the economy, which is facilitated by numerous historical sites in the town, including the Barkly Bridge, Cultural History Museum, St. Mary's Anglican Church, Barkly West Museum, the Old Toll House, Canteen Kopje, Rekaofela Resort, Oribi Game Reserve and Vaalbos National Park.

The closest town to the Project site (Ulco) is Delporthoop (seven kilometres); and it is situated between the Harts and Vaal rivers at the foot of the Ghaap Plato. The town started off as a miner's camp. Its economy is centred on mining (specifically for aluvial diamonds). Farming and tourism are also key economic activities.

Box 1.5 *Socio-economic Description of the Project Sites: Gong-gong and Ulco*

Gong-gong

- The Project-affected farm is Remainder of farm Longlands 231, which is owned by the Northern Cape Provincial Department of Public Works.
- The size of the land is unknown.
- An estimated 0.94ha will be acquired for the Project. Additional land may be required during the construction phase for the laydown area.
- Land use is unknown. From general observations, the land is currently not being used.

Ulco

- The Project affected farm is called farm Likatlong 317, the landowner owns the entire farm and it's divided into three portions.
- The farm is privately owned, and according to the landowner there are no pending land's claim on the farm.
- It is an estimated 899ha in size, 0.33ha will be acquired for the Project. Additional land may be required during the construction phase for the laydown area.
- Livestock (cattle) and crop (lurcene) farming are undertaken on the farm.
- Lurcene is grown closer to the Harts River, and the remainder of the farm is used for cattle grazing.
- There are three farm workers who reside on the farm during week days, and the landowner resides on the farm six days a week.
- Infrastructures currently found on the farm includes the farm house, worker's cottages, boreholes (one on which is 100 metres from the railway line), fences (camps), and a Cell C cellphone tower.

Figure 1.6 *Photolog of the Gong-gong and Ulco Project Sites*


Gong-gong – No visible signs of any land use was observed on both sides of the railway line

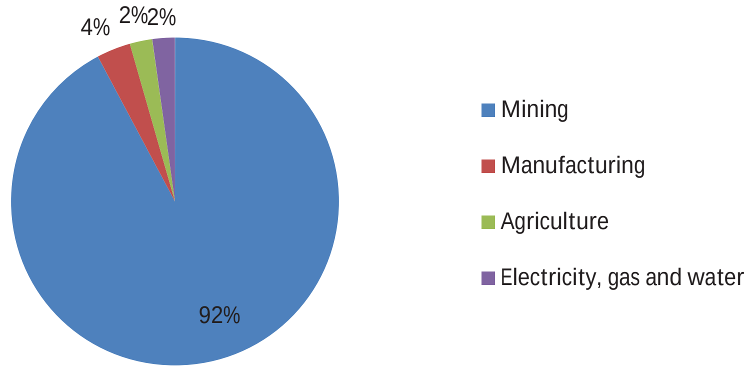
Ulco – some train wagons standing on site ---------Old and aboundoned Transnet houses

1.3.3 *Kgatelopele Local Municipality*

There is one proposed Project Site that falls within the Kgatelopele Local Municipality, namely Trewil. *Table 1.6* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.6 Kgatelopele Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	40,752	
Annual growth rate	2.8	Based on an increase of 14% over a five year period
Racial Composition:		
African / Black	38	
Coloured	46	
White	16	
Indian / Asian	0	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	18	an estimated 59% of the population has primary and secondary schooling
Primary Schooling	31	
Secondary Schooling	28	
Grade 12	17	
Tertiary	6	
Employment rate	53	
Unemployment rate	17	
Economically Inactive	30	
ECONOMIC INDICATORS (highest sector contributions)		

	Community Survey 2007 Data (in %)	Additional Comments
 		

Box 1.6 provides a brief description of the Project affected farm, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

The closest town to the Project site is Lime Acres (80km), which is a mining town. The main mineral mined in the town is lime stone.

Box 1.6 *Socio-economic Description of the Project Site: Trewil*

- The Project affected farm is known as portion of portion 6 of Farm No 299.
- The farm is privately owned in a family trust.
- The total size of the two farms adjacent to the railway line is 3,790ha.
- Land to be acquired for the Project is an estimated 1.27ha. Additional land may be required during the construction phase for the laydown area.
- The land is currently used for livestock farming (sheep and cattle).
- There are six people who permanently reside on the farm (including the farm workers).
- Infrastructure on the farm consists of the farm house, worker's cottages, workshop, boreholes, fences and fenced off camps, and other buildings.

Figure 1.7 Photolog of the Trewil Project Site

Farmer transporting his cattle from one side of his farm across the railway line to the other side

The farm opposite the Trawel Project Site

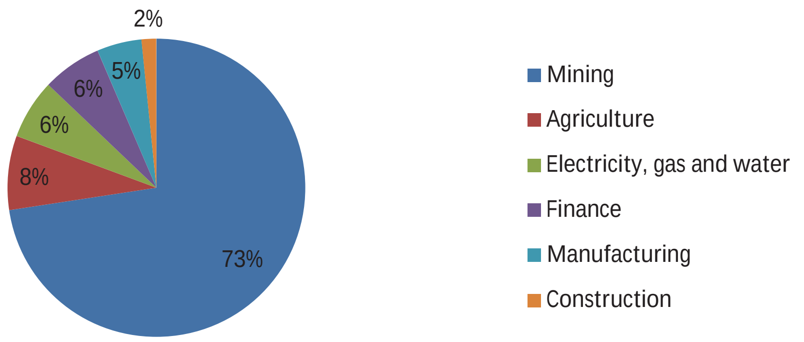
1.3.4 Tsantsabane Local Municipality

There are three proposed Project Sites that fall within the Tsantsabane Local Municipality, namely Postmasburg, Tsantsabane, and Glosam. *Table 1.7* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.7 Tsantsabane Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	28,005	
Annual growth rate	3.4	Based on an increase of 17% over a five year period
Racial Composition:		
African / Black	37	
Coloured	49	
White	14	
Indian / Asian	0	

	Community Survey 2007 Data (in %)	Additional Comments
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	23	
Primary Schooling	33	
Secondary Schooling	27	
Grade 12	9	
Tertiary	8	
Employment rate	37	
Unemployment rate	26	
Economically Inactive	37	
ECONOMIC INDICATORS *(highest sector contributions)*		



Box 1.7 provides a brief description of the Project affected farm / s, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

The closest town to the Project Sites are Postmasburg, it is 22km from Glosam, six kilometres from Tsantsabane , and two km Postmasburg. The town of Postmaburg is a medium size mining town. Diamond and manganese ore mining are the main economic activities undertaken in the town. Like many mining towns in the Northern Cape, the tourism industry is booming due to a lack of accommodation for miners, as such the mining companies are housing some of its workers in the local establishments.

Box 1.7 Socio-economic Description of the Project Sites: Glosam, Tsantsabane, and Postmasburg

There are three Project affected farms, namely farm Gloucester No. 674, portion of Remainder of ERF 1 Postmasburg (in two sections of the railway line), and portion of Remainder of portion 1 of the farm Beetshoek No 448.

Glosam

- The Project affected farm is farm Gloucester No. 674.
- The size of the farm is currently unknown.
- The size of the land to be acquired for the Project is 1.69ha. Additional land may be required during the construction phase for the laydown area.
- Farm Gloucester is owned by Khumani Mine (a subsidiary of ASSMANG).
- The land is used to house some of the mine's workers in Glosam village.

Tsantsabane

- The Project affected farm is Remainder of ERF 1 Postmasburg, which is owned by the Tsantsabane Local Municipality.
- The size of the farm is unknown.
- The size of the land to be acquired for the Project is 1.65ha. Additional land may be required during the construction phase for the laydown area.
- The current land is unknown. From general observations, the land is not being used.

Postmasburg

- The Project affected farms are Remainder of ERF 1 Postmasburg, which is owned by the Tsantsabane Local Municipality; portion of Remainder of portion 1 of the farm Beetshoek No 448 is owned by ASSMANG.
- The size of the farms is unknown.
- The size of the land to be acquired for the Project is 3.45ha. Additional land may be required during the construction phase for the laydown area.
- The land belonging to the mining company is being used to as a base to park its vehicles.
- The Municipal land is unknown, from observations, the land is used as a motor vehicle depot.

Figure 1.8 Photolog of the Glosam, Tsantsabane, and Postmasburg Project Sites

Land adjacent to the Glosam Project Site

Kumani Mine- workers' village

Tsantabane Project Site

Postmusburg Project Site

Veld fires close to the Project Site

1.3.5 *Gamagara Local Municipality*

There are two proposed Project Sites that fall within the Gamagara Local Municipality, namely Sishen and Wincanton. *Table 1.8* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.8 Gamagara Local Municipality

	Community Survey 2007 Data (in %)	Additional Comments
DEMOGRAPHIC INDICATORS		
Population Size	28,054	
Annual growth rate	4	21% increase over five years
Racial Composition:		
African / Black	43	
Coloured	33	
White	24	
Indian / Asian	0	
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling	20	Approx. 56% of the population have not completed schooling
Primary Schooling	27	
Secondary Schooling	29	
Grade 12	18	
Tertiary	6	
Employment rate	49	The majority of the employed people work within the mining, agricultural and tourism sectors.
Unemployment rate	17	
Economically Inactive	34	
ECONOMIC INDICATORS *(highest sector contributions)*		
The mining sector is the highest contributor to the local economy, followed by the agricultural sector, tourism and trade. No percentages are available for each sector contribution. Tourism has been boosted by the mining sector which has a shortage of accommodation for its workers, as such house the majority in the nearby establishments.		

Box 1.1 provides a brief description of the Project affected farms, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a ummary of infrastructure found on the farms.

Kathu is the closest settlement to the Sishen Project Site (15km). Kathu is a town that was started due to the mining activities in the Municipal area. It is the largest urban town in the Municipality and it also serves as the administrative centre for the local Municipality. The economy of the town centres on mining and tourism. Tourism has been boosted by the high demand for accommodation brought on by the mining industry due to a lack on miners' housing.

Dibeng is the closest settlement to the Wincanton Project Site (seven kilometres). Dibeng started off as a small settlement on the banks of the Gamagara River which provided water for the residents, but it has since grown to a larger settlement. The settlement is separated into two sections one with formal housing and another with RDP housing. The residential areas are characterised by the river in the centre of settlement and the rocky lime stone outcrops. The main economic activities are mining and agriculture, with the large number of people working in the agricultural sector as farmers or farm workers.

Box 1.8 Socio-economic Description of the Project Sites: Sishen and Wincanton

Sishen

The project affected farms are Remainder, portions 1, 2, and 7 of farm Gamagara No 541. The land belongs to Sishen Iron Ore Company.

- The size of the farms is unknown.
- The size of the land to be acquired for the Project is 6.8ha. In addition, land may be required during the construction phase for the laydown area.
- The land is currently used for mining activities and certain sections of the land are being used for the construction of the new railway line.
- The new railway line is being constructed by Kumba Iron Ore.
- Once the construction of the railway line is complete, Transnet will add a loop onto the line.

Wincanton

There are three Project affected farms, namely portion of Remainder of the farm Wincanton No 472, portion (2) of portion 6 of the farm Wincanton No 472, and portion of the Remainder of portion 1 of the farm Lime Bank No 471.

- All three farms are privately owned and there are no pending land's claims on them.
- The combined size of the farms is 1,241ha.
- The land to be acquired for the Project is 0.81ha. Additional land may be required during the construction phase for the laydown area.
- Both landowners of Wincanton farm portions (Remainder and portion (2) of portion 6) are in the final stages of selling their land to two different renewable energy developers, for the development of solar power facilities.
- On Remainder of Wincanton, the landowner has cattle (60), while on portion (2) of portion 6 of the farm Wincanton, there used to be cattle, sheep and goats, but the landowner decided to cease all agricultural activities in preparation for the solar project.
- There are workers currently residing on the farms, and the landowner on portion (2) of portion 6 of the farm Wincanton has asked for his worker to be employed on the solar project. The landowner will also be employed by the project.
- On Remainder of Wincanton, the landowner is planning to stop all farming activities and retire.

Figure 1.9 Photolog of the Sishen and Wincanton Project Sites

New Sishen Project Site –with the Kumba commissioned railway line under construction

Goats on the Road to the New Sishen Project Site

Wincanton Project Site

Farm labourer's accommodation- Wincanton

1.3.6 Joe Morolong Local Municipality

There are two proposed Project Sites that fall within the Gamagara Local Municipality, namely Sishen and Wincanton. *Table 1.9* provides a statistical summary of the socioeconomic indicators for the Local Municipality.

Table 1.9 Joe Morolong Local Municipality

	Community Survey 2007 Data (in %)	**Additional Comments**
DEMOGRAPHIC INDICATORS		
Population Size	28,054	
Annual growth rate	4	Based on a 21% increase over a five year period
Racial Composition:		
African / Black	43	
Coloured	33	
White	24	
Indian / Asian	0	

	Community Survey 2007 Data (in %)	Additional Comments
SOCIO-ECONOMIC INDICATORS		
Education		
No Schooling Primary Schooling Secondary Schooling Grade 12 Tertiary	29 40 23 7 1	The majority of the population (63%) have primary and secondary schooling, and only 1% has tertiary education
Employment rate **Unemployment rate** **Economically Inactive**	11 17 72	A large portion of the population are 19 years and younger, less than 5% are elderly.
ECONOMIC INDICATORS (*highest sector contributions*)		
The mining sector is the highest contributor to the local economy, followed by the agricultural sector, tourism and trade. No percentages are available for each sector contribution. Tourism has been boosted by the mining sector due to the shortage of accommodation for their workers, as such most accommodation facilities house the mine workers.		

Box 1.9 provides a brief description of the Project affected farm/s, and provides information related to the size of the farms, the type of agricultural activities undertaken, as well as a summary of infrastructure found on the farms.

The closest town to the Project Site is Hotazel (15km). The town started out as a mine workers' camps site, and over the years it has grown larger in size as miners' families moved into the area. The main economic activities are mining, trading and tourism.

Box 1.9 Socio-economic Description of the Project Site: Witloop

There are two Project Affected farms Remainder of the farm Smart No 314 and Remainder of the farm Kameel Aar No 315.

Remainder of the farm Smart is owned by Terra Nominees (Pty) Ltd, which is a subsidiary BHP Billiton, while the Remainder of the farm Kameel Aar is privately owned.

- The combined size of the farms is unknown.
- The land to be acquired for the Project is an estimated 0.27ha. Additional land may be required during the construction phase for the laydown area.
- No other details are available at present, as the landowner have not been interviewed

Figure 1.10 Photolog of the Witloop Project Site

Road leading to site used by mining company vehicles	Cattle grazing on the land opposite the Project Site

2 SOCIAL IMAPCT ASSESSMENT

2.1 INTRODUCTION

This section of the report analyses the social impacts that may result from the proposed expansion of the railway loops. These are based on research undertaken to date, including primary and secondary data.

The identified impacts (positive and negative) have been assessed in terms of the effects of the proposed project on the receiving socio-economic environment and stakeholders. The project activities are described in

Mitigation measures have been provided that aim to avoid, minimise, reduce, remediate or provide appropriate alternatives for the negative impacts and enhance the benefits of the Project. The section furthermore provides a prediction of the residual impact that will remain, assuming that all mitigation measures are implemented.

2.2 IMPACT ON THE LOCAL ECONOMY

The Project is expected to contribute to the local economy in the following ways:

- increased government revenue;
- increased exportation of manganese ore (operation only);
- creation of direct and indirect employment which will lead to increased spending; and
- procurement of local goods and services.

Construction

The capital investment required to expand the railway loops is high at approximately R19.2 billion, which will be spent over the construction period (12 to 18 moths per loop and four years for the overall Project). A portion of the above will be translated to government revenue from various taxes and permitting licenses required for the Project. Thus increasing the government's revenue (which is also used to provide and improve services to the country).

<u>Employment</u>

The Project is expected to create employment opportunities, of which 12,171 will be direct, and 9,128 will be indirect positions. The Project will require highly skilled, semi-skilled and unskilled workers during the construction phase. Due to the technical nature of the construction phase, a large proportion of the workforce will be highly skilled and semi-skilled employees. Transnet is planning to employ people from the local areas (areas closest to each Project site) for each construction work; which will result in a large number of people benefiting from the Project in a broader area (from the Eastern and Northern Cape). However, the construction period of each loop will be relatively short, lasting between 12 and 18 months. A limited number of highly people (such as engineers) are expected to work on all construction sites (they will move with the Project from site to site).

In addition to the direct employment opportunities available to local people, there will be a large number of in-direct employment opportunities generated through the Project. In-direct employment will be created through the supply chain and local procurement of goods and services. Induced employment will be created through increased spending in the economy by people employed to work on the Project.

Procurement

In addition to the creation of employment, procurement opportunities will be available to local businesses. However, the procurement benefits will be limited, as most of the goods/services required are highly specialised and are unlikely to be available in the local areas. Local procurement will, therefore, primarily benefit the civils and construction industry, hospitality and service industries, such as accommodation, catering, transport, vehicle servicing and security services.

Given the scale and nature of the project the vast majority of goods and services will either be procured nationally (predominantly Gauteng)/ and internationally (Europe). *Box 2.1* provides an overview of the major goods and services that will be procured as well as the anticipated origin thereof.

Box 2.1 Goods and Services to be Procured

International/ National:

- rails and turnout components will be sourced internationally;
- traction substation equipment will be sourced from South Africa and internationally;
- signalling and telecommunication equipment will be sourced from South Africa and internationally;
- sleepers and fastenings will be sourced within South Africa;
- overhead traction equipment will be sourced within South Africa; and
- overhead traction equipment, signalling and telecoms contractors will be sourced within South Africa.

Regionally/ Locally:

- ballast and layer works material will be sourced from the province, as close as possible to the site;
- civil and earthworks contractors will be sourced regionally and locally depending on availability of contractors; and
- plate laying contractors will be sourced regionally and locally depending on the availability of contractors.

Impact Assessment: Construction

The impact will be **positive** and **direct** as related to the generation of revenue to the economy, procurement, and creation of direct employment opportunities. The positive impacts related to employment and government revenue will be experienced at the **local, regional and national levels**. The scale of the impact will be **national** due to the revenue generated by the increased employment. For procurement, the impacts will extend beyond the country's borders (**internationally**) as some of the specialised equipment will be procured in Europe. The impacts related to construction will be **short term** and with a **moderate** likelihood. The severity of the impact will be **medium** as the majority of the construction jobs created will be **temporary** and government revenue will be minimal during this phase with the possibility to increase during operations.

The magnitude of this impact is linked primarily with the duration / timeframe of the employment and procurement opportunities, quality / level of employment, and the degree to which local workers will secure the employment opportunities. The number of people who will be employed during the construction phase is likely to be low in comparison with the number of job seekers in the Project area. As such, the overall magnitude of this positive impact will be **medium** during construction and **low** during operations (increased government revenue, employment, and procurement). As such the impact has been rated as **moderate positive significance** construction.

Operation

<u>Exportation</u>

The increase in exportation of manganese ore is expected to generate an estimated annual income of R23.4 billion for the proposed increase in tonnage during operations. A portion of the above income will be translated into government revenue along with export taxes and personal income taxes. The additional revenue is likely to be used for social developments and other government needs.

<u>Employment and Procurement</u>

During operation, a limited number of jobs will be created 572. The type of jobs that will be created include administrators, sundry workers, section managers, train drivers and assistants, train control officers, service drivers and general workers. It is unclear if the afore mentioned jobs will be created or if they are in existence.

In-direct employment opportunities (temporary and permanent) will be created in the manufacturing of wagons and equipment for the railway line. These jobs require skilled and semi-skilled workers with experience in the relevant fields. Overall, the procurement requirements during the operational phase will be limited to routine maintenance of the loops and signal equipment. This Project will have a nominal increase on the existing manufacturing industry.

Impact Assessment: Operation

The impact will be **positive** and **direct** as related to the generation of revenue to the economy, procurement and creation of direct employment opportunities. The positive impacts related to employment will be experienced at the **local, regional and national levels and internationally** as it relates to procurement. The impacts related to will be **long term** as it relates to government revenue generation and employment; but **short term** as it relates to procurement there will be decreased demand for some goods and services needed. The impact likelihood is rated as **moderate** as there will be limited procurement needed during operation; but **high** as it relates to government revenue.

The severity of the impact will be **high** for those who secure permanent jobs and increased government revenue**.** The magnitude of these impacts will be **low** as it relates to procurement and **medium** government revenue and employment. As such the impact has been rated as **low** as it relates to procurement and **moderate positive significance** as it relates to government revenue and permanent employment.

2.2.2 Mitigation Measures

The following measures will be implemented to ensure that employment of local people is maximised and procurement of local, regional and national services is maximised.

<u>Increased government revenue</u>:

Transnet will seek to work with government and other stakeholders throughout the life of the Project and designing mitigation and optimisation measures that align with the objectives of on-going government programmes.

<u>Employment:</u>

- Transnet will work closely with relevant local authorities, community representatives and organisations to ensure that the use of local labour and procurement is maximised. This may include:
    - sourcing and using available databases on skills/employment-seekers that local authorities may have.
    - advertising job opportunities and criteria for skills and experience needed through local and national media.
    - conducting an assessment of capacity within the Local Municipality and South Africa to supply goods and services over the operational lifetime of the project.

- No employment will take place at the entrance to the site. Only formal channels for employment will be used.

Procurement:

- Transnet will establish a recruitment and procurement policy. The policy will sets reasonable targets for the employment of local residents/suppliers (originating from the local municipalities) and promote the employment of women as a means of ensuring that gender equality is attained. Criteria will be set for prioritising, where possible, local residents/suppliers over regional or national people/suppliers.

- All contractors will be required to recruit and procure in terms of Transnet's recruitment and procurement policy.

- Ensure that the appointed project contractors and suppliers have access to Health, Safety, Environmental and Quality training as required by the Project. This will help to ensure that they have future opportunities to provide goods and services to the sector.

General:

- Transnet will implement a grievance procedure that is easily accessible to local communities, through which complaints related to contractor or employee behaviour can be lodged and responded to. Transnet will respond to all such complaints. Key steps of the grievance mechanism include:

    - Circulation of contact details of 'grievance officer' or other key Transnet contact.
    - Awareness raising among local communities (including all directly affected and neighbouring farmers) regarding the grievance procedure and how it works.
    - Establishment of a grievance register to be updated by Transnet, including all responses and response times.

2.2.3 Residual Impact

The proposed project is not going to generate significant direct, indirect or induced employment or procurement opportunities; however, the operations will, for a long time, generate increased revenue to the local economy from exports. If Transnet commits to maximising opportunities for South Africans, specifically locals, by implementing the mitigation measures, the positive impact, *albeit* small, will be realised. The post-mitigation significance rating will remain one of **moderate positive significance** during construction and **low positive significance** during operation. The pre- and post-mitigation impacts are compared in *Table 2.1* below.

Table 2.1 Pre- and Post- Mitigation Significance: Local Economy

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	MODERATE (+ve)	MODERATE (+ve)
Operation	LOW (+ve)	LOW (+ve)

2.3 LOSS OF AGRICULTURAL LAND

Agricultural land will be lost in certain sections of the railway line due to the shortage of land within the existing railway reserve. In order to mitigate for the shortage of land Transnet is planning to purchase only the required pieces of land for construction and lease land that is going to be used as laydown areas.

Construction

The combined size of the project affected farms is approximately 50,000 ha. It is estimated that 35.71 ha (less that 0.1 percent) of the total land will be required for the Project. The key issues that affect decision-making regarding any proposed changes to land use, from agricultural use to other use, are the following:

- Soil quality: The authorities are unlikely to allow any kind of development in an area that has good soil quality or high potential soil. Most of the soil in the Eastern Cape Province is considered to be of high quality with a few strips of low value soils, this makes it highly likely that a development may be stopped.

- Compatibility of farming and the proposed Project: The authorities would want to determine if the agricultural land will be maintained alongside the extended railway line. If the project is going to impact negatively on the sustainability of the farm the authorities are unlikely to give a permit for the change in land use.

The land needed for the extension is estimated to be 0.1 percent of the identified land parcels. The loss of land due to the Project will be minimal, but when considering other proposed developments on these farms (i.e. renewable energy projects), then the loss will be more significant in the future. The majority of the land owners have not raised any concerns in this regard but some would like the design and the layout of the Project to be reviewed. Two landowners in Wincanton are in the process of finalising the sale of their farms to renewable energy developers for solar power facilities. In Ripon-Kommadagga, there are two renewable energy projects being proposed, a wind power facility and a hydro-power facility on the same farm. At Sheldon farm there are two renewable facilties that are currently being planned on the site namely solar and wind power facilities. *Table 2.2.* lists Project affected farms where renewable energy projects have been proposed.

Table 2.2 Project Sites where Renewable Energy Projects have been Proposed

Project Site	Proposed Renewable Energy Project
Ripon-Kommadagga	Wind and Hydro power plants
Sheldon	Solar and Wind power plants
Drennan	Solar
Fieldsview	Solar
Wincantion	Solar

The affected landowners have been compensated for the loss of land to other projects, and they will be compensated for the loss of land by Transnet due to the Project; however, it is unknown how the landowners will use the income generated from these developments to develop their farms or supplement their incomes. It is anticipated that they will invest in improving their current farming methods and activities, and some are planning to retire from farming.

Impact Assessment: Construction

The impact on loss of agricultural land is going to be experienced as a **direct, negative** impact. The impact on agricultural land resulting from the construction activities will occur **on-site and local** levels. The loss of land due the Project will be **permanent**. The severity will be low to medium as agricultural land will be lost. The likelihood of the impact occurring is rated as **low**, and the overall impact magnitude is rated as **low negative significance**, as it relates to the expansion Project.

2.3.2 Mitigation Measures

- Transnet will consult the affected landowners to discuss sensitive areas on their property and design the infrastructure layout in a manner that limits loss of agricultural land.

- Transnet will continue to implement the grievance procedure that ensures that complaints related to Project activities can be lodged and responded to promptly, see *Section 2.2.2*.

2.3.3 Residual Impact

The implementation of the above mitigation measures would ensure that the construction and operation impacts remain of **low negative significance**. The pre- and post-mitigation impacts are compared in *Table 2.3* below.

Table 2.3 Pre- and Post- Mitigation Significance: Loss of Agricultural Land

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction and Operation	**LOW (-ve)**	**NEGLIGIBLE(-ve)**

2.4 *Disrupted Agricultural Activities*

The majority of the Project affected farms are solely used for agricultural purposes; including both crop and livestock farming. Livestock kept on the farms consists of sheep, goats, and cattle; while crops include Lucerne, peppers, maize, and fodder. During the construction phase of the Project the agricultural activities will be disrupted on the Project affected farms.

Construction

During the construction phase, there will be a relatively large amount of disruption to agricultural activities. There will be site clearance, road construction, assembly and installation of railway line, as well as the construction of associated infrastructure.

Livestock farming

The farmers' practice rotational farming as the grazing land requires time to regenerate. This is achieved through the division of the farm into camps which are individually fenced and gated; the farms are large enough to enable such rotational methods. During construction, the farmers will need to keep their livestock in alternate camps to the construction area in order to ensure that the stock are not harmed or lost as a result of the intensive construction methods.

As mentioned above, the farms are divided into camps and in order to access the full Project site it will be necessary for the construction team to travel between camps; requiring them to open and close gates as they move. They will, at times, also be required to travel across/alongside neighbouring farms to reach the selected sites. It is critical that the gates are always closed once the team has passed in order to secure the stock.

The high numbers of light and heavy vehicles that will be passing through the farm camps are likely to cause damage to the gates and fencing. Any damage to this infrastructure could also lead to stock losses.

Some of the landowners mentioned that they often loose sheep and goats when there are people maintaining the railway line. They are concerned that extended construction activities will result in increased livestock losses through theft and negligence.

Crop farming (irrigation farming)

Of the affected landowners, seven farmers undertake irrigated crop farming; Ripon, Kommadagga, Cookhouse, Golden Valley, Thorngrove, Drennan, Ulco, along with the neighbouring landowners. The landowners receive irrigation water from various sources, including formal irrigation schemes, boreholes on their farms, and through drawing water directly from the nearby Rivers. *Table 2.4* shows the type of irrigation farming undertaken in each of the Project farms growing crops.

Table 2.4 Project Sites where Irrigation Farming is Undertaken

Project Site	Crops Under Irrigation
Ripon -Kommadagga	Peppers and maize
Cookhouse-Golden Valley	Fodder
Thorngrove	Fodder, maize, lucerne
Drennan	Maize, Lucerne
Ulco	Lucerne

The irrigation systems used include flooding, pivot, and underground irrigation. According to the landowners the irrigation pipes for the underground systems are buried between 1.5m and five metres below the surface and can easily be disturbed. According to the landowners, some of the underground irrigation infrastructure is close to the railway line.

Any destruction of the irrigation system is likely to negatively affect the farming activities as the crops are solely dependent on the water from the system. Furthermore, the disruption will lead to an economic loss for the directly affected landowners along with their neighbours who use the same system.

Impact Assessment: Construction

The disruption to agricultural activities would be regarded as a **direct** and **negative** impact. The impacts of the Project will occur **locally and on-site**, as it will impact on the Project affected landowners along with their neighbours. The disruption as it relates to damage to irrigation pipes and veld fires will be **short**-to **long-term**. Irrigation farmers could experience financial losses brought on by damage to the irrigation pipes and temporary loss of access to irrigation. Livestock farmers will loose grazing land and possibly livestock; in case of loss of grazing land, the affected landowners may not all have the financial means to purchase livestock fodder / Lucerne and replace the lost livestock.

The severity will be **high** as the farmers will have some difficulty adapting to the disruption without some degree of support and compromise, especially crop farmers who rely heavily on irrigation. The impact is likely to occur and it is rated as **medium**, with the overall impact magnitude rated as being of a **high negative significance**, as it relates to construction impacts.

Operation

Operational activities are not expected to cause any disruption to agricultural activities. However, during the initial stakeholder consultation, the landowners and neighbours raised concerns related to the risk of veld fires. According to the stakeholders, trains cause sparks which sometimes cause veld fires that kill livestock and destroy crops. They suggested that Transnet need to keep the servitude clear of vegetation as an effective fire break in order to minimise damage to the livestock and crops.

Impact Assessment: Operation

The operational impacts as it relates to veld fires will be **direct** and **negative**. The impact when it occurs will be **localised/ on-site** affecting mainly the farmers within the area where the fire begins. The impact will be **short to long term** depending on the scale of the damage and the farmers' ability to recover. The severity of the impact will be **high** as it might take farmers longer to recover from the economic loss. The impact likelihood will be **medium**, given that fires are not common. The magnitude of the impact will be **medium**. The overall impact is rated as **moderate negative significance**.

2.4.2 Mitigation Measures

- Transnet will consult the affected landowners to discuss sensitive areas on their property and design the infrastructure layout in a manner that limits the impact on agricultural activities.

- Construction activities to be undertaken according to a schedule that is agreed upon with the landowners.

- Construction workers to ensure that the gates are closed at all times and that any damage to the infrastructure is repaired immediately.

- Any damage to natural vegetation (specifically grazing land) will be rehabilitated in accordance with mitigation proposed for the rehabilitation of natural vegetation after construction on the Project affected sites.

- Transnet to minimise the damage to farmland caused by construction activities by ensuring strict compliance with construction plans.

- The Code of Conduct must address the following aspects:

    - respect for local residents;
    - respect for farm infrastructure and agricultural activities;
    - no hunting or unauthorised taking of products or livestock;
    - compliance with the Traffic Management Plan and all road regulations; and
    - description of disciplinary measures for infringement of the Code and company rules.

- If workers are found to be in contravention of the Code of Conduct, which they signed at the commencement of their contract, they will face disciplinary procedures that could result in dismissal.

- Transnet will ensure that all weeds / vegetation growing along the railway line are constantly removed in order to avoid / minimise the possibility of veld fires.

- Transnet will continue to implement the grievance procedure that ensures that complaints related to Project activities can be lodged and responded to promptly, see *Section 2.2.2*.

- Transnet will create a compensation fund which will be used to compensate farmers for losses and any prolonged disruptions to agricultural activities that will have negative impacts on the financial situation of the Project affected farmers and their neighbours.

2.4.3 *Residual Impact*

The implementation of the above mitigation measures would reduce the construction impacts from **moderate** to **low negative significance** and the operation impacts will be reduced from **moderate** to **negligible significance**. The pre- and post-mitigation impacts are compared in *Table 2.5*.

Table 2.5 Pre- and Post- Mitigation Significance: Disrupted Agricultural Activities

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	HIGH (-ve)	LOW (-ve)
Operation	MODERATE (-ve)	NEGLIGIBLE (-ve)

2.5 *Increased Heavy and Light Load Vehicle Traffic on the Roads*

All construction materials will be transported to the various project sites by road; this will, in turn lead to an increase in road traffic on national, regional, main, and secondary roads.

Construction

Construction materials and goods will be transported to the various sites by road. A total of four major roads will be affected, namely the National Road (N10) in the Eastern Cape, and the Regional Roads (R31, R325, and R385) in the Northern Cape. These roads play an important role in the transportation of goods and people between the Eastern and Northern Cape, and other Provinces. Currently these roads carry a significant number of heavy vehicles, and some of the roads undergo regular upgrades and maintenance. For instance, there are between three and four road work sites on each of these roads at any given time, each of which operates using a "stop-and-go" system, causing a delay of between 15 and 30 minutes. In the Northern Cape, the majority of the heavy vehicles transport minerals and agricultural products from the mines and farms to other Provinces.

The introduction of additional heavy load vehicles on these roads will result in added strain and further deterioration to road quality. On sections of the roads where there are road works, the waiting time is likely to increase.

Secondary roads leading to the various Project Sites have gravel surfaces, and are narrow in sections; they are likely to be difficult to navigate when it is raining. These roads are currently being used by the farmers and local communities living close to the proposed Project Sites. All farms are fenced off, but at times livestock escape (especially in Sishen); this is due to some sections of the fences being unmanned (especially the ones belonging to Transnet) and people forgetting to close the farm gates. In some communities (e.g. Fieldsview) people ride horses on these roads, and the increase in vehicles on the roads will affect these people.

The introduction of both heavy and light vehicles (associated with construction) is likely to impact on the communities in the following ways:

- increased risk of accidents and injuries to people and livestock;
- increased pressure on the secondary roads; and
- increase nuisance factors such as dust and noise

The impact of increased heavy vehicle traffic on the roads will only occur during the construction phase. During operations phase only light vehicles will continue to use the roads to the Project sites. This will occur mainly during maintenance and emergency activities; thus reducing the strain on all Project affected roads.

Impact Assessment: Construction

The impact during the construction phase will be **negative** and **direct** as increased road traffic may lead to the deterioration of major roads, injuries and potential death (human and livestock) on secondary roads. The impact will be **short-term** as it will mainly occur during construction, it will be experienced on the **local**, and **regional/ provincial** levels. The impact severity will be **medium** on both major and secondary roads, as people travelling on the major roads may get frustrated with all the road works; while on the local level, people living close to the Project Sites will be affected by more than increased traffic but also by nuisance factors (dust and noise) and potential fatalities.

The impact is definitely going to occur, thus the likelihood is **high**. The overall impact magnitude (for construction) is rated as **moderate to high negative** due to the possibility of health problems brought on by increased dust, and fatalities to livestock and people.

Even though the Project will have an impact on the roads during construction, it is envisioned that it will have a positive impact during operations as it is likely to decrease the heavy vehicle traffic on the major roads.

Operation

Operational activities of the project are expected to decrease the heavy vehicle traffic on the roads, as the manganese will be transported by rail as opposed to by road on heavy vehicles.

Due to the low capacity of the railway line currently, the majority of the minerals being mined (including manganese ore, iron ore, and others) in the Northern Cape are being transported by road (using heavy vehicles). This places severe strain on the road infrastructure, especially the Regional Roads (R31, R325, and R385). It is expected that once the expansion process is completed, the railway line will reach its full capacity, thus taking the strain off these roads.

Many of the landowners' interviewed were pleased to hear that the expansion of the railway line will reduce the number of heavy load vehicles on the roads. Some reported that they have had accidents, whereby some of the rock materials have fallen off the back of the trucks and hit their car wind-screens.

Impact Assessment: Operation

The decrease in heavy load vehicle traffic will be experienced as an **in-direct positive** impact by many of the road users in the Eastern and Northern Cape. The impact will be **permanent**, as the reduction in road traffic will last beyond the Project lifespan. The Project impact will be of a **local/provincial and national** scale. The impact severity will be **medium,** as there is likely to be decreased heavy vehicle traffic on the roads. There will also be fewer road traffic accidents, as there will be less heavy vehicles on the roads. The impact will occur and its likelihood is rated as high. Overall the impact significance on decreased heavy vehicle traffic on the roads is rated as **moderate** positive.

2.5.2 Mitigation Measures

The following measures are related to construction activities:

- Transnet will inform National and Provincial road agencies about the Project and the scheduled transportation of goods and services to sites and determine the best way forward that will have limited impacts on the major roads (infrastructure and road traffic management).

- Transnet will upgrade the secondary roads should they further deteriorate as a result of Transnet's vehicles.

- Transnet will define and visibly display speed limits along all routes and enforce these amongst all project-related vehicles. Transnet drivers will be sensitised about potential accident risks to local users.

- Transnet to construct traffic calming measures on the road segments that pass through the villages or close to schools in order to reduce speeding.

- Transnet to ensure correct and safe loading of vehicles to avoid accidents.

- Transnet will develop a policy and procedure for assessing all damages and losses (e.g., damage to property, injury or death of people or livestock resulting from negligent project vehicle) and to determine appropriate measures to address these losses. This will be implemented in consultation with the affected parties and other relevant stakeholders, including the authorities.

- Transnet will develop a compensation fund which will be used to compensate farmers who loose livestock due to the Project activities, as well as to compensate people injured by the Project related vehicles.

- Transnet will continue to implement the grievance procedure that ensures that complaints related to Project activities can be lodged and responded to promptly, see *Section 2.2.2*.

- Transnet and its contractor/s will ensure that all drives adhere to the Code of Conduct, see *Section 2.2.2*.

2.5.3 Residual Impacts

The increase in traffic during the construction phases brings with it a number of key risks to the local communities, road users and road infrastructure. With the implementation of the above mitigation measures, these negative impacts can be reduced to **low** significance. The residual impact for the decrease in heavy vehicle traffic will remain **moderate positive**. The pre- and post-mitigation impacts are compared in *Table 2.6*.

Table 2.6 Pre- and Post- Mitigation Significance: Increased Traffic of Heavy Load and Light Vehicles on the Roads

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	**MODERATE to HIGH (-ve)**	**LOW (-ve)**
Operation	**MODERATE (+ve)**	**MODERATE (+ve)**

2.6 CHANGE IN SENSE OF PLACE

The Project activities will create an increase in road traffic, dust, noise and other nuisance factors. These are likely to affect people living close to the project sites, Project affected land owners and their neighbours and temporarily change their sense of place.

Construction

The construction phase activities will result in the creation of nuisance factors e.g. dust, noise, vibration and an increase in traffic. It is predicted that the impact of each of the afore mentioned will be negligible as reported in the specialist studies on noise, dust, vibration and traffic. The in-combination effect on the sense of place is likely to be exacerbated.

Operation

In addition, during operations there will be an increased in train traffic and the trains will be longer than before (between 105-200 wagons per loop), will resulting in an extended waiting times at level road crossings across both Project affected provinces.

Impact Assessment: Construction and Operation

Nuisance factors will be a direct **negative** impact for Project affected landowners and their neighbours; however, these will be **short-term** and experienced mostly during construction. The scale of the impact will be **on-site** and **local**, as it will only be felt by a limited number of people. The severity of the impact is **low** as community livelihoods will not be affected. There is a **high** likelihood that the impact will occur and as such, the overall magnitude of this impact is therefore **low** for construction and **negligible** for operations**.**

2.6.2 *Mitigation Measures:*

- Mitigation related to noise, vibration, and air quality impacts.
- Transnet will give adequate notice to the landowners and their neighbours before construction phase activities commences.
- Notice will be given to surrounding landowners before construction begins such that they are aware of the impacts and may make the necessary changes.
- Work together with local farmer unions and landowners to clearly explain the increased waiting time that is expected at the different crossings.

2.6.3 *Residual Impact*

With the implementation of the above mitigation measure, the impact can be reduced from **low** negative to **negligible**. The pre- and post-mitigation impacts are compared in *Table 2.7* below.

Table 2.7 Pre- and Post- Mitigation Significance: Change in Sense of Place

Phase	Significance (Pre-mitigation)	Residual Impact Significance
Construction	LOW (-ve)	LOW (-ve)
Operation	NEGLIGIBLE	NEGLIGIBLE

2.7 *MANAGING STAKEHOLDER EXPECTATIONS*

During the previous EIA (2009) for the railway upgrade, stakeholder concerns centred on employment and procurement opportunities for the local communities. The same issues were raised as part of the initial site visits for the current expansion Project. As stated in *Section 2.2*, there will be limited employment opportunities for unskilled labour; and the majority of the jobs that will be created will be temporary (mainly during the construction phase). Local civils and construction business owners raised concerns regarding with the awarding of tenders for such projects. They stated that businesses owned by previously disadvantaged people are often not awarded tenders as they lack experience in the construction / supply chain.

Issues related to the community benefits that extend beyond the creation of employment issues have also been raised. It is important for Transnet to pro-actively managed these expectations, as they can lead to escalated levels of conflict and tension if they are not managed in a proactive manner. As such all grievances raised need to be actively managed as per the process outlined in the grievance mechanism.

2.7.1 Precautionary Mitigation

- All concerns regarding jobs and other expectation will be addressed in accordance to the grievance procedures, see *Section 2.2.2.*

- Maximise local employment and procurement as outlined in *Section 2.2.2.*

- Advertise job criteria, required skills and experience for available jobs through local and national media and local communication channels.

- Advertise experience, quality and volume requirements for the supply chain needs.

- Local residents' expectations of Transnet will continue to grow over time. It will not be possible for Transnet to deliver on all community and stakeholder expectations; hence a **CSI Programme** should be developed that clearly outlines the anticipated initiatives. These initiatives will need to be identified in consultation with the local communities. The plan should outline what the nature of the assistance will be and how the investment projects will be distributed through the project area. This strategy will be communicated to stakeholders / local residents to ensure that their expectations remain realistic and are well-managed. Examples of potentially relevant programmes could include community policing, financial management, and drilling of boreholes.

2.8 DISCUSSION: RIPON-KOMADDAGGA

The proposed site layout for Ripon-Komaddagga will result in the relocation of six to eight households. These are located within the Project footprint. The resettlement of these households will result in Project delays and additional financial costs. As a result, Transnet working with Hatch (the engineers on the Project) have identified Sheldon as an alternative site. As a way forward, the Sheldon Project site will be assessed along with the other Project affected sites.

Appendix D6

Air Quality Baseline

H338525-2100-124-0026 Sub01

AIR QUALITY BASELINE ASSESSMENT FOR THE EXPANSION OF THE EXISTING MANGANESE ORE RAILWAY LINE FROM HOTAZEL IN THE NORTHERN CAPE TO THE PORT OF NGQURA IN THE EASTERN CAPE

Issued by:
uMoya-NILU Consulting (Pty) Ltd
P O Box 20622
Durban North, 4016
South Africa

Issued to:
Environmental Resources Management (Southern Africa) Pty Ltd
Silverwood House
Block A, SteenbergOffice Park
Steenberg 7945, Cape Town
South Africa

Mark Zunckel

June 2013

Report details

Client:	Environmental Resources Management (Southern Africa) Pty Ltd
Report title:	Air quality baseline assessment for the expansion of the existing manganese ore railway line from Hotazel in the Northern Cape to the Port of Ngqura in the Eastern Cape
Project:	uM012-12
Report number:	uM012-2012
Version:	Final

Author details

Author: Mark Zunckel
Reviewer: Sarisha Perumal

When used as a reference this report should be cited as follows:

uMoya-NILU (2012): Air quality baseline assessment for the expansion of the existing manganese ore railway line from Hotazel in the Northern Cape to the Port of Ngqura in the Eastern Cape, uMoya-NILU Consulting (Pty) Ltd, Report No. uM012-2012.

GLOSSARY OF ACRONYMS, TERMS AND UNITS

AEL	Atmospheric Emission License
AELA	Atmospheric Emission Licensing Authority
CO	Carbon monoxide
°C	Degrees Celsius
DEA	Department of Environmental Affairs
Emission	The direct or indirect release of substances from individual or diffuse sources in an installation into the air.
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
m/s	Meters per second
mtpa	Million tons per annum
NO_2	Nitrous oxide
NO_X	Oxides of nitrogen, NOx = NO + NO_2
PM_{10}	Particulate matter less than 10 microns
$PM_{2.5}$	Particulate matter less than 2.5 microns
SAWS	South African Weather Service
TSP	Total suspended particulates
SO_2	Sulphur dioxide
VOC	Volatile organic compounds
$\mu g/m^3$	Micrograms per cubic meter
US EPA	United States Environmental Protection Agency

TABLE OF CONTENTS

1. INTRODUCTION

Transnet SOC Ltd has appointed Environmental Resources Management (Southern Africa) (ERM) to undertake an Environmental Impact Assessment (EIA) for the expansion of the existing manganese ore railway line from Hotazel in the Northern Cape to the Port of Ngqura in the Eastern Cape (Figure 1). The upgrade involves, amongst other activities, the extension of existing loops and the development of new loops and the development of a compilation yard and common user facility at Mamathwane near Hotazel.

The construction work and the operation of the railway line, the compilation yard and common user facility are associated with potential impacts on air quality. ERM has therefore appointed uMoya-NILU Consulting (Pty) Ltd, a specialist air quality management consultancy, to conduct an air quality baseline assessment for the expansion project. This baseline assessment includes an overview of the railway line expansion project and the potential sources of air pollution, an overview of the pollutants, a discussion of the regulatory requirements with respect to air quality, and a description of the receiving environment with emphasis on air quality.

2. PROJECT DESCRIPTION AND AIR QUALITY

2.1 Project description

The existing manganese railway line from Hotazel is currently used to transport 5.5 mtpa of manganese ore to the export terminal at Port Elizabeth harbour. An upgrade of the line is necessary to meet the requirements of the proposed increase in export of manganese ore to 16 mtpa, through the planned terminal and the Port of Ngqura. The proposed upgrade activities include the:

- Extension of 11 loops at various places on the existing line to accommodate the 200 wagon trains
- Construction of a new loop at Sishen to accommodate the 200 wagon trains,
- Construction of a new loop at Witloop to accommodate 105 wagon trains,
- The doubling of the rail line at 2 sections (From Ripon to Kommadagga and Cookhouse to Golden Valley)
- Reinstating 105 km of double line track on the line between Kimberley to De Aar ;
- Upgrade of 11 3 kV DC single unit substations to double unit substations
- Upgrade of 8 25 kV AC single unit substations to double unit substations;
- Construction of new single unit substations at Witloop and Vlermuislaagte.
- Installing additional feeder lines and return conductors between substations or tie-stations for 336 km of track between Hotazel and Kimberley.
- Installing additional feeder lines and return conductors between substations or tie-stations for 286 km of track between Kimberley and De Aar.
- Installing additional feeder lines and return conductors between substations or tie-stations for 256 km of track between De Aar and Ngqura.
- Development of a compilation yard at Mamathwane; and
- Development of a Common User Facility at Mamathwane with a transfer point and stockpiles.

Figure 1: The manganese railway line from Hotazel to the Port of Ngqura showing rail loop extensions in green

2.2 Sources of air pollution

2.2.1 *Construction*

Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vehicle dust entrainment, excavation, ground levelling, etc. In most cases the dust is relatively course, but may include fine respireable particles (PM_{10}). Emissions are released close to ground level and have no buoyancy, which limits their dispersion. As a result the coarse particulates generally settle relatively close to the emission source. Finer particulates may be transported further from the point of release, as they are easily carried by wind.

Exhaust emissions from construction vehicles and equipment typically include particulates (including PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs) including benzene.

2.2.2 *Operations*

Railway line

Dust from open rail cars and emissions from locomotives are potential sources of air pollutants on the railway line. Little or no dust is expected to be blown from the ore wagons as the ore is sprayed during loading to bind the dust. Similarly, the wagons have closed bottoms so dust will not fall from them and deposit on the rail tracks. Analysis conducted on soil collected along the existing railway line did not show higher manganese content along the line than elsewhere (uMoya-NILU, 2008). There are no emissions from the electrically powered locomotives used to haul the manganese ore trains on the main railway line.

Compilation yard

The consolidation and deconsolidation of wagon trains by diesel locomotives in the compilation yard will result in emissions which include particulates, oxides of nitrogen (NO_X), sulphur dioxide (SO_2) and volatile organic compounds (VOCs) including benzene. The movement of vehicles and equipment in the compilation yard may generate dust. Dust may also be generated off open areas in the compilation yard by the wind.

Common user facility

Air pollutants will result in the Common User Facility from exhaust emissions and from haulage vehicles. The movement of vehicles and equipment in the compilation yard may generate dust. Dust may also result from stockpiles, from stacking and reclaiming activities as well as being generated from open areas in the facility by wind.

2.3 Air pollutant overview

Particulate matter

In the ambient environment airborne particulates are ranked according to size. Coarse particles associated with dust fallout or depositions are regarded as nuisance impacts, through accumulation and possible discolouration. Finer dust is categorised into sub-classes depending on its size and the associated human health impacts. The coarsest of the fine dust refers to all dust with a diameter of less than 100 µm, known as total suspended particulates (TSP). The fraction of TSP that is inhalable and associated with health impacts has a diameter equal to or smaller than 10 µm and is known as PM_{10}. When exposed to particulate matter through normal nasal breathing, particles larger than 10 µm would be removed in the passage of the air stream through the nose and upper respiratory airways, and particles between 3 µm and 10 µm would be deposited in the upper airways. Finer particles with a diameter equal to or less than 2.5 µm ($PM_{2.5}$) have yielded stronger associations with health impacts than PM_{10} as these particles can infiltrate deeper into the lung. Sources of $PM_{2.5}$ include combustion processes and the formation of atmospheric aerosols during chemical transformations in the atmosphere. Health effects of PM depend on particle size and chemical composition. While the deposition of particulates on to surfaces may pose a nuisance, they may also be a potential risk to human health and wellbeing. Depending on the chemical nature of the particulate and bioavailability of metals, runoff into drinking water or accumulation on vegetation can occur. The South African ambient air quality standards for PM_{10} and $PM_{2.5}$ and dust fallout limits are shown in Table 1.

Oxides of nitrogen (NO_x)

Nitrogen dioxide (NO_2) and nitric oxide (NO) are formed simultaneously in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines. NO_X is a term commonly used to refer to the combination of NO and NO_2. The route of exposure to NO_2 is inhalation and the seriousness of the effects depend more on the concentrations inhaled rather than the length of exposure. The site of deposition for NO_2 is the distal lung (because NO_2 does not readily dissolve in the moist upper respiratory system) where NO_2 reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). Nitrogen dioxide (present in the blood as the nitrite ion) oxidises unsaturated membrane lipids and proteins, which results in loss of control of cell permeability. Nitrogen dioxide causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work or exercise outside will be more at risk to NO_2 exposure (EAE, 2006). In the atmosphere, NO_2 reacts with water vapour to produce nitric acid. This acidic pollution can be transported over long distances by wind and deposited as acid rain, causing the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. NO_2 is also a major source of secondary fine particulate pollution which decreases visibility, and contributes to surface ozone formation through its reaction with VOCs in the presence of sunlight. The South African ambient air quality standards for NO_2 are shown in Table 1.

Sulphur dioxide (SO_2)

The major source of SO_2 is the combustion of sulphur containing fossil fuels such coal, oil and diesel. On inhalation, most SO_2 only penetrates as far as the nose and throat (because it is readily soluble in the moist lining of the upper respiratory system), minimal amounts reach the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high (CCINFO, 1998). The acute response to SO_2 is rapid, within 10 minutes for people suffering from asthma (WHO, 2005). Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise, that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999).SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function. SO_2 has the potential to form sulphurous acid or to slowly form sulphuric acid in the atmosphere via oxidation by the hydroxyl radical. The sulphuric acid may then dissolve in water droplets and fall as precipitation. The South African ambient air quality standards for SO_2 are shown in Table 1.

Benzene

Benzene is a natural component of crude oil, petrol, diesel and other liquid fuels and is emitted when these fuels are combusted. Diesel exhaust emissions therefore contain benzene. After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of benzene to which an individual is exposed and the length of time of the exposure. For example, brief exposure (5–10 minutes) to very high levels of benzene (14000 – 28000 µg/m^3) can result in death (ATSDR, 2007). Lower levels (980 – 4200 µg/m^3) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when they are no longer exposed and breathe fresh air. Inhalation of benzene for long periods may result in harmful effects on the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. Excessive exposure to benzene can be harmful to the immune system, increasing the chance of infection. Both the International Agency for Cancer Research and the Environmental Protection Agency(EPA) have determined that benzene is carcinogenic to humans, as long-term exposure to benzene can cause leukaemia, a cancer of the blood-forming organs. The South African ambient air quality standards for benzene are shown in Table 1.

Manganese

Manganese is a naturally occurring substance found in many types of rocks and soil. It does not occur in the environment as a pure metal, but combined with other substances such as oxygen, sulphur, and chlorine. Manganese is a trace element, necessary for good health. Manganese is used principally in steel production to improve hardness, stiffness, and strength in products like carbon steel, stainless steel, high-temperature steel, tool steel, cast iron and superalloys. The toxicity of manganese varies according to the route of exposure. By ingestion, manganese has relatively low toxicity at typical exposure levels and is considered a nutritionally essential trace element. By inhalation, however, manganese has been known to be toxic to workers (WHO, 2000). There is no South African ambient air quality standard for manganese. The IRIS Reference Concentration for Chronic Inhalation Exposure (RfC) of 0.05 µg/m^3 for manganese reports a Lowest Observed Adverse Effect Level (LOAEL) of 0.05 mg/m^3. This study has an uncertainty factor of 1000 with a confidence rating of 'medium' that had been applied to the study itself, to the data and to the RfC. The WHO ambient annual guideline value for manganese of 0.15µg/m^3 is derived by dividing the NOAEL by a factor to adjust for continuous exposure and to account for the uncertainty (WHO, 2000).

3. THE REGULATORY REQUIREMENTS

3.1 Atmospheric emission license

Section 21 of the National Environmental management: Air Quality Act (Act 39 of 2004), the AQA, defines Listed Activities as those that the Minister reasonably believes have or may have a significant detrimental effect on the environment. Government Notice 248 (DEA, 2010) defines the Listed Activities and where applicable, minimum emission standards and special conditions. According to Section 37 of the AQA, an application for and Atmospheric Emission License is required for all Listed Activities.

According to Category 5 (Mineral processing, storage and Handling and sub-category 5.1 (Storage and handling of ore or coal) of the list of activities, all installations that are not situated on a mine and hold more than 100 000 tons of ore or coal are classified as a Listed Activity. Transnet will therefore require an AEL for the Common User Facility and this must be supported by an atmospheric impact report (Section 30 of the AQA). The application must be lodged with the relevant AEL Authority.

The principal condition of sub-category 5.1 is that dust fall is measured in eight principal wind directions and the 3-month running average does not exceed the limit values for the adjacent land-use, according to the Draft National Dust Control Regulation (DEA, 2011b) (published on 27 May 2011 for public comment) which formalises the SANS recommendations.

This regulation states that no person may conduct any activity in such a way as to give rise to dust in such quantities and concentrations that:

a) The dust, or dust fall, has a detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or
b) The dust remains visible in the ambient air beyond the premises where it originates; or
c) The dust fall at the boundary and beyond the boundary of the premises where it originates exceeds:
    i) 600 mg/m^2/day averaged over 30 days in residential or light commercial areas measured using reference method ASTM D1739; or
    ii) 1200 mg/m^2/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM D1739.

3.2 Ambient air quality standards

Health-based ambient air quality standards have been established for criteria pollutants and one toxic air pollutant in South Africa. Being health-based, these standards imply that the ambient concentrations less than the standard do not pose a health risk, while concentrations above the standard may pose a risk. The national ambient air quality standard consists of a limit value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the tolerated exceedance of the limit value and accounts for high concentrations as a result of process upsets and meteorological variation. Compliance with the ambient standard, therefore implies that ambient concentrations are below the limit value and the frequency of exceedance does not exceed the permitted tolerance. The criteria pollutants of concern for this assessment are SO_2, NO_2, PM_{10}, $PM_{2.5}$ and benzene from diesel locomotives and ore handling. The national ambient standards are listed in Table 1.

Table 1: National ambient air quality standards (Republic of South Africa, 2009a and 2012)

Pollutant	Averaging period	Limit value µg/m^3	Frequency of exceedance	Compliance date
SO_2	10 min	500	526	In effect
	1-hour	350	88	In effect
	24-hour	125	4	In effect
	Annual	50	0	In effect
NO_2	1-hour	200	88	In effect
	Annual	40	0	In effect
PM_{10}	24 hour	120	4	In effect
	24-hour	75	4	1 Jan 2015
	Annual	50	0	In effect
	Annual	40	0	1 Jan 2015
$PM_{2.5}$	24-hour	65	0	In effect
		40	0	1 Jan 2016–31 Dec 2029
		25	0	1 Jan 2030
	Annual	25	0	In effect
		20	0	1 Jan 2016–31 Dec 2029
		15	0	1 Jan 2030
Benzene	Annual	10	0	In effect
		5	0	1 Jan 2015

4. AIR QUALITY STATUS

4.1 Climate

The climate of any location is determined primarily by its latitude, elevation and distance from the sea. Secondary influences are the general atmospheric circulation, the nature of the earth's surface, vegetation and the orientation topographical features. The climate will therefore vary considerably along the manganese railway line from Hotazel to the Port of Ngqura. Over the northern parts of the route in the Northern Cape daytime summer temperatures are hot and mild at night, winter daytime temperatures are mils and nights are cold. Rainfall is almost exclusively due to showers and thundershowers in summer. Over the Eastern Cape interior summer temperatures are not as extreme as over the Northern Cape, but winter nights are very cold. Towards the coast temperatures are moderated due to the influence of the warmer Indian Ocean. The average annual rainfall varies across the interior from 317 mm per annul to 418 mm at Postmasburg. The average annual rainfall at Port Elizabeth is 624 mm and rain occurs through the year.

The relative difference in monthly average maximum and minimum temperatures and daily average temperature are shown in Figure 2 from north to south at selected sites along the railway line at Postmasburg, Kimberley, de Aar, Cradock and Port Elizabeth. The average monthly rainfall is also shown.

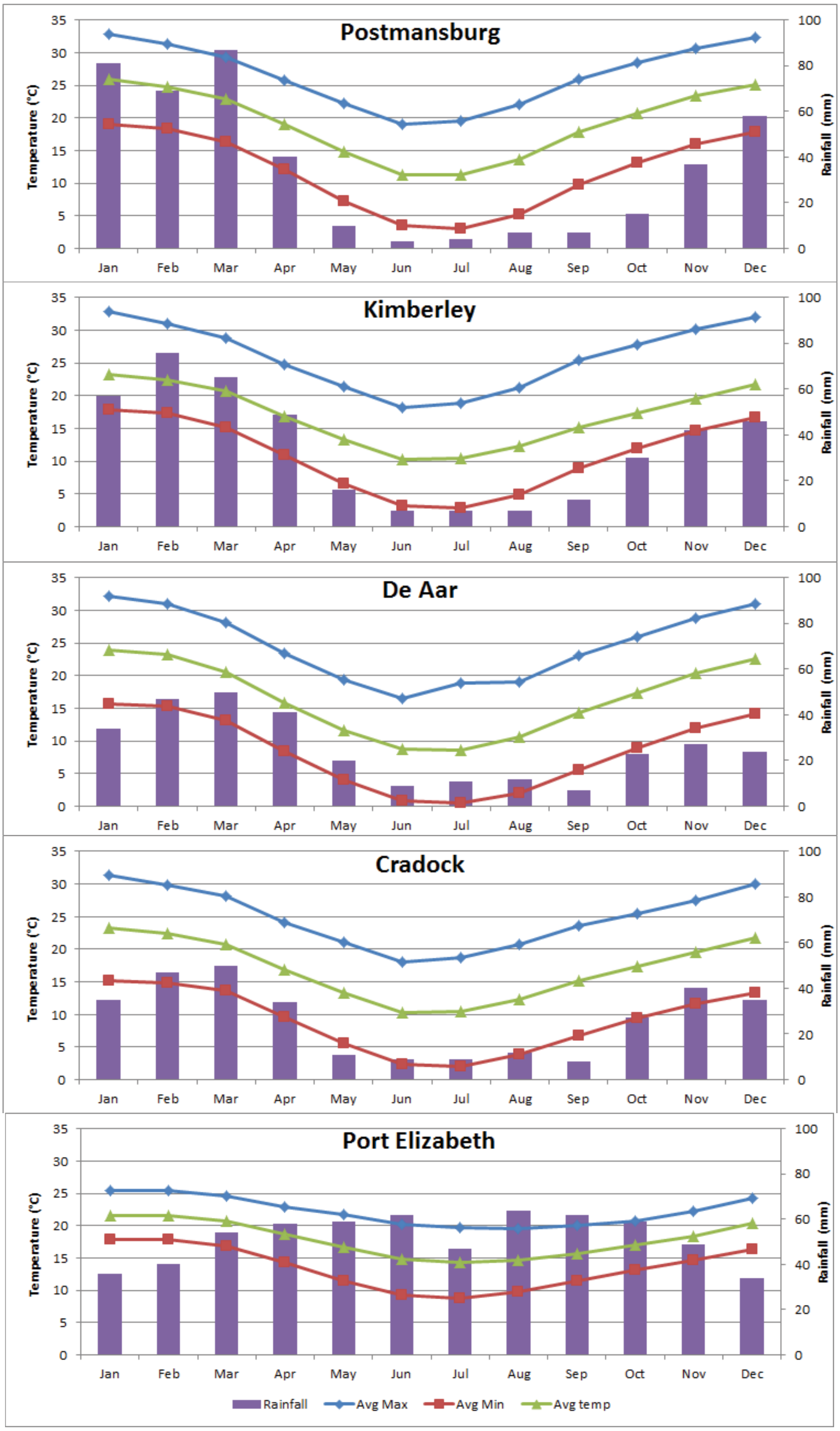


Figure 2: Average monthly maximum and minimum temperature and average daily temperature in °C and average monthly rainfall in mm at selected sites along the railway line route (SAWS, 1998)

Over the northern and central parts of the route in the Northern Cape and the Eastern Cape the winds are generally light to moderate and from the north to northeast. Over the extreme southern parts of the route the wind tends to follow the coastline and the prevailing winds in the Port Elizabeth area are west-southwesterlies and east-northeasterlies. Figure 3 shows the windrose at Port Elizabeth Airport which simultaneously depict the frequency of occurrence of wind from the 16 cardinal wind directions and wind speed classes, for a single site. Wind direction is given as the direction from which the wind blows, i.e., southwesterly winds blow from the southwest. Wind speed is given in meters per second (m/s), and each arc represents a percentage frequency of occurrence (5% in this case).

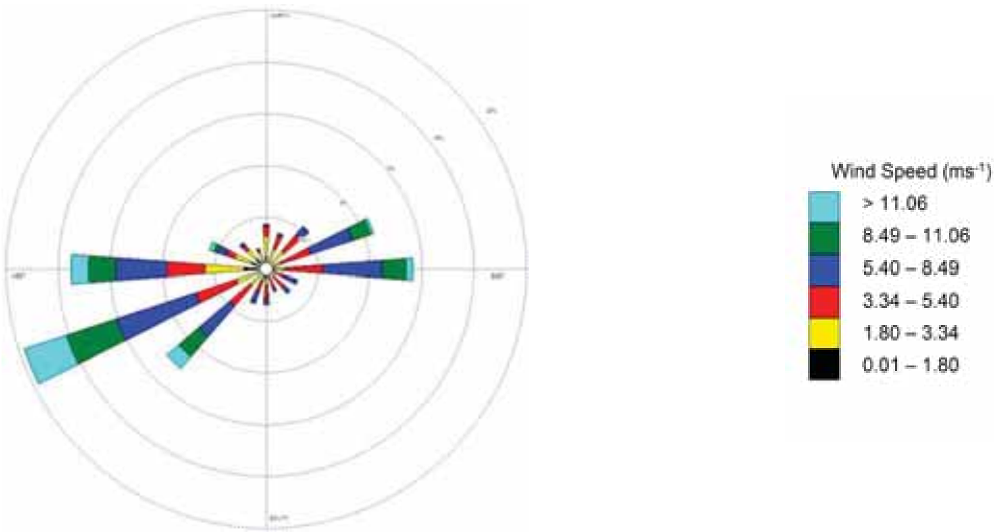


Figure 3: Annual wind roses for Port Elizabeth Airport for 2009-2011.

The poorest atmospheric dispersion conditions occur with inversion conditions and calm or light winds. Greater surface cooling in winter is conducive to the formation of surface temperature inversions and a shallow mixing layer, particularly at night. The mixing layer is the layer in which pollutants are able to mix. Pollutants released into the inversion layer are typically trapped between the surface and the top of the inversion. Under light wind conditions, pollutants will tend to accumulate. It is under these conditions for May to July, when the strongest inversions are expected to occur throughout the study area. The inversions are expected to be stronger over the whole of the interior than on the coast due to colder nigh time temperatures.

4.2 Ambient air quality

The manganese railway line runs from the mines at Hotazel to the Port of Ngqura. It passes mostly through sparsely populated rural areas consisting of agricultural lands and natural vegetation. It also passes through a number of urban centres of varying sizes. Industrial activity in all of these is relatively limited consisting of small manufacturing concerns with limited emissions of pollutants to the atmosphere. Emissions from these may include sulphur dioxide (SO_2), oxides of nitrogen (NO_X) and particulate matter including respireable PM_{10} and $PM_{2.5}$. In Hotazel mining, ore processing and handling are sources of particulates.

In un-electrified homes in residential areas along the route wood and other fuels are burnt for cooking and space heating. In winter typically more fuel is burnt than in summer because of the colder temperatures. Pollutants associated with wood burning include CO, NO_X and particulates. Vegetation burning for agricultural purposes and other forms of land management are also sources of gaseous and particulate pollutants.

There are no measurements of ambient air quality on the manganese railway line except at Van Zyl's Rus and Kuruman in the Northern Cape. At the mines and ore handling facilities in the Northern Cape, ambient particulate concentrations are expected to be relatively high. Air quality is expected to be relatively good and this is shown by manganese monitoring at Van Zyl's Rus and Kuruman. Measured concentrations at these residential sites are below the WHO annual ambient air quality guideline (DEA, 2009b).

In the urbanised centres along the freight route, ambient air quality is expected to be generally good and possibly only impacted on by emissions from sources such as small industrial boilers and motor vehicles. In residential areas that the railway line runs close to, where wood and other biomass fuels are used for heating and cooking, air quality may to be poor. In the evenings and early mornings when fires are made, especially in winter air quality in these areas will be most impacted. Elsewhere along the route ambient air quality is expected to be very good.

5. POTENTIAL IMPACTS

The manganese railway line passes mostly through sparsely populated rural areas consisting of agricultural lands and natural vegetation and a number of urban centres of varying sizes on route from Hotazel to the Port of Ngqura. There are no significant sources of air pollution with small manufacturing concerns and the use of wood and other fuels for cooking and heating. There are no measurements of ambient pollutants, but without significant sources air quality is expected to be good.

The civil construction activities associated with the railway line upgrade are likely to generate dust and the emission of particulates into the atmosphere as a result of vehicle entrained dust, excavation, ground levelling, and windblown dust from open areas. Dust from construction activities is generally relatively course, but may include fine respireable particles (PM_{10}). The dust is released close to ground level and has little or no buoyancy, limiting the extent of its dispersion. The coarse particulates generally settle relatively close to the point of release, but finer particulates may be transported further as they are easily carried by wind. Exhaust emissions from construction vehicles and equipment typically include particulates (including PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs) including benzene. They are released close to ground level and their dispersion in inhibited. With construction being relatively short in duration the impacts are likely to be temporary and a nuisance only.

Dust from open rail cars and emissions from locomotives are potential sources of air pollutants along the railway line. However the ore is sprayed with water during loading and dust id bound to the ore so little or no dust is expected to be blown from the ore wagons. Similarly, the wagons have closed bottoms so dust does not fall through and deposit on the rail tracks. There are no emissions from the electrically powered locomotives on the main railway line.

The consolidation and deconsolidation of wagon trains by diesel locomotives in the compilation yard will result in emissions of particulates, oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) including benzene. The activities will endure for the operational lifetime of the facility. These pollutants may pose a health risk in the neighbouring environment if the resultant ambient concentrations of these pollutants exceed the health-based ambient air quality standards. Wind entrained dust from open areas in the compilation yard and may present a nuisance impact.

Manganese ore will be dumped, stored, reclaimed and loaded into train wagons in the Common User Facility. Dust generated from the handling of ore as well wind entrained dust from the stockpiles and open areas may present nuisance impacts in the surrounding environment.

REFERENCES

CCINFO, (1998): The Canadian Centre for Occupational Health and Safety database. http://ccinfoweb.ccohs.ca visited on 21 July 2003.

EAE, (2006): Encyclopaedia of the Atmospheric Environment, 2006, Nitrogen [Online], http://www.ace.mmu.ac.uk/eae/Air_Quality/Older/Nitrogen_Dioxide.html

DEA, (2009a): National Ambient Air Quality Standards, DEA, 32861, Vol. 1210, 24 December 2009.

DEA, (2009b): State of Air Report 2005, A Report on the State of Air in South Africa, ISBN 978-0-621-38724-7.

DEA, (2010): Listed Activities and Associated Minimum Emission Standards indentified in terms of Section 21 of the Air Quality Act, Act No. 39 of 2004, DEA, 33064.

DEA, (2011): Draft National Dust Control Regulations in terms of the National Environmental of the Air Quality Act, Act No. 39 of 2004, Notice 309 of 2011, Government Gazette, 34307.

DEA, (2012): Proposed National Ambient Air Quality Standard for Particulate Matter of Aerodynamic Diameter less than 2.5 micrometers, Notice 515 of 2011, Government Gazette, 34493.

WHO, (1997): Guidance for setting air quality standards. Report on a Working Group. Barcelona, Spain 12-14.

WHO, (1999): Guidelines for Air Quality, World Health Organisation, http://www.who.int/peh/air/Airqualitygd.htm

WHO, (2000): Air Quality Guidelines for Europe, 2nd Edition, World Health Organisation, ISBN 92 890 1358 3.

WHO, (2005): WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, Global update 2005, Summary of risk assessment, WHO/SDE/PHE/OEH/06.02.

Appendix D7

Surface Water Assessment

WATERCOURSE ASSESSMENT FOR THE PROPOSED UPGRADE OF THE TRANSNET MANGANESE ORE RAILWAY (AREA 1 - KIMBERLEY – HOTAZEL)

Prepared for:
Hatch
11 Harrowdene Office Park,
Western Service Road,
Woodmead,
JOHANNESBURG, 2157

Prepared by:
Imperata Consulting
69 Chateaux de Grace,
71 Hardekool Avenue,
Val de Grace,
PRETORIA, 0040

March 2013

IMPERATA CONSULTING
Wetlands • Ecology • Responsibility

CC Reg. No: 2007/043725/23
Sole Member: LER Grobler
Wetland Ecologist (Pr. Sci. Nat)
Reg. No.: 400097/09

P.O. Box 72914
Lynnwood Ridge, 0040
Email: retief@imperata.co.za
Fax: 012 365 3217

SPECIALIST STATEMENT DETAIL

This statement has been prepared with the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (Act 107 of 1998), any subsequent amendments and any relevant other National and / or Provincial Policies related to biodiversity assessments in mind.

Report prepared by: Mr Retief Grobler Pr.Sci.Nat. (Ecological and Botanical Sciences)

Expertise / Field of Study: BSc (Hons) Botany, MSc Botany and wetland / riverine assessment consultant from 2006 to present.

I, **Mr. Retief Grobler** declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs

Signed:... .... Date:...25 March 2013........

Table of Contents

1. Introduction

Imperata Consulting was appointed to assist Hatch (on behalf of Transnet (SOC) Ltd) with conducting the relevant specialist assessments to fulfil the requirements of the respective Section 21 (c) & (i) water use licenses (WULAs) for the proposed expansion of the manganese export corridor (Hotazel through to the Port of Ngqura), with a specific focus on culvert construction works associated with the railway expansion project. The manganese corridor is proposed to be upgraded to facilitate the export of 16 million tons per annum and is divided into three primary work packages; Area 1 (Hotazel to Kimberley); Area 2 (Kimberley to De Aar) and Area 3 (De Aar to the Port of Ngqura).

Area 1 is the focus of this report and the scope of work includes, but is not limited to:

- The extension of 10 existing rail loops
- The construction of 1 new rail loop
- The construction of a new compilation yard
- The construction of a system separation yard.

The relevant water use licenses under the National Water Act (Act No 36 of 1998) are required for any construction that is to take place within a bed or bank of water course, impede or divert flows from a watercourse or within 500 m of a wetland. The construction of culverts, specifically the extension of existing culverts in rail loops, received special attention as part of the field assessment procedure. This was done in order to assess any watercourses that may be present at culvert positions, as well as the impact and risks of culvert construction works on identified watercourses. The water use license application must also be supported by additional documentation such as the Section 21 questionnaire, of which this report will form part.

This report assesses the extent of any wetlands, other watercourses, and drainage systems that may not be regarded as watercourses according to the National Water Act (Act 36 of 1998) within the proposed development footprints. A Present Ecological State (PES) assessment was also undertaken for all of the delineated drainage features. This assessment was based on one site visit conducted during November 2012. The following proposed sections were investigated in Area 1; new loop or loop extension distances that were investigated for each section are also indicated (total distance ±38.2 km):

Beaconsfield system separation facility (±3.8 km)	Glosam loop extension (±2 km)
Fieldsview loop extension (±5 km)	Sishen new loop (±2.7 km)
Gong-Gong loop extension (±2.6 km)	Wincanton loop extension (±3.2 km)
Ulco loop extension (±2.4 km)	Mamathwane compilation yard (±7 km)
Trewil loop extension (±1.2 km)	Burgervilleweg loop extension (± 2.6 km)
Tsantsabane loop extension (±1.2 km)	Linde loop extension (± 2.4 km)
Postmasburg loop extension (±3.3 km)	

The project involves the construction of eleven new loops and loop extensions, 1 compilation yard (Mamathwane), and a system separation yard (Beaconsfield) within Area 1. Several different biomes, vegetation types (ecosystems) and Ecoregions are spanned by the linear project, but each component is dealt with separately in terms of watercourse related findings and discussions. However, due to the nature of the impacts and the present state of the receiving environment (i.e. railways are already present), all impacts will be discussed as a whole for the entire project unless indicated otherwise.

Several terms and definitions are used in this report with regard the aquatic studies and the reader is referred to the box below for additional detail.

Definition Box

Present Ecological State (PES) is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State. Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development. The PES is determined per component - for rivers and wetlands this would be for the drivers: flow, water quality and geomorphology; and the biotic response indicators: fish, macroinvertebrates, riparian vegetation and diatoms. PES categories for every component would be integrated into an overall PES for the river reach or wetland being investigated. This integrated PES is called the EcoStatus of the reach or wetland.

Ecoregions are geographic regions that have been delineated in a top-down manner on the basis of physical/abiotic factors. • NOTE: For purposes of the classification system, the 'Level I Ecoregions' for South Africa, Lesotho and Swaziland (Kleynhans *et al.* 2005), which have been specifically developed by the Department of Water Affairs (DWA) for rivers but are used for the management of inland aquatic ecosystems more generally, are applied at Level 2A of the classification system. These Ecoregions are based on physiography, climate, geology, soils and potential natural vegetation.

Conservation importance and sensitivity of the individual systems also known as **Ecological Importance and Sensitivity (EIS)** was based on the following criteria based on an adaptation of the method proposed by Rountree & Malan (2010):

- Habitat uniqueness
- Species of conservation concern
- Habitat fragmentation with regard ecological corridors
- Ecosystem service (social and ecological)

EIS categories used include Very high, High, Moderate, Low/marginal.

2. Study Area Description

The 11 loop sections, one compilation yard and one system separation yard of Area 1 overlap with three different Water Management Areas (WMA), three Ecoregions (Level 1), and 10 Quaternary Catchments. A division has been made to describe geographically clustered component together based on a combination of Water Management Area and Ecoregion properties. Components that do not fall within a clearly defined WMA due to endorheic Quaternary Catchment features are discussed as such

2.1. Upper Orange Water Management Area – Southern Kalahari Ecoregion

A single separation yard, Beaconsfield, is located within this WMA and Ecoregion combination. The proposed separation yard is located in the southern portion of Kimberley and is orientated along the catchment divide between Quaternary Catchments C51L and C52L (Figure 1). Both Quaternary catchments drain towards the Riet River and have a mean annual rainfall that ranges between 350-377 mm per annum (Middleton & Bailey 2008). The Beaconsfield study area forms part of the Kimberley Thornveld vegetation unit, which is characterised by undulating plains with a sandy to loamy soils and a well developed tree layer that typically include *Acacia erioloba, A. tortilis*, *A. karroo* and *Boscia albitrunca* (Mucina & Rutherford 2006).

2.2. Lower Vaal Water Management Area – Southern Kalahari Ecoregion & Ghaap Plateau

Ten components are located within this WMA and Ecoregion combination that extend over 6 Quaternary Catchments. They include the following proposed loops: Fieldview, Gong Gong, Ulco, Trewil, Tsantsabane, Postmasburg, Glosam, Sishen, and Wincanton, as well as a single compilation yard at Mamathwane in the far north (Figure 1).

2.2.1. Fieldview & Gong Gong

Both of these loop extensions are located in Quaternary Catchment C91E in the Southern Kalahari Ecoregion and drain towards the Lower Vaal River, which is located in close proximity (Figure 1). They also form part of the Kimberley Thornveld vegetation unit and overlap with andesitic lavas of the Allanridge Formation, which is interspersed with quaternary substrates, such as sand and calcrete (Mucina & Rutherford 2006). The rainfall of the area is approximately 371 mm per annum with very dry winters (Middleton & Bailey 2008).

2.2.2. Ulco

Ulco loop extension is located in Quaternary Catchment C33C in the Southern Kalahari Ecoregion and drains toward the Lower Harts River, which is located in close proximity (Figure 1). The area is located within the Schmidtsdrif Thornveld, which consist of closed *Acacia* spp. shrubs (*A. mellifera* & *A. tortilis*) on shallow Mispah soils that are rocky and well drained (Mucina & Rutherford 2006). The mean annual rainfall in the area is approximately 397 mm with frost frequent during winter (Middleton & Bailey 2008).

2.2.3. Trewil

Trewil loop extension is the only component of Area 1 that is located in the Ghaap Plateau Ecoregion as well as the Ghaap Plateau Vaalbosveld vegetation unit. The area is located on a flat plateau with surface limestone and a geology that is derived from dolomite and chert of the Campbell Group. The resultant soils are shallow (0.1-0.25 m) and well drained (Mucina & Rutherford 2006).

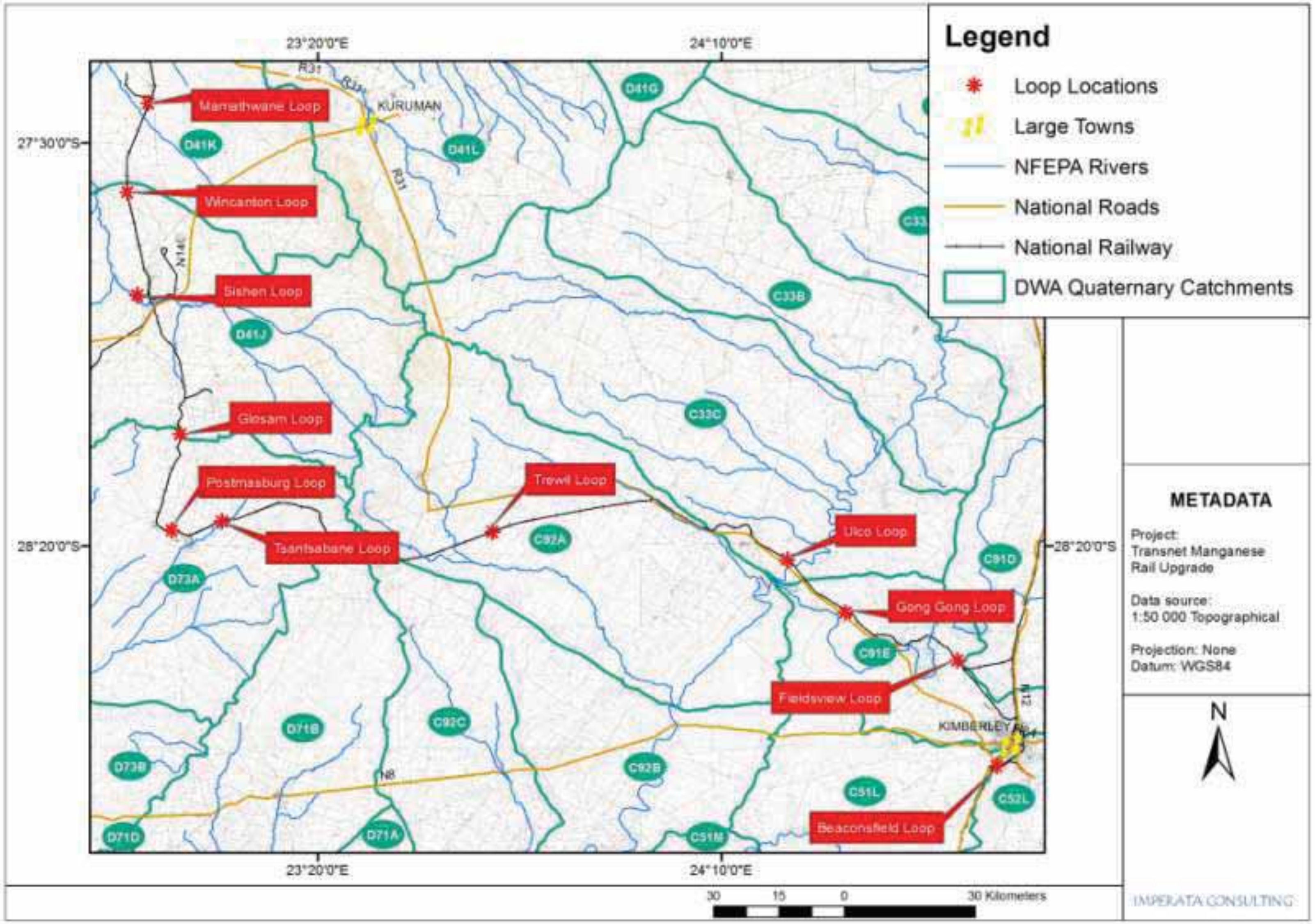


Figure 1: The eleven Area 1 study areas with their respective loop section and Quaternary Catchments. (Source DWA, NFEPA & Hatch).

Small depressions or arid pans are common on the flat and elevated surface of the landscape. The area falls within Quaternary Catchment C92A and drains towards the Klein Riet River, while it mean annual rainfall is 367 mm (Middleton & Bailey 2008).

2.2.4. Tsantsabane, Postmasburg & Glosam

All three loop extensions are located within the Southern Kalahari Ecoregion and Quaternary Catchment D73A, which is regarded as an entirely endorheic (inward draining) catchment that does not truly form part of the Lower Vaal or Lower Orange Water Management Areas (Middleton & Bailey 2008). Tsantsabane and Postmasburg loops drain towards the Groenwaterspruit, while Glosam drains toward an unnamed watercourse. The three areas extend across Kuruman Thronveld and Kuruman Mountain Bushveld vegetation units with landscapes that include flat rocky plains and rolling hills.

The geology includes dolomite and chert from the Campbell Group, as well as wind-blown Kalahari Group sediments, while Asbestos Hills around Postmasburg contain banded iron formation, with jaspilite, chert and riebeckite asbestos (Mucina & Rutherford 2006). The mean annual rainfall in the area is approximately 323 mm with frost frequent during winter (Middleton & Bailey 2008).

2.2.5. Sishen, Wincanton & Mamatwane

This new loop (Sishen) and loop extension (Wincanton) are located within Quaternary Catchment D41J, while the compilation yard (Mamatwane) is located in D41K (Figure 1). The two loops drain towards Ga-Mogara River, while Mamatwane first drains into Vlermuislaagte that crosses through the study area before it forms a confluence with the Ga-Mogara River further downstream. Kathu Bushveld forms the only vegetation unit in all three components, and is characterised by deep Aeolian red sands that are often associated with Hutton and Clovelly soil forms (Mucina & Rutherford 2006). The mean annual rainfall in the area ranges between 344-358 mm with frost frequent during winter (Middleton & Bailey 2008).

2.3. Lower Orange Water Management Area – Nama Karoo

A single loop extension, Burgervilleweg, is located within this WMA and Ecoregion combination. The proposed loop occurs within Quaternary Catchment D62D of the Brakrivier approximately 32 km southeast of De Aar (Figure 2). Permanent rivers or wetland areas are limited mostly to mainstem rivers, such as the Brakrivier, and none were expected within or adjacent to the loop footprint.

The Upper Nama Karoo (Nku3) vegetation of the region is limited by the low annual rainfall (ca. 190 – 200 mm/a) and is dominated by flat pediplain areas and hills with rocky outcrops. The geology is mostly Dwyka / Ecca shales overlaid with shallow sandy soils that drain well.

2.4. Upper Orange Water Management Area – Nama Karoo Ecoregion

A single loop, Linde, is located within this WMA and Ecoregion combination. The proposed Linde loop extension falls within the D32F Quaternary Catchment, which drains in a northern direction towards the Seekoei River (Figure 2). However, watercourse and other drainage systems found within the loop footprint are not connection with the Seekoei River drainage network.

The vegetation is dominated by the typical Eastern Upper Karoo (Nku4) (Mucina& Rutherford, 2006) vegetation type within the Nama Karoo Ecoregion within a landscape composed of flat and gently sloping plains interspersed with small hills, some with large rocky outcrops. The soils are mostly shallow and drain well. Vegetation associated with aquatic systems were thus limited possibly due to the sandy soils (underplayed by mudstone and sandstone) couple to a low annual rainfall (ca. 180 mm/a).

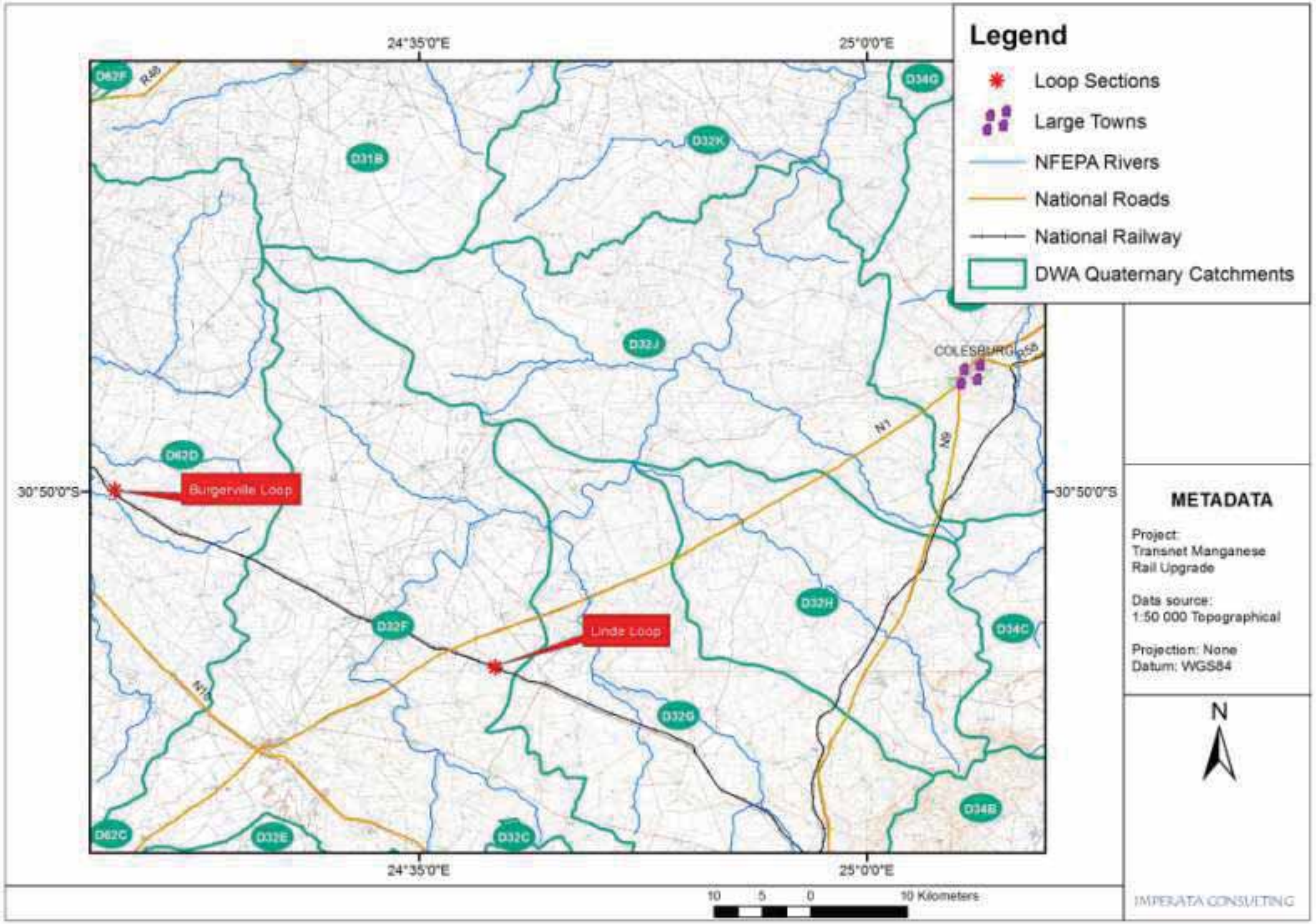


Figure 2: The Burgervilleweg and Linde study areas in relation to the Brakrivier Quaternary Catchment D62D and D32F respectively (Source DWA, NFEPA & Hatch).

3. Relevant Legislation and Policy

Locally the South African Constitution, seven Acts and one international treaty allow for the protection of natural vegetation, rivers and watercourses. These ecosystems are thus protected from the destruction or in the case of aquatic systems from pollution by the following:

- Section 24 of The Constitution of the Republic of South Africa;
- Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998;
- National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) inclusive of all amendments, as well as the NEM: Biodiversity Act, 2004 (Act 10 of 2004);
- National Water Act, 1998 (Act No. 36 of 1998);
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983);
- Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002);
- Nature and Environmental Conservation Ordinance (No. 19 of 1974);
- National Forest Act (No. 84 of 1998); and
- National Heritage Resources Act (No. 25 of 1999).

An amendment of the National Environmental Management: Biodiversity Act or NEM:BA (Act No. 10 of 2004) has been gazetted, which lists 225 threatened ecosystems based on vegetation type as described in Vegmap by Mucina & Rutherford (2006). Some of these are riverine specific and do occur within the Ecoregions (level 1). Should a vegetation type or ecosystem be listed, actions in terms of NEM:BA are triggered, however, **none** of these listed vegetation types occur within the study area, as all of the identified vegetation units described by Mucina & Rutherford (2006) in all of the study area components have a Least threatened conservation status. In addition, no areas identified in the National Protected Area Expansion Strategy of 2008 (NPAES) overlap with study area components, nor do any formally protected areas.

This report will be used as per the relevant submissions to the Department of Water Affairs in terms the registration / licensing (as required) for Section 21 c & i water uses.

Provincial legislation and policy

No accepted policies exist for the Northern Cape region of the study area and thus the following will be used for the study:

Various guidelines on suitable development have been issued in a number of the provinces, including the Eastern Cape Province and those stated in this report are based on accepted provincial guidelines as stated in the Eastern Cape Biodiversity Conservation Plan or ECBCP (Table 1). These are shown below to take cognisance of the required buffers during the planning phase. Although construction may have to take place within the watercourses, the associated batch plants, stockpiles, lay down areas and construction camps should avoid these buffer areas.

Currently there are no accepted wetland buffers distances provided by the provincial authorities. Until such a system is developed, it is recommended that a 50m buffer be set for all wetlands and 32m for rivers and watercourses, as well as indistinct drainage systems.

Table 1: Recommended buffers for rivers (the predominant buffer for the study region is highlighted in **blue)**

River criterion used	Buffer width (m)	Rationale
Mountain streams and upper foothills of all 1:500 000 rivers	50	These longitudinal zones generally have more confined riparian zones than lower foothills and lowland rivers and are generally less threatened by agricultural practices.
Lower foothills and lowland rivers of all 1:500 000 rivers	100	These longitudinal zones generally have less confined riparian zones than mountain streams and upper foothills and are generally more threatened by development practices.
All remaining 1:50 000 streams	32	Generally smaller upland streams corresponding to mountain streams and upper foothills, smaller than those designated in the 1:500 000 rivers layer. They are assigned the riparian buffer required under South African legislation.

4. Methods

4.1 Study terms of reference

The scope of work of the study is based on the following:

- Identify and delineate aquatic systems (watercourses and drainage systems) that may be impacted upon by the proposed railway expansion.
- Rate the PES & EIS of delineated systems using suitable methods accepted by the Department of Water Affairs.
- Identify and rate potential environmental impacts.
- Provide a significance rating of surface water impacts which includes a rating of the ecological sensitivity of the site, and the effect of the development on the ecology of the site based on available information.
- Identify mitigation measures for negative and positive impacts.

Based on our understanding of these requirements, Imperata Consulting would produce the following:

- Riparian and /or wetland area delineation supplied together with an analysis of the potential aquatic sensitivity (including any wetlands should they occur).
- The delineation of other watercourses, such as natural channels with regular or intermittent flow and marginal drainage systems that lack distinct wetland and riparian indicators, as well as channel features.
- PES assessment of each study area, in line with the Department of Water Affairs requirements with regards to the necessary Section 21 (c) & (i) water use licenses. Emphasis is placed on watercourse and drainage system crossings, as well as wetlands located within a 500 m radius of each project component.

- Compile an impact assessment report and provide suitable recommendations.

4.2 Study methods

This assessment was initiated with a survey of the pertinent literature, past reports that exist for the study region. Maps and Geographical Information Systems (GIS) were then employed to ascertain, which portions of the proposed development, could have the greatest impact on the watercourses and associated habitats.

A site visit was then conducted to ground-truth the above findings, thus allowing critical comment on the possible impacts. Information was also collected to determine the PES and Ecological Importance and Sensitivity (EIS) of the various watercourse crossings sites. These analyses were based on the models developed for the Department of Water Affairs using a modified version of the Index of Habitat Integrity (IHI) model (Kleynhans *et al*. 2008), with the results producing a ratings (A – F), summarised in Table 2. The IHI assess the state of a system or a small section of the system (reach), based on rating the integrity of the following aspects and / or impacts within the instream (riverbed) and riparian or floodplain habitats:

INSTREAM HABITAT

- Water abstraction
- Extent of inundation
- Water quality
- Flow modifications
- Bed modification
- Channel modification
- Presence of exotic macrophytes
- Presence of exotic fauna
- Presence of solid waste

RIPARIAN HABITAT

- Water abstraction
- Extent of inundation
- Water quality
- Flow modifications
- Channel modification
- Decrease of indigenous vegetation
- Exotic vegetation encroachment
- Bank erosion

It should be noted that the IHI model used in this assessment was modified as the majority of the systems were either small drainage lines or mostly ephemeral, thus the full IHI model was not applied.

The following method was used to assess aquatic areas (wetlands, other watercourses and marginal drainage systems), which were defined on the following basis:

- Vegetation type – verification of type and its state or condition based, supported by species identification using Germishuizen and Meyer (2003), Vegmap (Mucina and Rutherford, 2006 as amended) and the South African Biodiversity Information Facility (SABIF) database. The SABIF database contains older species records for areas, thus allowing to compare present versus past states.
- Plant species were further categorised as follows:
    - Terrestrial: species are not directly related to any surface or groundwater base-flows and persist solely on rainfall
    - Facultative: species usually found in wetlands (inclusive of riparian systems) (67 – 99% of occurrences), but occasionally found in terrestrial systems (DWAF, 2005)
    - Obligate: species that are only found within rivers and wetlands (>99% of occurrences) (DWAF, 2005)
- Mitigation measures or recommendations required

Table 2: Description of A – F ecological categories based on Kleynhans *et al*., (1999).

ECOLOGICAL CATEGORY	ECOLOGICAL DESCRIPTION	MANAGEMENT PERSPECTIVE
A	Unmodified, natural.	Protected systems; relatively untouched by human hands; no discharges or impoundments allowed
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	Some human-related disturbance, but mostly of low impact potential
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	**Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation**
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	**Often characterized by high human densities or extensive resource exploitation. Management intervention is needed to improve health, e.g. to restore flow patterns, river habitats or water quality**
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

Conservation importance and sensitivity of the individual systems also known as EIS was based on the following criteria based on an adaptation of the method proposed by Rountree & Malan (2010):

- Habitat uniqueness
- Species of conservation concern
- Habitat fragmentation with regard ecological corridors
- Ecosystem service (social and ecological)

The presence of any or a combination of the above criteria would result in a HIGH conservation rating if the wetland was found in a near natural state (high PES). Should any of the habitats be found modified the conservation importance would rate as MODERATE, unless a Species of conservation concern was observed (HIGH). Any system that was highly modified (low PES) or had none of the above criteria, received a LOW conservation importance rating.

Therefore should any of the systems be rate with a High PES and with HIGH conservation importance then they would be considered as extremely sensitive to development. None of the study area systems possessed any of these attributes, either due to their ephemeral nature, lack of biodiversity or were impacted upon.

It must be noted that the that investigations related to the presence of species of conservation concern was constrained by several factors that include a single site visit at the start of the growing season (November 2012) and site assessment that were mainly limited within the railway servitude, which was already impacted by existing development. It is therefore expected that the presence of species of conservation concern could have been missed in the study area, specifically in areas located away from the servitude. A confidence level has been applied to all of the assessed watercourses and drainage systems based on their suitability for PES and EIS assessments, the expected accuracy of the EIS and PES assessments and the prominence of watercourse and drainage system indicators (Appendix A)

The EIS categories are summarised as follows:

Very high
Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.

High
Quaternaries/delineations that are considered to be unique due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species) on a national scale. These areas (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.

Moderate
Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These areas (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.

Low/Marginal
Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity

From a functional and landscape ecology perspective, the endorheic systems, such as those near the Linde site are considered important refugia for aquatic organisms, specially adapted to ephemeral conditions. These systems form a network or cluster of wetlands between the various catchments, allowing organisms to "leapfrog" form one catchment to another. A network of wetlands also presents opportunities to organisms when presented with disease or droughts, thus other unaffected catchments allow for the continuation of a species. These systems should therefore be avoided, as they were rated as having a moderate to high sensitivity with regard the development impacts (rail construction).

5. Aquatic System and Wetland Assessment & Classification Results

The following buffers are proposed and thus indicated in the figures below, while exceptions (e.g. Mamathwane) are discussed in the text:

- 50m buffer be used for any wetland.
- 32m buffer for rivers and streams, as recommended by the Eastern Cape Biodiversity Conservation Plan. This was also applied to natural channels and marginal drainage systems.
- 500m from wetland boundary indicating the need for a Water Use License Application.

5.1. Upper Orange Water Management Area – Southern Kalahari Ecoregion

5.1.1. Beaconsfield System Separation Yard

Two drainage line crossings have been identified that are impacted by an existing tar road, a service road and rail way line crossings, as well as man-made channels (Figure 3). The drainage lines are marginal in nature with poorly developed natural channel features (Figure 4-5). The PES of the two systems is estimated to be D (Largely Modified) due to existing impacts (Appendix A), while according to Middleton & Bailey (2008) the PES of Quaternary Catchment C51L is also regarded as D (Largely Modified). The systems have a Low EIS due to an expected limited contribution to biodiversity and habitat fragmentation (Appendix A).

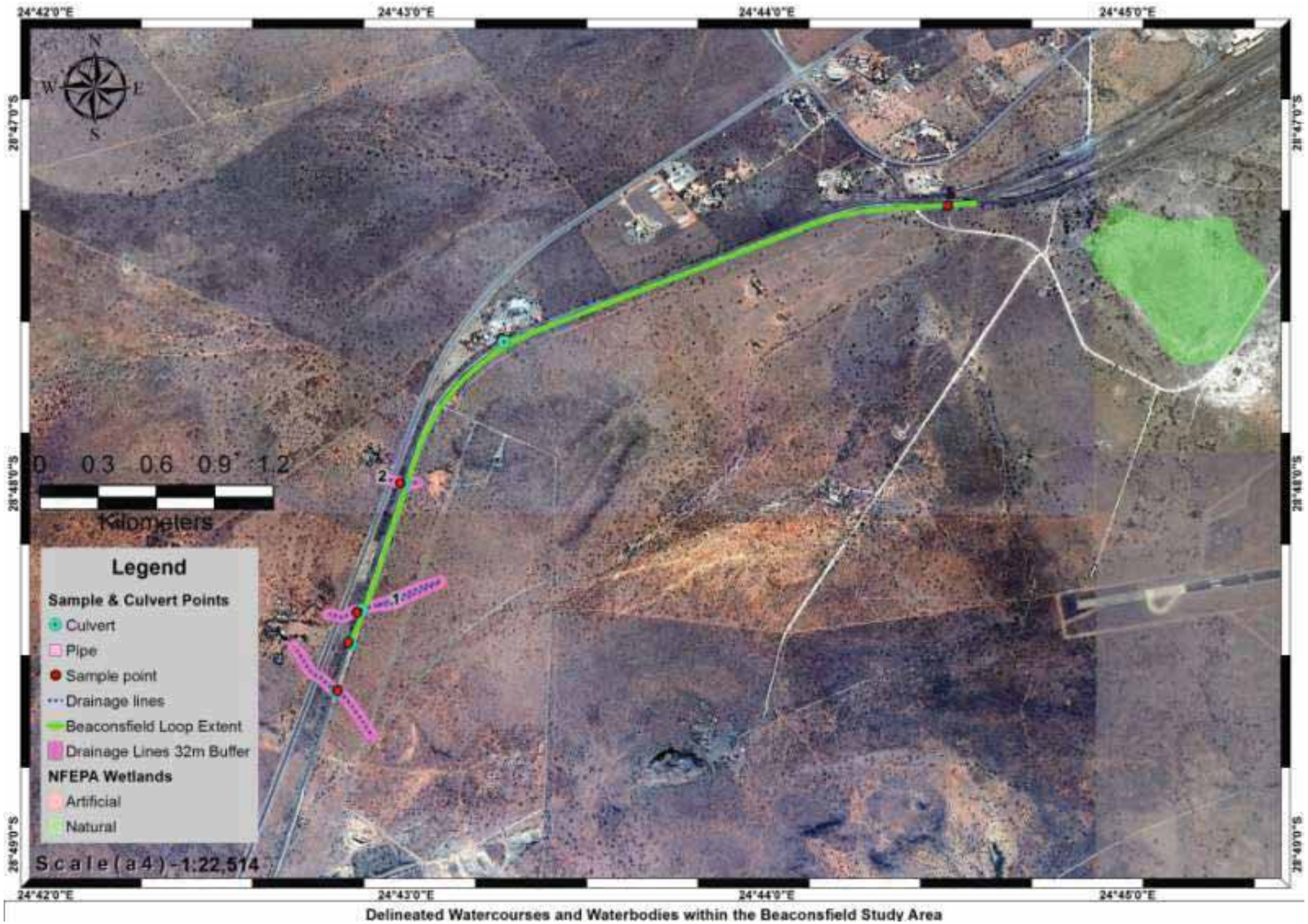


Figure 3: Delineated drainage systems and watercourses within the Beaconsfield study area.

Figure 4: Illustrates the Beaconsfield drainage line 1 crossing with its existing culvert (top left), indistinct channel development upstream of the loop (top right), created channel on the raised embankment downstream of the loop (center), and indistinct channel further downstream towards the road crossing (bottom).

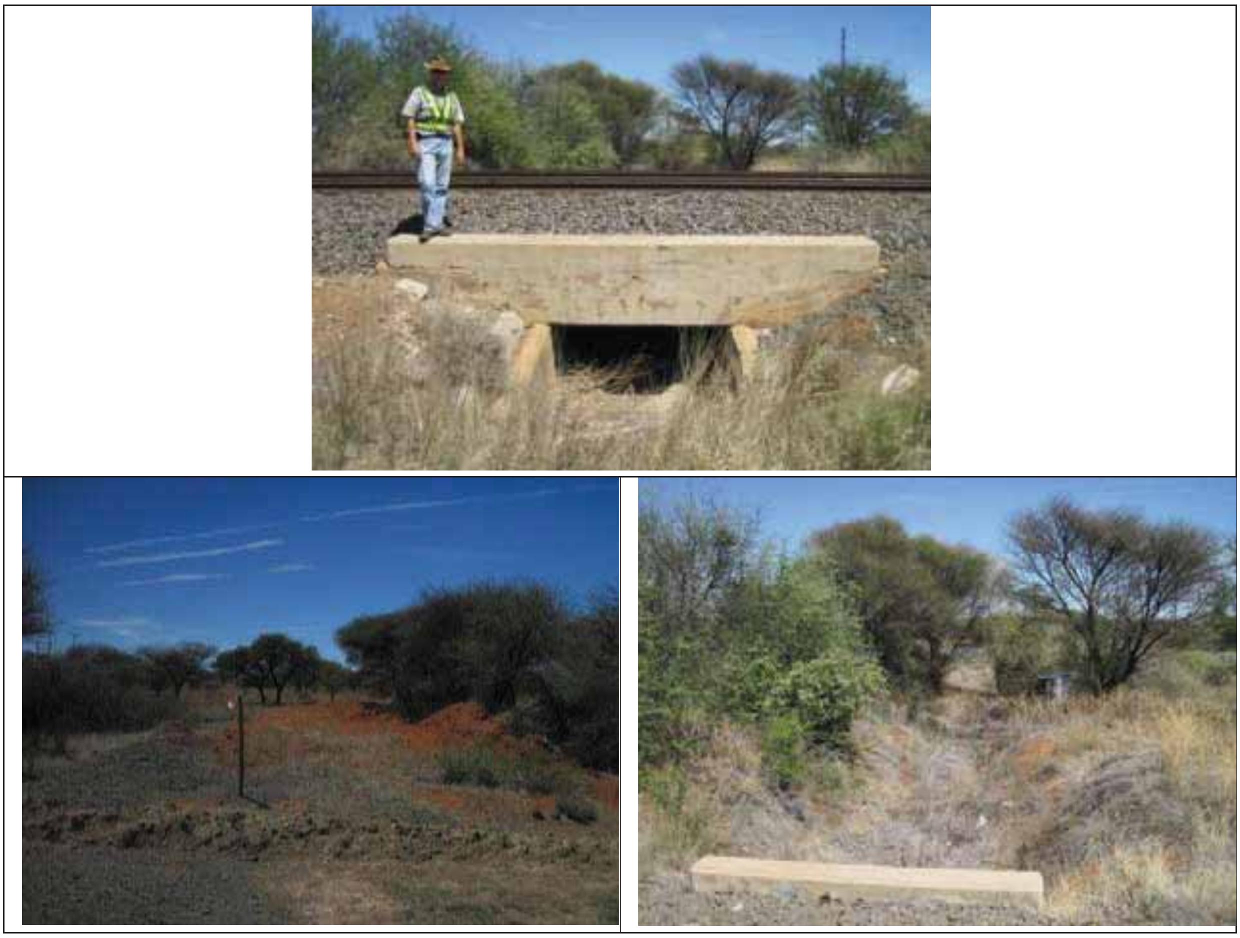


Figure 5: Illustrates the Beaconsfield drainage line 2 crossing with its existing culvert (top) indistinct channel development in the upstream direction (bottom left) and better defined channel downstream of the culvert (bottom right).

5.2. Lower Vaal Water Management Area – Southern Kalahari Ecoregion (Section 1)

5.2.1. Fieldsview Loop Extention

No watercourse or drainage system crossings are present in this section. A drainage line that lacks wetland features originates approximately 60 m west of the loop section (Figure 6 & 7). No existing culvert is present in the railway line and none is planed as part of the loop extension.

Figure 6: Illustrates the origin of a drainage line located approximately 60 m west of the Fieldsview loop.

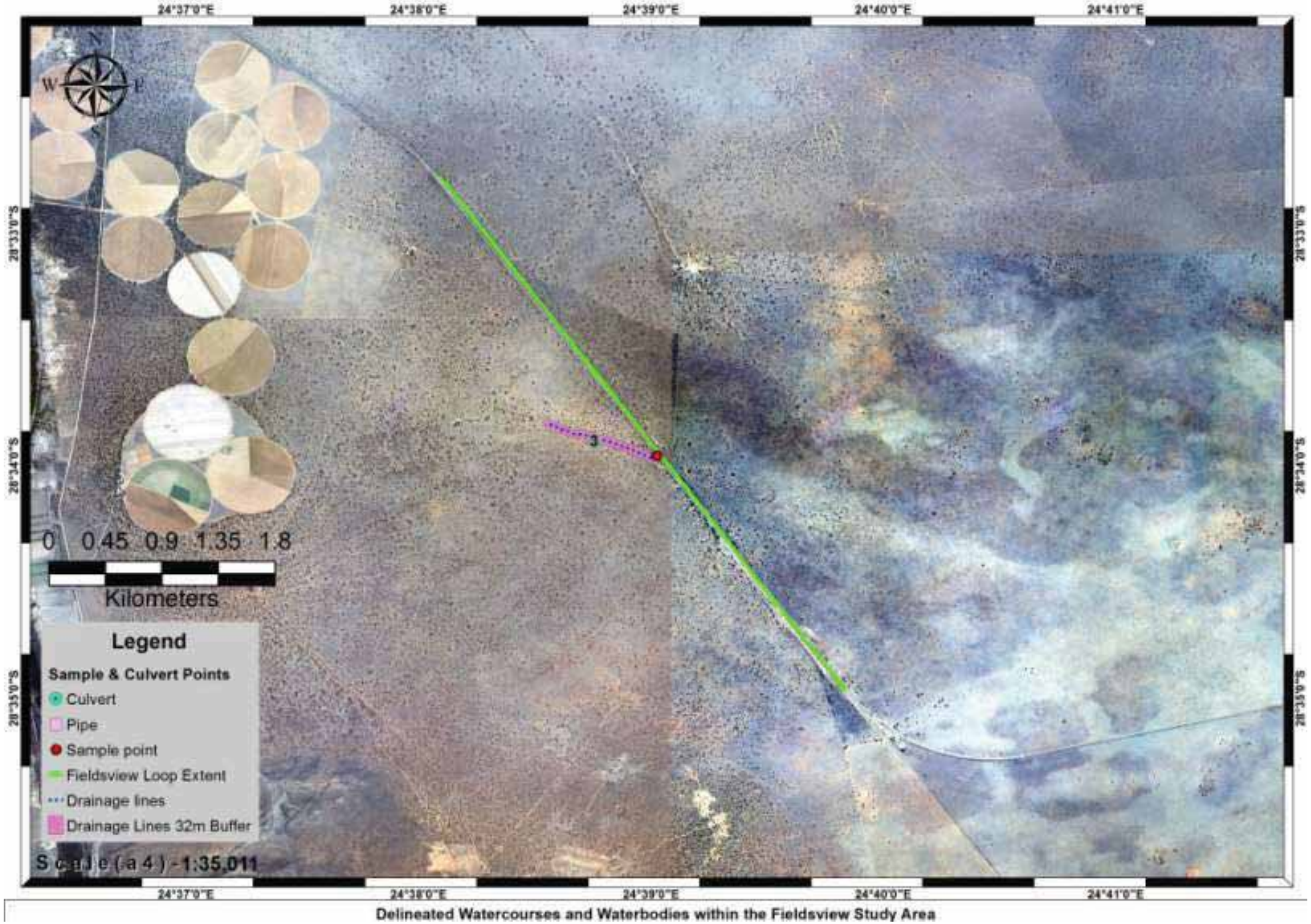


Figure 7: A delineated drainage line within the Fieldsview study area.

5.2.2. Gong Gong Loop

Three drainage system crossings occur within the Gong Gong section, a dry depression (pan) wetland (map label 4) and two dry drainage lines (map label 6 & 8), (Figure 8). These crossing positions are illustrated in Figure 8-11, as well as an excavation (digging) in the center of the loop section. All three of the crossings are impacted by the existing railway line and a service road parallel to the railway. Other drainage systems located in close proximity to the loop include drainage lines and the headwater of an indistinct wash (Figure 8 & 12).

The PES of the pan wetland and drainage lines that intersect with the loop was estimated as being D (Largely Modified) due to the existing impacts (Appendix A). While according to Middleton & Bailey (2008) the PES of Quaternary Catchment C91E and the nearby Vaal River are also regarded as D (Largely Modified). The systems have a Low EIS due to limited contribution to biodiversity caused by habitat transformation (Appendix A).

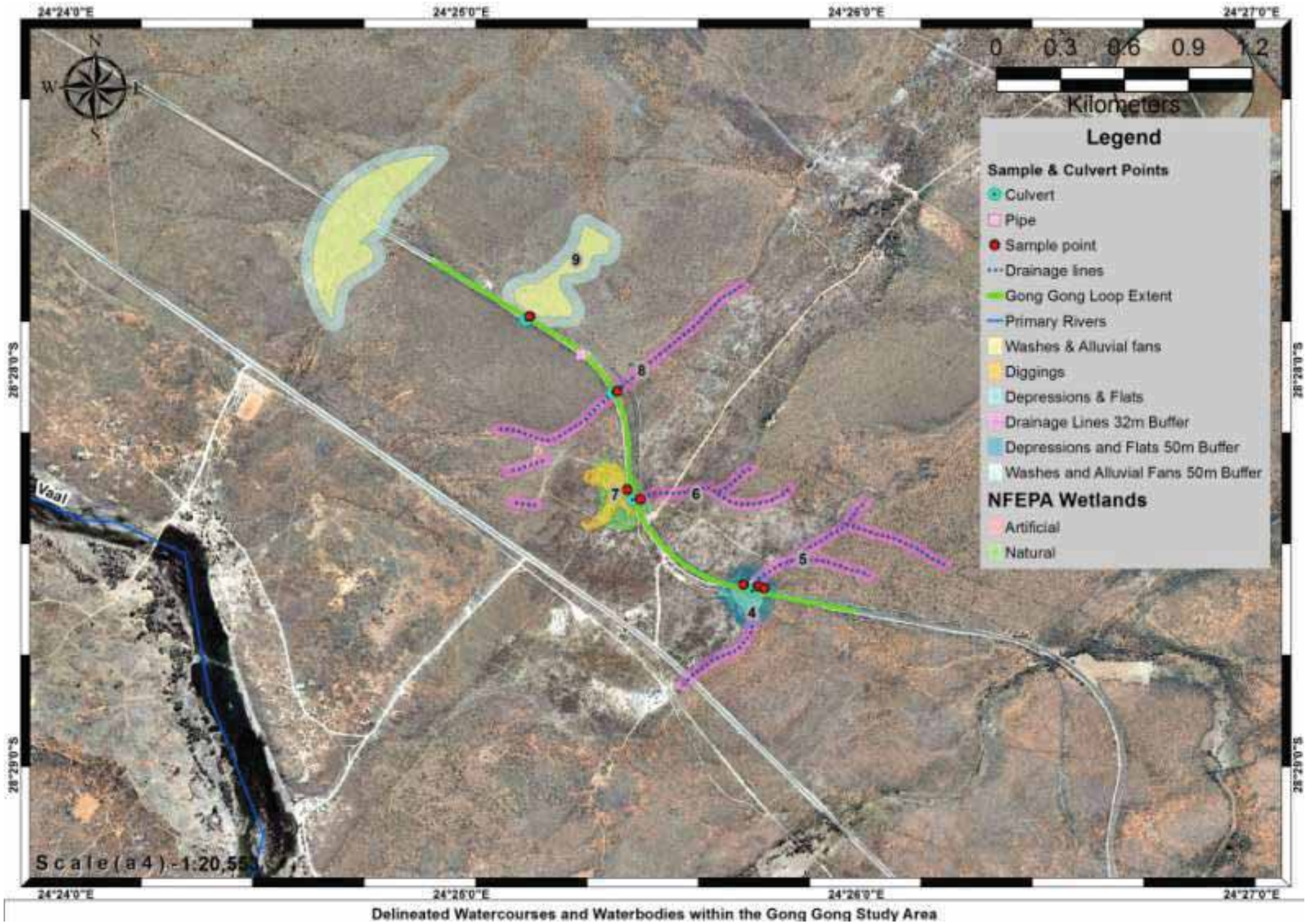


Figure 8: Delineated drainage systems and watercourses within the Gong Gong study area.

Figure 9: Illustrates the Gong-Gong area with a dry depression wetland crossing (map label 4). The depression or pan wetland contains no typical wetland indicators, apart from the terrain unit indicator, and had not been saturated recently. It is overgrazed and already bisected by the existing railway line.

Figure 10: Illustrates an eroded excavation adjacent to the Gong-Gong area (map label 7). This feature is not regarded as a natural watercourse.

Figure 11: Illustrates a Gong-Gong drainage line crossing (map label 7) with an existing culvert (top) and indistinct channel development in the upstream direction (bottom left) and downstream direction (bottom right). The proposed loop section will cross through the downstream section of the drainage line (bottom right).

Figure 12: Illustrates an indistinct wash on a flat slope in the Gong-Gong area (map label 9). The drainage feature is very marginal in nature and does not cross with the loop section.

5.2.3. Ulco Loop Extension

No watercourse or drainage system crossings are present in this section (Figure 13). Due to the upper catchment landscape position of the loop, limited surface water run-off is experienced within the study area. This contributed to weak drainage line and watercourse development. A headwater section of a wash drainage system that lacks wetland and channel features originates approximately 20 m northeast from the center of the Ulco loop (map label 12), (Figure 13-14). The estimated PES of this wash is regarded as C (Moderately Modified), (Appendix A), while according to Middleton & Bailey (2008) the PES of Quaternary Catchment C33C and the nearby Harts River are regarded as D (Largely Modified). The EIS of the wash drainage system (map label 12) is regarded as Moderate due to limited biodiversity contribution (Appendix A). The same applies to a suspected depression (pan) wetland located approximately 450 m southwest of the western end of the loop section (Figure 13; Appendix A).

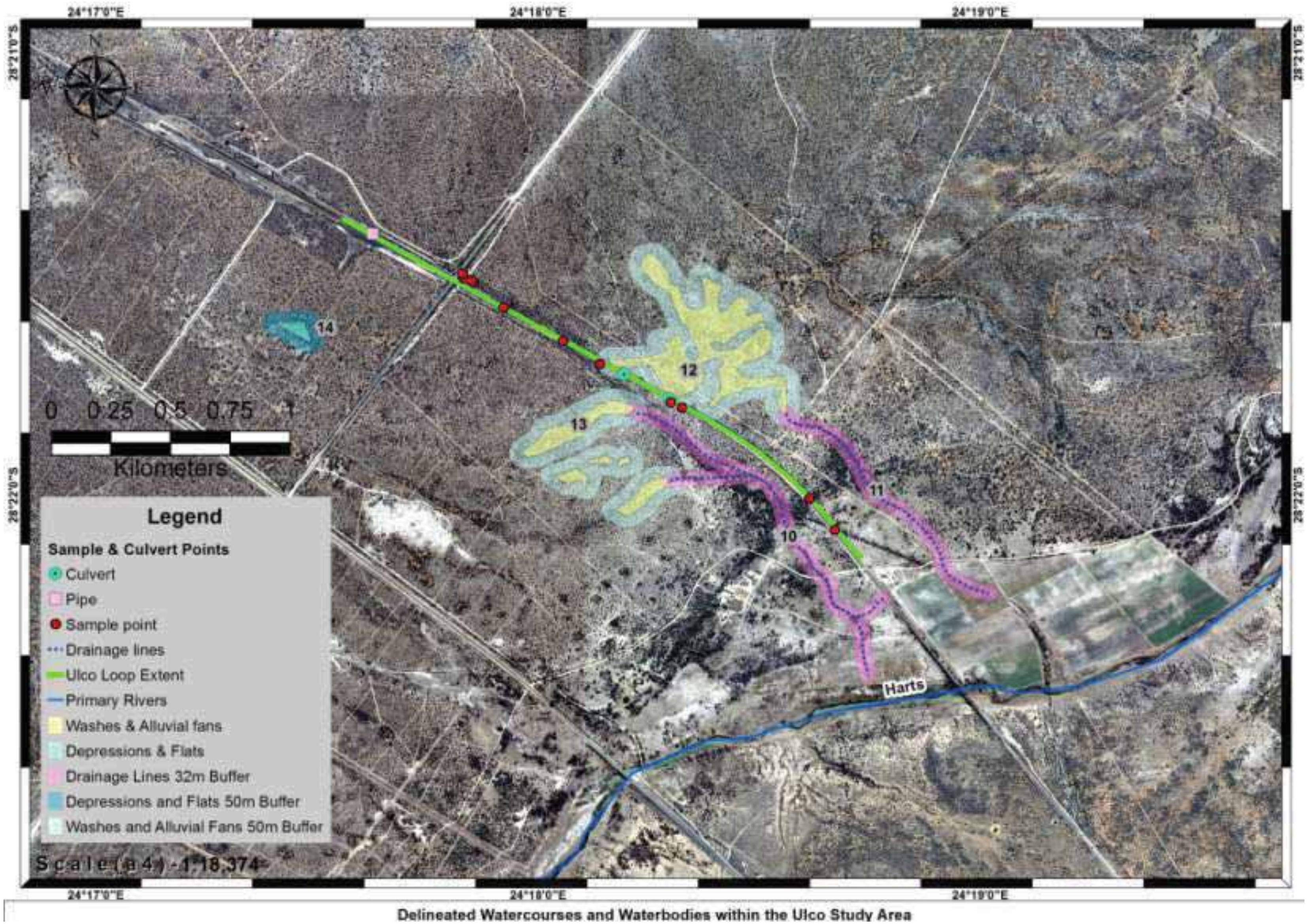


Figure 13: Delineated drainage systems and watercourses within the Ulco study area.

Figure 14: Illustrates a culvert and portion of a wash located adjacent to the Ulco area (map label 12); the wash is not well defined, but is located in close proximity to the loop extension. No channel features or signs of scour erosion are present upstream or downstream of the culvert.

5.3. Lower Vaal Water Management Area – Ghaap Plateau Ecoregion

5.3.1. Trewil Loop Extension

A single watercourse crossings is present within the Trewil section, a dry depression (pan) wetland (map label 19) is transected near the western end of the loop (Figure 15). A single culvert is present in the pan on the existing railway line, which will be extended into the new loop section. This arid pan is expected to only be cyclically inundated, with prolonged dry periods that can continue over more than one year. No distinct wetland indicators were recorded, apart from the terrain unit indicator. Six other depression - flat wetlands with similar properties were identified within a 500 m radius of the loop section.

Their PES were estimated at being B/C (Largely Natural to Moderately Modified), while the PES of intersected pan (map label 19) was estimated to be C/D (Moderately Modified to Largely Modified) as a result of the existing railway line and service road crossing (Figure 15 & 16; Appendix A). This is comparable to the C (Moderately Modified) PES score for Quaternary Catchment C92A and the nearby Vaal River (Middleton & Bailey 2008). The EIS of all the depression wetlands within the Trewil study area is regarded as Moderated due to their dry nature and indistinct wetland features.

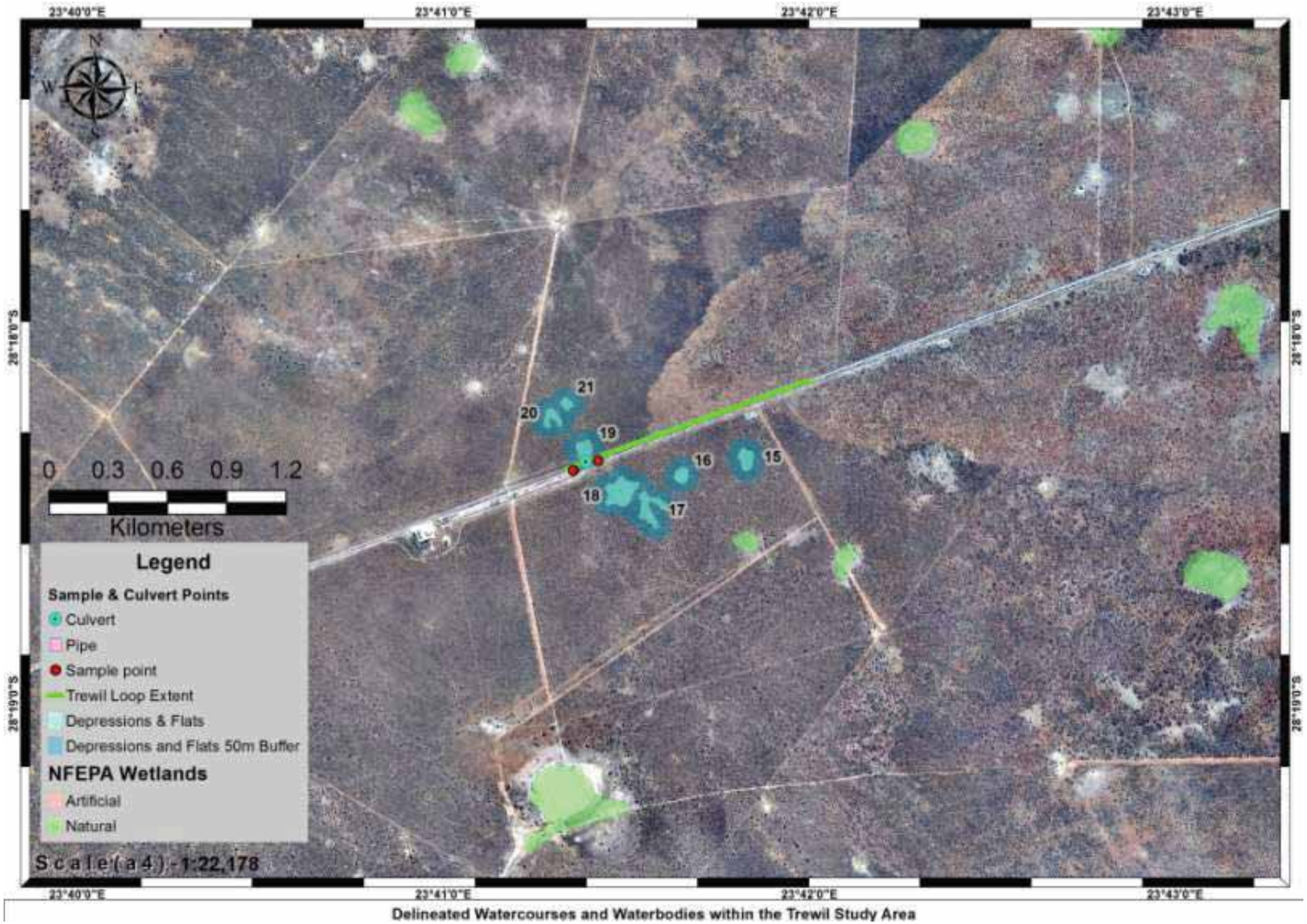


Figure 15: Delineated watercourses within the Trewil study area.

Figure 16: Illustrates the existing Trewil section, which will be extended in an easterly direction for a distance of approximately 1.2 km (top left). A culvert is located ±90 m from the start of the proposed new loop extension (top right) and is located in an arid depression wetland (map label 19) that will be crossed by the new loop (bottom). The dry pan does not contain distinct wetland features, apart from a marginally developed terrain unit indicator.

5.4. Lower Vaal Water Management Area – Southern Kalahari Ecoregion (Section 2)

5.4.1. Tsantsabane Loop Extension

No watercourse or drainage system crossings are present in this section (Figure 17). A single culvert was recorded in the center of the loop, but no channel features, riparian or wetness features were recorded up or downstream from the culvert apart from on the raised embankment (top), which is regarded as a purely man-made feature (Figure 17 & 18). Two non-wetland crossings border the Tsantsabane section, which are regarded as alluvial fan/wash drainage systems (map labels 22 & 24), (Figure 17, 19 & 20). Wetland habitat associated with an unchannelled valley bottom wetland along the Groenwaterspruit was identified and demarcated within a 500 m radius around the loop section (Figure 17 & 21).

This watercourse has a PES that is estimated as D/E (Largely to Seriously Modified) due to existing road and railway line crossings, as well as extensive cultivation and furrows within the wetland (Appendix A), while according to Middleton & Bailey (2008) the PES of Quaternary Catchment D73A and the Groenwaterspruit are regarded as B (Largely Natural). The EIS of the Groenwaterspruit unchannelled valley bottom is regarded as Moderate in spite of its impacts due to the rarity of the watercourse type within the larger landscape (Appendix A).

Figure 17: Delineated drainage systems and watercourses within the Tsantsabane study area.

Figure 18: Illustrates a culvert recorded within the center of the Tsantsabane area, which is not associated with a distinguishable drainage line or watercourse (top and bottom).

Figure 19: Illustrates an alluvial fan/ wash crossing (map label 22) **located approximately 210 m east of the Tsantsabane loop extension**. A channel is not clearly defined, but convergent contour lines are present, which indicate that surface flow is concentrate in the area after sufficient rainfall events.

Figure 20: Illustrates a culvert in a wash crossing (map label 24) west of the Tsantsabane area. No distinct channel features or scour marks are evident up and downstream of the culvert, but a linear drainage system is distinct on available aerial imagery.

Figure 21: Illustrates the Groenwaterspruit railway line crossing, which is located approximately 1.4 km east of the Tsantsabane loop extension. The Groenwaterspruit flows parallel to the Tsantsabane loop further downstream and occurs within a 500 m radius thereof. The Groenwaterspruit is regarded as an unchannelled valley bottom wetland in this area (map label 23), but has been largely transformed into cultivated land with drainage furrows (also see Figure 17).

5.4.2. Postmasburg Loop Extension

Three drainage line crossing have been identified and demarcated within the Postmasburg section, while a forth drainage line originates approximately 30 m downstream of the loop in its western half (map labels 25-28), (Figure 22). The eastern-most drainage line is more impacted compared to the rest due to several dirt road and railway line crossings, dumping and alien plant species (*Prosopis* cf. *glandulosa* and *Melia azedarach*) within the system (Figure 23). Impacts in the other drainage lines include railway line and road crossings, as well as ballast material that was frequently recorded in drainage lines (Figure 23-26). *Acacia mellifera*, was a dominant woody species in the less impacted systems and generally occurred in higher densities within the drainage lines compared to the surrounding areas.

An existing pipe located in the western-most portion of the loop section did not overlap with any watercourse or drainage system (Figure 22 & 27).

The eastern-most drainage line (map label 25) has a PES that is estimated at being E (Seriously Modified), while the remaining two drainage line crossings (map labels 26 & 27) have PES estimated at being C/D (Moderately to Largely Transformed). The PES of the western-most drainage line that is not intersected by the loop (map label 28) is estimated to be C (Moderately Modified) due to fewer impacts (Appendix A). According to Middleton & Bailey (2008) the PES of Quaternary Catchment D73A and the Groenwaterspruit are regarded as

B (Largely Natural). The EIS of all four drainage lines is regarded as Low due to impacts that include habitat fragmentation (Appendix A).

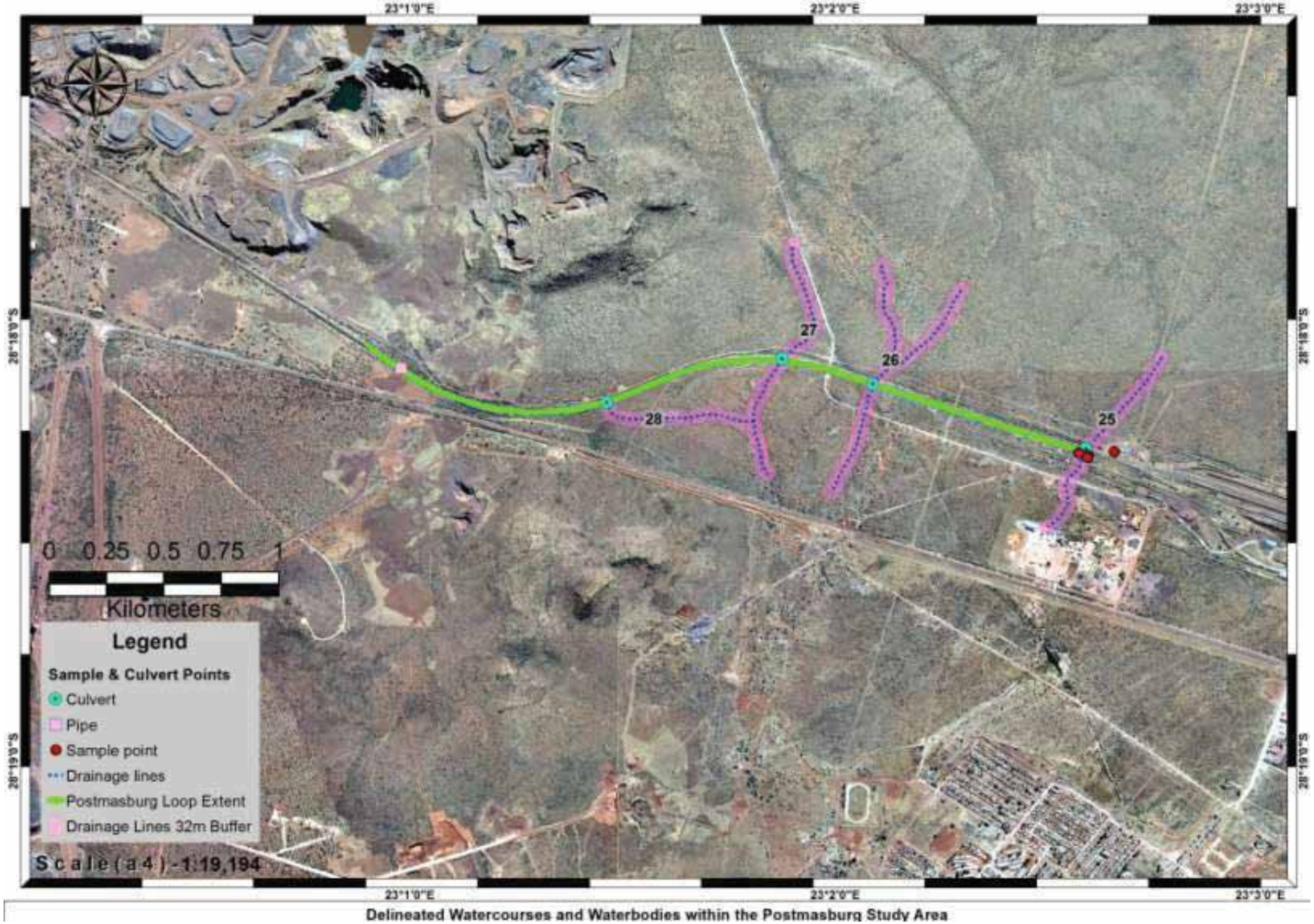


Figure 22: Delineated drainage systems and watercourses within the Postmasburg study area.

Figure 23: Illustrates an indistinct drainage line crossing in the western section of the Postmasburg section (map label 25), which has been seriously modified through dumping, as well as railway line and dirt road crossings. Exotic plant species, such as *Prosopis* cf. *glandulosa* and *Melia azedarach* are present within the drainage line.

Figure 24: Illustrates an indistinct drainage line crossing in the Postmasburg section (map label 26), with *Ziziphus mucronata* and *Acacia mellifera*. Note the presence of ballast material within and adjacent tothe drainage line.

Figure 25: Illustrates an indistinct drainage line crossing in the Postmasburg section (map label 27) with an existing culvert (top and bottom). The drainage line is dominated by *Acacia mellifera*, while an alien plant species (*Opuntia* sp.) is present on the rail embankment (bottom). Ballast material is present within and adjacent to the drainage line (bottom).

Figure 26: Illustrates an indistinct drainage line that originates approximately 30 m downstream of the Postmasburg loop extension (map label 28), (right). An existing culvert is present along with ballast material downstream of the culvert (left and right). Notice the gap that has been created in an upstream embankment to allow surface flow through the culvert (left).

Figure 27: Illustrates a pipe crossing in the far western section of the Postmasburg loop (top and bottom). No natural watercourse or drainage line feature, including a natural channel, occurs at this point (bottom); the perched pipe and human intervention has resulted in man-made channel-like feature in the embankment of the railway line (top and bottom).

5.4.3. Glosam Loop Extension

No watercourse or drainage line crossings were identified within the Glosam section (Figure 28). Three culverts were recorded, but none of them overlapped with natural watercourses or drainage systems. Man-made channels were identified downstream of the culverts that were created to help channel water away from the flat landscape position, as the loop is located along the catchment divide between Quaternary Catchments D73A and D41J (Figure 29-31)

One dry depression (pan) wetland was delineated within a 500 m radius of the Glosam loop (Figure 28). The pan has a PES estimated as being at B/C (Largely Natural to Moderately Modified), (Appendix A). According to Middleton & Bailey (2008) the PES of Quaternary Catchment D73A is regarded as B (Largely Natural). The EIS of the pan wetland is regarded as Moderate (Appendix A).

Figure 28: Delineated drainage systems and watercourses within the Glosam study area.

Figure 29: Illustrates a culvert crossing in the southern section of the Glosam loop; a man-made channel has been made to drain sheetwash away through the raised embankment and culvert (top). This creates the impression of a natural channel, but the channel feature disappears a short distance away from the railway line (bottom). No natural drainage line features were identified on aerial photographs or on site.

Figure 30: Illustrates a culvert crossing in the central section of the Glosam loop; a man-made channel has been made to drain sheetwash away through the raised embankment and culvert, the channel disappears downstream of the railway line crossing.

Figure 31: Illustrates a culvert crossing in the northern section of the Glosam loop with no drainage line or watercourse crossing present.

5.4.4. Sishen New Loop

A single flat drainage system is crossed by the new loop section in its south-eastern portion (Figure 32). The flat drainage system is marginal in nature and contains no signs of wetland or riparian features apart from vegetation gradient differences recorded in the aerial photograph (Figure 32 & 33). The system has been highly impacted through recent construction activities that are not associated with the project, but form part of the Sishen West Expansion project (SWEP). Consequently its PES is regarded as an E (Seriously Modified), (Appendix A).

No other drainage systems are crossed by the loop section, but a set of culverts recorded in the center of the SWEP rail line and loop section, is associated with a large channel that has been excavated in the downstream direction, towards the Ga-Mogara River (Figure 34). The reason for such a prominent set of culverts and associated channel in a non-watercourse remains unknown. Other watercourses and drainage systems recorded within a 500 m radius of the loop section include three depression wetlands that are arid in nature and only support surface water after sufficient rainfall event (map labels 31-33Figure 32). Their interpreted PES class is regarded as C (Moderately Modified), (Appendix A). The north-western end of the loop section is positioned between a depression wetland (map label 34) and a flat (map label 35), (Figure 32), both of which have been impacted by the SWEP development. The PES of this watercourse and drainage system is estimated at being E (Seriously Modified) and D (largely Modified) respectively (Appendix A). According to Middleton & Bailey (2008) the PES of Quaternary Catchment D41J and the Ga-Mogara River are regarded as B (Largely Natural).

Drainage systems crossed by this section and located adjacent to it are regarded to have a Low EIS due to limited contribution to biodiversity associated with habitat fragmentation and loss. The small and dry depression wetlands located further away from the loop section (map labels 31-33) are regarded to have a Moderate EIS with more intact natural habitat, but remains common in the surrounding landscape (Figure 32; Appendix A).

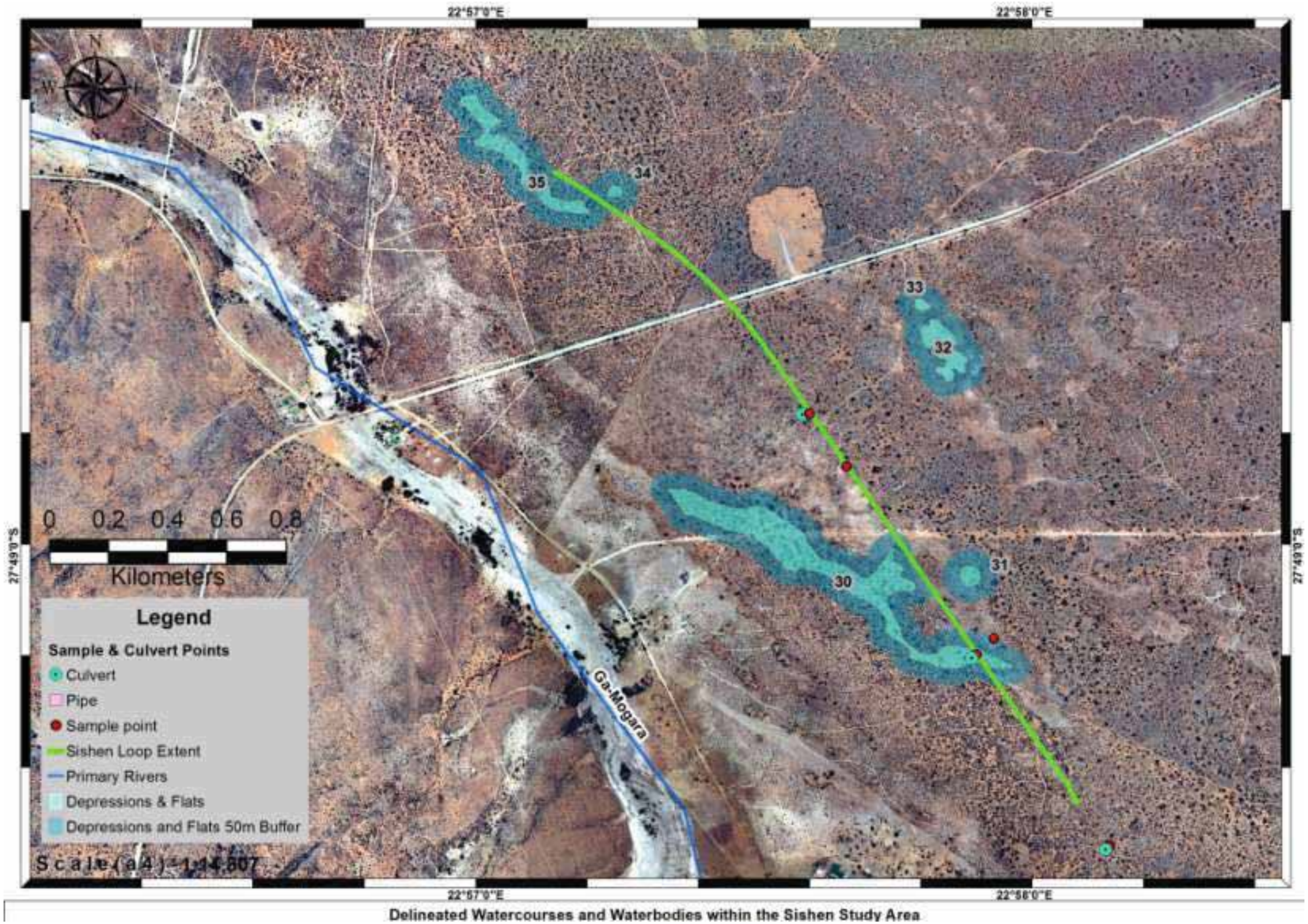


Figure 32: Delineated drainage systems and watercourses within the Sishen study area.

Figure 33: Illustrates the upstream (top) and downstream (center and bottom) sections of a flat drainage system crossing in the south-eastern section of the Sishen loop. The system has been recently impacted by a new railway line and road crossing associated with the Sishen West Expansion Project (top and centre), while a channel has been excavated downstream thereof (bottom).

Figure 34: A set of culverts and newly created downstream channel in the center of the Sishen loop section, with no watercourse or drainage system present.

5.4.5. Wincanton Loop Extension

No watercourse or drainage system crossing is located within the Wincanton section, but two depression (pan) wetlands are located within a 500 m radius of the loop section (Figure 35). Both depression wetlands are affected by a high grazing pressure, while the southern pan is crossed by the existing rail way line (Figure 36).

The PES was estimated as being C (Moderately Modified) for the central pan (map label 37) and D (Largely Modified) for the southern pan (map label 38), (Figure 35; Appendix A). According to Middleton & Bailey (2008) the PES of Quaternary Catchment D41J and the nearby Ga-Mogara River are regarded as B (Largely Natural). The two pans have Moderate EIS values due to amphibian-related biodiversity that may be associated with these wetlands when inundated for a few weeks during the summer months (Appendix A). Signs of recent, yet restricted, inundation were present in the southern pan in the form of pug marks, desiccation cracks and greener vegetation near the centre of the pan (map label 36).

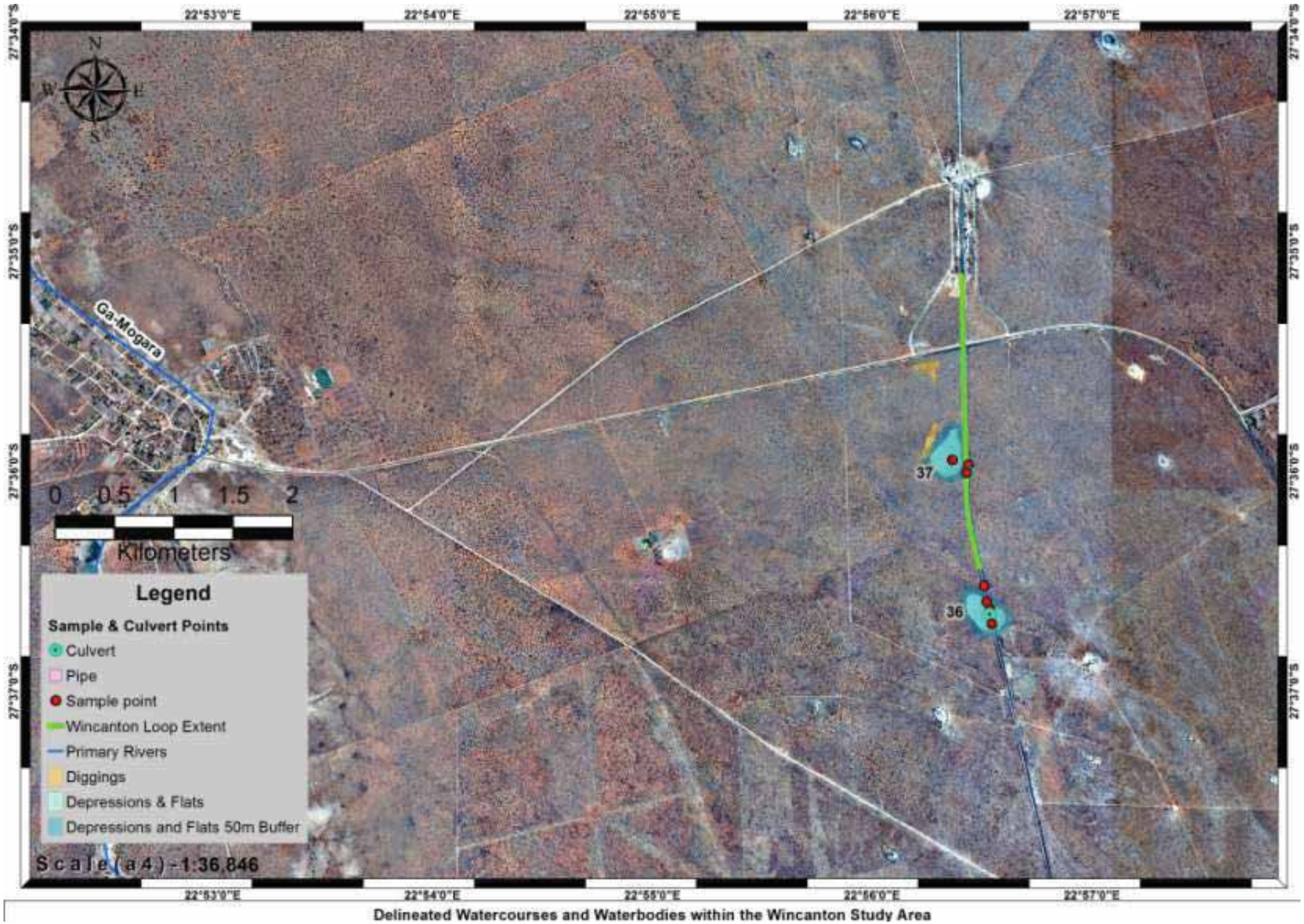


Figure 35: Delineated drainage systems and watercourses within the Wincanton study area.

Figure 36: Illustrates an arid depression (pan) wetland located approximately 30 m west of the Wincanton loop, near the center of the loop section, which has been severely overgrazed by livestock (top); a larger and better developed pan wetland is located approximately 220 m south of the loop section (bottom).

5.4.6. Mamathwane Compilation Yard

A single watercourse crossing is present on the southern portion of this section in the form a wash associated with the Vlermuisleegte watercourse, which is indicated on the 1:50000 topographic map (2722BD), as well as the 1:500000 DWA river dataset (Middleton & Bailey 2008), (Figure 37). The watercourse lacks clearly defined channel banks, but is characterised by tall *Acacia haematoxylon* trees that are associated with deep sands and dry watercourses (Van Wyk 1997), (Figure 38).

The watercourse is impacted by the existing railway line, dirt service roads on either side of the railway line, cattle camps, and cattle feed and watering points in close proximity to the loop crossing. The two large culverts are also used as a vehicle crossing point between the adjacent service roads (Figure 38). Its PES is estimated as being D (Largely Modified) due to the range of impacts in close proximity to the loop crossing (Appendix A). Middleton & Bailey (2008) indicate that the PES of the Vlermuisleegte watercourse reach within the study area was B (Largely Natural), while the PES for Quaternary Catchment D41K is also B. The EIS of the Vlermuisleegte wash crossing is regarded as High due to its upstream and downstream landscape connectivity, size, uniqueness, and intact habitat located away from the crossing. It is the only well defined wash crossing of its type within project scope investigated in the Lower Vaal Water Management Area.

The wash is buffered by a distance of 50 m and not 32 m (Figure 37). This is due to the large size of the watercourse crossing and inherent uncertainty regarding the accuracy of its delineated boundaries given the lack of typical wetland and riparian indicators (DWAF 2005).

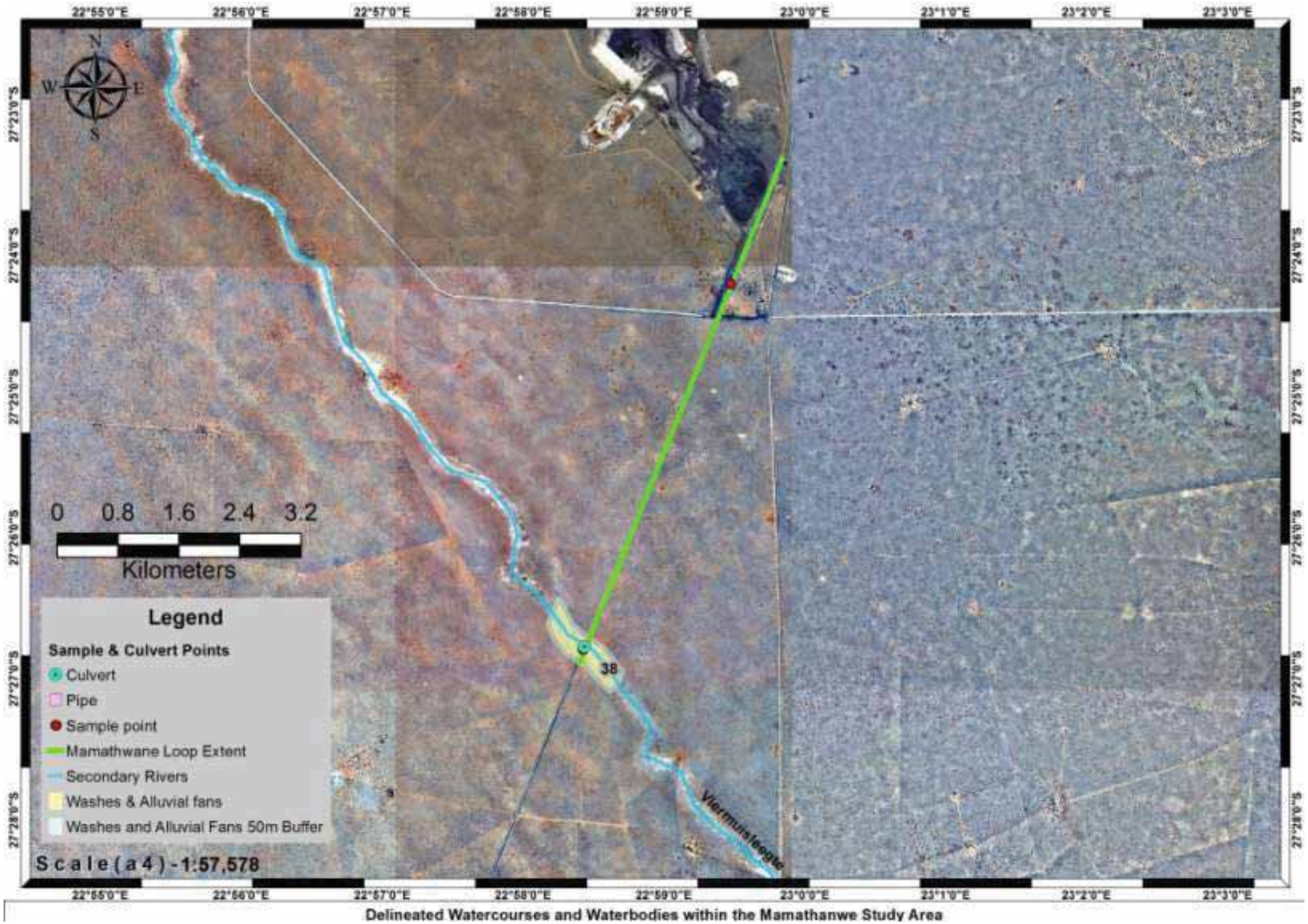


Figure 37: The delineated Vlermuisleegte watercourse within the Mamathwane study area.

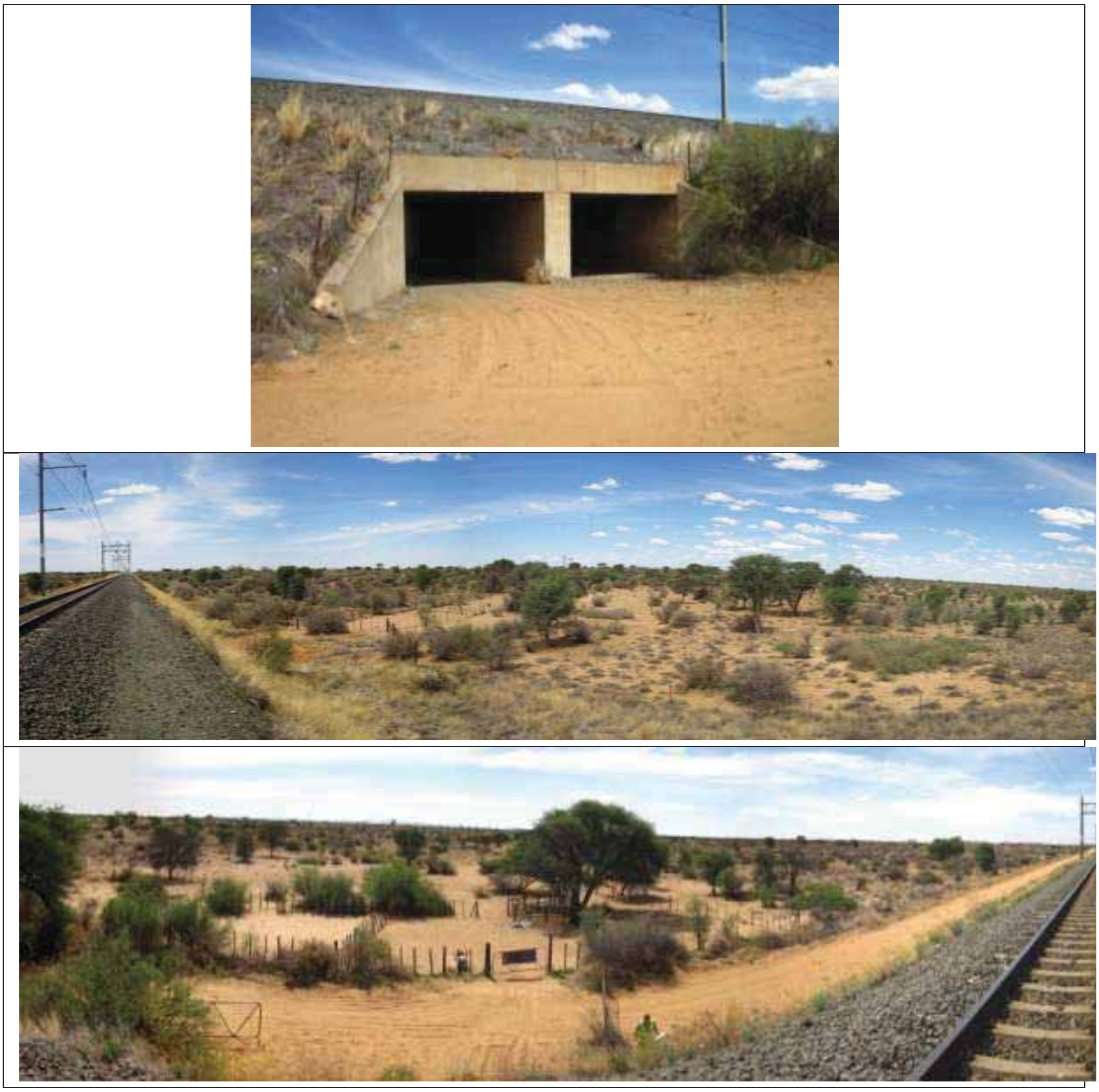


Figure 38: Illustrates two large culverts in the Vlermuisleegte wash crossing in the southern end of the Mamathwane section (top), as well as upstream and downstream potions of the wash from the existing railway line crossing (center and bottom respectively).

5.5. Lower Orange Water Management Area – Nama Karoo Ecoregion

5.5.1. Burgervilleweg Loop Extension

Three main drainage line systems were observed, which would be crossings in the form of upgrading the existing the culverts, i.e. extending the length of the culverts already in place. These three systems are typical of alluvial drainage lines of the Nama Karoo Ecoregion, and thus are mostly dry and only carry surface water flows for short periods of the year, which then quickly flow into the larger downstream systems such as the Brakrivier River. Surface ponding is usually unlikely unless berms attenuate any flows (Figure 39).

These berms (kuile) are either constructed within the water courses to provide livestock drinking areas, or increase the carrying capacity of the veld as the grasses respond well to the increase in surface waters. Under natural conditions these berms are also formed when bare soils are transported by the surface waters (alluvial transport) or by wind (aeolian sediment movement). A number of these bare soil areas together with the processes describe above then form blind depressions, in a variety of depths and shapes. Some of these had, until a few weeks prior to the site visit, contained water, however no true wetland or hydrophilic species (faunal or floral) were found in association with these systems. Most don't even have any connections with drainage lines or water courses and thus their ecological value is not well understood, however as they attenuate surface flows, these are very important in recharging shallow groundwater systems within the region (Figure 40).

Figure 39: A typical berm associated with the natural surface water / wind patterns within the region but not related to any drainage lines or watercourses.

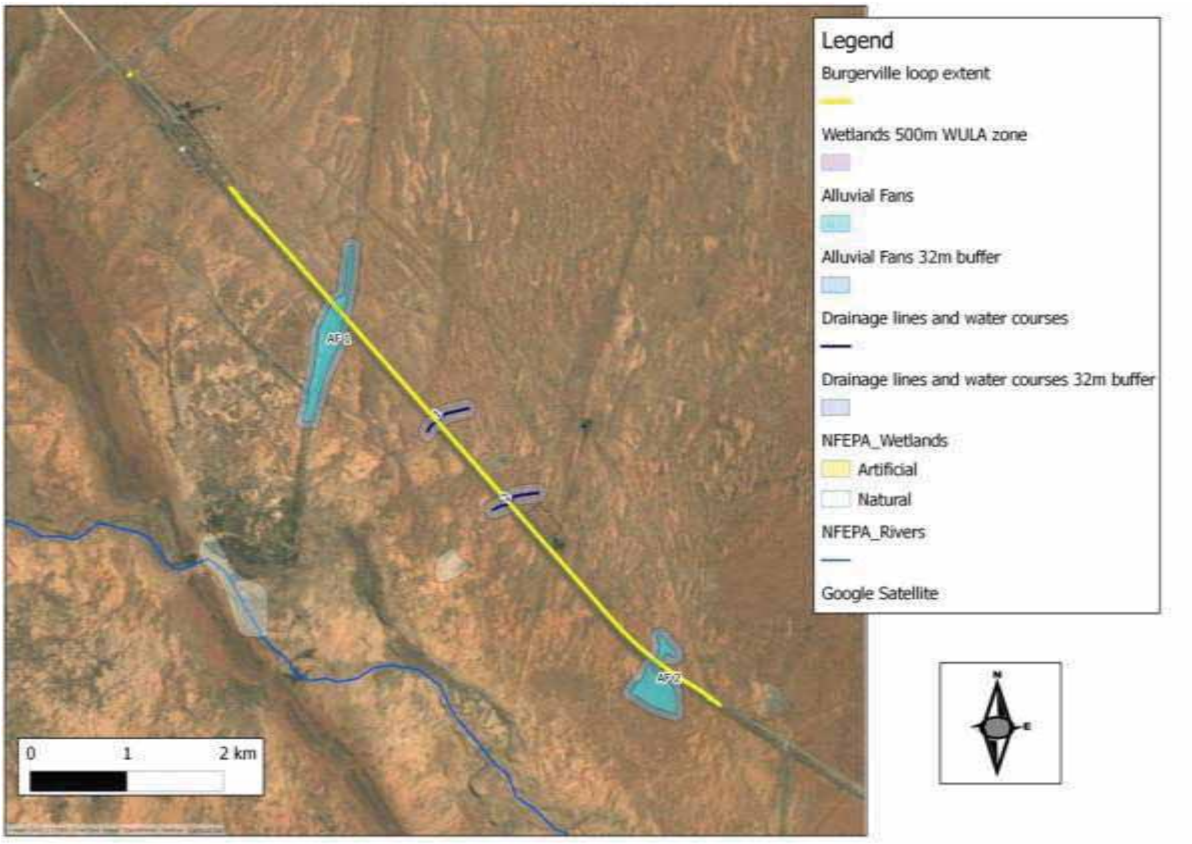


Figure 40: Delineated drainage systems within the Burgervilleweg study area.

The PES for the drainage lines and the alluvial fans in the study area were rated as C (Moderately Modified) due to the farming, road and rail activities already present (Appendix A). This would correspond to the Brakrivier system that was assessed in 1999 and was rated as having a PES of B (Kleynhans, 2000). These systems would also have Moderate EIS due to their limited contribution to biodiversity, but would aid in the recharge of shallow groundwater systems when water is present (Appendix A).

5.6. Upper Orange Water Management Area – Nama Karoo Ecoregion

5.6.1. Linde Loop Extension

The proposed Linde section contained a unique type of "river-wash" areas that could only be described as alluvial plain depressions. These are almost sinusoidal in shape (Figure 41) and would only contain water for short periods of time and thus don't contain any hydrophilic species (Figure 42). Three small drainage line areas were also observed, but these already have culverts in place and would only require extensions. None of these systems are, however, connected to the Seekoei River lower in the catchment, thus the study area systems would be considered endorheic (inward draining).

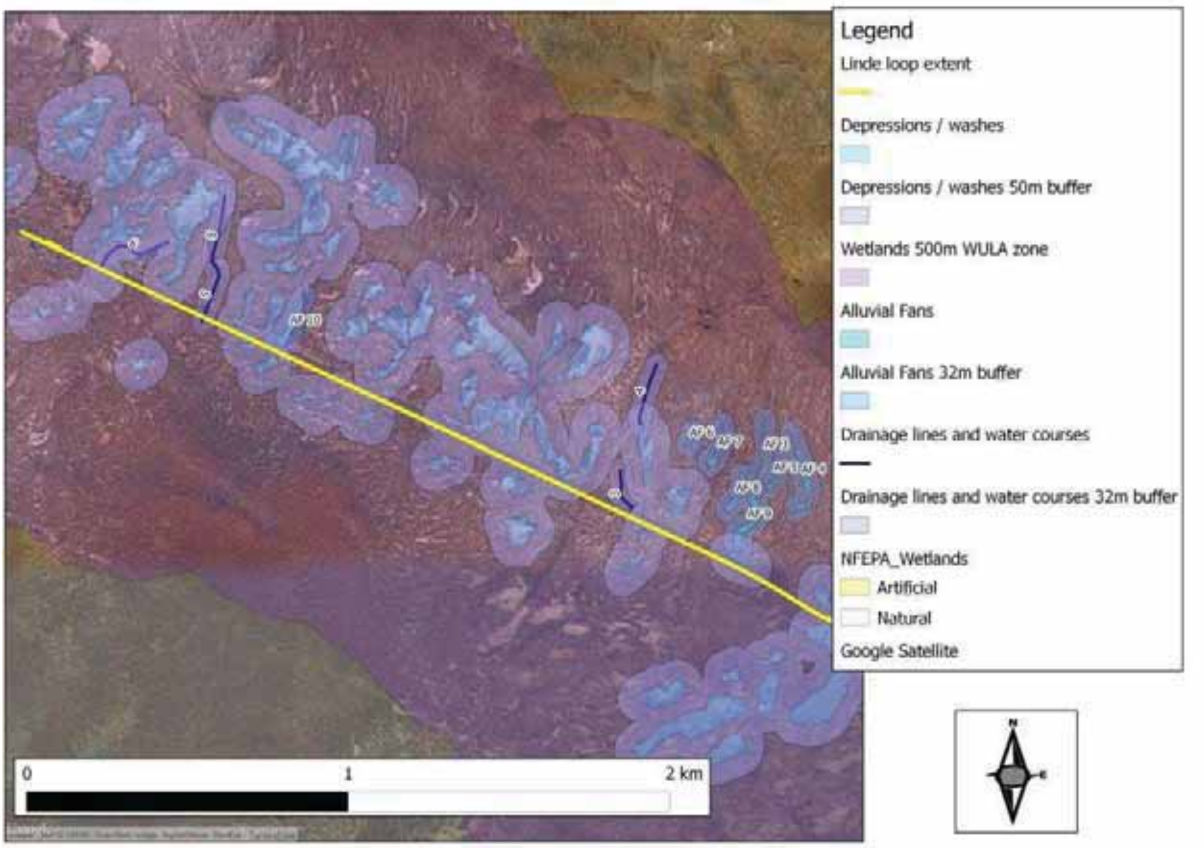


Figure 41: The drainage systems and watercourses observed within the Linde study area, indicating the proposed wetland buffers.

Figure 42: A small depression alongside the Linde rail section, with desiccation cracks indicating that until recently it had held some water

Based on the lack of aquatic environmental factors needed to assess the PES and EIS of the drainage systems and watercourse in the study area, were based on professional opinion it was estimated that the PES of all the systems in the study area would be B (Largely natural) due the farming, road and rail activities already present. These systems would also have MODERATE EIS due to their limited contribution to biodiversity, but would aid in the recharge of shallow groundwater systems when water is present.

The river wash depressions and the Alluvial Fan (AF10) shown in Figure 41 were rated as having a higher EIS, i.e. HIGH due to the unique habitat they provided as compared to the drainage lines that would be crossed.

6. Potential impacts and recommendations

Due to the nature of the receiving environment and the mostly ephemeral nature of the areas that will be impacted upon only three major impacts or environmental risks have been highlighted and have been rated based on the project actions / impacts, as well as any potential cumulative impacts during the construction and operational phases of the project. These were also assessed with and without mitigation. The impact assessment incorporates a risk assessment, as identified impacts are also regarded as threats that can negatively affect delineated watercourses. Furthermore, the risk of identified threats is evaluated by assessing aspects such as their probability of occurrence and their expected significance (magnitude of impact) on receiving watercourses.

It should be noted that all of the impacts assessed would have a negative impact (low to moderate magnitude) on the assessed aquatic systems. Each delineated watercourse (including wetlands) and drainage system have been assessed in terms of its overall impact associated with the project, based on the assumption that the proposed mitigation measures are implemented (Appendix A).

The potential impacts on the local drainage lines, watercourses and riparian systems would result from the physical changes, i.e. an increase in elevated areas (embankments) and the removal of vegetation in the local environment during the construction and operation of the rail loops extensions.

No species of special concern were observed in the areas that will be affected by construction, while all of the investigated areas are already degraded due to existing rail way line impacts. Potential impacts on species of conservation concern were therefore not assessed. However, species of conservation concern are expected to be under sampled within the different study area components. Similarly it is also anticipated that the potential impacts arising from watercourse habitat loss would be Low to none and thus no further assessment in this regard was undertaken.

The area of impact is likely to be limited to the construction footprint areas due to the arid nature of the study area and the avoidance of large watercourse crossings, which are more likely to experience regular bank fill flow events.

Impact 1: Changes to the hydrological regime and increased potential for erosion

Nature of the impact

A general comment on the current impacts affecting the hydrology of surveyed sites is that the present culverts would either seem too small as compared to the natural floodplain areas and are easily filled by sediments and windblown debris. Some even fill with ballast and this elevates the natural levels within the culvert areas, which would result in the impoundment of any surface flows. The larger culverts seen in this study all elevate natural ground levels and result in surface water impoundments. On the positive side, no signs of scour or channel incision were recorded downstream of any of the investigated culvert positions.

Due to the nature of the proposed project this would be an operational phase impact, limited to when the rail and water course crossing features and any erosion protection structures have been constructed. These structures could interfere with natural run-off patterns, either diverting flows or increasing the velocity of surface water flows. This has the potential to increase the potential for erosion in the study area, while increasing sedimentation of downstream areas, once flows subside.

Significance of impacts without mitigation

The soils within the study area are moderately susceptible to erosion when subjected to high flows (high volumes and velocities), and head-cuts can readily form within the water courses. These create bed and bank instability within the drainage lines and water course with the consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas.

Due to the nature of the study area hydrology, its present state and the present impacts, the negative impact, although permanent would be localised and probably result in a medium intensity impact. Thus the overall significance of the impact would be rated as **MEDIUM** as downstream areas are still intact (Table 3).

Proposed mitigation

- Surface water management features such as the crossing of drainage lines, should be placed in manner that flows remain unaltered in terms of direction, velocity and volume, thus the natural base flows, i.e. hydrological regime within these systems is maintained.
- It is also important that during construction and operations that excess ballast is not allowed to enter any water course areas, culverts etc., which if so doing alter these systems by forming impoundments as shown in this study.

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be Low, thus the overall significance of this impact would be **LOW** as the annual volumes of run-off within the study systems is low (Table 3). This impact is also partially reversible should the service roads /rail and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term, although it is envisaged that the service roads / rail once constructed would become a permanent feature.

Table 3: The potential impact of changes to the local hydrological regimes and increased potential of erosion

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Long-term 3	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	Low	-ve	High
Degree to which impact can be reversed				Partial				
Irreplaceability of resource				Low				

Impact 2: Diversion and increased velocity of surface water flows – reduction in permeable surfaces

Nature of the impact

The rail construction involves the creation of hard surfaces and embankments, which usually includes the provision of stormwater drainage such as culverts. This will divert further flow away from one water body, while increasing flow velocities of run-off into another during the operational phase. This impact is closely linked to the previous impact, but the reduction in permeable surfaces is assessed here due to the need for surface water to permeate into shallow, as well as deeper groundwater systems to sustain the local hydrology. The action of percolating water through permeable surfaces also aids in the reduction and / or removal of organic and inorganic pollutants contained in the surface waters.

Significance of impacts without mitigation

The soils within the study area are susceptible to erosion when subjected to high flows (high volumes and velocities), with head-cuts readily forming within the water courses. This creates bed and bank instability of the aquatic ecosystems and consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas. The drying out of areas also reduces the potential for surface water to recharge shallow and deep groundwater systems.

Due to the nature of the study area hydrology and its present state and the surrounding impacts, the negative impact, although permanent would be localised and probably result in a medium intensity impact. Thus the overall significance of the impact would be rated as **MEDIUM** as downstream areas are still in an intact state (Table 4).

Proposed mitigation

Surface water management features such as the crossing of drainage lines, should be placed in manner that flows remain unaltered in terms of direction, velocity and volume as far as practically possible based on constrains associated with existing culvert and stormwater management systems.

Through this approach the natural base flows, i.e. hydrological regime (water quantity and quality) within these systems would be better maintained (Table 4).

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be Low, thus the overall significance of this impact would be **LOW**. This is due to the fact that the surface flows within the study areas are naturally low and that most of the culverts are already in place and would only requiring extension.

This impact is also partially reversible should the rail and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term (Table 4).

Table 4: Potential impacts due to reduction in permeable surfaces

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Long-term 3	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	Low	-ve	High
Degree to which impact can be reversed				Partial				
Irreplaceability of resource				Low				

Impact 3: Impact of changes to water quality

Nature of the impact

Presently little is known about the water quality of the water courses, but it is assumed due to the activities in the study area, that the aquatic systems may already contain high levels of nitrates, phosphates and organic matter.

During construction various materials, such as sediments, diesel, oils and cement, will pose a threat to the continued functioning of the in-stream and adjacent areas, if by chance it is dispersed via surface run-off, or are allowed to permeate into the groundwater. The potential negative changes to water quality during the operational phase would be limited to sedimentation and erosion related issues. These negative impacts would persist into the medium term.

Significance of impacts without mitigation

Changes to water quality (surface and groundwater) impact on the functioning of plants and other in-stream biota. This impact without mitigation would have a **MEDIUM** significance, as excessive pollution will also impact on in-stream conditions due the introduction of toxins (Table 5).

Potential toxins include the following:

- Grout and concrete – these products contain cement which increases the pH (basic) of surfaces waters impairs the metabolism and breathing physiology of aquatic organisms
- Hydrocarbons (shutter oil, other lubricants, grease and fuels) – The persistent impact of these pollutants is varied, but can enact negatively on metabolic pathways, cellular structures (plant and animal), respiration and gene stability (heavy metals)

Proposed mitigation

- Any chemicals used/required must be stored safely on site and surrounded by bunds. Chemical storage containers must be regularly inspected so that any leaks are detected early.
- Littering and contamination of water sources during construction must be prevented by effective construction camp management.
- Emergency plans must be in place in case of spillages onto road surfaces and water courses.
- No stockpiling should take place within a water course or their defined buffer areas.
- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised.
- Stockpiles must be located away from river channels.
- Erosion and sedimentation into river channels must be minimised through the effective stabilisation (gabions and Reno mattresses) and then re-vegetation of any disturbed riverbanks must take place.
- The construction camp and necessary ablution facilities meant for construction workers must not be sited beyond the buffers described previously.

Significance of impact with mitigation

Should the construction works be managed properly, the negative impacts would remain localised and in the short-term, considering that in most cases the impacts are only related to the extension of culverts that are already in place. This would result in an overall significance of **VERY LOW** as the introduction of any pollutants would be limited with mitigation as most of the components would be precast and then installed *in situ* (Table 5).

Table 5: Impact on water quality

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	High 3	Medium term 2	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Short-term 3	Very Low 4	Probable	Very Low	-ve	High
Degree to which impact can be reversed	Partial							
Irreplaceability of resource	Low							

General mitigation measures and recommendations

In addition to the proposed mitigation measures provided in the above, the following general mitigation measures are also provided to help reduce impacts:

- Existing stormwater management measures should be included in all new and extended loop sections. Point discharges of stormwater should be targeted in buffer zones and not be released directly into watercourses and drainage systems.
- Placement of stockpiles and batching plants away from buffered watercourses and drainage systems, as well as the prevention of refuelling in these areas, would help to prevent sedimentation and low water quality impacts into receiving aquatic habitats.
- Ballast material should be cleared from watercourses and drainage systems, specifically in culverts, to prevent obstructions that could contribute to erosion damage during occasional high flow events.
- Monitoring during construction activities by a professionally registered ecologist with wetland experience is recommended in association with ECO's and EO's working on the project. Training can be provided to the environmental team to help increase expertise and impact mitigation successes during the construction phase.
- Rehabilitation should be undertaken after construction and a watercourse specific rehabilitation plan should be developed towards the end of the construction monitoring phase. All of the affected watercourses and drainage systems should be reinstated to a similar PES compared to their preconstruction condition. Other aspects that need to be addresses is the stabilisation of any new erosion features and the control of alien plant species, specifically *Prosopis* spp., which have been recorded at low densities within the study area near watercourses.

7. Conclusion

Several drainage line crossings, washes, and flats were identified and assessed according to their PES and EIS, (Appendix A). More pronounced watercourses included an arid river crossing (classified as a wash) at Mamathwane and two indistinct depression (pan) wetland crossings at Gong Gong and Trewil, which were also delineated and assessed according to their PES and EIS, (Appendix A). It would seem, based on the site visit and the type of watercourses and drainage systems observed that the proposed extension scope would have a limited impact on the aquatic environment if the mitigations and recommendations are upheld together with the following aspects that must be included into the Construction Environmental Management Plan (CEMP).

With regard to the potential impacts of the project on the aquatic environment, other than the physical destruction of any watercourse or wetland (including sedimentation and erosion or habitat change) the next most detrimental impact includes the potential for any water quality changes. Water quality risks include in broad categories:

- Increase in sediment loads, measured as increase suspended sediments
- Hydrocarbon pollution from spilled fuel, oils (incl. shutter and hydraulics) and grease
- Cement products that pose a risk to aquatic organisms
- Contamination from manganese ore i.e. seepage or dust should any spills occur, although unlikely.

Impact avoidance as the most ideal form of mitigation has been applied during the design and planning phases of the project. This resulted in zero overlap between the project components and perennial rivers, while crossings through well developed wetland systems have been restricted.

A monitoring programme should therefore be in place not only to ensure conformance with the CEMP, but also to monitor any environmental issues and impacts, which have not been accounted for in the CEMP or could result in significant environmental impacts for which corrective action is required.

The period and frequency of monitoring will most likely be stipulated by the Environmental Authorisation. Where this is not clearly dictated, the Environmental Officer (EO) should determine and stipulate the period and frequency of monitoring required in consultation with relevant stakeholders and authorities. The Resident Engineer and EO must ensure that the monitoring is conducted and reported.

The following protocols are recommended with regards to monitoring and should be read in conjunction with the Construction EMP (CEMP) which has already been finalised:

- Weekly environmental auditing for the duration of the construction period and 3 months into the operational phase.
- Monthly or quarterly environmental audit reports to be submitted to the Department of Water Affairs (DWA), or as advised by DWA for the duration of the construction period.
- Immediate notification of transgression to the Site Manager (& Project Contractor/Engineer) and provision of suitable mitigation measures to rectify environmental damage.
- If transgressions continue, report such incidences to the DWA immediately, although such incidences must be recorded in the audit reports.

To this end, it is suggested that the Proponent, Contractor and EO also consult the following guideline as reference:

- *Department of Water Affairs and Forestry, February 2005.* ***Environmental Best Practice Specifications: Construction Integrated Environmental Management Sub-Series No. IEMS 1.6. Third Edition. Pretoria***
- *Department of Water Affairs and Forestry, February 2005.* ***Environmental Monitoring and Auditing Guideline.*** *Integrated Environmental Management Sub-Series No. IEMS 1.7. Third Edition. Pretoria.*

The following is also proposed with regard the potential impacts on the aquatic environment:

- Monitoring of any spills, erosion of cleared areas or downstream sedimentation should occur on a daily basis, with any remediation being instituted immediately (Contractor's environmental representative reporting to the EO.
- Monitoring of any vegetated areas must take place at least every month during construction, and every three months during a maintenance period (EO & Contractor)
- Water that is discharged from dewatering during construction should be released in "silt bays" made from semi-permeable material, such as hay bales and geotextile material. These siltation structures should be located outside of watercourses, while water is released in a diffuse pattern.

Other forms of stormwater discharge during the construction phase should not result in concentrated flows or pose a risk for erosion development. Sediment should be trapped before stormwater is released into water courses, while any erosion features that develop immediately downstream of stormwater discharge points should be stabilised once observed.

Other important maintenance requirements that are recommended during the operational phase of the project pertain to culvert management:

- Culverts should be monitored for ballast material and sediment that can accumulate and concentrate surface flow patterns. These materials should be removed, especially before and during the rainy season.
- Channel incision and headcuts that may development immediately downstream of culverts should be stabilised once observed. Alien plant species that encroach into the servitude should be monitored and controlled at watercourse crossings.

8. References

Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998.

Agricultural Resources Act, 1983 (Act No. 43 of 1983).

Berliner D. and Desmet P. 2007. Eastern Cape Biodiversity Conservation Plan: Technical Report. Department of Water Affairs and Forestry Project No 2005-012, Pretoria. 1 August 2007

Department of Water Affairs and Forestry - DWAF (2005). A practical field procedure for identification and delineation of wetland and riparian areas Edition 1. Department of Water Affairs and Forestry , Pretoria.

Department of Water Affairs and Forestry - DWAF (2007). Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, C.J. 2000. Desktop estimates of the ecological importance and sensitivity categories (EISC), default ecological management classes (DEMC), present ecological status categories (PESC), present attainable ecological management classes (present AEMC), and best attainable ecological management class (best AEMC) for quaternary catchments in South Africa. DWAF report. Institute for Water Quality Studies.

Kleynhans CJ, Louw MD, Graham M, 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08

Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002), as amended.

National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended.

National Water Act, 1998 (Act No. 36 of 1998), as amended

Ramsar Convention, (1971) including the Wetland Conservation Programme (DEAT) and the National Wetland Rehabilitation Initiative (DEAT, 2000).

Appendix A - Summary of Watercourse and Other Drainage System according to Type, Distinctness, PES, EIS, Figure References, Quaternary Catchment and Level of Confidence

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
UPPER ORANGE WATER MANAGEMENT AREA – SOUTHERN KALAHARI ECOREGION									
Beaconsfield System Separation Yard									
1	Drainage line	Yes	Dry drainage line with indistinct channel development, apart from the section through the loop embankment. It is expected that this channel feature has been created or at least enhanced in the past. Little evidence was recorded of any surface water flows in the recent past. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods.	D	Low	Moderate	Figure 3	C51L & C52L	Moderate
2	Drainage line	Yes	Dry drainage line with indistinct channel development, apart from the section through the loop embankment. It is expected that this channel feature has been created or at least enhanced in the past. Little evidence was recorded of any surface water flows in the recent past.	D	Low	Moderate			Moderate
LOWER VAAL WATER MANAGEMENT AREA - – SOUTHERN KALAHARI & GHAAP PLATEAU ECOREGIONS									
Fieldsview Loop Extension (Southern Kalahari Ecoregion)									
3	Drainage line	No, located approximately 60 m west of the loop.	Dry drainage line that does not intersect with the loop section. No culvert is present in the existing the railway line across the start of the drainage line. The drainage line develops into an ephemeral channel with a distinct channel features further downstream, away from the loop. No evidence of recent surface flows was recorded within the drainage line.	C	Moderate	Low	Figure 7	C91E	Moderate/low
Gong Gong Loop Extension (Southern Kalahari Ecoregion)									
4	Depression (pan) wetland	Yes	Arid depression wetland with no distinct wetland indicators, apart from the terrain unit indicator. The pan wetland is overgrazed and bisected by an existing railway line. No signs of recent saturation were recorded. PES and EIS assessments are not ideally suited for this landscape feature. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods.	D	Low	Moderate	Figure 8	C91E	Moderate
5	Drainage line	No, located approximately	Dry and indistinct drainage line with no clear channel features. The drainage line appears to	C	Moderate	Very low			Low/very low

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
		70 m east of the loop	flow into the pan wetland. The drainage system is very marginal in nature and do not contain signs of recent flow.						
6	Drainage line	Yes	Dry and indistinct drainage line with no clear channel features. The drainage line appears to flow into the digging (excavation) on the western side of the Gong-Gong loop. The drainage system is very marginal in nature and do not contain signs of recent flow.	D	Low	Moderate			Low/very low
7	Digging (excavation)	No, located approximately 15 west of the loop	This digging area (quarry) may previously existed as a watercourse, but has been completely modified through excavation activities and erosion. The NFEPA data incorrectly refers to the area as a natural wetland. PES & EIS assessments are not applicable to this landscape feature. The area is, however, regarded as seriously disturbed.	N/A	N/A	Very low	Figure 8	C91E	Moderate
8	Drainage line	Yes	Dry and indistinct drainage line with poorly developed channel features. The drainage line contains little evidence of any surface water flows in the recent past	D	Low	Moderate			Moderate/low
9	Wash	No, located approximately 25 m northeast of the loop.	Dry and indistinct wash/alluvial fan drainage system that is poorly defined. The system contains little evidence of any surface water flows in the recent past. No sign of channel incision or scour downstream of railway line crossing. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods.	C	Moderate	Low			Low/very low
Ulco Loop Extension (Southern Kalahari Ecoregion)									
10	Drainage line	No, located approximately 80 m southwest of the loop.	Dry drainage line that is discontinuous in nature and drains largely parallel to the loop section. The drainage line is not expected to be associated with wetland habitat. An abandoned and old railway line section located nearby gives the impression of forming an additional drainage line. PES and EIS assessments were not determined for this non-wetland drainage system, as it is located some distance away from the loop section.	Not assessed	Not assessed	Very low	Figure 13	C33C	Low
11	Drainage line	No, located approximately 170 m	Dry drainage line that is discontinuous in nature and drains largely parallel to the loop section. The drainage line is not expected to be associated with	Not assessed	Not assessed	Very Low			Low

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
		northeast of the loop.	wetland habitat. PES and EIS assessments were not determined for this non-wetland drainage system, as it is located some distance away from the loop section.						
12	Wash	No, located ±20 m northeast from the loop section	Indistinct wash located adjacent to the Ulco loop section. No signs of recent flows events or other watercourse features were recorded. No channel development or evidence of scour was evident up or downstream of the surrounding culverts. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods.	C	Moderate	Moderate			Moderate/low
13	Wash	No, located ±80 m southwest from the loop section	Wash located adjacent to the Ulco loop section. No signs of recent flows events or other watercourse features were recorded. No channel development or evidence of scour was evident up or downstream of the surrounding culverts. PES and EIS assessments were not determined for this non-wetland drainage system, as it is located some distance away from the loop section.	Not assessed	Not assessed	Very low	Figure 13	C33C	Moderate/low
14	Depression wetland	No, located ±450 m southwest from the loop section	Arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods.	C	Moderate	Very low			Low
Trewil Loop Extension (Ghaap Plateau Ecoregion)									
15	Depression (pan) wetland	No, located approximately 175 m south-southeast of the loop.	Arid and indistinct depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	B/C	Moderate	Very low	Figure 15	C92A	Low
16	Depression (pan) wetland	No, located approximately 190 m south-southeast of the loop.	Arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	B/C	Moderate	Very low			Low
17	Flat wetland	No, located approximately 210 m south-southeast of	Arid flat wetland with no expected distinct Arid and indistinct depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and	B/C	Moderate	Very low			Low/very low

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
		the loop.	soil saturation is not expected.						
18	Depression (pan) wetland	No, located approximately 110 m south-southeast of the loop.	Arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	B/C	Moderate	Very low			Low
19	Depression (pan) wetland	Yes	Arid and indistinct depression wetland with no distinct wetland indicators, apart from the terrain unit indicator. No signs of recent inundation or soil saturation were recorded. A single culvert is present in the crossing with no signs of scour or channel developed present adjacent to culvert. Apart from the existing railway line crossing, other impacts include the presence of a dirt track through the depression.	C/D	Low	Moderate	Figure 15		Moderate/Low
20	Depression (pan) wetland	No, located approximately 165 m north-northwest of the loop.	Arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	B/C	Moderate	Very low		C92A	Moderate/Low
21	Depression (pan) wetland	No, located approximately 250 m north-northwest of the loop.	Arid and indistinct depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	B/C	Moderate	Very low			Moderate/Low
Tsantsabane Loop Extension (Southern Kalahari Ecoregion)									
22	Alluvial fan/ wash	No, located ± 210 m east of the loop section.	Dry alluvial fan/ wash drainage feature situated in a landscape setting with convergent contour lines, although no distinct channel is present. No signs of recent flow events were recorded, nor were any wetland features identified. PES and EIS assessments were not determined for this non-wetland drainage system, as it is located some distance away from the loop section, (is regarded to be similar the drainage system at map label 24).	Not assessed	Not assessed	Very low	Figure 17	D73A	Moderate/Low
23	Groenwaterspruit unchannelled valley bottom wetland	No, located ± 245 m south-southeast of the loop section.	A watercourse that is best regarded as an unchannelled valley bottom wetland associated with the Groenwaterspruit. Wetland wetness features are not well developed, but include facultative wetland species, such as	D/E	Moderate	Very low			Moderate

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
			Themeda triandra and *Gomphocarpus* cf. *fruticosa*, which are regarded as indicative of above average wetness conditions in this arid environment. The watercourse is has been largely transformed into cultivated land with drainage furrows.						
24	Wash	No, located ± 15 m west of the loop section.	Dry wash drainage feature that lacks a distinct channel op opposite sides of the railway line. The drainage system is, however, clearly illustrated on aerial photographs of the area. Two dirt roads bisect the drainage feature on either side of the railway line crossing. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods	C/D	Moderate	Moderate			Moderate/Low
Postmasburg Loop Extension (Southern Kalahari Ecoregion)									
25	Drainage line	Yes	A dry drainage line with indistinct channel features that is not associated with wetland conditions. The drainage feature has been impacted by dumping, alien plant species, as well as railway line and road crossings. Little evidence was recorded of any surface water flows in the recent past.	E	Low	Moderate	Figure 22	D73A	Moderate/Low
26	Drainage line	Yes	A dry drainage line with indistinct channel features that is not associated with wetland conditions. The drainage feature has been impacted by railway line and road crossings, as well as the deposition of ballast material. Little evidence was recorded of any surface water flows in the recent past.	C/D	Low	Moderate			Moderate/Low
27	Drainage line	Yes	A dry drainage line with indistinct channel features that is not associated with wetland conditions. The drainage feature has been impacted by railway line and road crossings, as well as the deposition of ballast material. Little evidence was recorded of any surface water flows in the recent past.	C/D	Low	Moderate			Moderate/Low
28	Drainage line	No, located approximately 30 m downstream of the loop	A dry drainage line with indistinct channel features that is not associated with wetland conditions. The drainage feature has been impacted by road crossings. Little evidence was recorded of any surface water flows in the recent past.	C	Low	Moderate			Moderate/Low
Glosum Loop Extension (Southern Kalahari Ecoregion)									
29	Depression (pan) wetland	No, located approximately	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain	B/C	Moderate	Low	Figure 28	D73A	Low

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
		400 m west of the loop.	unit indicator. Recent inundation and soil saturation is not expected.						
Sishen New Loop (Southern Kalahari Ecoregion)									
30	Flat	Yes	This indistinct flat or wash-like watercourse is not associated with wetland indicators and contains little evidence of any recent surface flows. The drainage feature has been affected by recent railway line construction, as well as the creation of a channel in the downstream direction. Calcrete is present near the surface as is evident from surrounding excavations.	E	Low	Moderate	Figure 32	D41J	Low
31	Depression (pan) wetland	No, located approximately 90 m east of the loop.	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	C	Moderate	Low			Low
32	Depression (pan) wetland	No, located approximately 420 m northeast of the loop.	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	C	Moderate	Low			Low
33	Depression (pan) wetland	No, located approximately 440 m northeast of the loop.	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	C	Moderate	Low			Low
34	Depression (pan) wetland	No, located approximately 50 m northeast of the loop.	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected. The watercourse has been seriously modified by recent construction and clearing activities associated with the construction of a new railway line (not visible on the aerial photograph in Figure 32).	E	Low	Low			Low/very low
35	Flat	No, located approximately 45 m southwest of the loop.	This indistinct flat or wash-like watercourse is not associated with wetland indicators and contains little evidence of any recent surface flows. The drainage feature has been largely transformed by recent railway line construction, which now transects the drainage feature (not visible on the aerial photograph in Figure 32).	D	Low	Moderate			Low/very low

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
Wincanton Loop Extension (Southern Kalahari Ecoregion)									
37	Depression (pan) wetland	No, located approximately 30 m west of the loop	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	C	Moderate	Low	Figure 35	D41J	Low
38	Depression (pan) wetland	No, located approximately 220 m south of the loop.	An arid depression wetland with no expected distinct wetland indicators, apart from the terrain unit indicator. Recent inundation and soil saturation is not expected.	D	Low	Low			Moderate/low
Mamatwane Compilation Yard (Southern Kalahari Ecoregion)									
36	Wash	Yes	A watercourse that is best regarded as wash associated with the Vlermuislaagte 1:500000 secondary river (Middleton & Bailey, 2008). Wetland wetness features are not well developed, and a distinct channel bed and channel banks are also absent. The watercourse is has been largely transformed through a railway line crossing on a raised embankment, dirt tracks and a grazing. PES and EIS assessments are not ideally suited for this type of drainage system due to a lack of suitable methods	D	High	Moderate	Figure 37	D41K	Moderate
LOWER ORANGE WATER MANAGEMENT AREA – NAMA KAROO ECOREGION									
Burgerville Loop Extension									
1	Drainage line	Yes	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 40	D26D	Moderate
2	Drainage line	Yes	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low			
AF1	Alluvial fan	Yes	Alluvial sand deposit with no distinct drainage line or water course	C	Moderate	Moderate			
AF2	Alluvial fan	Yes	Alluvial sand deposit with no distinct drainage line or water course	C	Moderate	Moderate			
UPPER ORANGE WATER MANAGEMENT AREA – NAMA KAROO ECOREGION									
Linde Loop Extension									
3	Drainage line	Yes	Small dry river bed crossing requiring culvert extension only	B	Moderate	Low	Figure 41	D32F	Moderate
5	Drainage line	Yes	Small dry river bed crossing requiring culvert	B	Moderate	Low			

Map label	Drainage system type	Crossed by road alignment	Description	Approximate Present Ecological State (PES) Score	Approximate Ecological Importance & Sensitivity (EIS) Score	Project impact significance (with mitigation)	Report Figure	Quaternary Catchment	Confidence in feature prominence, PES & EIS
			extension only						
6	Drainage line	Yes	Small dry river bed crossing requiring culvert extension only	B	Moderate	Low	Figure 41		
AF10	Alluvial fan	Yes	Alluvial sand deposit with no distinct drainage line or water course	B	High	Moderate			
Depressions / Washes	"wetland" and or within 500 of wetland boundary	Yes	Sandy depression with no wetland characteristics other than holding surface water during heavy rainfall periods	B	High	Moderate			

WATERCOURSE ASSESSMENTS FOR THE NGQURA 16 MTPA MANGANESE ORE RAIL EXPANSION: AREA 3 (COEGA – DE AAR).

Prepared for:

Imperata Consulting
69 Chateaux de Grace,
71 Hardekool Avenue,
Val de Grace,
PRETORIA, 0040

On behalf of:

Hatch
14 Harrowdene Office Park,
Western Service Road,
Woodmead,
JOHANNESBURG, 2157

Prepared by:

Scherman Colloty & Associates
1 Rossini Road
PORT ELIZABETH, 6070

FEBRUARY 2012

SPECIALIST STATEMENT DETAIL

This statement has been prepared with the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (Act 107 of 1998), any subsequent amendments and any relevant other National and / or Provincial Policies related to biodiversity assessments in mind.

Report prepared by: Dr. Brian Colloty Pr.Sci.Nat. (Ecology) / Certified EAP / Member SAEIES & SASAqS

Expertise / Field of Study: BSc (Hons) Zoology, MSc Botany (Rivers), Ph.D Botany Conservation Importance rating (Estuaries) and interior wetland / riverine assessment consultant from 1996 to present.

I, **Dr. Brian Michael Colloty** declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs

Signed:... .... Date:...6 February 2012.........

1 - Background

Hatch is undertaking the feasibility studies required for the Ngqura 16 million ton per annum (Mtpa) expansion for the manganese ore rail infrastructure on behalf of Transnet Capital Projects (TCP). The rail route originates in the Northern Cape at Hotazel where the manganese ore is mined and currently terminates at Port Elizabeth. The route is proposed to terminate at Ngqura Port (currently the focus of an Environmental Impact Assessment Process).

The scope of work for the proposed rail line upgrade is divided into three areas, namely Area 1 (Hotazel to Kimberley), Area 2 (Kimberley to De Aar), and Area 3 (De Aar to Port of Ngqura). The following activities, amongst others are proposed: the development of new rail loops and the extension of existing rail loops.

Several authorisations are required for the proposed project and include Environmental Authorisations under the National Environmental Management Act (Act No 107 of 1998) as amended, as well as the National Water Act (Act 36 of 1998). The latter requires the submission of three Water Use License Applications as required by Section 21 of the Act for Areas 1, 2, and 3 as mentioned previously.

2 - Introduction

Scherman Colloty & Associates (SC&A) was appointed to assist Hatch via Imperata Consulting with conducting the relevant specialist assessments to fulfil the requirements of the respective Section 21 Water Use License Applications. The relevant water use licenses under the National Water Act (Act No 36 of 1998) are required for any construction that is to take place within a bed or bank of a water course, impede or divert flows from a watercourse or take place within 500m of a wetland. These applications must also be supported by additional documentation such as the Section 21 questionnaire, of which this report will form part. This report will be used as per the relevant submissions to the Department of Water Affairs in terms the registration / licensing (as required) for Section 21 c & i water uses.

This report assesses the extent of any wetlands or drainage lines within the proposed development footprints and conducts a Present Ecological State assessment for Area 3 (De Aar to Ngqura) only. This assessment was based on one site visit conducted during October 2012 and January 2013, after significant rainfall within the region. This aided the assessment with regard to observing flows or ponding within the areas under investigation.

The following proposed loop sections were investigated in Area 3 (total distance ±32.2 km):

- Tafelberg (± the extension of the rail loop will be for a distance of ±2.4 km)
- Rosmead (±2.5 km)
- Knutsford (± 2.3 km)
- Drennan (± 2 km)
- Thorngrove (± 3.8 km)
- Cookhouse – Golden Valley (± 4.5 km)
- Sheldon (± 1.40 km)
- Ripon – Kommadagga (± 5.5 km)
- Verby (± 2.8 km)

As the project involves the expansion of nine loops within Area 3, which span several different biomes, vegetation types (ecosystems) and Ecoregions, the study areas, results and discussions will be dealt with separately for each loop. However due to the nature of the impacts and the present state of the environment (i.e. rail way line is already present) the impacts will be discussed as a whole for the entire project unless indicated otherwise.

Several terms and definitions are used in this report with regard to the aquatic studies and the reader is referred to the box below for additional detail.

Definition Box

Present Ecological State (PES) is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State which is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development. The PES is determined per component - for rivers and wetlands this would be for the drivers: flow, water quality and geomorphology; and the biotic response indicators: fish, macroinvertebrates, riparian vegetation and diatoms. PES categories for every component would be integrated into an overall PES for the river reach or wetland being investigated. This integrated PES is called the EcoStatus of the reach or wetland.

Ecoregions are geographic regions that have been delineated in a top-down manner on the basis of physical/abiotic factors.
NOTE: For purposes of the classification system, the 'Level I Ecoregions' for South Africa, Lesotho and Swaziland (Kleynhans *et al.* 2005), which have been specifically developed by the Department of Water Affairs (DWA) for rivers but are used for the management of inland aquatic ecosystems more generally, are applied at Level 2A of the classification system. These Ecoregions are based on physiography, climate, geology, soils and potential natural vegetation.

3 – Study area description

3.1 Tafelberg

Figure 1 indicates the proposed locality of the Tafelberg rail loop expansion within the Q41D Quaternary catchment of the Klein Brak River. Two perennial streams associated with this river flow in a southerly direction alongside the proposed loop. The region is dominated by the vegetation associated with the Eastern Upper Nama Karoo (Nku4) vegetation type (Mucina & Rutherford, 2006) within the Drought Corridor Ecoregion. The drought corridor experiences approximately 300 – 400 mm/a of rainfall, thus this region contains elements of the Karoo region, i.e. shrubland, while water courses contain a higher number of woody tree species as compared to the Nama Karoo Ecoregion. Soils are mostly sandy and drain quickly.

.

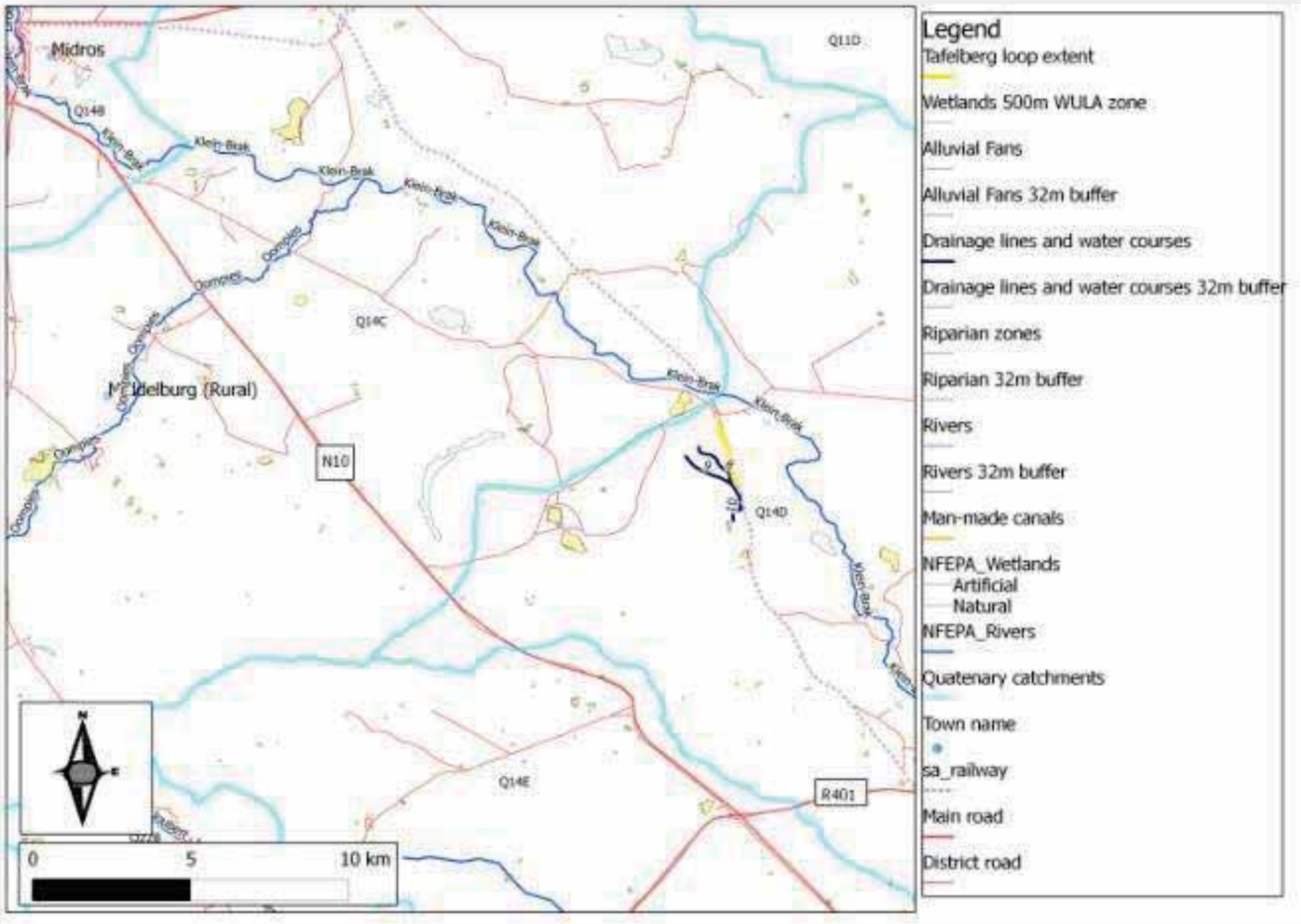


Figure 1: The Tafelberg study area (shown in yellow) in relation to the Klein Brak River in the Q14D Quaternary catchment (Source DWA, NFEPA & Hatch).

3.2 Rosmead

The Rosmead rail loop is also found within the Drought Corridor Ecoregion and thus rivers and water course are dominated by a woody element. The rail loop expansion footprint is dominated by the Eastern Upper Karoo vegetation type (Mucina & Rutherford, 2006), within an undulating landscape contained within a number of hills and outcrops. The soils are mostly sandy and are well drained, thus ponding or standing surface water bodies were not observed within the study area (Figure 2).

As with the other loops found in this Ecoregion, dominant tree species associated with the riparian zones include (Kuni Bush) *Rhus undulata,* (Olive) *Olea* species and Sweet Thorn (*Acacia karroo)*. Mainstem systems, with which the study has no direct link, have a higher Mean Annual Runoff and would thus, contain obligate riparian species such as Combretum species and Buffalo Thorn (*Ziziphus mucronata*).

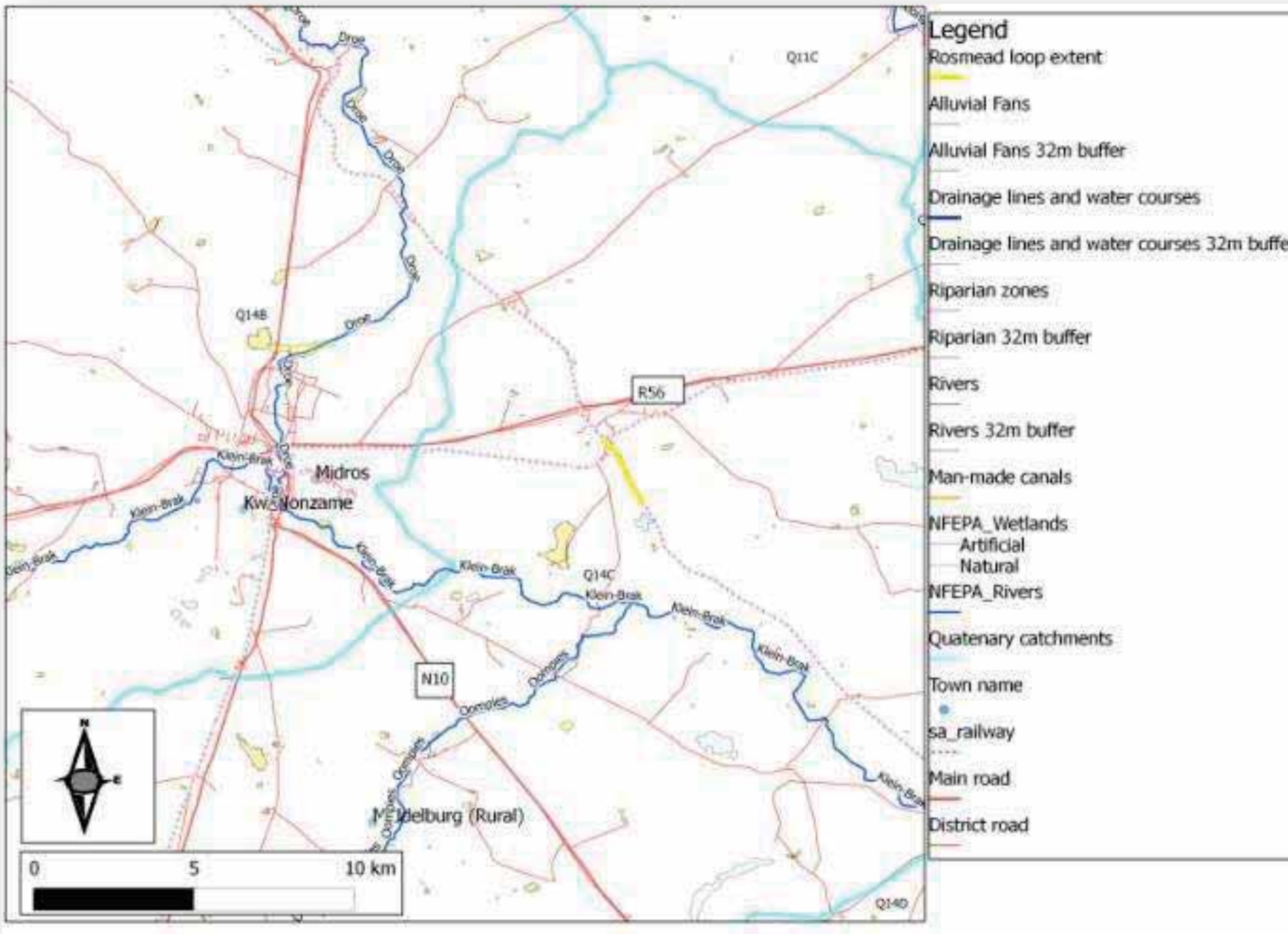


Figure 2: The Rosmead study area (shown in yellow) in relation to the Klein Brak River in the Q14C Quaternary catchment (Source DWA, NFEPA & Hatch).

3.3 Knutsford

The Knutsford rail loop traverses two vegetation types based on Mucina & Rutherford (2006). The larger portion of the proposed rail loop will cross a portion of the Eastern Upper Karoo vegetation type (Nku4). The second vegetation type is a unique vegetation type associated with rivers in the Western and Eastern Cape region. The Southern Karoo Riviere vegetation type is associated with alluvial deposits dominated by *Acacia karroo,* (Wild tamarisk) *Tamarix usneoides* and Tumble weed (*Salsola species)*. Rainfall within the study region varies between 300 and 400 mm/a. The rail loop expansion footprint (Figure 3) is located adjacent to the Great Fish River (Quaternary Q13C), but is well elevated and not within any floodplain areas, but is typical of the Drought Corridor Ecoregion.

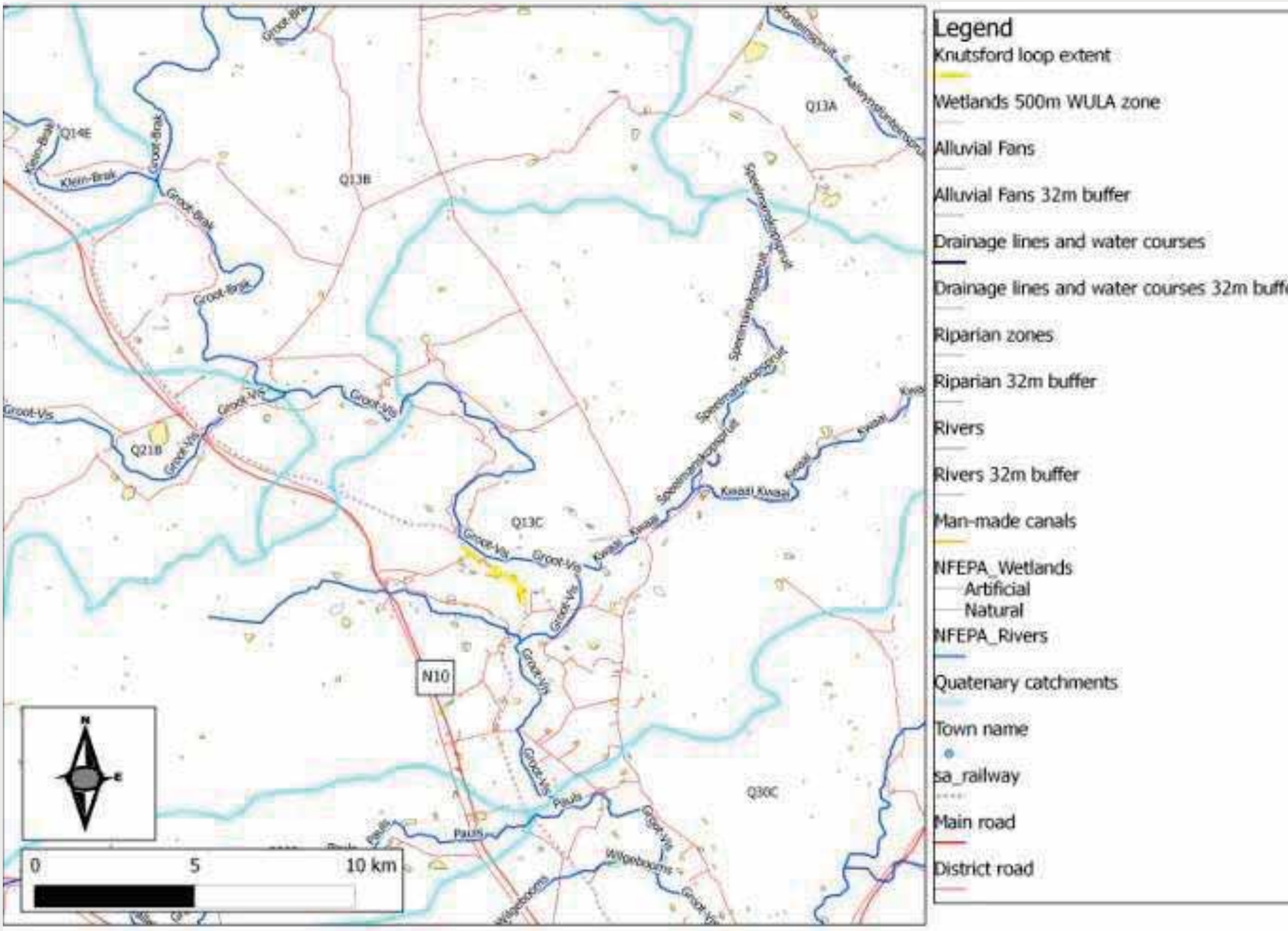


Figure 3: The Knutsford study area (shown in yellow) in relation to the Great Fish River in the Q13C Quaternary catchment (Source DWA, NFEPA & Hatch).

3.4 Drennan

The Drennan rail loop is located within the Great Fish River Quaternary Q50A (Figure 4) in the Drought Corridor Ecoregion. The proposed rail loop expansion will span three vegetation types namely the Eastern Upper Karoo, Southern Karoo Riviere and Albany Thicket types (Mucina & Rutherford, 2006). The undulating topography is dominated by shales. The region typically receives between 300 – 400 mm/a of rainfall, thus the small drainage lines and water course have little or no riparian vegetation, with the exception of the Great Fish River itself that has a broad riparian zone due to the higher and modified (part of Interbasin Transfer scheme) Mean Annual Runoff.

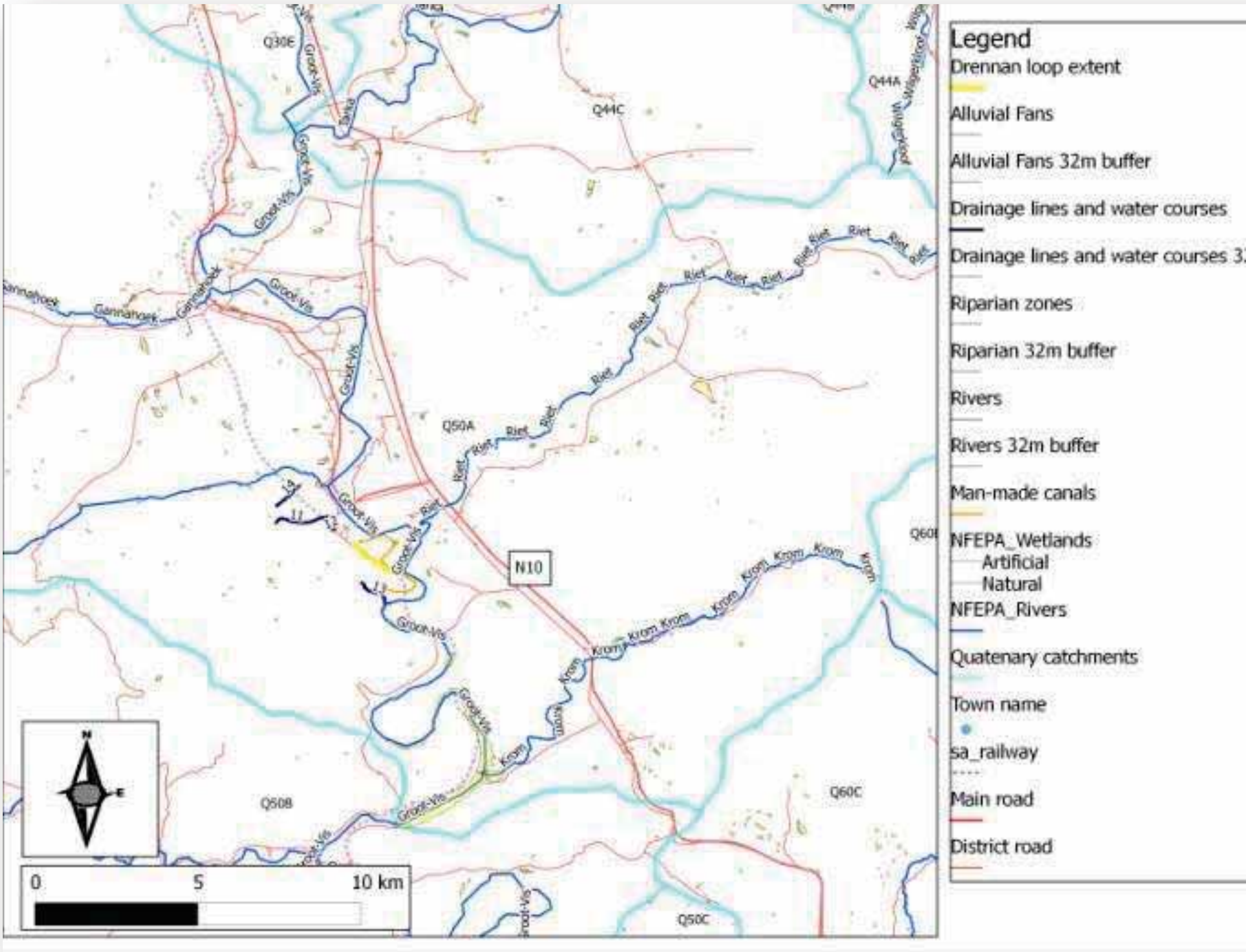


Figure 4: The Drennan study area (shown in yellow) in relation to the Great Fish River in the Q50A Quaternary catchment (Source DWA, NFEPA & Hatch).

3.5 Thorngrove

Figure 5 indicates the proposed Thorngrove rail loop within the Q50C Quaternary catchment of the Great Fish River. It should be noted that most of the Mean Annual Runoff within this system is modified due to the Gariep (Orange) – Fish – Sundays Interbasin Transfer Scheme. The study area is found within the Drought Corridor Ecoregion and within the footprint area is dominated by the Albany Thicket and Southern Karoo Riviere vegetation types described previously. Rainfall and soils are also typical of this region.

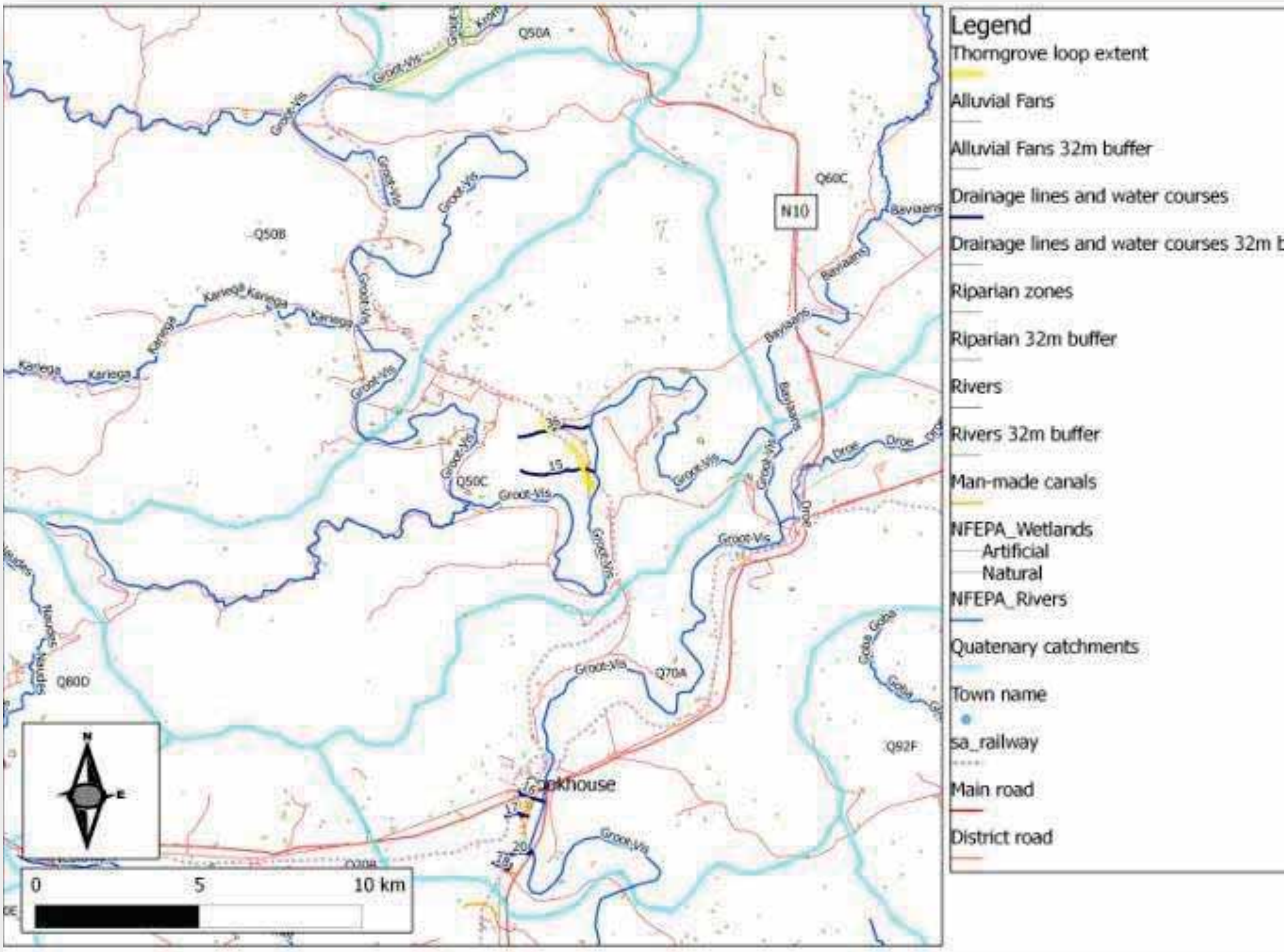


Figure 5: The Thorngrove study area (shown in yellow) in relation to the Great Fish River in the Q50C Quaternary catchment (Source DWA, NFEPA & Hatch).

3.6 Cookhouse – Golden Valley

The Cookhouse - Golden Valley rail loop (Figure 6) is located within the Q70B & Q70A Quaternary catchments of the Great Fish River and spans three vegetation types within this portion of the Drought Corridor Ecoregion. These include the Southern Karoo Riviere, Bedford Dry Grassland and Albany Broken Veld (Mucina & Rutherford, 2006). With the exception of the Southern Karoo Riviere vegetation, the remaining vegetation has no direct association within any water bodies and drainage lines. Therefore no obligate riparian species are associated with these systems. Where the Mean Annual Runoff increases (lower catchment areas), typical riparian species are more evident and usually include *Acacia karroo, Tamarix usneoides*, *Salsola species* and *Rhus undulata*.

The rainfall and soils is similar to the other regions discussed however the following two factors, namely; frost (to a lesser extent) and fire regime (to a greater extent) plays an important role in allowing more woody species to develop as compared to grasses and the karroid shrubs.

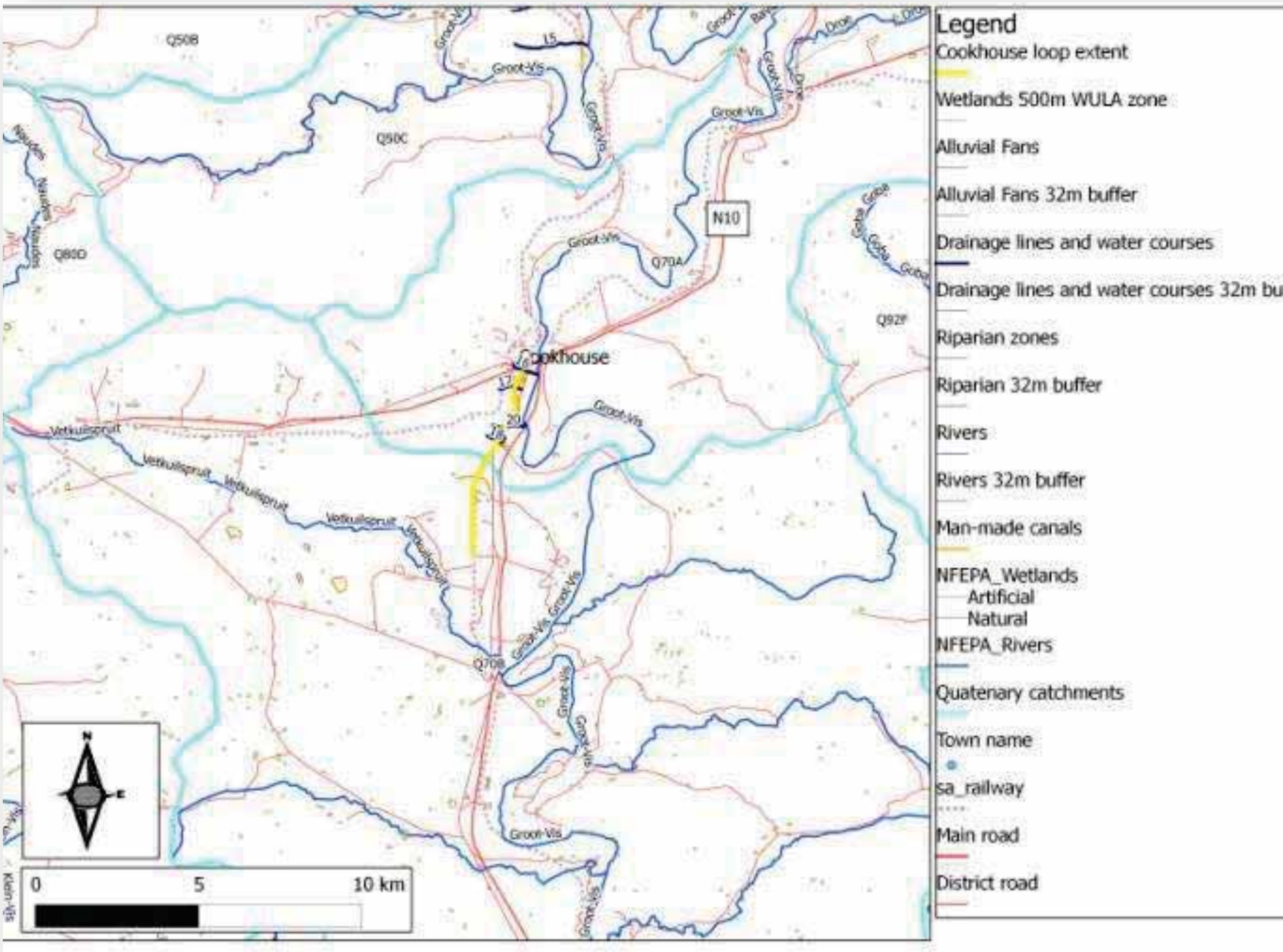


Figure 6: The Cookhouse-Golden Valley study area (shown in yellow) in relation to the Great Fish River in the Q70B & Q70A Quaternary catchment (Source DWA, NFEPA & Hatch).

3.7 Sheldon

The proposed Sheldon Loop expansion is found within the upper catchment areas of Quaternary catchment Q70C (Figure 7) of the Great Fish River dominated by the Bedford Dry Grassland vegetation type of Mucina & Rutherford (2006). Again within this region frost (to a lesser extent) and fire regime (to a greater extent) plays an important role in allowing more woody species to develop as compared to grasses and the karroid shrubs. Obligate riparian species are not evident with the riverbanks being dominated by *Rhus undulata* and *Acacia karroo*.

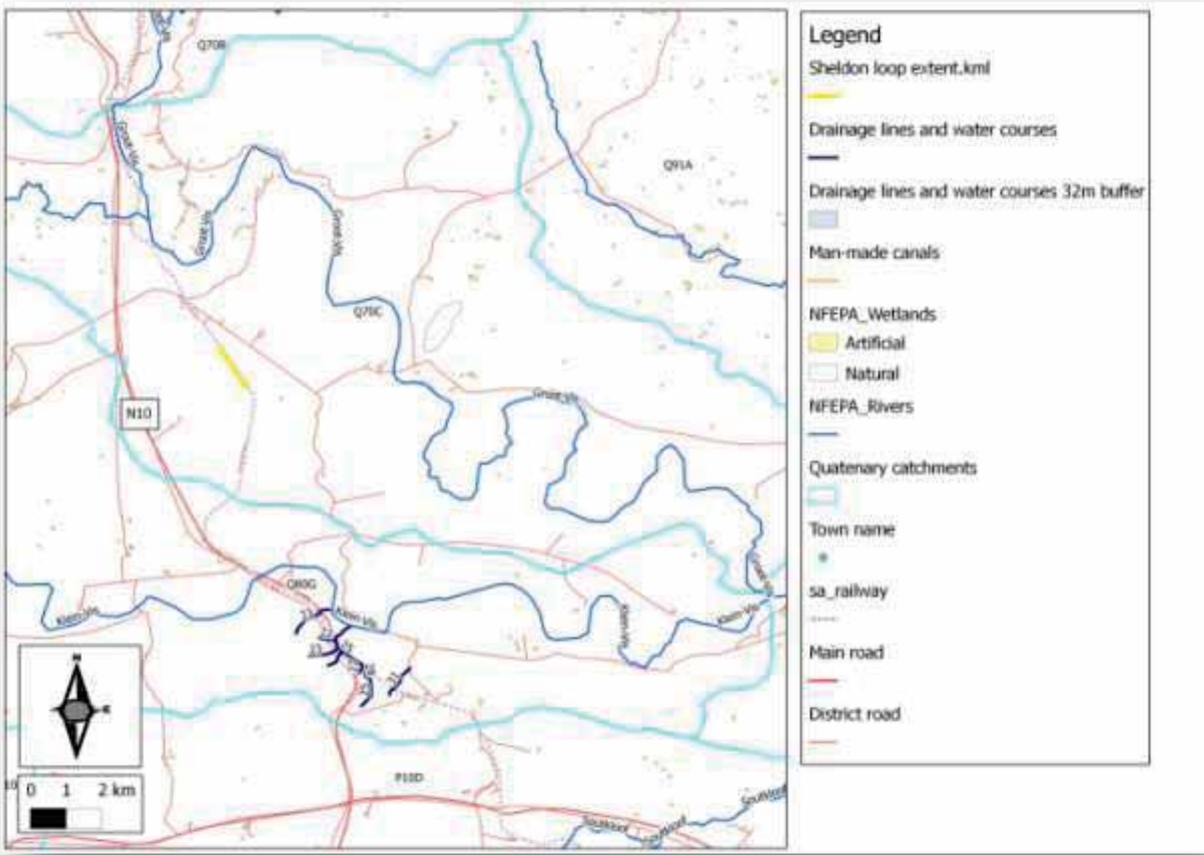


Figure 7: The Sheldon study area (in yellow) in relation to regional Quaternary catchment (Source DWA, NFEPA & Hatch)

3.8 Ripon – Kommadagga

The Ripon - Kommadagga rail loop is found within the Little Fish catchment (Q80G) (Figure 8) and is dominated by Southern Karoo Riviere, Albany Broken Veld and Kowie Thicket vegetation types (Mucina & Rutherford, 2006). The geology is dominated by the shale and sandstones of the Beaufort, Ecca and Dywka Groups, with most having shallow soils, typical of the Drought Corridor Ecoregion. The exception being the Southern Karoo Riviere alluvia found along the banks and floodplains of the Little Fish system. Rainfall in this region can reach up to 500 mm/a. The increased rainfall as compared to the previous rail loop areas, allows for the development of thicket vegetation, with *Grewia, Euclea* and *Boscia* species being the most prevalent.

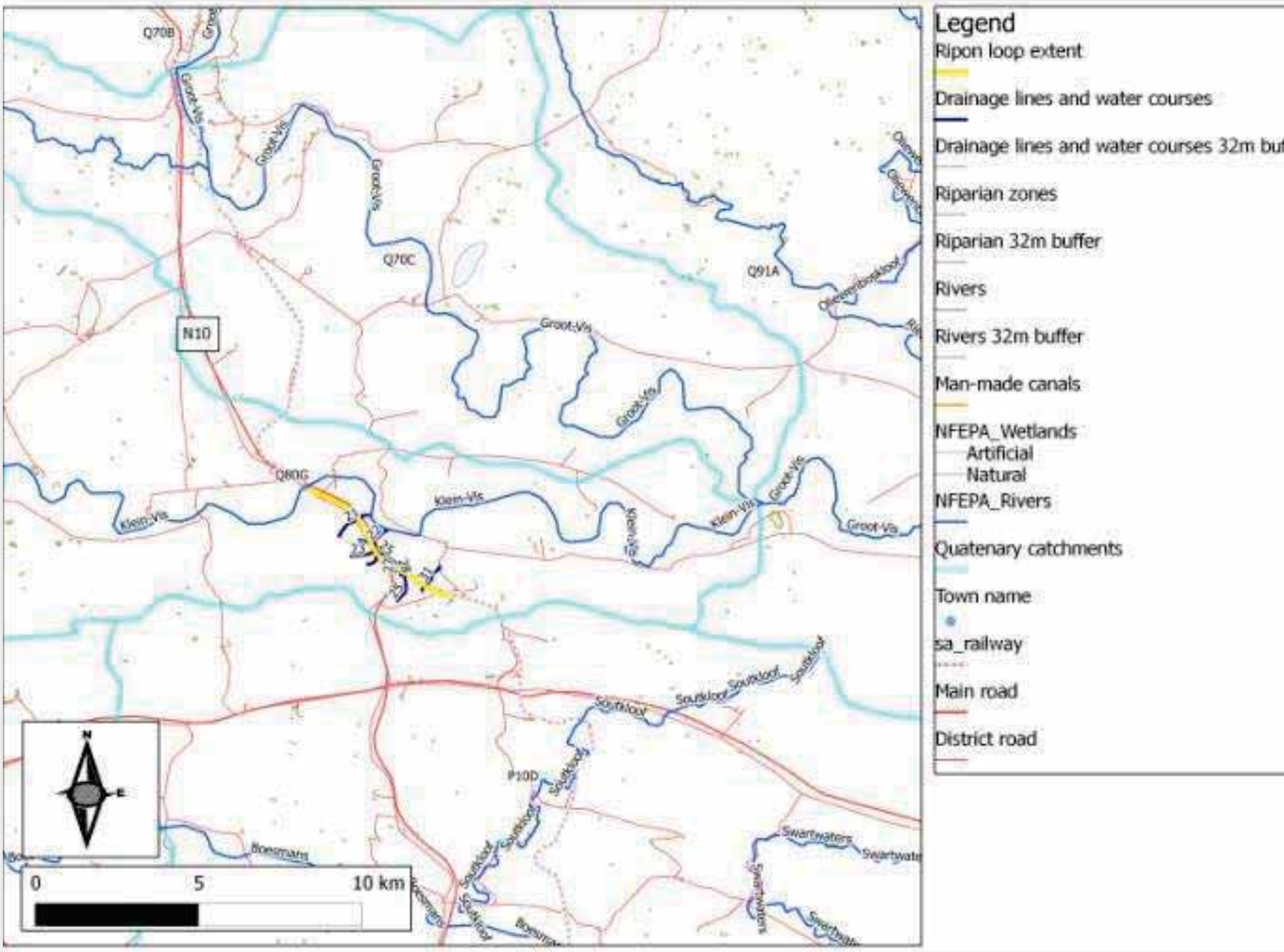


Figure 8: The Ripon study area (shown in yellow) in relation to the Little Fish River in the Q80G Quaternary catchment (Source DWA, NFEPA & Hatch).

3.9 Verby

Of the nine rail loops surveyed, the proposed Verby loop is located below the Zuurberg coastal escarpment and thus falls within the South Eastern Coastal Belt Ecoregion. The study area is located in the P10E Quaternary catchment of the upper Bushmans River (Figure 9). The higher annual rainfall allows (650 mm/pa) for the development of the Kowie Ticket vegetation type as compared to the other study areas (Mucina & Rutherford, 2006). The sandy soils are however deeper in this region due to the underlying sandstones and the relict sand dunes within the region that have become vegetated over time.

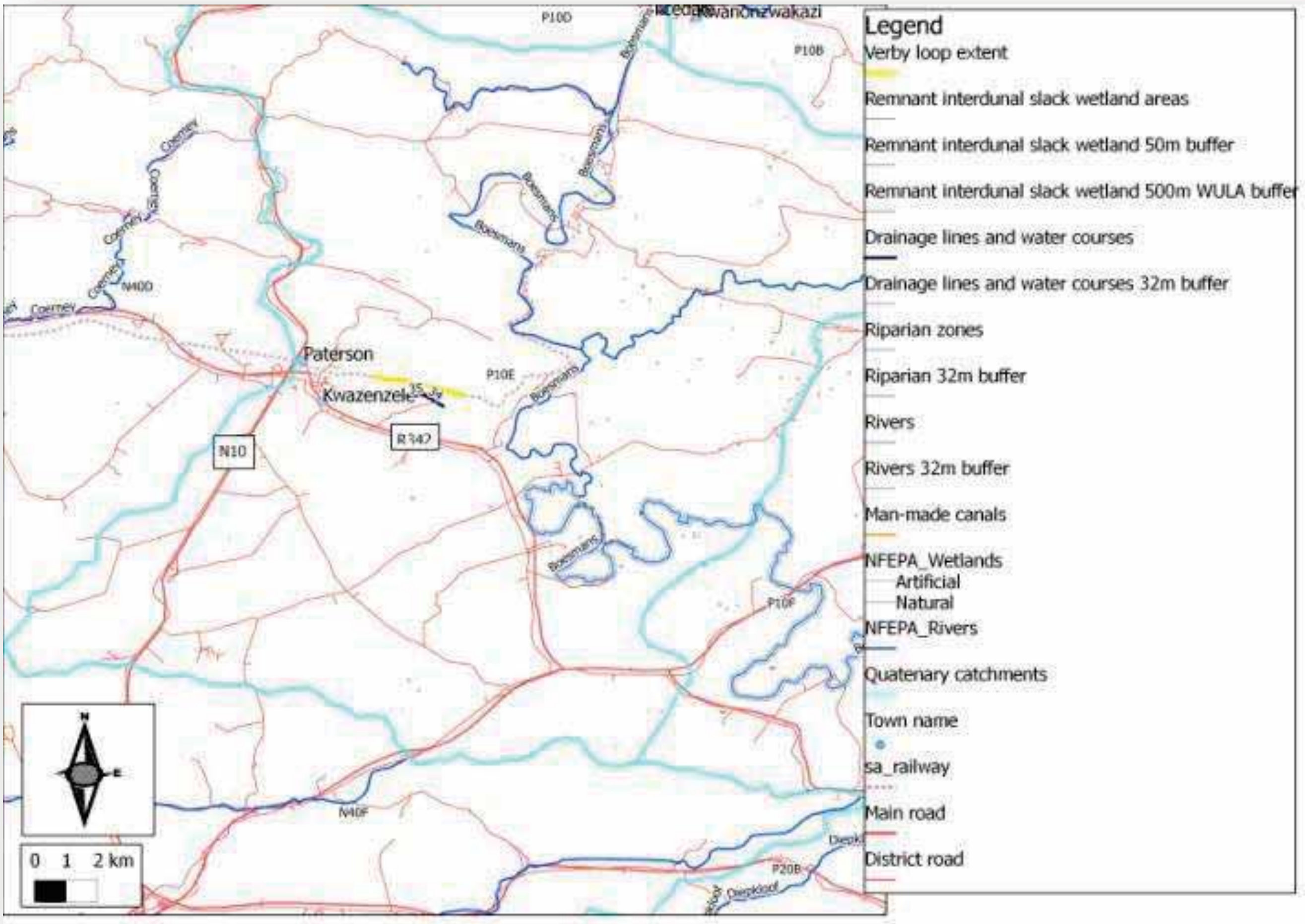


Figure 9: The Verby study area (shown in yellow) in relation to the Bushmans River in the P10E Quaternary catchment (Source DWA, NFEPA & Hatch).

4 - Relevant legislation and policy

Locally, the South African Constitution; seven Acts; and one international treaty allow for the protection of natural vegetation, rivers and water courses. These ecosystems are thus protected from the destruction or in the case of aquatic systems from pollution by the following:

- Section 24 of The Constitution of the Republic of South Africa;
- Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998;
- National Environmental Management Act (NEMA), 1998 (Act No. 107 of 1998) inclusive of all amendments, as well as the NEM: Biodiversity Act, 2004 (Act 10 of 2004);
- National Water Act, 1998 (Act No. 36 of 1998);
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983);
- Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002);
- Nature and Environmental Conservation Ordinance (No. 19 of 1974);
- National Forest Act (No. 84 of 1998); and
- National Heritage Resources Act (No. 25 of 1999).

An amendment of the National Environmental Management: Biodiversity Act or NEM:BA (Act No 10 of 2004) has been gazetted, which lists 225 threatened ecosystems based on vegetation type (Vegmap 2006). Some of these are riverine specific and do occur within the Ecoregions. Should a vegetation type or ecosystem be listed, actions in terms of NEM:BA are triggered however **none** of these listed vegetation types occur within the study area.

This report will be used as per the relevant submissions to the Department of Water Affairs in terms the registration / licensing (as required) for Section 21 c & i water uses.

Provincial legislation and policy

No accepted policies exist for the Northern Cape region of the study area and thus the following will be used for the study:

Various guidelines on suitable development have been issued in a number of the provinces, including the Eastern Cape Province and those stated in this report are based on accepted provincial guidelines as stated in the Eastern Cape Biodiversity Conservation Plan or ECBCP (Table 1). These are shown below to make the engineers and contractors aware of these buffers during the planning phase. Although construction may have to take place within the water courses, the associated batch plants, stockpiles, lay down areas and construction camps should avoid these buffer areas.

Currently there are no accepted wetland buffers distances provided by the provincial authorities. Until such a system is developed, it is recommended that a 50m buffer be set for all wetlands and 32m for rivers and water courses.

Table 1: Recommended buffers for rivers (the predominant buffer for the study region is highlighted in blue)

River criterion used	Buffer width (m)	Rationale
Mountain streams and upper foothills of all 1:500 000 rivers	50	These longitudinal zones generally have more confined riparian zones than lower foothills and lowland rivers and are generally less threatened by agricultural practices.
Lower foothills and lowland rivers of all 1:50 000 rivers	100	These longitudinal zones generally have less confined riparian zones than mountain streams and upper foothills and are generally more threatened by development practices.
All remaining 1:50 000 streams	32	Generally smaller upland streams corresponding to mountain streams and upper foothills, smaller than those designated in the 1:500 000 rivers layer. They are assigned the riparian buffer required under South African legislation.

5 – Methods

5.1 Study terms of reference

SC&A based this study on the following scope:

- Identify and delineate aquatic systems and associated biota that may be impacted upon by the proposed rail expansion;
- Rate the PES of the study area systems using suitable methods accepted by the Department of Water Affairs;
- Identify and rate potential environmental impacts;
- Provide a significance rating of surface water impacts which includes a rating of the ecological sensitivity of the site, and the effect of the development on the ecology of the site;
- Identify mitigation for negative and positive impacts.

Based on our understanding of these requirements, SC&A would produce the following:

- Riparian and /or wetland area delineation supplied together with an analysis of the potential aquatic sensitivity (including any wetlands should they occur).
- PES assessment of each study area system after the short site visit was conducted, in line with the Department of Water Affairs requirements with regard the necessary Section 21 c & i water use licenses.
- Compile an impact assessment report and provide suitable recommendations.

5.2 Study methods

This assessment was initiated with a survey of the pertinent literature and past reports that exist for the study region. Maps and Geographical Information Systems (GIS) were then employed to ascertain which portions of the proposed development could have the greatest impact on the water courses and associated habitats.

A site visit was then conducted to ground-truth the above findings, thus allowing critical comment on the possible impacts. Information was also collected to determine the PES and Ecological Importance and Sensitivity (EIS) for any of the affected waterbodies. These analyses were based on the models developed for the Department of Water Affairs using a modified version of the Index of Habitat Integrity (IHI) model (Kleynhans *et al*. 2008), with the results producing a ratings (A – F), summarised in Table 2. The IHI assesses the state of a system or a small section of the system (reach), based on rating the integrity of the following aspects and / or impacts within the instream (riverbed) and riparian or floodplain habitats:

INSTREAM HABITAT

- Water abstraction
- Extent of inundation
- Water quality
- Flow modifications
- Bed modification
- Channel modification
- Presence of exotic macrophytes
- Presence of exotic fauna
- Presence of solid waste

RIPARIAN HABITAT

- Water abstraction
- Extent of inundation
- Water quality
- Flow modifications
- Channel modification
- Decrease of indigenous vegetation
- Exotic vegetation encroachment
- Bank erosion

It should be noted that the IHI model used in this assessment was modified as the majority of the systems were either small drainage lines or mostly ephemeral in nature. These systems lacked the presence of distinct wetland indicators. As a result the full IHI model was not used, but principles related to hydrology, geomorphology and vegetation components were inferred to determine Present Ecological State (PES) values for non-wetland drainage lines

The following method was used to assess the aquatic areas (Figures 9 – 18) that were defined on the following basis:

- Vegetation type – verification of type and its state or condition, supported by species identification using Germishuizen and Meyer (2003), Vegmap (Mucina and Rutherford, 2006 as amended) and the South African Biodiversity Information Facility (SABIF) database. The SABIF database contains older species records for areas, thus allowing for a comparison of present versus past states.
- Plant species were further categorised as follows:
    - Terrestrial: species are not directly related to any surface or groundwater base-flows and persist solely on rainfall
    - Facultative: species usually found in wetlands (inclusive of riparian systems) (67 – 99% of occurrences), but occasionally found in terrestrial systems (DWAF, 2005)
    - Obligate: species that are only found within rivers and wetlands (>99% of occurrences) (DWAF, 2005)
- Mitigation measures or recommendations required.

Table 2: Description of A – F ecological categories based on Kleynhans *et al*., (1999).

ECOLOGICAL CATEGORY	ECOLOGICAL DESCRIPTION	MANAGEMENT PERSPECTIVE
A	Unmodified, natural.	Protected systems; relatively untouched by human hands; no discharges or impoundments allowed
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	Some human-related disturbance, but mostly of low impact potential
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	**Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation**
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	**Often characterized by high human densities or extensive resource exploitation. Management intervention is needed to improve health, e.g. to restore flow patterns, river habitats or water quality**
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

Conservation importance and sensitivity of the individual systems also known as Ecological Importance and Sensitivity (EIS) was based on the following criteria based on an adaptation of the method proposed by Rountree & Malan (2010):

- Habitat uniqueness
- Species of conservation concern
- Habitat fragmentation with regard ecological corridors
- Ecosystem service (social and ecological)

The presence of any or a combination of the above criteria would result in a HIGH conservation rating if the wetland was found in a near natural state (high PES). Should any of the habitats be found modified the conservation importance would rate as MODERATE, unless a species of conservation concern was observed (HIGH). Any systems that was highly modified (low PES) or had none of the above criteria, received a LOW conservation importance rating.

Therefore should any of the systems be rated with a high PES and with HIGH conservation importance then they would be considered as extremely sensitive to development. **None of the study area systems possessed any of these attributes, either due to their ephemeral nature, lack of biodiversity or were impacted upon.**

The EIS categories are summarised as follows:

Very high
Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.

High
Quaternaries/delineations that are considered to be unique due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species) on a national scale. These areas (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.

Moderate
Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These areas (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.

Low/marginal
Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity.

From a functional standpoint, the endorheic systems, such as those near the Linde site are considered important refugia for aquatic organisms, specially adapted to ephemeral conditions, while forming a network of wetland systems between the various catchments, allowing organisms to "leapfrog" form one catchment to another. A network of wetlands also presents opportunities to organisms when presented with disease or droughts, thus other unaffected catchments allow for the continuation of a species. Therefore these systems should be avoided, as they were rated as having a moderate to high sensitivity with regard the development impacts (rail construction).

6 -Aquatic system and wetland classification results

A general comment on the current impacts on the sites surveyed is that the present culverts would either seem too small as compared to the natural floodplain areas and are easily filled by sediments and windblown debris. Some even fill with ballast and this elevates the natural levels within the culvert areas, which would result in the impoundment of any surface flows. The larger culverts seen in this study all elevate natural ground levels and result in surface water impoundments.

No aquatic protected or species of special concern (fauna & flora) were observed within the wetland areas during the site visit.

The following buffers are proposed and thus indicated in the figures below:

- 50m ecological buffer be used for any wetland,
- 32m buffer while rivers and streams should receive a, as recommended by the Eastern Cape Biodiversity Conservation Plan,
- 500m from wetland boundary indicating the need for a Water Use License Application (WULA). This is not a development exclusion buffer, only a zone that will indicated what activities, should they take place within this zone, will require a WULA.

6.1 Tafelberg

The Tafelberg study area contained two small watercourses dominated by a narrow riparian strip containing species such as *Acacia karroo*, *Rhus undulata* and *Grewia robusta*. These two systems converge and then join the Klein Brak River, which flows in a southerly direction. However the proposed rail loop expansion will not cross any systems shown in Figure 10 and as a consequence no Water Use License Applications would be required for this area.

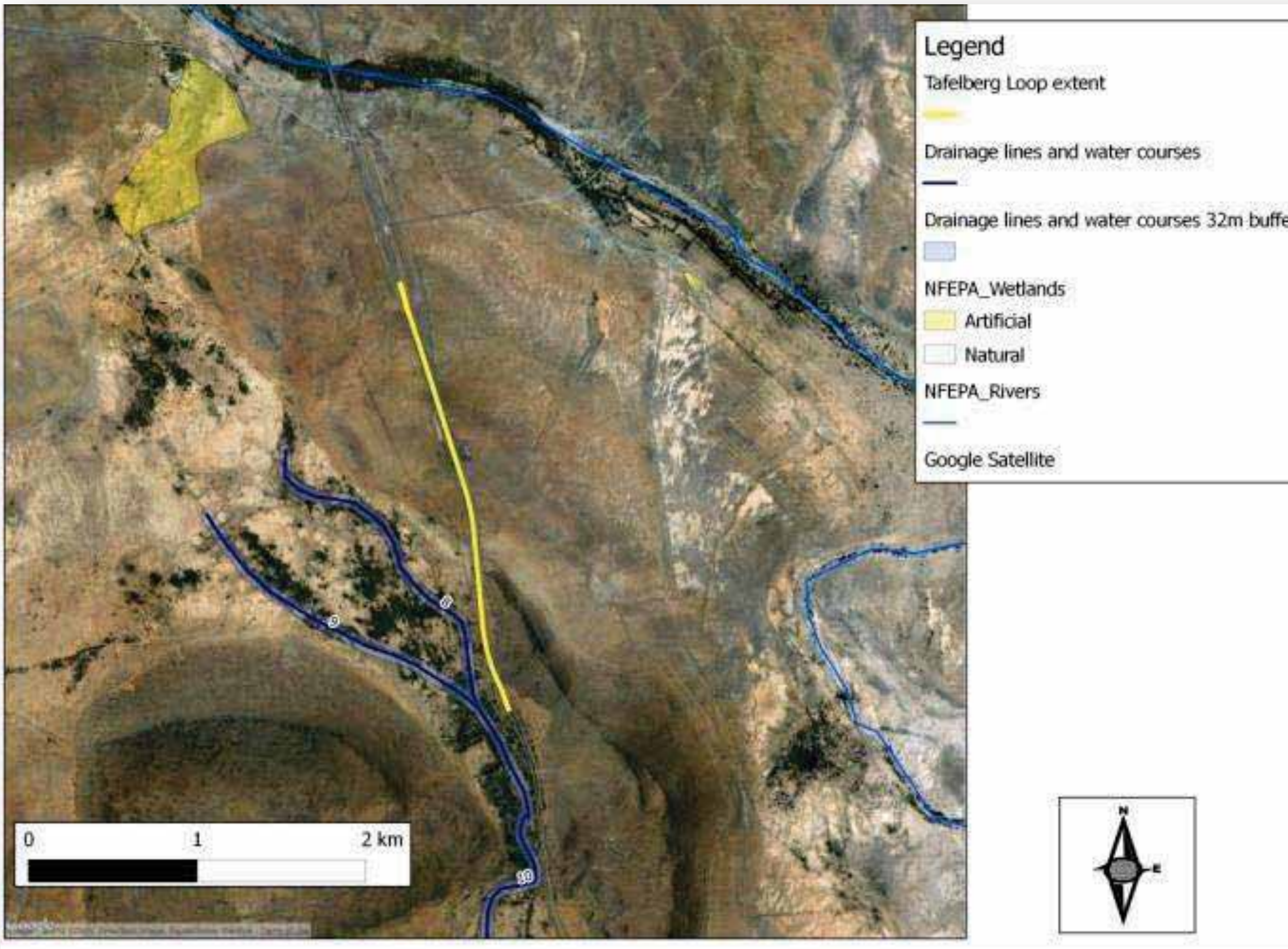


Figure 10: The watercourses observed within the Tafelberg study area, indicating the proposed 32m buffer

6.2 Rosmead

A large number of impacts occur within this site due to past and present rail activities (housing, shunting yards, diesel stores, ash dumps etc.). A significant area is also covered by what seems to have been lime stockpiles, with remnants now slowly washing into the observed water course (Figure 11).

It was also noted that the current ballast and sleeper refurbishment (13 September 2012) had resulted in large amounts of excess ballast falling into the culverts. This has raised the levels of the natural ground within the water course and will impede future flows (Plate 1).

Lastly the proposed loop seems to span a large floodplain area, based on the extent of the observed riparian vegetation. The riparian zone contained species such as *Acacia karroo*, *Rhus undulata* and *Grewia robusta*.

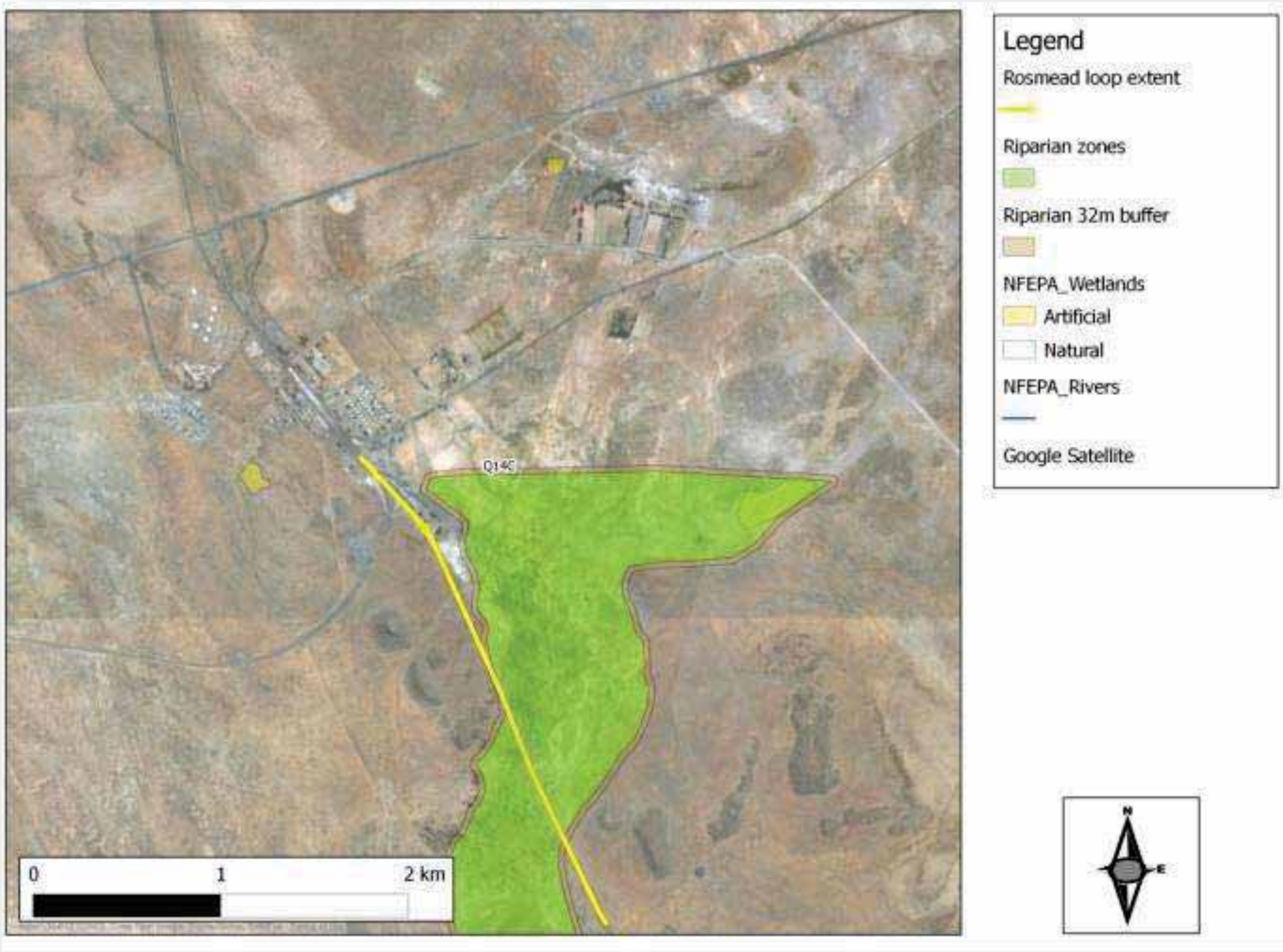


Figure 11: The riparian zone observed within the Rosemead study area, indicating the proposed 32m buffer

The PES would be C (Moderately Modified) due to the farming, road and rail activities already present (Appendix A).

The system would also have MODERATE EIS due to its limited contribution to biodiversity, but would aid in the recharge of shallow groundwater systems when water is present, while attenuating flows and flood prevention (Appendix A).

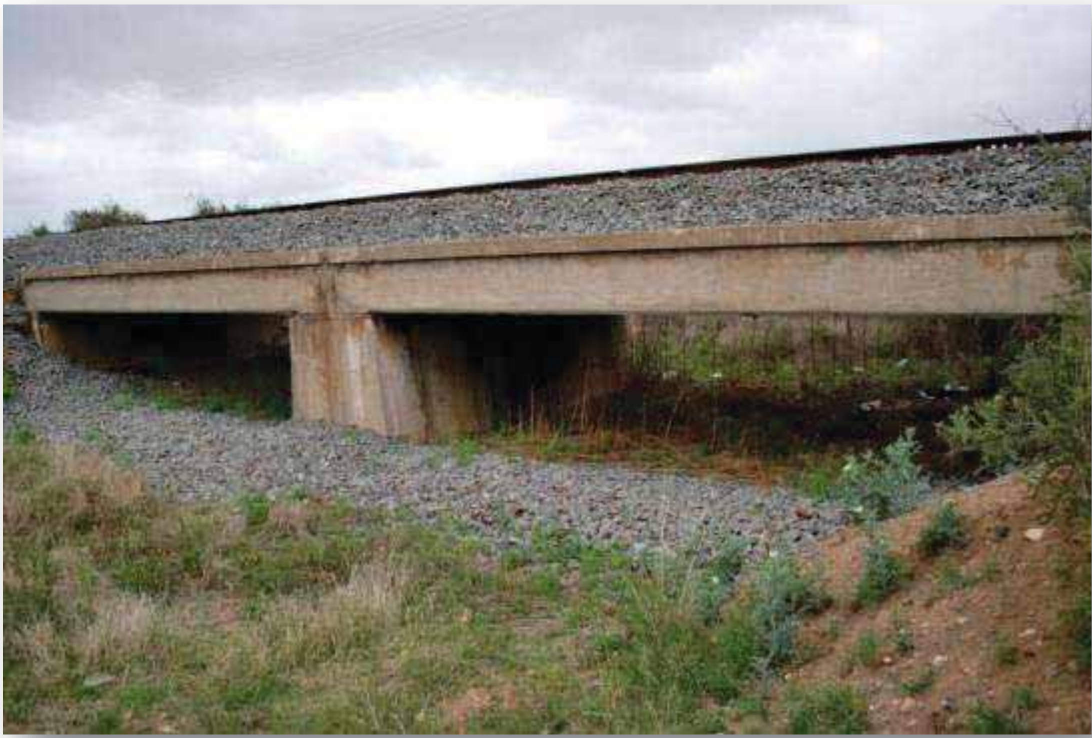


Plate 1: Excess ballast falls into the culverts and creating berms, which impede flows

6.3 Knutsford

The current rail line is elevated, or within deep cuttings and together with the surrounding man-made canals no surface water flows occur within the study area (Figure 12). The study area is also well above the Great Fish River floodplain, which has been converted to agricultural lands, thus no impacts within this area by the proposed project are anticipated. Consequently no Water Use License Applications would be required.

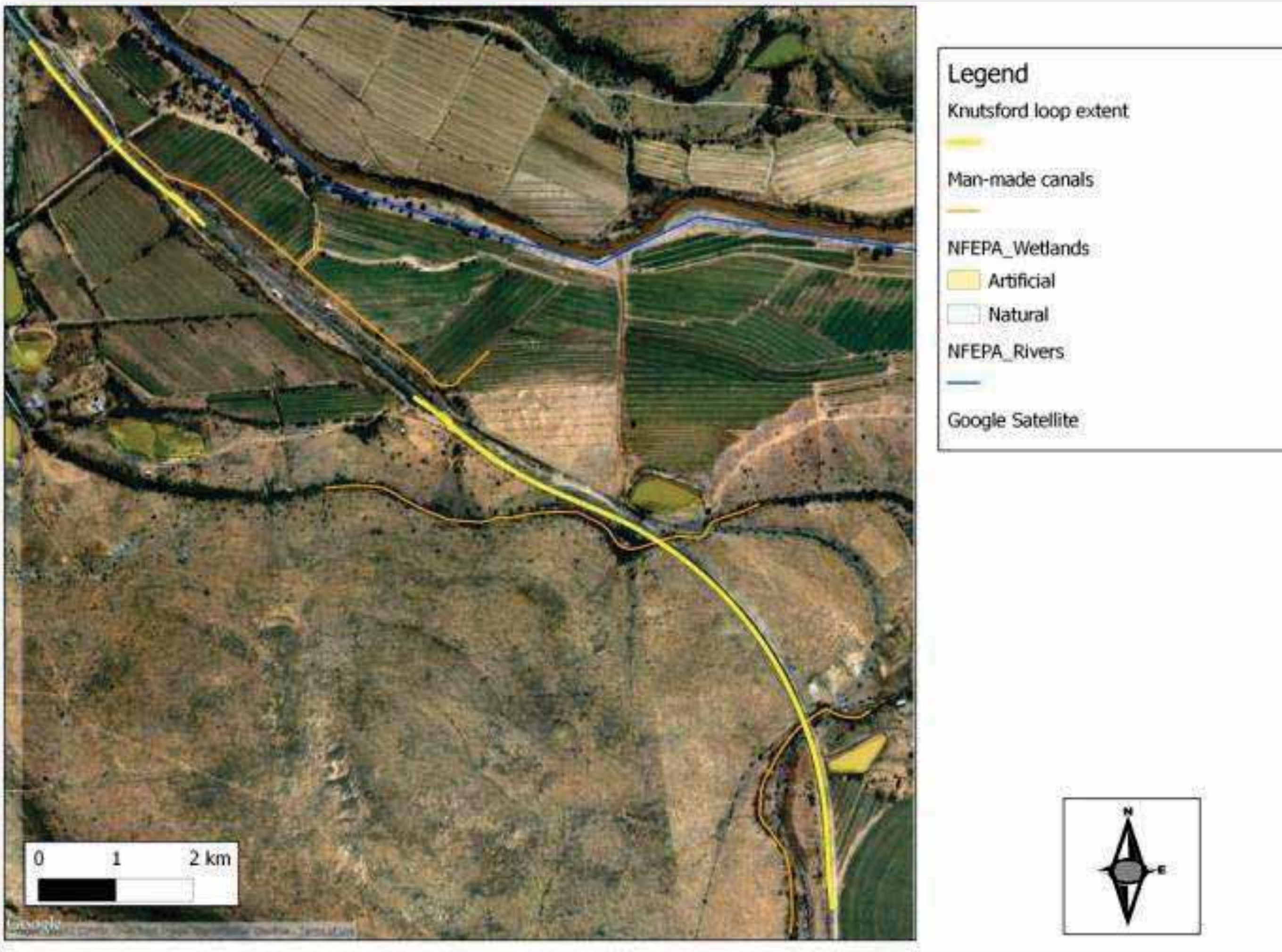


Figure 12: The man-made canals and the Great Fish River adjacent to the Knutsford site

6.4 Drennan

All of the drainage lines are impacted upon by the high number of farm dams, and man-made canals within the area. However the proposed rail loop extension will not cross any systems shown in Figure 13.

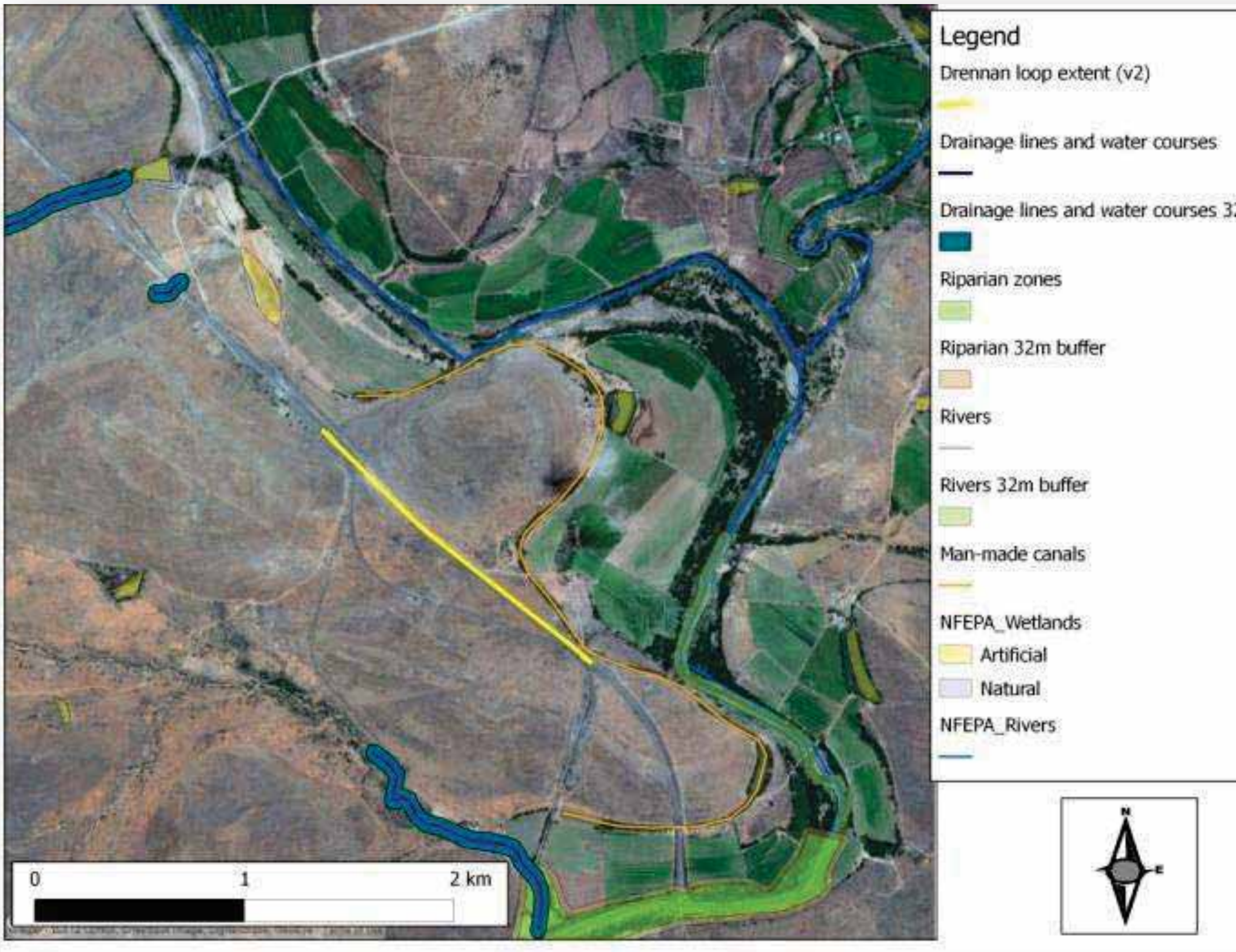


Figure 13: The watercourses and Great Fish River observed within the Drennan study area, indicating the proposed 32m buffers

6.5 Thorngrove

The only significant drainage line has ceased to flow due to the high number of farm dams, and man-made canals within the area. However the proposed loop will not cross the Great Fish River and its associated riparian zone (Figure 14).

The PES was estimated at being C (Moderately modified) due to the dams, road and rail activities already present within the two crossings observed (Appendix A). While according to the DWA 1999 assessment the PES of the Great Fish River reach within the study area was D or largely modified (Kleynshans, 2000).

These systems would also have MODERATE EIS due to their contribution to biodiversity, and act as important biological corridors and refugia within the greater region (Appendix A).

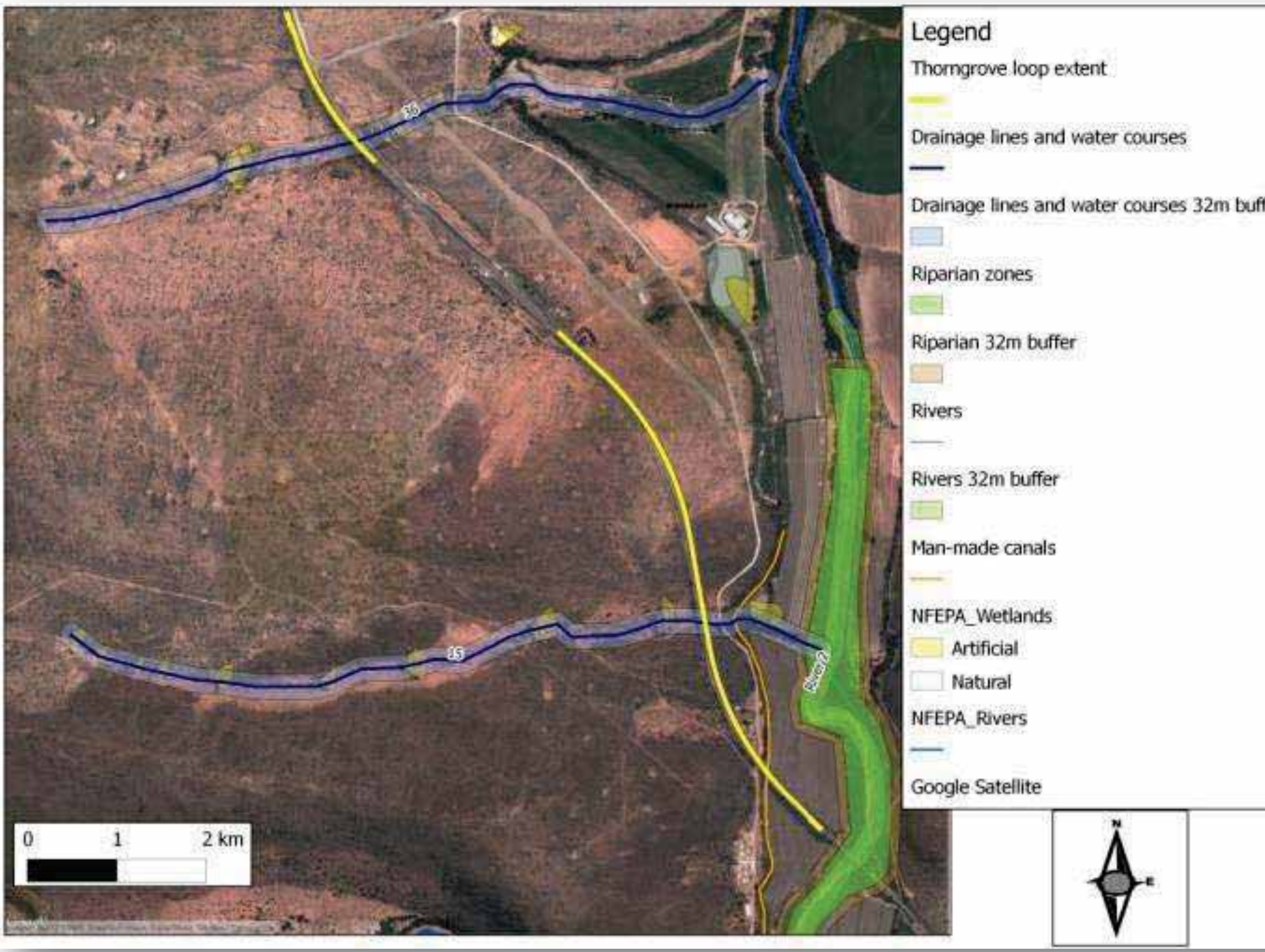


Figure 14: The watercourses and riparian zones observed within the Thorngrove study area, indicating the proposed 32m buffer

6.6 Cookhouse – Golden Valley

All of the drainage lines are impacted upon by the runoff from the low income housing development in Cookhouse, a number of irrigation balance dams and the man-made canals within the area (Figure 15).

The PES was estimated at being D (Largely modified) due the dams, road and rail activities already present within the four crossings that will be required (Figure 15 & Appendix A). While according to the DWA 1999 assessment the PES of the Great Fish River reach within the study area was D or largely modified (Kleynshans, 2000).

These four systems would also have LOW EIS due to their lack of any biodiversity and provide little in terms of ecosystem services (Appendix A).

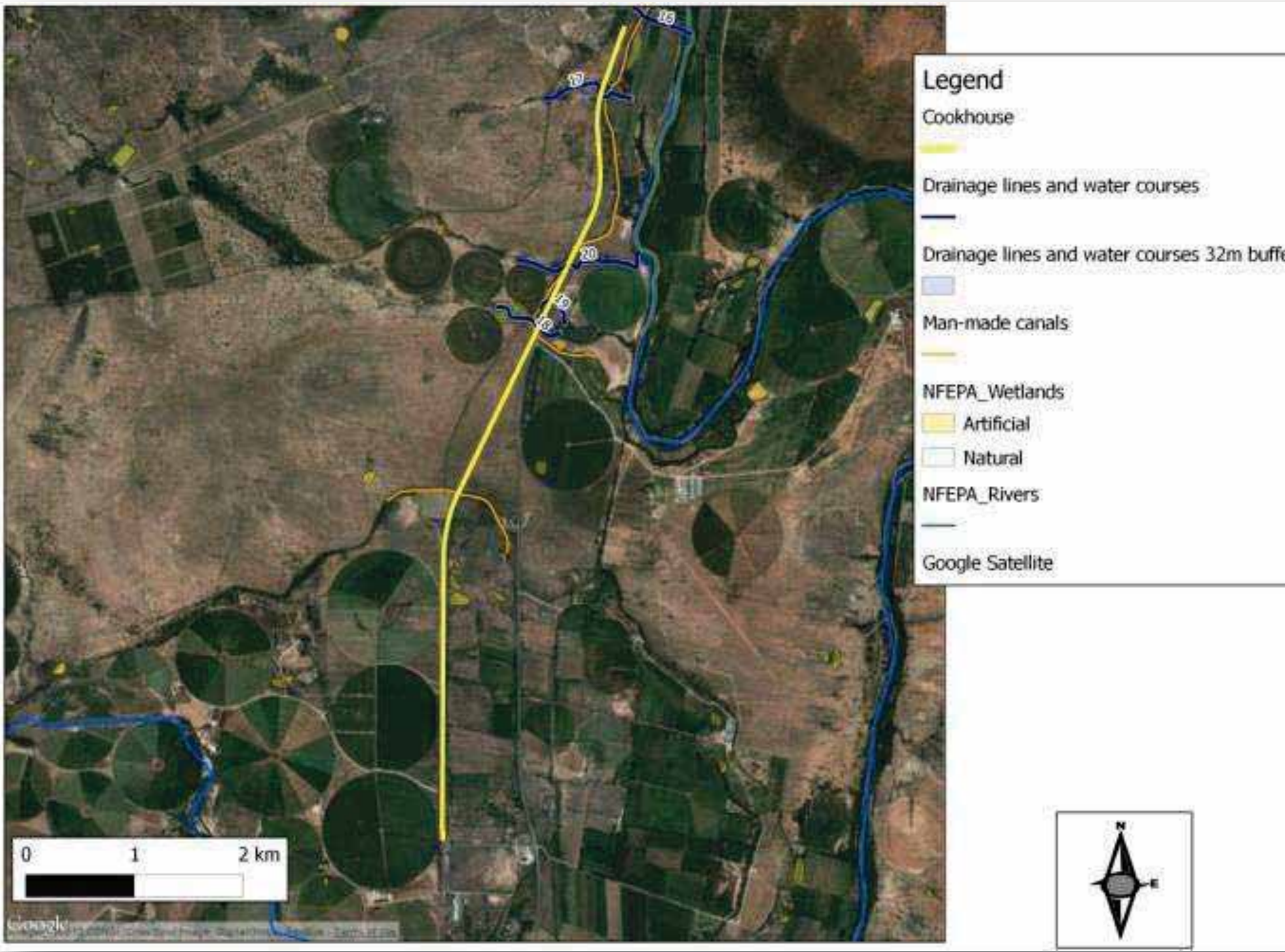


Figure 15: The watercourses observed within the Cookhouse-Golden Valley study area, indicating the proposed 32m buffers

6.7 Sheldon

Due to locality of the drainage lines being within the upper catchment, limited surface water run-off is experienced within the study area (Figure 16) and only one such system was observed that would require the extension of a culvert.

The PES was estimated at being C (Moderately Modified) with only a small number of impacts present (road, rail and erosion) for the 10 crossings observed within this loop (Figure 19 & Appendix A). While according to the DWA 1999 assessment the PES of the Great Fish River reach within the study area was D or largely modified (Kleynshans, 2000).

These systems would also have MODERATE EIS due to their limited contribution to biodiversity, but would aid in the recharge of shallow groundwater systems when water is present and act as important biological corridors and refugia within the greater region.

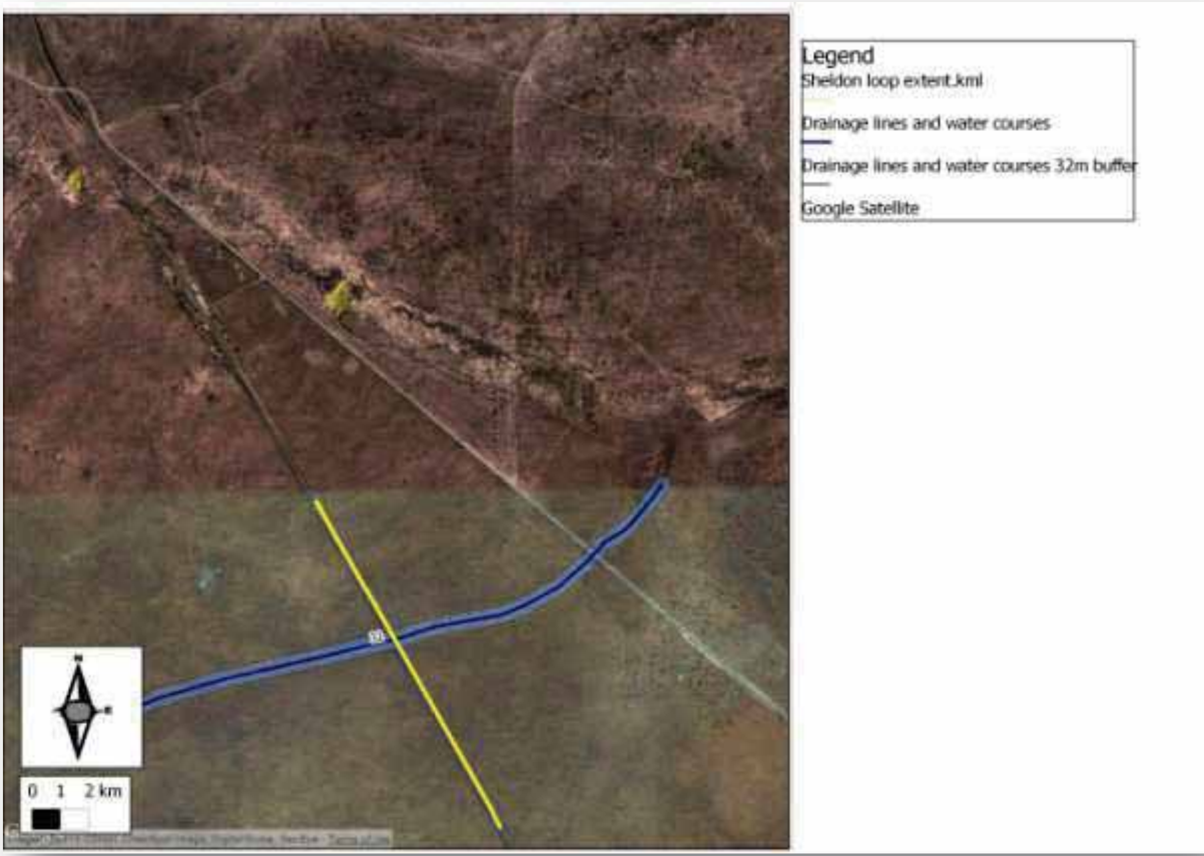


Figure 16: The observed watercourse within the Sheldon study area together with the proposed 32m buffer.

6.8 Ripon – Kommadagga

All of the drainage lines are impacted upon by the high number of farm dams, and man-made canals within the area. However the proposed rail loop extension will not cross the Great Fish River and its associated riparian zone (Figure 17). A further impact that was noted was the change in natural ground levels by the present rail and road culverts, which raise the height of the riverbed (Plate 2). This has impacts with regard to the movement of aquatic fauna in particular fish (habitat fragmentation), while resulting of inundation of upstream area (altering the hydrological regime). During high flows these areas also increase the volume and velocity of the surface waters, resulting in erosion of the downstream areas, i.e. the creation of sediment hungry flows

The PES was estimated at being C (Moderately Modified) with only a small number of impacts present (road, rail and erosion) for the 10 crossings observed within this loop (Figure 19 & Appendix A). While according to the DWA 1999 assessment the PES of the Great Fish River reach within the study area was D or largely modified (Kleynshans, 2000).

These systems would also have MODERATE EIS due to their limited contribution to biodiversity, but would aid in the recharge of shallow groundwater systems when water is present and act as important biological corridors and refugia within the greater region.

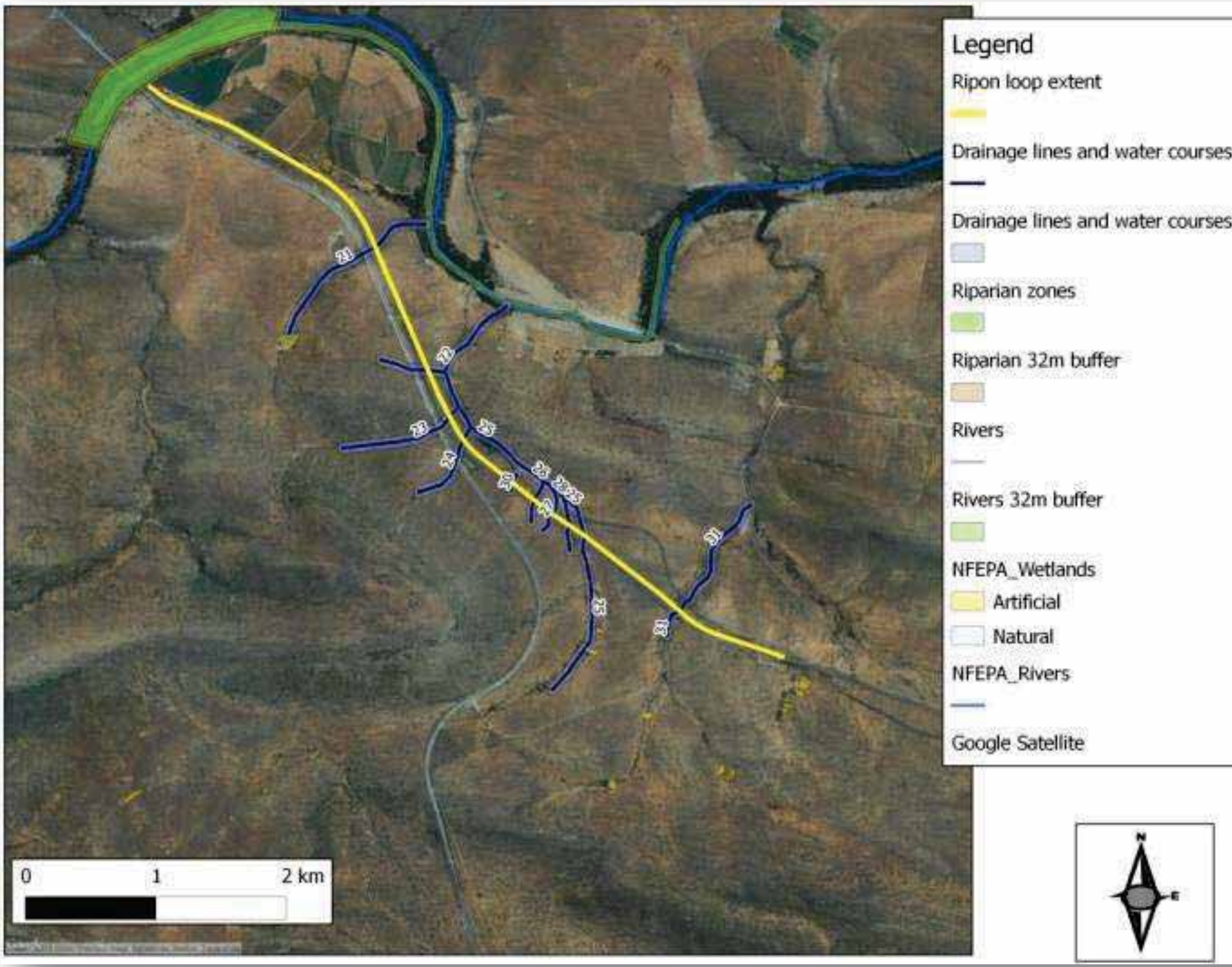


Figure 17: The watercourses observed within the Ripon study area, indicating the proposed 32m buffers for the drainage lines and riparian zones

Plate 2: An example of an elevated culvert that as raised the level of riverbed resulting in a form of habitat fragmentation

6.9 Verby

No water courses were found directly associated or linked to the study area surface drainage (Figure 18). However a rather unique landscape feature that has resulted in ephemeral wetland areas (Plate 3) was observed. The area to the south west of the proposed rail loop contains an area of relict or destabilised dune area and seepage and surface runoff collecting in the dune slack areas has been colonized by the facultative plant *Juncus kraussii*. This area or type of wetland this far from the coast is not well documented and thus should be protected from development by the indicated 50m buffer shown in Figure 18. The proposed loop thus falls just within this buffer area, however the construction will take place on the northern side of the current road and railway and thus have no direct impact on this area (Impact = Low). This area of construction will require a Water Use license Application as it occurs within the 500m zone (Figure 18) thus needing Section 21 c & 1 applications to be completed.

The PES was estimated at being B (Largely natural) with only a small number of impacts present (road, rail and erosion). The wetland area would have a HIGH EIS due to this system being unique within the region and little is known or understood with regard the functioning of these wetland areas (Appendix A).

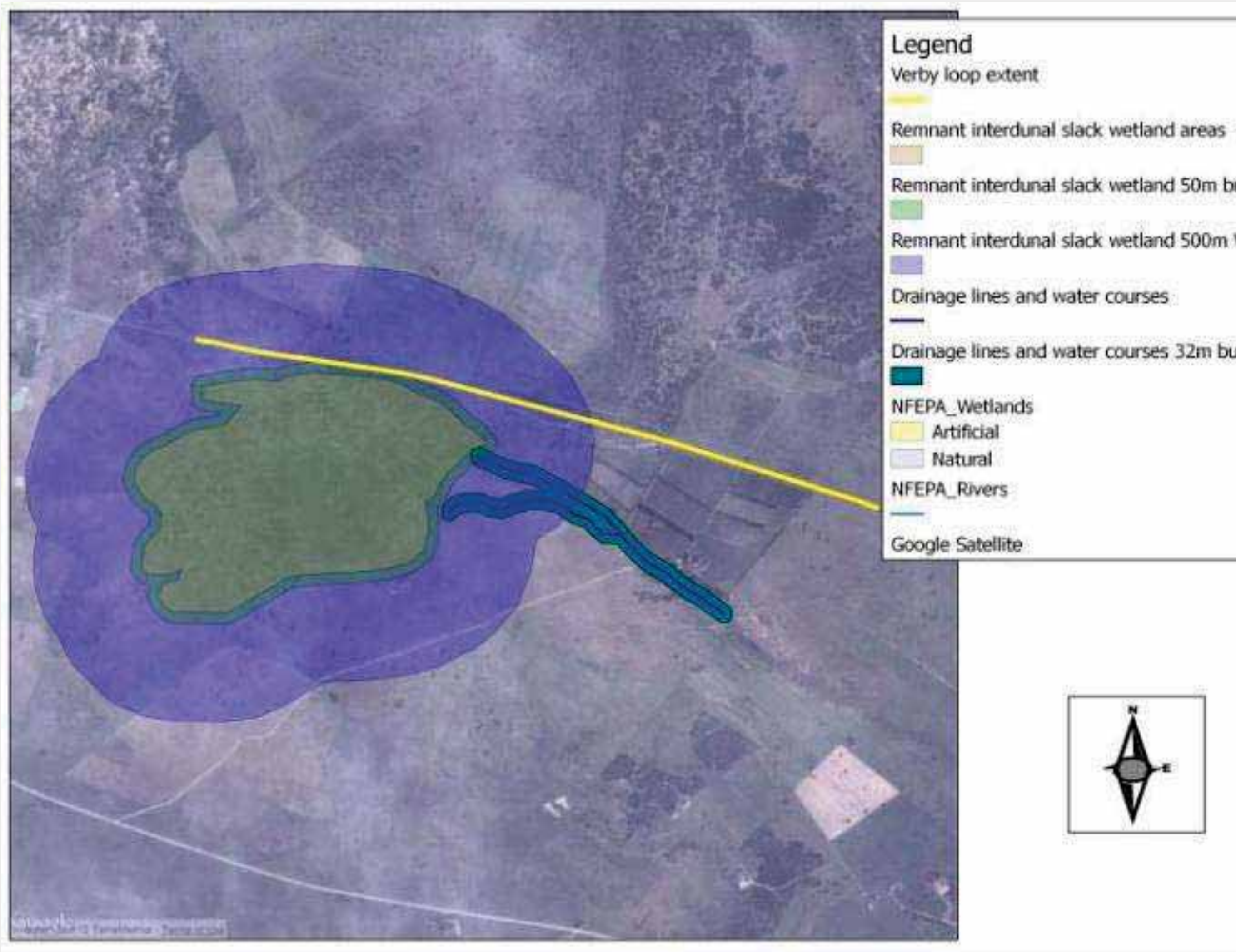


Figure 18: The watercourses observed within the Verby study area, indicating the drainage lines and dune areas within sand dune wetland areas and the proposed buffers

Plate 3: The sand dune environment adjacent to the Verby site dominated by the wetland species *Juncus kraussii*

7 – Potential impacts and recommendations

Due to the nature of the receiving environment and the mostly ephemeral nature of the areas that will be impact upon only three major impacts or environmental risks have been highlighted and have been rated based on the project actions / impacts, as well as any potential cumulative impacts during the construction and operational phases of the project. These were also assessed with and without mitigation. The impact assessment incorporates a risk assessment, as identified impacts are also regarded as threats that can negatively affect delineated watercourses. Furthermore, the risk of identified threats is evaluated by assessing aspects such as their probability of occurrence and their expected significance (magnitude of impact) on receiving watercourses.

It should be noted that all of the impacts assessed would have a negative impact on the aquatic systems, being assessed with a high degree of confidence based on the understanding of aquatic systems in the region and past experience in assessing similar types of proposals.

The potential impacts on the local drainage lines, watercourses and riparian systems would result from the physical changes, i.e. an increase in elevated areas (embankments) and the removal of vegetation in the local environment during the construction and operation of the rail loops extensions.

As no species of special concern or conservation important habitats were observed in the areas that will be constructed in and are already degraded, these potential impacts were not assessed. Similarly it is also anticipated that no wetland habitat will be lost thus the potential impacts arising would be Low to none and thus no further assessment in this regard was warranted.

Impact 1: Changes to the hydrological regime and increased potential for erosion

Nature of the impact

Due to the nature of the proposed project this would be an operational phase impact, limited to when the rail and water course crossing features and any erosion protection structures have been constructed. These structures could interfere with natural run-off patterns, either diverting flows or increasing the velocity of surface water flows. This has the potential to increase the potential for erosion in the study area, while increasing sedimentation of downstream areas, once flows subside.

Significance of impacts without mitigation

The soils within the study area are moderately susceptible to erosion when subjected to high flows (high volumes and velocities), and head-cuts can readily form within the water courses. These create bed and bank instability within the drainage lines and water course with the consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas.

Due to the nature of the study area hydrology, its present state and the present impacts, the negative impact, although permanent would be localised and probably result in a medium intensity impact. Thus the overall significance of the impact would be rated as **MEDIUM** as downstream areas are still intact (Table 3).

Proposed mitigation

- Surface water management features such as the crossing of drainage lines, should be placed in manner that flows remain unaltered in terms of direction, velocity and volume, thus the natural base flows, i.e. hydrological regime within these systems is maintained.
- It is also important that during construction and operations that excess ballast is not allowed to enter any water course areas, culverts etc., which if so doing alter these systems by forming impoundments as shown in this study.

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be Low, thus the overall significance of this impact would be **LOW** as the annual volumes of run-off within the study systems is low (Table 3). This impact is also partially reversible should the service roads /rail and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term, although it is envisaged that the service roads / rail once constructed would become a permanent feature.

Table 3: The potential impact of changes to the local hydrological regimes and increased potential of erosion

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Long-term 3	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	Low	-ve	High
Degree to which impact can be reversed				Partial				
Irreplaceability of resource				Low				

Impact 2: Diversion and increased velocity of surface water flows – reduction in permeable surfaces

Nature of the impact

The rail construction involves the creation of hard surfaces and embankments, which usually includes the provision of stormwater drainage such as culverts. This will divert further flow away from one water body, while increasing flow velocities of run-off into another during the operational phase. This impact is closely linked to the previous impact, but the reduction in permeable surfaces is assessed here due to the need for surface water to permeate into shallow, as well as deeper groundwater systems to sustain the local hydrology. This is important in both the maintenance of riparian associated vegetation dependent on subsurface flows in particular the loops from Rosmead southwards. The action of percolating water through permeable surfaces also aids in the reduction and / or removal of organic and inorganic pollutants contained in the surface waters.

Significance of impacts without mitigation

The soils within the study area are susceptible to erosion when subjected to high flows (high volumes and velocities), with head-cuts readily forming within the water courses. This creates bed and bank instability of the aquatic ecosystems and consequent sedimentation of downstream areas. Should surface water flows be diverted, changes in regional hydrological patterns could also occur, i.e. lead to the drying out of certain areas. The drying out of areas also reduces the potential for surface water to recharge shallow and deep groundwater systems.

Due to the nature of the study area hydrology and its present state and the surrounding impacts, the negative impact, although permanent would be localised and probably result in a medium intensity impact. Thus the overall significance of the impact would be rated as **MEDIUM** as downstream areas are still in an intact state (Table 4).

Proposed mitigation

Surface water management features such as the crossing of drainage lines, should be placed in manner that flows remain unaltered in terms of direction, velocity and volume, thus the natural base flows, i.e. hydrological regime (water quantity and quality) within these systems is maintained (Table 4).

Significance of impact with mitigation

Although permanent changes to the local hydrological regime are probable, the intensity of negative impact in the operational phase would be Low, thus the overall significance of this impact would be **LOW**. This is due to the fact that the surface flows within the study areas are naturally low and that most of the culverts are already in place and would only requiring extension.

This impact is also partially reversible should the rail and related infrastructure be decommissioned, i.e. changes to local soil structure and surrounding vegetation would still be apparent in the long term (Table 4).

Table 4: Potential impacts due to reduction in permeable surfaces

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	Medium 2	Long-term 3	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Long-term 3	Low 5	Probable	Low	-ve	High
Degree to which impact can be reversed				Partial				
Irreplaceability of resource				Low				

Impact 3: Impact of changes to water quality

Nature of the impact

Presently little is known about the water quality of the water courses, but it is assumed due to the activities in the study area, that the aquatic systems may already contain high levels of nitrates, phosphates and organic matter.

During construction various materials, such as sediments, diesel, oils and cement, will pose a threat to the continued functioning of the instream and adjacent areas, if by chance it is dispersed via surface run-off, or are allowed to permeate into the groundwater. The potential negative changes to water quality during the operational phase would be limited to sedimentation and erosion related issues. These negative impacts would persist into the medium term.

Significance of impacts without mitigation

Changes to water quality (surface and groundwater) impact on the functioning of plants and other instream biota. This impact without mitigation would have a **MEDIUM** significance, as excessive pollution will also impact on instream conditions due the introduction of toxins (Table 5). This is mostly relevant to the Knutsford, Drennan, Thorngrove, Cookhouse – Golden Valley and Ripon rail loop extensions, as these areas are directly adjacent to flowing rivers, streams and the irrigation canals.

Potential toxins include the following:

- Grout and concrete – these products contain cement which increases the pH (basic) of surfaces waters impairs the metabolism and breathing physiology of aquatic organisms
- Hydrocarbons (shutter oil, other lubricants, grease and fuels) – The persistent impact of these pollutants is varied, but can enact negatively on metabolic pathways, cellular structures (plant and animal), respiration and gene stability (heavy metals)

Proposed mitigation

- Any chemicals used/required must be stored safely on site and surrounded by bunds. Chemical storage containers must be regularly inspected so that any leaks are detected early
- Littering and contamination of water sources during construction must be prevented by effective construction camp management.
- Emergency plans must be in place in case of spillages onto road surfaces and water courses.
- No stockpiling should take place within a water course or their defined buffer areas (Figure 9 - 18).
- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimised.
- Stockpiles must be located away from river channels.
- Erosion and sedimentation into river channels must be minimised through the effective stabilisation (gabions and Reno mattresses) and then re-vegetation of any disturbed riverbanks must take place.
- The construction camp and necessary ablution facilities meant for construction workers must not be sited beyond the buffers described previously.

Significance of impact with mitigation

Should the construction works be managed properly, the negative impacts would remain localised and in the short-term, considering that in most cases the impacts are only related to the extension of culverts that are already in place. This would result in an overall significance of **VERY LOW** as the introduction of any pollutants would be limited with mitigation as most of the components would be precast and then installed *in situ* (Table 5).

Table 5: Impact on water quality

	Spatial extent	Intensity	Duration	Consequence	Probability	Significance	Status	Confidence
Without mitigation	Local 1	High 3	Medium term 2	Medium 6	Probable	Medium	-ve	High
With Mitigation	Local 1	Low 1	Short-term 3	Very Low 4	Probable	Very Low	-ve	High
Degree to which impact can be reversed				Partial				
Irreplaceability of resource				Low				

8 – Conclusion

Several drainage line crossings and a single well defined wetland crossing was identified and assessed according to their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS), (Appendix A). It would seem, based on the site visit and the type of waterbodies observed, that the proposed extension of existing rail loops for all nine areas would have a limited impact on the aquatic environment if the mitigations and recommendations are upheld together with the following aspects that must be included into the Environmental Management Plan:

With regard the potential impacts of the project on the aquatic environment, other than the physical destruction of any watercourse or wetland (incl sedimentation and erosion or habitat change) the next most detrimental impact includes the potential for any water quality changes. Water quality risks include in broad categories:

- Increase in sediment loads, measured as increase suspended sediments
- Hydrocarbon pollution from spilled fuel, oils (incl. shutter and hydraulics) and grease
- Cement products that pose a risk to aquatic organisms
- Contamination from Mn ore i.e. seepage or dust should any spills occur, although unlikely.

Impact avoidance as the most ideal form of mitigation has been applied during the design and planning phases of the project. This resulted in zero overlap between loop extensions and perennial rivers, while crossings through well developed wetland systems have been restricted.

A monitoring programme should therefore be in place not only to ensure conformance with the EMP, but also to monitor any environmental issues and impacts, which have not been accounted for in the EMP or could result in significant environmental impacts for which corrective action is required.

The period and frequency of monitoring will most likely be stipulated by the Environmental Authorisation. Where this is not clearly dictated, the EO should determine and stipulate the period and frequency of monitoring required in consultation with relevant stakeholders and authorities. The Resident Engineer and EO must ensure that the monitoring is conducted and reported.

The following protocols are recommended with regards to monitoring and should be read in conjunction with the CEMP which has already been finalised:

- Weekly environmental auditing for the duration of the construction period and 3 months into the operational phase.
- Monthly or quarterly environmental audit reports to be submitted to the Department of Water Affairs (DWA), or as advised by DWA for the duration of the construction period.
- Immediate notification of transgression to the Site Manager (& Project Contractor/Engineer) and provision of suitable mitigation measures to rectify environmental damage.
- If transgressions continue, report such incidences to the DWA immediately, although such incidences must be recorded in the audit reports.

To this end, it is suggested that the Proponent, Contractor and EO also consult the following guideline as reference:

*Department of Water Affairs and Forestry, February 2005. **Environmental Best Practice Specifications:** Construction Integrated Environmental Management Sub-Series No. IEMS 1.6. Third Edition. Pretoria*

*Department of Water Affairs and Forestry, February 2005. **Environmental Monitoring and Auditing Guideline**. Integrated Environmental Management Sub-Series No. IEMS 1.7. Third Edition. Pretoria.*

The following is also proposed with regard the potential impacts on the aquatic environment:

- Monitoring of any spills, erosion of cleared areas or downstream sedimentation should occur on a daily basis, with any remediation being instituted immediately (Contractor's environmental representative reporting to the Transnet Environmental Officer (EO).
- Monitoring of any vegetated areas must take place at least every month during construction, and every three months during a maintenance period (Transnet Environmental Officer & Contractor)
- Water that is discharged from dewatering during construction should be released in "silt bays" made from semi-permeable material, such as hay bales and geotextile material. These siltation structures should be located outside of watercourses, while water is released in a diffuse pattern.

Other forms of stormwater discharge during the construction phase should not result in concentrated flows or pose a risk for erosion development. Sediment should be trapped before stormwater is released into water courses, while any erosion features that develop immediately downstream of stormwater discharge points should be stabilised once observed.

Other important maintenance requirements that are recommended during the operational phase of the project pertain to culvert management:

- Culverts should be monitored for ballast material and sediment that can accumulate and concentrate surface flow patterns. These materials should be removed, especially before and during the rainy season.
- Channel incision and headcuts that may development immediately downstream of culverts should be stabilised once observed. Alien plant species that encroach into the servitude should be monitored and controlled at watercourse crossings.

9 – References

Agenda 21 – Action plan for sustainable development of the Department of Environmental Affairs and Tourism (DEAT) 1998.

Agricultural Resources Act, 1983 (Act No. 43 of 1983).

Berliner D. and Desmet P. 2007. Eastern Cape Biodiversity Conservation Plan: Technical Report. Department of Water Affairs and Forestry Project No 2005-012, Pretoria. 1 August 2007

Department of Water Affairs and Forestry - DWAF (2005). A practical field procedure for identification and delineation of wetland and riparian areas Edition 1. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry - DWAF (2007). Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types by M. Rountree (ed); C.P. Todd, C. J. Kleynhans, A. L. Batchelor, M. D. Louw, D. Kotze, D. Walters, S. Schroeder, P. Illgner, M. Uys. and G.C. Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kleynhans, C.J. 2000. Desktop estimates of the ecological importance and sensitivity categories (EISC), default ecological management classes (DEMC), present ecological status categories (PESC), present attainable ecological management classes (present AEMC), and best attainable ecological management class (best AEMC) for quaternary catchments in South Africa. DWAF report. Institute for Water Quality Studies.

Kleynhans CJ, Louw MD, Graham M, 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 377-08

Minerals and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002), as amended.

National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended.

National Water Act, 1998 (Act No. 36 of 1998), as amended

Ramsar Convention, (1971) including the Wetland Conservation Programme (DEAT) and the National Wetland Rehabilitation Initiative (DEAT, 2000).

10 – Appendix A

Loop name	Map Label	Crossing type	Description	Present Ecological State Score	Ecological Importance & Sensitivity Score	Impact significance of project	Report Figure	Quaternary Catchment
Rosmead	Riparian zone	Broad riparian zone with two channels	A well developed riparian zone with two channels that already have two culverts in place	C	Moderate	Moderate	Figure 10	Q14C
Tafelberg	N/A							
Knutsfords	N/A							
Drennan	N/A							
Thorngrove	15	Water course	Dry river bed with a hig number of farm dams with little evidence of any surface water flows in the recent past	C	Moderate	Low	Figure 14	Q50C
	36	Water course	Dry river bed with a hig number of farm dams with little evidence of any surface water flows in the recent past	C	Moderate	Low	Figure 14	
Cookhouse - Golden Valley	17	Water course	Water course with several culvert crossings in place for present rail, N10 road and the canal systems	D	Low	Low	Figure 15	Q70A ONLY
	18	Water course	Water course with several culvert crossings in place for present rail, N10 road and the canal systems	D	Low	Low	Figure 15	
	19	Water course	Water course with several culvert crossings in place for present rail, N10 road and the canal systems	D	Low	Low	Figure 15	
	20	Water course	Water course with several culvert crossings in place for present rail, N10 road and the canal systems	D	Low	Low	Figure 15	

Sheldon	32	Drainage lines	Site contains upper catchment drainage line with no channel and requires the lengthening of the culvert	C	Moderate	Low	Figure 16	Q70C
Ripon	21	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	Q80G
	22	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	23	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	24	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	25	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	26	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	27	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	28	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	30	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
	31	Drainage line	Small dry river bed crossing requiring culvert extension only	C	Moderate	Low	Figure 17	
Verby	Wetland 50m buffer	Dune wetland area	Interdunal or dune slack depression that accumulates water	B	High	Low	Figure 18	P10E